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Review Papers

Bioactive essential oils from the Cameroonian rain forest: A review - Part I

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ABSTRACT

Forty traditional medicinal plants from the Cameroonian rain forest belonging to twelve families are reviewed related to botanical description, taxonomy, common names, traditional use, essential oil composition as well as bioactivity and toxicity of their essential oils. A correlation is drawn between traditional use and bioactivity *in vitro*/*in vivo*, and structures of seventy-three main oil ingredients are given. Collected data indicate that plant essential oils unfold their biological activity related to functional groups of major and minor compounds, in a complex, fine-tuned interaction, modulated by environmental factors like the vegetation cycle of the plant, the altitude and the presence or absence of plant pathogen microbes, certain crop weevils as well as nematodes, varying with climatic seasons. Comparison of traditional use with laboratory results indicates effectivity of a good number of essential oils received from various plant parts, like leaves, bark, fruit, roots and rhizomes against *Plasmodium falciparum*, food borne microbes, dermatophytes, the malaria vector *Anopheles gambiae*, cancer cell lines, river blindness as well as plant pathogen weevils and fungi. However, toxicological studies are needed before any recommendation for application can be given. Importantly, leaf and fruit oil of *Cupressus lusitanica* (Cupressaceae) displayed strong acute toxicity in animal model, and the bark oil of *Cinnamomum verum* (Lauraceae) showed high toxicity in a normal cell line, so that preparations should be applied with care. Preformulation and formulation studies will be needed to develop a range of suitable dosage forms to introduce optimized pharmaceuticals (high active, low toxic) as replacement of current crude plant essential oil preparations in Cameroon and other Subsaharan countries.

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1. Introduction

Cameroon, officially the Republic of Cameroon, is a country in Central Africa bordered by Nigeria to the west, Chad to the north, the Central African Republic to the east, and Equatorial Guinea, Gabon and the Republic of the Congo to the south. Its coastline lies on the Bight of Bonny, which is part of the Gulf of Guinea and the Atlantic Ocean. Cameroon´s rain forest counts as one of the most biological diverse terrestrial ecosystems on earth, presenting a source of novel molecular structures and biologically active compounds.

In Cameroon, as in most other developing countries, plants are used for medicinal purposes long before prehistoric period, to cure variuos infectious diseases caused by parasites (Pavunraj et al., 2017; Mohammadhosseini, 2017; Mohammadhosseini et al., 2017). Traditional medicine continue to be widely practised on many area of this country. Plants have been extensively investigated, due to their biological activities and their econic value (Mohammadhosseni, 2016). These plants are used in various forms by

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local medicine practitioners as: decoctions, infusions, ointment, powder and maceration, friction and chewing. Several of these species, many of them endemic to Cameroon or Western/Central Africa, have been investigated within the last decades regarding their essential oil composition, analysed by gas chromatography (GC), which was combined with determination of their bioactivities *in vitro/in vivo*. Plants selected for research have been collected from all parts of Cameroon: Maroua, Kodeck, Lara, Touloum, Kaele, Tchecal-baila and Guirvidig in the Far North Region; Ngaoundéré in the Adamaoua (North) Region; Bamumbou, Bangang, Bafoussam, Dschang and Mbouda in the West Region; Sehn in the North West Region; Mbitom in the East Region; Yaoundé, Nkoldom, Mount Kalla and Mbalmayo in the Center Region; Douala in the Littoral Region; as well as Kribi and Lolodorf in the South Region. Selection of plant species for research had been focused on plants known for their traditional medicinal use and application in food/crop protection. This Part I on Essential Oils of Cameroon covers families of Annonaceae, Burseraceae, Chenopodiaceae, Compositae, Cyperaceae, Cupressaceae and Lamiaceae, reviewing data on common names, plant taxonomy, traditional use, GC-analyses of essential oils as well as their bioactivity *in vitro*. Structures of the two most abundand main components of essential oils are attached for plant parts of each species analysed.

2. Materials and Mthods

2.1. Methods

In order to assess the uses, chemical constituents and bioactivities of the essential oils, a wide range of literature sources were interrogated at Google accessible at https://www.google.com/ and Google Scholar at https://scholar.google.com/. Relevant items were identified systematically by searching for key terms including essential oils activity Cameroon etc. Additional information was accessed at The Plant List at www.theplantlist.org/, The Global Biodiversity Information Facility at www.gbif.org/, JSTOR Global Plants at https://plants.jstor.org/, and there under Collection: Useful Plants of West Tropical Africa; as well as Encyclopedia of Life at www.eol.org/ and Biodiversity Heritage Library at https://www.biodiversitylibrary.org/. Structures were drawn with the help of the National Institute of Standards and Technology, accessible in google under webbook.nist.gov/cgi/cbook.cgi?ID.

2.2. Plant material

All plants listed in this review were collected in all regions of Cameroon, from North to South and from East to West (Fig. 1), identified and vouchers were stored at the National Herbarium of Cameroon, at the Botanica Garden in Limbe or at the various research centers in Cameroonian universities. The periods of collection were in rainy and dry seasons. Cameroonian plant materials had been investigated for their essential oil composition by hydrodistillation using a Clevenger-type apparatus followed by gas chromatography analysis.

Fig. 1. Map of Cameroon and bordering countries.

Common names

Epazote (Spanish) meaning skunk smell, American wormseed, goosefoot, Jerusalem tea, Indian wormseed (English).

Fig. 2. The photograph of *Dysphania ambrosioides* (L.) Mosyakin & Clemants.

3. Results and Discussion

Cameroonian plant materials had been investigated for their essential oil composition by hydrodistillation using a Clevenger-type apparatus followed by gas chromatography analysis. Resulting compound profiles together with traditional use and *in vitro/in vivo* bioactivities of essential oils are presented and discussed in the following (Table 1).

3.1. Amaranthaceae

3.1.1. *Dysphania ambrosioides* (L.) Mosyakin & Clemants

3.1.1.1. Traditional use

The plant (Fig. 2) is traditionally used to kill insects and is recorded among the Baka living in the Dja biosphere reserve, Cameroon for use against intestinal helminthiasis (Betti, 2004; Pavela et al., 2016).

It is utilized as diuretic, antifungal, wound healing

Table 1
Essential oils composition and percentages of compounds.

Species	Plant part	Essential oil compounds	Bioactivity of essential oil and toxicity
		1. Amaranthaceae	
Dysphania ambrosioides	Aerial parts Bafou , Dschang in December 2016.	***p*-Cymene 1** (29.2%), limonene (0.2%), allyxl hexanoate (0.3%), *p*-cymenene traces, *p*-methyl acetophenone traces, *p*-cymen-8-ol (0.3%), α-terpineol traces, dihydroascaridole (0.7%), ***cis*-ascaridol 2** (35.4%), *cis*-piperitone epoxide (0.1%), *trans*-piperitone epoxide (0.4%), *trans*-ascaridole glycol (1.7%), *cis*-ascaridole glycol (2.1%), carvacrol (0.1%), ***trans*-ascaridole 3** (26.0%), 4-hydroxy-cryotone (0.1%) (Pavela et al., 2017)	Toxic to crop weevils (Pavela et al., 2017); antiplasmodial (Pollack, et al., 1990); activity in cancer cells in vitro (Effert et al., 2002; Bezerra et al., 2009); antileishmanial, anti-Plasmodium falciparum activity (Wu, 2013; Monzote et al., 2014)
	Leaf	-	Toxic to crop weevils (Denloye et al., 2010; Soares et al., 2017); anti- Entamoeba histolytica (Ávila-Blanco et al., 2014); activity in cancer cells *in vitro* (Degenhardt et al., 2016); but not toxic in normal fibroblast cells *in vitro* (Soares et al., 2017)
	Twigs	-	Toxic to crop weevils (Pandey et al., 2014)
		2. Amaryllidaceae	
Allium cepa	Bulbs Yaounde in August 2013	Diallyl sulphide 1.(38%), 2,5-dimethyl thiophene (0.82%), octyl aldehyde (2.26%), phenylacetaldehyde (2.69%), 2-propenyl propyl disulphide (5.15%), *trans*-propenyl propyl disulfide (2.86%), dipropyl disulphide (2.71%), 1-propenyl propyl disulphide (3.77%), 3,5-dimethyl-1,2,4-trithiolane (1.81%), methyl propyl trisulfide (8.14%), benzylcyanide (2.52%), dimethyl tetrasulfide (1.32%), 2,5-dimethylthiazole (4.62%), **diallyl trisulfide 4** (22.17%), **dipropyl trisulfide 5** (11.11%), 1-propenyl propyl sulphide (1.26%), di-1-propenyl sulphide (1.71%), 2-methyl-3-isothiozolone (2.23%), 2-methyl-3,4-dithiaheptane (9.88%), *p*-methoxybenzylisothiocyanate 3.55%, dipropyl tetrasulfide (8.07%) (Ndoye et al., 2016)	Anti-inflammatory (Ndoye et al., 2016); antioxidant, acetylcholinesterase inhibitory, activity in cancer cells (Zou et al., 2017); antifungal (Skrinjar et al. 1999; Dimić et al., 2004; Kocić -Tanackov at al., 2017); antidiabetic (El-Soud and Khalil, 2010)
Allium sativum	Bulbs Yaounde in August 2013	2,4-Dimethylthiophene (0.63%), diallyl sulfide (7.10%), methyl propyl disulphide (1.19%), dimethyl trisulfide (0.58%), 2-phenyl furan (0.48%), limonene (0.62%), 2-propenyl propyl disulfide (0.20%), 2,5-dimethyl-1,3,4-thiadiazole (0.74%), **diallyl disulfide 6** (19.74%), linalool (0.88%), dipropyl disulfide (0.62%), allyl methyl trisulfide (12.95%), 3,4-dihydro-3-vinyl-1,2-dithiin (1.37%), dimethyl tetrasulfide (1.59%), **diallyl trisulfide 4** (41.62%), 3-methoxyoctane (0.62%), allyl propyl sulfide (1.30%), di-1-propenyl sulfide (2.08%), *p*-methoxybenzylcyanide (0.85%), β-caryophyllene (0.23%), γ-cadinene (0.39%), diallyl tetrasulfide (4.22%) (Ndoye et al., 2016).	Antibacterial, antioxidant (Tsao et al., 2003); antifungal (Mallet et al., 2014); antioxidant, anti -inflammatory (Ndoye et al., 2016)
	Aerial parts	-	Antibacterial (Najafi et al., 2016)
		3. Annonaceae	
Annona senegalensis	Red bulbs Yaoundé in August 2013	**α-Cadinol 7** (14.97%), **γ-cadinol 8** (13.36%), (*Z*)-β-ocimene (5.96%), linalool (5.21%) (Jirovetz et al., 2002)	Insecticidal activity mL (Kouniki et al., 2007a,b; N gamo et al, 2007a,b). Toxic to crop weevils (Kouniki et al., 2007a,b; Ngamo et al., 2007a,b)
	Peel	**γ-Cadinol 8** (15.81%),**α-cadinol 7** (15.22%), 1,8-cineole (eucalyptol) (12.02%), linalool (7.13%), (*Z*)-β-ocimene (6.04%) (Jirovetz et al., 2002)	-
	Leaf	**Linalool 9** (9.04%), limonene (8.78%), α-phellandrene (7.012%),γ-cadinol (6.27%), caryophyllene alcohol (5.84%), α-cadinol (5.65%), δ-cadinol (5.09%) (Jirovetz et al., 2002)	
Cananga odorata	Flowers Yaounde in September 2012	Germacrene D (1.5%), germacrene B (4.9%), **linalool 9** (17.4%), **geranyl acetate 10** (9.2%) (Nyegue et al., 2017).	Antibacterial (Lee et al., 2014; Nyegue et al., 2017); antimicrobial (Hammer et al., 1999); antioxidant, antifungal (Saccetti et al., 2005); anti-Aedes aegypti and Anopheles dirus activity (Phasomkusolsil and Soonwera, 2011; Smith et al., 2014)
Cleistopholis patens	Stem bark in yaounde, December 2008	β-Pinene (0.28%), γ-terpinene (0.24%), linalool (0.65%), δ-elemene (2.44%), α-cubebene (1.33%), α-ylangene (0.42%), **α-copaene 11** (16.90%), β-elemene (2.44%), cyperene (1.66%), (*Z*)-α-bergamotene (0.43%), β-caryophyllene (2.58%), γ-elemene + β-cubebene (2.91%), (*E*)-α-bergamotene (1.10%), (*E*)-β-farnesene (0.80%), α-humulene (0.90%), alloaromadendrene (0.80%), γ-muurolene (1.80%), germacrene D (3.80%), α-muurolene (1.19%), β-bisabolene (0.94%), (*Z*)-γ-bisabolene (0.87%), γ-cadinene (0.33%), bicyclogermacrene (2.81%), **δ-cadinene 12** (28.70%), (*E*,*Z*)-germacrene B (4.91%), germacrene B (7.40%), spathulenol (2.52%), caryophyllene oxide (2.90%), cubenol (2.46%), *epi*-α-muurolol (1.92%), and α-cadinol (0.30%) (Boyom et al., 2011)	Anti-Plasmodium falciparum activity (Boyom et al., 2011)
	Leaves in yaounde, December 2008	α-Thujene (0.16%), α-pinene (0.12%), camphene (0.10%), sabinene (0.10%), β-pinene (0.10%), myrcene (2.00%), δ-3-carene (0.15%), α-terpinene (0.1%), *p*-cymene (0.22%), limonene (1.15%), γ-terpinene (0.21%), linalool (0.22%), terpinen-4-ol (0.10%), α-terpineol (0.10%), δ-elemene (0.86%), α-cubebene (0.10%), α-ylangene (0.11%), α-copaene (1.12%), β-elemene (1.57%), (Z)-α-bergamotene (0.10%), **β-caryophyllene 13** (27.54%), γ-elemene + β-cubebene (3.2%), (*E*)-α-bergamotene (0.10%), (*E*)-β-farnesene (0.20%), α-humulene (2.77%), alloaromadendrene (1.27%), γ-muurolene (0.42%), **germacrene D 14** (16.14%), α-muurolene (0.70%), β-bisabolene (1.00%), (*Z*)-γ-bisabolene (0.80%), γ-cadinene (0.70%), bicyclogermacrene (4.23%), δ-cadinene (1.60%), cadina-1,4-diene (0.70%), (*E*,*Z*)-germacrene B (1.97%), germacrene B (15.98%), spathulenol (0.78%), caryophyllene oxide (3.80%), cubenol (0.43%), epi-α-muurolol (2.39%), and α-cadinol (2.42%) (Boyom et al., 2011)	
Hexalobus crispiflorus	Stem bark Mbalmayo, April 2001	Camphene (0.13%), β-pinene (0.12%), terpinen-4-ol (0.13%), δ-elemene (0.21%), α-cubebene (0.36%), α-ylangene (0.33%), **α-copaene 11** (13.27%), β-elemene (1.92%), **cyperene 15** (11.53%), *iso*-caryophyllene (0.75%), β-	

Table 1 (Continued)

		caryophyllene (1.30%), aromadendrene (1.08%), α-humulene (1.76%), alloaromadendrene (8.52%), γ-muurolene (1.93%), germacrene D (2.62%), α-muurolene (1,29%), γ-cadinene (2.53%), β-selinene (2.20%), α-selinene (3.37%), δ-cadinene (10.07%), calacorene (7.82%), (*Z*)-calamenene (1.09%), cadalene (1.56%), (*E*)-nerolidol (2.82%), spathulenol (1.97%), caryophyllene oxide (2.54%), γ-eudesmol (0.99%), humulene oxide (1.38%), *epi*-α-cadinol (7.34%), 1,10-di-*epi*-cabenol (1.30%), β-eudesmol (1.08%), α-cadinol (1.41%), α-eudesmol (1.61%), and *epi*-α-bisabolol (1.47%) (Boyom et al., 2003)	
Duguetia confinis	Stem bark Mbalmayo, April 2001	α-Thujene (0.59%), sabinene (0.59%), δ-3-carene (1.1%), α-terpinene (0.48%), *p*-cymene (0.32%), (*E*)-β-ocimene (1.93%), terpinolene (0.4%), linalool (0.22%), fenchol (0.18%), (*E*)-pinocarvol (0.31%), pinocarvone (3.16%), terpinen-4-ol (0.16%), δ-elemene (0.53%), α-cubebene (0.52%), α-copaene (7.06%), β-elemene (0.73%), **cyperene 15 (**15.54%), α-cedrene (6.02%), α-gurjunene (1.86%), β-caryophyllene (0.28%), (*E*)-α-bergamotene (0.18%), α-humulene (5.04%), γ-muurolene (0.35%), germacrene D (0.84%), γ-cadinene (3.51%), bicyclogermacrene (2.41%), β-selinene (0.28%), (*E,E*)-α-farnesene (2.66%), α-selinene (1.41%), **δ-cadinene 12 (**8.06%), (*Z*)-calamenene (2.32%), α-cadinene (1.01%), elemol (1.24%), (*E*)-nerolidol (2.42%), spathulenol (2.16%), caryophyllene oxide (7.24%), globulol (2.38%), humulene oxide (3.17%), cubenol (3.23%), T-muurolol + torreyol (2.1%), epi-α-cadinol (1.25%), α-muurolol (0.64%), α-cadinol (1.16%), farnesol (0.35%), eugenyl acetate (1.78%), 2,4,5-trimethoxy-styrene (0.43%), and benzyl benzoate (0.21%) (Boyom et al., 2003)	Anti-Plasmodium falciparum activity (Boyom et al., 2003)
Monodora myristica	Fruit Kribi, March 2012	α-Thujene (1.4%), **α-phellandrene** 1**5** (67.1%), **α-pinene 17 (**4.2%), sabinene (0.1%), β-pinene (0.3%), myrcene (3.8%), α-terpinene (0.1%), *p*-cymene traces, limonene (1.8%), β-phellandrene (3.05%), (*Z*)-β-ocimene (0.3%), (*E*)-β-ocimene (0.2%), γ-terpinene traces, terpinolene traces, linalool (2.1%), *cis*-p-menth-2-en-1-ol traces, *trans*-p-menth-2-en-1-ol traces, α-terpineol (0.6%), *trans*-thujen-3-ol (0.7%), β-elemene (0.1%), β-caryophyllene (0.3%), α-humulene (0.3%), γ-muurolene (0.4%), *trans*-muurola-4(14),5-diene (0.3%), α-muurolene (0.4%), γ-cadinene (1.7%), δ-cadinene (3.2%), germacrene D-4-ol (1.3%), epi-α-cadinol (0.9%), α-cadinol (0.9%), shyobunol (0.3%), (2*Z*, 6*Z*)-farnesol (1.1%) (Bakarnga-Via et al., 2014)	Activity in cancer cells *in vitro* (Bakarnga-Via et al., 2014)
	Seeds	-	No antifungal activity against *Aspergillus flavus, A. fumigatus* and *Fusarium moniliforme* (Nguefack et al., 2004a)
Uvariastrum pierreanum	Stem bark Yanoude Decembre 2008	α-Copaene (5.7%), β-elemene (0.1%), (*Z*)-α-bergamotene (5.20%), α-cedrene (1.00%), α-santalene (4.50%), β-caryophyllene (0.90%), (*E*)-α-bergamotene (9.00%), (*E*)-β-farnesene (3.00%), α-humulene (0.10%), α-farnesene (5.70%), *ar*-curcumene (8.60%), **β-bisabolene 18 (**28.20%), δ-cadinene (0.70%), (*Z*)-calamenene (3.00%), β-sesquiphellandrene (5.30%), (*E*)-calamenene (0.70%), (*E*)-nerolidol (0.8%), caryophyllene oxide (1.20%), γ-eudesmol (1.00%), *epi*-α-cadinol (0.10%), α-cadinol (0.70%), β-bosabolol (2.30%) and **α-bisabolol 19 (**11.50%) (Boyom et al., 2011)	anti-Plasmodium falciparum activity (Boyom et al., 2011)
	Leaves Yanoude Decembre 2008	**α-Pinene 17 (**22.80%), camphene (0.50%), **β-pinene 20 (**23.00%), myrcene (2.50%), *p*-cymene (0.80%), limonene (0.5%), (*Z*)-β-ocimene (0.10%), (*E*)-β-ocimene (0.8%), terpinolene (0.10%), *neo-allo*-ocimene (0.10%), linalool (0.80%), borneol (0.10%), terpinen-4-ol (0.3%), α-terpineol (4.00%), geraniol (0.10%), α-cubebene (0.10%), α-copaene (7.90%), β-elemene (0.10%), (*Z*)-α-bergamotene (0.88%), α-cedrene (0.10%), β-caryophyllene (0.10%), (*E*)-α-bergamotene (2.50%), (*E*)-β-farnesene (1.70%), α-farnesene (1.80%), *ar*-curcumene (0.80%), β-bisabolene (4.30%), δ-cadinene (2.60%), (*Z*)-calamenene (0.30%), (*E*)-nerolidol (1.22%), caryophyllene oxide (0.10%), γ-eudesmol (0.50%), *epi*-α-cadinol (0.10%), α-cadinol (0.10%), β-bisabolol (0.20%), α-bisabolol (4.56%) and (*E, E*)-farnesol (1.22%) (Boyom et al., 2011)	anti-Plasmodium falciparum activity (Boyom et al., 2011)
Xylopia aethiopica	Stem bark Mbalmayo near Yaoundé, April 2001	α-Thujene (0.61%), α-pinene (4.05%), camphene (4.87%), sabinene (0.46%), **β-pinene 20 (** 10.07%), α-terpinene (0.43%), *p*-cymene (1.72%), (*E*)-β-ocimene (1.13%), γ-terpinene (0.58%), terpinolene (0.37%), linalool (1.58%), nopinone (2.53%), (*E*)-pinocarvol (5.42%), camphor (1.40%), pinocarvon e (1.84%), terpinen -4-ol (0.49%), myrtenal (2.85%), α-terpineol (4.99%), **myrtenol 21 (**6.40%), verbenone (2.68%), bornyl acetate (0.67%), δ-elemene (0.44%), α-cubebene (1.04%), α-ylangene (5.32%), α-copaene (4.07%), β-elemene (1.34%), cyperene (3.95%), α-gurjunene 0.64%, β-caryophyllene (1.67%), α-humulene (1.09%), γ-muurolene (2.64%), germacrene D (0.94%), α-muurolene (1.84%), (*E,E*)-α-farnesene (0.56%), α-selinene (0.82%), δ-cadinene (4.3%), cadina -1,4-diene (0.67%), calacorene (0.84%), (*Z*)-calamenene (0.93 %), elemol (1.09%), spathulenol (6.33%), caryophyllene oxide (1.99%), *epi*-α-cadinol (1,00%), and β-eudesmol (1.15%) (Boyom et al., 2003)	anti-*Plasmodium falciparum* activity (Boyom et al., 2011)
	Fruit Yaounde not priode of collection	α-Thujene (0.30%), **α-pinene 17 (**18.44%), β-thujene (4.38%), **β-pinene 20 (**37.80%), α-phellandrene (0.46%), *p*-cymene (1.00%), D-limonene (8.62%), (*E*)-β-ocimene (0.52%), 1,8-cineole (5.38%), *p*-menth-8-en-1-ol (0.76%), linalool (0.80%), pinocarveol (0.86%), 1,4-terpineol (1.10%), *p*-menth-1-en-8-ol (1.18%), α-thujenal (1.06%), γ-elemene 0.96%), α-cubebene (0.77%), β-cubebene (7.74%), α-zingiberene (0.53%), γ-cadinene (0.39%), γ-himachalene (1.20%), kaurene (0.70%), and (-)-spathulenol (0.91%) (Gardini et al., 2009)	activity in cancer cells *in vitro* (Asekun and Adeniyi, 2004; Bakarnga-Via et al., 2014); antifungal (Tatsadjieu et al., 2010; Tegang, et al., 2017); antibacterial (Gardini et al., 2009); Toxic to crop weevils (Kouninki et al., 2005; Ngamo et al., 2007; Ousman et al., 2007)
	Fruit, Kribi, March 2012	α-Thujene (1.00%), α-pinene (10.80%), sabinene (4.00%), **β-pinene 20 (**28.20%), myrcene (0.30%), α-phellandrene (0.50%), α-terpinene (3.40%), *p*-cymene (0.80%), limonene (0.40%), β-phellandrene (5.80%), (*Z*)-β-ocimene (1.30%), (*E*)-β-ocimene (1.30%), γ-terpinene (5.70%), terpinolene (1.50%), *trans*-sabinene hydrate (0.30%), *cis*-*p*-menth-2-en-1-ol (0.30%), *trans*-pinocarveol (0.90%), **terpinen-4-ol 22 (**15.10%), α-terpineol (3.60%), mytenal	

Table 1 (Continued)

		(1.40%), δ-elemene (0.80%), α-cubebene (0.40%), α-ylangene (0.40%), α-copaene traces, β-elemene (0.50%), β-caryophyllene traces, α-humulene (0.80%), γ-muurolene (1.10%), germacrene D (5.10%), bicyclogermacrene (0.30%), δ-cadinene (0.30%), germacrene B (0.50%), α-cadinol (0.30%) (Bakarnga-Via et al., 2014)	
	Fruit, Mbitom, July 2008	α-Thujene (2.22%), α-pinene (11.10%), **β-pinene 20 (**27.90%), **sabinene 23 (**23.90%), α-phellandrene (0.10%), α-terpinene (2.22%), *p*-cymene (0.50%), β-phellandrene (15.91%), 1,8-cineole + limonene (3.25%), δ-3-carene (0.30%), *trans*-β-ocimene (0.10%), γ-terpinene (0.10%), *cis*-sabinene hydrate (0.20%), terpinolene (0.40%), cymemene (0.30%), *cis*-p-menth-2-en-1-ol traces, *trans*-pinocarveol (0.20%), sabinol (0.10%), *trans*-verbenol (0.30%), β-pinene oxide traces, p-mentha-1,5-dien-8-ol (0.20%), terpinen-4-ol (5.13%), cryptone (0.30%), myrtenal (0.20%), myrtenol (0.10%), verbenone (0.10%), cuminal traces, carvone (0.30%), myrtenyl acetate (0.10%), *trans* ascaridol (0.20%), bornyl acetate traces, iso ascaridol (0.10%), (*E*)-caryophyllene traces, δ-elemene (0.30%), β-cubebene (0.20%), cyclosativene traces, α-ylangene (0.10%), α-copaene traces, β-elemene (0.20%), β-ylangene (0.10%), β-copaene traces, aromadendrene (0.10%), germacrene D (3.54%), γ-amorphene (0.10%), β-selinene traces, 10-*epi*-zonarene (0.30%), *cis*-cadina-1,4-diene traces, α-murolene (0.10%), (*Z*)-γ-bisabolene traces, δ-cadinene (0.1%), (*E*)-γ-bisabolene (0.10%), α-cadinene (0.20%), (*E*)-nerolidol traces, spathulenol traces, caryophyllene oxyde (0.30%), thujopsan-2α-ol 0.2%, 1,10-di-epicubebol traces, cubebol (0.10%), and *ent*-13-*epi*-manoyl oxyde (0.20%) (Nguemtchouin et al., 2010)	
	Fruit, Ngaoundéré, March 2005.	α-Pinene (1.70%), camphene (0.30%), sabinene (5.80%), **β-pinene 20 (**12.90%), myrcene (0.10%), α-phellandrene (4.80%), β-phellandrene (1.80%), δ-3-carene (0.90%), α-terpinene (0.40%), *p*-cymene (1.20%), (*E*)-β-ocimène (2.20%), α-terpinene (1,00%), terpinolene (0.30%), 1,8-cineole (0.60%), (*E*)-sabinene hydrate (0.50%), nerol (0.80%), fenchol (0.10%), geraniol (0.10%), *iso*-pulegone (0.70%), borneol (0.10%), bornyl acetate (0.20%), **terpinen-4-ol 22 (**8.90%), α-terpineol (4,00%), pinocarvone (0.90%), pinocarvaneol (2.30%), terpinyl acetate (0.20)%, piperitone (0.10%), eugenol (1.10%), ylangene (1.30%), α-copaene (1.10%), β-elemene (2.10%), δ-elemene (0.40%), α-elemene (0.40%), β-caryophyllene (2.80%), *cis*-α-bergamotene (0.30%), α-cubebene (0.70%), α-farnesene (1.20%), α-humulene (0.80%), α-cadinene (1.80%), patchoulene (0.80%), δ-cadinene (0.60%), aromadendrene (0.50%), germacrene (2.20%), α-muurolene (0.40%), patchoulenol (0.90%), elemol (0.50%), caryopyllene oxyde (1.60%), spathulenol (1.90%), nerolidol (1.10%), cedrol (0.50%), α-cadinol (0.70%), δ-cadinol (0.40%), and α-farnesol (0.90%) (Tatsadjieu et al., 2010)	
	Fruits Bafoussam, West Cameroon in July 2015	α-Thujene (1.92%), α-pinene (7.39%), α-fenchene (0.12%), **β-pinene 20** (32.16%), α-phellandrene (6.80%), α-terpinene (0.61%), *p*-cymene (0.44%), β-phellandrene + 1,8-cineole (0.03%), (*Z*)-β-ocimene (1.12%), limonene (0.68%), β-phellandrene (10.71%), *cis*-β-ocimene (2.37%), γ-terpinene (2.09%), camphenilone (0.18%), *p*-cymenene (1.94%), terpinolene (0.39%), β-thujone (0.46%), *cis*-p-menth-2-en-1-ol (0.22%), nopinone (0.19%), myroxyde E (0.24%), isopulegol (0.18%), β-pinene oxide (0.02%), p-mentha-1,5-dien-8-ol (0.44%), terpinene-4-ol (0.11%), cryptone (0.03%), α-terpineol (0.05%), myrtenal (0.13%), methyl chavicol (0.04%), verbenone (4.67%), *trans* carveol (0.06%), (R)-(+)-β- citronellol (0.74%), (*E*)-citral (0.21%), cuminal (0.20%), carvone (0.12%), peryllaldehyde (0.33%), bornyl acetate (0.04%), thymol (0.35%), 2E,4Z-decadienal (0.05%), longycyclene (1.37%), α-copaene (0.20%), β-bourbonene (0.63%), α-cubebene (0.04%), cyperene (0.13%), β-elemene (0.49%), (*Z*)-caryophyllene (0.47%), *cis*-prenyl limonene (0.60%), β-copaene (0.08%), aromadendrene (0.21%), α-humulene 0.95%, *trans*-prenyl limonene (0.09%), aromadendr-9-ene (0.20%), germacrene D (0.19%), **(*Z*)-γ-bisabolene 24** (10.07%), δ-cadinene (0.13%), (*E*)- γ-bisabolene (0.87%), α-cadinene (0.12%), α-calacorene (0.14%), selina-3,7(11)-diene (0.56%), germacrene B (0.04%), elemol (0.04%), caryophyllene oxide (0.10%), thujopsan-2-α-ol (0.56%), neryl isovalerate (0.19%), *epi*-globulol (0.16%), *epoxy-allo* alloaromadendrene (0.06%), isospathulenol (0.04%), α-eudesmol (0.25%), velerianol (0.11%), α-cadinol (0.14%), E-apritone (0.08%) (Tegang et al., 2017)	
	Seeds Cameroon in October 2012	**sabinene 23** (23.70%), **β-pinene 20** (17.20%), α-pinene (9.40%), limonene (13.70%), eucalyptol (12.00%) (Nyegue et al., 2017).	Antibacterial (Nyegue et al., 2017) Toxic to crop weevils (Kouninki et al., 2007) Toxic to crop weevils (Kouniki, 2007)
Xylopia parviflora	Fruits Kribi, March 2012	**α-Pinene 18** (10.80%), sabinene (3.00%), **β-pinene 20 (**32.90%), *p*-cymene (2.80%), limonene (0.50%), β-phellandrene (0.70%), 1,8-cineole (2.00%), (*Z*)-β-ocimene traces, (*E*)-β-ocimene (8.00%), linalool (0.70%), *trans*-pinocarveol (3.20%), *trans*-verbenol (0.40%), pinocarvone (0.70%), borneol (0.60%), terpinen-4-ol (0.70%), *p*-cymen-8-ol (0.70%), α-terpineol (1.70%), myrtenol (5.20%), bornyl acetate (0.40%), δ-elemene traces, α-cubebene traces, α-ylangene (0.60%), α-copaene (0.50%), β-elemene (0.40%), β-caryophyllene traces, β-copaene (1.10%), γ-muurolene (0.50%), germacrene D (2.00%), *trans*-muurola-4(14),5-diene (1.80%), α-muurolene (0.80%), δ-cadinene (3.70%), cubebol (1.70%), elemol (2.00%), caryophyllene oxide (2.00%), *epi*-α-cadinol (2.40%), α-muurolol (2.90%), germacra-4(15),5, 10(14)-triene-1-α-ol (1.50%) (Bakarnga-Via et al., 2014)	Activity in cancer cells *in vitro* (Bakarnga-Via et al., 2014)
Xylopia phloiodora	Stem bark, Yaoundé, April 2001	α-Pinene (0.58%), camphene (1.38%), β-pinene (0.68%), *p*-cymene (0.35%), linalool (0.31%), nopinone (0.65%), (*E*)-pinocarvol (1.23%), *p*-cymen-8-ol (1.58%), myrtenal (0.28%), verbenone (2.23%), thymol (0.28%), δ-elemene (3.29%), α-copaene (0.53%), cyclosativene (2.07%), β-elemene (0.58%), cyperene (0.34%), (*E*)-α-bergamotene (0.04%), *epi*-bicyclo-	anti-*Plasmodium falciparum* activity (Boyom et al., 2003)

Table 1 (Continued)

		sesquiphyllandrene (3.00%), germacrene D (1.02%), γ-cadinene (11.27%), bicyclogermacrene (1.43%), **α-selinene 25** (21.92%), **δ-cadinene 12** (15.11%), calacorene (0.89%), cadalene (7.65%), elemol (2.04%), (*E*)-nerolidol (0.64%), spathulenol (1.02%), caryophyllene oxide (5.07%), fonenol (0.76%), globulol (1.93%), humulene oxide (0.68%), T-muurolol + torreyol (3.7%), *epi*-α-cadinol (0.95%), α-muurolol (0.58%), α-cadinol (0.5%), farnesol (0.37%), ethyl benzoate (0.25%), methoxy cinnamaldehyde (1.47%), and benzyl benzoate (0.83%) (Boyom et al., 2003)	
		4. Asteraceae	
Ageratum conyzoides	Entire plant Ngoaekele-Yaounde, Cameroon in June 2011	α-Pinene (0.7%), camphene (1.8%), α-phellandrene (0.7%), α-terpinene (0.9%), *p*-cymene (1.2%), limonene (0.5%), menthyl acetate (2.1%), **β-*trans*-caryophyllene 26** (24.6%), *trans*-β-farnesene (0.4%), β-ionone (4.7%), **germacrene 4** (41.6%), β-bisabolene (2.9%), *cis*-β-bisabolene (1.4%), cardinene (1.3%), zingiberinol (3.4%), caryophyllene oxide (0.5%) (Voundi et al., 2015)	Antibacterial (Voundi et al., 2015)
	Leaf	-	Toxic to crop weevils (Bouda et al., 2001)
Ageratum houstonianum	Flowers Dschang, collection date is not reported.	**Demethoxyageratochromene (Precocene I) 27** (48.01%), **ageratochromene (Precocene II) 28** (36.55%), β-caryophyllen (8.37%), germacrene D (2,34%), bornyl acetate (2.29%), β-cubebene (1,22%), and β-farnesene (0.66%) (Tedonkeng et al., 2004b)	Anti-tick (Tedonkeng et al., 2004b)
	Leaf	-	Anti-tick (Tedonkeng et al., 2005)
Bidens pilosa	Leaf Moutourwa in Far-Nord Cameroon in June 2015	1-Hexanol (1.1%), **α-pinene** (14.7%), β-myrcene (1.9%), δ-3-carene (1.3%), **β-ocimene 29** (12.8%), limonene (2.3%), *p*-cymene-8-ol (3.6%), α-terpinolene (2.5%), γ-terpinene (0.1%), *trans*-linalool oxide (1.6%), *cis*-linalool oxide (1.4%), linalool (4.4%), terpinene-4-ol (0.3%), bourbonene (3.9%), δ-elemene (2.5%), farnesene (1.5%), isoledene (1.2%), methyleugenol (0.1%), *cis*-β-elemene (0.1%), **E-caryophyllene 30** (13.5%), α-humulene (0.2%), β-selinene (0.1%), megastigmatrienone (7.1%), α-nerolidol (1.2%), caryophyllene oxide (3.5%), cubebene (4.8%), cadinene (10.1%) (Goudoum et al., 2016)	Antioxidant, antimicrobial (Deba et al., 2008; Goudoum et al., 2016)
	Flower	-	Antioxidant, antimicrobial (Deba et al., 2008)
Chromolaena odorata	Leaves Campus University of Dschang, in April 2001	α-Pinene (9.36%), β-pinene (3.77%), α-terpinene (3.69%), *p*-cymene (1.49%), limonene (0.78%), *cis*-p-mentha-2,8-dien-1-ol (0.72%), borneol (0.03%), α-terpineol (0.13%), carvacrol (2.63%), α-elemene (2.80%), (*Z*)-β-farnesene (9.98%), α-humulene (0.09%), **bicyclogermacrene 31** (12.55%), cadina-1,4-dien (4.60%), α-humulene oxide (5.82%), **geijerene 32** (11.85%), pregeigerene (1.29%) (Tedonkeng et al., 2004a)	Toxic to crop weevils (Bouda et al., 2001); anti -tick (Tedonkeng et al., 2004a)
		Silphiperfol-6-ene (23.0%), presilphiperfolan-8-ol (22.7%) (Pavela et al., 2016; Kamte et al., 2017)	Toxic to crop weevils (Pavela et al., 2016; Kamte et al., 2017); not toxic in normal mouse fibroblast cells *in vitro* (Kamte et al., 2017)
Echinops giganteus	Root Bafoussam Cameroon	α-Pinene traces, mycrene traces, δ-3-carene traces, limonene traces, terpinolene traces, silphiperfol-5-ene (2.1%), presilphiperfol-7-ene (7.8%), silphinene (1.7%), 7-*epi*-silphiperfol-5-ene (3.5%), modheph-2-ene (3.0%), **silphiperfol-6-ene 33** (23.0%), α-isocomene (2.4%), *iso*-longifolene traces, β-isocomene (2.1%), α-gurjunene traces, (*E*)-caryophyllene (6.3%), α-humulene (2.0%), (*E*)-β-farnesene traces, germacrene D (0.3%), *ar*-curcumene (0.1%), *epi*-cubebol (0.1%), silphiperfolan-6-α-ol (1.0%), cameroonan-7-α-ol (7.1%), δ-cadinene (0.3%), silphiperfolan-7-β-ol (2.5%), silphiperfolan-6-β-ol (1.7%), prenopsan-8-ol (3.2%), **presilphiperfolan-8-ol 34** (22.7%), 1,10-di-*epi*-cubenol (0.1%), caryophylla-4(12),8(13)-dien-5-ol traces, *epi*-α-muurolol (0.4%), α-muurolol (0.1%), α-cadinol (0.4%), curcuphenol (0.4%) (Pavela et al., 2016; Kamte et al., 2017)	
Erigeron floribundus	Leaves, Yaoundé, April 2000/2001	α-Pinene (1.0%), β-pinene (1.6%), myrcene (0.2%), limonene (11.2%), (*E*)-β-ocimene (0.5%), (*Z*)-β-ocimene < (0.1%), umbellulone < (0.1%), terpinen-4-ol (0.1%), α-terpineol (0.1%), γ-elemene (0.1%), α-copaene < (0.1%), α-isocomene (0.1%), β-cubebene (0.1%), β-elemene (0.5%), β-isocomene < (0.1%), **β-caryophyllene 13** (16.6%), β-copaene < (0.1%), α-humulene (3.6%), **(*E*)-β-farnesene 35** (15.7%), γ-muurolene < (0.1%), germacrene D (1.4%), (*Z*,*E*)-α-farnesene (0.1%), bicyclogermacrene < (0.1%), (*E*,*E*)-α-farnesene (0.3%), γ-cadinene (0.4%), δ-cadinene (1.6%), germacrene B (0.5%), eudesmol (0.2%), nerolidol (1.5%), spathulenol (3.5%), epiglobulol (0.5%), caryophyllene oxide (5.4%), rosifoliol (0.2%), *epi*-α-cadinol (0.4%), *epi*-α-muurolol (0.5%), α-muurolol (0.2%), α-cadinol (1.4%), (*Z*)-3-hexenol (0.6%), lachnophyllum-γ-lactone (0.1%), oxacyclotridec-10-en-2-one < (0.1%), **(*E*)-2-lachnophyllum ester 35** (25.6%), (*E*)-4,8-dimethyl-1,3,7-nonatriene < (0.1%), and procoene I < (0.1%) (Kuiate et al., 2005)	Antifungal (Kuiate et al., 2005)
	Leaves, Bafoussam, Feb 2001	α-Pinene < (0.1%), β-pinene (0.6%), myrcene (0.5%), limonene (11.4%), (*E*)-β-ocimene (1.5%), (*Z*)-β-ocimene < (0.1%), umbellulone < (0.1%), terpinen-4-ol (0.1%), α-terpineol (1.0%), γ-elemene (0.2%), α-copaene < (0.1%), α-isocomene (0.1%), β-cubebene (0.3%), β-elemene (0.6%), β-*iso*-comene < (0.1%), **β-caryophyllene 13** (14.7%), β-copaene < (0.1%), α-humulene (2.8%), **(*E*)-β-farnesene 35** (14.6%), γ-muurolene < (0.1%), germacrene D (1.6%), (Z, E)-α-farnesene (0.1%), bicyclogermacrene < (0.1%), (*E*,*E*)-α-farnesene (1.7%), γ-cadinene (0.6%), δ-cadinene (1.6%), germacrene B (1.0%), eudesmol (0.1%), nerolidol (2.1%), spathulenol (4.1%), epiglobulol (0.8%), caryophyllene oxide (3.2%), rosifoliol (0.1%), *epi*-α-cadinol (0.5%), *epi*-α-muurolol (0.5%), α-muurolol (0.1%), α-cadinol (1.4%), (*Z*)-3-hexenol (0.5%), lachnophyllum-γ-lactone (0.1%), oxacyclotridec-10-en-2-one < (0.1%), **(*E*)-2-lachnophyllum ester 36** (26.2%), (*E*)-4,8-dimethyl-1,3,7-nonatriene < (0.1%), and procoene I < (0.1%) (Kuiate et al., 2005)	
	Leaves, Dschang, March	α-Pinene (0.3%), β-pinene (0.2%), myrcene (0.1%), limonene (9.5%), (*E*)-β-ocimene (7.1%), (*Z*)-β-ocimene (0.1%), umbellulone (0.3%), terpinen-4-ol	

Table 1 (Continued)

	2001	(0.1%), α-terpineol (0.1%), γ-elemene (0.1%), α-copaene (0.1%), α-isocomene (0.1%), β-cubebene (0.1%), β-elemene (0.6%), β-isocomene (0.1%), **β-caryophyllene 13** (8.5%), β-copaene (0.2%), α-humulene (0.9%), **(*E*)-β-farnesene 35 (**16.5%), *allo*-aromadendrene (0.1%), germacrene D (2.8%), (*Z,E*)-α-farnesene (0.6%), bicyclogermacrene (5.0%), (*E,E*)-α-farnesene (1.8%), δ-cadinene (1.1%), germacrene B (0.2%), eudesmol (0.3%), nerolidol (1.5%), spathulenol (1.0%), epiglobulol (0.7%), caryophyllene oxide (4.0%), rosifoliol (0.1%), *epi*-α-cadinol (0.3%), *epi*-α-muurolol (0.5%), α-muurolol (0.2%), α-cadinol (1.1%), (*Z*)-3-hexenol (0.3%), lachnophyllum-γ-lactone (0.2%), oxacyclotridec-10-en-2-one < (0.1%), **(*E*)-2-lachnophyllum ester 36** (23.7%), (*E*)-4,8-dimethyl-1,3,7-nonatriene (0.2%), and prococene I (0.9%) (Kuiate et al., 2005)	
	Flower Yaoundé, April 2000	α-Pinene (0.1%), β-pinene (0.2%), myrcene (0.1%), limonene (2.5%), (*Z*)-β-ocimene (3.1%), umbellulone (0.1%), terpinen-4-ol (0.1%), α-terpineol (0.1%), sativene (0.1%), γ-elemene (0.2%), α-copaene (0.8%), α-isocomene (0.2%), β-elemene (0.6%), β-isocomene (0.1%), **β-caryophyllene 13** (19.1%), β-copaene (0.6%), α-humulene (0.9%), (*E*)**-β-farnesene 35 (**24.1%), *allo*-aromadendrene (1.4%), γ-muurolene (2.3%), germacrene D (11.0%), (*Z,E*)-α-farnesene (0.6%), bicyclogermacrene (7.8%), (E, E)-α-farnesene (0.1%), γ-cadinene (0.1%), δ-cadinene (3.8%), cadina-1,4-diene (0.3%), germacrene B (0.1%), eudesmol (0.8%), nerolidol (0.9%), spathulenol (1.3%), *epi*-globulol (1.6%), caryophyllene oxide (0.8%), globulol (1.6%), *epi*-α-cadinol < (0.1%), *epi*-α-muurolol < (0.1%), α-muurolol < (0.1%), α-cadinol (0.4%), lachnophyllum-γ-lactone (0.3%), (*E*)-2-lachnophyllum ester (3.1%), and prococene I < (0.5%) (Kuiate et al., 2005)	
	Flower, Bafoussam, Feb 2001	α-Pinene < (0.1%), β-pinene (0.1%), myrcene (0.2%), limonene (3.4%), (*E*)-β-ocimene < (0.1%), (*Z*)-β-ocimene (1.5%), umbellulone (0.1%), terpinen-4-ol < (0.1%), α-terpineol (0.1%), sativene (0.1%), γ-elemene (0.1%), α-copaene (0.4%), α-isocomene (0.1%), β-elemene (1.0%), β-isocomene (0.2%), **β-caryophyllene 3** (20.1%), β-copaene (0.5%), α-humulene (1.3%), **(*E*)-β-farnesene 35** (22.3%), alloaromadendrene (0.8%), γ-muurolene (2.1%), germacrene D (10.2%), (*Z,E*)-α-farnesene (0.5%), bicyclogermacrene (8.3%), (*E,E*)-α-farnesene (1.0%), γ-cadinene (0.1%), δ-cadinene (3.1%), cadina-1,4-diene (0.1%), germacrene B (0.2%), eudesmol (0.6%), nerolidol (1.0%), spathulenol (1.0%), epiglobulol (1.1%), caryophyllene oxide (1.1%), globulol (1.8%), rosifoliol (0.1%), *epi*-α-cadinol < (0.1%), *epi*-α-muurolol < (0.1%), α-muurolol (0.1%), α-cadinol (0.2%), lachnophyllum-γ-lactone (0.1%), (*E*)-2-lachnophyllum ester (4.2%), and prococene I (0.7%) (Kuiate et al., 2005)	
	Flower, Dschang, March 2001	α-Pinene < (0.1%), β-pinene (0.2%), myrcene (0.1%), limonene (3.7%), (*Z*)-β-ocimene (2.3%), umbellulone (0.1%), terpinen-4-ol (0.1%), α-terpineol (0.1%), sativene (0.1%), γ-elemene (0.1%), α-copaene (0.6%), α-isocomene (0.3%), β-elemene (0.7%), β-isocomene (0.2%), **β-caryophyllene 13** (17.3%), β-copaene (0.8%), α-humulene (1.2%), **(*E*)-β-farnesene 35 (**23.3%), *allo*-aromadendrene (1.2%), γ-muurolene (2.6%), germacrene D (10.1%), (*Z,E*)-α-farnesene (0.8%), bicyclogermacrene (8.3%), (*E,E*)-α-farnesene (1.7%), γ-cadinene (0.2%), δ-cadinene (3.7%), cadina-1,4-diene (0.3%), germacrene B (0.2%), eudesmol (0.7%), nerolidol (0.8 %), spathulenol (1.3%), epiglobulol (1.4%), caryophyllene oxide (1.0%), globulol (1.7%), rosifoliol (0.2%), *epi*-α-cadinol (0.1%), *epi*-α-muurolol < (0.1%), α-muurolol < (0.1%), α-cadinol (0.3%), lachnophyllum-γ-lactone (0.1%), oxacyclotridec-10-en-2-one < (0.1%), (*E*)-2-lachnophyllum ester (3.4%), and prococene I (0.6%) (Kuiate et al., 2005)	Antifungal (Kuiate et al., 2005)
Helichrysum cameroonense	Flower Bamumbou village, Sept 2006, sample 1	Octen-3-ol (1.2%), α-thujene < (0.1%), **α-pinene 17 (**46.4%), verbenene (2.6%), sabinene (1.1%), β-pinene (2.0%), myrcene < (0.1%), *p*-cymene < (0.1%), δ-3-carene (1.5%), (*E*)-β-ocimene (1.1%), campholenal (1.0%), pinocarveol (3.2%), **camphor 37 (**11.5%), α-phellandrol (5.3%), terpinen-4-ol (3.3%), α-terpineol (1.3%), myrtenol (1.8%), *p*-cymen-8-ol (4.1%), myrtenyl acetate (3.3%), β-caryophyllene (1.3%), caryophyllene oxide (2.2%), and δ-guaienol (5.4%) (Tchoumbougnang et al., 2010)	
	Flower, Bamumbou village, Sept 2006, sample 2	nonanal < (0.1%), octen-3-ol (1.1%), α-thujene < (0.1%), **α-pinene 17 (**31.4%), verbenene < (0.1%), sabinene < (0.1%), β-pinene (1.6%), myrcene (1.0%), *p*-cymene < (0.1%), δ-3-carene < (0.1%), γ-terpinene (1.2%), linalool < (0.1%), campholenal (3.1%), pinocarveol < (0.1%), camphor (1.7%), α-phellandrol (3.0%), pinocarvone (3.8%), terpinen-4-ol < (0.1%), α-terpineol (1.7%), myrtenol (2.0%), *p*-cymen-8-ol (2.8%), myrtenyl acetate (8.5%), geranyl acetate (1.1%), α-copaene (1.4%), β-caryophyllene (3.8%), α-humulene < (0.1%), β-bisabolene (1.4%), β-selinene < (0.1%), α-selinene < (0.1%), δ-guaiene (1.2%), δ-cadinene < (0.1%), spathulenol (1.0%), caryophyllene oxide (4.4%), humulene oxide (1.4%), **δ-guaienol 38 (**18.9%), and valerianone (2.2%) (Tchoumbougnang et al., 2010)	
Helichrysum cymosum	Leaves Bamumbou village, date of harvest not reported	Bornylene (2.7%), α-pinene (6.8%), camphene (7.4%), β-pinene (0.6%), α-terpinene (1.6%), *p*-cymene (0.6%), **δ-3-carene 39 (**16.1%), limonene (1.7%), (*Z*)-β-ocimene < (0.1%), (*E*)-β-ocimene < (0.1%), terpinolene < (0.1%), 1,8-cineole (1.7%), linalool < (0.1%), octyl acatate (1.6%), borneol < (0.1%), terpinen-4-ol < (0.1%), α-terpineol (0.6%), δ-elemene (1.9%), α-copaene (0.5%), β-elemene (0.8%), **β-caryophyllene 13 (**12.0%), aromadendrene (3.6%), methyl hexyl bourgene (7.2%), α-humulene (5.6%), γ-selinene (1.2%), germacrene D (0.6%), β-selinene (5.7%), germacrene B (2.3%), α-selinene (6.8%), spathulenol (0.9%), caryophyllene oxide (1.1%), humulene oxide (0.9%), β-eudesmol (2.7%), α-eudesmol (1.3%), and valerianone (1.4%) (Tchoumbougnang et al., 2010)	Antifungal (Tchoumbougnang et al., 2010)

Table 1 (Continued)

Helichrysum globosum	Leaves, Bamumbou village, date of harvest not reported	Octen-3-ol < (0.1%), **α-pinene 17** (38.6%), verbenene < (0.1%), sabinene < (0.1%), myrcene < (0.1%), δ-3-carene (7.2%), terpinolene (2.5%), α-terpineol (1.3%), β-caryophyllene (3.8%), α-humulene (3.0%), γ-selinene (4.1%), β-selinene (6.0%), γ-cadinene (2.9%), α-selinene (8.6%), nerolidol (5.0%), α-cadinol (3.0%), and δ-guaienol (1.8%), **valerianone 40** (10.9%) (Tchoumbougnang et al., 2010)	Antifungal (Tchoumbougnang et al., 2010)
Laggera pterodonta	Leaf + flowers	**γ-Eudesmol 41** (45%), α-eudesmol (15%), **2,5-dimethoxy-*p*-cymene 42** (50%), juniper camphor (12%) (Ngassoum et al., 2000)	anti-*Anopheles gambiae* activity (Nlôga et al., 2007)
	Flower	**γ-Terpinene 43** (32%), **terpinen-4-ol 22** (14.1%) and β-phellandrene (6%) (Ngassoum et al., 2000)	
		5. Burseraceae	
Aucoumea klaineana	Resin Lolodorf, May	α-Thujene (0.2%), **α-pinene 17** (29.3%), camphene (0.6%), sabinene (0.3%), β-pinene (0.8%), menthene (1.6%), **α-phellandrene 16** (30.9%), δ-3-carene (2.3%), α-terpinene (2.4%), *p*-cymene (9.2%), limonene (0.4%), γ-terpinene (0.3%), terpinolene (4.6%), 1,8-cineole (9.0%), camphor (0.8%), terpinen-4-ol (2.5%), α-terpineol (3.1%), and carveol (1.4%) (Dongmo et al., 2010)	Antiradical and antioxidant activities (Dongmo et al., 2010)
Canarium schweinfurthii	Resin, Lolodorf, May	α-Pinene (1.7%), sabinene (2.0%), β-pinene (0.4%), α-phellandrene (1.1%), δ-3-carene (0.3%), α-terpinene (0.5%), *p*-cymene (9.8%), **limonene 44** (42.7%), γ-terpinene (1.9%), terpinolene (1.5%), 1,8-cineole (0.3%), terpinen-4-ol (2.3%), and **α-terpineol 45** (34.4%) (Dongmo et al., 2010)	Antiradical and antioxidant activities (Dongmo et al., 2010)
	Resin, Mbouda, May	α-Pinene (2.6%), sabinene (0.2%), β-pinene (1.2%), myrcene (0.5%), α-phellandrene (4.1%), α-terpinene (2.7%), ***p*-cymene 1** (25.3%), **limonene 43** (36.6%), γ-terpinene (0.2%), 1,8-cineole (0.5%), linalool (0.3%), terpinen-4-ol (0.4%), α-terpineol (18.0%), carveol (1.4%), geraniol (0.5%), carvone (0.4%), and piperitone (3.8%) (Dongmo et al., 2010)	
		6. Chenopodiaceae	
Chenopodium ambrosioides	Aerial parts *Dschang*, April 1999	α-Pinene (0.1%), **α-terpinene 46** (51.3%), ***p*-cymene 1** (23.4%), limonene (0.9%), β-phellandrene (0.2%), γ-terpinene (0.7%), dehydro-p-cymene (0.1%), l-carvacrol (0.1%), *p*-mentha-1,8-diene (15.3%), oxyde de piperitone (0.4%), ascaridole (0.7%), thymol (0.2%), carvacrol (0.3%), and *iso*-ascaridole (5.1%) (Tapondjou et al., 2002)	Toxic to crop weevils (Tapondjou et al., 2002, 2003); antifungal (Chekem et al., 2010)
	Aerial parts, Dschang, August 2008	**α-Terpinene 46** (37.6%), ***p*-cymene 1** (cymol) (50.0%), *cis*-β-farnesene (1.4%), ascaridol (3.5%), carvacrol (3.5%) (Tapondjou et al., 2002, 2003)	
	Leaf	α-Terpinene (37.6%), *p*-cymene (50.0%) (Tapondjou et al., 2002, 2003)	
		7. Cupressaceae	
Cupressus lusitanica	Leaves, Dschang, June 2003, sample 1	α-Thujene (0.6%), **α-pinene 17** (7.4%), sabinene (1.0%), β-pinene (0.2%), myrcene (1.2%), δ-3-carene (0.1%), α-terpinene (0.6%), *p*-cymene (0.5%), limonene (3.5%), γ-terpinene (1.0%), terpinolene (0.9%), 1,8-cineol (0.4%), *cis*-linalool oxide (0.1%), *trans*-linalool oxide (furanoid) (0.1%), linalool (1.3%), **umbellulone 47** (18.3%), cryptone (0.2%), terpinen-4-ol (2.6%), p-cymen-8-ol (0.2%), α-terpineol (0.5%), bornyl acetate (0.1%), thymol (1.6%), *cis*-acetoxylinalool oxide (0.9%), terpin-4-yl acetate (0.4%), α-terpinyl acetate (1.3%), 2-heptyl acetate (0.4%), heptyl propanoate (3.3%), hexyl butanoate (0.5%), 2-heptyl butyrate (0.2%), α-copaene (0.2%), β-elemene (0.1%), α-cedrene (1.7%), β-caryophyllene (0.7%), β-copaene (0.2%), *cis*-muurola-3,5-diene (4.2%), α-humulene (0.6%), α-acoradiene (0.5%), germacrene D (8.2%), γ-curcumene (3.0%), γ-amorphene (0.5%), alaskenea (0.8%), *epi*-zonarene (5.0%), bicyclogermacrene (0.3%), α-muurolene (0.9%), cuparene traces, β-bisabolene (0.2%), β-curcumene (1.1%), γ-cadinene (0.1%), *trans*-calamenene (3.8%), δ-cadinene traces, *cis*-calamenene (0.6%), α-calacorene (0.2%), β-calacorene (0.2%), β-acoradiene (1.6%), cedrol (1.6%), *epi*-α-cubenol (0.9%), α-acorenol (6.0%), β-acorenol (0.9%), *epi*-α-cadinol (0.3%), *epi*-α-muurolol (0.2%), α-muurolol (0.1%), α-cadinol (1.2%), *cis*-14-nor-muural-5-en-4-one (1.1%), (*Z*)-nuciferol (0.2%) (Kuiate et al., 2006b)	Toxic in Swiss mice experiment (Teke et al., 2013)
	Leaves, Dschang, June 2003, sample 2	α-Thujene (0.5%), **α-pinene 17** (5.3%), α-fenchene (0.1%), sabinene (4.9%), β-pinene (0.2%), myrcene (1.5%), δ-3-carene (2.3%), α-terpinene (0.2%), *p*-cymene (4.0%), limonene (4.2%), γ-terpinene (0.1%), terpinolene (0.2%), 1,8-cineole (0.2%), *cis*-linalool oxide (0.2%) *trans*-linalool oxide (furanoid) (0.1%), linalool (0.2%), **umbellulone 47** (17.3%), cryptone (0.3%), terpinen-4-ol (2.0%), *p*-cymen-8-ol (0.6%), α-terpineol (0.7%), linalyl acetate (0.2%), isobornyl acetate (0.6%), bornyl acetate (0.2%), thymol (0.6%), *cis*-acetoxylinalool oxide (0.1%), terpin-4-yl acetate (0.7%), α-terpinyl acetate (2.5%), 2-heptyl acetate (0.2%), 2-heptyl butyrate (0.3%), α-copaene (0.4%), α-cedrene (1.3%), β-caryophyllene (0.4%), β-cedrene (0.2%), β-copaene (0.1%), *cis*-muurola-3,5-diene (0.4%), α-humulene (0.3%), α-curcumene (2.1%), germacrene D (2.5%), γ-curcumene (1.5%), γ-amorphene (0.5%), alaskene (0.5%), *epi*-zonarene (0.7%), bicyclogermacrene (0.1%), α-muurolene (0.8%,) cuparene (0.4%), β-curcumene (0.1%), γ-cadinene (1.9%), *trans*-calamenene (3.6%), δ-cadinene (1.0%), *cis*-calamenene (0.3%), α-calacorene (0.3%), β-calacorene (0.3%), cadalene (0.2%), β-acoradiene (1.4%), spathulenol (0.3%), caryophyllene oxide (0.9%), cedrol (1.5%), humulene oxide II (0.3%), *epi*-α-cubenol (0.9%), α-acorenol (5.8%), β-acorenol (1.0%), α-cubenol (0.9%), *epi*-α-cadinol (1.0%), *epi*-α-muurolol (1.3%), α-muurolol (0.3%), α-cadinol (2.3%), (*Z*)-nuciferol (2.7%) (Kuiate et al., 2006b)	
	Flower, Dschang, Dec 2003	**α-Pinene 17** (15.4%), β-pinene (1.2%), δ-3-carene (0.9%), *p*-cymene (1.4%), limonene (5.4%), (*Z*)-β-ocimene (0.3%), γ-terpinene (0.1%), terpinolene (0.2%), linalool (7.2%), borneol (0.2%), umbellulone (0.4%), terpinen-4-ol (1.1%), *p*-cymen-8-ol (0.3%), α-terpineol (0.7%), linalyl acetate (0.6%), thymol	

Table 1 (Continued)

		(1.7%), α-terpinyl acetate (0.4%), 2,5-dimethoxy-*p*-cymene (0.2%), 3-octanol (4.7%), hexyl butanoate (0.4%), α-cubebene (0.2%), α-copaene (1.3%), β-bourbonene (2.0%), β-elemene (2.6%), **β-caryophyllene 13** (9.6%), β-copaene (0.4%), α-humulene (1.9%), α-curcumene (0.2%), germacrene D (2.4%), β-selinene (4.9%), α-selinene (4.1%), α-muurolene (0.6%), β-bisabolene (0.2%), *trans*-calamenene (0.7%), α-xadinene (0.5%), geranyl acetone (0.5%), (*E*)-nerolidol (0.3%), spathulenol (0.6%), caryophyllene oxide (2.6%), cedrol (0.8%), humulene oxide II (0.5%), *epi*-α-cubenol (2.7%), α-acorenol (0.8%), β-acorenol (0.2%), α-cubenol (0.9%), α-muurolol (0.3%), α-cadinol (2.5%) (Kuiate et al., 2006b)	
	Fruit, Dschang, March 2004	α-Thujene (0.4%), **α-pinene 17** (64.5%), α-fenchene (0.2%), camphene (0.3%), sabinene (2.5%), β-pinene (3.1%), **myrcene 48** (16.0%), δ-3-carene (6.5%), α-terpinene (1.0%), *p*-cymene (0.1%), limonene (3.5%), (Z)-β-ocimene (0.3%), *trans*-linalool oxide (furanoid) (0.3%), linalool (0.3%), umbellulol (0.3%), umbellulone (0.3%), terpinen-4-ol (1.9%), *p*-cymen-8-ol (0.5%), α-terpineol (1.7%), bornyl acetate (0.1%), thymol (0.1%), α-terpinyl acetate (0.1%), 2-heptyl acetate (0.3%), 2-heptyl butyrate (0.1%), β-caryophyllene (0.6%), α-humulene (0.7%), α-curcumene (0.1%), *trans*-calamenene (0.1%), δ-cadinene (0.1%), caryophyllene oxide (0.6%), humulene oxide II (0.4%) (Kuiate et al., 2006b)	
	Leaves, Dschang, August 2010	Tricyclene (0.3%), α-pinene (0.6%), sabinene (0.3%), myrcene (0.4%), δ-3-carene (0.5%, α-phellandrene (0.1%), α-terpinene (0.2%, *p*-cymene (0.5%), limonene (2.3%), 1,8-cineole (0.8%), γ-terpinene (0.4%), *cis*-linalooloxide (0.5%), linalool (6.0%), umbellulone (6.0%), terpinen-4-ol (6.3%), *p*-cymen-8-ol (1.0%), *p*-menth-2-en-1-ol (0.3%), citronellol (0.2%), linalyl acetate (1.2%), thymol (0.4%), α-cubebene (0.3%), α-copaene (0.1%), α-cedrene (0.1%), β-caryophyllene (1.5%), β-cedrene (0.4%), α-humulene (0.6%), zingiberene (0.1%), α-curcumene (4.1%), **germacrene D 14** (18.5%), α-amorphene (2.0%), ***epi*-zonarene 49** (8.2%), α-muurolene (1.1%), β-bisabolene (0.3%), α-cadinene (0.2%), ***cis*-calamenene 50** (8.2%), α-calacorene (0.5%), spathulenol (0.2%), caryophyllene oxide (0.6%), cedrol (1.2%), di-*epi*-α-cedrene (4.9%), 14-norcadin-5-en-4-one (0.9%), naphthalene (0.8, kaur-15-ene (0.2%) (Teke et al., 2013)	
	Leaf + fruit	-	Low antimicrobial activity (Kuiate, 2006 a,b ;Teke et al., 2013)
Cupressus sempervirens	Leaves, Dschang, April 1999	α-Pinene (9.9%), **sabinene 23** (14.8%), δ-3-carene (4.2%), mycrene (2.3%), α-terpinene (4.2%), limonene (3.9%), α-phellandrene (1.5%), terpine ne (5.7%), *p*-cymene (cymol) (3.8%), terpineolene (2.4%), **terpinen-4-ol 22** (11.4%), bicyclosesquiphellandrene (2.3%), terpineol (2.7%), α-terpinyl-acetate (3.3%), eucumene (1.4%), *cis*-calamenene (1.7%), α-cadinene (1.9%), and cedrol (3.3%) (Tapondjou et al., 2005)	Toxic to crop weevils (Langsi et al., 2017; Tapondjou et al., 2005); Tunisian sample activity in cancer cells (Loizzo et al., 2008)
	Aerial parts	-	Tunisian sample antioxidant, antibacterial (Ben Nouri et al., 2015); antimicrobial (Boukhris et al., 2012)
		8. Cyperaceae	
Cyperus articulatus	Roots and rhizomes, Sehn village, Feb 2012	(percentages not reported). Camphenol, bicyclo[3.1.1]heptan-3-ol, 6,6-dimethyl-2-methylene-[1S-(1à,3à,5à)]bicyclo[3.1.1]hept-3-en-2-ol, 4,6,6-trimethyl-[1S-(1à,2a,5à)]bicyclo[3.1.0]hexan-3-ol, 4-methylene-1-(1-methylethyl)-[1S-(1à,3a,5à)]-(−)-myrtenol, bicyclo[3.1.0]hex-3-en-2-one, 4-methyl-1-(1-methylethyl)-bicyclo[3.1.1]hept-3-en-2-one, 4,6,6-trimethyl-(1S)-3,5-heptadienal, 2-ethylidene-6-methylbicyclo[4.4.0]dec-2-en-4-o1, 2-methyl-9-(prop-1-en-3-01-2-yl)-isolongifolene, 9,10-dehydro-copaene, α-cubebene, cadina-1(10),6,8-triene, 7-tetracyclo[6.2.1.0(3.8)O(3.9)]undecanol, 4,4,11,11-tetramethyl-naphthalene, 1,2,3,4,4a,5,6,8a-octahydro-7-methyl-4-methylene-1-(1-methylethyl)-(1à,4aà,8aà)naphthalene, 1,2,3,4-tetrahydro-1,6-dimethyl-4-(1-methylethyl)-(1S-*cis*)-(+)-*epi*-bicyclosesquipheliandrene, 2,3,4-trifluorobenzoic acid, 4-nitrophenylester, 7-tetracyclo[6.2.1.0(3.8)0(3.9)]undecanol, 4,4,11,11-tetramethyl-2-naphthalenemethanol, 1,2,3,4,4a,8a-hexahydro-à,à,4a,8-tetramethyl-[2R(2à,4aà,8aà)]-cycloisolongifolene, 8,9-dehydro-caryophyllene oxide, longipinocarvone-3-Isopropyl-6,7-dimethyltricyclo[4.4.0.0(2,8)]decane-9,10-diol; cis-Z-α-bisabolene epoxide, longiverbenone, 2,2,7,7-tetramethyltricyclo[6.2.1.0(1,6)]undec-4-en-3-one, acetic acid, 3-hydroxy-6-isopropenyl-4,8a-dimethyl-1,2,3,5,6,7,8,8a-octahydronaphthalen-2-yl ester, 5(1H)-azulenone-2,4,6,7,8,8a-hexahydro-3,8-dimethyl-4-(1-methylethylidene), (8S-*cis*)-perhydrocyclopropa[e]azulene-4,5,6-triol, 1,1,4,6-tetramethyl-1H-cycloprop[e]azulen-7-01, decahydro-1,1,7-trimethyl-4-methylene-[1ar-(1aà,4aà,7a,7aa,7bà)], (−)-spathulenol, corymbolone, ketoalcohol, spiro[4.5]decan-7-one, 1,8-dimethyl-8,9-epoxy-4-isopropyl-9H-cycloisolongifolene, 8-oxo-2(1H)naphthalenone, 3,5,6,7,8,8a-hexahydro-4,8adimethyl-6-(1-methylethenyl)-*E*-15-heptadecenal, 6-isopropenyl-4,8a-dimethyl-1 ,2,3,5,6,7,8,8aoctahydronaphthalene-2,3-diol, 2(1H)-naphthalenone, 4a,5,6,7,8,8a-hexahydro-6-[1-(hydroxymethyl)ethenyl]-4,8adimethyl-[4ar-(4aà,6à,8aà)]-1-naphthalenol, decahydro-1,4a-dimethyl-7-(1-methylethylidene)-[1R-(1à,4aa,8aà)]-cyclodecasiloxane, eicosamethyl-tetracosamethyl-cyclododecasiloxane, 2,6-dimethyl-1,3,5,7-octatetraene-*E,E*-benzene, 1-methyl-3-(1-methylethyl)-1H-cycloprop[e]azulene, 1a,2,3,4,4a,5,6,7-boctahydro-1,1,4,7-tetramethyl-[1aR-(1aà,4à,4aa,7bà)]-3H-3a,7-methanoazulene, 2,4,5,6,7,8-hexahydro-1,4,9,9-tetramethyl-[3aR-(3aà,4a,7à)]-benzene, 1-(1,5-dimethyl-4-hexenyl)-4-methyl-benzene, 1-methyl-4-(1,2,2-trimethylcyclopentyl)-(R)-azulene, 1,2,3,5,6,7,8,8a-octahydro-1,4-dimethyl-7-(1-methylethenyl)-[1S-(1à,7à,8aa)]-α-calacorene,	anti-Onchoceras ochengi activity; no acute toxicity in monkey kidney cells and mice experiment (Metuge et al., 2014a)

Table 1 (Continued)

		octacosane, oodecanoic acid, n-hexadecanoic acid, (*Z,Z*)-9,12-octadecadienoic acid, cis-13-octadecenoic acid, (*Z,Z,Z*)-9,12,15-octadecatrienoic acid, *cis*-13-octadecenoic acid, octadecanoic acid, eicosanoic acid, isophthalic acid, di(2-methylprop-2-en-1-yl)ester, myrtenyl acetate, trichloroacetic acid, hexadecyl ester, bis(2-ethylhexyl)phthalate, oodecanoic acid, dodecyl ester, (−)-*trans*-pinocarvyl acetate, undecanoic acid, tetradecyl ester, oodecanoic acid, hexadecyl ester (Metuge et al., 2014a) The two main compounds reported in a second publication were **mustakone 51** and **linoleic acid 52** (Metuge et al., 2014b)	
		9. Euphorbiaceae	
Euphorbia golondrina	*Leaves mount Bambouto Cameroon*	Benzoquinoline (1.76%), indole (1.18%), camphor (9.41%), eucalyptol (2.92%), caryophyllene (1.59%), **caryophyllene oxide 53** (14.16%), panasinsene (0.9%), selinene (4.94%), (-)-spathulenol (1.29%), phytol (5.75%), 2,6-diisopropylnaphthalene (3.75%), 2(1H)-naphthalene (0.9%), 1,3-diisopropylnaphthalene (2.39%), 1,4-diisopropylnaphthalene (4.31%), furan (3.04%), trans-2-(2-pentenyl)furan (0.9%), dibutylphthalate (2.75%), nonanal (3.32%), 2,4-decadienal (0.75%), 5-pyrimidinecarbonitrile (1.38%), α-glucopyranoside (1.15%), 3,4-dimethylanisole (2.3%), furazan-3-carboxamidine (0.9%), 1-naphthalenol (1.48%), oxirane (2.4%), **2-pentadecanone 54** (13.78%), 2-(2-fluorphenyl)silane (1.25%), 2,4-dimethylthiosemicarbazide (1.76%), **2-ethylacridine 55** (4.38%), **octasiloxane 56** (4.38%) (Ndam et al., 2016)	Antioxidant and significant antibacterial/antifungal activity (Ndam et al., 2016)
		10. Lamiaceae	
Hyptis spicigera	Flower, Guirvidig, May 2006	**α-Pinene 17** (14.0%), sabinene + β-pinene (6.0%), α-phellandrene (4.0%), α-terpinene (0.2%), *p*-cymene (2.6%), β-phellandrene + 1,8-cineole (14.8%), terpinolene (0.3%), isoamyl isovalerate (2.0%), α-campholenal (0.2%), nopinone (0.1%), *cis*-sabinol (1.3%), α-phellandren-8-ol (0.5%), terpinen-4-ol (0.4%), *p*-cymen-8-ol (0.6%), α-terpineol (0.3%), myrtenal + myrtenol (0.7%), verbenone (0.1%), cuminaldehyde (0.4%), phellandral (0.3%), thymol (0.1%), carvacrol (0.4%), α-ylangene (0.3%), α-copaene (0.1%), β-bourbonene (0.1%), β-cubebene (0.2%), iso-caryophyllene (0.2%), **β-caryophyllene 13 (**23.4%), γ-elemene (0.2%), guaia-6,9-diene (0.2%), α-humulene (1.3%), germacrene D (0.2%), bicyclosesquiphellandrene (0.1%), γ-cadinene (2.2%), δ-cadinene (0.6%), α-cadinene (0.2%), α-calacorene (0.5%), caryophyllene oxide (10.9%), 1-*epi*-cubenol (0.3%) (Noudjou et al., 2007)	Toxic to crop weevils (Kouninki et al., 2007; Ngamo et al., 2007b; Ngassoum et al., 2007)
	Flower, Guirvidig, Jan 2006	α-Thujene (0.7%), **α-pinene 17** (27.1%), camphene (0.1%), sabinene + β-pinene (9.4%), **α-phellandrene 16** (22.5%), α-terpinene (0.1%), *p*-cymene (0.1%), β-phellandrene+1,8-cineole (20.9%), γ-terpinene (0.2%), terpinolene (0.9%), isoamyl isovalerate (1.2%), α-campholenal (0.1%), *cis*-sabinol (0.1%), α-phellandren-8-ol (0.1%), myrtenal + myrtenol (0.1%), α-ylangene (0.1%), β-cubebene (0.1%), β-caryophyllene (10.8%), γ-elemene (0.1%), guaia-6,9-diene (0.1%), α-humulene (0.6%), germacrene D (0.2%), γ-cadinene (0.1%), δ-cadinene (0.1%), caryophyllene oxide (2.0%), 1-*epi*-cubenol (0.1%) (Noudjou et al., 2007)	
	Flower, Kodeck, May 2006	α-Thujene (0.4%), **α-pinene 17** (36.3%), sabinene + β-pinene (14.1%), **α-phellandrene 16** (7.8%), α-terpinene (0.4%), *p*-cymene (3.0%), β-phellandrene + 1,8-cineole (23.2%), γ-terpinene (0.4%), terpinolene (0.4%), isoamyl isovalerate (0.3%), *cis*-sabinol (0.7%), α-phellandren-8-ol (0.3%), terpinen-4-ol (2.2%), *p*-cymen-8-ol (0.8%), α-terpineol (0.3%), myrtenal + myrtenol (0.6%), thymol (0.1%), α-copaene (0.2%), β-caryophyllene (3.6%), α-humulene (0.3%), germacrene D (0.1%), bicyclosesquiphellandrene (0.1%), γ-cadinene (0.6%), δ-cadinene (0.2%), caryophyllene oxide (1.8%) (Noudjou et al., 2007)	
	Flower, Kodeck, Jan 2006	α-Thujene (0.4%), **α-pinene 17** (39.6%), camphene (0.2%), sabinene + β-pinene (15.1%), myrcene (0.6%), α-phellandrene (1.9%), *p*-cymene (0.1%), β-phellandrene + 1,8-cineole (14.7%), γ-terpinene (0.35%, **terpinolene 57** (15.2%), linalool (0.2%), isoamyl isovalerate (0.6%), α-campholenal (0.2%), *cis*-sabinol (0.5%), α-phellandren-8-ol (0.1%), terpinen-4-ol (0.6%), *p*-cymen-8-ol (0.4%), α-terpineol (0.4%), myrtenal + myrtenol (0.11%), α-ylangene (0.1%), β-caryophyllene (6.1%), guaia-6,9-diene (0.1%), α-humulene (0.3%), germacrene D (0.1%), δ-cadinene (0.1%), caryophyllene oxide (0.5%) (Noudjou et al., 2007)	
	Flower, Lara, May 2006	α-Thujene (1.1%), **α-pinene 17** (19.8%), camphene (0.4%), verbenene (0.3%), sabinene + β-pinene (13.1%), myrcene (0.2%), α-phellandrene (0.3%), α-terpinene (0.4%), p-cymene (1.2%), **β-phellandrene 58** + **1,8-cineole 59** (27.4%), γ-terpinene (1.2%), terpinolene (1.9%, isoamyl isovalerate (0.9%, α-campholenal (0.7%), nopinone (0.2%), *cis*-sabinol (1.9%), α-phellandren-8-ol (0.7%), terpinen-4-ol (2.9%), *p*-cymen-8-ol (0.8%), α-terpineol (0.6%), myrtenal + myrtenol (1.3%), verbenone (0.1%), cuminaldehyde (0.2%), phellandral (0.2%), carvacrol (0.1%), α-ylangene (0.2%), α-copaene (0.1%), β-bourbonene (0.2%), β-cubebene (0.1%), *iso*-caryophyllene (0.1%), β-caryophyllene (9.1%), guaia-6,9-diene (0.1%), α-humulene (0.6%), germacrene D (0.1%), γ-cadinene (0.8%, δ-cadinene (0.2%), α-cadinene (0.1%), caryophyllene oxide (5.1%), 1-*epi*-cubenol (0.2%) (Noudjou et al., 2007)	
	Flower, Lara, Jan 2006	α-Thujene (2.2%), **α-pinene 17 (**42.1%), camphene (0.2%), **sabinene 23 + β-pinene 20** (22.7%), myrcene (0.7%), α-phellandrene (4.4%), *p*-cymene (0.1%), β-phellandrene + 1,8-cineole (13.7%), γ-terpinene (0.6%, terpinolene (4.5%), isoamyl isovalerate (0.6%), α-campholenal (0.1%), *cis*-sabinol (0.1%), α-phellandren-8-ol (0.1%), terpinen-4-ol (0.1%), myrtenal + myrtenol (0.1%), α-	

Table 1 (Continued)

		ylangene (0.1%), α-copaene (0.1%), β-cubebene (0.1%), β-caryophyllene (4.9%), guaia-6,9-diene (0.1%), α-humulene (0.3%), germacrene D (0.2%), caryophyllene oxide (0.7%) (Noudjou et al., 2007)	
	Flower, Touloum, May 2006	α-Thujene (1.4%), **α-pinene 17** (31.7%), camphene (0.7%), verbenene (0.3%), sabinene + β-pinene (16.1%), myrcene (0.2%), α-phellandrene (6.7%), α-terpinene (0.4%), p-cymene (3.1%), **β-phellandrene 58** + **1,8-cineole 59** (23.7%), γ-terpinene (0.8%), terpinolene (1.1%), linalool (0.7%), isoamyl isovalerate (0.5%), β-thujone (0.1%, α-campholenal (0.2%), nopinone (0.1%), *cis*-sabinol (0.7%), α-phellandren-8-ol (0.3%), terpinen-4-ol (1.6%), *p*-cymen-8-ol (1.6%), α-terpineol (0.2%), myrtenal + myrtenol (0.5%), verbenone (0.1%), cuminaldehyde (0.1%), phellandral (0.1%), thymol (0.1%), α-copaene (0.1%), β-bourbonene (0.1%), β-cubebene (0.1%), β-caryophyllene (2.8%), α-humulene (0.3%), germacrene D (0.1%), δ-cadinene (0.1%), caryophyllene oxide (0.8%) (Noudjou et al., 2007)	
	Flower, Touloum, Jan 2006	α-Thujene (0.4%), **α-pinene 17** (23.8%), camphene (0.1%), sabinene + β-pinene (10.7%), myrcene (0.1%), α-phellandrene (14.2%), α-terpinene (0.1%), p-cymene (0.1%), **β-phellandrene 57** + **1,8-cineole 59** (20.5%), γ-terpinene (0.2%), terpinolene (3.2%), linalool (0.6%), isoamyl isovalerate (0.8%), α-campholenal (0.2%), *cis*-sabinol (0.8%), α-phellandren-8-ol (0.1%), terpinen-4-ol (0.6%), *p*-cymen-8-ol (0.2%), α-terpineol (0.5%), myrtenal + myrtenol (0.15%), α-ylangene (0.2%), α-copaene (0.1%), β-cubebene (0.1%), *iso*-caryophyllene (0.1%), β-caryophyllene (13.7%), γ-elemene (0.1%), guaia-6,9-diene (0.1%), α-humulene (0.7%), germacrene D (0.2%), γ-cadinene (0.1%), δ-cadinene (0.1%), caryophyllene oxide (2.3%), 1-*epi*-cubenol (0.1%) (Noudjou et al., 2007)	
	Flower, Kaele, May 2006	α-Thujene (3.1%), **α-pinene 17 (**20.6%), camphene (0.5%), verbenene (0.3%), sabinene + β-pinene (17.6%), myrcene (0.2%), α-phellandrene (3.0%), α-terpinene (0.8%), *p*-cymene (3.0%), **β-phellandrene 58** + **1,8-cineole 59 (**23.5%), γ-terpinene (1.7%), terpinolene (2.3%), linalool (0.2%), isoamyl isovalerate (1.1%), β-thujone (0.3%), α-campholenal (0.5%), nopinone (0.2%), *cis*-sabinol (1.3%), α-phellandren-8-ol (0.3%), terpinen-4-ol (3.6%), *p*-cymen-8-ol (3.7%), α-terpineol (0.3%), myrtenal + myrtenol (1.0%), verbenone (0.1%), cuminaldehyde (0.3%), phellandral (0.2%), thymol (0.1%), carvacrol (0.1%), α-ylangene (0.1%), α-copaene (0.1%), β-bourbonene (0.1%), β-cubebene (0.1%), β-caryophyllene (3.2%), α-humulene (0.2%), germacrene D (0.1%), δ-cadinene (0.1%), α-calacorene (1.2%) (Noudjou et al., 2007)	
	Flower, Kaele, Jan 2006	α-Thujene (0.5%), **α-pinene 17** (34.8%), camphene (0.2%), sabinene + β-pinene (17.0%), myrcene (0.3%), α-phellandrene (0.2%), *p*-cymene (0.1%), **β-phellandrene 58 + 1,8-cineole 59 (**19.4%), γ-terpinene (0.3%), terpinolene (2.1%), linalool (0.6%), isoamyl isovalerate (0.8%), α-campholenal (0.4%), *cis*-sabinol (1.0%), α-phellandren-8-ol (0.5%), *p*-cymen-8-ol (0.2%), α-terpineol (0.5%), myrtenal + myrtenol (0.3%), α-ylangene (0.2%), α-copaene (0.3%), β-cubebene (0.1%), *iso*-caryophyllene (0.1%), β-caryophyllene (11.7%), γ-elemene (0.1%), α-humulene (0.6%), germacrene D (0.2%), γ-cadinene (0.1%), δ-cadinene (0.2%), caryophyllene oxide (2.9%), 1-*epi*-cubenol (0.1%) (Noudjou et al., 2007)	
	Flower, Tchecal-baïla, May 2006	α-Thujene (0.1%), **α-pinene 17** (27.8%), camphene (0.6%), verbenene (0.3%, sabinene + β-pinene (10.9%), myrcene (0.2%), α-phellandrene (1.3%), α-terpinene (0.1%), *p*-cymene (2.0%), **β-phellandrene 58** + **1,8-cineole 59** (21.3%), γ-terpinene (0.1%), terpinolene (2.2%), linalool (0.3%), isoamyl isovalerate (1.1%), α-campholenal (0.4%), nopinone (0.1%), *cis*-sabinol (1.7%), α-phellandren-8-ol (0.6%), terpinen-4-ol (0.5%), *p*-cymen-8-ol (1.2%), α-terpineol (0.3%), myrtenal + myrtenol (0.9%), verbenone (0.1%), cuminaldehyde (0.2%), phellandral (0.1%), thymol (0.4%), carvacrol (0.2%), α-ylangene (0.2%), α-copaene (0.1%), β-bourbonene (0.1%), β-cubebene (0.1%), *iso*-caryophyllene (0.1%, β-caryophyllene (12.3%), γ-elemene (0.1%), guaia-6,9-diene (0.1%), α-humulene (0.7%), germacrene D (0.2%), γ-cadinene (0.8%), δ-cadinene (0.3%), α-calacorene (0.2%), caryophyllene oxide (4.8%), 1-*epi*-cubenol (0.1%) (Noudjou et al., 2007)	
	Flower, Tchecal-baïla, Jan 2006	α-Thujene (10.7%), α-pinene (11.9%), camphene (0.1%), **sabinene 23 + β-pinene 20** (39.8%), myrcene (1.1%), α-phellandrene (0.3%), *p*-cymene (0.5%), β-phellandrene + 1,8-cineole (8.8%), γ-terpinene (1.2%), **terpinolene 57** (17.7%), isoamyl isovalerate (0.8%), α-campholenal (0.1%), *cis*-sabinol (0.7%), terpinen-4-ol (0.3%), α-copaene (0.1%), β-cubebene (0.1%), β-caryophyllene (3.3%), α-humulene (0.2%), germacrene D (0.1%), caryophyllene oxide (0.8%) (Noudjou et al., 2007)	
	Entire plant + flower	-	Toxic to crop weevils (Kouninki et al., 2005; Ngamo et al., 2007)
Mentha piperita	Leaves, Nkoldom, Oct 2010	α-Pinene (0.3%), sabinene (0.4%), β-pinene (0.7%), *p*-cymene traces, β-phellandrene (5.8%), limonene (0.7%, *neo*-menthol (0.3%), **menthol 60** (10.0%, pulegone (0.6%), carvacrol methyl ether (2.3%), **piperitone 61** (67.5%), α-terpineol acetate (0.2%), β-cubebene (0.5%), α-bourbonene (0.6%), β-caryophyllene (1.9%), β-copaene (0.35%), α-guaiene (0.2%), γ-cadinene (0.2%), δ-cadinene (0.1%), α-copaene (0.35%), caryophyllene oxyde (1.7%) (Nyegue et al., 2014)	Anti-dermatophytic (Nyegue et al., 2014)
	Whole mature plant, West Region of Cameroon, Mbouda, September 2003	3-Octan-2-one (0.18%), α-thujene (0.23%), α-pinene (8.21%), camphene (0.32%), β-pinene (0.69%), mycrene (1.24%), δ-3-carene (0.90%), α-terpinene (0.21%), *p*-cymene (0.28%), limonene (13.36%), (*Z*)-β-ocimene (0.09%), γ-terpinene (0.34%), terpinolene (0.44%), 1,8-cineole (1.28%), linalool (0.40%), (*Z*)-epoxy-ocimene (0.44%), (*E*)-pinocarveol (0.22%), camphor (0.23%), **menthone 62** (18.47%), isoborneol (3.50%), **menthol 60** (33.59%), isomenthol (0.60%), α-terpineol (0.55%), piperitone (4.66%), menthyl acetate	

Table 1 (Continued)

		(3.73%), (*E*)-isoeugenol (0.80%), α-cubebene (0.21%), (*Z*)-caryophyllene (0.30%), β-cedrene (0.31%), (*E*)-9-*epi*-caryophyllene (0.76%), germacrene D (0.24%), α-selinene (0.26%), δ-cadinene (0.35%) (Ambindei et al., 2017)	
	Aerial parts	-	Antimicrobial (Reddy et al., 2017)
	unknown	-	Anti-leishmanial; not totoxic to normal cell line (Robledo et al., 2017)
Ocimum americanum	Flower, Maroua, Dec 2005	α-Thujene (0.2%), α-pinene (2.1%), **β-pinene 21** (8.8), myrcene (1.6%), **limonene 17** (49.2%), (*E*)-caryophyllene (8.6%), and elemene (3.2%) (Ngassoum et al., 2007)	Toxic to crop weevils (Ngassoum et al., 2007)
	Leaves, Douala, May 2004	α-Thujene (0.3%), α-pinene (0.8%), sabinene (0.3%), β-pinene (1.0%), myrcene (0.6%), *p*-cymene (1.2%), **limonene 43** (10.9%), (*Z*)-β-ocimene (0.9%), (*E*)-β-ocimene (0.4%), γ-terpinene (1.5%), 1,8-cineole (3.2%), fenchone (2.4%), **linalool 9** (56.3%), pinocarveol (0.7%), terpinene-4-ol (4.7%), α-terpineol (1.1%), thymol (0.5%), β-caryophyllene traces, β-humulene (3.5%), α-*trans*-bergamotene (0.3%), α-humulene (0.3%), germacrene D (0.7%), (*E,E*)-α-farnesene (0.3%), γ-cadinene (0.7%), δ-cadinene (0.8%) (Tchoumbougnang et al., 2009)	anti-Anopheles gambiae activity (Bassolé et al., 2003; Nlôga et al., 2007; Tchoumbougnang et al., 2009); anti-Anopheles funestus activity (Ntonga et al., 2014); anti-Plasmodium falciparum activity (Ntonga et al., 2014); anti-Aedes aegypti activity (Bassolé et al., 2003); antioxidant, antifungal (Sameza et al., 2016)
	Leaves, Douala, June 2009	α-Thujene (0.17%), α-pinene (1.66%), camphene (0.27%), sabinene (0.49%), β-pinene (1.94%), myrcene (0.97%), α-terpinene (0.32%, *p*-cymene (0.95%), limonene (~3%), (*Z*)-β-ocimene (0.11%), (*E*)-β-ocimene (2.44%), δ-terpinene (0.70%), terpinolene (0.38%), perillene (0.14%), (*E*)-β-epoxyocimene (2.04%), **1,8-cineole 59** (< 29.04%), 5-isopropyl-2-methylbicyclo[3.1.0]hexan-2-ol (0.80%), fenchone (2.87%), *trans*-linalool oxide (furanoid) (0.07%), **linalool 9 (**19.07%), camphor (2.00%), terpinen-4-ol (7.53%), α-terpineol (2.31%), fenchyl acetate (endo) (0.12%), isobornyl acetate (0.17%), α-copaene (0.21%), β-elemene (0.67%), β-caryophyllene (0.42%), *trans*-α-bergamotene (3.49%), aromadendrene (0.22%), α-humulene (0.51%), *epi*-bicyclosesquiphellandrene (0.17%), germacrene-D (0.76%), bicyclogermacrene (0.30%), δ-guaiene (0.31%), α-cadinene (0.70%), calamenene (0.07%), δ-cadinene (0.30%), (*E*)-α-bisabolene (0.97%), spathulenol (0.12%), eugenol (8.01%), 1,2-dimethoxy-4-propenylbenzene (0.24%), (*Z*)-3-hexen-1-ol (0.17%), oct-1-en-3-ol (0.15%), (*Z*)-3-hexen-1-yl acetate (0.2%), octyl acetate (0.11%) (Ntonga et al., 2014)	
	Leaves, Nkoldom II, Aug 2012	Eugenol (0.2%), thymol (0.1%), γ-terpinene (0.7%), **1,8-cineole 59** (70.2%), β-bisabolene (0.2%), α-thujene (0.2%), α-pinene (3.2%), sabinene (1.4%), **β-pinene 20** (5.7%), myrcene (0.9%), α-terpinene (0.4%), *cis*-sabinene hydrate (0.6%), terpinolene (0.2%), 6,7-epoxymyrcene (0.3%), linalool (0.4%), δ-terpineol (0.9%), terpinen-4-ol (1.5%), α-terpineol (4.0%), *trans*-carveol (0.2%), α-copaene (0.6%), β-caryophyllene (0.6%), β-copaene (1.1%), α-humulene (0.6%), germacrene D (0.7%), δ-cadinene (0.6%), (*E*)-γ-bisabolene (3.1%) (Hüe et al., 2015)	
	Leaves were harvested in March 2011 in Douala	Hexan-1-ol (0.2%), α-thujene (0.3%), α-pinene (1.9%), camphene (0.3%), sabinene (0.5%), β-pinene (2.1%), mycrene (1.1%), α-phellandrene (0.2%), *p*-cymene (0.5%), β-phellandrene (0.9%), limonene (4.3%), (*E*)-β-ocimene (3.9%), α-terpinene (1.1%), terpinolene (3.6%), **1,8-cineole 59** (20.8%), hydrate *cis*-sabinene (0.3%), **linalool 9** (14.3%), *trans*-pinocarveol (0.6%), campher (3.2%), borneol (0.4%), terpinen-4-ol (7.4%), α-terpineol (2.2%), *cis*-carveol (0.1%), hydrate sabinene acetate traces, thymol (0.2%), eugenol (11.9%), carvyl *cis*-acetate (0.1%), α-cubebene (0.1%), α-copaene (0.2%), α-bergamotene (0.3%), (*Z*)-β-farnesene (0.1%), α-humulene (0.7%), germacrene D (4.9%), α-zingiberene (0.1%), α-cadinene (0.1%), δ-cadinene (0.9%), α-cadinene (0.3%), germacrene B (0.5%), elemol traces, nerolidol (0.1%), germacrene D-4-ol (1.3%), caryophyllene oxide traces, humulene II epoxide (0.5%), β-eudesmol (1.5%), α-bisabolol (0.1%), (2*Z*,6*E*)-farnesol (0.3%), (2*E*,6*E*)-farnesol (1.9%), (2*E*,6*E*)-methyl farnesoate (0.1%), 1,3,5-trimethylbenzene (0.1%) (Sameza et al., 2016)	
	Entire plant	-	Toxic to crop weevils (Ngamo et al., 2007a)
Ocimum basilicum	Whole plants, Yaoundé, Jan 1995	α-Thujene traces, α-pinene (0.8%), sabinene traces, β-pinene traces, myrcene (2.1%), **limonene 16** (10.4%), (*E*)-β-ocimene (1.8%), δ-terpinene (0.9%), 1,8-cineole (3.1%), **linalool 9** (50.8%), terpinen-4-ol (3.5%), α-terpineol (1.2%), α-copaene traces, β-elemene (0.7%), β-caryophyllene (2.2%), (*E*)-β-farnesene traces, a-humulene (0.5%), germacrene D (2.2%), bicyclogermacrene (0.8%), (*E,E*)-α-farnesene traces, δ-cadinene (1.0%), bisabolene (0.5%), T-cadinol (3.4%), torreyol traces, α-cadinol traces, and eugenol (13.5%) (Zollo et al., 1998)	Low to moderate active against yeasts, destructive and contaminant filamentous fungi and dermatomycosis agents (Zollo et al., 1998).
	Leaves, Douala, June 2009	α-Thujene (0.09%, α-pinene (0.51%, sabinene (0.34%), β-pinene (0.96%), myrcene (0.99%, α-terpinene (0.18%), *p*-cymene (0.34%), limonene (~1%), (*Z*)-β-ocimene (0.08%), (*E*)-β-ocimene (1.18%), δ-terpinene (0.38%), terpinolene (0.13%), **1,8-cineole 59** (< 13.95%), 5-isopropyl-2 methylbicyclo[3.1.0]hexan-2-ol (0.10%), *cis*-linalool oxide (furanoid) (0.12%), fenchone (0.64%), *trans*-linalool oxide (furanoid) (0.10%), **linalool 9** (**51.86%), camphor (0.13%), α-terpineol (0.23%), terpinen-4-ol (2.98%), α-terpineol (1.32%), fenchyl acetate (endo) (0.11%), neral (0.64%), geraniol (0.18%), geranial (0.79%), isobornyl acetate (0.13%), α-copaene (0.07%), β-elemene (0.39%), β-caryophyllene (0.4%), *trans*-α-bergamotene (1.39%), aromadendrene (0.14%), α-humulene (0.18%), *epi*-bicyclosesquiphellandrene (0.13%), germacrene-D (0.49%), bicyclogermacrene (0.21%), δ-guaiene (0.18%,) δ-cadinene (0.50%), calamenene (0.04%), α-cadinene (0.11%), (*E*)-α-bisabolene (0.26%), spathulenol (0.08%), eugenol (8.39%), 1,2-dimethoxy-4-propenylbenzene (0.09%), (*Z*)-3-hexen-1-ol (0.24%), oct-1-en-3-ol (0.26%), octyl acetate (0.08%) (Ntonga et al., 2014)	Anti-*Anopheles funestus* activity; anti -*Plasmodiuzm falciparum* activity (Ntonga et al., 2014); low to high antibacterial (Nguefack et al., 2004b; Silva et al., 2015); antioxidant (Goudoum et al., 2017); antifungal (Shirazi et al., 2014; Cardoso et al., 2017); activity in cancer cells (Shirazi et al., 2014); anti -Vibrio; (Snoussi et al., 2016); Toxic to crop weevils (Kéita et al., 2001)
	Leaves Maroua in Far-North	α-Thujene (0.11%), α-pinene (0.35%), camphene (0.32%), sabinene (0.21%, β-pinene (0.52%), mycrene (0.01%), α-terpinene (0.91%), *p*-cymene (1.86%),	

Table 1 (Continued)

	Cameroon, January 2016	**limonene 44** (27.65%, β-phellandrene (14.86%), 1,8-cineole (0.1%), (*E*)-β-ocymene (1.81%), terpinolene (0.21%), fenchone (0.25%), **linalool 9** (21.51%), terpine-4-ol (2.01%), neral (0.13%), thymol (4.52%), carvacrol (1.47%), eugenol (2.86%), farnesene (3.02%), α-copaene (1.65%), β-elemene (1.92%), β-caryophyllene (0.23%), α-humulene (0.14%), germacrene D (2.02%), (*E*)-α-bisabolene (0.53%), δ-cadinene (1.04%, cardinol (3.68%) (Goudoum et al., 2017)	
	Leaf + stem	-	Activity in cancer cells (Fitsiou et al., 2016)
Ocimum gratissimum	Leaves, Yaoundé, July 1993/2003	α-Thujene (3.5%), α-pinene (1.0%), camphene (0.1%), sabinene (0.7%), β-pinene (0.4%), myrcene (3.2%), α-phellandrene (0.3%), δ-3-carene (0.2%), α-terpinene (2.8%), *p*-cymene (7.0%), limonene (1.1%), (Z)-β-ocimene (0.6%), (*E*)-β-ocimene (0.2%), **δ-terpinene 63 (**20.0%), terpinolene (0.2%), (*E*)-sabinene hydrate (1.0%), fenchone (0.2%), linalool (0.4%), terpinen-4-ol (0.1%), α-terpineol traces, **thymol 64 (**46.2%), carvacrol (0.2%), δ-elemene traces, a-copaene (0.4%), β-elemene (0.2%), β-caryophyllene (2.3%), α-humulene (0.3%), *allo*-aromadendrene (0.2%), guaiene (1.5%), α-selinene (0.7%), δ-cadinene (1.0%), α-cadinene (0.8%), spathulenol traces, caryophyllene epoxide (0.4%), τ-muurolol (0.4%), and τ-cadinol (0.1%) (Zollo et al., 1998; Nguefack et al., 2007)	Antifungal (Zollo et al., 1998; Nguefack et al., 2004 a, b, 2007 b, 2008, 2009, 2012; Tagne et al., 2008; Tatsadjieu et al., 2008, 2010; Sessou et al., 2012; Galani et al., 2013); acaricidal (Hüe et al., 2015); antibacterial (Ngassoum et al., 2003; Nguefack et al., 2004 b; ; Voundi et al., 2015); toxic to crop weevils (Ngouemtchouin et al., 2013)
	Leaves, Ngaoundéré, 2007	Hexanal-2 (0.5%), sabinene (0.7%), myrcene (0.8%), β-phellandrene (1.9%), β-3-carene (0.4%), **β-terpinene 65** (14.3%), *p*-cymene (8.5%), dehydro-*p*-cymene (1.3%), limonene (2.6%), *trans*-β-ocimene (0.9%), terpinolene (2.3%), 1,8-cineole (1.6%), β-thujone (0.5%), linalool (0.6%), carvacrol (0.9%), terpinen-4-ol (0.5%), 3,9-epoxy-*p*-mentha-1,8-diene (1.1%), β-terpineol (1.4%), **thymol 64** (47.7%), bisabolene (0.5%), β-copaene (0.5%), β-caryophyllene (1.3%), β-cubebene (0.5%), β-farnesene (0.8%) and caryophyllene oxide (0.5%) (Tatsadjieu et al., 2008)	
	Leaves, Douala, April 2009	α-Thujene (6.5%), α-pinene (1.8%), camphene (0.2%, sabinene (1.4%), β-pinene (0.7%), myrcene (5.5%), α-phellandrene (0.2%), ***p*-cymene 1** (32.1%), limonene (2.0%), (*Z*)-β-ocimene (0.2% (*E*)-β-ocimene (8.0%), γ-terpinene (0.8%), terpinolene (1.6%), linalool (1.4%), borneol (0.3%), terpinene-4-ol (1.3%), α-terpineol (1.7%), **thymol 64** (24.3%), carvacrol (0.5%), δ-elemene (0.1%), α-cubebene traces, α-eopaene (0.7%), β-elemene (0.2%), β-gurjunene (3.5%), β-humulene (0.4%), β-bisabolene (1.7%), δ-cadinene (0.2%) (Tchoumbougnang et al., 2009)	
	Leaves, Yaoundé, Nov 2009	α-Thujene (3.6%), α-pinene (1.2%), camphene (0.1%), β-pinene (0.4%, myrcene (2.5%), α-terpinene (2.1%), ***p*-cymene 1** (23.5%), limonene (1.5%), δ-terpinene (6.9%), *trans*-sabinene hydrate (0.7%), 1-methyl-4(1-methylethenyl)benzene (0.8%), linalool (0.5%), borneol (0.2%), terpinen-4-ol (2.3%), **thymol 64** (40.6%), carvacrol (0.3%), α-copaene (1.1%), β-caryophyllene (3.6%), β-selinene (1.9%), a-selinene (0.7%), δ-cadinene (0.7%), and α-caryophyllene (0.8%) (Nguefack et al., 2012)	
	Leaves Ngaoundere Adamaoua region, July 2010	α-Thujene (1.5%), α-pinene (3.2%), camphene (0.1%), sabinene (0.2%), β-pinene (0.6%), mycrene (5.5%), α-phellandrene (0.3%), α-terpinene (2.0%), *p*-cymene (3.9%), limonene (2.0%), Z-β-ocimene (0.6%), (*E*)-β-ocimene (0.2%), γ-**terpinene 63** (17.8%), linalool (0.2%), 1,3,8-*p*-menthatriene (0.1%), *trans*-thujone (0.1%), *neo*-*allo*-ocimene (0.3%), terpinen-4-ol (0.6%, *p*-cymen-8-ol (0.4%), **thymol 64 (**53.9%), carvacrol (0.9%), α-cubebene (0.1%), α-copaene (0.7%), β-cubebene (0.2%), β-elemene (0.2%), β-caryophyllene (2.8%), α-humulene (0.3%), germacrene (0.1%), α-selinene (0.6%), 7-*epi*-α-selinene (0.2%), δ-cardinene (0.4%), caryophyllene oxide (0.4%) (Ngouemtchouin et al., 2013)	
	Leaves, Nkolodom II, August 2012	Eugenol (0.1%), **thymol 64** (30.5%), **δ-terpinene 63** (33.0%), (*Z*)-β-ocimene (1.0%), α-thujene (4.8%), α-pinene (1.2%), sabinene (0.6%), β-pinene (0.4%), myrcene (4.0%), α-phellandrene (0.4%), α-terpinene (4.5%), *p*-cymene (7.0%), limonene (1.1%), (*E*)-β-ocimene (0.3%), *cis*-sabinene hydrate (0.1%), *p*-cymenene (1.0%), linalool (0.1%), borneol (0.1%), terpinen-4-ol (1.3%), α-terpineol (0.1%), carvacrol (0.3%), α-copaene (0.4%), β-caryophyllene (3.5%), α-humulene (0.3%), germacrene D (0.1%), β-selinene (1.1%), α-selinene (0.3%), δ-cadinene (0.3%) (Hüe et al., 2015)	
	Fresh leaves Cameroon in July 2012	α-Pinene (4.1%), camphene (1.2%), β-pinene (0.6%), α-phellandrene (3.7%), mycrene (0.3%), α-terpinene (0.8%), ***p*-cymene 1** (14.0%), limonene (1.1%), (*Z*)-β-ocimene (0.5%), (*E*)-β-ocimene (0.3%), δ-**terpinene 63** (16.6%), borneol (0.5%), terpinen-4-ol (1.1%), α-terpineol (0.4%), **thymol 64** (47.1%), carvacrol (0.6%), α-copaene (0.4%), β-*trans*-caryophyllene (0.6%), δ-cadinene (0.9%), cardinene (0.3%), eudesmol (1.6%) (Voundi et al., 2015)	
	Entire plant	-	Toxic to crop weevils (Kouninki et al., 2007 b; Ngamo et al., 2007; Ousman et al., 2007; Tatsadjieu et al., 2010; Tchoumbougnang et al., 2009); anti- Plasmodium berghei activity in mouse model (Tchoumbougnang et al., 2005)
Plectranthus glandulosus	Leaves, Ngaoundéré, 2007	β-Pinene (0.6%), myrcene (2.2%), β-phellandrene (0.7%), β-3-carene (1.5%), β-terpinene (0.8%), limonene (3.2%), *trans*-β-ocimene (0.6%), **terpinolene 60** (25.2%), **β-thujone 69** (30.8%), neral (0.8%), fenchol (1.5%), *trans*-*p*-menth-2-en-ol (0.5%), borneol (0.5%), *p*-cymene-8-ol (3.6%), oxide *cis*-piperitone (3%), oxide *trans*-piperitone (0.5%), thymol (0.4%), *trans*-2-hydroxypiperitone (0.6%), 4-hydroxypiperitone (0.7%), piperitenone (1.3%), piperitenone oxide (10.9%), isopulegone (1.8%, and germacrene (1.0%) (Tatsadjieu et al., 2008). (18.3%), sample Ngaoundéré October (Nukenine et al., 2010)	Strong antifungal (Tatsadjieu et al., 2008; Aoudou et al., 2010, 2011); strong insecticidal (Goudoum et al., 2010; Nukenine et al., 2010; Danga et al., 2014); anti -Aedes aegypti and anti -Anopheles gambiae activity (Danga et al., 2014)
	Leaves, Ngaoundéré, October 2004	**Terpinolene 57** (8.7%), **fenchone 67** (18.3%), *cis*-piperitone oxide (19.5%), piperitone epoxide (17.7%), piperitone oxide (8.9%), piperitone (1.2%), diosphenol (2.5%), and thymol (3.7%) (Nukenine et al., 2010)	

Table 1 (Continued)

	Leaves, Ngaoundéré, July 2008	α-Pinene (0.4%), mycrene (1.5%), δ-3-carene (1.5%), a-terpinene (0.3%), *p*-cymene (2.6%), limonene (6.2%), (*E*)-β-ocimene (0.3%), δ-terpinene (0.5%), **terpinolene 57** (30.8%), α-terpinolene (0.6%), **fenchone 67** (13.2%), α-fenchone (0.4%), fenchol (0.5%), geraniol (4.6%), camphor (1.1%), borneol (0.4%), terpene-4-ol (11%), piperitone (1.3%), epoxypiperitone (0.3%), 4-hydroxypiperitone (2.4%), thymol (1.9%), safrole (0.5%), piperitenone (1.2%), piperitenone oxide (8%, eugenol (1.1%), α-copaene (0.4%), β-elemene (1.1%), β-carophyllene (0.6%), (*E*)- carophyllene (0.5%), β-gurjunene (0.4%), β-copaene 0.5%), α-humulene (0.4%), germacrene D (0.8%), humulene oxide (0.9%), δ-cadinene (0.3%), nerolidol (0.3%), α -cadinol (0.7%) (Aoudou et al., 2011)	
Thymus vulgaris	Leaves, Dschang, July 2003	α-Thujene (1.2%), α-pinene (1.0%), camphene (1.2%), sabinene (0.4%), β-pinene (0.3%), myrcene (1.7%, α-phellandrene (0.2%), **p-cymene 1 (**23.6%), limonene (1.5%), hydrate (1.0%), linalool (5.2%), camphor (1.9%), terpinen-4-ol (1.3%), α-terpineol (0.3%), **thymol 64 (**27.2%), carvacrol (3.3%), β-caryophyllene (3.5%), germacrene D (0.6%), δ-cadinene (0.3%), caryophyllene oxide (0.6%), and τ-muurolol (0.4%) (Nguefack et al., 2007a)	Antifungal (Zollo et al., 1998; Nguefack et al., 2004, 2007 a, 2009; Tagne et al., 2008 ; Al-Shahrani et al., 2017); antibacterial (Nguefack et al., 2004b); antimicrobial (Fani and Kohanteb, 2017); Toxic to crop weevils (Al-Shahrani et al., 2017).
	Leaves, Bangang, May 2005	α-Thujene (0.9%), α-pinene (1.2%), camphene (1.2%), sabinene (0.6%), myrcene (0.4%), α-phellandrene traces, ***p*-cymene 1** (23.4%), β-phellandrene (0.5%), **γ-terpinene 63** (15.1%), terpinolene (1.7%), fenchone traces, borneol (4.5%), terpinene-4-ol (1.4%), α-terpineol (0.5%), **thymol 67 (**40.1%), carvacrol (2.4%), δ-elemene traces, α-cubebene traces, α-ylangene (0.3%), β-caryophyllene (1.3%), β-humulene traces, α-guaiene traces, γ-muurolene traces (Tchoumbougnang et al., 2009)	
	Leaves, Bafoussam, Nov 2009	α-Thujene (0.9%), α-pinene (0.9%), camphene (0.9%), β-pinene (0.7%), myrcene (1.0%), α-terpinene (1.2%), ***p*-cymene 1** (30.9%), limonene (0.9%), **δ-terpinene 63** (5.9%), *trans*-sabinene hydrate (0.7%), linalool (3.2%), camphor (1.6%), borneol (2.1%), terpinen-4-ol (1.2 %), **thymol 64** (28.1%), carvacrol (2.6%), bornyl acetate (3.5%), α-copaene (0.5%), β-caryophyllene (4.6%), α-amorphene (0.3%), α-selinene (0.2%), δ-cadinene (0.7%), and α-caryophyllene (0.7%) (Nguefack et al., 2012)	
	The whole plant was in October 2012	α-Pinene (0.8%), α-thujene (0.5%), camphene (1.0%), sabinene (5.3%), β-pinene (1.1%), α-phellandrene (1.0%, mycrene (0.9%), **p-cymene 1 (**25.0%), limonene (2.6%), linalool (0.3%), phenylacetaldehyde alcohol (4.2%), β-terpineol (0.5%, borneol (0.7%), terpinen-4-ol (2.0%), ascaridol (1.3%), **thymol 64** (45.5%), carvacrol (0.4%), eugenol (3.0%), β-*trans*-caryophyllene (1.7%), β-thujaplicinol (0.4%), caryophyllene (1.3%) (Voundi et al., 2015)	Antifungal (Zollo et al., 1998; Nguefack et al., 2004, 2007a, 2008, 2009); low antibacterial (Voundi et al., 2015)
	Whole mature plant, Dschang, September 2013	Heptanal (0.08%), 3-octan-2-one (0.06%), α-thujene (0.94%), α-pinene (0.89%), camphene (0.99%), sabinene (0.52%), β-pinene (0.19%), mycrene (1.38%), α-phellandrene (0.11%), α-terpinene (1.09%), **p-cymene 1** (25.36%), limonene (0.46%), **γ-terpinene 63** (12.48%), *p*-menthe-3,8-diene (0.57%), 1,8-cineole (0.12%), linalool (4.72%), camphor (2.38%), borneol (1.14%), terpinen-4-ol (0.97%), **thymol 64** (35.12%), carvacrol ethyl ether (0.30%), carvacrol (2.01%), eugenol (0.16%) (Ambindei et al., 2017)	
	The aerial parts Yaoundé October 2012	Main essential oil components were **thymol 64** (45.5%), linalool (4.2%), ***p*-cymene 1** (25.0%), γ-terpinene (5.3%) (Nyegue et al., 2017)	
Vitex rivularis	Aerial parts, Yaoundé, 2005/2006, population A	1-Octen-3-ol (2.2%), linalool (2.6%), 1-octen-3-yl acetate (0.2%), α-terpineol (0.3%), δ-elemene (0.4%), α-cubebene (0.3%), α-ylangene (0.4%), α-copaene (6.4%), β-bourbonene (0.6%), β-cubebene (0.2%), β-elemene (0.5%), isoitalicene (0.3%), *cis*-α-bergamotene (1.1%), β-caryophyllene (7.3%), δ-elemene (0.4%), *trans*-α-bergamotene (2.6%), α-humulene (2.6%), β-farnesene (2.4%), δ-muurolene (3.2%), ***ar*-curcumene 68 (**9.1%), δ-curcumene (7.8%), **germacrene D 14 (**12.6%), β-selinene (0.8%), δ-selinene (0.8%), valencene (0.9%), α-selinene (0.6%), α-muurolene (1.4%), δ-cadinene (1.4%), (Z)-calamenene (0.7%), δ-cadinene (5.7%), a-cadinene (0.6%), germacrene B (1.4%), β-nerolidol (1.1%), caryophyllene oxide (0.9%), τ-cadinol (0.6%), τ-muurolol (1.1%), α-muurolol (0.6%), α-cadinol (2.1%), and phytol (4.1%) (Cabral et al., 2009)	Stong anti -dermatophytic fungi activity (Cabral et al., 2009)
	Aerial parts, Yaoundé, 2005/2006 population B.	1-Octen-3-ol (1.0%), linalool (3.9%), 1-octen-3-yl acetate (0.1%), α-terpineol (0.7%), δ-elemene (1.5%), α-cubebene (0.1%), α-ylangene (0.3%), α-copaene (5.0%), β-bourbonene (0.4%), β-cubebene (0.2%), β-elemene (0.1%), isoitalicene (0.2%), *cis*-α-bergamotene (1.0%), β-caryophyllene (6.6%), δ-elemene (0.8%), *trans*-α-bergamotene (3.0%), α-humulene (1.7%), β-farnesene (2.3%), δ-muurolene (3.1%), *ar*-curcumene (5.5%), **germacrene D 14 (**20.6%), **δ-curcumene 68 (**9.7%), β-selinene (0.5%), δ-selinene (0.9%), valencene (1.0%), α-selinene (0.8%), α-muurolene (1.5%), δ-cadinene (1.4%), (Z)-calamenene (1.0%), β-cadinene (6.4%), α-cadinene (0.8%), germacrene B (1.8%), β-nerolidol (1.1%), caryophyllene oxide (0.7%), τ-cadinol (0.5%), τ-muurolol (1.0%), α-muurolol (0.6%), α-cadinol (2.7%), and phytol (0.1%) (Cabral et al., 2009)	
		11. Lauraceae	
Cinnamomum verum	Leaves, forest area Cameroon, May/July 2015	α-Pinene (0.36%), camphene (0.15%), mycrene (0.18%), δ-3-carene (0.27%), limonene (1.21%), (*Z*)-β-ocimene (0.45%), linalol (0.31%), *iso*-geranial (0.14%), myrtenal (0.55%), linalol acetat (0.76%), hydroxy citronellal (1.25%), neryl acetone (1.11%), ethyl cinnamate (0.22%), hydro-cinnamaldehyde (0.62%), verbenene (0.43%), **β-cubebene 69** (78.10%), botrydiol (0.11%), **phenylethyl alcohol 70** (13.04%), *p*-tolualdehyde (0.14%) (Akono et al., 2016)	anti-*Anopheles gambiae* activity (Akono, 2 016a); antifungal (Ambindei et al., 2017)
	Leaves, West Region, Mbouda, September 2013	Heptanal (0.15%), benzaldehyde (1.06%), α-thujene (0.17%), α-pinene (6.31%), camphene (2.76%), β-pinene (2.24%), mycrene (0.42%), α-phellandrene (1.25%), δ-3-carene (0.16%), *p*-cymene (1.75%), limonene	

Table 1 (Continued)

		(2.50%), terpinolene (0.19%, 1,8-cineole (0.56%), linalool (2.80%), nerol oxide (0.50%), (*Z*)-isocitral (0.80%), borneol (0.95%), terpinen-4-ol (0.23%), α-terpineol (0.49%), myrtenol (0.19%), *cis*-carveol (0.31%), geraniol (0.28%,) piperitone (0.29%), **(*E*)-cinnamaldehyde 71** (13.03%), safrole (0.21%), eugenol (12.15%), (*E*)-cinnamic acid (3.26%), eugenyl acetate (4.30%), 2-hexyl-(*Z*)-cinnamaldehyde (10.66%), α-copaene (0.93%), β-cubebene (4.22%), **(*E*)-β-caryophyllene 72 (**21.82%), α-selinene (0.95%), caryophyllene oxide (1.94%), guaiol (0.23%) (Ambindei et al., 2017)	
	Bark	-	Antimicrobial, activity in cancer cells , toxic to normal fibroblasts (Unlu et al., 2010); anti -Anopheles gambiae activity (Norris et al., 2015).
12. Leguminosae			
Dichrostachys cinera	Seeds Bafoussam	β-Pinene (0.1%), mycrene (0.3%), *p*-cymene (0.1%), limonene traces, 1,8-cineole (2.3%), ethylhexanol (0.2%), cis-linalool oxide (0.1%), ligustracin (5.1%), linalool (4.0%), *cis-p*-menth-2-en-1-ol (0.3%), α-campholenal (0.1%), *trans*-pinocarveol (0.7%), *trans-p*-menth-2-en-1-ol (0.3%), *cis*-verbenol (0.2%,) *trans*-pinocamphone (0.4%), pinocarvone (0.1%), borreol (0.7%), *cis*-pinocamphone (0.8%), umbellulone (3.8%, terpinen-4-ol (7.5%), *p*-cymen-8-ol (0.3%), α-terpineol (3.3%), myrtenal (0.2%), myrtenol (1.1%), *trans*-piperitol (0.1%), *trans*-carveol (0.2%), nerol (0.2%), citronellol (0.3%), neral (0,2%), piperitone (0.3%), **geraniol 73** (18.2%), thymol (0.9%), methyl myrtenate (2.0%), carvacrol (0.7%), α-terpinyl acetate (0.3%), decanoic acid (2.8%), geranyl acetone (1.2%), elemicin (3.0%), isoaromadendrene epoxide (1.8%), caryophyllene oxide (1.1%), α-acorenol (1.0%), *epi*-α-muurolol (0.7%), α-cadinol (1.4%), ageratochromene (0.8%), 3-oxo-β-ionone (0.9%), cyperotundone (0.9%), (2*E*,6*Z*)-farnesol (2.4%), (2*E*,6*Z*)-farnesal (1.0%), (2*E*,6*E*)-farnesal (1.7%) (Pavela et al., 2016; Kamte et al., 2017)	Toxic to crop weevils (Pavela et al., 2016)
	Leaf	-	not antitrypanosomal active (Kamte et al., 2017)

and in the treatment of respiratory and inflammatory disorders (Kishore et al., 1996; Kurmar et al., 2007; Jardim et al., 2008). A decoction prepared with leaves and occasionally with flowers is taken orally for dysmenorrhea and menses regulation and disorders. The leaves and flowers are also used as a poultice to help dissolve fibroids and to treat uterine hemorrhaging (Ososki et al., 2002; Cruz et al., 2007).

3.1.1.2. Bioactivities

3.1.1.2.1. Aerial parts

The aerial parts essential oil was investigated by larvicidal toxicity assay using third instar larvae of the filariasis and West Nile virus vector *Culex quinquefasciatus* and adult houseflies of the species *Musca domestica*. Tests resulted in LC_{50} of 62.1 µL/L and LD_{50} 51.7 µg/adult, respectively, while a 1:1 mixture with the leaf essential oil of *Clausena anisata*-alone displaying 29.3 µL/L - showed synergistic effect with an LC_{50} of 19.3 µL/L against *Culex quinquefasciatus*. In addition, this mixture displayed an LD_{50} of 75.9 µg / adult against *Musa domestica*, which was more active than the aerial parts from essential oil alone, displaying an LD_{50} of 51.7 µg/adult. Furthermore, the acetylcholinesterase (AChE) inhibitory assay gave an IC_{50} of 77 µg/mL, compared to galantamine with 9.4 µg/mL. It was suggested that an application in synergistic binary blends may lead to the development of a new eco-friendly, safe and effective herbal insecticide (Pavela et al., 2018). Interestingly, the compound ascaridole, present in the aerial parts essential oil, was found to be a potent inhibitor of plasmodial growth: after 3 days, development was arrested by a drug concentration of 0.05 µM, and at 0.1 µM no parasites were visible in the culture. At lower concentrations, the effect was observed mainly at the trophozoite stage, whereas the ring stage was marginally affected. However, even at these lower concentrations, the ring culture could not continue normal development and ceased to grow at a later stage (Pollack et al., 1990). Moreover, ascaridol showed antineoplastic activity when assayed against human T-cell leukemia cell line CCRF-CEM, human acute myeloid leukemia cell line HL-60 and breast cancer cell line MDA-MB-231, so that it was suggested that the compound may be an interesting novel candidate drug for cancer treatment (Effert et al., 2002). *in vitro*, ascaridol also presented IC_{50} values of 6.3 to 18.4 µg/mL in human acute myeloid leukemia cell line HL-60 and human colorectal adenocarcinoma cell line HCT 8, while *in vivo* antitumor activity in a sarcoma murine model demonstrated inhibition rates of 33.9% at 10 mg/kg and 33.3% at 20-mg/kg doses. Histopathological examination showed that the organs were only weakly affected by the treatment (Bezerra et al., 2009). In addition, the aerial parts essential oil was assayed against promastigotes and amastigotes of *Leishmania amazonensis* MHOM/77BR/LTB0016, compared to mammalian macrophages showing an IC_{50} of 3.7, 4.6 and 58.2 µg/mL, respectively, resulting in a a selectivity index (SI) of 13, while the pure compound ascaridole delivered 0.1, 0.3 and 1.1 µg/mL, respectively, leading to an SI of 3. In addition, assays employing *Plasmodium falciparum* Ghana strain, *Trypanosoma cruzi* Tulahuen CL2, *Trypanosoma brucei* Squib-427 and *Leishmania infantum* MHOM/MA(BE)/67 gave IC_{50}s of 0.2, 1.9, 0.2 and 6.4 µg/mL, respectively, compared to the positive controls chloroquine, benznidazol, suramine and miltefosine with IC_{50}s of 0.3, 2.2, 0.05 ad 7.7 µg/mL, respectively (Monzote et al., 2014). It should be noted that the aerial parts essential oil reported here differed widely from the Cameroonian one, showing as main compounds ascaridole in 2006. Moreover, the aerial parts essential oil was reported to display IC_{50} values of 18.75, 9.45 and 10.50 μg/mL at 6, 24 and 48 h, respectively, in estrogen receptor-positive human breast cancer cell line MCF 7 as measured by MTT assay (Wu et al., 2013).

3.1.1.2.2. Leaf

A fumigant toxicity assay employing the leaf essential oil against the cowpea weevil *Callosobruchus maculatus* and the maize weevil *Sitophilus zeamais* gave after 24 h LC_{50}s of 1.33, 2., 2.07 and 43.68 μL/L for adults, eggs and larvae, respectively, of *Callosobruchus maculatus*, while adults of *Sitophilus zeamais* showed an LC_{50} of 1.90 μL/L (Denloye et al., 2010). The maize weevil *Sitophilus zeamais* treated with the leaf essential oil showed an LC_{50} of 41.09 μL/kg of maize seeds; complete suppression of F1 progeny at 200 μL / kg of maize seeds; and *in vitro* repellency on filter paper assay due to treatment with essential oil of 75% at 8 μL/kg. Due to the volatile nature of the oil, it was shown that mortality was reduced to zero on day 14 post treatment. The leaf essential oil of this plant was suggested to be an alternative response to the use of synthetic pesticides that are not easily biodegradable, biotoxic, promote the development of resistance in insects and are not usually available (Langsi et al., 2017). At 25 and 12.5 μg/mL, the essential oil showed LC_{50}s of 6.50, 3.66 and 3.65 μg/mL at 24, 48 and 72 h, respectively, against adult *Schistosoma mansoni* worms, while the IC_{50} against the normal fibroblasts cell line GM07492-A was recorded with 207.1 μg/mL. The selectivity index showed that the essential oil was 31.8 times more toxic *in vitro* to *Schistosoma mansoni* than to the cell line (Soares et al., 2017).

3.1.1.2.3. Twigs

The twig essential oil showed repellent activity of 100% against stored pigeon seeds weevils *Callosobruchus chinensis* and *Callosobruchus maculatus* at 0.36 μL/mL-LD_{50}s were recorded with 0.8 μL and 2.5 μL of the oil, respectively. During *in vivo* evaluation, 0.29 and 0.58 μL/mL of the oil significantly enhanced feeding deterrence in insects and reduced the seed damage as well as weight loss of fumigated pigeon pea seeds up to 6 months of storage (Pandey et al., 2014).

3.2. Amaryllidaceae

3.2.1. *Allium cepa* L.

3.2.1.1. Traditional use

In west tropical Africa, the clove (Fig. 3) is used in general healing, in blood disorders, as laxative, against swellings, oedema, malnutrition, debility, and as antidote for venomous stings and bites (Burkill, 1985).

Common names

Agnoussi (Bafang) Agnoss (Beti) Onion, spring onion (English), oignon, ognon, siboule (French), Zwiebel (German).

Fig. 3. The photograph of *Allium cepa* L brum and red fruit.

Common names

Agnoussi lail (Bafang) garlic (English), ail (French), Knoblauch (German).

Fig. 4. The photograph of fruit of *Allium sativum* L..

3.2.1.2. Bioactivities

3.2.1.2.1. Bulbs

The red bulbs essential oil was tested for antioxidant activity by ferric reducing antioxidant power (FRAP) assay; DPPH radical scavenging assay (RSA); and anti-inflammatory activity by anti-denaturation of bovine serum albumin method, resulting in activities of 2.75 μg AAE/mg; SC_{50}=0.20 μg/mL compared to ascorbic acid with 1.98 μg/mL; and IC_{50}=44.31 μg/mL compared to sodium diclofenac with 104.44 μg/mL, respectively (Ndoye et al., 2016).

3.2.2. *Allium sativum* L.

3.2.2.1. Traditional use

In west tropical Africa, the clove (Fig. 4) is used against blood disorders, arthritis, rheumatism, pulmonary and stomach troubles and vermifuge as well as for cutaneous and subcutaneous infections, as febrifuge, against heart problems and for protection of arteries and veins (Burkill, 1985).

3.2.2.2. Bioactivities

3.2.2.2.1. Bulbs

Interestingly, the garlic bulb essential oil components diallyl sulphide and diallyl disulphide showed protective action against methicillin resistant *Staphylococcus aureus* infection in mouse experiment: Mice injected with 200 μL of *Staphylococcus aureus*-PBS solution were treated with diallyl sulphide at 10% and 5% or diallyl disulphide at 1% and 0.5%. As a result, it was shown that

Common names

Wild custard apple, African custard apple (English), pomme chanelle de brousse, pomme chanelle du Sénégal, annone (French), danga, daga, dagan, dahen (West Africa), falo (Bamileke, Cameroon).

Fig. 5. The photograph of *Annona senegalensis* Pers.

the oral administration of diallyl sulphides significantly reduced both fibronectin and interleukin-6 levels that had risen, as well as the risen malondialdehyde level. In addition, these essential oil components showed antioxidant protection (Tsao et al., 2003). The red bulbs essential oil was tested for antioxidant activity by ferric reducing antioxidant power (FRAP) assay; DPPH radical scavenging assay (RSA); and in addition for anti-inflammatory activity by anti-denaturation of bovine serum albumin method. Activities were recorded with 5.33 µg AAE/mg; SC_{50}=0.19 µg/mL compared to ascorbic acid with 1.98 µg/mL; and IC_{50}=61.577 µg/mL compared to sodium diclofenac with 104.44 µg/mL, respectively (Ndoye et al., 2016).

3.2.2.2.2. Aerial parts

Furthermore, the aerial plant parts essential oil was tested against the bacterium *Staphylococcus aureus* ATCC 25923 by macro broth dilution method, giving an MIC of 15 µg/mL (Najafi et al., 2016).

3.3. Annonaceae

3.3.1. *Annona senegalensis* Pers.

3.3.1.1. Traditional use

The leaves (Fig. 5) are used to create a general health tonic and in the treatment of pneumonia. Bark can be processed to produce insecticides or medicine for treating worms parasitic on the intestines or flesh, notably Guinea worm.

The bark is as well used for the treatment of diarrhea, gastroenteritis, lung infections, toothaches and snakebites. Natural gum in the bark is used as a wound dressing. Roots are applied to treat dizziness, indigestion, chest colds and venereal diseases. Certain parts of the plant are used to treat skin or eye disorders. Furthermore, the leaves are applied against naso-pharyngeal affections, the bark against dysentery, as genital stimulant/depressant and against veneral diseases and leprosy, and the root against cholera, as lactation stimulant, as antidote after venomous stings and bites and for the treatment of insanity. In addition, bark and roots are used in general healing and as vermifuge, while young twigs, stem bark and root bark are applied in emetics, the twig and the bark as medicine against kidney problems and as diuretics, and the leaf and root as homeopatic preparation. The plant is further used for a medicinal preparation against pain (Burkill, 1985).

3.3.1.2. Bioactivities

3.3.1.2.1. Leaf

Various bioactivity studies have shown that the leaf essential oil possesses partly significant insecticidal activity against the crop weevils *Tribolium castaneum*, *Sitophilus zeamais* and *Sitophilus oryzae* with LD_{50} values of 163.63-433.88 µg/mL (Kouninki et al., 2007a, 2007b; Ngamo et al., 2007a, 2007b). The plant is applied traditionally against severe diseases, and it is suggested that this may be partly due to bioactive essential oil ingredients - further research is recommended here.

3.3.2. *Cananga odorata* (Lam.) Hook. F. & Thomson

3.3.2.1. Traditional use

In west tropical Africa, leaves (Fig. 6) are used as medicine for skin and mucosae, probably a traditional use overtaken from Malaya, where the plant is native and leaves are rubbed onto the skin for itch. In addition, the bark is applied in Java against scurf (Burkill, 1985). Its flower essential oil is largely used in cosmetic industries to produce products of high added value (Nyegue et al., 2017).

3.3.2.2. Bioactivities

3.3.2.2.1. Flower

The essential oil of the flower showed a value of MIC 25 mg/mL against *Salmonella typhimurium* clinical isolate, while the positive control gentamycin displayed 0.012 mg/mL. No activity was found as well against *Escherichia coli* ATCC 25922 and *Salmonella*

Common names

Ilang-ilang, yi-lan, perfume tree, Macassar oiltree, wooly-pine (English), Ylang-Ylangbaum (German), cadmia, cananga (Spanish).

Fig. 6. The photograph of leaves and flower *Cananga odorata* (Lam.) Hook. F. & Thomson.

Common names

Salt-and-oil-tree (English), nee-wahn-johr (Bassa, Cameroon).

Fig. 7. The photograph of fruits of *Cleistopholis patens* Engl. & Diels.

paratyphimurium clinical isolate (Nyegue et al., 2017). While the essential oil of the flower in micro dilution assay showed an MIC>4.0% against *Staphylococcus aureus* NCTC 6571 and *Escherichia coli* NCTC 10418, it completely inhibited the growth of *Candida albicans* ATCC 10231 at a concentration of 2.0% of the oil - however, positive and negative controls were not reported (Hammer et al., 1999).

3.3.3. *Cleistopholis patens* (Benth.) Engl. & Diels

3.3.3.1. Traditional use

Bark decoctions are taken to treat stomachache, diarrhoea, tuberculosis, bronchitis and hepatitis. Bark pulp is applied against swellings, oedema and whitlow, bark sap is dropped into the nose to treat headache and rubbed on to treat rickets in children (Burkill, 1985). The bark is said to yield water when cut-the Bassa (Cameroon) name means "tree which gushes water" in allusion to this (Cooper and Record, 1931). Leaf infusions or decoctions are administered against hepatitis, fever, trypanosomiasis, rheumatoid arthritis and as vermifuge (Fig. 7).

A leaf-infusion is taken against fever in Subsaharan countries, and sometimes with lemon grass, papaya or other plants against infective hepatitis (Irvine, 1961; Raponda-Walker and Sillans, 1961).The leaf is as well applied against liver problems and as febrifuge, and the root bark as vermifuge (Burkill, 1985).

Interestingly, stem bark and fruit essential oils from materials collected at the same sample site and the same day, display a very different main compound pattern: the **δ-cadinene (28.70%)** is main compound the stem bark essential oil while, in the fruit essential oil it is the **β-caryophyllene (27.54%)**. It is suggested that essential oils-together with non-oil secondary metabolites-are part of the plant´s defense system against plant pathogens or attractors of insects as pollinators, as well as regulators towards other environmental factors. In this regard, the example presented below shows that stem bark as well as leaves seem to have developed their own optimal strategical compound pattern (Table 2).

Table 2
Comparison of main oil components from stem bark and fruits of *Cleistopholis patens* (*Annonaceae*) collected during the dry season.

Sample location	**Mount Calla (Center region)**	
Essential oil component	**Stem bark**	**Leaves**
δ-Cadinene	**28.70%**	1.60%
α-Copaene	**16.90%**	1.12%
β-Caryophyllene	2.58%	**27.54%**
Germacrene D	3.80%	**16.14%**

3.3.3.2. Bioactivities

3.3.3.2.1. Stem bark

The essential oils of the stem bark and leaves showed antimalarial acitivity with IC_{50} of 9.19 and 15.19 μg/mL, respectively, against the chloroquine resistant *Plasmodium falciparum* W2 strain (Boyom et al., 2011). For a crude oil, this activity is remarkable, correlating with the traditional use of crushed bark in Uganda for preparations to treat malaria as reported above. δ-Cadinene and α-copaene are main active oil components, with higher amounts in the stem bark oil obviously resulting in its higher antiplasmodial activity compared to the leaf oil. However, toxicological *in vivo* studies will be needed before recommendation for further medicinal use can be given.

3.3.4. *Hexalobus crispiflorus* A. Rich.

3.3.4.1. Traditional use

The inner bark (Fig. 8) is used as a masticatory together with kola nut. A decoction of the twig bark is drunk as emetic and purgative.

In Cameroon, the bark is stripped off from young trees and applied to treat gonorrhea and syphilis (Le Thomas, 1969). In Subsaharan countries, a macerate of the bark is taken against malaria and venereal diseases (Raponda-Walker, 1952; Raponda-Walker and Sillans, 1961). Freshly pulped bark is applied as a wet dressing on wounds, buboes and furuncles (Bouquet, 1969).

3.3.4.2. Bioactivities

3.3.4.2.1. Stem bark

Common names

Evota (Baka, Cameroon), Pouta (Baya, Cameroon).

Fig. 8. The photograph of fruits of *Hexalobus crispiflorus* A. Rich..

Common names

Ntom (Yaoundé, Cameroon), ntouma, ineton (Western Africa).

Fig. 9. The photograph of fruits of *Duguetia confinis* (Engl. and Diels) Chatrou.

Common names

African nutmeg, false nutmeg, calabash nutmeg (English), fausse noix muscade, muscadier de calabash (French), Kalabassenmuskat (German).

Fig. 10. The photograph of flower, fruits and seeds of *Monodora myristica* (Gaertn.) Dunal.

The essential oil of the stem bark displayed antimalarial activity against the chloroquine resistant *Plasmodium falciparum* W2 with an IC_{50} of 2.0 μg/mL (Boyom et al., 2003). This very significant antiplasmodial activity of the stem bark essential oil corresponds with respective traditional use reported above from Cameroon. Also here, like for the stem bark of *Cleistopholis patens* (Annonaceae), α-copaene as main essential oil ingredient might be discussed as important factor controlling this activity. Follow up by *in vivo* toxicity studies will be needed to guarantee safe application in traditional medicine.

3.3.5. *Duguetia confinis* (Engl. and Diels) Chatrou

3.3.5.1. Traditional use

A decoction or maceration of the stem bark (Fig. 9) is used in Cameroon against body lice (Le Thomas, 1969).

3.3.5.2. Bioactivities

3.3.5.2.1. Stem bark

The stem bark essential oil displayed antimalarial activity against the chloroquine resistant *Plasmodium falciparum* W2 with an IC_{50} of 16.6 μg/mL (Boyom et al., 2003).

In addition, it would be of interest to validate the activity of the stem bark essential oil against body lice - as reported from Cameroon - by toxicity assays employing lice of this species.

3.3.6. *Monodora myristica* (Gaertn.) Dunal

3.3.6.1. Traditional use

The plant (Fig. 10) is used in Cameroon as a stimulant, stomachic, against headaches, sores and as insect repellent.

The bark is used to treat stomachaches, constipation, Guinea worm infection, febrile pains, eye diseases and hemorrhoids (Kerharo and Adam, 1974; Weiss, 2002). Interestingly, the preparation of a collyrium for treating filaria in the eye is recorded from Cameroon where the bark is also used in a vapor bath to relieve febrile lumbago, while the juice is expressed from it to paint over itch (Bouquet, 1969). Furthermore, the bark is applied against cutaneous and subcutaneous parasitic infections, as fabrifuge and against arthritis as well as rheumatism, while seeds are used for general healing, against naso-pharyngeal affections and as anti-emetic (Burkill, 1985). Ground to a powder, the seeds may be taken as a stimulant or stomachic or to relieve constipation, while the powder may be sprinkled on sores, especially those caused by the Guinea worm or the powder may be fried and made up into oily pomade (Dalziel and Hutchinson, 1937; Oliver, 1960; Raponda-Walker and Sillans, 1961). Dusting or application of the pomade is used to disinfect from fleas and lice (Raponda-Walker, 1953; Raponda-Walker and Sillans, 1961; Irvine, 1961). The seeds chewed up are applied to the forehead for headache (Dalziel and Hutchinson, 1937) and against migraine in Gabon (Raponda-Walker, 1953; Raponda-Walker and Sillans, 1961). They are as well used against naso-pharyngeal affections or loss of voice, applied on sores, or eaten as an anti-emetic in Congo (Bouquet, 1969).

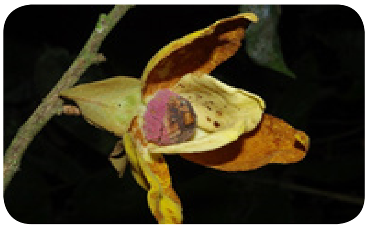
3.3.6.2. Bioactivities

3.3.6.2.1. Fruit

The fruit essential oil displayed very significant activity on breast cancer MCF-7 cells with an IC_{50} of 0.265 μL/mL, while on normal ARPE-19 cells it showed an IC_{50} 1.266 μL/mL, expressing a selectivity index (SI) of 4.777 (Bakarnga-Via et al., 2014). Thus, this is worth to be followed up as a probable new crude drug for developing countries, subject to *in vivo* toxicity studies to guarantee safe application. α-phellandrene (67.1%) might be discussed and tested as main oil ingredient causing this activity. It should be noted that traditional antimalarial use of this oil had not been reported before.

3.3.6.2.2. Seeds

No antifungal activity of the seed essential oil against the plant pathogen fungi *Aspergillus flavus*, *A.*



Common names

Nvuma (Cameroon).

Fig. 11. The photograph of flower of *Uvariastrum pierreanum* Engl. & Diels.

Table 3
Comparison of main oil components (in bold) from stem bark and leaves of *Uvariastrum pierreanum* (*Annonaceae*) collected during the dry period.

Sample location	**Mount Calla (Center region)**	
Main essential oil compounds	**Stem bark**	**Leaves**
β-Bisabolene	**28.20%**	4.30%
α-Bisabolol	**11.50%**	4.56%
β-Pinene	-	**23.00%**
α-Pinene	-	**22.80%**

fumigatus and *Fusarium moniliforme* was reported - at 500 ppm, the mycelial growth of these strains was not suppressed (Nguefack et al., 2004a).

Due to the high use of seeds in traditional medicine against various conditions, further laboratory testing of the seed oil may be considered.

3.3.7. *Uvariastrum pierreanum* Engl. & Diels

3.3.7.1. Traditional use

The wood is hard and sometimes used for making guns in West Africa (Burkill, 1985; Irvine, 1961).

Like above already reported and discussed for stem bark and leaves (Fig. 11) of *Cleistopholis patens* (Annonaceae), *Uvariastrum pierreanum* as well shows very different main essential oil composition for stem bark and leaf oil collected at the same place and the same day.

The main compound in the stem bark oil is β-bisabolene and in the leaf oil is β-pinene. It should be noted that the major constituents of the stem bark are not even found in trace in the leaves, this could be due to the differences in the expression levels of unigenes between the leaves and stem barks (Table 3).

3.3.7.2. Bioactivities

3.3.7.2.1. Stem bark & leaf

It was shown that stem bark and leaf essential oil both display antimalarial activity *in vitro* with IC_{50} of 6.08 and 13.96 µg/mL, respectively, against *Plasmodium falciparum* strain W2 (Boyom et al., 2011). The stem bark oil activity is remarcable, however had not been reported from traditional use. *in vivo* toxicity studies should be carried out before a recommendation for medical application can be given.

Common names

Ethiopian pepper, Guinea pepper, Ethiopian pepper, spice tree (English), fausse maniguette, pimont noir de Guinée, poivre de Guinée, poivrier de Etiopie, poivrier de Guinée, poivrier de Sédhiou, poivrier negre (French).

Fig. 12. The photograph of fruits of *Xylopia aethiopica* (Dunal) A. Rich..

3.3.8. *Xylopia aethiopica* (Dunal) A. Rich.

3.3.8.1. Traditional use

The fruit (Fig. 12) is used for the treatment of a cough, stomach ache, dizziness, amenorrhea, bronchitis, dysentery, headache, neuralgia, as carminative, against female sterility, as purgative ad against biliousness and skin infections (Okwu, 2001).

For the treatment of malaria, a decoction is prepared from a teaspoon of bark crushed in a liter of water and then drank. For the treatment of fevers, the same procedure is applied to the dry fruit (Tsabang et al., 2012). Furthermore, an infusion of the bark or fruit is taken in the treatment of bronchitis and dysenteric conditions, and as a mouthwash to treat toothache. The bark, when steeped in palm wine, is applied to treat asthma, stomachaches and rheumatism. Fruits are used in Cameroon as a cough remedy, to relieve flatulence, as a post-partum tonic, against stomach ache, bronchitis, dysentery and fever (Faulkner et al., 1985; Nguefack et al., 2004b; Bakarnga-Via et al., 2014; Iwu, 2014). In Subsaharan countries, a fruit-extract or decoction of the bark, as of the fruit, is applied against bronchitis, dysentery and biliousness (Dalziel and Hutchinson, 1937) as well as against febrile pains (Bouquet and Debray, 1974). In Gabon, a decoction of the leaves is applied against rheumatism and as an emetic (Raponda-Walker, 1953). Powdered leaves are taken as snuff for headaches, and used in friction on the chest against bronchitis and pneumonia. The leaf-sap mixed with kola nut (Malvaceae) is given at the time of epileptic fits, and suitable prayers and offerings must be made (Bouquet, 1969). Fruits are often incorporated in preparations for enemas and external uses calling on its revulsive properties for pains in the chest, sides

Table 4
Comparison of main oil components (in bold) from fruits and stem bark of *Xylopia aethiopica* (*Annonaceae*) collected during the raining period across the country.

Sampling location	**Kribi (South)**	**Yaounde (Center)**	**Mbitom (North)**	**Ngaoundéré (Far North)**	**Yaoundé (Center)**
Source of oil			**Fruit**		**Stem bark**
Collector	Bakanga-Via et al., 2014	Gardini et al., 2009	Nguemtchouin et al., 2010	Tatsadieu et al., 2010	Boyom et al., 2003
Month of harvest	March	not reported	July	March	April
Main oil components:					
β-Pinene	**28.20%**	**37.80%**	**27.90%**	**12.90%**	**10.07%**
Terpinen-4-ol	**15.10%**	-	5.13%	**8,90%**	0.49%
Sabinene	4.00%	-	**23.90%**	-	0.46%
α-Pinene	10.80%	**18,44%**	11.10%	1,70%	4.05%
Myrthenol	-	**-**	0.10%	-	**6.40%**

and ribs (Cooper and Record, 1931). It was accordingly deemed to have abortifacient properties (Easmon, 1891). Crushed fruits are rubbed on the forehead for headache and neuralgia, or a poultice of leaves and fruit may be applied, and an extract of the seeds is also taken as a vermifuge for roundworms and as an emetic for biliousness (Dalziel and Hutchinson, 1937).

When comparing main essential oil components from fruits of the plant collected along a geographical line stretching from Kribi (south region, rain forest), Yaoundé (center region, rain forest), Mbitom (Adamaoua region, savannah) to Ngaoundéré (Adamaoua region, savannah) in the North across 1100 km and two climate zones, the most abundant oil component reported for all fruit samples is **β-pinene**. The occurrence of **β-pinene** as the major compound in the fruits of *Xylopia aethiopica* collected in differents part of the country could be due to the presence of the constitutive genes that influence phenotypic characteristics of the plant. The differences in composition of compounds in the fruits and stem bark essential oils of *Xylopia aethiopica* from different region could be attributed to different expression levels of genes that confer the biosynthesis of various plant secondary metabolites. The secondary metabolites vary greatly across physical and biotic environments due to local adaptation, genotypic sorting and selection across habitats (Table 4).

3.3.8.2. Bioactivities

3.3.8.2.1. Stem bark

The essential oil of the stem bark displayed antimalarial activity against *Plasmodium falciparum* W2 with an IC_{50} of 17.8 µg/mL (Boyom et al., 2003), which can be correlated with traditional antimalarial use in Cameroon, where a teaspoon of bark crused in a liter of water is applied for malaria treatment. However, toxicological studies might be carried out before this leaf oil / leaf is recommended for further use.

3.3.8.2.2. Fruit

The fruit essential oil displayed cytotoxicity against the human breast cancer MCF-7 cell line with IC_{50}=0.600 µL/mL, compared to the IC_{50} of 0.825 µL/mL of normal cells, leading to a very low selectivity index (SI) of 1.375 (Bakarnga-Via et al., 2014). Furthermore, it revealed potent antifungal activity against the plant pathogen fungus *Aspergillus flavus* and insecticidal activity against the maize weevil *Sitophilus zeamais* in two weeks storage at a dose of 300 ppm (Tatsadjieu et al., 2010). In addition, the fruit oil significantly inhibited the food-born bacterium *Listeria monocytogenes* Scott A: at a concentration of 300 ppm, the oil increased three times the detection time (DT) of this species, while at 600 ppm, there was a four-fold increase of DT; in addition, the food-born bacterium *Staphylococcus aureus* SR231 showed a three-fold DT increase at 300 ppm, and *Salmonella enteritidis* 155A an increase lower than 50% at 600 ppm (Gardini et al., 2009). Use of the fruit oil against food spoiling bacteria had been reported from traditional use. However, toxicological assays will be needed before this oil can be recommended as food additive. Furthermore, the fruit essential oil displayed an LD_{50} value of 244.75% against the red flour weevil *Tribolium castaneum* (Ngamo et al., 2007a); a reduction rate of *T. castanenum nymphosis* of 25% compared to the negative control displaying 8% after 14 days of incubation was observed (Kouninki et al., 2005); and an ingestion assay found an LD_{50} of 83.19% after 96 hours of exposure to the maize grain weevil *Sitophilus zeamais*, while contact assays using oil-maize mixtures in plastic flasks displayed LD_{50} of 45.59 % after 4 minutes of exposure (Ousman et al., 2007).

The fruits essential oil of *Xylopia aethiopica* showed activity against four microorganisms and cytotoxicity to carcinoma cell line Hep-2 cell at 5 mg/mL concentration (Asekun and Adeniyi, 2004). The fruit essential displayed MICs of 3000 ppm against *Aspergillus niger* and *Fusarium oxysporium* and 4000 ppm against *Aspergillus flavus*, *Aspergillus fumigatus* and *Aspergillus versicolor*, which is low activity (Tegang et al., 2017).

3.3.8.2.3. Leaf

At a dose of 300 ppm, the leaf essential oil resulted in 75% nymphosis of the red flour weevil Tribolium castaneum after 14 days, compared to the negative control displaying 92% nymphosis (Kouninki et al., 2007a).

3.3.8.2.4. Fruit & Fibre

In a toxicity assay against the maize weevil *Sitophilus zeamais*, main terpenic compounds of the whole-fruit extract and the fibre led to mortalities of 100% for both parts of the plant after 24 h of exposure to 1 mL of oil/100 g of maize seeds. When testing main compounds α-pinene, β-pinene, δ-3-carene and terpinene-4-ol at 0.10, 0.38, 0.03 and 0.05 mL/100g, mortalities were 0.0, 50, 0.0 and 2%, respectively, for the whole fruit essential oil and 2.0 10.0, 0.0 and 50% for the fibre. Most interestingly, a mixture of main terpenic compounds α-pinene + β-pinene + δ-3 carene + terpinene-4-ol at 0.56 mL/100 g for the whole fruit essential oil and at 0.42 mL/100 g for the fibre displayed 98 and 96% mortality, respectively, indicating here strong synergistic effects of main oil components (Kouninki et al., 2007b).

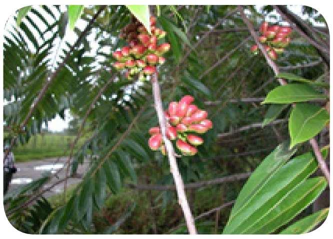
3.3.8.2.5. Seeds

The essential oil of the seeds was assayed by micro dilution method employing bacterial strains of *Escherichia coli* ATCC 25922, *Salmonella typhimurium* and *Salmonella paratyphimurium*, the latter two being clinical isolates identified at the Centre Pasteur du Cameroun and Yaoundé Central Hospital. MICs were recorded with 6.25, 6.25 and 25 mg/mL, compared to the positive control gentamycin giving MICs of 0.003, 0.012 and 0.006 mg/mL, which is low active (Nyegue et al., 2017). It should be noted that the use of powdered root in local treatment of cancer in Nigeria might be followed up by appropriate cell line assays.

Common names

Fondé des rivières (French).

Fig. 13. The photograph of fruits of *Xylopia parviflora* Spruce.



Common names

Odjobbo (Bulu, Cameroon).

Fig. 14. The photograph of fruits of *Xylopia phloiodora* Mildbr..

3.3.9. *Xylopia parviflora* Spruce

3.3.9.1. Traditional use

The fruit (Fig. 13) is applied against stomach disorders, barrenness, headache relief and as analgesic and antispasmodic (Nishiyama et al., 2010), while in other Western African countries the leaves and roots are used against nasopharyngeal affections and stem bark and fruit for skin and mucosa (Burkill, 1985; Malcolm and Sofowora, 1969).

3.3.9.2. Bioactivities

3.3.9.2.1. Fruit

The fruit essential oil displayed extremely high activity against breast cancer cell line MCF-7, with an IC_{50} of 0.166 µg/mL, while on normal cell line ARPE-19 it showed an IC_{50} of 0.920 µg/mL, expressing an SI of 5.542 (Bakarnga-Via et al., 2014) This activity is even stronger than against *Monodora myristica* (Annonaceae) reported above - and worth to be further investigated as a probable new crude drug for developing countries, subject to further toxicity studies to guarantee safe application. Notably, traditional anticancer use of this oil in Cameroonm had not been reported before.

3.3.10. *Xylopia phloiodora* Mildbr.

3.3.10.1. Traditional use

In Cameroon, the plant (Fig. 14) is traditionally claimed to heal hepatitis (Moundipa et al., 2007).

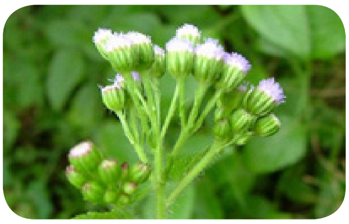
3.3.10.2. Bioactivities

3.3.10.2.1. Stem bark

The essential oil of the stem bark was assayed for antimalarial activity against the chloroquine resistant *Plasmodium falciparum* W2. Above 0.6 mg/mL, the extract showed toxicity against erythrocytes, however, antiplasmodial activity was seen at much lower concentration with an IC_{50} of 17.9 µg/mL (Boyom et al., 2003).

3.4. Asteraceae

3.4.1. *Ageratum conyzoides* (L.) L.



Common names

Goat weed, billy goat weed (English), roi des herbes (French), ewudu a nji (Douala, Cameroon).

Fig. 15. The photograph of flower of *Ageratum conyzoides* (L.) L..

3.4.1.1. Traditional use

The leaves are used in Cameroon to treat conjunctivitis, ophthalmia, headache and otitis, while the juice is reported to have analgesic properties (Bouda et al., 2001). In Subsaharan countries, leaf (Fig. 15) sap is used as ear drops for deafness and orally against cough, stomach ache, tachycardia and baked in palm oil are used for rheumatism, its also given as a sedative and pain killer during pregnancy (Bouquet, 1969; Raponda-Walker, 1953; Raponda-Walker and Sillans, 1961). A decoction is used for toothache (Bouquet, 1969).

An infusion is taken in Subsaharan countries for blennorrhoea (Raponda-Walker, 1953). While the roots are chewed for indigestion and abdominal pains (Bally, 1937; Watt and Breyer-Brandwijk, 1962).

3.4.1.2. Bioactivities

3.4.1.2.1. Leaf

The leaf essential oil delivered mortality of the maize grain weevil *Sitophilus zeamais* in a feeding experiment with an LD_{50} of 0.09 % in 24 hours (Bouda et al., 2001), which is very significant and might indicate potential of the leaf oil for future eco friendly agricultural application. Interestingly, leaves find wide application in traditional Subsaharan plant medicine, and it is suggested that part of this effectivity is caused by bioactive essential oil ingredients. Research is recommended concerning validation of the leaf´s activity against rheumatism, river blindness, gonorrhea as well as blennorrhoea, which is an inflammation of the conjunctiva and the eyelids, usually caused by the plant *Phormium tenax* (Xanthorrhoeaceae) used in traditional medicine as well.

3.4.1.2.2. Entire plant

The entire plant essential oil was submitted to macro dilution assay employing the spore forming bacteria *Bacillus cereus* T, *Bacillus megaterium* 8174, *Bacillus subtilis* NCTC 3610 and *Geobacillus stearothermophilus* CNCH 5781. It should be noted that, since bacteria spores are very resistant to physical and chemical agents, they can remain in food after sterilization (Aouadhi et al., 2013). MICs of 1.25, 2.5, 0.312 and 1.25 mg/mL, repectively, for inhibition of bacterial growth, and 0.37, 0.009 and 0.09 mg/mL for inhibition of spore germination of the first three bacteria, while for *Geobacillus stearothermophilus*, an MIC was not recorded (Voundi et al., 2015).

Common names

Garden ageratum (English).

Fig. 16. The photograph of flower of *Ageratum houstonianum* Mill..

3.4.2. *Ageratum houstonianum* Mill.

3.4.2.1. Traditional use

In western Africa, the herb (Fig. 16) is used as an antiphlogiostic, to relieve sweelling and pain in the throat, while a leaf paste is applied to cure allopecia. Moreove, a leaf paste mixed with lime is applied on deep cuts (Quattrocchi, 2013).

3.4.2.2. Bioactivities

3.4.2.2.1. Flower

The flower essential oil delivered an LD_{50} of 0.07 µL/cm^2 measured by filter paper assay in petri dishes after one day of exposure of ticks of the species *Rhipicephalus lunulatus* (Tedonkeng et al., 2004b). It should be noted that the flower essential oil impresses with a huge amount of demethoxy ageratochromene (Precocene I) and ageratochromene (Precocene II), compounds that were not recorded from any other essential oil from the Cameroonian rain forest.

3.4.2.2.2. Leaf

In addition, filter papers soaked with soap and various concentrations of the leaf essential oil were exposed to the parasite *Rhipicephalus lunulatus*. The preparation was applied on infected goats, and the mortality of ticks over time was recorded, delivering an LD_{50} of 0.0259 g/g for *in vitro* and 0.0173 g/g for *in vivo* application (Tedonkeng et al., 2005).

3.4.3. *Bidens pilosa* L.

3.4.3.1. Traditional use

In Northern Cameroon, leaves (Fig. 17) are used as

Common names

Black jack, black fellows (English), sornet (French).

Fig. 17. The photograph of flower of *Bidens pilosa* L..

protectant of stored grains (Goudoum et al., 2016).

The leaf is taken against nasopharyngeal affections, diarrhea and dysentery and as vermifuge, against liver problems and hemorrhoids. The flower is applied against pulmonary troubles and diarrhea, dysentery and as vermifuge (Burkill, 1985). The plant-sap with or without the addition of pepper is used in the ear for ear ache, and alone in the eye for conjunctivitis and as a styptic to arrest bleeding (Ainslie, 1937; Dalziel and Hutchinson, 1937; Irvine, 1961). Seeds are used as pain killer and sedative, while the sap finds application in cutaneous and subcutaneous parasitic infections, as abortifaciens and antidote for venomous stings and bites (Burkill, 1985).

4.4.3.2. Bioactivities

4.4.3.2.1. Leaf

The leaf essential oil was submitted to antioxidant assays of scavenging ability on 1,1-diphenyl-2-picrylhydrazyl radical (DPPH), reducing power determination and β-carotene-linoleate model system, displaying changes within 2 weeks of exposure of the oil at 20 mg/mL to sunlight from 77.4 to 18.69%, from 59.55 to 19.14% and from 91.88 to21.8%, respectively (Goudoum et al., 2016).

4.4.3.2.2. Leaf & flower

In DPPH free radical scavenging activity assay, the leaf and flower essential oils showed very similar activity with IC_{50}s of 47 and 50 µg/mL, respectively, whereas those of the synthetic butylhydroxytoluol (BHT) and the natural antioxidant α-tocopherol displayed 21 and 36 µg/mL, respectively. Furthermore, in an antibacterial assay carried out by agar diffusion method, the leaf and flower essential oils 400 µg/disc showed zones of inhibition of 12.7, 17.3, 19.0, 12.3, 13.7 and 125 mm for leaf oil and 8.7, 11.7, 11.2, 10.8, 20.3 and 13.7 mm for flower oil against ther bacteria *Micrococcus flavus*, *Bacillus subtilis*, *Bacillus cereus*, *Bacillus pumilus*, *Escherichia coli* and *Pseudomonus ovalis*, respectively, compared to amoxicillin at 30 µg/disc displaying 44.3, 28.3, 17.7, 29.7, 33.7 and 15.3 mm, respectively. Moreover, antifungal assays carried out by agar dilution method employing the plant pathogenic fungi *Corticum rolfsii* f.sp. Curzi, Roma N.S., *Fusarium solani* MAFF 237472 and *Fusarium oxysporum* Mormodiace, gave for the leaf essential oil at 100 ppm inhibition of mycel by 85.7, 68.2 and 74.9%, respectively, and at 250 ppm by 96.0, 77.9 and 87.9%, respectively, while the flower essential oil at 100 ppm displayed inhibition of mycel by 60.4, 89.2 and 86.9%, respectively, and at 250 ppm by 89.4, 98.0, and 94.9%, respectively (Deba et al., 2008).

3.4.4. *Chromolaena odorata* (L.).

3.4.4.1. Traditional use

The leaf (Fig. 18) decoction is used in Cameroon to treat asthma and as an antipyretic in children infected with chicken-pox (Kerharo and Adam, 1974; Sofowora, 1984; Raponda-Walker and Sillans, 1961).

3.4.4.2. Bioactivities

3.4.4.2.1. Leaf

The essential oil of the leaves was assayed for efficacy on the mortality of the maize grain weevil *Sitophilus zeamais*. Twenty seven days old adult weevils were fed on maize grains treated with concentrations of the leaf essential oil relative to the maize grains of 0.063, 0.125, 0.25 and 0.50% (v/w) in petri dishes. The mortality of *S. zeamais* increased with the concentration of the essential oil and the duration of exposure of the weevils, delivering a significant insect mortality with an LD_{50} of 6.78 % already after 24 hours (Bouda et al., 2001), which might be followed up regarding its value as eco friendly crop protection alternative. Traditional effectivity of the leaf essential oil against severe diseases like asthma and malaria might be validated by appropriate *in vitro* assays. Furthermore, in a toxicity assay employing the tic *Rhipicephalus lunulatus*, the leaf essential oil showed 100% mortality after six days of exposure at a concentration of 0,31 mL/cm^2 (Tedonkeng et al., 2004a).

Common names

Bokassa weed (Cameroon), Siam weed, Malay weed, Enugu plantation weed (English).

Fig. 18. The photograph of leaves of *Chromolaena odorata* (L.).

Common names

Globe thistle (English), ayilagwem, kahgoh, tsegem, soapte, kessa (Cameroon), Kugeldistel (German).

Fig. 19. The photograph of leaves of *Echinops giganteus* A. Rich..

3.4.5. *Echinops giganteus* A. Rich.
3.4.5.1. Traditional use

In Cameroon and Nigeria, roots are used for the treatment of heart and gastric troubles, to calm stomach ache, to give carminative help and reduce the effects of alcohol, and to reduce asthma attacks. In Cameroon, the roots, flowers and leaves (Fig. 19) are often harvested by the local people to treat many types of ailments such as yellow fever, abdominal pain, constipation, cough and menstrual pain. It could also treat respiratory problems, hernias, dental pain and general body pains. (Menut et al., 1997; Tene et al., 2004). In addition, the plant is employed to treat several diseases and parasites, as well as to control populations of arthropod pests (Adebayo et al., 1999; Ahua et al., 2007; Karunamoorthi and Hailu, 2014).

3.4.5.2. Bioactivities

3.4.5.2.1. Roots

The root essential oil was investigated by larvicidal toxicity assay using larvae of the filariasis and West Nile virus vector *Culex quinquefasciatus*. Tests resulted in LC_{50} of 227.4 µL/L. It should be noted that cameroonan-7-α-ol, present in above essential oil analysis with 7.1%, is the major contributor to the strong woody and patchouli-like smell of the root oil. Furthermore, the root essential oil was assayed against the parasite *Trypanosoma brucei* TC 221 causing African sleeping sickness, resulting in an IC_{50} of 10.50 µg/mL, compared to the positive control suramin with 0.0286 µg/mL. Toxocity in mouse embryonic fibroblast cell line Balb/3T3 was recorded very low with >100 µg/mL, leading to a favourable selectivity index (SI) of > 9.52 (Kamte et al., 2017).

Common names

Zo a gili (Cameroon).

Fig. 20. The photograph of flower of *Erigeron floribundus* (Kunth) Sch. Bip.

3.4.6. *Erigeron floribundus* (Kunth) Sch. Bip

3.4.6.1. Traditional use

In Cameroon, the plant is used for the treatment of angina, female infertility. The leaves are used along with those of *Bidens pilosa* (Asteraceae) and *Ageratum conyzoides* (Asteraceae) to treat malaria and jaundice. The decoction of leaves (Fig. 20) is also used in the treatment of dental pain and headache (Biholong, 1986).

In Subsaharan countries the plant is applied for treating ophthalmia, fever conditions with cramps and stiffness: the leaf sap is instilled into the nose or eyes and rubbed on the patient's thorax. Nasal drops are also given for vertigo, epilepsy and attacks of insanity and the leaves are made into cigarettes for inhalation against tuberculosis and asthma (Bouquet, 1969). The plant is recorded as a fever medicine in Tanganyika, where dried leaf-powder is as well used in the topical treatment of burns (Haerdi, 1964).

The main component from the leaf essential oil ((*E*)-2-lachnophyllum ester>β-caryophyllene>(*E*)-β-farnesene), and from the flower essential oil ((*E*)-β-farnesene>β-caryophyllene>germacrene) collected in

Table 5
Comparison of main oil components from leaves/flowers of *Erigeron floribundus* (Asteraceae) collected during the raining period in the Center and West province.

Main oil ingredients	Leaf			Flower		
	Bafoussam	Dschang	Yaoundé	Bafoussam	Dschang	Yaoundé
(*E*)-β-Farnesene	**14.6**	**16.5**	**15.5**	**22.3**	**23.3**	**24.1**
β-Caryophyllene	**14.7**	**8.5**	**16.6**	**20.1**	**17.3**	**19.1**
(*E*)-2-Lachnophyllum ester	**26.2**	**23.7**	**25.6**	4.2	3.4	3.1
Germacrene D	1.6	2.8	1.4	**10.2**	**10.1**	**11**

Yaoundé (center region), Bafoussam (west region) and Dschang (west region) are sensibly similar (Table 5). This is due to the presence of the constitutive genes that influence phenotypic characteristics of the plant. However, the differences in percentage of compounds is attributed to the variations in resources for growth including soil nutrients, soil moisture, light, atmospheric carbon dioxide and the presence or absence of enemies, competition or mutualists.

3.4.6.2. Bioactivities

3.4.6.2.1. Leaf & flower

Essential oils from plants collected at Dschang were tested for activity against the dermatophytes *Candida neoformans* IP8506, *Trichophyton mentagrophytes* IP 840 336 and *T. rubrum* IP 1400 delivering MICs of 8.5, < 12.5, and 12.5 µL/mL for the flower oil and <12.5, <12.5, and <12.5 µL/mL for the leaf oil; even at low concentrations of 1.25 µL/mL, the mycelial growth of all fungi was inhibited by more than 50%, indicating that these oils are fungistatic. Interestingly, both oils showed good activity against the dermatophyte *C. albicans* IP487 26 with an MIC of 2.25 µL/mL (Kuiate et al., 2005). It should be noted that this activity is significant, corresponding well to the traditional use of this plant for the treatment of skin disorders. Since leaves are applied for traditional treatment of severe diseases like malaria, tuberculosis and asthma, appropriate bioassays are recommended to further evaluate the biologic potential of the leaf oil as a possible carrier of these activities.

3.4.7. *Helichrysum cameroonense* Hutch. & Dalziel

3.4.7.1. Traditional use

The plant (Fig. 21) is used in Cameroon for the treatment of infectious diseases (Lembé et al., 2013). It has been reported that *Helichysum* species are used to relief abdominal pain, heart burn, cough, cold, wounds, female sterility, menstrual pain (Malolo et al., 2015).

Common names

The plant is confined to the Cameroonian Mountain and extending to the Bamumbou region-local names may be in use.

Fig. 21. The photograph of flower of *Helichrysum cameroonense* Hutch. & Dalziel.

Common names

Mba´a (Cammeroon, Aguambu and Bamumbu area).

Fig. 22. The photograph of flower of *Helichrysum cymosum* (L.) D. Don.

3.4.7.2. Bioactivities

3.4.7.2.1. Leaf

Assays were carried out by the dilution method on an agar medium against the yam rot fungus *Penecillium oxalicum* isolated and purified from infected yams tubers. The leaf essential oil showed 100% inhibition at 2.5 mg/mL, which is significantly better than amphotericine B® displaying a very slow increase of inhibitory activity of 85.4% to 87.9% from 0.312 mg/mL to 5 mg/mL (Tchoumbougnang et al., 2010). This result makes the leaf oil an alternative for small Cameroonian farmers in the treatment of infected yams tubers on an eco friendly basis. Knowledge about this activity should ideally be spread between Sub-Saharan farmers: since yam is a backbone food source, affordable bio control is urgently needed to fight harvest losses. It should be noted here that the other two *Heliochrysum* species presented below as well display significant activity in above assay, however are less potent than this species.

3.4.8. *Helichrysum cymosum* (L.) D. Don

3.4.8.1. Traditional use

In the Aguambu and Bamumbu area of Cameroon, the whole plant (Fig. 22) is burned and cold infusion of ashes taken orally against flatulence and weak bones (Focho et al., 2009). It should be noted that *Helichrysum* species are used to relief abdominal pain, heart burn, cough, cold, wounds, female sterility, menstrual pain (Malolo et al., 2015).

3.4.8.2. Bioactivities

3.4.8.2.1. Leaf

in vitro assays were carried out by the dilution method on agar medium against the yam rot fungus *Penicillium oxalicum* that had been isolated and purified from infected yams tubers. The leaf essential oil displayed 66% inhibition at 5 mg/mL, which is not much less active than amphotericine B® displaying a very

Common names

Mba´a (Cammeroon, Aguambu and Bamumbu area); it should be noted that although the local name used by the Mba´a is the same like for Helichrysum cymosum, plants are distinguishes concerning traditional medicinal application.

Fig. 23. The photograph of flower of *Helichrysum globosum* Sch.Bip..

slow increase of inhibition activity of 85.4% to 87.9% from 0.312 mg/mL to 5 mg/mL (Tchoumbougnang et al., 2010).

3.4.9. *Helichrysum globosum* Sch.Bip.

3.4.9.1. Traditional use

In the Aguambu and Bamumbu area, Cameroon, the whole plant (Fig. 23) is burnt to ashes and a cold infusion is taken orally against rickets, which is a softening of the bones in young children caused by impaired bone metabolism primarily due to inadequate levels of available phosphate, calcium, and vitamin D, or because of resorption of calcium. Furthermore, the ash is applied for the treatment of fractures (Focho et al., 2009).

3.4.9.2. Bioactivity

3.4.9.2.1. Leaf

The leaf oil displayed significant activity against the plant pathogen fungus *Penicillium oxalicum* with 54.7% inhibition at 2.5 mg/mL, while the positive control amphotericine B® displayed a very slow increase of inhibitory activity of 85.4% to 87.9% from 0.312 mg/mL to 5 mg/mL (Tchoumbougnang et al., 2010).

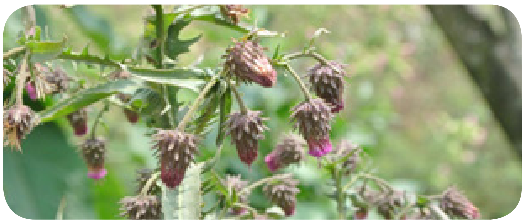
3.4.10. *Laggera pterodonta* (DC.) Sch. Bip.ex Oliv.

3.4.10.1. Traditional use

The local Cameroonian population reports the effectivity of this palnt (Fig. 24) in the struggle against mosquitoes (Nlôga et al., 2007).

3.4.10.2. Bioactivities

3.4.10.2.1. Leaf



Common names

Taba agbe (West, Cameroon).

Fig. 24. The photograph of flower of *Laggera pterodonta* (DC.) Sch. Bip.ex Oliv..

Common names

Angouma, okoum, mfumu (Cameroon), Gaboon mahogany (English), okoumé (French).

Fig. 25. The photograph of leaves of *Aucoumea klaineana* Pierre.

The leaf essential oil showed toxicity against the malaria vector Anopheles gambiae with LD_{50} of 12.5 μg/cm^2 after 8 hours of incubation (Nlôga et al., 2007) corresponding well with the reported traditional Cameroonian use against mosquitos. The reported activity might give a rational to further investigate this oil for application in eco friendly vector control.

3.5. Burseraceae

3.5.1. *Aucoumea klaineana* Pierre

3.5.1.1. Traditional use

In Sub Saharan countries, a decoction of the bark (Fig. 25) is used against colic, cough, chest pain, veneral diseases (Cameroon) and dysentery, and it is one of the ingredients found in insecticidal powders (Vivien and Faure, 1985).

The bark is as well used against diarrhea and in menstrual cycle problems (Burkill, 1985). It finds use in Gabonese hospitals for treating abscesses. Scrapings of the bark with seeds of maleguetta pepper and leaves of a bitter *Solanum* species (Solanaceae) are taken by girls at the commencement of puberty (Raponda-Walker and Sillans, 1961).

3.5.1.2. Bioactivities

3.5.1.2.1. Resin

Common names

Bòsao b´eyidi (Douala, Cameroon), Wotua (Kpe, Cameroon), Hehe (Kundu, Cameroon), African elemi, incense tree, bush candle tree, African Canarium, Canarium, white mahogany (English), elémier d´Afrique, elémi de Moahum, elémier du Gabon, elémi d´Ouganda for the gum resin (French).

Fig. 26. The photograph of fruits and seeds of *Canarium schweinfurthii* Engl..

The resin oil displayed antiradical and antioxidant activitieswith SC_{50}=23.7 g/L and SC_{50}=9.0 mg/L, respectively, compared to the positive control butylated hydroxytoluene® (BHT) with SC_{50}=0.007 g/L and SC_{50}=0.102 mg/L, respectively (Dongmo et al., 2010). Overall, the bioactivity *in vitro* received from the resin oil is rather not impressive, ranking it low in the list of essential oils recommended for further investigation.

3.5.1.2.2. Bark

The plant´s is applied in Subsaharan African medicine against veneral diseases, abscesses as well as in insecticidal powders, which might be followed up by laboratory assays.

3.5.2. *Canarium schweinfurthii* Engl.

3.5.2.1. Traditional use

In Cameroon, the bark (Fig. 26) is used for chancre (Dalziel and Hutchinson, 1937), which is a painless ulceration most commonly formed during the primary stage of syphilis.

In other Subsaharan countries, a decoction of the tree bark is used against colic, dysentery, to mature abscesses and in insecticidal powders (Vivien and Faure, 1985). The sap is taken together with cassava (Euphorbiaceae) for pulmonary affections. A decoction of the bark is taken against stomach complaints, food-poisoning and gynecological conditions requiring purging and emesis, it is also applied in a steam bath for the treatment of rheumatism (Bouquet, 1969).

3.5.2.2. Bioactivities

3.5.2.2.1. Resin

The resin oils from the localities Lolodorf / Mbouda displayed antiradical activity with SC_{50}s of 32.2 and 28.0 g/L, respectively, compared to the positive control BHT® showing 0.007 g/L. Antioxidant activity was measured with SC_{50} of 51.3 mg/L for the Lolodorf sample compared to the positive control BHT® with 0.102 mg/L, while the Mbouda sample was not active. In addition, the oil showed anti-inflammatory activity with an IC_{50} of 62.6 ppm for the Lolodorf sample compared to the positive control NDGA® with 0.66 ppm, while the Mbouda sample was also in this assay not active (Dongmo et al., 2010).

The traditional use of the root oil against adenitis and the bark oil against chancre may be investigated as probable carriers of the activities.

To give an overview on published data starting with the Amaranthaceae family up to Burseracea reviewed above, the following Table 5 composes findings concerning main essential oil compounds and their percentual contribution to the oil as reported from analyses, as well as bioactivity of essential oils and toxicity data resulting from laboratory assays carried out *in vitro* and *in vivo*.

Common names

Indian wormseed, sweet pigweed, Mexican tea, Jesuit's tea (English), anserine, herbe à vers (French).

Fig. 27. The photograph of *Chenopodium ambrosioides* L..

3.6. Chenopodiaceae

3.6.1. *Chenopodium ambrosioides* L.

3.6.1.1. Traditional use

In the past, *Chenopodium ambrosioides* (Fig. 27) and *C. anthelminticum* L., the former true American wormseed and the official source of *Chenopodium* oil, were seen as separate species but are currently united under the name *C. ambrosioides* (Burkill, 1985).

The Banso people of Bamenda, West Cameroon, boil the leaves and drink the water to treat stomach pains and the leaf sap is applied to oedemas and areas of local pain, and the aromatic smell is inhaled for the treatment of headache (Bouquet, 1969). Furthermore, an infusion prepared from the whole plant is used as febrifuge, against indigestion, as a laxative and for the treatment of cough and tuberculosis (Ainslie, 1937).

3.6.1.2. Bioactivities

Common names

Mexuican cypress, Portuguese cypress (English).

Fig. 28. The photograph of *Cupressus lusitanica* Mill.

3.6.1.2.1. Leaf

The leaf essential oil killed more than 60% of the wheat weevil *Sitophilus granarius* and the maize weevil *Sitophilus zeamais* two days after treatment at a dose of 0.4%, while a dosage of 6.4% induced 100% mortality. At concentrations, F^1 progeny production and adult emergence was completely inhibited. The dosage of 0.2 mL/cm^2 of grains killed 80-100% of the wheat weevil *Sitophilus granarius*, the bean weevils *Callosobruchus chinensis* and *Acanthoscelides obtectus*, the wheat weevil *Sitophilus granarius* and the maize and dried cassava weevil *Prostephanus truncatus* within 24 hours. For the cowpea weevil *Callosobruchus maculatus* and the maize weevil *Sitophilus zeamais*, 20% and 5% mortality, respectively, was induced at 0.2 mL/cm^2 (Tapondjou et al., 2002). Moreover, at a dose of 0.4% (mixed with grains), the leaf powder killed 92% of *C. maculatus* after 4 days of exposure, while the LD_{50} was 0.28% after two days (2.8g/kg of grains) and repellency was 97% on filter paper assay at a dose of 0.416 µL/cm^2 (Tapondjou et al., 2003). In addition, antifungal assays employing the dermatophytic fungi *Candida albicans* ATCC 9002, *C. albicans* ATCC 2091, *C. albicans* ATCC 1663, *C. glabrata*, *C. guilliermondi*, *C. krusei*, *C. lusitaneae*, *C. parapsilosis* and *C. tropicalis* revealed MICs between 0.50 and 2.0 mg/mL compared to the positive control nystatin® with MICs between 0.0005-0.002 mg/mL. Though this activity is rather low, treatment of vaginal candidiasis in mice experiment with essential oil from the aerial plant parts at 0.1%, 1% and 10% (w/v) led to complete healing within 12 days, as with nystatin® (Chekem et al., 2010) revealing the leaf oil to be an effective alternative to nystatin.

It should be noted that the essential oil is an irritant to the mucous membrane of the gastrointestinal tract, kidneys and liver. Overdoses of this oil have caused fatalities in both men and rats. The primary symptoms during an acute intoxication are gastrointestinal, such as gastroenteritis with diffuse hyperemia at first, followed by alterations in the Central Nervous System, such as headache, facial flushing, impaired vision, vertigo, incoordination and paresthesis (De Pascual et al., 1980). Furthermotre, since the whole plant and leaves are applied in Nigeria against tumours, this activity might be followed up by appropriate *in vitro* assays.

3.7. Cupressaceae

3.7.1. *Cupressus lusitanica* Mill.

3.7.1.1. Traditional use

The essential oil from the leaves (Fig. 28) is used in Cameroon to treat hemorrhoids, rheumatism, wooping cough and styptic problems (Brink, 2007).

The leaves are used in some areas of the Western Highlands of Cameroon traditionally to protect stored grains from insect infestation and also to cure skin diseases (Kuiate et al., 2006a; Teke et al., 2013).

3.7.1.2. Bioactivities

3.7.1.2.1. Leaf & fruit

The leaf and fruit oil of this plant displayed low to moderate antifungal and antibacterial activities *in vitro* (Kuiate et al., 2006a,2006b; Teke et al., 2013).

3.7.1.2.2. Leaf

An acute toxicity study of the leaf oil in Swiss mice showed for ≥ 4 g/kg uncontrolled movements and increasing respiratory rhythm, progressing with increase in dose. The oil provoked death of mice at 2 g/kg (0/6), 4 g/kg (1/6), 6 g/kg (2/6) and 8 g/kg (6/6) within a 48 hours observation period. The LD_{50} was determined with 6.33 g/kg bodyweight (Teke et al., 2013). As a consequence, the leaf essential oil should be applied with care, which concerns its application against hemorrhoids, rheumatism, wooping cough and styptic problems as reported for traditional Cameroonian use. Furthermore, it would be of interest to assay main essential oil compounds germacrene D, *epi*-zonarene and *cis*-calamenene in order to identify the source of the oil´s toxicity.

3.7.2. *Cupressus sempervirens* L.

3.7.2.1. Traditional use

The leaves (Fig. 29) are used by communities of the Western Highlands of Cameroon to protect stored grains from insect infestation (Tapondjou et al., 2000).

A decoction of the cones and leaves is used in a sitz bath three times a day for one week for hemorrhoids, while cones and leaves are used internally as an astringent. Externally, the extract is incorporated in preparations as ointment and suppository, and applied to treat varicose veins and venous circulation disorders. The essential oil is taken as antiseptic and antispasmodic for coughs (Rawat et al., 2010), and used

Common names

Mediterrean cypress, graveyard cypress, Italian cypress, pencil pine (English), cyprès commun, cyprès de Montpellier, cyprès de Provence, cyprès d'Italie, cyprès méditerranéen, cyprès ordinaire, cyprès pyramidal, cyprès sempervirent, cyprès toujours vert (French).

Fig. 29. The photograph of *Cupressus sempervirens* L..

as deodorant, diuretic, to promote venous circulation to the kidneys and bladder area, to improve bladder tone and adjuvant in the therapy of urinary incontinence and enuresis (Mahmood et al., 2013). Furthermore, for the treatment of blisters and boils, leaves are prepared as a paste and few drops of the juice of *Citrus medica* (Rutaceae) are added. Finally, dried leaves are burned as incense (Quattrocchi, 2013).

3.7.2.2. Bioactivities

3.7.2.2.1. Leaf

The leaf oil resulted in an LD_{50} of v0.84 and 0.74 µL/cm^2 when impregnated filter paper or coating into maize grains was exposed for three days to the maize grain weevil *Sitophilus zeamais* and the red flour beetle *Tribolium confusum*, repectively, In addition, the oil produced 100% reduction in adult emergence at a dose of 100 µL/40 g grain, and produced a stronger repellent activity than the oil ingredient *p*-cymene alone, which displayed LD_{50}s of 1.35 and 0.96 µL/cm^2, respectively, indicating a synergistic effect (Tapondjou et al., 2005). Furthermore, the maize weevil *Sitophilus zeamais* treated with the leaf essential oil showed an LC_{50} of 43.06 µL/kg of maize seeds; 92.98% reduction of F1 progeny at 200 µL/kg of maize seeds; and *in vitro* repellency of 55% in filter paper assay at 8 µL/kg. Due to the volatile nature of the oil, mortality was reduced to zero on day 14 post treatment. The leaf essential oil of this plant was suggested to be an alternative response to the use of synthetic pesticides that are not easily biodegradable, are biotoxic, promote the development of resistance in insects and are not usually available (Langsi et al., 2017).

3.7.2.2.2. Aerial parts

The MICs received by micro dilution assay employing *Bacillus subtilis* ATCC 6633, *Escherichia coli* ATCC 8739, *Klebsiella oxytoca* CECT 8207, *Morganella morganii* ATCC 25830, *Shigella* ATCC 29930 and *Vibrio cholerae* CECT 8265 were recorded with 250, 125, 125, 500, 125 and 062.5 µg/mL, respectively (Ben Nouri et al., 2015). In addition, micro dilution assay employing microbial strains of *Pseudomonas aeruginosa* ATCC 15442, *Escherichia coli* ATCC 10536, *Staphylococcus aureus* ATCC 6538, *Bacillus subtilis* ATCC 6633, *Halomonas elongate*, *Salmonella typhimurium* TA 97, *Enterococcus hirae* ATCC 10541, *Aspergillus niger* ATCC 16404, *Candida albicans* ATCC 10231 and *Trichoderma reesei* Rut C30 resulted in MICs of 0.62, 0.62, 0.15, 0.62, 0.62, 0.62, 0.15, 2.5, 0.15 and 0.62 µg/mL (Boukhris et al., 2012). The latter activities are remarkable; however, results still need to be verified against a positive control.

Common names

Aldrue, joined flat sedge (English), souchet articulé, souchet odorant, grand jonc (French).

Fig. 30. The photograph of *Cyperus articulatus* L..

3.8. Cyperaceae

3.8.1. *Cyperus articulatus* L.

3.8.1.1. Traditional use

In North Western Cameroon, roots and rhizomes of this plant (Fig. 30) are chopped, dried, boiled in water and taken as decoction for the treatment of onchocerciasis, called river blindness (Metuge et al., 2014a).

In other Subsaharan countries, the pulped root is rubbed into the skin for oedema and rheumatism, and onto the body of babies with fever (Bouquet, 1969), the rhizome is made into an application to the head for migraine (Raponda-Walker, 1953; Raponda-Walker and Sillans, 1961). A decoction is drunk for respiratory troubles (Bouquet, 1969). The root is held to be aphrodisiac, vermicidal and beneficial in menstrual affections (Bouquet, 1969). The taste is bitter and it is antiemetic and sedative, and is used to arrest vomiting in cases of yellow fever (Watt and Breyer-Brandwijk, 1962).

3.8.1.2. Bioactivities

3.8.1.2.1. Root & Rhizome

The root and rhizome essential oil was tested towards microfilariae, adult male worms, and adult female worms of the nematode *Onchoceras ochengi* as a model species for the human pathogen *Onchoceras volvulus* causing river blindness in Africa. IC_{50}s of 23.4, 23.4 and

31.25 µg/mL, respectively, were measured, while all worms died at 62.5, 62.5 and 125 µg/mL, respectively. Since assays against monkey kidney cells LLC-MK2 ATCC displayed low activity with an IC_{50} of 93.7 µg/mL, six were favourable with 4.0, 4.0 and 2.99, respectively. Furthermore, oral toxicity studies in mice with the root and rhizome oil showed no acute effects at 2000 mg/kg (Metuge et al., 2014a). The fraction AMJ1 containing mustakone as the major component and linoleic acid killed microfilariae and adult worms of *O. ochengi* in a dose dependent manner. The IC_{50} s for AMJ1 were 15.7 µg/mL for microfilariae, 17.4 µg/mL for adult male and 21.9 µg/mL for adult female worms, while linoleic acid gave 15.7, 31.0 and 44.2 µg/mL, respectively (Metuge et al., 2014b).

Bioassay results of the root and rhizome oil correlate with traditional use of chopped root and rhizome material in Cameroon and Nigeria. Assays towards *Onchoceras volvulus* itself would be here of interest.

3.9. Euphorbiaceae

3.9.1. *Euphorbia golondrina* L.C. Wheeler

3.9.1.1. Traditional use

Until recently, the plant (Fig. 31) has not been collected in Africa and was considered as absent from the continent.

During recent botanical explorations in Cameroon, it was collected from disturbed habitats. The white latex from the stem is employed as an ointment in the treatment of warts and painful swellings by the Mundani people of the mount Bambouto Caldera, South Western Cameroon (Ndam et al., 2015a,2015b).

3.9.1.2. Bioactivities

3.9.1.2.1. The leaf essential oil

The essential oil from the leaf of this plant was submitted to agar well diffusion assay revealing antibacterial activity with inhibition zone diameter of 20 mm against *Bacillus cereus* followed by *Staphylococcus aureus* with 17 mm and MICs of 0.01 and 2.5 mg/mL, respectively, compared to the positive control amoxicillin showing 35 and 32 mm, respectively, and MICs of < 0.01 mg/mL for both strains. For the yeast *Candida albicans*, the zone of inhibition was 21 mm and the MIC 0.01 mg/mL compared to the positive control amphotericin B with 22 mm and < 0.01 mg/mL, respectively, which was comparable. Activities are significant, taking into account that the essential oil was compared to pure compounds as positive controls. Furthermore, the ABTS scavenging activity was higher than that of gallic acid and BHT at concentrations greater than 0.1 and 0.2 mg/mL, respectively, while at all concentrations, nitric oxide scavenging activity was higher than those of both rutin and vitamin C (Ndam et al., 2016).

Common names

Boquillas sandmat, swallow spurge, Boquillas broomspurge, shrubby milkwort (English).

Fig. 31. The photograph of *Euphorbia golondrina* L.C. Wheeler.

3.10. Lamiaceae

3.10.1. *Hyptis spicigera* Lam.

3.10.1.1. Traditional use

The plant (Fig. 32) is traditionally used in Cameroon as an insecticide (Golob et al., 1999).

Infusions prepared with leaves are used to treat cough, bronchitis and headaches (Jirovetz et al., 2000). The leaf is recognized in Cameroon as a valuable bio-pesticide, because when mixed with grains - 3g of dried leaf powder for 1kg of grains -, it exhibits strong insecticidal and repellent activities against stored grains insects (Lambert et al., 1985). In the Ngamo and Mapongmetsem area of Northern Cameroon, the plant is used to protect cowpeas and sorghum against insect infestations (Noudjou et al., 2007), while local Cameroonian people report efficiency of the leaves against mosquitos (Nlôga et al., 2007). In western Africa, the leaf, inflorescence and seeds are used for general healing, while the seeds alone are applied as pain killer, for eye treatment and nasopharyngeal affections. Furthermore, the leaves are used against pulmonary troubles, and leaves together with flowers against diarrhea and dysentery as well as against cutaneous and subcutaneous parasitic infections. Furthermore, leaves are used in magic social ceremonies (Burkill, 1985).

The occurrence of common compounds from the

Common names

Black beni-seed, black sesam (English).

Fig. 32. The photograph of *Hyptis spicigera* Lam..

Table 6

Comparison of main essential oil components from the flower of *Hyptis spicigera* (Lamiaceae) collected at North Cameroonian sample sites during raining season/dry season.Center and West province.

Collection period 2006	**May**	**January**	**May**	**January**	**May**	**January**	**May**	**January**
Oil component	α-Pinene		α-Phellandrene		Terpinolene		β-Caryophyllene	
Guirviding	14.00%	↑↑27.10%	4.00%	↑↑22.50%	0.30%	↑ 0.90%	23.40%	↓↓10.80%
Kodeck	36.30%	↑39.60%	7.80%	↓ 1.90%	0.40%	↑↑15.20%	3.30%	↑ 6.10%
Lara	19.80%	↑↑42.10%	0.30%	↑ 4.40%	1.90%	↑ 4.50%	9.10%	↓ 4.90%
Touloum	31.70%	↓23.80%	6.70%	↑14.20%	1.10%	↑ 3.20%	2.80%	↑↑13.70%
Kaele	20.60%	↑↑34.80%	3.00%	↓ 0.20%	2.30%	↓ 2.10%	3.20%	↑11.70%
Tehecal-baila	27.80%	↓↓11.90%	1.30%	↓ 0.30%	2.20%	↑↑17.70%	12.30%	↓↓ 3.30%

↑↑ and ↓↓ = strongly rising / dropping value during dry season, compared to raining season.

flower of *Hyptis spicigera* collected from different populations in far north of Cameroon (Gurviding, Kodeck, Lara, Touloum, Kaele and Tehecal-baila) and in different months could be due to similar constitutive genes that influence phenotypic characteristics of the plant. All these compounds come from the biosynthesis that occur in plants (Table 6).

3.10.1.2. Bioactivities

3.10.1.2.1. Entire plant & flower

In a contact/inhalation assay, the entire plant essential oil showed an LD_{50} of 50.30 µg/mL against the rice weevil *Sitophilus oryzae* after 24 hours (Ngamo et al., 2007a), while a contact/inhalation assay with the flower essential oil gave LD_{50} values of 10.67 ppm against the first stage larvae of *Sitophilus zeamais*. Later stages of the insect were up to 120 fold less sensitive to the oil (Kouninki et al., 2005).

3.10.1.2.2. Flower

In a chronic toxicity assay with the flower essential oil at a dose of 2.5×10^{-2} mL/mL, five females maize grain weevil individuals of *Sitophilus zeamais* layed only two eggs compared to the same number of untreated individuals producing a total of 19 eggs within 10 days. Moreover, mean number of attacked maize grains was reduced from 37 in untreated grains to 17 after 100 days of rearing, indicating loss of appetite (Ngamo et al., 2007b). In another toxicity assay, the flower essential oil displayed an LD_{50} of 112.0 ppm against the rice weevil *Sitophilus oryzae*. LD_{50}s of 75.8 and 182.1 ppm were received for the combinations flower essential and flower essential oil *Ocimum americanum* (Lamiaceae) and leaf essential oil of *Vepris heteropylla* (Rutaceae), respectively, which is more activity than the expected values of 77.5 and 230.9, indicating synergistic effects (Ngassoum et al., 2007). The flower essential oil gave an LD_{50} of 210.67 ppm against the first stage larvae of the red flour beetle *Tribolium castaneum*, which was around 60% more active than old adults were (Kouninki et al., 2007a).

Thus, apart from the leaf already recognized in Cameroon as a valuable bio pesticide, the flower essential oil may be considered in Cameroon as well for this purpose, due to its significant effect against the maize grain weevil *Sitophilus zeamais*, the rice weevil *Sitophilus oryzae* and the red flour beetle *Tribolium castaneum*.

3.10.2. *Mentha piperita* L.

3.10.2.1. Traditional use

The plant (Fig. 33) is used in Western Africa for the treatment of nasopharyngeal affections, stomach troubles as well as for general healing (Burkill, 1985).

Herbalists consider the plant as an astringent, antipruritic, antispasmodic, antiemetic, carminative, analgesic, antimicrobial and a stimulant (Hoffman, 1996; Jiofack et al., 2010). It is widely used for treatment of loss of appetite, common cold, bronchitis, fever, nausea and vomiting (Barbalho et al., 2017).

3.10.2.2. Bioactivities

3.10.2.2.1. Leaf

The leaf essential oil displayed significant MICs

Common names

Peppermint (English), nana (Arabic).

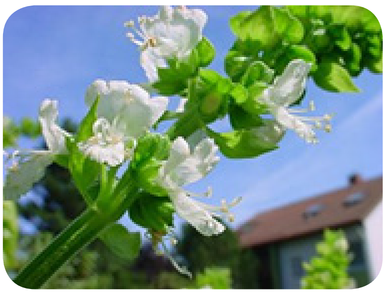
Fig. 33. The photograph of *Mentha piperita*.

towards isolates of the dermatophyte Trychophyton rubrum causing infection of nail and ringworm as well as *T. violaceus* and *T. soudanese* causing fungal infection of the hair with 2 μL/mg against each, while the positive control Ketoconazole® displayed an MIC of 0.128 μL/mL against all three species of Trychophyton. Further exploration of the leaf essential oil for the treatment of dermathophytosis was suggested (Nyegue et al., 2017). Intererstingly, the essential oil shows a huge amount of piperitone with 67% which might contribute to this activity.

3.10.2.2.2. Aerial parts

Furthermore, the essential oil of the aerial parts was subjected to disc diffusion assay against microbial strains of *Bacillus cereus* ATCC10876, *B. macerans* M58, *B. megaterium* M3, *B. subtilis* ATCC 6633, *B. abortus* A77, *B. cepacia* A255, *Enterococcus cloacae* ATCC13047, *E. faecalis* ATCC49452, *Listeria monocytogenes* ATCC15313, *Staphylococcus aureus* ATCC 25923, *Mucor flavus* ATCC 9341, *Staphylococcus epidermidis* A 233, *Clavibacter michiganense* A 277, *Streptococcus pyogenes* ATCC 176, *Acinetobacter baumannii* ATCC 19606, *Escherichia coli* ATCC 25922, *Klebsiella pneumoniae* ATCC 27853, *Pseudomonas mirabilis* ATCC 35659, *Salmonella typhimurium* ATCC 13311, *Citrobacter freundi* ATCC 13311, *Enterobactetr aerogenes* ATCC 13048, *Salmonella enteritides* I K27, *Proteus vulgaris* A 161, *P. syringae* A 35, and *Xanthomonas campestris* A 235 delivering MICs in the range of 0.5-3.5 μg/mL, the only exception being *X. campestris* A 235 displaying 80.0μg/mL in this assay. *Aspergillus alternaria* MNHN 843390, *A. flavus* MNHN 994294, *A. fumigatus* MNHN 566, *Candida albicans* ATCC 26790, *C. herbarum* MNHN 3369, *Fusarium oxysporum* MNHN 963917, *Aspergillus variecolor*, *F. acuminatum*, *F. solani*, *F. tabacinum*, *Monilinia fructicola*, *Rhizoctonia solani*, *Sclerotonia minor*, *S. selerotiorum*, *Trichophyton mentagrophytes* and *T. rubrum* displayed a broader activity range with MICs between 0.5 and 10 μg/mL, compared to the positive control amphotericin giving MIC values between 1.0 and 5.0 μg/mL (Reddy et al., 2017).

Essential oil, plant part unknown. In a flow cytometry assay employing *Leishmania panamensis* amastigotes, the essential oil displayed an EC_{50}<3 mg/mL, while it was shown to be not toxic to normal macrophages cell line U-937 in MTT assay (Robledo et al., 2017).



Common names

Camphor basil, African mint (English).

Fig. 34. The photograph of *Ocimum americanum*.

3.10.3. *Ocimum americanum* L.

3.10.3.1. Traditional use

Cameroonian people report efficiency of the leaves (Fig. 34) against mosquitos, and unspecified parts of the plant are used as insect repellent and insecticide (Mapi, 1988; Nlôga et al., 2007; Ntonga et al., 2014).

The leaf is used in west tropical Africa for a multitude of disorders, like pain, eye and ear problems, nasopharyngeal affections, disorders of the skin and mucosae, as well as for the treatment of diarrhea and dysentery. In addition, it is applied as vermifuge, for liver and kidney complaints, against cutaneous and subcutaneous parasitic infections and in addition as febrifuge, against malnutrition and debility, and as antidote against venomous stings and bites. The leaf oil is also used for the treatment of skin and mucosal disorders and cutaneous and subcutaneous parasitic infections (Burkill, 1985). The plant is used specially for lowering the blood glucose level and against cold, fever, parasitic infestations on the body and inflammation of joints and headaches (Ngassoum et al., 2004). Moreover, the leaf essential oil possesses antibacterial and insecticidal properties (Bassolé et al., 2003).

3.10.3.2. Bioactivities

3.10.3.2.1. Flower

The flower essential oil gave an LD_{50} of 42.9 ppm against the rice weevil *Sitophilus oryzae*, while the oil in combination with that of *Hyptis spicigera* (Lamiaceae) and *Vepris heteropylla* (Rutaceae) displayed 75.8 and 103.8 ppm respectively, which was higher active than the expected values of 77.5 and 196.0 ppm, respectively, indicating synergistic effects (Ngassoum et al., 2007).

3.10.3.2.2. Entire plant

Contact/inhalation assays with the entire plant essential oil employing the red flour weevil *Tribolium castaneum* gave an LD_{50} of 88.6 ppm after 24 hours of incubation (Ngamo et al., 2007a).

3.10.3.2.3. Leaf

The leaf oil displayed an LD_{50} of 11.95 μg/cm^2 in filter paper assay against adults of the malaria vector Anopheles gambiae, measured after 6 hours of incubation (Nlôga et al., 2007). Furthermore, larvae of A. gambiae showed 100% mortality at 400 ppm of the leaf oil (Tchoumbougnang et al., 2009). Activity

Common names

Sweet basil, hoary basil, American basil (English), basilic, herbe royale (French).

Fig. 35. The photograph of *Ocimum basilicum*.

against the yellow fever vector *Anopheles funestus* was recorded with LD_{50} 74.1 ppm towards the third stage larvae and 91.2 ppm towards the forth-stage larvae for the leaf oil. Moreover, the oil displayed an IC_{50} of 20.6 µg/mL against the chloroquine-resistant strain FcB_1/Colombia of *Plasmodium falciparum* (Ntonga et al., 2014). Moreover, antioxidant activity of the oil was reported with 49.3 mol/L measured by ferric reducing antioxidant power (FRAP method). It was suggested that this activity could be related to the presence of compounds such as eugenol, thymol and 1-8 cineole known for their antioxidant properties as reported by Misra et al. (2013). An antifungal assay employing agar incorporation method led to inhibition of mycelial growth of *Aspergillus flavus* by the leaf essential oil with 100% at 325 ppm. It was suggested that the observation might single out this oil for smoked stored fish preservation against *Aspergillus flavus* in Cameroon (Sameza et al., 2016). It should be noted that this activity correlates well with antifungal activity of its most abundant oil compound, 1,8-cineole, recorded with 76.5, 68.5, 68.3, 52.3, 71.1, 67.2, 80.0, 73.6, 73.2, 80.0, 89.9, 68.9 and 70.3% mycelial growth inhibition at 0.918 mg/mL of fungi isolated from chickpea seeds, namely *Absidia ramosa*, *Alternaria alternata*, *Aspergillus fumigatus*, *Aspergillus niger*, *Aspergillus oryzae*, *Chetomium* sp., *Dreschelera* sp., *Fusarium nivale*, *Fusarium oxysporum*, *Fusarium* sp., *Mucor* sp., *Penicillium citrinum* and *Trichoderma* sp., respectively, compared to the positive control nystatin with 40.0, 52.8, 41.7, 38.5, 56.7, 34.9, 58.3, 58.8, 40.2, 48.3, 58.6, 50.2 and 43.5% mycelial growth inhibition at 1.0 mg/mL, respectively. Moreover, 1,8-cineole completely inhibited aflatoxin B1 production of *Aspergillus flavus* NKD 208 at 0.918 mg/mL, whereas 121.7 mg mycelial weight was recorded at this concentration (Shukla et al., 2012). When tested for ovicidal effect against the malarial vector *Anopheles gambiae*; larvicidal effect against *Anopheles gambiae*; and against the dengue vector *Aedes aegypti*, LC_{50}s were recorded with 188.7, 258.5 and 301.6 ppm, respectively (Bassolé et al., 2003).

3.10.4. *Ocimum basilicum* L.

3.10.4.1. Traditional use

The plant (Fig. 35) is widely used in Cameroon as insect repellent (Ntonga et al., 2014). Furthermore, it is applied in general healing, against arthritis, rheumatism and for eye treatment, as well as against diarrhea and against liver problems and against cutaneous and subcutaneous parasitic infections, swellings and oedema.

In addition, the plant is used as abortifaciens, in menstrual cycle problems, as lactation stimulant as well as against paralysis, epilepsy, convulsions and spasms. The leaves are applied against ear troubles and nasopharyngeal affections, against malnutrition and debility, while the leaf-sap is used against stomach troubles (Burkill, 1985).

3.10.4.2. Bioactivities

3.10.4.2.1. Leaf

A toxicity assay with the leaf oil towards the third- and forth-stage larvae of the mosquito *Anopheles funestus*, the vector of yellow fever, was recorded with LD_{50}s of 131.8 and 144.5 ppm, respectively. The same extract displayed an IC_{50} of 21.0 µg/mL against the chloroquine-resistant *Plasmodium falciparum* strain FcB1/Colombia, the vector of severe malaria (Ntonga et al., 2014). It should be noted that this oil is not not been reported for traditional antimalaria use in Cameroon. However, the leaf oil displayed low antibacterial activity against food born bacteria *Listeria innocua*, *L. monocytogenes* and *Staphylococcus aureus* (Nguefack et al., 2004b). Furthermore, the oil was investigated for its ability as antioxidant protectant for the safe storage of crude palm oil at room temperature. For concentrations ranging from 1 to 10 mg/L, the antioxidant activity rose from 23.07 DPPH free radical to 92.20 and from 10.37 to 73.02%, respectively, from the first day to after one month of storage. This antioxidant activity may be useful in the conservation of vegetable oils intended for human consumption (Goudoum et al., 2017). While the ethanol crude extract and hexane fraction of the leaves presented MICs of 625 and 156 µg/mL, respectively, against *Cryptococcus neoformans* T444, a fungus that causes cryptococcosis affecting the central nervous system and having high levels of mortality, the leaf essential oil showed an MIC of 1250 µg/mL, compared to amphotericin B with 1.56 µg/mL. A synergistic effect was observed in the combination of amphotericin B and the ethanol crude extract, reducing their MICs from 1.56 to 0.099 µg/mL and 625 to 78 µg/mL, respectively. The combination of ethanol crude extract and leaf essential oil reduced the MICs from 625 to 39 µg/mL and 1250 to 157.2 µg/mL, respectively, and the combination of hexane fraction and leaf essential oil reduced the MICs from 156 to 20 and 1250 to 78.72 µg/mL, respectively. When amphotericin B was combined with 78 µg/mL of the hexane fraction, the MIC was reduced from 1.56 to 0.396 µg/mL. Furthermore, combinations of extracts and fractions - without the addition of amphotericin B - were able to reduce pigmentation, capsule size and ergosterol synthesis of *Cryptococcus neoformans* T444, which suggested important mechanisms of action (Cardoso et al., 2017). Furthermore, the oil was tested antioxidant, as well as antimicrobial, delivering MICs of 145, 160, 45, 40, 80 and 95 µg/mL against the bacteria *Salmonella typhi* PTCC 1609, *Escherichia coli* PTCC 1330/ATCC 8739, *Staphylococcus aureus* PTCC 1112/ATCC 6538, *Bacillus subtilis* PTCC 1023/ATCC 6633 and the fungi *Aspergillus niger* PTCC 5010/ATCC 9142 and *Candida albicans* PTCC 5027/ATCC 10231, respectively. In nasopharyngeal cancer cell line KB and hepatocellular carcinoma cell line HepG-2, IC_{50} were 45 and 40 µg/mL, respectively (Shirazi et al., 2014). Moreover, in an MIC assay employing strains of the bacterium *Vibrio gen*., the essential oil delivered MICs between 23 and 47 µg/mL. It was demonstrated that the oil can inhibit and eradicate mature biofilm formed on polystyrene surfaces even at low concentrations with high magnitude (Snoussi et al., 2016). Employing various strains of *Staphylococcus aureus* ATCC 25926/6538, strains of *Pseudomonas aeruginosa* ATCC 25853/9027 and 12 clinical isolates, MICs were determined for the oil with MICs between 512 and 1024 µg/mL, and 32 µg/mL for linalool against *Staphylococcus aureus* ATCC 25923, compared to the positive controls imipenem and ciprofloxacin giving 8 and 2 µg/mL, respectively. In addition, linalool showed an MIC of 32 µg/mL against *Pseudomonas aeruginosa* LAC-21-1, compared to the controls displaying each 2 µg/mL. However, the *Pseudomonas* strain was resistant to the essential oil itself (Silva et al., 2015). Finally, at a dose of 25 µL/vial, the leaf essential oil exposed to newly emerged cowpea beetles *Callosobruchus maculatus* for 12 h of fumigation, 80% mortality was recorded. Interestingly, the LD_{50} was 65 µL/g and the egg hatch rate was reduced to 3%, compared to the negative control showing 95%, while adult emerge was completely inhibited for 1g of kaolin powder aromatized with 30 µL of the oil. A follow up showed that in storage bioassays on infested seeds from which adults had been removed, complete protection was reached over 3 months with 400 µL oil/1g kaolin powder (Kéita et al., 2001).

3.10.4.2.2. Whole plant

The whole plant essential oil was low to moderately active against several potentially pathogenic yeasts, destructive and contaminant filamentous fungi and dermatomycosis agents (Zollo et al., 1998).

3.10.4.2.3. Leaf & stem

The combined essential oil of chopped leaves and stems was assayed against hepatocellular carcinoma cell line HepG2, human breast adenocarcinoma cell line MCF-7, human colon adenocarcinoma cell line $Caco_2$ and human leukemic monocytic cell line THP-1 using the sulforhodamine B assay. EC_{50}s were recorded with 180, 170, 71 and 670 µg/mL, respectively, compared to etoposide displaying 0.65, 1.67, 7.3 and 0.45 µg/mL, respectively (Fitsiou et al., 2016).

Common names

Ndali, lisepo (Bakundou), messep (Ewondo), masebi (Bassa), ose-mo-se (Bakossi) nkuwri (Bangwa), mahepo (Douala), ndoundo (Baya), tchâm (Medumba-Ndé), ossim (Boulou); fever plant, fever leaf, fever bush, tea bush, mosquito plant, thymol tree (English); menthe sauvage, basilic de Ceylan (French).

Fig. 36. The photograph of *Ocimum gratissimum*.

3.10.5. *Ocimum gratissimum* L.

3.10.5.1. Traditional use

Parts of the plant (Fig. 36) are used together with parts of *Annona squamosa* (Annonaceae) and *Ocimum americanum* (Lamiaceae) for the treatment of malaria in different African communities (Kaou et al., 2008).

An infusion of the leaves is used as pulmonary antiseptic, antitussive and antispasmodic, and the leaf essential oil is applied externally as mosquito repellent (Oliver-Bever, 2009). Fresh leaves are used in Cameroon to preserve stored cowpea and maize from insect and fungal damage (Illiassa, 2004), and in other tropical regions as stomachic, antipyretic and pectoral treatment (Perry and Metzger, 1980), in vaginal infections (Bouquet, 1969) and as an ingredient of many malaria remedies (Iwu, 2014). The leaves are taken in general healing, as sedative, against arthritis, rheumatism, for eye and ear treatment, for emetics, as laxative, against diarrhoea and dysentery. Furthermore, leaves are applied as vermifuge, for liver and kidney problems, as diuretic, against haemorrhoids and as well against cutaneous and subcutaneous infections, for the treatment of veneral diseases, as febrifuge and against leprosy, and as antidote after venomous stings and bites. Further use of the leaves was reported for the treatment of paralysis, epilepsy, convulsions and spasms. Leaves and flowers are applied as pain killer and for nasopharyngeal affections, while leaves and roots are prepared as medicine against pulmonary troubles,

Table 7
Comparison of main essential oil components from the leaves of three *Ocimum* species collected during the raining period in April-June in the surroundings of Douala.

Compound	*Ocimum basilicum*	*Ocimum americanum*	*Ocimum gratissimum*
p-Cymene	0.34%	0.95%	**32.1%**
Thymol	-	-	**24.3%**
Linalool	**51.86%**	**19.07%**	1.4%
1,8-Cineole	**~13.95%**	**~29.04%**	-

for intestinal problems. Leaves, roots and flowers are applied against swellings and oedema while roots alone are prepared as medicine against malnutrition and debility. Furthermore, the plant was reported to have a positive effect on the brain and nervous system (Burkill, 1985).

A comparison of main leaf essential oil components from *Ocimum basilicum*, *O. americanum* and *O. gratissimum* presented above shows linalool and 1,8-cineol as main essential oil compounds for *O. basilicum* and *O. americanum*, while *O. gratissimum* produces a completely different essential oil spectrum, with main compounds being *p*-cymene and thymol. Interestingly, phylogenetic analyses carried out on *Ocimum* genus revealed that *O. basilicum* is genetically much closer to *O. americanum*, while *O. gratissimum* clusters together with *O. viride* and *Hyptis suaveolens*, the latter one already belonging to a different genus within this family of Lamiaceae (Mahajan et al., 2015) (Table 7).

3.10.5.2. Bioactivities

3.10.5.2.1. Entire plant

The entire plant essential oil displayed an LD_{50} of 210.13 ppm towards the red flour beetle *Tribolium castaneum* after 24 h (Ngamo et al., 2007a). Further assays showed moderate to significant insecticidal activity (Kouninki et al., 2007b; Ousman et al., 2007; Tatsadjieu et al., 2010; Tchoumbougnang et al., 2009). In addition, a four day suppressive test at 500 mg/kg of mouse per day resulted in 77.8% suppression of parasitaemia, and mice were still alive 10 days after infection with *Plasmodium berghei* ANKA, while untreated infected mice died after 6-7 days. The positive control chloroquine® resulted in 100% suppression of parasitaemia at 10 mg/kg of mouse (Tchoumbougnang et al., 2005).

3.10.5.2.2. Leaf

Assays using poisoning technique showed that the leaf oil controlled 91% of the fungus *Fusarium verticiloides* and other fungal infections of maize seeds compared to that of the synthetic fungicide Benlate® which achieved 99% at the same concentration. Moreover, the oil improved germination with 93% compared to Benlate® displaying 94%, while untreated maize showed 88% germination (Tagne et al., 2008). Media supplemented with 400 ppm of the oil showed 100% inhibition.of the fungus *Phytophthora infestans*, causal agent of late blight, while the synthetic fungicides Banko Plus® and Plantizeb® 80WP showed 100% inhibition at 100 ppm, and Kocide® 2000 gave 100% inhibition only at 5000 ppm (Galani et al., 2013). In addition, moderate to significant antifungal properties against other strains was reported as well (Zollo et al., 1998; Nguefack et al., 2004a, b, 2007b, 2009, 2012; Tatsadjieu et al., 2008, 2010).

Furthermore, the oil applied as slurry on cultivars led to reduction of crop seed infection by the plant pathogen fungi *Alternaria padwickii*, *Bipolaris oryzae* and *Fusarium moniliforme* to 1.7, 0.7 and 0%, respectively, while seed to seed transmission was reduced to 2.6, 1.9 and 0.9%, respectively. In contrast, treatment with the fungicide Dithane M-45® led to reduction of crop seed infection to 0.1, 0.7 and 0%, respectively, while seed to seed transmission was reduced to 2.6, 1.6 and 0.6%, respectively. In comparison, untreated seeds showed seed infection of 33.6, 28.0 and 6.0 %, respectively, and seed to seed transmission of 17.5, 11.1 and 15.2 %, respectively. Results show that the oil studied has potential as control agent of some plant pathogen fungi (Nguefack et al., 2008). Furthermore, the leaf essential oil was extensively tested *in vitro* for acaricidal (Hüe et al., 2015) and antibacterial (Ngassoum et al., 2003; Nguefack et al., 2004b) properties showing interesting results.

In addition, leaf essential oil was tested for bactericidal effects employing the spore forming bacteria *Bacillus cereus* T., *Bacillus megaterium* 8174, *Bacillus subtilis* NCTC 3610 and *Geobacillus stearothermophilus* CNCH 5781 whose spores are very resistant to physical and chemical agents and can remain in food after sterilization, which was pointed out by Aouadhi et al. (2013). In macro dilution assays, MICs of 2.5, 1.25, 2.5 and 1.25 mg/mL were reported for inhibition of bacterial growth, respectively. Spore germination inhibition of *Bacillus cereus*, *Bacillus megaterium* and *Bacillus subtilis* were recorded with MICs of 1.5, 0.75 and 0.75 mg/mL, respectively (Voundi et al., 2015). In agar medium assay, the oil was reported to suppress mycelial growth of *Aspergillus aculeratus*, *Aspergillus niger*, *Aspergillus*

Common names

Fru-fru (Cameroon).

Fig. 37. The photograph of *Plectranthus glandulosus*.

terreus, *Aspergillus ustus*, *Penicillium brevicompactum* and *Scopulariopsis brevicaulis*-isolated and identified from a traditional cheese named wagashi, collected near its vendors in Benin - with 100% at 800, 1000, 800, 1000, 1000 and 400 μg/mL, respectively (Sessou et al., 2012). Finally, in insecticidal assays employing young adults of the maize weevil *Sitophilus zeamais*, a concentration of 32.8 μg/ mL and 225 μg/mL of the essential oil led to 45% and 100% mortality, respectively, while the LC_{50} was recorded with 37.9 μg/mL (Nguemtchouin et al., 2013).

3.10.6. *Plectranthus glandulosus* Hook. f.

3.10.6.1. Traditional use

This strongly aromatic plant (Fig. 37) is cultivated in Cameroon as a spice and is used as well against influenza, cough and chest complaints (Oliver-Bever, 2009).

Fresh leaves are applied to preserve stored cowpea and maize from insect and fungal damage (Galani et al., 2013) and as mosquito repellent and anthelmintic (Nukenine et al., 2003; Nlôga et al., 2007). In the Adamawa region of Cameroon, leaves are applied against colds, sore throat and to protect stored grains against insect attacks (Ngassoum et al., 2001; Nukenine et al., 2003).

3.10.6.2. Bioactivities

3.10.6.2.1. Leaf

Notably, the leaf oil displayed significant bioactivity *in vitro*: it killed 100% of the plant pathogen fungus *Aspergillus flavus* at 800 μg/mL, and completely inhibited its aflatoxin B1 production for duration of 8 days at 1000 μL/mL (Tatsadjieu et al., 2008). In agar dilution assay, the oil displayed MICs of 0.8-2.0 mg/mL against various plant pathogen *Aspergillus*, *Fusarium* and *Penicillium* strains (Aoudou et al., 2010, 2011). In addition, the leaf oil was more toxic to the maize weevil *Sitophilus zeamais* and maize and dried cassava weevil *Prostephanus truncatus* than fenchone, one of its main ingredients, indicating synergistic effects (Nukenine et al., 2010). Remarkably, still 25% of the fourth generation of the red flour weevil *Tribolium castaneum* was killed after leaf oil application into the great-grand parent generation, but only 5% by imidacloprid®. In other words, the insect could acquire resistance to imidacloprid® five times faster than to the leaf essential oil (Goudoum et al., 2010). In addition, the oil displayed a significant LD_{50} of 17.06 μg/cm^2 against the malaria vector *Anopheles gambiae* already after nine hours of incubation with impregnated filter paper (Jirovetz et al., 2000). The oil led to significant LC_{50} values of 2.66, 7.37 and 43.16 ppm against the larvae of *Aedes aegypti*, the yellow fever vector, *Anopheles gambiae*, the malaria vector, and *Culex quinquefasciatus*, the vector for *Wucheria bancrofti*, avian malaria and arbo virus, respectively. It showed as well LC_{50}s of 27.22, 22.60 and 104.75 ppm, respectively, against their pupae, so that the oil was recommended as a replacement candidate of the synthetic chemical DDVP® for vector control in Cameroon (Danga et al., 2014).

3.10.7. *Thymus vulgaris* L.

3.10.7.1. Traditional use

In Cameroon, the plant (Fig. 38) is cultivated on rocky soils of the Western highlands (Hutchinson et al., 1954).

Flowering parts and leaves are extensively used as herbal tea, tonic, carminative, antitussive and antiseptic, as well as for treating colds (Maksimović et al., 2008; Rota et al., 2008). An infusion prepared from the whole plant is applied against respiratory problems, and its essential oil displays strong antibacterial action (Debuigne, 2000). Furthermore, it is used in general healing, as vermifuge, for kidney problems, as diuretic, for the treatment of menstrual cycle problems as well as against paralysis, epilepsy, convulsions and spasms (Burkill, 1985). The plant is considered as an antispasmodic and antioxidant agent in its area of distribution. A preparation is administered for whooping cough, bronchitis, laryngitis gastritis, upper respiratory congestion and diarrhea. The leaf oil is used in the treatment of sore throat,

Common names

Thyme (English), thym when cultivated, serpolet when wild (French).

Fig. 38. The photograph of *Thymus vulgaris* L..

Table 8
Comparison main leaf essential oil ingredients of *Thymus vulgaris* (Lamiaceae) during raining and beginning dry period.

Sample location	**Bangang**	**Dschang**	**Bafoussam**
Season	Raining period		Beginning dry period
Thymol	**40.1%**	**27.2%**	**28.1%**
p-Cymene	**23.4%**	**23.6%**	**30.9%**
γ-Terpinene	15.1%	22.7%	5.9%

tonsillitis, gum diseases, rheumatism and arthritis (Tsai et al., 2011; Van Vuuren et al., 2009).

The leaf essential oil of this plant with sample locations Bafoussam around 200 km to the Yaoundé road, Dschang and Bangang, all three located in the most humid zone of Cameroon with 2000 mm annual rainfall, contains as main essential oil components thymol, *p*-cymene and *γ*-terpinene. While for all sample sites production of thymol>*p*-cymene>*γ*-terpinene, the amount of *p*-cymene increased and *γ*-terpinene strongly dropped down with the beginning of the dry period, probably reflecting adjustment of the essential oil composition to changing environmental threads (Table 8).

3.10.7.2. Bioactivities

3.10.7.2.1. The whole plant

The whole plant essential oil applied as slurry on cultivars led to reduction of crop seed infection by the plant pathogen fungi *Alternaria padwickii*, *Bipolaris oryzae* and *Fusarium moniliforme* to 0.2, 0.0 and 0.0% respectively, and reduction of seed to seed transmission to 3.7, 1.0 and 0.7%, respectively. In contrast, the treatment with the fungicide Dithane M-45® led to reduction of crop seed infection to 0.1, 0.7 and 0.0% respectively, and reduction of seed to seed transmission to 2.6, 1.6 and 0.6%, respectively. Untreated seeds showed infection of 33.6, 28.0 and 6.0%, respectively, and seed to seed transmission of 17.5, 11.1 and 15.2%, respectively. Results show that the essential oil studied has potential as control agent of some plant pathogen fungi (Nguefack et al., 2008). Against *Bacillus cereus* T, *Bacillus megaterium* 8174, *Bacillus subtilis* NCTC 3610 and *Geobacillus stearothermophilus* CNCH 5781 the oil gave MICs of 1.25 mg/mL for inhibition of bacterial growth, and 0.37, 1.5 and 0.75 mg/mL, respectively, for inhibition of spore germination of the first three bacteria, while *Geobacillus stearothermophilus* was not tested (Voundi et al., 2015).

3.10.7.2.2. Leaf

In poisoning technique method, the leaf oil controlled 92% of *Fusarium verticillioides* and other fungal infections of maize seeds compared to synthetic fungicide Benlate® with 99%. It improved germination with 91% compared to Benlate® with 94%, while untreated maize showed 88% germination. The oil was recommended as substitute of synthetic fungicides (Tagne et al., 2008). Other leaf and whole plant essential oils gave moderate to significant antifungal activities (Zollo et al., 1998; Nguefack et al., 2004a, 2007a, 2009). The leaf essential oil was further tested *in vitro* for antimalarial (Tchoumbougnang et al., 2009) and antibacterial activity. The oil was reported to significantly suppress food spoiling bacteria *Listeria innocua*, *Listeria monocytogenes* and *Staphylococcus aureus*-flow cytometry testing of *L. innocua* indicated that the oil could permeabilize the cytoplasmic membrane (Nguefack et al., 2004b). Furthermore, for the oral pathogen bacteria *Streptococcus pyogenes*, *Streptococcus mutans*, *Porphyromonas gingivalis*, *Aggregatibacter actinomycetemcomitans* as well as the facultative pathogen yeast *Candida albicans*, MICs of 3.6, 1.9, 32, 32 and 16.3 µg/mL, respectively, were measured compared to the positive controls vancomycin with MICs of 0.95 and 0.66 µg/mL against *Streptococcus pyogenes* and *Streptococcus mutans*, respectively, being resistant to the two other bacteria, and amikacin with MICs of 29.1 and 24.1 µg/mL against *Porphyromonas gingivalis* and *Aggregatibacter actinomycetemcomitans*, respectively, being resistant to the two other bacteria, while nystatin gave an MIC of 15 µg/mL against *Candida albicans*. MICs against pathogenic fungal strains of *Fusarium* spp, *Aspergillus flavus*, *Aspergillus niger*, *Candida albicans* ATCC 10231, *Candida glabra* ATCC 15126, *Candida parapsilosis* ATCC 22019 and *Candida kefyr* ATCC 66028 were measured with 2.5-≤10 mg/mL, which indicates no activity. Finally, the leaf oil inhibited proliferation of human breast cancer cell line MDA-MB-231 with an IC_{50} of 108-115 µg/mL after 24 h (Al-Shahrani et al., 2017).

Common names

Antelope´s garden egg (English).

Fig. 39. The photograph of *Vitex rivularis* Gürke.

3.10.8. Vitex rivularis Gürke

3.10.8.1. Traditional use

The plant (Fig. 39) is used in Cameroon as a tonic for newborns and to treat epilepsy (Neuwinger, 2000).

A preparation of the bark is applied as sedative, and the fruit is used against paralysis, convulsions and spasms.

3.10.8.2. Bioactivities

3.10.8.2.1. Aerial parts

The oil of plant population A and B harvested at Yaoundé gave MICs of 5, 1.25-0.64, 0.32, 0.16, 0.32, 0.64 and 0.32 µL/mL for population A against the dermatophytes *Candida guillermondii*, *C. neoformans*, *Epidermophyton floccosum*, *Trichophyton rubrum*, *T. mentagrophytes*, *Microsporum canis* and *M. gypseum*, respectively, and MICs of 5, 2.5-5, 0.32, 0.32-0.64, 0.64, 1.25 and 1.25 µL/mL, respectively, for population B compared to fluconazole® showing MICs of 8, 16, 16, 16, 16-32, 128 and 128 µg/mL (Cabral et al., 2009). Oil MICs and the positive control MIC are given here in different units, making a comparison difficult.

3.11. Lauraceae

3.11.1. *Cinnamomum verum* J. Presl

3.11.1.1. Traditional use

In West Africa, the leaves (Fig. 40) are used to prepare infusions for general healing, while preparations from the bark are applied as pain killers, against arthritis, rheumatism, nasopharyngeal affections, stomach troubles, as well as against diarrhea and dysentery (Burkill, 1985).

Oils of the plant are also traditionally used for bloating, nausea, flatulence, colic, and gastrointestinal tract spastic conditions (Torizuka, 1998).

3.11.1.2. Bioactivity *in vitro*

3.11.1.2.1. Bark

The antimicrobial activity of the bark essential oil was investigated against 21 bacteria and 4 *Candida* species, using disc diffusion method. MICs were recorded in the range of <0.04 to 1.12 mg/mL for bacteria as well as for fungi. The cytotoxic effect of the essential oil on cell line Ras active fibroblasts 5RP7 and normal fibroblasts F2408 gave IC_{50} values less than 20 µg/mL for both cell types in MTT assay (Unlu et al., 2010). Furthermore, the oil displayed an LD_{50} of of 2.1 µg/g mosquito against *Anopheles gambiae* (Norris et al., 2015).

Common names

Cinnamon tree (English), cannellier de Ceylan (French).

Fig. 40. The photograph of Cinnamomum verum J. Presl.

Common names

Sicklebush, bell mimosa, Chinese lantern tree, Kalahari christmas tree (English), acacia Saint Domingue (French), Kalahari-Weihnachtsbaum, Farbkätzchenstrauch (German).

Fig. 41. The photograph of *Dichrostachys cinera* Villiers.

3.11.1.2.2. Leaf

The essential oil induced pupal and larval mortality of *Anopheles gambiae*, the vector of malaria transmission with 30% and 100%, respectively, at 400 ppm. The LC_{50} for larvae and nymphs were 98.95 and 489.2 ppm, respectively (Akono et al., 2016). In addition, the oil displayed MICs of 4.7, 9.0, 8.7, 8.0, 16.3 and 5.5 µL/75 mL air space against the food spoilage fungi *Rhizopus oryzae*, *Aspergillus tamarii*, *Aspergillus parasiticus*, *Rhizopus stolonifer*, *Aspergillus flavus* and *Talaromyces purpureogenus*, respectively, measured by micro-atmospheric method (Ambindei et al., 2017).

3.12. Leguminosae

3.12.1. *Dichrostachys cinera* Villiers

3.12.1.1. Traditional use

In Africa, the plant (Fig. 41) is considered highly effective against various insects and is used in the treatment of malaria (Innocent and Hassanali, 2015).

In Cameroon, Kenya, South Africa and Tanzania, a decoction of its leaves and roots is used against venereal disease, eye inflammations, skin diseases, and snake bites. The root is used for chest complaints and the twigs for gonorrhoea and syphilis. In Cameroon, the plant is used ion addition to control populations of insect pests (Pavela et al., 2016). The smoke of the leaf and the root are used for pulmonary tuberculosis (Deniz,

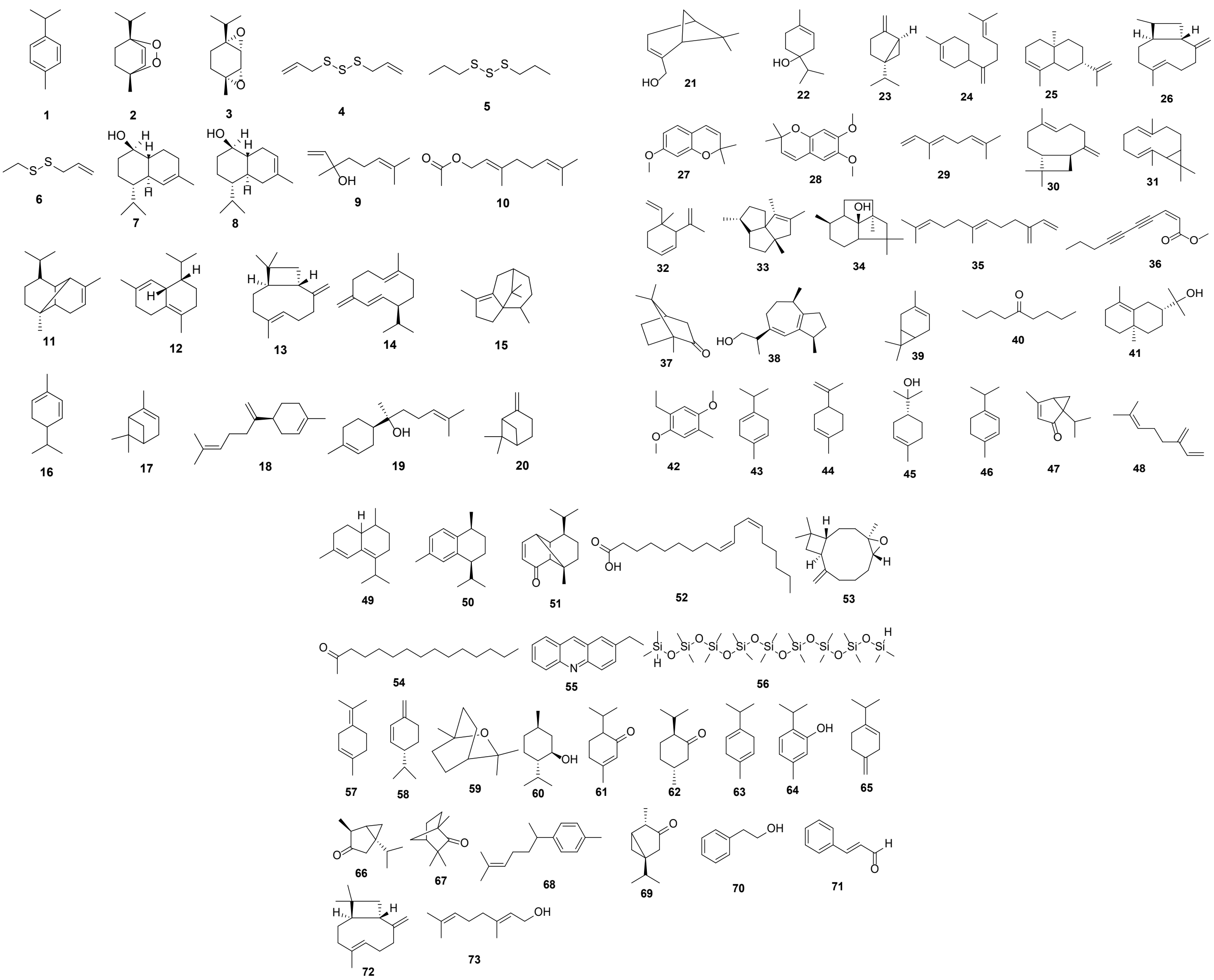


Fig. 42. Structures of main components of the characterized and reported essential oils.

2009). In addition, the plant is employed to treat several diseases and parasites, as well as to control populations of arthropod pests (Ahua et al., 2007; Karunamoorthi and Hailu, 2014).

3.12.1.2. Bioactivities

3.12.1.2.1. Seeds

The seed essential oil was investigated by larvicidal toxicity assay using larvae of the filariasis and West Nile virus vector *Culex quinquefasciatus*. Tests resulted in LC_{50} of 39.1 µL/L. It was suggested that the major oil compound, geraniol, plays a predominant role in this activity (Pavela et al., 2016), since it is used as tick repellent and acaricidal agent as reported by Khallaayoune et al. (2009). Moreover, geraniol was documented by Chen and Viljoen (2010) to possess larvicidal and repellent effects on mosquitos.

3.12.1.2.2. Leaf

The leaf essential oil was assayed against the parasite *Trypanosoma brucei* TC 221 causing African sleeping sickness, resulting in an IC_{50}>100 µg/mL, compared to the positive control suramin with 0.0286 µg/mL, so that this result was not further followed up (Kamte et al., 2017).

To give an overview on published data reviewed above starting with the plant family Chenopodiaceae up to Legumionosea, the following table 9 compiles findings concerning main essential oil compounds and their percentual contribution to the oil as reported from analyses, as well as bioactivity of essential oils and toxicity data resulting from laboratory assays carried out *in vitro* and *in vivo*.

3.13. Correlation traditional use with bioactivity *in vitro in vivo*

For some Cameroonian medicinal oils, *in vitro* bioactivity tests have been carried out successfully in regard to valorization of the plants effectiveness in traditional medicine. However, for plants compiled below, researchers do not yet fully understand the mechanisms of bioactive ingredients and their synergistic action within the essential oil.

The whole plant of *Hexalobus crispiflorus* (Annonaceae) is applied in the neighbouring Nigeria against malaria (Odugbemi, 2008). The essential oil of the stem bark displayed very significant antimalarial activity against the chloroquine resistant *Plasmodium falciparum* W2 with an IC_{50} of 2.0 µg/mL (Boyom et al., 2003).

In Western Africa, the fruit of *Xylopia aethiopica* (Annonaceae) is applied against microbial infections (Odugbemi, 2008). The fruit essential oil displayed significant activity against the pathogen bacteria *Listeria monocytogenes*, *Staphylococcus aureus* and *Salmonella enteritidis* (Gardini et al., 2009).

Erigeron floribundus (Asteraceae) is used in Ivory Coast for the treatment of skin disorders and various diseases of microbial origin (Koné et al., 2002). Leaf and fruit essential oil display significant activity against dermatophytes *Candida neoformans*, *C. albicans*, *Trichophyton mentagrophytes* and *T. rubrum* (Kuiate et al., 2005).

In Cameroon, *Laggera pterodonta* (Asteraceae) is used against mosquitos. The leaf essential oil showed significant toxicity against the malaria vector Anopheles gambiae (Nlôga et al., 2007).

Leaves of *Cupressus sempervirens* (Cupressaceae) are used to protect stored grains from weevil attacks (Tapondjou et al., 2000). The leaf essential oil showed significant toxicity towards the maize grain weevil *Sitophilus zeamais* and the red flour beetle *Tribolium confusum* and 100% reduction in adult emergence at low dose (Tapondjou et al., 2005).

In Cameroon, roots and rhizomes of *Cyperus articulatus* (Cyperaceae) are used in some remote areas along river sides against river blindness. Essential oil of roots and rhizomes displayed significant activity towards microfilariae, adult male worms and adult female worms of the river blindness model organism *Onchocera ochengi* (Metuge et al., 2014a).

Fresh leaves of *Plectranthus glandulosus* (Lamiaceae) are applied to preserve stored cowpea and maize from fungal damage (Galani et al., 2013). The leaf oil showed significant activity against *Aspergillus flavus* and suppression of aflatoxin B1 production (Tatsadjieu et al., 2008; Aoudou et al., 2011).

Fresh leaves of *Plectranthus glandulosus* (Lamiaceae) are also applied to preserve stored grains from insect damage (Ngassoum et al., 2001; Nukenine et al., 2003; Galani et al., 2013). The crop pest insect *Tribolium castaneum* could acquire resistance to imidacloprid® five times faster than to the leaf essential oil (Goudoum et al., 2010).

Leaves of *Ocimum americanum* (Lamiaceae) are used in Cameroon against mosquitos, as insect repellent and insecticide (Mapi, 1988; Nlôga et al., 2007; Ntonga et al., 2014). The leaf oil displayed significant activity against the mosquito *Anopheles gambiae* and its larvae (Mapi, 1988; Nlôga et al., 2007; Tchoumbougnang et al., 2009).

Leaves of *Ocimum gratissimum* (Lamiaceae) are applied in Cameroon as ingredient of many malaria remedies (Iwu, 2014). The leaf essential oil showed significant activity in the plasmodium model strain *Plasmodium berghei* in animal experiment (Tchoumbougnang et al., 2005).

In Cameroon, fresh leaves of *Plectranthus glandulosus* (Lamiaceae) are used to preserve stored cowpea and maize from fungal damage (Illiassa, 2004). The leaf oil caused significant suppression of plant pathogen fungi *Fusarium verticiloides* and *Phytophthora infestans* comparable to Benlate®, Banko Plus® and Plantizeb® 80WP and was 12 fold stronger than Kocide® (Tagne et al., 2008; Galani et al., 2013); the leaf oil significantly controlled the plant pathogen fungi *Aspergillus padwickii*, *Bipolaris oryzae* and *Fusarium moniliforme*, comparable to Dithane M-45® (Nguefack et al., 2008).

Fresh leaves of *Plectranthus glandulosus* (Lamiaceae) are applied in Cameroon as mosquito repellent (Nukenine et al., 2003; Nlôga et al., 2007). The leaf essential oil displayed very significant activity against *Anopheles gambiae* (Jirovetz et al., 2000) and LC_{50} values of 2.66, 7.37 and 43.16 ppm against *Aedes aegypti*, *Anopheles gambiae* and *Culex quinquefasciatus* larvae, respectively, together with 27.22, 22.60 and 104.75 ppm against their respective pupae (Danga et al., 2014).

In the Western highlands of Cameroon, the whole plant of *Thymus vulgaris* (Lamiaceae) is known for its essential oil to display strong antibacterial action (Hutchinson et al., 1954; Debuigne, 2000). Significant activity of the leaf oil against food spoiling bacteria *Listeria monocytogenes*, *Staphylococcus aureus* and *Listeria innocua* was reported. It was shown that the oil is able to permeabilize the cytoplasmic membrane of *Listeria innocua* (Nguefack et al., 2004b).

Above plant oils might be investigated for acute toxicity in animal experiment to guarantee safe application in medicine and agriculture in developing countries.

4. Concluding remarks

From forty Cameroonian plant species belonging to twelve families, a good number of essential oils were reported to display good to significant activity in laboratory assays, some of them valorizing the effectivity of Cameroonian traditional medicinal and agricultural preparations. It also appears that the biological activity attributed to the essential oil is due to the major compounds found in the corresponding plant.

The main essential compounds form some part of plant collected in different regions of Cameroon and different periods are sensibly similar. This is due to the presence of the similar constitutive genes that influence phenotypic characteristics of the plant. However, The differences in percentage of compounds is attributed to the variations in resources for growth including soil nutrients, soil moisture, light, atmospheric carbon dioxide and the presence or absence of enemies, competition or mutualists. All these compounds come from the biosynthesis that occur in plants.

However, traditional medicinal use of plants against severe medical conditions points to a huge medical treasure of not yet assayed essential oils. Most importantly, toxicological studies in animal experiment are needed to guarantee future safe traditional medicines for Cameroon and other Sub-saharan countries based on plant oils. The goal is to pave the way towards medicinal preparations with proven effectivity and low toxicity.

Conflict of interest

The authors declare that there is no conflict of interest.

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