Trends in Phytochemical Research (TPR)

Journal Homepage: http://tpr.iau-shahrood.ac.ir

Review Paper

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

Jean Duplex Wansi[1,2,✉], Norbert Sewald[3], Lutfun Nahar[2], Claire Martin[4] and Satyajit Dey Sarker[2]

[1]Department of Chemistry, University of Douala, Faculty of Sciences, 24157 Douala, Cameroon

[2]School of Pharmacy and Biomolecular Sciences, Liverpool John Moores University, James Parsons Building, Byrom Street, Liverpool L3 3AF, UK

[3]Organic and Bioorganic Chemistry, Department of Chemistry, Bielefeld University, 33501 Bielefeld, Germany

[4]Department of Biological Sciences, Institute of Science and the Environment, St. John's Campus. University of Worcester, Henwick Grove, Worcester, WR2 6AJ, UK

ABSTRACT

Eighty-nine essential oil analyses carried out on Cameroonian plant material by gas chromatography are reviewed, and structures of sixty one main oil compounds are presented. Plant samples had been collected all over the rainforest area and further northwards, covering forty plant species belonging to ten families. For these plants, common names, traditional use as well as bioactivity and toxicity of their essential oils *in vitro* and *in vivo* are compiled. Data show that oils from leaves, bark, roots, fruit, rhizome or seeds display their own one to four main essential oil components. Each of them contributing more than 10% to over 90% of the oil´s volume, which sums up to species-unique essential oil fingerprints and decreasing similarity of these fingerprints with increasing phylogenetic distance between species. This review article shows that the environmental factor include, temperature, rainfall (Littoral region), humidity (Center, South, East and West regions) and solar radiation (Adamaoua, North and Far-north regions) as well as the soil nutrients influence the secondary metabolite composition of the plants. Bioassays valorized traditional use of a good number of oils, for example against the dermatophytic fungus *Trichophyton rubrum* being twice as effective as amphothericin B®; against the chloroquine resistant *Plasmodium falciparum*; against cancer cell lines; and against a variety of human pathogen bacteria, being up to ten times as effective as ciproxin®, lidaprim®, tetracycline hydrochloride® and lidaprim®. Importantly, in an experiment employing the stored product beetle *Callosobruchus maculatus*, the leaf oil of *Lippia adoensis* (Verbenaceae) indicated neurotoxicity, so that preparations should be applied with care. Follow up work may focus on bioassays with commercial pure compounds, with the goal to improve effectivity and doses calculation for traditional essential oil medicines and agricultural products.

ARTICLE HISTORY

Received: 17 March 2018
Revised: 15 December 2018
Accepted: 12 February 2019
ePublished: 10 March 2019

KEYWORDS

Bioactivity
Cameroon
Essential oil
Medicinal plants
Traditional use
Toxicity

1. Introduction

Medicinal plants of the Cameroonian rainforest, savannahs and deserts have been known for millennia as a rich source of therapeutic agents for the treatment and prevention of various diseases such as: malaria, thiphoid fever schistosomiasis, onchocerciasis, lymphatic filariasis, African trypanosomiasis, and dengue (Pavunraj et al., 2017; Mohammadhosseini, 2017; Mohammadhosseini et al., 2017). Plants occupying an important place in the socio-cultural, spiritual and for agricultural application (Mohammadhosseini et al., 2019). This knowledge was handed down from generation to generation either orally or mystically, and effective plants have been selected by trial and error. Today, a part of this traditional knowledge is still in use in Cameroon, specilally in some villages of West and North-West. The sacred forests from the central parts of the rainforest, in which no agriculture is allowed, still conserve knowledge on the bioeffectivity of plants.

✉ Corresponding author: Jean Duplex Wansi
Tel: +237 674 725 425; Fax: +237 674 725 425
E-mail address: jdwansi@yahoo.fr

These plants are used in various forms by local medicine practitioners as: decoctions, infusions, ointment, powder and maceration, friction and chewing. Because of significant costs and severe toxicity of synthetic modern drugs and crop protectants, Cameroonian natural product chemists follow the strategy of using freely available natural resources to investigate alternatives. During the last decades, ethnobotanical and chemical studies have been undertaken by Cameroonian research groups and structured questionnaires applied to traditional practitioners or herbalists, medicinal plant gardeners and traders. 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 second part of the essential oils of Cameroon covers families of Meliaceae, Myrtaceae, Pentadiplandraceae, Phyllanthaceae, Piperaceae, Poaceae, Putranjivaceae, Rutaceae, Verbenaceae and Zingiberaceae, reviewing data on common names, plant taxonomy, traditional use, GC-analyses of essential oils as well as their bioactivity *in vitro*. Furthermore, molecular structures of two main components in the chemical profiles of essential oils are attached for each species analyzed.

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 like essential oils, bioactivity and Cameroon. Additional information was accessed at The Plant List at www.theplantlist.org/, The Global Biodiversity Information Facility at www.gbif.org/ and JSTOR Global Plants at https://plants.jstor.org/, 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.cgiID.

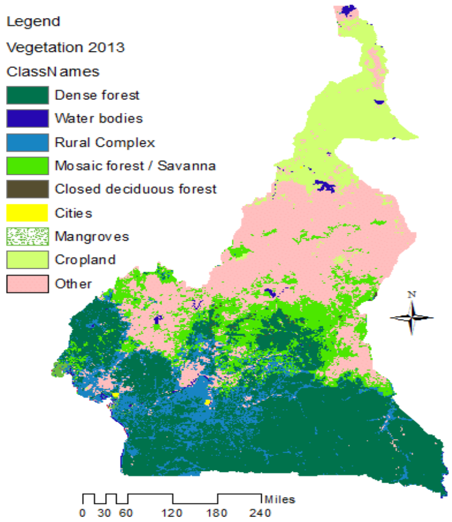

Fig. 1. Map of Cameroon and vegetations.

2.2. Plant material

All plants listed in this review were collected in all regions of Cameroon, from North to South and 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.

3. Results and Discussion

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

3.1. Meliaceae

3.1.1. *Azadirachta indica* A. Juss.

3.1.1.1. Traditional use

The Laves and fruits (Fig. 2) are considered by many people living in Africa as a miraculous remedy for a wide range of uses such as antimalarial, anti-inflammatory and skin healer (Kamte et al., 2017).

The seed oil is used against arthritis, for ear treatment and against leprosy, while the fruit is applied for kidney problems, as diuretic and against hemorrhoids. The leaf and the bark are applied against pulmonary troubles, stomach problems, verms, liver problems, cutaneous and subcutaneous parasitic infections and fever. The

Table 1
Essential oils composition, percentages of compounds.

Species	Plant part	Essential oil compounds	Bioactivity of essential oil and toxicity
		1. Meliaceae	
Azadirachta indica A. Juss.	Leaves, Guidiguis, Maroua January 2016.	δ-Elemene (0.1%), α-copaene (0.2%), bourbonene (0.3%), β-elemene (0.9%), (*E*)-caryophyllene (2.4%), **γ-elemene 1** (18.3%), α-humulene (0.4%), germacrene D (0.5%), (*E*)-β-ionone (0.5%), δ-cadinene (0.2%), selina-3,7(11)-diene (0.2%), **germacrene B 2** (74%), (3*Z*)-hexenyl benzoate (0.3%) (Kamte et al., 2017).	Antitrypanosomia,, low toxocity (Kamte et al., 2017).
	Seeds	-	Toxic to crop weevils, antioxidant activity, antimalarial (Okoh et al., 2015; Tofel et al., 2017).
		2. Myrtaceae	
Callistemon citrinus	Leaves Bonamoussadi-Douala, in April 2006.	Isobutyle isobutyrate (0.4%), (3*Z*)-hexenyl acetate traces, (3*E*)-hexenyl acetate (0.2%), β-pinene (0.5%), **α-pinene 3** (16.3%), myrcene (0.2%), *p*-cymene (0.5%), γ-terpinene (0.2%), **1,8-cineole 4** (73.8%), linalool (0.3%), *trans*-pinocarveol (0.4%), borneol (0.2%), terpinen-4-ol (0.5%), α-terpineol (4.8%), alcohol (M 152) (0.4%), β-bisabolene (0.2%), δ-cadinene (0.3%) and phenyl ethyl acetate traces (Dongmo et al., 2009).	Antibacterial Insecticide, cytotoxicity (Dongmo et al., 2009; Sameza et al., 2016).
	Leaves Douala, March 2011.	Isovaleric acid (0.2%), 5-hydroxylpentanal (0.2%), isobutyl isobutyrate (0.3%), α-thujene (0.5%), **α-pinene 3** (18.5%), β-pinene (0.7%), mycrene (0.4%), α-phellandrene (1.7%), δ-3-carene (0.3%), *p*-cymene traces, β-phellandrene (2.0%), limonene (5.0%), (*E*)-β-ocimene (0.1%), γ-terpinene (0.4%), terpinolene (0.2%), **1,8-cineole 4** (60.6%), linalool (0.6%), *trans*-picocarveol (0.1%), borneol (0.1%), terpinen-4-ol (0.7%), α-terpineol (5.0%), hydrate sabinene acetate (0.1%), eugenol (0.2%), carvyl *cis*-acetate (0.1%), δ-cadinene (0.3%), germacrene B traces, elemol (0.2%), caryophyllene oxide (0.2%), viridiflorol (0.1%) (Sameza et al., 2016).	
Callistemon rigidus	Leaves,Ngaoundéré, April 2006.	γ-Butyrolactone (0.2%), isobutyl isobutyrate (0.1%), **α-pinene 3** (12.9%), sabinene (0.1%), β-pinene (0.8%), myrcene (0.2%), α-phellandrene (0.4%), γ-terpinene (0.1%), **1,8-cineole 4** (79.1%), linalool (0.3%), *trans*-pinocarveol (0.3%), borneol (0.1%), terpinen-4-ol (0.3%), α-terpineol (4.1%), nerol 0.1%), geranial (0.1%), (*Z*)-farnesene (0.1%), germacrene D (0.1%), β-bisabolene (0.1%), δ-cadinene (0.1%), α-cadinene (0.1%) and α-humulene oxide (0.1%) (Dongmo et al., 2009).	Antifungal (Dongmo et al., 2009), antimalarial (Danga et al., 2014).
Callistemon viminalis	Leaves, Dschang, Nov 2003.	δ-3-Carene (8.61%), 2-methylpropylisobutyrate (0.44%), β-pinene (0.93%), isoamylacetate (0.12%), limonene (7.01%), **1,8-cineole 4** (58.49%), α-pinene (0.38%), ocimene (0.81%), **β-linalool 5** (11.00%), 4-terpinenol (0.79%), ocimenol (0.18%), α-terpinol (5.83%) and eugenol (0.17%) (Ndomo et al., 2009).	Insecticidal activity Antibacterial (Ndomo et al., 2009)
Eucalyptus camaldulensis	Leaves	**1,8-Cineole 4** (69.46%), **γ-terpinene 6** (15.10%), α-pinene (5.47%) and globulol (2%) (Mehdi et al., 2010).	Insecticidal activity, Antimalarial (Nlôga et al., 2007, Mehdi et al., 2010).
Eucalyptus globulus	Leaves Yaoundé Sept. 2012.	**α-Pinene 3** (20%), globulol (7.6%), **caryophyllene oxide 7** (16.2%), α-sesquiphellandrene (11.1%), camphor (10.3%) and eucalyptol (10.2%) (Nyegue et al., 2017).	Antioxidant, antifu ngal (Goldbeck et al., 2014, Harkat-Madouri et al., 2015)
Eucalyptus saligna	Leaves, Dschang, April 1999.	**α-Pinene 3** (39.4%), limonene (2.1%), 1,8-cineole (eucalyptol) (9.8%), γ-terpinene (9.5%), ***p*-cymene 8** (31.1%), terpinen-4-ol (0.6%), α-terpineol (3,7%) and carvacrol (1.7%) (Tapondjou et al., 2005).	Insecticidal activity fungicidal (Tapondjou et al., 2005, Metsoa et al., 2017).
Pimenta pseudocaryophyllus	Buds Mfoundi Yaoundé, Oct. 2010.	α-pinene traces, **eugenol 9** (80.0%), α-ylangene (0.1%), **β-caryophyllene 10** (8.3%), germacrene D (4.0%), eugenol acetate (6.7%) and caryophyllene oxide (0.1%) (Nyegue et al., 2014).	Antimicrobial (Nyegue et al., 2014).
Psidium guajava	Leaves	**Limonene 11** (42.1%) and **β-caryophyllene 10** (21.3%) (Ogunwande et al., 2003).	Increase of sperms density and motility (Ngoula et al., 2017).
Syzygium aromaticum	Clove buds Penja, Cameroon, July 2016.	*p*-Cymene (0.01%), terpinolene (0.03%), 1,8-cineole (0.03%), fenchone (0.03%), camphenol (0.03%), carveol (0.01%), geraniol (0.35%), **eugenol 9** (87.62%), dihydro-eugenol (0.21%), isoeugenol (0.67%), eugenylacetate (0.05%), δ-elemene (0.09%), β-caryophyllene (5.88%), *epi*-(*E*)-caryophyllene (0.05%), γ-gurjunene (0.02%), germacrene D (0.02%), β-selinene (0.08%), β-bisabolene (4.41%), δ-cadinene (0.05%), elemol (0.02%), spathulenol (0.14%), guaiol (0.02%), cubenol (0.04%), γ-eudesmol (0.01%), β-bisabolol (0.04%), 3(*E*)-hexenol (0.01%) and 4-heptanol (0.02%) (Fankem et al., 2017).	Antiradical Fungicidal (Fankem et al., 2017).
	Fruits Bafoussam, Cameroon in July 2012.	α-Thujene traces, β-pinene traces, α-terpinene traces, linalool traces, terpinen-4-ol traces, α-terpineol traces, **eugenol 9** (81.9%), β-elemene (7.7%), β-caryophyllene traces, **δ-cadinene 12** (10.2%), α-cadinol traces, myristic acid traces and oleic acid traces (Sokamte et al., 2016).	Antiradical, Antibacterial (Sokamte et al., 2016).
	Blossoms were purchased/collected in Cameroon in June 2012.	Linalool (0.3%), **eugenol 9** (87.7%), β-*trans*-caryxophyllene (4.3%), dihydroeugenol acetate (6.5%), 2-acetyl-naphtalene (0.2%) and β-cedreneepoxide (1.3%) (Voundi et al., 2015).	Antifungal (Voundi et al., 2015).
		3. Pentadiplandraceae	
Pentadiplandra brazzeana	Roots Yaoundé in August 2013.	Campholenol (0.31%), benzylcyanide (0.86%), **benzylisothiocyanate 13** (97.63%), *p*-methoxybenzylcyanide (1.2%) (Ndoye et al., 2016).	Antioxidant, anti -inflammatory, antiradical, toxic (Ndoye et al., 2016, Nyegue et al., 2008).

Table 1 (Continued)

	Roots Olembé, Cameroon in June 2002.	Benzaldehyde (0.4%), **benzylcyanide 14** (17.0%), benzylmethylacetate (0.1%), *p*-anisaldehyde (0.9%), *p*-methoxybenzyl alcohol (0.2%), **benzylisothiocyanate 13** (78.0%), 4-methoxyphenylacetonitrile (2.5%), β-caryophyllene (0.1%), 4-methoxybenzylisothiocyanate (0.1%) and 3-methoxybenzylisothiocyanate traces (Nyegue et al., 2008).	
	Roots	Benzylisothiocyanate, benzylcyanide (Ndoye, 2001).	
		4. Phyllanthaceae	
Antidesma laciniatum	Leaves, Mount Kalla, March 1999.	Linalool (9.4%), geraniol (0.5%), **geranyl acetate 15** (14.9%), α-copaene (2.2%), β-bourbonene (0.5%, β-caryophyllene (5.2%), α-copaene (0.3%), α-humulene (2.1%), γ-muurolene (0.7%), germacrene D (8.5%), α-muurolene (1.5%), γ-cadinene (0.3%), (*E,E*)-α-farnesene (0.5%), δ-cadinene (1.3%), α-cadinene (0.3%, germacrene D-4-ol (0.4%), spathulenol (1.4%), caryophyllene oxide (8.5%), humulene oxide (3.5%), *epi*-α-cadinol (0.2%), *epi*-α-muurolol (2.5%), α-muurolol (1%), α-cadinol (3%), (*E,E*)-farnesol (2%), (*E,E*)-farnesyl acetate (1.3%), *p*-methyl anisol (2.1%), methyl benzoate (0.5%), benzyl acetate (1.5%), (*E*)-anethole (0.5%), (*E*)-cinnamyl acetate (0.6%), **benzyl benzoate 16** (19.1%) and benzyl salicylate (3%) (Boyom et al., 2003).	Antiplasmodial (Boyom et al., 2003)
Phyllanthus muellerianus	Stem bark, Abing, July 2009.	Phenylethyl alcohol (0.05%), octanoic acid (0.08%), anisaldehyde (0.12%), 2-isopropylbenzoic acid (2.64%), *p*-propylanisole (0.16%), methyl *p*-anisat (0.43%), β-cubebene (0.11%), *E*-caryophyllene (1.16%), *E*-isoeugenol (0.40%), α-humulene-4 (0.67%), *E*-methyl isoeugenol (1.05%), β-bisabolene (0.13%), δ-cadinene (0.31%), α-copaen-11-ol (0.25%), elemicin (0.74%), *E*-nerolidol (0.24%), spathulenol (0.19%), **caryophyllene oxide 7** (22.54%), salvial-4(14)-en-1-one (0.32%), ledol (0.35%), humulene epoxide II (2.04%), junenol (1.51%), **isoelemicin 17** (36.40%), a-cadinol (11.23%), *epi*-β-bisabolol (0.97%), oplopanone (0.26%) and 6-methylantranylic acid methyl ester (0.09%) (Brusotti et al., 2012).	Antibacterial (Boyom et al., 2003).
		5. Piperaceae	
Piper capense	Fruits, April 2005, Western Region.	α-Thujene (0.1%), α-pinene (10.5%), camphene (0.3%, **sabinene 18** (14.7%), **β-pinene 19** (59.3%), myrcene (1%), δ-3-carene traces, α-terpinene (0.1%), *p*-cymene (1.2%), (*Z*)-β-ocimene (0.1%), (*E*)-β-ocimene (0.2%), γ-terpinene (0.1%), terpinolene ((0.1%), sabinene hydrate (0.1%), linalol (0.1%), camphor (0.1%), borneol traces, terpinen-4-ol (0.3%), α-terpineol (0.2%), thymol (0.5%), bornyl acetate (0.1%), β-cubebene traces, α-copaene (0.2%), β-cubebene (0.1%), β-elemene (0.2%), β-caryophyllene (3.4%), (*E*)-β-farnesene traces, α-humulene (0.1%), valencene (0.1%), germacrene D (2.5%), β-bisabolene (0.3%), γ-cadinene traces, δ-cadinene (0.1%), (*E,E*)-α-farsenene (0.6%), germacrene B (0.1%), (E)-nerolidol (0.2%), spathulenol traces, *epi*α-bisabolol (1.4%) and α-cadinol traces (Tchoumbougnang et al., 2009a).	Antifungal (Tchoumbougnang et al., 2009a).
	Leaves, April 2005, Western Region.	α-Thujene (2.1%), **α-pinene 3** (12.8%), camphene (0.1%, sabinene (8.8%), **β-pinene 19** (50.1%), myrcene (1.3%), α-phellandrene (0.6%), δ-3-carene traces, *p*-cymene (0.4%), limonene (1.8%), (*Z*)-β-ocimene (0.4%), (*E*)-β-ocimene (0.5%), sabinene hydrate traces, linalol (1.6%), terpinen-4-ol (0.1%), α-terpineol (0.2%), α-copaene (0.6%), β-cubebene (0.5%), β-elemene (0.8%), β-caryophyllene (12.4%), β-gurjunene traces, (*Z*)-β-farnesene (0.1%), α-humulene (0.2%), valencene traces, germacrene D 1.4%), γ-muurolene (0.1%), β-bisabolene (0.1%), γ-cadinene traces, δ-cadinene (0.5%), (*E,E*)-α-farsenene (0.4%), (*E*)-nerolidol (0.7%), τ-cadinol (0.2%) and α-cadinol (0.2%) (Tchoumbougnang et al., 2009a).	
	Stems, April 2005, Western Region.	α-Thujene (0.7%), **α-pinene 3** (14.3%), camphene (0.5%), sabinene (0.1%), **β-pinene 19** (61.4%), myrcene (3.3%), α-phellandrene traces, δ-3-carene traces, α-terpinene (0.1%), *p*-cymene traces, limonene (2%), (*Z*)-β-ocimene (0.2%), (*E*)-β-ocimene (0.2%), γ-terpinene (0.1%), terpinolene (0.1%), sabinene hydrate (0.2%), camphor (0.2%), borneol (0.1%), terpinen-4-ol (0.1%, α-terpineol traces, thymol (0.5%), bornyl acetate (0.3%), α-cubebene (0.5%), α-copaene (0.3%), β-elemene (0.6%), β-caryophyllene (4.1%), β-gurjunene (0.4%), (*E*)-β-farnesene (0.2%), α-humulene (1.2%), valencene (0.5%), germacrene D (1.7%), α-selinene (2.9%), γ-muurolene (0.8%), β-bisabolene traces, δ-cadinene (0.3%), (*E,E*)-α-farsenene (0.2%), germacrene B (0.3%), (*E*)-nerolidol (0.4%), spathulenol (0.1%), caryophyllene oxide (0.1%) and *epi*-α-bisabolol (0.1%) (Tchoumbougnang et al., 2009a).	
Piper guineense	Fruits, April 2005, Western Region.	α-Thujene (1%), α-pinene (10.6%), camphene (1%), sabinene (5.6%), β-pinene (12.1%), myrcene (1.8%), α-phellandrene (3.4%), δ-3-carene (4.2%), α-terpinene (4.9%), *p*-cymene (0.2%), **limonene 11 (**15.8%), β-phellandrene (1%), (*Z*)-β-ocimene (0.1%), (*E*)-β-ocimene (0.6%), γ-terpinene (0.4%), terpinolene (0.9%), sabinene hydrate (0.2%), linalool (0.6%), camphor traces, terpinen-4-ol (0.3%), α-terpineol traces, δ-elemene (0.8%), α-cubebene (1%), β-cubebene (1.7%), β-elemene (4.3%), **β-caryophyllene 10** (20.8%), α-bergamotene traces, (*E*)-β-farnesene (0.1%), (*Z*)-β-farnesene traces, *allo*-aromadendrene traces, germacrene D (0.5%), α-selinene (0.8%), γ-muurolene (0.3%), α-curcumene (1%), (*Z, E*)-α-farsenene (1.9%), β-bisabolene (0.6%), calamenene (0.1%) and (*E*)-nerolidol (1%) (Tchoumbougnang et al., 2009a).	Anxiolotic effect, Antifungal and anticancer (Tchoumbougnang et al., 2009a)
	Leaves, April 2005, Western Region.	α-Thujene (0.2%), sabinene (0.3%), β-pinene (1.1%), myrcene (0.2%), α-phellandrene (0.6%), δ-3-carene (1.1%), α-terpinene (0.7%), *p*-cymene (0.1%),	

Table 1 (Continued)

		limonene 11 (10.3%), β-phellandrene (0.3%), (*E*)-β-ocimene (0.5%), γ-terpinene (0.5%), linalool (5.3%), α-terpineol traces, δ-elemene (8.8%), α-cubebene (3%), α-copaene (0.7%), β-cubebene traces, β-elemene (0.3%), α-gurjunene (0.8%), β-caryophyllene (4.1%), β-gurjunene (1.4%), α-bergamotene (0.1%), (*E*)-β-farnesene traces, α-humulene (3.7%), *allo*-aromadendrene (0.5%), germacrene D (2.7%), α-selinene (0.9%), α-curcumene (1.4%), (*Z, E*)-α-farsenene (3.9%), β-bisabolene (1%), calamenene traces, δ-cadinene (2%), (*E,E*)-α-farsenene (2%,) **germacrene D 20 (25.1%)**, elemol (0.1%), (*E*)-nerolidol (0.1%), spathulenol (2%), caryophyllene oxide (2.2%), *epi* α-bisabolol (4.5%), torreyol (0.4%), γ-eudesmol (0.5%), α-cadinol (2.7%) and myristicine (2.3%) (Tchoumbougnang et al., 2009a).	
	Liana, April 2005, Western Region.	α-Thujene (0.3%), α-pinene (2.3%), camphene (0.1%), sabinene (0.9%), β-pinene (0.5%), myrcene (1.1%), α-phellandrene (1.2%), δ-3-carene (1.2%), α-terpinene traces, *p*-cymene traces, **limonene 11** (19.7%), β-phellandrene (0.4%), (*Z*)-β-ocimene (0.1%), γ-terpinene (0.1%), terpinolene (1.5%), linalool (1%), camphor traces, terpinen-4-ol (0.1%,) δ-elemene (0.7%), α-copaene (0.1%), β-cubebene traces, β-elemene (1.3%), β-caryophyllene (6.4%), β-gurjunene traces, α-bergamotene traces, (*E*)-β-farnesene (4.2%), (*Z*)-β-farnesene (0.1%), α-humulene (0.1%), germacrene D (1%), α-selinene (0.8%), γ-muurolene traces, α-curcumene (2.5%), β-zingiberene (1,6%), **(*Z, E*)-α-farsenene 21** (28.7%), β-bisabolene (4.2%), δ-cadinene (0.2%), (*E,E*)-α-farsenene (3.5%), germacrene B (0.1%), (*E*)-nerolidol (0.1%), caryophyllene oxide (0.1%), γ-eudesmol (1.5%), α-cadinol (0.1%) and myristicine (10.9%) (Tchoumbougnang et al., 2009a).	
	Fruit, May 2005, Central Region.	α-Pinene (1.8%), camphene (4.8%), β-pinene (9.2%), β-phellandrene (2.3%), δ-3-carene (2.2%), δ-limonene (0.9%), *p*-cymene (1.2%), α-copaene (1.5%), camphor (2%), **linalool 5** (41.8%), β-elemene (2.1%), caryophyllene (3.6%), aromadendrene (1.5%), isoborneol (2.4%), α-humulene (1.4%), α-terpineol (4.1%), γ-elemene (1.2%), **3,5-dimethoxytoluene 22** (10.9%), safrole (1.6%), caryophyllene oxide (1.6%), elemol (0.9%) and guaiol (1%) (Tankam and Ito, 2013).	Sedative activity (Tankam and Ito, 2013).
Piper nigrum	Fruits, April 2005, Western Region.	α-Thujene (1.8%), α-pinene (5.6%), camphene (0.1%), sabinene (11.2%), β-pinene (6.7%), myrcene (2.5%), α-phellandrene (4.5%), **δ-3-carene 23** (18.5%), α-terpinene (0.9%), *p*-cymene (0.7%), **limonene 11** (14.7%), (*E*)-β-ocimene (0.1%), γ-terpinene (1%), terpinolene (1.2%), sabinene hydrate (0.3%), linalool (0.7%), terpinen-4-ol (2%), α-terpineol (0.2%), δ-elemene (1.7%), β-cubebene (0.2%), α-copaene (1.4%), β-cubebene traces, β-elemene (1.3%), α-gurjunene (0.2%), β-caryophyllene (12.8%), α-bergamotene (0.2%), α-humulene (1.3%), allo-aromadendrene (0.2%), germacrene D (0.2%), α-selinene (2.2%), β-selinene (2.2%), β-bisabolene traces, calamenene (0.2%), δ-cadinene (0.6%), spathulenol traces, τ-cadinol (0.8%), α-cadinol (0.1%) and (*E,E*)farnesol (0.2%) (Tchoumbougnang et al., 2009a).	Antifungal (Ousman et al., 2007).
	Leaves, April 2005, Western Region.	Camphene traces, sabinene (3.5%), β-pinene (1.2%), δ-3-carene (0.3%), limonene (2.3%), (*E*)-β-ocimene (0.4%), linalool (2%), δ-elemene (6.4%), α-cubebene (1.4%), α-copaene (2.5%), β-cubebene traces, β-elemene (4.6%), α-gurjunene (3%), β-caryophyllene (8.9%), α-bergamotene (3.4%), (*Z*)-β-farnesene (1.2%), α-humulene (6.2%), allo-aromadendrene (2.4%), germacrene D (2.4%), **α-selinene 24 (**16.5%), **β-selinene 25 (**14.6%), β-bisabolene (1.4%), calamenene (0.9%), δ-cadinene (1.2%), (*E*)-nerolidol (2.3%), spathulenol traces, caryophyllene oxide (1.0), humulene oxide (0.8%), torreyol (2.6%), τ-cadinol (1.3%), α-cadinol (0.6%) and (*E,E*)-farnesol (3.9%) (Tchoumbougnang et al., 2009a).	Toxicity effect (Tchoumbougnang et al., 2009a).
	Stems, April 2005, Western Region.	Thujene (0.8%), α-pinene (2.1%), sabinene (2.8%), β-pinene (1.1%), myrcene (1.1%), α-phellandrene (2.8%), **δ-3-carene 23** (14.4%), α-terpinene (0.8%), *p*-cymene (0.5%), limonene (4.4%), (*E*)-β-ocimene (0.4%), γ-terpinene (1.2%), terpinolene (1%), linalool (1.9%), terpinen-4-ol (2.2%), α-terpineol (0.2%), δ-elemene (1.1%), α-cubebene (0.2%), α-copaene (0.4%), β-cubebene traces, β-elemene (1.5%), α-gurjunene (0.4%), **β-caryophyllene 10** (36%), α-bergamotene (1.2%), α-humulene (3.5%), allo-aromadendrene (0.7%), germacrene D (0.7%), α-selinene (6.5%), β-selinene (4.6%), β-bisabolene traces, calamenene (0.7%), δ-cadinene (0.4%), (*E*)-nerolidol (0.4%), caryophyllene oxide (1%), τ-cadinol (0.5%, α-cadinol (0.8%) and (*E,E*)-farnesol (0.9%) (Tchoumbougnang et al., 2009a).	
		6. Poaceae	
Cymbopogon citratus	Leaves, Yaoundé, April 1989.	**Mycrene 28** (12.8%), limonene (0.3%), linalool (1.2%), citronellol (0.1%), **neral 26** (33.5%), geraniol (2.5%, **geranial 27** (45.9%), geranyl acetate (0.2%) and 6-methyl-5-hepten-2-one (0.8%) (Chalchat et al., 1997).	Antiplasmodial, antimicrobial, toxicity effect, cytotoxicity (Akono et al., 2016 b, Tchoumbougnang et al., 2005)
	Leaves, Yaoundé, September 2002.	β-Pinene (10.5%), **myrcene 28** (16.2%), limonene (0.1%), (*Z*)-β-ocimene (0.4%), (*E*)-β-ocimene (0.5%), linalool (2.1%), camphor (0.1%), nerol (0.5%), citronellal (0.5%), **neral 26** (29.0%), linalyl acetate (3.3%), **geranial 27** (32.8%), thymol (0.2%), β-caryophyllene (0.1%), nerolidol (0.4%) and τ-cadinol (0.1%) (Tchoumbougnang et al., 2005).	

Table 1 (Continued)

	Leaves, Yaoundé, July 2003.	Sabinene (2.2%, myrcene (3.9%), limonene oxide (0.3%), (*Z*)-β-ocimene (0.3%), linalool (1.3%), methyl chavicol (0.8%), citronellal (0.5%), *trans*-pinocarvyl acetate (0.7%), **neral 26** (34.4%), **geranial 27** (49.8%), bornyl acetate (0.4%), neryl acetate (1.9%) and germacrene D (0.3%) (Nguefack et al., 2007b).	
	Leaves, Douala, April 2005.	α-Thujene traces, sabinene (0.9%), **myrcene 28** (14.0%), *p*-cymene (0.2%), β-phellandrene (0.3%), (*Z*)-β-ocimene (0.2%), (*E*)-β-ocimene (0.1%), terpinolene (0.1%), fenchone (0.1%), linalool traces, pinocarveol (0.4%), camphor (1.8%), borneol (2.0%), terpinene-4-ol (0.1%), α-terpineol traces, **neral 26** (21.9%), geraniol (15.6%), **geranial 27** (39.3%), geranyl acetate (0.1%), carvacrol (0.3%), δ-elemene (0.2%), α-cubebene (0.1%), α-ylangene traces, β-caryophyllene traces, α-guaiene (0.1%) and γ-muurolene (0.1%) (Tchoumbougnang et al., 2009b).	
	Leaves, Douala, June 2009.	**Myrcene 28** (11.43%), limonene (0.04%), (*Z*)-β-ocimene (0.27%), α-terpinene (0.22%), 1,8-cineole (0.22%), linalool (0.72%), isocitral (0.30%), (*E*)-chrysanthenal (0.17%), citronellal (0.15%), (*Z*)-chrysanthenol (1.17%), (*E*)-chrysanthenol (1.62%), **neral 26** (30.21%), geraniol (8.19%), **geranial 27** (32.82%), neryl acetate (0.46%), β-caryophyllene (0.05%)), *trans*-α-bergamotene (0.07%), eugenol (0.13%), 6-methyl-hept-5-en-2-one (0.96%), undecan-2-one (0.17%) and tridecan-2-one (0.10%) (Ntonga et al., 2014)	
	Leaves, Bafoussam, November 2009.	α-Pinene (0.1%), camphene (0.1%), myrcene (2.5%), *p*-cymene (0.5%), limonene (0.2%), linalool (1.1%), camphor (0.2%), borneol (0.2%), terpinen-4-ol (0.9%), **neral 26** (21.2%), geraniol (0.5%), **geranial 27** (37.7%), bornyl acetate (0.7%), neryl acetate (1.0%), geranyl acetate (0.4%), α-copaene (1.1%), γ-selinene (0.7%), β-caryophyllene (1.8%), α-humulene (1.2%), (*E*) α-bisabolene (0.7%), α-amorphene (0.2%), s-cadinene (0.3%), α-selinene (1.2%), germacrene D (1.3%), β-selinene (0.9%), δ-cadinene (1.0%), α-cadinene (0.3%), α-caryophyllene (1.6%), selina-6-en-4-ol (8.9%) and sesquiterpene alcohol (1.7%) (Nguefack et al., 2012).	
	Leaves Littoral, Ndogpassi, August 2014.	Eugenol (0.16%), **mycrene 28** (19.23%), limonene (0.02%), (*Z*)-β-ocimene (0.19%, γ-terpinene (0.35%), 1,8-cineole (0.45%), linalool (1.02%), isocitral (0.27%), citronellal (0.23%), (*Z*)-chrysanthenol (1.02%), (*E*)-chrysanthenol (1.45%), **neral 26** (32.78%), geraniol (7.23%), **geranial 27** (31.17%), neryl acetate (1.06%), β-caryophyllene (0.12%), (*E,E*)-α-bergamotene (0.03%), undecan-2-one (0.21%), tridecan-2-one (0.15%) and 6-methyl-hept-5-en-2-one (1.05%) (Akono et al., 2016b).	
	Leaves Cameroon in July 2012.	α-pinene (0.4%), sabinene (0.7%), (2*E*)-octene-2-ol (1.0%), mycrene (5.9%), limonene (0.6%), camphor (0.3%), borneol (0.4%), terpinen-4-ol (0.6%), α-terpineol (0.9%), linalol (1.0%), **neral 26** (34.4%), (2*E*)-decanal (0.5%), geraniol (1.8%), **geranial 27** (49.2%), geranyl acetate (0.4%), and germacrene (0.4%) (Voundi et al., 2015).	
Cymbopogon giganteus	Flowers, Waza-Park near Mora-City, Feb. 2005.	(*E*)-3-Hexenol (0.1%), (*Z*)-3-hexenol (0.1%), hexanol (0.2%), α-thujene (0.2%), sabinene (0.2%), *p*-cymene (0.2%), limonene (5.2%), benzyl alcohol (0.1%), *p*-cymenene (0.2%), *cis*-*p*-menth-2-en-1-ol (0.3%), linalool (0.2%), *trans*-*p*-mentha-2,8-dien-1-ol (17.3%), *trans*-*p*-menth-2-en-1-ol (0.4%), *cis*-*p*-mentha-2,8-dien-1-ol (8.3%), *trans*-limonene oxide (0.2%), camphor (0.6%), *trans*-verbenol (1.4%), 4-isopropenylcyclohex-2-enone (0.1%), *p*-methylacetophenone (0.3%), *cis*-verbenol (0.1%), nonanol (0.1%), 3,9-epoxy-mentha-1,8(9)-diene (0.7%), ***trans*-*p*-mentha-1(7),8-dien-2-ol 29** (24.9%), terpinen-4-ol (0.4%), α-terpineol (0.2%), isopulegone (1.3%), isopiperitenol I (1.8%), *p*-menthen-9-al (0.4%), isopiperitenol II (0.9%), verbenone (0.2%), *trans*-carveol (4.8%), ***cis*-*p*-mentha-1(7),8-dien-2-ol 30** (22.8%), *cis*-carveol (0.2%), carvone (1.8%), piperitone (0.1%), isoamyl hexanoate (0.5%), carvone oxide (0.2%), thymol (0.3%), isopiperitenone (0.3%), perillaldehyde (0.7%), perillyl alcohol (0.3%), β-caryophyllene (0.2%), α-humulene (0.1%), germacrene D (0.2%), caryophyllene oxide (0.1%), (*E*)-nerolidol (0.1%) and (*E,E*)-farnesol (0.1%) (Jirovetz et al., 2007).	Antimicrobial (Jirovetz et al., 2007).
	Leaves, Waza-Park near Mora-City, Feb. 2005.	(*E*)-3-Hexenol (0.1%), (*Z*)-3-hexenol (0.5%), (*E*)-2-hexenal (0.2%), (*Z*)-2-hexenol (0.1%), (*E*)-2-hexenol (0.2%), hexanol (0.1%), α-thujene (0.1%), sabinene (0.1%), 1-octen-3-ol (0.2%), *p*-cymene (0.1%), limonene (4.9%), (*E*)-β-ocimene (0.1%), *p*-cymenene (0.1%), *cis*-*p*-menth-2-en-1-ol (0.1%), linalool (0.1%), ***trans*-*p*-mentha-1(7),8-dien-2-ol 29** (22.1%), *trans*-*p*-menth-2-en-1-ol (0.1%), *cis*-*p*-mentha-2,8-dien-1-ol (5.4%), *trans*-limonene oxide (0.1%), camphor (0.5%, *trans*-verbenol (1.7%), *p*-methylacetophenone (0.9%), *cis*-verbenol (0.2%), nonanol (0.1%), 3,9-epoxy-mentha-1,8(9)-diene (0.3%), *trans*-*p*-mentha-1(7),8-dien-2-ol (21.6%), terpinen-4-ol (0.1%), isopulegone (0.1%), isopiperitenol I (2.2%), *p*-menthen-9-al (0.2%), isopiperitenol II (0.7%), verbenone (0.1%), *trans*-carveol (2.9%), ***cis*-*p*-mentha-1(7),8-dien-2-ol 30 (27.7%)**, *cis*-carveol (0.1%), carvone (0.9%), piperitone (0.2%), isoamylhexanoate (0.8%), carvone oxide (0.1%), thymol (0.1%), isopiperitenone (0.2%), perillaldehyde (0.2%), 2-undecanone (0.1%), perillyl alcohol (0.2%), eugenol (0.1%), isopulegone oxide (0.1%), β-caryophyllene (0.8%), α-humulene (0.5%), isoamyl octanoate (0.2%), germacrene D (0.1%), 2-tridecanone (0.1%), spathulenol (0.1%), caryophyllene oxide (0.3%), (*E*)-nerolidol (0.1%) and (*E,E*)-farnesol (0.2%) (Jirovetz et al., 2007).	

Table 1 (Continued)

	Stems, Waza-Park near Mora-City, Feb. 2005.	(*E*)-3-Hexenol (0.1%), (*Z*)-3-hexenol (0.1%), (*E*)-2-hexenal (0.1%), (*Z*)-2-hexenol (0.1%), α-thujene (0.1%), heptanol (0.2%), sabinene (0.1%), 1-octen-3-ol (0.2%), *p*-cymene (0.1%), limonene (1.3%), benzyl alcohol (0.1%), (*E*)-β-ocimene (0.1%), ***trans*-*p*-mentha-2,8-dien-1-ol 31** (21.4%), *cis*-*p*-mentha-2,8-dien-1-ol (4.6%), camphor (0.1%), *trans*-verbenol (1.4%), *p*-methylacetophenone (0.6%), *cis*-verbenol (0.3%), nonanol (1.6%), 3,9-epoxy-mentha-1,8(9)-diene (0.1%), ***trans*-*p*-mentha-1(7),8-dien-2-ol 29** (28.1%), terpinen-4-ol (0.3%), isopulegone (0.3%), isopiperitenol I (1.2%), *p*-menthen-9-al (0.1%), isopiperitenol II (0.3%), verbenone (0.2%), *trans*-carveol (2.6%), ***cis*-*p*-mentha-1(7),8-dien-2-ol 30** (29.1%), *cis*-carveol (0.2%), carvone (0.4%), isoamylhexanoate (0.3%), thymol (0.7%), isopiperitenone (0.1%), perillaldehyde (0.1%), 2-undecanone (0.9%), perillyl alcohol (0.1%), eugenol (0.4%), isopulegone oxide (0.1%), β-caryophyllene (0.1%), isoamyloctanoate (0.5%) and 2-tridecanone (0.5%) (Jirovetz et al., 2007).	
7. Putranjivaceae			
Drypetes gossweileri	Stem bark Yaoundé August 2013.	2,4-Dimethylthiophene (0.03%), diallyl sulphide (0.11%), allyl methyl disulphide (0.01%), *N,N´*-dimethyl thiourea (0.01%), benzaldehyde (0.28%), phenylacetaldehyde (0.06%), 2-propenyl propyl disulfide (0.02%), terpinolene (0.02%), phenylmethanol (0.01%), campholenol (0.03%), **benzylcyanide 14** (35.72%), dimethyl tetrasulfide (0.02%), **benzylisothiocyanate 13** (63.19%), germacrene D (0.02%), β-sesquiphellandrene (0.05%, benzyl sulfide (0.06%) and methyl linolenate (0.06%) (Ndoye et al., 2016).	Antioxidant activity Anti-inflammatory activity, Anti-denaturation Antimicrobial (Ndoye et al., 2016).
	The stem bark in Ntongo, Cameroon June 2011.	Benzylaldehyde (0.7%), **benzylcyanide 14** (12,6%) and **benzylisothiocyanate 13** (86.7%) (Voundi et al., 2015).	
8. Rutaceae			
Citrus aurantifolia	The pericarp of the ripe fruit, Edéa, Cameroon, March 2013.	Methylnaphthalene I (3.33%), α-thuyene (0.36%), α-pinene (2.46%), camphene (0.14%), sabinene (2.83%), **β-pinene 19** (24.88%), myrcene (0.15%), α-terpinene (0.26%), *p*-cymene (1.37%), **limonene 11** (46.84%), (*E*)-β-ocimene (0.33%), hydrated (*E*)-sabinene (5.44%), linalool (0.44%, terpinen-4-ol (0.10%), α-terpineol (1.35%), carveol (0.21%), nerol (0.36%), geraniol (2.59%), lynalyl acetate (0.39%), bicyclo-elemene (0.20%), β-elemene (0.10%), β-caryophyllene (0.51%), (*E,E*)-α-bergamotene (0.42%), β-bisabolene (0.63%), γ-cardinene (0.49%), octanal (1.08%) and decanal (1.73%) (Akono et al., 2015).	Anticancer, Antimalarial, antimicrobial (Akono et al., 2015), (Mirzaei-Najafgholi et al., 2017)
	The leaf	**Limonene 11** (47.2%), geraniol (9.8%), geranyl acetate (9.3%), linalool (6.7%), citral (5.2%), citronellal (4.9%), and *trans*-caryophyllene (3.9%) (Mirzaei-Najafgholi et al., 2017)	
Citrus limon	Pericarps Littoral, Mbanga, August 2014.	Methylnaphthalene/eugenol (0.07%), α-thuyene (0.12%, α-pinene (0.30%, δ-3-carene (0.17%, sabinene (4.23%), β-pinene (0.03%), β-phellandrene (0.08%), **limonene 11** (84.71%), (*E*)-β-ocimene (1.06%), α-terpinene (0.23%), *E*-sabinene hydrate (0.12%), linalool I oxide (0.03%), linalool (0.02%), limonene I oxide (0.06%), myrtenal (0.34%), α-pinene oxide (0.07%), γ-terpineol (0.37%), carvone (0.27%), carveol (0.11%), neral (0.08%), nerol (0.12%), lynalyl acetate (0.06%), geraniol (0.04%), bornyl acetate (0.05%), β-elemene (0.23%), β-caryophyllene (0.14%), (*E,E*) α-bergamotene (0.08%), bicyclogermacrene (0.05%), γ-cardinene (0.23%), globulol (0.06%) and octanal (2.07%) (Akono et al., 2016b).	Anticancer, Antimalarial, antimicrobial (Akono et al., 2016b, Voundi et al., 2015).
	The pericarp of the ripe fruit, Edéa, Cameroon, March 2013.	Methylnaphthalene I (0.12%), α-thuyene (0.03%), α-pinene (0.58%), sabinene (2.76%), β-pinene (0.19%), β-phellandrene (0.14%), δ-3-carene (0.05%), α-terpinene (0.15%), **limonene 11** (91.43%), (*E*)-β-ocimene (0.16%), hydrated (*E*)-sabinene (0.25%), linalool-1-oxide (0.08%), linalool (0.07%), α-pinene oxide (0.05%), limonene-1-oxide (0.02%), myrtenol (0.62%), γ-terpineol (0.30%), carvone (0.14%), carveol (0.03%), neral (0.03%), nerol (0.08%), geraniol (0.08%), lynalyl acetate (0.04%), bornyl acetate (0.01%), β-elemene (0.03%), β-caryophyllene (0.04%), (*E,E*)-α-bergamotene (0.11%), bicyclogermacrene (0.03%), γ-cardinene (0.14%), globulol (0.03%) and octanal (1.97%) (Akono et al., 2015).	
	The pericarp was Cameroon in July 2012.	α-Pinene (0.5%), sabinene (1.7%), β-pinene (2.7%), **limonene 11** (86.4%), terpinolene (0.4%), thujone (0.8%), terpinene-4-ol (3.0%), citronellol (1.3%), citral (0.3%), geraniol (0.3%), 2-undecanone (0.6%), carvacrol (0.8%), eugenol (0.2%), β-*trans*-caryophyllene (0.4%) and geranyl isobutanoate (0.5%) (Voundi et al., 2015).	
Citrus maxima	Leaves, forest area Cameroon, May/July 2015.	α-Pinene (0.91%), limonene (3%), octen-3-ol (7.71%), norboneol acetate (1.55%), camphor (0.65%), **iso-geranial 32** (10.04%), myrtenol (1.5%), verbenone (0.29%), nerol (7%), noneal (2.12%), 3-octenol propanoate (0.72%), carvacrol (0.69%), nonalactone (2.57%), dictamnol (2.91%), geranyl propanoate (0.53%), fokienol (1.35%), lyral (2.93%), elemol-acetate (0.6%), *E*-nerolidyl-acetate (0.96%), zerumbone (1.21%), catalponone (0.99%), β-elemene (3.62%), (*Z*)-β-farnesene (1.03%), α-corocalene (0.66%), acorenone B (8.46%), β-bisabolenal (3.02%), β-bisabolenol (1.53%), ***cis*-decahydro-naphthalene 33** (16.09%), pentyl-benzene (1.35%), *meta*-tolualdehyde (2.81%) and dictamine (0.69%) (Akono et al., 2016a).	Toxicity, antimicrobial, antimalarial (Akono et al., 2016a).

Table 1 (Continued)

	Pericarps Littoral, Mbanga, August 2014.	Methylnaphthalene I/eugenol (0.83%), α-pinene (0.26%), β-pinene (1.02%), myrcene (0.52%), **limonene 11** (90.7%), γ-terpinene (0.23%), *E*-sabinene hydrate (0.15%), linalool I oxide (0.53%), linalool II oxide (1.10%), linalool (0.51%), limonene I oxide (0.17%), α-terpineol (0.18%), α-pinene oxide (1.08%), γ-terpineol (0.42%), carveol (0.31%), nerol (0.02%), lynalyl acetate (0.04%), geraniol (0.27%), β-elemene (0.02%), β-caryophyllene (0.32%), germacrene D (0.15%), γ-cardinene (0.17%), decenol (0.03%) and nonanal (0.32%) (Akono et al., 2016b).	
Citrus medica	Leaves, forest area Cameroon, May/July 2015.	α-pinene (0.43%), furfuryl acetate (3.49%), α-terpinene (0.25%), ***Z*-β-ocimene 34** (33.03%), α-fenchocamphorone (2.76%,) citronellal (0.22%), pinocarvone (1.76%), iso-geranial (1.23%), bornyl acetate (4.49%), geraniol (13.36%), sabinyl acetate (5.23%), **neryl formate 35** (20.52%), isobornyl propanoate (5.01%), β-silphiperfolan-6-ol (0.2%), juniperol (0.63%), α-cubebene (2.04%), cyperene (0.45%), coumarin (2.34%), decanal (0.01%) and dodecanal (0.36%) (Akono et al., 2016a).	Cytoxicity, antimicrobial, antimalarial (Akono et al., 2016a, Nyegue et al., 2017).
	Pericarps Yaoundé October 2012.	**Limonene 11** (47.6%), **β-pinene 19** (18.2%), γ-terpinene (8.1%), terpinene-4-ol (4.3%) and linalool (3.1%) (Nyegue et al., 2017).	
Citrus reticulata	The pericarp of the ripe fruit, orchard in Edéa, Cameroon, March 2013.	Methylnaphthalene I (0.07%), α-thuyene (0.44%), α-pinene (1.31%), sabinene (0.16%), β-pinene (1.10%), myrcene (1.10%), β-phellandrene (0.29%), δ-3-carene (0.06%), α-terpinene (0.32%), **limonene 11** (76.14%), linalool-1-oxide (0.23%), linalool (0.71%), α-pinene oxide (0.05%), myrtenol (0.44%), γ-terpineol (0.80%), carveol (0.09%), neral (0.12%), bornyl acetate (0.08%), thymol (0.16%), santalene (0.80%), β-caryophyllene (0.06%), γ-cardinene (0.15%), octanal (1.54%) and **octanol 36** (14.14%) (Akono et al., 2015).	Cytoxicity, antimicrobial, antimalarial (Akono et al., 2016a, Nyegue et al., 2017).
	The pericarp was collected in Cameroon in July 2012.	α-Pinene (0.8%), sabinene (1.1%), β-pinene (1.1%), α-phellandrene (1.1%), **limonene 11** (74.8%), γ-terpinene (7.3%), thujone (1.4%), terpinen-4-ol (1.8%), citronellol (2.8%), *p*-menth-1-en-4-ol (0.4%,) menth-1-9-ol (0.9%), eugenol (1.9%), citronellyl acetate (1.0%) and β-ylangene (4.1%) (Voundi et al., 2015).	
Citrus sinensis	Leaves, forest area Cameroon, May/July 2015.	3-methyl cyclohexanol (1.21%), α-pinene (0.11%), **β-pinene 19** (20.69%), α-terpinene (7.45%), limonene (5.02%), *E*-β-ocimene (5.02%), **α-fenchocamphorone 37** (18.62%), α-campholene aldehyde (0.99%), **α-terpineol 38** (12.1%), α-terpineol (0.13%), citronellol (3.52%), genariol (1.37%), geranial (3.02%), nonenal (2.77%), thymol (0.65%), nonenol acetate (0.3%), 3-methylpentenoate (0.48%), *Z*-trimenal (2.96%), fokienol (0.25%), α-copaene (0.85%), β-copaene (1.82%), α-acoradiene (0.55%), δ-cadinene (0.76%), α-corocalene (0.14%), isoamyl geranate (0.4%), acorenone B (0.95%), eugenol (1.62%), spathulenol (0.21%), α-eudesmol (0.57%), β-bisabolenal (0.2%), pentyl-benzene (2.46%), cinnamyl-acetate (0.25%) and *meta*-tolualdehyde (1.51%) (Akono et al., 2016a).	Cytoxicity, antimicrobial, antimalarial (Akono et al., 2016a).
	Pericarps from ripe fruits, orchard in Edéa, Cameroon, March 2013.	Methylnaphthalene I (0.19%), α-pinene (0.43%), β-pinene (0.31%), myrcene (0.03%), β-phellandrene (0.08%), δ-3-carene (0.04%), α-terpinene (0.06%), **limonene 11** (94.92%), γ-terpinene (0.05%), hydrated (*E*)-sabinene (0.02%), linalool-1-oxide (0.08%), linalool (0.02%), carveol (0.04%), geraniol (0.13%), bornyl acetate (0.02%), β-bisabolene (0.03%), octanal (1.79%), decanal (0.12%) and decenol (0.06%) (Akono et al., 2015).	
	Pericarps from an orchard of the Littoral region of Cameroon, Mbanga, February 2014.	Methylnaphthalene/eugenol (0.22%), α-pinene (0.34%), δ-3-carene (0.15%), β-pinene (0.24%), myrcene (0.15%), β-phellandrene (0.03%), **limonene 11** (92.87%), α-terpinene (0.04%), γ-terpinene (0.02%), *E*-sabinene hydrate (0.01%), linalool I oxide (0.12%), linalool (0.04%), (*E*)-chrysanthenal (0.2%), (*E*)-chrysanthenol (1.05%), carveol (0.07%), geraniol (0.25%), bornyl acetate (0.07%), β-bisabolene (0.05%, octanal (1.07%), decenol (0.12%), decanal (0.07%) (Akono et al., 2016b).	
Clausena anisata	Leaves, Bafou, April 1999.	***trans*-Anethole 39** (80.77%), ***trans*-isoeugenolmethylether 40** (11.47%), α-terpinene (1.76%), myrcene (0.72%), sabinene (0.53%) and germacrene D (1.02%) (Tapondjou et al., 2002).	Antiparasitic, antimicrobial, toxicity effect (Tapondjou et al., 2002, Kamte et al., 2017, Yaouba et al., 2011, Ngassoum et al., 1999b).
	Leaves Bafou, Menoua Division, Western Cameroon.	Terpinen-4-ol traces, *p*-cymen-8-ol traces, α-terpineol traces, methyl chavicol (2.0%), (*Z*)-anethole (0.3%), *p*-anisaldehyde (0.7%), **(*E*)-anethole 39** (64.6%), carvacrol traces, α-elemene (0.1%), α-copaene traces, β-bourbonene (0.1%), β-elemene (0.1%), anisyl methyl ketone (0.1%), (*E*)-caryophyllene (0. 8%), methyl eugenol (0.3%), δ-elemene (0.1%), α-humulene (0.8%), germacrene D (2.2%), *ar*-curcumene traces, bicyclogermacrene (0.1%), benzaldehyde,3,4-dimethoxy- (0.2%), α-zingiberene (0.1%), **(*E*)-methyl isoeugenol 40** (16.1%), β-bisabolene (0.3%), (*E,E*)- α-farnesene (0.3%), γ-cadinene (0.1%), β-sesquiphellandrene traces, germacrene B (0.3%), spathulenol (0.1%), humulene epoxide II traces, epi-α-muurolol traces, α-cadinol traces (Kamte et al., 2017).	
	Leaf	**(*Z*)-Tagetenone 41** (26.8%), **(*E*)-tagetenone 42** (19.2%), (*E*)-nerolidol (11.5%) (Ngassoum et al., 1999b); ***trans*-anethole 39** (80.8%) and ***trans*-isoeugenolmethylether 40** (11.5%) (Ndomo et al., 2008); **(*E*)-ocimenone 42** (15.2%), **(*Z*)-ocimenone 41** (11.5%), **γ-terpinene 6** (11.4%) and **germacrene D 20** (10.9%) (Yaouba et al., 2011).	
	Seed	**(*Z*)-Tagetenone 41** (15.3%), **(*E*)-tagetenone 42** (14.8%) and **(*E*)-nerolidol 43** (10.3%) (Ngassoum et al., 1999b).	

Table 1 (Continued)

Vepris heterophylla	Leaves, Mokolo, 1984.	α-Thujene (0.4%), α-pinene (0.1%), **sabinene 18 (**14.0%), β-pinene (0.3%), mycrene (4.2%), α-phellandrene (0.1%), α-terpinene (0.8%), cymene (0.5%), limonene (4.3%), (*Z*)-β-ocimene (0.7%), **(*E*)-β-ocimene 44 (**14.0%), γ-terpinene (1.3%), terpinolene (1.6%), allo-ocimene (0.3%), pregeijerene (0.2%), *cis*-sabinene hydrate (0.11%), linalool (0.9%), *cis-p*-menth-2-en-l-ol (0.1%), *trans-p*-menth-2-en-1-ol traces, terpinen-4-ol (3.3%), α-terpineol (1.7%), methyl salicylate (0.2%), safrole (3.0%), neryl acetate traces, geranyl acetate traces, ethyl eugenol (0.3%), bicycloelemene traces, α-cubebene traces, α-ylangene (0.4%), α-copaene (0.3%), β-boubonene traces, β-elemene (0.8%), (*E*)-caryophyllene (3.1%), β-copalene (0.3%), γ-elemene traces, α-humulene (1.9%), acora 3(10),14-diene (0.1%), γ-muurolene (0.2%), germacrene D (3.4%), ledene (0.1%), γ-amorphene (0.4%), δ-amorphene (0.1%), γ-cadinene (0.1%), δ-cadinene (0.6%), β-cadinene (0.2%), cubebol (0.16%), **elemol 45 (**14.37%), caryophillene oxide (0.05%), **guaiol 46 (**12.85%), humulene epoxide II (0.11%),10-*epi*-γ-eudesmol (0.11%), γ-eudesmol (1.26%), β-eudesmol (0.73%), α-eudesmol + valerianol (1.78%), bulnesol (1.7%) (Ngamo et al., 2007b).	Antiparasitic, antimicrobial, toxicity effect (Ngamo et al., 2007b, Ngassoum et al., 2007).
	Leaves, Meri, 2006.	α-Thujene (0.4%), α-pinene (0.1%), **sabinene 18 (**19.1%), β-pinene (0.3%), mycrene (2.8%), α-phellandrene traces, α-terpinene (0.5%), cymene (0.2%), limonene (4.1%), (*Z*)-β-ocimene 0.5%), **(*E*)-β-ocimene 44** (9.2%), γ-terpinene (0.9%), terpinolene (1.3%), allo-ocimene (0.3%)), pregeijerene (0.2%), *cis*-sabinene hydrate (0.3%), linalool (0.6%), *cis-p*-menth-2-en-l-ol (0.1%), *trans-p*-menth-2-en-1-ol traces, terpinen-4-ol (2.1%), α-terpineol (1.2%), safrole (1.7%), neryl acetate traces, bicycloelemene traces, α-cubebene traces, α-ylangene (0.1%), α-copaene (0.1%), β-boubonene traces, β-elemene (0.6%), (*E*)-caryophyllene (1.7%), β-copalene (0.3%), α-humulene (1.2%), acora 3(10),14-diene traces, γ-muurolene traces, germacrene D (2.3%), ledene traces, γ-amorphene (0.4%), δ-amorphene traces, δ-cadinene traces, δ-cadinene (0.5%), β-cadinene (0.4%), germacrene D traces, cubebol (0.25%), **elemol 45 (**23.99%), caryophillene oxide (0.12%), **guaiol 46** (13.47%), humulene epoxide II (0.21%), 10-*epi*-γ-eudesmol (0.07%), γ-eudesmol (0.61%), α-muurolol (0.08%), β-eudesmol (0.7%), α-eudesmol + valerianol (1.63%) and bulnesol (1.59%) (Ngamo et al., 2007b).	
	Leaves, Maroua, December 2005.	α-Pinene (0.2%), **sabinene 18** (17.3%), myrcene (1.9%), cymene (p/o) (0.2%), limonene (4.0%), (*E*)-β-ocimene (10.2%), γ-terpinene (0.7%), terpinolene (1.4%), linalool (0.9%), terpinen-4-ol (1.5%), α-terpineol (1.2%), safrole (3.0%), (*E*)-caryophyllene (2.3%), germacrene D (1.6%), γ-amorphene (0.4%), δ-cadinene (3.2%), **elemol 45** (19.4%), **guaiol 46** (15.2%), humulene epoxide II (1.6%) and α-eudesmol + valerianol (1.1%) (Ngassoum et al., 2007).	
Zanthoxylum leprieurii	Fruit.	α-Pinene (0.21%), δ-3-carene (0.64%), *p*-cymene (0.40%), δ-limonene (3.94%), (*E*)-β-ocimene (2.51%), γ-terpinene (0.93%), **2,6-dimethyl-2,6-octadiene 47** (11.38%), santolina triene (0.23%), linalool (0.64%), isopulegol (2.23%), β-citronellal (6.51%), L-4-terpineol (3.57%), (*Z*)-carveol (0.36%), **(*R*)-(+)-β-citronellol 48 (**17.37%), (*E*)-citral (0.10%), geraniol (5.91%), terpinol hydrate (1.07%), **citronellic acid 49 (**15.99%), geranic acid (1.12%), geranyl acetate (2.77%), citronellyl acetate (0.66%), α-cubebene (0.29%), β-elemene (0.14%), β-cubebene (4.03%), α-zingiberene (0.69%), γ-cadinene (1.12%), γ-gurjunene (0.20%), nerolidol (0.59%), τ-muurolol (0.73%), γ-eudesmol (0.30%), τ-cadinol (0.51%), farnesol (0.27%), decanal (0.74%), eugenol (0.24%), cyclooctane (0.32%) and α-ionene (1.98%) (Gardini et al., 2009)	Anticancer, antimicrobial, (Gardini et al., 2009, Fogang et al., 2012, Misra et al., 2013, Ngassoum et al., 2007).
	Fruit, Dschang Dec. 2009.	α-Pinene (8.1%), camphene (0.1%), thuja-2,4(10)-diene traces, sabinene (0.2%), β-pinene (0.2%), **myrcene 28** (28.6%), α-phellandrene traces, *p*-cymene (0.1%), **limonene 11** (13.6%), (Z)-β-ocimene (0.8%), **(*E*)-β-ocimene 44** (29.4%), *n*-octanol (0.3%), rosefuran (0.7%), linalool (1.0%), perillene (1.0%), 1,5,8-*p*-menthatriene (0.1%), 3,5-heptadien-2-one,6-methyl (0.2%), (*E,E*)-2,6-dimethyl-1,3,5,7-octa-tetraene (0.1%), nopinone traces, *trans*-limonene oxide (0.4%), (*E*)-myroxide (0.8%), terpinen-4-ol (0.1%), α-terpineol (0.2%), myrtenol (0.7%), octanol acetate (0.8%), *trans*-carveol (0.4%), *cis*-carveol traces, citronellol (0.6%), carvone (0.3%), bornyl acetate (0.3%), myrtenyl acetate (2.2%), citronellyl acetate (0.2%), neryl acetate (0.1%), α-copaene (0.1%), *cis*-myrtanol acetate (0.1%), *trans*-myrtanol acetate (0.1%), (*E*)-caryophyllene (1.5%), α-humulene (0.3%), germacrene traces, β-selinene traces, β-bisabolene (0.1%), (*E,E*)-α-farnesene (0.1%), δ-cadinene traces, caryophyllene oxide (2.0%) and 8-heptadecene (0.1%) (Fogang et al., 2012).	
	Fruits, Douala, Dec. 2009.	β-Myrcene (0.16%), α-phellandrene (0.10%), δ-3-carene (0.11%), *p*-cymene (0.29%), limonene (0.26%), (*Z*)-β-ocimene (0.73%), **(*E*)-β-ocimene 44** (77.36%), γ-terpinene (0.07%), linalool oxide *cis* (0.14%), p-cresol (0.27%), terpinolene (0.84%), linalool (0.53%), *cis*-thujone (1.06%), fenchol endo (0.3%), alloocimene (0.07%), limonene oxide (0.24%), sabinol *trans* (0.56%), borneol (0.28%), pinocampheol (0.26%), menthol (0.09%), terpinen-4-ol (0.12%), α-terpineol (0.16%), methylchavicol (0.32%), *trans* pulegol (0.12%), nerol (0.12%), isobornylformate (0.08%), isogeijerene C (0.17%), geraniol (0.28%), carvacrol (0.59%), terpinyl acetate *trans*-dihydro-α (0.16%), α-cubebene (0.24%), eugenol (0.14%), β-cubebene (0.33%), β-elemene (0.16%), α-gurjunene (0.20%), α-*cis*-bergamotene (0.18%), γ-elemene (0.14%), β-humulene (0.27%), (*Z*)-β-farnesene (0.26%), α-humulene (0.16%), γ-	

Table 1 (Continued)

		muurolene (0.20%), germacrene D (0.07%), β-selinene (0.11%), α-selinene (0.10%), α-bulnesene (0.07%), γ-cadinene (0.22%), cadina-1,4-diene (0.75%), α-(*E*)-nerolidol (0.07%), spathulenol (0.13%), globulol (0.44%), viridiflorol (0.11%), guaiol (0.10%), γ-eudesmol (0.15%), α-cadinol (0.14%), bulnesol (0.10%), cadalene (0.09%), apiole (0.12%) and *n*-octadecane (0.12%) (Misra et al., 2013).	
Zanthoxylum xanthoxyloides	Fruit	(*S*)-α-Pinene (1.08%), β-thujene (1.06%), δ-limonene (4.82%), (*E*)-β-ocimene (1.92%), **2,6-dimethylocta-2,6-diene 47** (9.33%), linalool (1.31%), (*Z*)-rose oxide (0.73%), pinocarveol (0.69%), isopulegol (5.36%), β-citronellal (4.73%, L-4-terpineol (1.35%, ***(R)*-(+)-β-citronellol 48** (18.11%), geraniol (6.17%), terpinol hydrate (1.55%), geranyl acetate (5.89%), β-cubebene (0.82%), (-)-spathulenol (0.67%), τ-cadinol (1.10%), manoyl oxide (5.53%), farnesol (0.93%), 2,4-dimethyl-1,3-cyclopentanedione (2.56%) and α-ionene (1.32%) (Gardini et al., 2009).	Anticancer, antimicrobial, toxicity effect anaemia, (Gardini et al., 2009, Fogang et al., 2012, Misra et al., 2013).
	Fruit, Dschang December 2011.	α-Thujene (0.1%), α-pinene (1.3%), 5-hepten-2-one, 6-methyl traces, camphene (0.2%), sabinene (0.4%), β-pinene (0.3%), myrcene (1.8%), n-octanal (0.1%), α-terpinene traces, *p*-cymene (0.8%), limonene (5.5%), (*Z*)-β-ocimene traces, (*E*)-β-ocimene (0.8%), bergamal (0.6%), γ-terpinene traces, *cis*-linalool oxide (0.1%), *n*-octanol (0.7%), terpinolene traces, *m*-cymenene (0.1%), rosefuran (0.4%), linalool (2.0%), nonanal (0.1%), *cis*-rose oxide (1.3%), 1,3,8-*p*-menthatriene (0.2%), α-campholenal traces, *trans*-rose oxide (0.7%), isopulegol (3.7%), isoisopulegol (1.2%), citronellal (4.6%), borneol (0.2%), neoisopulegol (0.2%), terpinen-4-ol (2.6%), *p*-cymen-8-ol (0.1%), α-terpineol (0.4%), *cis* dihydrocarvone (0.4%), *n*-decanal (0.3%), octanol acetate traces, *trans*-carveol (0.6%), **citronellol 48** (29.9%), carvone (0.8%), **geraniol 30** (11.5%), geranial (0.6%), *n*-decanol (2.2%), citronellyl formate traces, bornyl acetate (0.2%), *n*-tridecane (3.9%), geranyl formate (0.7%), myrtenyl acetate (0.2%), α-cubebene (0.3%), citronellyl acetate (5.5%), α-copaene (0.3%), β-cubebene traces, geranyl acetate (1.3%), (*E*)-caryophyllene (0.1%), decyl acetate (0.1%), α-humulene traces, γ-muurolene traces, germacrene traces, *n*-dodecanol (0.2%), *n*-pentadecane (0.6%), β-bisabolene traces, δ-cadinene (0.2%), α-calacorene traces, elemol (0.1%), 1,5-epoxysalvial-4(14)-ene (0.2%), (*E*)-nerolidol (0.3%), spathulenol (0.6%), caryophyllene oxide (0.3%), salvial-4(14)-en-1-one (0.1%), τ-cadinol (0.1%), β-eudesmol (0.3%), (*E*)-citronellyl tiglate (0.1%), 8-heptadecene (1.7%) and *n*-heptadecane (0.2%) (Fogang et al., 2012).	
	Fruit, Douala, December 2009.	α-Thujene (0.24%), camphene (0.1%), sabinene (0.23%), β-pinene (0.08%), β-myrcene (0.50%), α-phellandrene (0.10%), *p*-cymene (2.00%), myrcenol (2.00%), limonene (1.00%), 1,8-cineole (0.07%), (*Z*)-β-ocimene (0.26%), (*E*)-β-ocimene (0.35%), γ-terpinene (0.40%), terpinolene (0.11%), linalool (1.50%), *cis*-thujone (0.12%), fenchol endo (2.50%), pinene hydratecis (0.06%), alloocimene (2.00%), limonene oxide (0.10%), *trans* sabinol (0.35%), isopulegol (3.00%), citronellal (2.25%), isoborneol (2.22%), borneol (0.09%), pinocampheol (0.19%), menthol (0.27%), terpinen-4-ol (2.00%), α-terpineol (0.09%), myrtenol (0.27%), methylchavicol (0.41%), *trans* pulegol (0.15%), nerol (0.07%), **β-citronellol 48** (40.00%), neral (1.00%), **geraniol 30** (9.00%), geranial (0.33%), safrole (0.07%), pregeijerene (0.20%), thymol (0.22%), carvacrol (0.12%), eugenol (0.08%), nerylacetate (0.80%), α-ylangene (0.09%), α-copaene (0.28%), β-bourbonene (0.70%), β-elemene (0.22%), longifolene (0.08%), **α-*cis*-bergamotene 50** (10.07%), β-gurjunene (0.07%), ***(Z)*-β-farnesene 21** (10.08%), α-humulene (0.10%), alloaromadendrene (0.07%), γ-muurolene (0.16%), germacrene D (0.16%), β-selinene (0.16%), α-selinene (0.12%), α-bulnesene (1.20%), β-bisabolene (0.11%), γ-cadinene (0.12%), δ-cadinene (1.00%), cadina-1,4-diene (0.08%), α-cadinene (0.14%), elemol (0.14%), (*E*)-nerolidol (1.00%), spathulenol (1.00%), globulol (0.54%), viridiflorol (0.13%), guaiol (0.21%), humulene epoxide (0.29%), 10-*epi*-γ-eudesmol (0.50%), dill apiole (0.11%), γ-eudesmol (0.40%), hinesol (0.13%), cubenol (0.42%), α-muurolol (0.42%), α-cadinol (1.00%), bulnesol (0.10%), cadalene (0.30%), apiole (3.00%), *epi*-α-bisabolol (0.19%), caryophyllene acetate (0.21%), *trans* farnesol (0.40%), *n*-octadecane (0.10%), (*Z,E*) farnesyl acetate (0.11%) and totarene (0.17%) (Misra et al., 2013).	
		9. Verbenaceae	
Lantana camara	Flowers and leaves, Ngaoundere,1998.	***ar*-Curcumene 51** (25%), **β-caryophyllene 10** (13%), caryophyllene epoxide (7%), sabinene (1-9%), α-pinene (2-4%), 1,8-cineole (1-3%) and linalool (1-3%) (Ngassoum et al., 1999a).	Insecticidal (Ngassoum et al., 1999a).
Lippia adoensis	Young leaves, Mbe Cameroon.	α-Pinene (0.404%), α-thujene (1.138%), β-pinene traces, sabinene (0.312%), 3-carene (0.107%), α-phellandrene traces, α-terpinene (1.327%), limonene (3.212%), β-phellandrene (0.361%), α-terpinene (6.419%), *Z*-ocimene (0.082%), ***p*-cymene 8** (13.854%), terpinolene (0.079%), fenchone (0.099%), 1-octen-3-ole (0.071%), *E*-limonen oxide (0.180%), *Z*-β-terpineole (0.190%), camphor (0.002%), linalool (0.377%,) 3-aminopyrazole (3.304%), caryophyllene (3.508%), terpinen-4-ol (0.628%), umbellulone (0.126%), β-farnesene (2.640%), α-caryophyllene (0.076%), *m*-*tert*-butylphenol (1.186%), β-cubebene (0.112%), verbenone (0.722%), carvone (1.883%), **thymol acetate 52** (15.207%), *para*-thymol (0.955%), piperitone (0.077%),	Antimicrobial (Akami et al., 2016).

Table 1 (Continued)

		caryophyllene oxide (0.389%), triacetin (9.131%), eugenol (0.079%), **thymol 53** (22.0147%), carvacrol (3.264%) (Akami et al., 2016).	
Lippia rugosa	Leaves, Ngaoundéré, 2008.	(*Z*)-3-hexanol (0.02%), (*E*)-1-hexen-3-ol (0.02%), hexanol (0.09%), 1-octen-3-ol (0.07%), camphene (0.05%), β-pinene (0.01%), mycrene (1.59%), *p*-cymene (0.01%), limonene (0.04%), (*Z*)-β-ocimene (0.03%), (*E*)-β-ocimene (0.02%), γ-terpinene traces, terpinolene (0.02%), 1,8-cineole (0.04%), (*Z*)-linalool oxide (furanoid) (0.03%), (*E*)-linalool oxide (furanoid) (0.06%), (*E*)-sabinene hydrate traces, citronellal (0.15%), linalool (4.56%), linalyl acetate (0.09%), citronellyl formate (0.24%), citronellyl acetate (0.06%), neral (1.14%), geranyl formate (0.08%), borneol traces, **nerol 54** (18.6%), **geranial 27** (10.4%), α-terpineol (0.08%), neryl acetate (0.14%), geranyl acetate (1.35%), citronellol (0.03%), **geraniol 30** (51.5%), isogeraniol (0.16%), β-bourbonene (0.04%), β-elemene (0.04%), β-caryophyllene (0.76%), (*E*)-β-farnesene (3.43%), α-cubebene (0.05%), bicyclogermacrene (0.09%), α-cadinene traces, germacrene D (1.16%), isocaryophyllene oxide (0.28%), caryophyleene oxide (0.12%), nerolidol (0.15%), τ-muurolol (0.29%) and farnesol (0.25%) (Tatsadjieu et al., 2009).	Antimicrobial (Tatsadjieu et al., 2009, Aoudou et al., 2011).
	Leaves, Ngaoundéré, March 2008.	α-Thujene (2.2%), α-pinene (0.6%), sabinene (0.6%), β-pinene (0.1%), mycrene (4.9%), α-phellandrene (1.9%), δ-3-carene (0.1%), α-terpinene (0.2%), ***p*-cymene 8** (15.5%), limonene (4.7%), (*E*)-β-ocimene (0.2%), (*Z*)-β-ocimene (0.2%), γ-terpinene (9.4%), terpinolene (0.2%), α-terpinolene (0.4%), linalool (2%), fenchone (0.4%), geraniol (1.7%), (*E*)-pinocarveol (0.1%), isoborneol (0.2%), terpene-4-ol (0.5%), myrtenol (0.2%), (*Z*)-ocimenone (1.1%), (*E*)-ocimenone (0.8%), carvone (2.3%), geranial (0.2%), **thymol 53** (26.7%), carvacrol (0.2%), **thymol acetate 52** (13.2%), carvacrol acetate (0.1%), eugenol (0.8%), β-carophyllene (4.2%), (*E*)-β-farnesene (2.3%), α-humulene (0.7%), germacrene D (0.2%), β-bisadolene (0.2%) and caryophyllene oxide (0.3%) (Aoudou et al., 2011).	
		10. Zingiberaceae	
Aframomum citratum	Seeds, Kribi, Dec. 1991.	α-Thujene (0.1%), α-pinene (0.2%), camphene (0.2%), sabinene (0.1%), β-pinene (0.1%), mycrene (1.5%), α-phellandrene (0.7%), δ-3-carene (0.1%), α-terpinene (0.1%), *p*-cymene (0.4%), limonene (0.7%), (*Z*)-β-ocimene (0.5%), terpinolene (0.3%), **linalool 5** (15.1%), α-terpineol (0.7%), nerol (0.3%), citronellol (0.1%), neral (0.1%), **geraniol 30** (70.0%), geranial (0.2%), geranyl acetate (0.3%) and 6-methyl-5-hepten-2-one (0.1%) (Chalchat et al., 1997).	Antimicrobial (Chalchat et al., 1997).
Aframomum dalzielii	Seeds, Fontem, Aug. 2008.	Myrcene (0.1%), β-phellandrene (0.1%), (*Z*)-β-ocimene (0.4%), (*E*)-β-ocimene (0.4%), 1,8-cineole (0.1%), linalool (0.1%), α-terpineol (0.3%), dihydrocarveol acetate (neoiso) (0.1%), (*Z*)-β-farnesene (0.3%), *ar*-curcumene (0.1%), (*E,E*)-α-farnesene 0.2%), β-bisabolene (0.1%), **(*E*)-nerolidol 43** (91.2%), α-bisabolol oxide (0.4%), α-bisabolol (0.3%), (*2E, 6E*)-farnesol (0.2%), (*2E,6E*)-farnesyl acetate (0.1%), *O*-guaiacol (0.2%), 2-phenylethyl acetate (0.5%), (*E*)-cinnamyl acetate (0.3%), 2-heptanol (0.1%), 2-heptylacetate (2.8%), acetyl acetate (0.1%) and decyl acetate (0.7%) (Nguikwie et al., 2013).	Antimicrobial (Nguikwie et al., 2013).
	Pericarp, Fontem, August 2008.	α-Thujene (0.3%), α-pinene (7.8%), camphene (0.1%), **sabinene 18 (**14.2%), **β-pinene 19 (**42.3%), myrcene (0.5%), α-terpinene (0.6%), p-cymene (0.5%), limonene (2.7%), γ-terpinene (1.3%), terpinolene (0.4%), **1,8-cineole 4** (10.6%), *cis*-sabinene hydrate (0.1%), linalool (2.6%), trans-sabinene hydrate (0.1%), *cis*-*p*-menth-2-en-1-ol (0.1%), pinocarvone (0.1%), terpinen-4-ol (4.2%), α-terpineol (0.1%), myrtenol (2.0%), myrtenyl acetate (0.5%), (E)-β-caryophyllene (4.8%), α-humulene (0.3%), selina-4,11-diene (0.1%), eremophyllene (0.1%), β-selinene (0.2%), caryophyllene oxide (1.3%) and α-selin-11-en-4-ol (1.6%) (Nguikwie et al., 2013).	
	Rhizome, Fontem, August 2008.	α-Thujene (0.4%), α-pinene (7.8%), camphene (0.1%), **sabinene 18** (22.9%), **β-pinene 19** (37.9%), myrcene (0.6%), *p*-cymene (0.3%), limonene (1.6%), γ-terpinene (0.3%), terpinolene traces, 1,8-cineole (3.2%), *cis*-sabinene hydrate (0.5%), linalool (1.3%), *trans*-sabinene hydrate (0.2%), α-campholenal (0.1%), *trans*-pinocarveol (0.2%), pinocarvone (0.1%), *cis*-pinocarveol (0,1%), terpinen-4-ol (0.6%), α-terpineol (0.3%), myrtenol (0.6%), cuminaldehyde (0.1%), α-terpinen-7-al (0.1%), *trans*-pinocarvyl acetate (0.1%), myrtenyl acetate (0.3%), α-copaene traces, β-elemene (0.1%), cyperene (0.9%), (*E*)-β-caryophyllene (6.4%), α-humulene (0.4%), selina-4,11-diene (0.4%), eremophyllene (0.3%), β-selinene (0.5%), viridiflorene (0.4%), (*E*)-nerolidol (0.3%), caryophyllene oxide (4.5%), humulene epoxide II (0.3%), caryophylla-4(12),8(13)-dien-5-ol (0.1%), α-selin-11-en-4-ol (3.0%) and cyperenone (0.1%) (Nguikwie et al., 2013).	
	Leaves, Fontem, August 2008.	α-Thujene traces, α-pinene (0.5%), camphene traces, sabinene traces, β-pinene **(**12 3.9%), *p*-cymene traces, limonene (0.2%), 1,8-cineole (0.1%), terpinen-4-ol traces, α-terpineol (0.3%), myrtenyl acetate traces, α-copaene traces, β-elemene (0.2%), α-gurjunene (0.4%), **(*E*)-β caryophyllene 10** (81.4%), α-humulene (4.3%), selina-4,11-diene (0.3%), eremophyllene (0.2%), β-selinene (0.2%), (*E,E*)-α-farnesene (0.1%), β-bisabolene (0.1%), viridiflorene (0.3%), (*E*)-nerolidol (0.3%), caryophyllene oxide (3.3%), humulene epoxide II (0.3%), caryophylla-4(12),8(13)-dien-5-ol (0.1%), α-selin-11-en-4-ol (1.1%), α-selin-3,11-dien-6-ol (0.1%) and α-bisabolol (0.1%) (Nguikwie et al., 2013).	

Table 1 (Continued)

Aframomum daniellii	Leaves Bamougoum Cameroon, western region.	α-Thujene (1.0%), α-pinene (2.4%), camphene traces, **sabinene 18** (43.9%), β-pinene (5.8%), mycrene (1.5%), α-phellandrene traces, α-terpinene (0.9%), *p*-cymene (1.0%), limonene (0.7%), 1,8-cineole (0.5%), (*E*)-β-ocimene (0.3%), γ-terpinene (1.9%), *cis*-sabinene hydrate (1.1%), terpinolene (0.4%), *trans*-sabinene hydrate (0.9%), linalool (1.8%), *cis*-*p*-menth-2-en-1-ol (0.2%), *trans*-*p*-menth-2-en-1-ol (0.1%), terpinen-4-ol (3.7%), α-terpineol (0.2%), myrtenal (0.1%), myrtenol (0.4%), *cis*-piperitol traces, trans-ascaridol glycol traces, isobornyl acetate traces, *trans*-sabinyl acetate traces, *cis*-pinocarvyl acetate (0.1%), myrtenyl acetate (1.9%), α-copaene (0.2%), β-bourbonene traces, β-cubebene traces, β-elemene traces, **(*E*)-caryophyllene 10** (16.6%), α-*trans*-bergamotene (0.1%), α-humulene (1.5%), (*E*)-β-farnesene traces, germacrene D (0.3%), selina-4,11-diene (0.1%), bicyclogermacrene (0.1%), (*Z*)-α-bisabolene (0.1%), β-bisabolene (0.9%), transcalamenene traces, δ-cadinene traces, hedycaryol (1.5%), (*E*)-nerolidol (0.7%), caryophyllene oxide (2.2%), guaiol (0.5%), humulene epoxide II (0.1%), 10-*epi*-γ-eudesmol (0.3%), eremoligenol (0.4%), α-eudesmol (0.4%), β-eudesmol (1.5%), caryophylla-4(12),8(13)-dien-5-ol (0.2%), α-eudesmol (0.5%), intermedeol (0.1%) and α-bisabolol (0.4%) (Pavela et al., 2016; Kamte et al., 2017).	larvicidal toxicity, amtimlarial, antiparasitic (Kamte et al., 2017; Pavela et al., 2016).
	Seeds Bamougoum western region of Cameroon.	α-Thujene traces, α-pinene (2.9%), camphene traces, sabinene (0.5%), **β-pinene 19** (11.2%), dehydro-1,8-cineole (0.3%), mycrene (0.3%), α-phellandrene (0.1%), α-terpinene (0.1%), *p*-cymene (0.7%, limonene (1.5%), **1,8-cineole 4** (48.8%), (*E*)-β-ocimene (0.1%), γ-terpinene (1.0%), terpinolene (0.1%), 2-methyl butyl-2-methyl butyrate traces, *trans*-pinocarveol traces, borneol traces, δ-terpineol (0.4%), *p*-mentha-1,5-dien-8-ol (0.4%), terpinen-4-ol (0.3%), **α-terpineol 38** (10.8%), myrtenol (0.1%), thymol, methyl ether traces, carvacrol, methyl ether (0.4%), thymol traces, carvacrol (0.1%), α-terpinyl acetate (0.2%), α-copaene (0.3%), β-cubebene traces, β-elemene (1.1%), cyperene (0.1%), (*E*)-caryophyllene (0.7%), α-*trans*-bergamotene (0.8%), α-guaiene (0.8%), α-humulene (0.3%), (*E*)-β-farnesene (0.1%), γ-gurjunene (0.7%), selina-4,11-diene (1.0%), β-selinene (1.0%), γ-muurolene (0.6%), α-bulnesene (1.2%), β-bisabolene (3.2%), δ-cadinene traces, (*E*)-nerolidol traces, guaiol traces, 10-*epi*-γ-eudesmol (0.7%), eremoligenol (0.2%), β-eudesmol (1.3%), α-eudesmol (0.2%), *neo*-intermedeol (0.2%) and intermedeol (0.4%) (Pavela et al., 2016).	
	Pericarps Bamougoum western region of Cameroon.	α-Thujene (0.5%), α-pinene (4.4%), camphene (0.6%), **sabinene 18** (11.7%), **β-pinene 19** (17.6%), mycrene (1.1%), δ-2-carene (0.1%), α-phellandrene (5.5%), δ-3-carene (0.2%), α-terpinene (0.5%), *p*-cymene ((2.6%), limonene (3.8%), 1,8-cineole (5.9%), (*Z*)-β-ocimene (0.3%), (*E*)-β-ocimene (1.5%), γ-terpinene (1.1%), *cis*-sabinene hydrate (0.7%), terpinolene (0.9%), trans-sabinene hydrate (0.7%), **linalool 5** (10.2%), *cis*-*p*-menth-2-en-1-ol (0.1%), *trans*-pinocarveol traces, geijerene (0.1%), camphor (1.0%), pinocarvone (0.1%), borneol (0.4%), terpinen-4-ol (2.3%), *cis*-pinocarveol (0.2%), myrtenal (0.7%), myrtenol (2.1%), geraniol (0.3%), isobornyl acetate (0.6%), carvacrol traces, *cis*-pinocarvyl acetate (0.2%), myrtenyl acetate (1.0%), δ-elemene (0.1%), α-terpinyl acetate (0.1%), α-copaene (0.1%), β-elemene (0.2%), cyperene (0.4%), (*E*)-caryophyllene (1.7%), α-humulene (0.3%), germacrene D (1.5%), selina-4,11-diene (0.1%), β-selinene (0.1%), bicyclogermacrene (0.2%), α-zingiberene (0.1%), β-bisabolene (0.5%), sesquicineole (0.3%), δ-cadinene (0.1%), hedycaryol (2.1%), (*E*)-nerolidol (0.1%), spatholenol (0.1%), caryophyllene oxide (0.6%), guaiol (0.7%), humulene epoxide II (0.1%), 10-epi-γ-eudesmol (0.3%), eremoligenol (0.1%), γ-eudesmol (0.6%), 1,10-di-epi-cubenol (2.2%), α-eudesmol (1.3%), *neo*-intermedeol (1.3%), intermedeo (1.8%), *epi*-β-bisabolol (0.1%), *epi*-α-bisabolol (0.2%), α-bisabolol (1.4%) and *n*-tricosane (0.1%) (Pavela et al., 2016).	
Aframomum letestuanum	Seeds, Mbouda, August 2008.	1,8-Cineole traces, linalool (2.2%), β-cubebene (0.5%), (*E*)-β-caryophyllene (0.2%), δ-cadinene (0.2%), **(*E*)-nerolidol 43** (88.0%), caryophyllene oxide (1.1%), humulene epoxide II (1.3%), α-bisabolol oxide (1.0%), (*2E,6E*)-farnesol traces, (*2E,6E*)-farnesyl acetate traces, 2-phenylethyl acetate (0.3%), 2-heptyl acetate (0.7%) and octyl acetate (0.8%) (Nguikwie et al., 2013).	Antimicrobial, antiparasitic (Nguikwie et al., 2013, Kamte et al., 2017).
	Pericarp, Mbouda, August 2008.	α-Thujene (0.9%), α-pinene (6.4%), sabinene (0.8%), **β-pinene 19** (38.5%), myrcene traces, α-terpinene traces, *p*-cymene (1.2%), limonene (2.5%), γ-terpinene (0.4%), 1,8-cineol 4 (11.2%), *cis*-sabinene hydrate (0.7%), linalool 5 (10.1%), *trans*-pinocarveol (1.9%), pinocarvone (0.8%), terpinen-4-ol (0.8%), α-terpineol (0.8%), myrtenol (2.7%), α-terpinen-7-al (0.2%), *trans*-pinocarvyl acetate (0.3%), *cis*-pinocarvyl acetate (0.1%), myrtenyl acetate (2.6%), (*E*)-β-caryophyllene (0.4%), (*E*)-nerolidol (0.3%), caryophyllene oxide (8.9%), humulene epoxide II (0.4%), caryophylla-4(12),8(13)-dien-5-ol (1.5%), α-selin-11-en-4-ol (1.4%) and α-selin-3,11-dien-6-ol (2.1%) (Nguikwie et al., 2013).	

Table 1 (Continued)

Aframomum daniellii	Leaves Bamougoum Cameroon, western region.	α-Thujene (1.0%), α-pinene (2.4%), camphene traces, **sabinene 18** (43.9%), β-pinene (5.8%), mycrene (1.5%), α-phellandrene traces, α-terpinene (0.9%), *p*-cymene (1.0%), limonene (0.7%), 1,8-cineole (0.5%), (*E*)-β-ocimene (0.3%), γ-terpinene (1.9%), *cis*-sabinene hydrate (1.1%), terpinolene (0.4%), *trans*-sabinene hydrate (0.9%), linalool (1.8%), *cis*-*p*-menth-2-en-1-ol (0.2%), *trans*-*p*-menth-2-en-1-ol (0.1%), terpinen-4-ol (3.7%), α-terpineol (0.2%), myrtenal (0.1%), myrtenol (0.4%), *cis*-piperitol traces, trans-ascaridol glycol traces, isobornyl acetate traces, *trans*-sabinyl acetate traces, *cis*-pinocarvyl acetate (0.1%), myrtenyl acetate (1.9%), α-copaene (0.2%), β-bourbonene traces, β-cubebene traces, β-elemene traces, **(*E*)-caryophyllene 10** (16.6%), α-*trans*-bergamotene (0.1%), α-humulene (1.5%), (*E*)-β-farnesene traces, germacrene D (0.3%), selina-4,11-diene (0.1%), bicyclogermacrene (0.1%), (*Z*)-α-bisabolene (0.1%), β-bisabolene (0.9%), transcalamenene traces, δ-cadinene traces, hedycaryol (1.5%), (*E*)-nerolidol (0.7%), caryophyllene oxide (2.2%), guaiol (0.5%), humulene epoxide II (0.1%), 10-*epi*-γ-eudesmol (0.3%), eremoligenol (0.4%), α-eudesmol (0.4%), β-eudesmol (1.5%), caryophylla-4(12),8(13)-dien-5-ol (0.2%), α-eudesmol (0.5%), intermedeol (0.1%) and α-bisabolol (0.4%) (Pavela et al., 2016; Kamte et al., 2017).	larvicidal toxicity, amtimlarial antiparasitic (Kamte et al., 2017, Pavela et al., 2016).
	Seeds Bamougoum western region of Cameroon.	α-Thujene traces, α-pinene (2.9%), camphene traces, sabinene (0.5%), **β-pinene 19** (11.2%), dehydro-1,8-cineole (0.3%), mycrene (0.3%), α-phellandrene (0.1%), α-terpinene (0.1%), *p*-cymene (0.7%, limonene (1.5%), **1,8-cineole 4** (48.8%), (*E*)-β-ocimene (0.1%), γ-terpinene (1.0%), terpinolene (0.1%), 2-methyl butyl-2-methyl butyrate traces, *trans*-pinocarveol traces, borneol traces, δ-terpineol (0.4%), *p*-mentha-1,5-dien-8-ol (0.4%), terpinen-4-ol (0.3%), **α-terpineol 38** (10.8%), myrtenol (0.1%), thymol, methyl ether traces, carvacrol, methyl ether (0.4%), thymol traces, carvacrol (0.1%), α-terpinyl acetate (0.2%), α-copaene (0.3%), β-cubebene traces, β-elemene (1.1%), cyperene (0.1%), (*E*)-caryophyllene (0.7%), α-*trans*-bergamotene (0.8%), α-guaiene (0.8%), α-humulene (0.3%), (*E*)-β-farnesene (0.1%), γ-gurjunene (0.7%), selina-4,11-diene (1.0%), β-selinene (1.0%), γ-muurolene (0.6%), α-bulnesene (1.2%), β-bisabolene (3.2%), δ-cadinene traces, (*E*)-nerolidol traces, guaiol traces, 10-*epi*-γ-eudesmol (0.7%), eremoligenol (0.2%), β-eudesmol (1.3%), α-eudesmol (0.2%), *neo*-intermedeol (0.2%) and intermedeol (0.4%) (Pavela et al., 2016).	
	Pericarps Bamougoum western region of Cameroon.	α-Thujene (0.5%), α-pinene (4.4%), camphene (0.6%), **sabinene 18** (11.7%), **β-pinene 19** (17.6%), mycrene (1.1%), δ-2-carene (0.1%), α-phellandrene (5.5%), δ-3-carene (0.2%), α-terpinene (0.5%), *p*-cymene ((2.6%), limonene (3.8%), 1,8-cineole (5.9%), (*Z*)-β-ocimene (0.3%), (*E*)-β-ocimene (1.5%), γ-terpinene (1.1%), *cis*-sabinene hydrate (0.7%), terpinolene (0.9%), trans-sabinene hydrate (0.7%), **linalool 5** (10.2%), *cis*-*p*-menth-2-en-1-ol (0.1%), *trans*-pinocarveol traces, geijerene (0.1%), camphor (1.0%), pinocarvone (0.1%), borneol (0.4%), terpinen-4-ol (2.3%), *cis*-pinocarveol (0.2%), myrtenal (0.7%), myrtenol (2.1%), geraniol (0.3%), isobornyl acetate (0.6%), carvacrol traces, *cis*-pinocarvyl acetate (0.2%), myrtenyl acetate (1.0%), δ-elemene (0.1%), α-terpinyl acetate (0.1%), α-copaene (0.1%), β-elemene (0.2%), cyperene (0.4%), (*E*)-caryophyllene (1.7%), α-humulene (0.3%), germacrene D (1.5%), selina-4,11-diene (0.1%), β-selinene (0.1%), bicyclogermacrene (0.2%), α-zingiberene (0.1%), β-bisabolene (0.5%), sesquicineole (0.3%), δ-cadinene (0.1%), hedycaryol (2.1%), (*E*)-nerolidol (0.1%), spatholenol (0.1%), caryophyllene oxide (0.6%), guaiol (0.7%), humulene epoxide II (0.1%), 10-epi-γ-eudesmol (0.3%), eremoligenol (0.1%), γ-eudesmol (0.6%), 1,10-di-epi-cubenol (2.2%), α-eudesmol (1.3%), *neo*-intermedeol (1.3%), intermedeo (1.8%), *epi*-β-bisabolol (0.1%), *epi*-α-bisabolol (0.2%), α-bisabolol (1.4%) and *n*-tricosane (0.1%) (Pavela et al., 2016).	
Aframomum letestuanum	Seeds, Mbouda, August 2008.	1,8-Cineole traces, linalool (2.2%), β-cubebene (0.5%), (*E*)-β-caryophyllene (0.2%), δ-cadinene (0.2%), **(*E*)-nerolidol 43** (88.0%), caryophyllene oxide (1.1%), humulene epoxide II (1.3%), α-bisabolol oxide (1.0%), (*2E,6E*)-farnesol traces, (*2E,6E*)-farnesyl acetate traces, 2-phenylethyl acetate (0.3%), 2-heptyl acetate (0.7%) and octyl acetate (0.8%) (Nguikwie et al., 2013).	Antimicrobial, antiparasitic (Nguikwie et al., 2013, Kamte et al., 2017).
	Pericarp, Mbouda, August 2008.	α-Thujene (0.9%), α-pinene (6.4%), sabinene (0.8%), **β-pinene 19** (38.5%), myrcene traces, α-terpinene traces, *p*-cymene (1.2%), limonene (2.5%), γ-terpinene (0.4%), 1,8-cineol 4 (11.2%), *cis*-sabinene hydrate (0.7%), linalool 5 (10.1%), *trans*-pinocarveol (1.9%), pinocarvone (0.8%), terpinen-4-ol (0.8%), α-terpineol (0.8%), myrtenol (2.7%), α-terpinen-7-al (0.2%), *trans*-pinocarvyl acetate (0.3%), *cis*-pinocarvyl acetate (0.1%), myrtenyl acetate (2.6%), (*E*)-β-caryophyllene (0.4%), (*E*)-nerolidol (0.3%), caryophyllene oxide (8.9%), humulene epoxide II (0.4%), caryophylla-4(12),8(13)-dien-5-ol (1.5%), α-selin-11-en-4-ol (1.4%) and α-selin-3,11-dien-6-ol (2.1%) (Nguikwie et al., 2013).	

Table 1 (Continued)

	Leaves, Mbouda, August 2008.	α-Thujene traces, α-pinene (2.2%), **β-pinene 19** (13.4%), limonene (0.3%), linalool (0.3%), α-campholenal (0.1%), pinocarvone (0.2%), terpinen-4-ol (0.1%), α-terpineol (0.4%), myrtenyl acetate (0.3%), α-copaene (0.1%), β-elemene traces, cyperene (0.5%), **(*E*)-β-caryophyllene 10** (18.4%), (*Z*)-β-farnesene (0.1%), **α-humulene 55** (12.4%), γ-muurolene (0.2%), selina-4,11-diene (0.1%), eremophyllene (0.5%), β-selinene (0.3%), (*E*)-nerolidol (1.3%), **caryophyllene oxide 7** (23.7%), **humulene epoxide II 56** (10.0%), caryophylla-4(12),8(13)-dien-5-ol (0.5%), α-bisabolol oxide (0.4%), α-selin-11-en-4-ol (2.9%), α-bisabolol (1.4%), cyperenone (0.7%), (*2E,6E*)-farnesol (0.2%) and (*2E,6E*)-farnesyl acetate (0.7%) (Nguikwie et al., 2013).	
	Rhizome, Mbouda, August 2008.	α-Thujene (0.6%), α-pinene (5.9%), **sabinene 18** (11.6%), **β-pinene 19** (32.9%), myrcene (0.5%), α-terpinene (1.1%), *p*-cymene (0.5%), limonene (2.2%), (*Z*)-β-ocimene (0.1%), γ-terpinene (2.0%), terpinolene (0.6%), 1,8-cineole (4.3%), *cis*-sabinene hydrate (0.6%), linalool (4.8%), pinocarvone (0.3%), α-terpineol (3.5%), myrtenol (2.0%), verbenone (0.3%), cuminaldehyde (0.3%), myrtenyl acetate (1.1%), cyperene (4.9%), (*E*)-β-caryophyllene (2.9%), (*Z*)-β-farnesene (0.1%), α-humulene (2.1%), selina-4,11-diene (0.9%), eremophyllene (0.4%), β-selinene (0.7%, viridiflorene (0.4%), caryophyllene oxide (2.9%), humulene epoxide II (1.7%), α-selin-11-en-4-ol (3.1%), α-bisabolol (0.6%) and cyperenone (0.4%) (Nguikwie et al., 2013).	
Afromomum melegueta	Seeds Foumbam (western Cameroon) in December 2015.	Isopentyl acetate traces, 2-methyl buty acetate traces, 2-heptanone traces, 2-heptanol (0.2%), α-thujene traces, α-pinene (2.0%), α-fenchene (0.1%), camphene (0.3%), sabinene traces, β-pinene (7.1%), dehydro-1,8-cineole (0.1%), myrcene (0.2%), α-phellandrene (0.3%), α-terpinene (0.3%), *p*-cymene (1.1%), limonene (1.5%), **1,8-cineole 4** (58.5%), (*E*)-β-ocimene (0.1%), γ-terpinene (0.9%), terpinolene (0.8%), α-cymenene (0.2%), 2-nonanone traces, linalool traces, n-nonanal traces, *endo*-fenchol (0.3%), α-campholenal traces, *trans*-pinocarveol (0.2%), *cis*-β-terpineol traces, pinocarvone traces, borneol (0.2%), *p*-mentha-1,5-dien-8-ol (1.1%), terpinene-4-ol (1.4%), *cis*-pinocarveol traces, cryptone traces, *p*-cymen-8-ol traces, **α-terpineol 38** (19.4%), myrtenal (0.2%), myrtenol (0.2%), γ-terpineol traces, *trans*-carveol traces, *cis*-carveol traces, thymol methyl ether traces, carvone traces, carvacrol methyl ether traces, (*E*)-cinnamaldehyde traces, phellandral (0.1%), thymol (0.1%), carvacrol (0.5%), α-terpinyl acetate traces, (*E*)-caryophyllene traces, isoamyl benzoate traces, α-humulene traces, β-selinene traces, 7-*epi*-α-selinene traces, 10-*epi*-γ-eudesmol traces, γ-eudesmol traces, β-eudesmol (0.2%), α-bisabolol traces and *n*-tricosane (0.1%) (Kamte et al., 2017).	
Aframomum pruinosum	Seeds, Mbouda, March 2008.	(*E*)-β-Ocimene (1.6%), 1,8-cineole (0.3%), *cis*-sabinene hydrate (0.1%), (*Z*)-β-farnesene (0.7%), *ar*-curcumene (0.3%), (*E,E*)-α-farnesene (0.3%), β-bisabolene (0.3%), **(*E*)-nerolidol 43** (95.1%), α-bisabolol (0,5%), (*2E, 6E*)-farnesol (0.3%) and octyl acetate (0.2%) (Nguikwie et al., 2013).	
	Pericarp, Mbouda, March 2008.	α-Thujene (0.7%), α-pinene (5.9%), camphene traces, sabinene (2.9%), **β-pinene 19** (29.0%), myrcene traces, *p*-cymene (4.0%), limonene (7.0%), **1,8-cineole 4** (14.0%), α-campholenal (0.6%), *cis*-*p*-menth-2-en-1-ol (1.7%), *trans*-pinocarveol (0.7%), pinocarvone (0.9%), *cis*-pinocarveol traces, terpinen-4-ol (4.6%), α-terpineol (4.4%), myrtenol (1.7%), cuminaldehyde (0.5%), *trans*-pinocarvyl acetate (0.3%), *cis*-pinocarvyl acetate (0.5%), myrtenyl acetate (1.5%), 4-terpinyl acetate (1.3%), α-terpinyl acetate 0.4%), dihydrocarveol acetate (neoiso) (0.3%), α-copaene (0.4%), β-elemene (0.2%), α-humulene (0.4%), (*E*)-nerolidol (0.3%), caryophyllene oxide (9.0%), humulene epoxide II (0.3%), caryophylla-4(12),8(13)-dien-5-ol (0.3%), α-bisabolol oxide (0.8%), α-selin-11-en-4-ol (0.2%), α-bisabolol (1.2%), (*2E, 6E*)-farnesyl acetate (0.9%) and 2-phenylethyl acetate (0.4%) (Nguikwie et al., 2013)	
	Leaves, Mbouda, March 2008.	α-Pinene (3.9%), camphene (1.1%, sabinene (0.3%), **β-pinene 19** (27.8%), limonene (0.4%), 1,8-cineole (0.2%), terpinen-4-ol (0.2%), α-terpineol (0.2%), myrtenol (0.4%), myrtenyl acetate (0.2%), β-elemene (0.1%), cyperene (0.4%), α-gurjunene (0.4%), **(*E*)-β-caryophyllene 10** (47.7%), α-humulene (3.0%), selina-4,11-diene (0.3%), δ-cadinene (0.1%), (*E*)-nerolidol (0.4%), caryophyllene oxide (6.2%), humulene epoxide II (0.2%), caryophylla-4(12),8(13)-dien-5-ol (0.3%), α-selin-11-en-4-ol (2.1%) and α-bisabolol (0.6%) (Nguikwie et al., 2013).	
	Rhizome, Mbouda, March 2008.	α-Thujene (1.9%), α-pinene (5.2%), sabinene (9.8%), **β-pinene 19 (**34.3%), myrcene traces, α-terpinene (0.5%), p-cymene (2.7%), limonene (1.5%), γ-terpinene (1.2%), terpinolene (0.5%), 1,8-cineole (2.5%) and linalool (5.5%), *trans*-sabinene hydrate (0.8%), *trans*-pinocarveol (1.7%), pinocarvone (0.8%), terpinen-4-ol (3.1%), α-terpineol (0.7%), myrtenol (3.7%), myrtenyl acetate (3.0%), cyperene (4.4%), (*E*)-β-caryophyllene (0.8%), caryophyllene oxide (1.0%), humulene epoxide II (1.3%), caryophylla-4(12), 8(13)-dien-5-ol (1.1%), α-selin-11-en-4-ol (1.1%) and cyperenone (0.6%) (Nguikwie et al., 2013).	
Curcuma longa	Rhizomes, 2008.	α-Phellandrene (3.95%), *p*-cymene (0.58%), terpinolene (0.43%), 1,8-cineole (2.79%), (*Z, E*)-α-farnesene (0.50%), β-cubebene (1.96%), zingiberene (3.46%), α-bisabolene (0.34%), δ-cadinene (2.32%), **tumerone 57** (43.09%), ***ar*-tumerone 58** (17.63%), **curlone 59** (17.47%), caryophyllene oxide (0.48%) *p*-*tert*-octylphenol (0.74%) and sotolon (0.43%) (Gardini et al., 2009).	Antimicrobial (Gardini et al., 2009*)*.

Table 1 (Continued)

Zingiber officinale	Rhizome, Meiganga, July 2009.	Percentages of compounds not reported. α-pinene, camphene, β-myrcene, 6-methylhept-5-en-2-one, limonene, sabinene, cineole, nonan-2-one, linalol, citronellal, α-terpineol, neral, geranial, nerol, tridecan-2-one, 1-(1,5-dimethylhex-4-enyl)-4-methylbenzene, α-zingiberene, β-bisabolene and (*E*)-β-farnesene, nerolidol B (percentages of compounds were not reported) (Talla et al., 2013).	Antimicrobial, anticancer, cytotoxicity (Lee, 2016, Nguefack et al., 2004a,b, Santos et al., 2016).
	Rhizomes Yaounde, Cameroon February 2012.	α-Pinene (2.6%), α-thujene (0.7%), **camphene 60** (9.6%), β-pinene (0.3%), α-phellandrene (1.1%), mycrene (0.3%), α-terpinene (0.3%), 1,8-cineole (7.0%), limonene (3.7%), linalool (2.2%,) methylthiopyrazine (0.7%), cryptone (0.7%), borneol (0.2%), decanal (0.3%), terpinen-4-ol (3.6%), α-terpineol (0.5%), citronellol (1.2%), **neral 26 (15.0%)**, pinane-2,3-epoxy (1.0%), geraniol (1.1%), ***p*-menth-1-en-4-ol 61** (23.2%), geranial (0.8%), thymol (0.9%), γ-muurolene (3.1%), α-zingiberene (7.6%), cardinene (0.7%), α-sesquiphellandrene (1.9%), *cis*-nerolidol (1.6%), elemol (3.2%), *trans*-sesquisabinene hydrate (0.7%), β-bisabolol (0.5%) and zingiberenol (0.3%) (Voundi et al., 2015).	

Common names

Neem (English), margosa, margose, Lilas des Indes; nîm; arbre à Djèkoudadjo (French), tubabo toboro = jujube (fruit) of the European (Cameroon).

Fig. 2. The photograph of the leaves, fruits and flower of *Azadirachta indica* A. Juss.

Common names

Scarlet bottlebrush, lemon bottlebrush or red bottlebrush, crimson bottlebrush (English), Zylinderputzer, Pfeifenputzer, Flaschenputzer (German), rince-bouteilles, plante goupillon (French).

Fig. 3. The photograph of the flower of *Callistemon citrinus* (Curtis) Skeels.

bark is used as vermifuge and for the treatment of veneral diseases (Burkill, 1985).

3.1.1.2. Bioactivities

3.1.1.2.1. Leaves

Leaf essential oil was assayed against the parasite *Trypanosoma brucei brucei* TC 221 causing African sleeping sickness, resulting in an IC_{50} of 15.21 µg/mL, compared to the positive control suramin with 0.0286 µg/mL. Low toxocity in mouse embryonic fibroblast cell line Balb/3T3 was recorded with >100 µg/mL, leading to a favourable selectivity index (SI) of > 6.57 (Kamte et al., 2017).

3.1.1.2.2. Seeds

The seed essential oil was tested by 2,2'-dipphenyl-1-picrylhydrazyl (DPPH), 2,2-azinobis-(3-ethylbenzothiazolin-6-sulfonic acid) diammonium salt (ABTS), lipid peroxyl (LP) and nitric oxide (NO) radicals scavenging assay giving IC_{50} of 1.50, 3.01, 0.98 and 0.82 mg/mL, respectively, compared to the postive controls vitamin C and β-carotene displaying 1.60, 1.2, 1.02, 1.18 and 1.27, 0.97, 0.90, 0.93, respectively. Interestingly, in scavenging DPPH radical, the IC_{50} showed that antioxidant activity is comparable to vitamin C and β-carotene (Okoh et al., 2015). In adult mortality assay employing seed essential oil against the cowpea weevil *Callosobruchus maculatus*, 100% mortality was reached at 6 mL of oil/kg cowpea seeds, while for the maize weevil *Sitophilus zeamais*, 96.25 and 100% mortality was recorded at 6 mL of oil/kg maize seeds for those dried ion the shade or sun, respectively. 100% progeny inhibition for *Callosobruchus maculatus* and *Sitophilus zeamais* were received for both insects at 2 g/kg sun-dried seed kernel oil (Tofel et al., 2017).

3.2. Myrtaceae

3.2.1. *Callistemon citrinus* (Curtis) Skeels

3.2.1.1. Traditional use

In Cameroon, leaves are used to protect stored food products (Sameza et al., 2016). The plant is known for its anti-cough, anti-bronchitis and insecticidal effects, and its volatile oil is used as antimicrobial and antifungal agent (Anonymous, 1956; Chopra et al., 1956; Kirtikar and Basu, 1975). Aerial parts (Fig. 3) are used in ethnic tribal communities (Shinde et al., 2012). It is further used to treat conditions like gastrointestinal distress, pain, and infections from bacteria, fungi, viruses and parasites (Goyal et al., 2012).

3.2.1.2. Bioactivities

3.2.1.2.1. Leaves

In a controlled field trial, the leaf essential oil applied to rice seeds of the variety Tox 3145-34-3-2 resulted in 71.0% emergence of plants, compared to 65.4% emergence after treatment with the synthetic product carbenzadim + chlorothalonil® and 34.0% emergence for untreated rice, all recorded one month after nursery. Final total production was 15.5 kg, 14.9 kg and 7.4 kg, respectively. In addition, seed treatment with the oil increased emergence of plants significantly for rice varieties IR 7167-33-2-3 and Nericea (Nguefack et al., 2007a); the oil when given on rice seeds reduced infection with the plant pathogen fungus *Bipolaris oryzae* to 15-0%; increased germination of an irrigated rice cultivar by 10.6%, and it was found that the combined use of the leaf essential oil as a seed treatment and spraying the plants with 2% ethanol followed by 2% (w/v) aqueous leaf essential oil increased the emergence, tillering, panicles/plant and the grain yield by 25-55% and reduced brown spot severity by 36-42%. This was suggested to be a direct result of strongly reduced *B. oryzae* infection (Nguefack et al., 2013). Furthermore, in agar medium assay, the leaf essential oil showed 100% inhibition of the plant pathogen fungus *Phaeoramularia angolensis* at 6000 mg/mL (Dongmo et al., 2009). In an antifungal assay employing agar incorporation method, the inhibition of mycelial growth of *Aspergillus flavus* by the leaf essential oil was reported with 89.74% 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 the latter activity correlates well with antifungal activity of its most abundant 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 isolaterd 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). Moreover, a leaf essential oil from Nepal possessing eugenol with 14.2% - in higher quantity than the samples from some other geographical locations - but otherwise resembling the Cameroonian sample with 1,8-cineole as most abundant compound, showed insecticidal activity against the fruit fly *Drosophila melanogaster* and termites of the species *Reticulitermes virginicus* with LC_{50s} of 57.4 µg/mL and 38 µg/mL, respectively. In addition, the oil was found to be not cytotoxic, displaying 17.5% kill at 100 µg/mL against human breast adenocarcinoma cell line MCF7 and an LC_{50}>2500 µg/mL against the nematode *Caenorhabditis elegans* (Shrestha et al., 2015). The leaf oil from South African plant material - strongly resembling the Cameroonian leaf oil - was investigated in antibacterial assays against human pathogens whose effects are noticeable in skin, intestinal and respiratory infections, namely *Bacillus cereus* ATCC 10702, *Bacillus pumilus* ATCC 14884, *Staphylococcus aureus* ATCC 3983, *Staphylococcus aureus* ATCC 6538, *Streptococcus faecalis* ATCC 29212, *Enterobacter cloacae* ATCC 13047, *Escherichia coli* ATCC 4983, *Klebsiella pneumoniae* ATCC 2982, *Pseudomonas vulgaris* ATCC 6830, *Pseudomonas vulgaris* CSIR 0030, *Pseudomonas aeruginosa* ATCC 7700 and *Serratia marcescens* ATCC 9986, leading to MICs of 1.25, 1.25, 0.31, 0.63, 0.63, 1.25, 1.25, 2.5, 2.5, 2.5, 2.5 and 0.63 mg/mL, compared to gentamycin and tetracycline displaying 0.63, 1.25, 0.31, 0.63, 1.25, 2.5, 0.16, 0.08, 0.31, 5, 0.63, 2.5 and 1.25, 1.25, 0.31, 0.31, ND, 2.5, 0.13, 0.63, ND, 5, 0.63, 0.63 mg/mL, respectively (Oyedeji et al., 2009).

Common names

Crimson Spokes, bottle brush, erect bottle brush, stiff bottle brush (English).

Fig. 4. The photograph of the flower of *Callistemon rigidus* R. Br.

3.2.2. *Callistemon rigidus* R. Br

3.2.2.1. Traditional use

The plant (Fig. 4) is used in Cameroon as a remedy for cough and bronchitis (Danga et al., 2014).

3.2.2.2. Bioactivities

Leaf. 1.8-cineole isolated from a fraction of the leaf oil inhibitedthe plant pathogen fungus *Phaeoramularia angolensis* at 6000 µg/mL, while a fraction composed of 1,8-cineole 81.8% and α-terpineol 3.4% achieved complete inhibition at 4000 µg/mL, hence suggesting synergistic effects (Dongmo et al., 2009). This synergism is of interest for eco-friendly *P. angolensis* control as an alternative to synthetic copper fungicides. In addition,

Table 2
Comparison of main essential oil components from leaves of *Callistemon citrinus*, *Callistemon rigidus* and *Callistemon viminalis* (Myrtaceae) collected from Littoral, North and West Provinces of Cameroon.

Plant species	***Callistemon citrinus***	***Callistemon rigidus***	***Callistemon viminalis***
Location	Douala (Littoral)	Ngaoundéré (Adamaoua)	Dschang (West)
Month of collection	April		November
Climate	humid	semi-arid	humid
1,8-cineole	**73.8%**	**79.1%**	**58.49%**
α -pinene	**16.3%**	**12.9%**	0.38%
linalool	0.3%,	0.3%	**11.00%**

the leaf oil also displayed significant LC_{50} values of 2.66, 7.37 and 43.16 ppm against the larvae and 27.22, 22.60 and 104.75 ppm against the pupae of the mosquitos *Aedes aegypti*, the vector of yellow fever, *Anopheles gambiae*, the vector of malaria and *Culex quinquefasciatus*, the vector of *Wucheria bancrofti*, avian malaria and arboviruses, respectively. It was suggested that the leaf essential oil could be used as an ideal eco-friendly alternative to the synthetic DDVP® (2,2-dichlorovinyl dimethyl phosphate or dichlorvos) for vector control (Danga et al., 2014).

3.2.3. *Callistemon viminalis* (Sol.ex Gaertn.) G.Don ex Loudon

3.2.3.1. Traditional use

While traditional medicinal use was not reported from Cameroon, the plant (Fig. 5) spread worlwide in tropical zones - is used in traditional Chinese medicine against haemorroids (Ji, 2009; Islam et al., 2010).

3.2.3.2. Bioactivities

Significant LD_{50} values of 0.103 µL/cm² and 0.152 µL/g were obtained against adults of the major bean insect *Acanthoscelides obtectus* in a contact toxicity assay with filter paper discs and beans soaked in leaf essential oil, respectively (Ndomo et al., 2009). Also against *A. obtectus*, an LC_{50} of 0.011 µL/cm³ was reported from a fumigation assay with the vapours of the leaf essential oil after 12 h of exposure; an LC_{50} of 0.133 µL/g was measured by contact on grains assay; and an LC_{50} of 0.100 µL/g for an aromatized clay powder formulation of the oil. Using the same assays, the cowpea weevil, *Callosobruchus maculatus*, displayed similar susceptibility. Notably, in the aromatized clay powder assay, the doses of 0.133 µL/g and 0.266 µL/g caused 100% and 68.7% inhibition of F1 progeny of *A. obtectus* and *C. maculatus*, respectively (Ndomo et al., 2010). Apart from agricultural use, the leaf oil might be investigated by suitable assays for its effectivity against gastroenteritis, diarrhoea, haemorroids and skin infection as reported from traditional medicinal use.

A comparison of main leaf essential oil components of *Callistemon citrinus*, *C. rigidus* and *C. viminalis* shows for all three plants a high 1,8-cineole percentage in the oil, while the second main compound, α-pinene, strongly dropped down for *Callistemon viminalis* in favour of linalool being here the second most abundant compound, probably rising as an adjustment of the plant to seasonal change of threads from organisms or the climate. The chemical interaction between plants and their environment is mediated by the biosynthesis of secondary metabolites, which exert their biological roles, as a plastic adaptive response to their environment (Table 2).

Common names

Weeping bottle brush (English).

Fig. 5. The photograph of the flower of *Callistemon viminalis* (Sol.ex Gaertn.) G.Don ex Loudon.

3.2.4. *Eucalyptus camaldulensis* Dehnh.

3.2.4.1. Traditional use

The essential oil from the leaves (Fig. 6) is used as a disinfectant and in medicinal applications (Musa et al., 2011). Fresh leaves are reported for the treatment of

Common names

Blue gum, eucalyptus, Murray red gum, river gum (English), gommier des rivières (French), Rotgummibaum, Roter Eukalyptus (German).

Fig. 6. The photograph of the leaves of *Eucalyptus camaldulensis* Dehnh.

Common names

Tasmanian bluegum, Victorian blue gum, Blue gum, Southern blue gum, Bluegum eucalyptus (English), Blaugummibaum, Fieberbaum (German), Eucalipto azul (Spanish), Eucalipto-comum (Portuguese).

Fig. 7. The photograph of the leaves of *Eucalyptus globulus* Labill.

bronchitis and sinusitis (Shagal et al., 2012). The plant is also used against lung diseases and in tuberculosis (Dongmo et al., 2008; Ghalem and Mohamed, 2008).

3.2.4.2. Bioactivities

Leaf. The leaf essential oil from Cameroonian material displayed insecticidal activity with an LD_{50} of 16.76 µg/cm^2 against *Anopheles gambiae* mosquitos, following 14 h of exposure to filter paper impregnated with the oil (Nlôga et al., 2007). This activity is significant and may pave the way for application of this leaf oil in ecofriendly vector control of severe *Plasmodium falciparum* malaria. The leaf essential oil sample from Iran led to 100% mortality at 320 ppm of the forth instar larvae of the malaria vector *Anopheles stephensi* (Mehdi et al., 2010).

3.2.5. *Eucalyptus globulus* Labill.

3.2.5.1. Traditional use

In Africa, before the role of the malaria mosquito in spreading the disease was understood, there was a belief that the leaves of *Eucalyptus globulus* released an essence which purified the air of fever germs. In fact, the benefit is derived from the loss of suitable breeding sites for mosquitos, brought about by the capacity of the trees to evaporate water from swampy ground. The plant (Fig. 7) is used to treat inflammatory diseases (Silva et al., 2003), applied against diabetes in South America and Africa (Duke, 1985; Lewis, 1949) and used in the treatment of bronchitis, asthma and other respiratory diseases (Vigo et al., 2004).

3.2.5.2. Bioactivity *in vitro*

3.2.5.2.1. Leaves

The oil delivered a MIC of 0.28 mg/mL against the periodontopathogenic bacterium *Porphyromonas gingivalis* ATCC33277, carried out by micro dilution assay (Harkat-Madouri et al., 2015), while an MIC of 0.013 mg/mL was reported for *Streptococcus mutans*, the primary bacterium involved in caries - which was more effective than the 0.1% commercial NaF (Goldbeck et al., 2014). The adult earthworm *Pheretima posthuma* as a model strain for intestinal roundworm parasites reacted to the oil with complete paralysis within 79 minutes at 2.5 mg/mL, and death after 85 minutes. In comparison, the positive control 1% piperazine citrate showed paralysis after 88 minutes and death after 96 minutes (Weldemariam et al., 2015). Furthermore, significant inhibitory effect on glycation of albumin by methylglyoxal of around 50% was reported for the leaf essential oil in an anti-glycation capacity assay, offering prospects for preventive treatment of pathogenesis under conditions associated with complications of diabetes, aging and a wide range of other conformational disorders (Btissam et al., 2017).

3.2.5.2.2. Fruit + leaves

IC_{50s} of 27.0, 32.8 and 4.9 mg/mL for the fruit oil and 0.05, 0.048 and 0.048 mg/mL for the leaf oil were reported for free radical-scavrenging (DPPH), reducing power (RP) and inhibition of lipid peroxidastion method (LP), respectively, compared to the positive control butyl hydroxyanisole (BHA) showing 0.05, 0.03 and 0.5 mg/mL and 0.05, 0.048 and 0.048 mg/mL, respectively (Noumi et al., 2011; Said et al., 2016).

3.2.5.2.3. Fruits

IC_{50s} of 4, 4, 4, 5 and 3 mg/mL against *Bacillus subtilis* ATCC 6633, *Staphylococcus aureus* ATCC 43300, *Escherichia coli* ATCC 25922, *Pseudomonas aeruginosa* ATCC 27853 and *Listeria innocua* CLI 74915 were measured by microdilution broth method (Said et al., 2016).

3.2.6. *Eucalyptus saligna* Sm.

3.2.6.1. Traditional use

The leaves (Fig. 8) are used in the Western highlands of Cameroon to protect stored grains from insect infestation, while the leaf oil is further well known for its insecticidal properties against bedbugs, black beetles,

Common names

Black peppermint, Sydney bluegum, Saligna eucalyptus (English).

Fig. 8. The photograph of the leaves and flowers of *Eucalyptus saligna* Sm.

Common names

Clove tree (English), chá de bugre, craveiro do mato (Portugese).

Fig. 9. The photograph of the leaves and flowers of Pimenta pseudocaryophyllus (Gomes) Landrum.

flies, lice, and mosquitos (Tapondjou et al., 2000).

3.2.6.2. Bioactivities

3.2.6.2.1. Leaves

In a toxicity assay with grains impregnated with leaf essential oil powder, the cowpea weevil *Callosobruchus maculatus* was found to have an LD_{50} value of 32.2% after two days. Leaf oil impregnated filter paper or grain coating produced an LD_{50} value of 0.36 and 0.48 µL/cm² after three days against the maize grain weevil *Sitophilus zeamais* and red flour beetle *Tribolium confusum*, respectively. In addition, at 100 µL/40g grain, the oil produced 100% reduction in adult emergence of both insects. The crude plant oil displayed a stronger repellency than its second major constituent *p*-cymene alone, suggesting synergistic effects (Tapondjou et al., 2005). As a conclusion, this oil has a good potential for Cameroon to be applied in agriculture as eco friedly alternative to synthetic insecticides. Moreover, in a toxicity assay by agar disc diffusion method against *Rigidoporus lignosus*, causative agent of white root-rot disease of the rubber tree *Hevea brasiliensis* (Euphorbiaceae) in Cameroon, the leaf essential oil completely inhibited mycelial growth of the fungus at 5000 ppm and showed in addition fungicidal effect at that concentration (Metsoa Enama et al., 2017).

3.2.7. *Pimenta pseudocaryophyllus* (Gomes) Landrum

3.2.7.1. Traditional use

In Cameroon, cloves of this plant (Fig. 9) are dried for one month to have a cure for toothache and some infections (Nurdjannah and Bermawie, 2001), and are taken internally as a tea in the treatment of internal parasites, stomach upsets, chills and impotence. In addition, the essential oil itself is applied externally in the treatment of toothache, headache, cold, arthritis and rheumatism. It is also useful for treating ulcers, bruises, burns, bronchitis, asthma, minor infections and colic and to ease nausea (Brown, 1995).

3.2.7.2. Bioactivities

Common names

Guava, lemon guava (English), goyavier (French), guayaba, guyab (Senegal), Echte Guave (German), banjiro (Japanese) goiaba, goiabeiro (Portuguese) guayaba, guayabo (Spanish).

Fig. 10. The photograph of the leaves and fruits of *Psidium guajava* L.

3.2.7.2.1. Buds

The bud essential oil displayed very significant MICs towards two *Trychophyton rubrum* fungal isolates causing infection of nail and ringworm as well as *T. violaceus* and *T. soudanese* causing fungal infection of the hair; and furthermore towards two fungal isolates of *Candida albicans* with 0.25, 0.25, 0.25, 0.125, 0.5 and 0.5 µL/mL, respectively, while the positive control Ketoconazole® displayed an MIC of 0.128 µL/mL against all three species of *Trychophyton*. However, for *C. albicans*, a positive control was not reported (Nyegue et al., 2014). It should be noted that eugenol with 80% of the bud essential oil might be a major contribuitor to this activity. Toxicological studies will be needed before the bud oil can be recommended as an alternative drug for the treatment of dermathophytoses and *Candida* infection.

3.2.8. *Psidium guajava* L.

3.2.8.1. Traditional use

In Cameroon and other West and Central African countries, a decoction of the leaves (Fig. 10) serve as a gargle for sore throat, laryngitis and swelling of the mouth, and it is used externally for skin ulcers, vaginal irritation and discharge (Gutiérrez et al., 2008).

Leaves are further used to treat diarrhea in some parts of Cameroon (Nundkumar and Ojewole, 2002) and are applied in preparations as pain killer, against pulmonary and stomach troubles, as laxative, as well as against diarrhea, dysentery and hemorrhoids. It is furthermore used for the treatment of cutaneous and subcutaneous parasitic infections, to improve the menstrual cycle and against small pox, chicken pox and measles. Many of above conditions are also treated with preparations from the fruits. While the bark is also used against diarrhea and dysentery, the root is taken against stomach problems (Burkill, 1985). Ethnopharmacological studies show that the plant is applied in many parts of the world for the treatment of inflammation, diabetes, hypertension, caries, wounds, pain and fever. The fruit

Common names

Clovetree, clove (English), giroflier (French), Gewürznelkenbaum (German), clavero giroflé, clavo de olor, árbol del clavo (Spanish), cravo-da-India (Portuguese), kryddnejlika (Swedish).

Fig. 11. The photograph of the leaves and flowers of *Syzygium aromaticum* (L.) Merr. & L.M. Perry.

has a reputation in the management of cardiovascular and gastrotintestinal disorders (Burkill et al., 1966; Goh et al., 1995; Ticzon, 1997; Yamashiro et al., 2003).

3.2.8.2. Bioactivities

3.2.8.2.1. Leaves

Leaf essential oil from material collected from the Guava trees inside the Campus of the University of Dschang, West Region of Cameroon, in January 2014 was employed in an experiment on cavies, exposed to heat from 8.00 to 15.00 pm. Over 60 days, control animals and animals of group 1 kept at 35ºC and of group 2 kept at 45ºC orally received distilled water daily at 100 µL/kg of body weight, while those of group 3 kept at 45ºC were treated orally in addition with leaf essential oil at 100 µL/kg body weight. Evaluation of sperm density, motility and morphology, sperm DNA integrity as well as evaluation of testicular proteins and oxidative stress parameters showed for essential oil treated animals an increase of sperms density and motility, reduced sperms defects, as well as reduced rate of free radicals and hence lipid peroxidation. It was suggested that the leaf oil could be used as an alternative to alleviate the effects of heat stress in male reproductive system and fertility (Ngoula et al., 2017).

3.2.9. *Syzygium aromaticum* (L.) Merr. & L.M. Perry

3.2.9.1. Traditional use

The buds are well known for their anaesthetic effect and thus chewed for the treatment of toothache. In Cameroon, the plant (Fig. 11) is largely exploited for its dry fruits to be used in traditional medicine as dental analgesic, antineuralgic, stimulans and against stomach troubles (Debjit et al., 2012).

3.2.9.2. Bioactivities

3.2.9.2.1. Clove buds

In 2,2-diphenyl-1-picrylhydrazyl (DPPH) assay, the essential oil of the clove buds had an antiradical power 10 times greater than that of butylated hydroxytoluene (BHT). Moreover, the oil was more active than the positive control griseofulvin against dermatophytes, being fungicidal at 400 ppm against *Trichophyton rubrum*, 900 ppm against *Microsporum gypseum* and 825 ppm against *Trichophyton tonsurans* (Fankem et al., 2017).

3.2.9.2.2. Fruits

In addition, the fruit essential oil studied by DPPH method showed that its antiradical activity with SC_{50}=23.17 mg/L was higher than that of BHT displaying SC_{50}=65.03 mg/L. In addition, in incorporation technique assay, the oil showed MICs of 300 ppm against food spoiling fungi *Aspergillus niger* and *Aspergillus carbonarius*, 400 ppm against *Aspergillus flavus*, *Aspergillus versicolor* and *Fusarium oxysporum* and 500 ppm against *Aspergillus fumigatus* (Sokamte et al., 2016).

3.2.9.2.3. Blossoms

The blossom 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. In order to investigate the oil´s minimal inhibitory concentration for inhibition of bacterial growth as well as inhibition of germination of spores, macro dilution assays were carried out with the blossom essential oil resulting in MICs of 2.5 mg/mL for all bacterial strains for inhibition of bacterial growth, and 0.75 mg/mL for inhibition of spore germination of *Bacillus megaterium* and *Bacillus subtilis* (Voundi et al., 2015).

3.3. Pentadiplandraceae

3.3.1. *Pentadiplandra brazzeana* Baill.

3.3.1.1. Traditional use

In Cameroon, a leaf (Fig. 12) decoction is used to wash the skin against scabies, and the macerated roots are taken orally or applied as an enema against malaria. The Mezime people of Cameroon take a decoction of the root bark as an aphrodisiac. The liana is applied in Western tropical Africa against various medical disorders, like arthritis, rheumatism, pulmonary troubles, diarrhea, dysentery, helminths, kidney problems, as well as cutaneous and subcutaneous parasitic infections, as abortifacient and in veneral diseases.

Furthermore, the liana is used as pain killer and diuretic (Burkill, 1985). The root of this plant is used in Cameroon and other places in West and Central Africa

Common names

J´oublie (French), joy perfume tree (English).

Fig. 12. The photograph of leaves and flowers of *Pentadiplandra brazzeana* Baill.

Common names

Ogbomaton.

Fig. 13. The photograph of leaves and fruits of *Antidesma laciniatum* Müll.Arg.

as a folk remedy against hemorrhoids (Makumbelo et al., 2008), toothache (Betti, 2004) and as an analgesic for the treatment of chest, abdominal and intercostal pain, as well as rheumatic disorders (Dounias, 2008). The plant is applied as an antiseptic in the treatment of wounds, an analgesic in the treatment of dental caries and against rheumatism (Kamtchouing et al., 2002). In Bangamte (west region of Cameroon), one spoonful of powdered root is mixed into 75 mL of hot water, and a glassful twice a day is applied against peptic ulcers (Noumi and Dibakto, 2000). While parasitic diseases caused by bacteria of the *Phylum chlamydiae* are treated with a preparation (Villiers, 1973), an extract of the plant is locally distributed in Cameroon as « Sirop gamma du Dr Wandji ». Local populations use the roots for food flour preservation. One patent concerns a cosmetic preparation for preventing and treating cellulite, comprising *P. brazzeana* extract in its composition (Conduzorgues and Sincholle, 2000).

3.3.1.2. Bioactivities

3.3.1.2.1. Roots

The root 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 0.08 μg AAE/mg; SC_{50}=0.19 μg/mL compared to ascorbic acid with 1.98 μg/mL; and IC_{50}=45.66 μg/mL compared to sodium diclofenac with 104.44 μg/mL, respectively (Ndoye et al., 2016). For the oil, antiradical scavenging activity against DPPH was measured with SC_{50}=1.5 g/L, compared to BHT showing 8.8 mg/L, while the inhibitory effect of soybean 5-lipoxygenase as an indicator of anti-inflammatory activity was found to have an IC_{50} of 35 ppm, compared to NDGA with 0.23 ppm. MICs reported against microbes isolated and identified by the Centre Pasteur of Yaoundé and on post-crops products from IRAD of Nkolbisson of the facultative pathogenic *Candida albicans* and the fungi *Microsporum canis*, *Trichophyton rubrum*, *Fusarium moliniforme*, *Aspergillus flavus* and *Aspergillus niger* were recorded with 31.2, 50, 15.6, 125, 125 and 62 μg/mL, compared to amphotericine B® with 31.2, 15.6, 15.6, 62.5, 62.5 and 125 μg/mL. Moreover, MICs against bacterial strains isolated and identified by the Centre Pasteur of Yaoundé, Cameroon of *Escherichia coli*, *Pseudomonas aeruginosa* and *Staphylococcus aureus* were recorded with 200, 125 and 50 μg/mL, compared to gentamycine® with, 0.25 and 0.5 μg/mL. It should be noted that benzylcyanide, the second major component of the essential oil, is described as toxic and irritant by Guest et al. (1982) if inhaled or absorbed through the skin; the presence of this component in the essential oil is a real problem for its use without control of benzylcyanide content; in the same manner, the presence of cyanide ions in the plant material highlights the necessity of treating the roots before consumption by local populations (Nyegue et al., 2008). Moreover, phenylethylisothiocyanate was found to decrease the secretion of inflammatory signalling molecules by white blood cells and to decrease DNA binding of NF-kappaB, a pro-inflammatory transcription factor (Gerhäuser et al., 2003; Steele et al., 2003), while benzylisothiocyanate was found to induce apoptosis in human breast cancer *in vitro* (Xiao et al., 2006).

3.4. Phyllanthaceae

3.4.1. *Antidesma laciniatum* Müll.Arg.

3.4.1.1. Traditional use

In Western Africa, the plant (Fig. 13) is used in general medicine against stomach troubles, while the leaf is applied as antiabortifacient (Burkill, 1985). In Cameroon, powdered bark is taken in water or palm wine as an aphrodisiac, a bark decoction is taken orally or as an enema to treat internal upsets (Hutchinson et al., 1954).

3.4.1.2. Bioactivities

3.4.1.2.1. Leaves

The essential oil of the leaves was evaluated for antimalarial activity against the chloroquine® resistant *Plasmodium falciparum* strain W_2. Antiplasmodial activity was observed at an IC_{50} of 29.4 μg/mL, which was well below the essential oil concentration toxic to erythrocytes with > 0.6 mg/mL (Boyom et al., 2003).

3.4.2. *Phyllanthus muellerianus* (Kuntze) Exell

3.4.2.1. Traditional use

There is a wide spectrum of traditional use of this plant (Fig. 14) in Subsaharan African countries: In Cameroon, Baka pygmies apply a decoction of the stem bark as a remedy for tetanus (Brisson, 1999). In other regions, the stem sap is applied to relieve ophtalmia and pain in the eye (Ainslie, 1937; Burkill, 1985); the twig is used to prevent toth ache, and leafy twigs prepared with a pulp are rubbed topically on the body to cure paralysis (Kerharo and Bouquet, 1950); the bark is sometimes added to palm-wine to render it strongly intoxicating, while dried bark powder is taken for colds and sinusitis (Burkill, 1985); the root bark is also taken against colds and sinusitis (Ainslie, 1937) and to reduce swellings (Vergiat, 1970); the roots are used for intestinal troubles and cooked with a maize meal against severe dysentery (Dalziel and Hutchinson, 1937; Irvine, 1961), while water in which roots have been pounded is drunk for the treatment of diarrhea and boiled roots are given as enema for stomach pain (Burkill, 1985). In addition, a root decoction is used as febrifuge (Ainslie, 1937), and powdered roots are applied as an enema for throat troubles with glandular fevers (Kerharo and Bouquet, 1950). A root decoction against hard abscesses (Haerdi et al., 1964) and leaves are believed to promote male fertility, a decoction is taken against anaemia and constipation, and a mouth wash against toothache (Bouquet, 1969; Burkill, 1985; Vergiat, 1970).

Furthermore, freshly pounded leaves are applied as wound dressing (Ainslie, 1937; Dalziel and Hutchinson, 1937) and made into an eye-pad on the lids (Kerharo and Bouquet, 1950), while the leaf sap is used as a wash for fevers and skin eruptions (Dalziel and Hutchinson, 1937) and as instillation for eye troubles (Adjanohoun and Aké Assi, 1972; Bouquet and Debray, 1974; Dalziel and Hutchinson, 1937; Irvine, 1961; Kerharo and Bouquet, 1950; Oliver, 1960; Vergiat, 1970). In addition, root charcoal is taken for stomach upsets and as an antiemetic (Bouquet, 1969); roots and leaves are given to children against eruptive fevers (Burkill, 1985); young roots with young leafy twigs are prepared against jaundice, dysentery and urethral discharges (Ainslie, 1937; Dalziel and Hutchinson, 1937; Oliver, 1960); the powered dried root and bark is sprinkled on wounds as a dressing (Haerdi et al., 1964); an infusion of young shoots is applied against chronic dysentery and chest complaints (Ainslie, 1937; Dalziel and Hutchinson, 1937); and the root is cut into small pieces with those of *Psychotria umbellata* (Rubiaceae) and *Harrisonia abyssinica* (Simaroubaceae), then decocted, and the liquid drunk for cough and whooping cough (Ampofo, 1983).

Common names

Ogbomaton.

Fig. 14. The photograph of leaves and fruits of Phyllanthus muellerianus (Kuntze) Exell.

3.4.2.2. Bioactivities

3.4.2.2.1. Stem bark

In a microdilution assay with the bacterium *Clostridium sporogenes* ATCC 3584, the stem bark oil diplayed a significant MIC value of 13.5 μg/mL, compared to the positive control amphothericin B® showing 0.7 μg/mL (Brusotti et al., 2012). Thus, the use of stem bark decoctions by the Baka pygmies against tetanus should be further investigated, since *Clostridium sporogenes* is a close relative of *Clostridium tetani*, the causal agent of tetanus. Furthermore, the stem bark oil gave an MIC of 250 μg/mL against the dermatophytic fungus *Trichophyton rubrum* LM 237, which was a higher activity than the positive control amphothericin B® displaying 500 μg/mL. Voriconazole® was shown to display much stronger activity with an MIC of 4 μg/mL (Brusotti et al., 2012), however, this drug has been associated with an increased risk of squamous cell carcinoma of the skin (Epaulard et al., 2010).

3.4.2.2.2. All part of plant

Since all parts of this plant are widely used in traditional African medicine, partly for the treatment of severe diseases, further investigation of its essential oils as carrier of strong bioactivity is recommended.

3.5. Piperaceae

3.5.1. *Piper capense* L.f.

3.5.1.1. Traditional use

In Cameroon, the aerial parts (Fig. 15) are used to treat epileptic fits, and powdered seeds are used in the Western highlands of Cameroon for the protection of stored grains against insects (Tchoumbougnang et al., 2009a), while the fruit is applied as anthelmintic and as sleep inducing medicine (Kuete et al., 2011).

Common names

Wild pepper (English), Poivrier du Cap (French), ngonyi (Cameroon).

Fig. 15. The photograph of leaves and flowers of Piper capense L.f.

Furthermore, Subsaharan African use was reported for the fruit in the treatment of kidney and heart problems, for the roots against paraslysis, epilepsy, convulsions and spasms, along with for the roots and fruit in pulmonary troubles and the leaves and fruit as vermifuge (Burkill, 1985).

3.5.1.2. Bioactivities

3.5.1.2.1. Fruits

The fruit essential oil displayed significant activity against the maize grain weevil *Sitophilus zeamais* with an LD_{50} value of 16.1 µL/g of grain, which was compared to the synthetic product Poudrox® showing 100% mortality with a 5% solution (Tchoumbougnang et al., 2009a). Since the fruit is involved in several Subsaharan medicinal recipies of kidney, heart and pulmonary troubles, its oil might be further investigated by suitable *in vitro/in vivo* assays.

3.5.2. *Piper guineense* Schumach &Thonn

3.5.2.1. Traditional use

In Cameroon, the seed powder is applied as a stimulant (Sofowora, 1984), and is used in the Western highlands of Cameroon for the protection of stored grains (Tchoumbougnang et al., 2009a), while the fruits (Fig. 16) are applied in respiratory infections, female infertility and as aphrodisiac (Noumi et al., 1998).

In other Subsaharan countries, the fruit is applied against arthritis, rheumatism, as vermifuge, and against tumours and cancers, while the leaf is used in nasopharyngeal affections, antiabortifaciet, small pox, chicken pox and measles. In addition, the liana is taken for the treatment of kidney problems; leaves and roots as pain killer; leaves, liana and roots in pulmonary troubles and leaves and fruit to cure veneral diseases (Burkill, 1985).

3.5.2.2. Bioactivities

3.5.2.2.1. Fruits

Common names

West African black pepper; Ashanti pepper; Benin pepper; Guinea cubebs; bush pepper (English), poivrier (the plant) or poivre (the fruit or pepper) des Achantis, poivre de Guinée, poivre de liane, poivre de la forêt, poivre du Kissi, cubèbe (French).

Fig. 16. The photograph of leaves and fruits of *Piper guineense* Schumach &Thonn.

In a contact toxicity assay with maize grains, the fruit essential oil displayed a significant LD_{50} value of 10 µL/g of grain against the maize grain weevil *Sitophilus zeamais*, compared to the synthetic product Poudrox® showing 100% mortality with a 5% solution (Tchoumbougnang et al., 2009a). Furthermore, in open field and light/dark transition test in mice by inhalation administration, the fruit essential oil from a sample from the Central Region showed significant sedative activity at an effective dose of 4.0×10^{-5} mg per cage. It also showed potent anxiolytic effect at a dose of 4.0×10^{-6} mg per cage, with the potency comparable to that of the essential oil of *Lavandula angustifolia* (Lamiaceae). The main compounds of this fruit essential oil, linalool with 41.8% and 3,5-dimethoxytoluene with 10.9%, were shown to play a major role in the sedative activity. In combination, these two compounds were even more effective, indicating synergistic action (Tankam and Ito, 2013). The Subsaharan African traditional use of the fruit in cancers might be followed up by *cancer cell lines* to identify the source of this activity.

3.5.3. *Piper nigrum* L.

3.5.3.1. Traditional use

Powdered seeds are used in the Western highlands of Cameroon for the protection of stored grains (Tchoumbougnang et al., 2009a). Furthermore, in other Subsaharan countries, the fruit (Fig. 17) is applied as pain killer, against stomach and kidney troubles, abortifacient and to increase uterine contractions to facilitate delivery, while fruit and roots are used as febrifuge and for the treatment of tumours and cancers (Burkill, 1985).

3.5.3.2. Bioactivities

3.5.3.2.1. Fruit

In an ingestion assay using a maize container, the

Table 3
Comparison of most abundant essential oil component from fruit, leaves and stem/liana of three species of *Piper* gen., harvested during the raining period in the Western region of Cameroon.

Species	***Piper capense***			***Piper guineense***			***Piper nigrum***		
Original occurrence	East Cameroon			West Cameroon			Center Cameroon		
	Fruit	Leaf	Stem	Fruit	Leaf	Liana	Fruit	Leaf	Stem
α-Pinene	59.3%	50.1%	61.4%						
β-Caryophyllene				20.8%					36.0%
Germacrene D					25.1%				
(*Z,E*)-α-Farsenene						28.7%			
δ-3-Carene							18.5%		
α-Selinene								16.5%	

fruit essential oil showed a significant LD_{50} of 16.95% towards the maize grain weevil *Sitophilus zeamais* after 96 h of exposure, while in a contact toxicity assay using oil-maize mixtures in plastic flasks, the LD_{50} value was 22.89% after only 4 minutes of exposure (Ousman et al., 2007). In addition, a contact toxicity assay of the fruit essential oil displayed an LD_{50} value of 26.4 µL/g towards *S. zeamais* compared to Poudrox® showing 100% mortality with a 5% solution (Tchoumbougnang et al., 2009a). The traditional use of the fruit and roots in Subsaharan Africa in cancers might be followed up by appropriate assays.

Above three species of the genus *Piper* originally had grown in different areas of Cameroon, collected for analysis in the Western Region of Cameroon where only *Piper guineense* grows in its endemic habitat. The plants´ different origin correlates with a completely different main essential oil compound spectrum. In fact, for *Piper capense* and *Piper guineense*, the phylogenetic tree shows far genetic distance, with a number of other not African species of the genus Piper closer related to *Piper capense* than *Piper guineense* (Jaramillo et al., 2008) (Table 3).

3.6. Poaceae

3.6.1. *Cymbopogon citratus* (DC.) Stapf

3.6.1.1. Traditional use

Extracts of the plant (Fig. 18) are applied in Cameroon traditionally against stomach complaints (Mapi, 1988) and for the treatment of malaria, where a decoction of the leaves or bark is administered (Saotoing et al., 2011), while the leaves are also used in tea as fabrifuge (Sawyer, 1982). It has been planted in Western Africa in tsetse fly areas as a control to discourage flies breeding, however with yet unclear results.

The leaves are used in infusions to make a tea form beverage, commonly shown in Nigerian and West Cameroon. This infusion is taken as a febrifuge, sudorific and dyspeptic, and put into hot baths for fumigation (Dalziel and Hutchinson, 1937). Leaves boiled with guava leaves are taken in Nigeria for cough (Ainslie, 1937). In North Cameroon, their use as chew-sticks is said to assuage toothache. The rhizomes are used in Northern Cameroon for the treatment of toothache, and in other regions of Western Africa to rub on teeth for cleansing (Dalziel and Hutchinson, 1937; Raponda-Walker and Sillans, 1961). Furthermore, leaves together with rhizomes are believed in Trinidad to be good for colds, flu, pneumonia, cough and fever (Wong, 1976). When comparing leaf essential oils from Yaoundé, Douala and Bafoussam, - located in a triangle of around 200 km side length with Bafoussam in the North - where

Common names
Pepper; black pepper; white pepper (English), poivre (French).

Fig. 17. The photograph of leaves and fruits of *Piper nigrum* L.

Common names
Ossanga, hunde, beyebe ti, bealibe ti, bejaba ti (Cameroon), lemon grass, fever grass, fragrant thatch grass (English), verweinede Indes, herb-citron, citronelle, fausse citronelle (French), ostindisches Lemongras, hohes Lemongras (German).

Fig. 18. The photograph of leaves of *Cymbopogon citratus* (DC.) Stapf.

environmental conditions are comparable with 2000 - 3000 mm annual rain fall, main constituents during the raining period were reported with geranial > neral, followed by myrcene. For the Bafoussam sample taken at the end of the raining period, an interesting emerge of selina-6-en-4-ol replacing myrcene was recorded, probably as an adjustment to changing environmental conditions (Table 3).

3.6.1.2. Bioactivities

3.6.1.2.1. Leaf

Concerning antiplasmodial activity, the leaf oil was shown to display very significant activity against the chloroquine® resistant *Plasmodium falciparum* strain FcB1/Colombia with an IC_{50} of 4.2 µg/mL (Akono et al., 2014). In a four days suppressive test with mice infected with *Plasmodium berghei* ANKA, untreated infected animals died between the sixth and seventh day, whilst those treated with the oil dosed at 500 mg/kg/day were still alive 13 days after infection (Tchoumbougnang et al., 2005). However, P. *berghei* is not pathogen towards humans, and a positive correlation between activities with *P. falciparum* and *P. berghei* is not reported. Concerning the malaria vector, the leaf oil showed potent activity with an LD_{50} value of 18 ppm against *Anopheles gambiae* (Tchoumbougnang et al., 2009b) as well as good activity with LD_{50}=35.5 and 34.6 ppm towards the third and forth stage larvae of *Anopheles funestus* (Akono et al., 2014). Furthermore, at 200, 100 and 50 ppm, the knock-down time (Tkd_{50}) for female adult Anopheles gambiae exposed to the leaf essential oil for 60 minutes was 0.043, 0.82 and 1.48 minutes, while at 200, 100 and 50 ppm the mortality rate after 24 hours of observation was 100% for all concentrations (Akono et al., 2016b) In a toxicity assay, the leaf oil displayed an LC_{50} of 18.0 mg/mL against larvae of the malaria vector *Anopheles funestus* (Tchoumbougnang et al., 2009b), and topical application on the malaria vector *Anopheles gambiae* resulted in an LD_{50} of 3 µg/g mosquitoe (Norris et al., 2015).

Furthermore, for antifungal activity, in an assay using counts of colony forming units expressed as Number of Decimal Reduction of the colony forming units per mL (NDR cfu), the leaf essential oil displayed NDRcfu=0.36 and 0.48 against the fungus *Penicillium expansum* MRC 6935 and MRC 6939, respectively, when measured at 1000 ppm. Interestingly, a fraction was reported with activities at least 10 fold superior to that of the essential oil, and for some mixed fractions, synergistic effects were observed (Nguefack et al., 2012). In addition, the essential oil of the leaves was studied by the agar dilution method for antifungal activities on the radial growth of mycelia of the plant pathogen fungi *Aspergillus flavus* IBT 3660, IBT 15606, IBT 15714, IBT 18438 and IBT 19412, *A. fumigatus* IBT 16901, IBT 17328, IBT 20466, IBT 20886 and IBT 21712 and *Fusarium moniliforme* IBT 9490, IBT 9494, IBT 9495, IBT 9498 and IBT 9504. At 200 ppm, the oil reduced the mycelial growth of *F. moniliforme* by 64%. At 500 ppm, the radial growth of *A. flavus* and *A. fumigatus* was reduced by 48% and 77%, respectively. Total inhibition was obtained at 300 ppm for *F. moniliforme* and 1200 ppm for *A. flavus* and *A. fumigatus* (Nguefack et al., 2004a). Also, from fractionation of the leaf essential oil, three active fractions were obtained exhibiting two to seven fold higher activity than the crude essential oil against strains of *Aspergillus ochraceus* MRC2132 and *Penicillium expansum* MRC2169 (Nguefack et al., 2009). Interestingly, leaf essential oil applied as a slurry on rice cultivars resulted in seed infection rates by the plant pathogen fungi *Alternaria. padwickii*, *Bipolaris oryzae* and *Fusarium. moniliforme* of 17.4, 2.1 and 0.3%, while treatment with the synthetic fungicide Dithane M-45® gave 0.1, 0.7 and 0%. For reference, untreated samples exhibited seed infection rates of 33.6, 28.0 and 6.0%. Seed-to-seed transmission of *A. padwickii*, *B. oryzae* and *F. moniliforme* following treatment with leaf essential oil was reduced to 4.2, 4.0 and 1.6%, while treatment with Dithane M-45® reduced transmission to 2.6, 1.6 and 0.6%, compared to rates of transmission for untreated plants of 17.5, 11.1 and 15% respectively (Nguefack et al., 2008). Exploration of the leaf oil in a poisoning technique assay employing the plant pathogen fungus *Fusarium verticiloides* resulted in 90% kill rate, versus 99% with Benlate®. Seed germination rate of 93% and 94% were observed after treatment with leaf oil and Benlate® respectively, both of which compare favourably against an untreated maize germination rate of 88% (Tagne et al., 2008). On agar media, the leaf oil showed complete inhibition of *Phytophthora infestans*, causal agent of late bligh at 400 ppm, while synthetic fungicides Banko Plus® and Plantizeb 80WP® applied in Cameroon completely inhibited the fungus at 100 ppm, and Kocide 2000® only at 5000 ppm (Galani et al., 2013). In a toxicity assay by agar disc diffusion method against *Rigidoporus lignosus*, causative agent of white root-rot disease of the rubber tree *Hevea brasiliensis* (Euphorbiaceae) in Cameroon, the leaf essential oil completely inhibited mycelial growth of the fungus at 500 ppm and showed in addition fungicidal effect at that concentration (Metsoa Enama et al., 2017).

Concerning antibacterial activity, the leaf essential oil was found to inhibit the food spoiling bacteria *Staphylococcus aureus* ATCC 9144, *Escherichia coli* ATCC 25922, *Proteus mirabilis* ATCC 29906, *Klebsiella pneumoniae* ATCC 10031 as well as the fungus *Candida albicans* ATCC 10231 with MICs of 0.25, 1.15, 1.15, 0.30, and 0.30 mg/mL. However, the oil was inactive towards *Pseudomonas aeruginosa* ATCC 27853 displaying an MIC > 9 mg/mL (Chalchat et al., 1997), while in a flow cytometry assay employing the food spoiling bacterium *Listeria innocua* ATCC33090 the leaf oil was found to be able to permeabilize the cytoplasma membrane (Nguefack et al., 2004b). Moreover, in MIC assay with

Table 4

Comparison of leaf essential oil main compounds (in bold) and other major ingredients from the Central/Littoral/Western Province, harvested during the raining period.

Location	Yaoundé			Douala		Bafoussam
Sampling month	April	July	Sept	April	June	Nov
Investigator	Chalchat et al., 1997	Nguefack et al., 2007b	Tchoumbougnang et al., 2005	Tchoumbougnang et al., 2009b	Ntonga et al., 2014	Nguefack et al., 2012
Geranial	**45.9%**	**49.8%**	**37.8%**	**39.3%**	**32.8%**	**37.7%**
Neral	**33.5%**	**34.4%**	**29.0%**	**21.9%**	**30.2%**	**21.2%**
Myrcene	12.8%	3.9%	16.2%	14.0%	11.4%	2.5%
Selina-6-en-4-ol	-	-	-	-	-	8.9%

caries-related bacteria *Streptococcus mutans* ATCC 35688, *Streptococcus gordonii* ATCC 10558, *Streptococcus sanguinis* ATCC 10556, *Streptococcus. sobrinus* ATCC 33478, *Streptococcus mitis* ATCC 9811, *Lactobacillus acidophilus* ATCC 4356 and *Actinomyces naeslundii* ATCC 19039 the leaf essential oil gave values of 2.61, 1.32, 2.61, 2.61, 2.61, 1.32 and 1.32 mg/mL, respectively, relative to the positive control - mouthwash containing chlorhexidine digluconate at 1.2 mg/mL - showing 0.04, 0.09, 0.04, 0.02, 0.18, 0.02 and 0.02 mg/mL. In addition, cytotoxicity of the oil to the human keratinocyte cell line HaCaT supplemented with 5% of inactivated fetal bovine serum and and penicillin/streptomycin performed by MTT assay resulted in 98% viability at 0.25 mg/mL, compared to the negative control dimethyl sulfoxide (DMSO) with 100% viability of untreated cells and doxorubicin at 50 µg/mL with 0% viability (Carvalho de Oliveira et al., 2017). The leaf 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. Since bacteria spores are very resistant to physical and chemical agents, they can remain in food after sterilization, as explained by Aouadhi et al. (2013). Macro dilution assays were carried out with the leaf essential oil resulting in MICs of 5.0, 2.5, 2.5 and 2.5 mg/mL, repectively, for inhibition of bacterial growth, and 0.09, 0.37, 0.37 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).

In animal model employing Swiss mice, pretreatment was done with leaf essential oil at 125, 250 and 500 mg/kg body weight or the standard drug at 200 mg/kg body weight for seven days. Hepatotoxicity was induced by a single dose of acetaminophen at 250 mg/kg. Leaf essential oil pretreatment decreased significantly the levels of the liver function markers alanine aminotransferase, aspartate aminotransferase and alkaline phosphatase, while myeloperoxidase activity and nitric oxide production in the livers were decreased. It was suggest that the oil has protective activity against liver toxicity induced by paracetamol (Uchida et al., 2017). The leaf essential oil was investigated for its effect on the sandfly *Phlebotomus duboscqi*, a vector of zoonotic cutaneous leishmaniasis causing strong public health problems in Eastern Africa. With regard to protection time and biting deterrence, the effective dosis (ED_{50}) was 0.04 mg/mL, while the percentage repellency of 1 mg/mL was 100%. A lower dose of 0.5 mg/mL, 89.13% repellency was reported (Kimutai et al., 2017).

The *Cymbopogon citratus* collected in different localities and in different periods display the same essential oil main compounds pattern: the **generial (46 to 33%)** and **neral (35 to 22%)**. It should be also noted that other environmental factors that may affect soil conditions in the three remotely distant regions (Yaounde, Douala and Ngaoundere) have not demonstrated significant influence on the percentage of the metabolic profile of the plant (Table 4).

3.6.2. *Cymbopogon giganteus* Chiov.

3.6.2.1. Traditional use

Decoctions of leaves and flowers are used in local African medicine against rheumatism, fever, cough, skin disorders and arterial hypertension (Popielas et al., 1991; Sidibé et al., 2001), while a leaf decoction is applied in Senegal against stomachache, fumigation of the leaves against lumbago (Kerharo and Adam, 1964) and a poultice of pounded leaves in Cameroon for the treatment of sore throat (Dalziel and Hutchinson, 1937). The plant (Fig. 19) is made up into a masticatory to treat gingivitis, aphthres and stomatitis, and is believed to have prophylactic and curative power against fever, yellow fever and jaundice (Kerharo, 1973; Kerharo and Adam, 1963, 1974; Haerdi et al., 1964). A decoction or infusion of the inflorescences is used against yellow fever (Adam, 1954; Kerharo, 1973; Kerharo and Adam, 1974), while dried panicles are commonly sold in markets as a fever remedy and for the treatment of cough (Dalziel and Hutchinson, 1937).

3.6.2.2. Bioactivities

3.6.2.2.1. Flower + leaf + stem

Common names

Wadjalo (Cameroon), Tsauri grass (English), beigne fala, citronelle, verveine de Ceylan, verveine de Sri Lanka (French), großes Zitronengras (German).

Fig. 19. The photograph of leaves of *Cymbopogon giganteus* Chiov.

Common names

Horse-radish tree, moringa (English).

Fig. 20. The photograph of leaves and fruit of *Drypetes gossweileri* S. Moore.

For antimicrobial assays, the bacteria *Staphylococcus aureus* ATCC 6538P, *Enterococcus faecalis* clinical isolate, *Escherichia coli* ATCC 8739, *Proteus vulgaris* clinical isolate, *Pseudomonas aeruginosa* G 28, *Salmonella* sp. clinical isolate, *Klebsiella pneumoniae* clinical isolate, and *Salmonella* sp. clinical isolate as well as the yeast *Candida albicans* ATCC 10231 were used. From the flower essential oil, two samples both gave MICs between 6 and 600 ppm depending on the strain, while the leaf essential oil was recorded to be active towards all tested microbes with an MIC of 60 ppm. In addition, the stem essential oil displayed MICs between 60 and 600 ppm. All tests results were compared to the synthetic drugs ciproxin®, lidaprim® and tetracycline hydrochloride® which showed MICs of 600 ppm, except lidaprim® with 60 ppm against *Proteus vulgaris* and *Salmonella* sp. (Jirovetz et al., 2007). Data show that flower, leaf and stem essential oil of this plant are comparable to or more effective than current synthetic drugs used against bacterial/fungal infections.

3.7. Putranjivaceae

3.7.1. *Drypetes gossweileri* S. Moore

3.7.1.1. Traditional use

While the root is used in general healing, the bark finds application as pain killer, genital stimulant/depressant, against veneral diseases and as febrifuge. It is as well a good fish poison and reptile repellent (Burkill, 1985). The plant (Fig. 20) is applied for the treatment of wounds and toothache (Troupin, 1983). In Central Africa, it is widely used to treat helmintic diseases and rheumatism (Walker and Sillians, 1961).

3.7.1.2. Bioactivities

3.7.1.2.1. Stem bark

The stem bark 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 0.76 µg AAE/mg; SC_{50}=0.20 µg/mL compared to ascorbic acid with 1.98 µg/mL; and IC_{50}=88.30 µg/mL compared to sodium diclofenac with 104.44 µg/mL, respectively (Ndoye et al., 2016). Furthermore, stem bark 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. Macro dilution assays were carried out with the stem bark essential oil resulting in MICs of 9, 4, 9 and 9 µg/mL, repectively, for inhibition of bacterial growth, and 2, 2, 1 µg/mL for inhibition of spore germination of the first three bacteria (Voundi et al., 2015). It should be noted that no toxic effect was noticed in male and female albinos Wistar rats treated per os with the crude stem bark extract at a dose up to 12g/kg of body weight (Ngouana et al., 2011).

Interestingly, the root oil of *Pentadiplandra brazzeana* (Pentadiplandraceae) analysed by Ndoye et al. (2016) and Nyegue et al. (2008), see chapter 3.1., as well as the stem bark oil of *Drypetes gossweileri* (Putranjivaceae) analysed by Ndoye et al. (2016) and Voundi et al. (2015), both show benzylisothiocyanate and benzylcyanide as major compounds-compounds that have not been identfied from any of the other sample analysed from Camerroonian rain forest material. Possible implications concening plant taxonomy might be discussed.

3.8. Rutaceae

3.8.1. *Citrus aurantifolia* (Christm.) Swingle

3.8.1.1. Traditional use

In Western Africa, the leaf is used in general healing, for kidney problems and as diuretic, as febrifuge, and against diarrhea and dysentery, while fruit juice is applied as pain killer, in eye treatments, as laxative, against veneral diseases, for treatment of small-pox, checken-pox and measles, further as antidote for venomous stings and bites. In addition, seeds and roots

Common names

Common lime, Egyptian lime, Indian lime, key lime, lime, Mexican lime, sour lime, sweety (English), lineci (Cameroon).

Fig. 21. The photograph of fruits of *Citrus aurantifolia* (Christm.) Swingle.

are used for kidney problems and as diuretic, while seeds are taken in the treatment of veneral diseases, as well (Burkill, 1985). Fruit juice (Fig. 21) warmed with sugar is taken with aspirin as a contraceptive. For eczema, a small piece of the peel is powdered together with pepper and the whole plant of *Euphorbia prostrata* Aiton (Euphorbiaceae).

For headache, chest- and bodyache, roots are boiled together with roots and leaves of *Senna occidentalis* (Leguminosae) and roots of *Acacia polyacantha* (Leguminosae) and the filtrate is drunk. For cough, leafy twigs together with those of *Azadirachta indica* (Meliaceae) and *Eucalyptus camaldulensis* (Myrtaceae) are decocted and drunk; and for the treatment of rheumatoid arthritis, leaves and ginger are made into a paste and rubbed on the affected body part (Quattrocchi, 2012).

3.8.1.2. Bioactivities

3.8.1.2.1. Leaf + epicarp

Leaf and epicarp essential oils were subjected to mycelium growth inhibition and inhibition of sporangium production assay against the fungus *Phytophthora colocasiae* causing taro leaf blight disease. While mycelium growth inhibition for the leaf essential oil at 250, 300, 350, 400, 450, 500 and 550 ppm was recorded with 78.52, 86.42, 85.47, 96.33, 98.42 100 and 100%, respectively, the epicarp essential oil at 650, 700, 750, 800, 850, 900, 950 and 1000 ppm showed 61.42, 71.66, 83.33, 83.76, 96.33, 100, 100 and 100%, respectively, compared to the positive control metalaxyl which gave complete inhibition at 750 ppm. The sporangium production inhibition for the leaf essential oil at 62.5, 125.0, 250.0 and 400 ppm resulted in 45.56, 47.53, 52.67 and 72.84%, respectively, while the epicarp essential oil measured at 100, 300, 600 and 800 ppm displayed 48.14, 55.96, 72.01 and 80.65%, respectiverly, also compared to the positive control metalaxyl which gave 100% inhibition at 750 ppm (Tchameni et al., 2017).

3.8.1.2.2. Pericarp

In a toxicity assay against stage four larvae of the malaria vector *Anopheles gambiae* strains from Kisumu and Logbessou, Cameroon, the essential oil from pericarps of ripe fruits displayed IC_{50s} of 57.47 and 73.81 ppm, respectively, while IC_{95s} after exposition for 12 hours were 201.86 and 271.89 ppm, respectively (Akono et al., 2015).

3.8.1.2.3. Leaf

The leaf essential oil was tested against the bacterium *Xanthomonas citri* causing *Citrus* bacterial canker (CBC), one of the most devastating citrus diseases. The MIC of the leaf oil was recorded with 0.5 mg/mL, and for α-terpineol, citral, citronellal, geraniol, linalool and linalyl acetate values were 0.625, 0.375, 1.0, 0.9, 0.85 and 8.5 mg/mL, respectively. Synergistic effects were highest in a combination of citral-geraniol with a fractional inhibitory concentration (FIC index) of 0.313 (Mirzaei-Najafgholi et al., 2017).

3.8.1.2.4. Fruit

The fruit essential oil showed 78% inhibition of human colon cancer cells SW-480 with 100 µg/mL concentration at 48h. The volatile oil showed DNA fragmentation and induction of caspase-3 up to 1.8 and 2- folds after 24h and 48h, respectively, which may be due to the involvement of apoptosis. Analysis of apoptosis-related protein expression further confirmed apoptosis induction (Patil et al., 2009).

3.8.2. *Citrus limon* (L.) Osbeck

3.8.2.1. Traditional use

While the fruit (Fig. 22) is used in Africa for general healing, bark, leaf, root and fruit juice are taken against stomach troubles, and leaf, root and fruit juice against liver problems. In addition, the root is applied against veneral diseases, and the leaf as well as the fruit juice as febrifuge (Burkill, 1985). Seed pultrice with tubers of *Cyperus rotundus* (Cyperaceae) is applied against inflammation of joints, while the aroma of the bruised leaves is inhaled to stop vomiting. Furthermore, leaves are pounded with leaves of *Gossypium herbaceum* (Malvaceae), warmed with coconut oil and rubbed on the body as febrifuge. In veterinary medicine, fruit juice is applied in bruises and contusions (Quattrocchi, 2012).

3.8.2.2. Bioactivities

3.8.2.2.1. Pericarp

The pericarp essential oil was submitted to macro dilution assay employing the spore forming bacteria

Common names

Lemon (English), citron, citronnier (French).

Fig. 22. The photograph of fruits of *Citrus aurantifolia* (Christm.) Swingle.

Bacillus cereus T, *Bacillus megaterium* 8174, *Bacillus subtilis* NCTC 3610 and *Geobacillus stearothermophilus* CNCH 5781. Macro dilution assays were carried out with the pericarp essential oil resulting in MICs of 1.25, 2.5, 1.25 and 1.25 mg/mL, respectively, for inhibition of growth, and 0.75, 0.37, 0.37 mg/mL, respectively, for inhibition of spore germination of the first three bacteria (Voundi et al., 2015). In a toxicity assay against stage four larvae of the malaria vector *Anopheles gambiae* strains from Kisumu and Logbessou, Cameroon, the essential oil from pericarps of ripe fruits displayed IC_{50s} of 13.75 and 32.28 ppm, respectively, while IC_{95s} after exposition for 12 hours were 54.94 and 104.70 ppm, respectively (Akono et al., 2015). Furthermore, at 200, 100 and 50 ppm, the knock-down time (Tkd_{50}) for female adult *Anopheles gambiae* exposed to the pericarp oil for 60 minutes was 1.99, 6.48 and 14.4 minutes, while at 200, 100 and 50 ppm, the mortality rate after 24 hours was 90, 83 and 15%, respectively (Akono et al., 2016b).

3.8.2.2.2. Flower

In an antibacterial assay employing foodborne bacteria of *Bacillus subtilis* ATCC 6633, *Bacillus cereus* ATCC 14579, *Staphylococcus aureus* ATCC 25923, *Staphylococcus epidermis* ATCC 12228, *Enterococcus faecalis* ATCC 29212, *Listeria monocytogenes* ATCC 19117, *Salmonella enterica* ATCC 43972, *Escherichia coli* ATCC 25922 and *Pseudomonas aeruginosa* ATCC 9027, MICs obtained by microdilution assay were recorded for the flower essential oil with 0.625, 1.25, 0.078, 1.25, 0.625, 0.039, 0.625, 1.25 and 2.5 mg/mL, respectively. In addition, assays employing plant pathogen/food spoiling fungi *Aspergillus niger* CTM 10099, *Aspergillus flavus* (food isolate), *Aspergillus nidulans* (food isolate), *Aspergillus fumigatus* (food isolate), *Fusarium graminearum* ISPAVE 271, *Fusarium oxysporum* CTM10402, *Fusarium culmorum* ISPAVE 21w and *Alternaria alternata* CTM 10230 resulted in minimum fungicidal concentrations (MFCs) of 0.625, 0.312, 0.625, 0.625, 0.625, 0.625, 0.312 and 1.25 mg/mL, respectively (Hsouna et al., 2017).

3.8.2.2.3. Leaf

Common names

Forbidden fruit, pomelo, pummelo, shaddock (English), bomali, pomaly (Arabic), Pampelmuse (German), pamplemoussier for the tree, pamplemousse for the fruit (French), youi (China).

Fig. 23. The photograph of fruits of *Citrus maxima* (Burm.) Merr.

MICs determined for *Staphylococcus aureus* ATCC 25923, *Bacillus cereus* PTCC 1154, *Streptococcus faecium* ATCC 10541, *Escherichia coli* ATTC 25992, *Salmonella typhi* PTCC 1609 and *Shigella dysenteria* PTTC 188 resulted in MICs of 59, 30, 49, 52, 30 and 57 mg/mL (Hojjati and Barzegar, 2017). However, positive controls were not reported for MIC assays.

3.8.3. *Citrus maxima* (Burm.) Merr.

3.8.3.1. Traditional use

In Cameroon, fruits (Fig. 23) of the genus *Citrus* are used as medicines to fight against cough and as natural source of vitamins (Nyegue et al., 2017). Moreover, leaves of *Citrus maxima* are applied against epilepsy, chorea, convulsive cough and also in the treatment of hemorrhage diseases, while flowers are used as sedative in nervous affection and fruits to treat leprosy, asthma, cough, hiccough, mental aberration, epilepsy and heart problems.

Furthermore, the rind is taken as antiasthmatic, sedative in nervous affection, brain tonic and believed to be helpful against vomiting, griping of the abdomen, diarrhea, headache and eye troubles Vijaylakshmi and Radha, 2015). In Indian traditional medicine, fruits are applied as antiseptic, astringent, for skin diseses, for the treatment of irregular menstrual flow, for dizziness, fevers, and dysentery, as an emetic and against sore throat. Leaves are regarded as effective in cholera, epilepsy and convulsive cough. For swellings, a bath is taken in boiled leaves. Moreover, salted root paste is applied in cough, bronchitis and catarrh (Quattrocchi, 2012).

3.8.3.2. Bioactivities

3.8.3.2.1. Leaf + peel

The leaf and peel essential oil was shown to be effective in a toxicity assay as ovicide having an LC_{50} of 14.02 ppm and 17.06 ppm after 72 h, respectively, against the house mosquito *Culex quinquefasciatus*, which is the vector of avian malaria and arboviruses as well as the parasite *Wucheria bancrofti* transmitting lymphatic filariasis. In addition, larvicidal activity displayed an LC_{50} of 18.53 and 40.59 ppm after 72 h, respectively (Mahanta et al., 2017).

3.8.3.2.2. Leaf + pericarp

The leaf oil displayed LC_{50s} against stage four larvae and pupae of the malaria vector *Anopheles gambiae* of 103.08 ppm and 145.18 ppm, respectively, while the pericarp essential oil showed mortality rates of 23.25 and 5.75% of *Anopheles gambiae* and the mosquitoe *Anopheles coluzzii*, respectively, at 50 ppm (Akono et al., 2016a,b).

3.8.3.2.3. Pericarp

At 200, 100 and 50 ppm, the knock-down time (Tkd_{50}) for female adult *Anopheles gambiae* exposed to the pericarp oil for 60 minutes was 0.01, 0.97 and 3.64 minutes, respectively, while at 200, 100 and 50 ppm the mortality rate after 24 hours of observation was 100, 100 and 93%, respectively (Akono et al., 2016b).

3.8.3.2.4. Leaf

In an assay using bacterial pathogens *Staphylococcus aureus* PTCC 1112, *Escherichia coli* PTCC 1399, *Bacillus subtilis* PTCC 1156 and *Salmonella typhi* PTCC 1609, MICs caused by the leaf essential oil were recorded with 900, 150, 600 and 300 μg/mL, respectively (Saeb et al., 2016).

3.8.3.2.5. Fruit peel

In a repellency test using rats, 20% of the oil provided 94.7% protection of the test animal against female *Aedes aegypti* bites up to 3 hours, which is slightly lower than 97.9% repellency of the positive control, 15% *N,N*-diethyl-m-toluamide (DEET). Moreover, in a study on the repellency effect against female blood hungry *Aedes aegypti* mosquitoes, the oil led to an effective repellency of 33.2, 79.0 and 93.8% at 10, 100 and 1000 ppm, respectively and gave an LC_{50} of 29.43 and 25.23 ppm 24 and 48 h post treatment, respectively, against larvae of *Aedes aegypti* (Malar et al., 2017a,b).

3.8.4. *Citrus medica* L.

3.8.4.1. Traditional use

In Western Africa, the fruit (Fig. 24) is used for general healing, while bark, leaf, root and fruit juice are applied against stomach troubles. Furthermore, leaf, root and fruit juice are taken in the case of liver complaints, and root and leaf/fruit juice are applied against veneral diseases and as febrifuge, respectively (Burkill, 1985; Walker and Sillians, 1961). Fruits and leaves are used in different countries in the treatment of allergic inflammation, for treating colds, as a decongestant, an expectorant, and a carminative or, in the case of pathologies of the intestinal tract and rectum, as well as a stomachic, antispasmodic, diuretic and digestive (Uzun and Yesiloglu, 2012; Yeung, 1985).

Common names

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

Fig. 24. The photograph of *Cyperus articulatus* L..

Ripe fruits find many medical applications: along with milk, it is given in dysentery; a decoction mixed with honey is applied on the forehead in mental disorders and hysteria; and the rind juice is dropped in eyes trouble and swelling. Bark and leaf juice are given as vermifuge (Quattrocchi, 2012).

3.8.4.2. Bioactivities

3.8.4.2.1. Leaf

The leaf essential oil when exposed for 10 h to stage four larvae and pupae of the malaria vector *Anopheles gambiae* resulted in LC_{50s} of 123.96 and 92.76 ppm, resperctively (Akono et al., 2016a).

3.8.4.2.2. Pericarp

In agar plate diffusion assay, the pericarp essential oil showed low inhibition zones of 6 mm to bacterial strains of *Escherichia coli* ATCC 25922, clinical strains of *Salmonella typhimurium* and *Salmonella paratyphimurium* (Nyegue et al., 2017).

3.8.4.2.3. Peel

Peel essential oil of *Citrus medica* var. *rogosa* and *Citrus medica* var. *liscia* were investigated against *Bacillus cereus* 4384, *Bacillus cereus* 4384, *Escherichia coli* DSM 8579, *Pseudomonas aeruginosa* ATCC 50071 and *Staphylococcus aureus* DSM 25693, giving MICs of 0.5, 0.1, 0.2, 0.8 and 0.8 μL for *Citrus medica* var. rogosa and 0.1 μL against all above test bacteria for *Citrus medica* var. *liscia*. Furthermore, in a cytotoxicity assay employing neuroblastoma cell line SH-SY5Y, the two oils gave MICs of 718.2 μg/mL and > 2000 μg/

mL, respectively. However, in MTT assay at 800 μg/mL, *Citrus medica* var. *liscia* essential oil resulted in a stronger cytotoxicity with 38% cell death (Aliberti et al., 2016).

3.8.5. *Citrus reticulata* Blanco

3.8.5.1. Traditional use

The rind is used in Cameron traditional medicine as tonic, stomachic, astringent, and carminative, antiscorbutic as well as for the treatment of gastric and abdominal distension and against cough and vomiting. In addition, the fruit (Fig. 25) oil is appled as anodyne and antispasmodic (Quattrocchi, 2012).

3.8.5.2. Bioactivities

3.8.5.2.1. Pericarp

The pericarp 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. Macro dilution assays were carried out with the pericarp essential oil resulting in MICs of 2.5 mg/mL against the bacteria Bacillus megaterium, *Bacillus subtilis* and *Geobacillus stearothermophilus* for inhibition of their growth, and 1.5, 0.75 and 1.5 mg/mL, respectively, for inhibition of spore germination of the first three bacteria (Voundi et al., 2015). In a toxicity assay against stage four larvae of the malaria vector *Anopheles gambiae* strains from Kisumu and Logbessou, Cameroon, the essential oil from pericarps of ripe fruits displayed IC_{50s} of 33.17 and 49.64 ppm, respectively, while IC_{95s} after exposition for 12 hours were 88.32 and 132.13 ppm, respectively (Akono et al., 2015).

3.8.5.2.2. Peel

The peel essential oil was submitted to antibacterial assays by microdilution plate method showing MICs of 5 μl/mL against *Listeria innocua* CLIP 74915, *Staphylococcus aureus* ATCC 25923/ATCC 43300 methicillin-resistant, *Escherichia coli* ATCC 25922 and *Candida albicans* ATCC 10231 (Boudries et al., 2017). Furthermore, the fruit peel essential oil was assayed against adult worms of *Schistosoma mansoni* causing chronic parasitic disease which remains a truly neglected tropical disease. LC_{50s} of 81.7 μg/mL after 24 as well as 72 h were recorded. Furthermore, an IC_{50} of 987.7 μg/mL against the human lung fibroblast cell line GM 07492-A was recorded by colorimertric assay (XTT) (Martins et al., 2017). The peel essential oil was assayed against adults the rusty grain beetle *Cryptolestes ferrugineus* with > 80.0% repellency after 60 h of exposure; > 99.0% after 48 h of exposure at the dosage of 2.0 μL/cm² in contact toxicity assay; and 89.0 and 100.0% in fumigant toxicity assay at the dosages of 40 and 80 μL/L of air, respectively (Lü, 2017).

3.8.5.2.3. Leaf

The leaf essential oil was tested by modified E-test method against *Staphylococcus aureus* PTCC 1112, *Escherichia coli* PTCC 1399 and *Bacillus subtilis* PTCC 1156 delivering MICs of 900, 900 and 1800 μg/mL (Saeb et al., 2016). However, a positive control was not reported.

3.8.6. *Citrus sinensis* (L.) Osbeck

3.8.6.1. Traditional use

In western Africa, the fruit (Fig. 26) is applied for skin and mucosae troubles, while the fruit rind is used against stomach problems. In addition, the leaf is taken as sedative, against pulmonary disorders, as febrifuge, and the flower as sedative and febrifuge. A preparation from the seeds is taken as febrifuge as well (Iwu, 1993; Irvine, 1961; Purseglove, 1972; Watt and Breyer-Brandwijk, 1962).

3.8.6.2. Bioactivities

Common names

Mandarin, mandarin orange, tangerine, clemantine, satsuma (English), mandarine for the fruit, mandarinier for the tree, tangarine for the fruit, tangarinier for the tree (French), ponkan (Japanese).

Fig. 25. The photograph of fruits of *Citrus maxima* (Burm.) Merr.

Common names

Orange, sweet orange, Mediterranean orange, Spanish orange, blood orange, navel orange (English), orange douce, oranger (French); Orange, Apfelsine (German).

Fig. 26. The photograph of fruits of *Citrus sinensis* (L.) Osbeck.

3.8.6.2.1. Pericarp

In a toxicity assay against stage four larvae of the malaria vector *Anopheles gambiae* strains from Kisumu and Logbessou, Cameroon, the essential oil from pericarps of ripe fruits displayed IC_{50s} of 37.45 and 56.54 ppm, respectively, while IC_{95s} after exposition for 12 hours were 150.38 ppm for both strains (Akono et al., 2015). Furthermore, at 200, 100 and 50 ppm, the knock-down time (Tkd_{50}) for female adult *Anopheles gambiae* exposed to the pericarp oil for 60 minutes was 0.03, 0,92 and 1.86 minutes, respectively, while at 200, 100 and 50 ppm, the mortality rate after 24 hours of observation was 100, 100 and 98%, respectively (Akono et al., 2016b).

3.8.6.2.2. Leaf + pericarp

The leaf essential oil displayed LC_{50s} against stage four larvae and pupae of the malaria vector *Anopheles gambiae* of 136.98 ppm and 78.41 ppm, respectively, while the pericarp essential oil at 50 ppm showed mortality rates of 24.5 and 16.25% of *Anopheles gambiae* and the mosquitoe *Anopheles coluzzii*, respectively (Akono et al., 2016a,b).

3.8.6.2.3. Fruit

In human bait method, the fruit essential oil displayed repellency of 84% of *Anopheles dirus* for 24 minutes at a concentration of 0.21 mg/cm² (Phasomkusolsil and Soonwera, 2011).

3.8.6.2.4. Leaf

In an assay employing *Citrus exocortis* viroid (CEVd) and *hot stunt cachexia viroid* (HSVd) infected plants, the peel essential oil displayed IC_{50s} of 54.58 and 36.6 µg/mL, respectively, against trophozoites of *Acanthamoeba castellanii* (Zouaghi et al., 2017). *Acanthamoeba castellanii* is a free-living protozoan that causes keratitis in humans and has been associated with pneumonia and granulomatous amoebic encephalitis in dogs, sheep, and other species (Kennett et al., 1999).

3.8.7. *Clausena anisata* (Willd.) Hook. f. ex Benth.

3.8.7.1. Traditional use

In Cameroon, leaves are used against parasitic infections, especially by flatworms, hepatic diseases causing bad breath and against malaria and fevers. The dried plant (Fig. 27) is burned to repel mosquitoes (Okunade and Olaifa, 1987). It is administered for the treatment of rheumatism, influenza and as a heart tonic. Farmers of the Cameroonian Western highlands use dried leaves to protect stored products against insect infestations (Tapondjou et al., 2000).

The leaf is further applied as sedative, against stomach troubles, as an emetic, as febrifuge, against small-pox, chicken-pox, measles, malnutrition, debility, paralysis, epilepsy, convulsions and spasms, while the root is used for the treatment of troubled ear, as vermifuge, against haemorrhoids, as abortifacient, for stimulation of lactation, against dropsy, swellings, oedema and insanity. Both leaf and root are given in preparations for the treatment of arthritis, rheumatism, pulmonary troubles and stomach complaints (Burkill, 1985).

3.8.7.2. Bioactivities

3.8.7.2.1. Leaf

In a contact toxicity assay with dried ground leaves on beans, LD_{50} values were 6.3% against the mung bean pest *Callosobruchus maculatus* and 12.5% against the green pea's pest *C. chinensis* after two days of exposure. In a contact toxicity assay on filter paper, LD_{50s} were reported with 0.01 and 0.052 µL/cm² for the leaf oil and 0.01 and 0.003 µL/cm² for its component anethole after one day of exposure to *C. maculatus* and *C. chinensis*, respectively. Furthermore, in a toxicity assay with leaf essential oil and anethole on beans, LD_{50} values were recorded with 5.97 and 4.30 µL/40 g beans for the leaf essential oil and 0.37 and 0.65 µL/40 g beans for anethole. Moreover, F1 progeny production of *C. maculatus* was completely inhibited at 0.625g/50g beans treated with dried ground leaves and 8 µL/40g beans treated with the leaf essential oil. In addition, F1 progeny production of *C. chinensis* was completely inhibited at 5g/50g beans and by 98.3% at 8 µL/40 g beans. Moreover, repellency of *C. maculatus* was 95% for leaf essential oil at 0.416 µL/cm² on filter paper and 90% for anethole at 0.208 µL/cm². For *C. chinensis*, it was 95% for leaf essential oil at 0.416 µL/cm² on filter paper and 90% for anethole at 0.104% µL/cm². Results of the study were suggested to underpin the scientific rationale for the incorporation of the leaves of this plant into stored product protection practices of communities in the Western highlands of Cameroon

Common names

Saman ndobir, samandua (Cameroon), clausena, horsewood (English), Perdepis (Africaans).

Fig. 27. The photograph of fruits of *Clausena anisata* (Willd.) Hook. f. ex Benth.

(Tapondjou et al., 2002). In addition, contact/inhalation assays carried out with the leaf oil on filter paper in petri dishes gave an LD_{50} of 651.0 ppm against the red flour beetle *Tribolium castaneum*, but was inactive against the maize weevil *Sitophilus zeamais* and the rice weevil *Sitophilus oryzae* (Ngamo et al., 2007b). Interestingly, a toxicity assays with the leaf oil resulted in an LD_{80} value of 410 ppm against *Tribolium castaneum*, compared to the industrial insecticide imidacloprid® displaying an LD_{80} value of 800 ppm. At the forth generation, 25% and 5% of *T. castaneum* did not survive after original treatment with the leaf oil and imidacloprid®, respectively. Thus, *T. castaneum* could acquire resistance to imidacloprid® five times faster than to the leaf essential oil (Goudoum et al., 2010). Furthermore, after 2 days, a contact toxicity assay against adults of the kidney bean weevil *Acanthoscelides obtectus* using the leaf essential oil and a mixture of leaf essential oil and clay resulted in LD_{50s} of 0.081 μL/g grain and 0.069 μL/g grain, respectively, while both preparations led to considerably reduced F1 progeny production. Against adults, repellent action was moderate, however, fumigant toxicity impressed with LC_{50}=0.093 μL/cm^3 (Ndomo et al., 2008). The leaf essential oil was assayed against the parasite *Trypanosoma brucei brucei* TC 221 causing African sleeping sickness, resulting in an IC_{50} of > 100 μg/mL, compared to the positive control suramin with 0.0286 μg/mL (Kamte et al., 2017). The acute toxicity of the leaf essential oil against larvae of the filariasis vector, *Culex quinquefasciatus*, and the housefly, *Musca domestica*, gave LC_{50s} of 29.3 μL/L and 90.1 μg/adult. Furthermore, antioxidant activity measured by DPPH and ABTS method, resulted in IC_{50s} of 1.81 and 1.31 mg/mL, respectively, compared to the Trolox equivalent (TE) of 8.38 and 7.68 μmol TE/g, respectively (Pavela et al., 2018). In addition, after 10 days of incubation on leaf essential oil supplemented medium, the growth of *Aspergillus flavus*, *Aspergillus niger*, *Aspergillus parasiticus* and *Fusarium moniliforme* was totally inhibited by 4, 5, 5 and 5 mg/mL, respectively, while the antiradical activity with SC_{50}=5.1 g/L was less than that of butylated hydroxyl toluene (BHT) displaying SC_{50}=0.007 g/L (Yaouba et al., 2011).

Traditional medicinal use of the leaf, roots and bark reported against severe diseases like flatworm infection and malaria might be investigated by appropriate *in vitro* assays on its oils, as probable carrier of activities.

3.8.8. *Vepris heterophylla* (Engl.) Letouzey

3.8.8.1. Traditional use

In Cameroon, the leaves are used traditionally in crop protection for the reduction of post harvest losses due to insect pests, and are also applied in the treatment of rheumatism, malaria, as anthelmintic, parasiticide and purgative. In addition, a leaf extract is taken in Mali as diuretic, antipyretic, to treat conjunctivitis and to reduce

Common names

Ampodiberavina, itampody, mampodifotsy.

Fig. 28. The photograph of leaves and flowers of *Vepris heterophylla* (Engl.) Letouzey.

high blood pressure, while a boiled decoction of leaves (Fig. 28) is drunk as remedy against the fever of malaria (Ngamo et al., 2007b; Nordeng et al., 2013).

3.8.8.2. Bioactivities

3.8.8.2.1. Leaf

In a toxicity assay, the leaf essential oil displayed an LD_{50} value of 349.8 ppm against the grain pest *Sitophilus oryzae*, while its combination with the flower essential oil of *Hyptis spicigera* (Lamiaceae) and flower essential oil *Ocimum canum* (Lamiaceae) displayed 182.1 and 103.8 ppm, respectively. This was more active than the expected values of 230.9 and 196.0 ppm, respectively, indicating synergistic effects (Ngassoum et al., 2007). In a contact/inhalation assay, the leaf essential oil showed LD_{50} of 49.44 ppm against the red flour weevil *Tribolium castaneum*, but was inactive against the maize weevil *Sitophilus zeamais* and the rice weevil *S. Oryzae*. In another contact/inhalation assay with leaf oil impregnated filter paper in petri dishes, the volume of oil from Makolo plants required to kill half the population of *T. castaneum* was 49.44 μL and 61.21 μL for oil received from Meri plants, while 32% of insects were attracted by both oils impregnated on filter paper (Ngamo et al., 2007a, b). The leaf oil might be assayed *in vitro*/*in vivo* for effectivity against severe diseases like malaria and high blood pressure as reported from traditional Cameroonian medicinal use of the leaves.

3.8.9. *Zanthoxylum leprieurii* Guill. & Perr.

3.8.9.1. Traditional use

Not further specified parts of plants (Fig. 29) used by traditional healers in Cameroon for the treatment of stomach disorders, gonorrhea, intestinal parasites and sterility. An infusion from the fruit is taken in Cameroon for the treatment of sickle cell anemia as well Misra et al., 2013), while bark, seeds and fruits are applied against abdominal pain, asthma, appendicitis, toothache, gastritis, gingivitis, bilharzias, as antidiarrheal, against cancer, as laxative, antimicrobial and against ulcer and

Common names

Minlam, melem (Cameroon), sand knobwood (English).

Fig. 29. The photograph of trunk of *Zanthoxylum leprieurii* Guill. & Perr.

Common names

Senegal prickly ash, prickly ash, artar root, toothache bark (English), Fagara jaune (French), Senegalpfeffer (German).

Fig. 30. The photograph of leaves and fruits of *Zanthoxylum xanthoxyloides* (Lam.) Zepern. & Timler.

kidney ache (Ngane et al., 2000).

The plant is used in Cameroon as well for the treatment of fever, coughs, colds and toothache (Reisch et al., 1985) and against skin infection, urinary tract infection and dysentery (Noumi, 1984). The fruits are taken against stomach disorders, and roots and bark against gonorrhea, intestinal parasites and sterility (Kerharo and Adam, 1974).

3.8.9.2. Bioactivities

3.8.9.2.1. Fruit

In MTT assay, the fruit essential oil displayed IC_{50} values of 89.6, 76.0, 96.8 and 92.5 µg/mL against human glioblastoma cell line T98G, human breast adenocarcinoma cell line MDA-MB 231, human malignant melanoma cell line A375 and human colon carcinoma cell line HCT116, respectively, compared to cisplatin® displaying 2.3, 2.1, 0.2 and 2.6 µg/mL, respectively (Fogang et al., 2012). Furthermore, the fruit oil inhibited the growth of foodborne bacteria *Salmonella enteritidis* 155A, *Listeria monocytogenes* Scott A and *Staphylococcus aureus* SR231 600 ppm in detection time assay. Best results were here received against *Listeria monocytogenes*, where the oil delayed the detection time around two fold compared to the negative control (Gardini et al., 2009).

Activity of the fruit applied in Cameroonian traditional medicine against sickle cell anaemia and bark and seeds against cancer might be further investigated by appropriate *in vitro*/*in vivo* assays.

3.8.10. *Zanthoxylum xanthoxyloides* (Lam.) Zepern. & Timler

3.8.10.1. Traditional use

In Cameroon, the aqueous decoction of leaves and roots is used to bathe wounds and root bark against intestinal worms and edema. A combination of the roots with roots and leaves of *Festuca flavescens* (Poaceae), *Uvaria chamae* (Annonaceae) and *Hibiscus surattensis* (Malvaceae) is applied for the treatment of sickle cell anaemia, while root bark mixed with rhizomes of *Aframomum melegueta* (Zingiberaceae) is applied to relieve abdominal pain and hyperthermia.

Other uses include treatment of indigestion, diarrhoea, urinary tract infections and gingivitis (Iwu, 2014; Noumi, 1984). The plant is also taken against haemolysis of red blood cells in patients with malignant neoplastic diseases (Miller et al., 1956) and applied against cough, fever, colds, toothache and snake bite (Neuwinger, 2000; Ngassoum et al., 2003; Oliver-Bever, 2009) as well as against cancer (Olowokudejo et al., 2008). Treatment of dysentery, guinea worm and as an antiodontalgic was reported as well (Kerharo and Adam, 1974).

3.8.10.2. Bioactivities

3.8.10.2.1. Fruit

In MTT assay, the fruit essential oil displayed IC_{50s} of 35.4, 18.2, 47.6 and 27.8 µg/mL against human glioblastoma cell line T98G, human breast adenocarcinoma cell line MDA-MB 231, human malignant melanoma cell line A375 and human colon carcinoma cell line HCT116, respectively, compared to cisplatin® with 2.3, 2.1, 0.2 and 2.6 µg/mL, respectively. Results give some rationale for the local Cameroonian use of this plant for the treatment of cancers Fogang et al., 2012). Furthermore, in an antibacterial assay, the detection time of foodborne bacteria *Salmonella enteritidis* 155A, *Listeria monocytogenes* Scott A and *S. aureus* SR231 was doubled for *Listeria monocytogenes* and tripled for *Staphylococcus aureus* at 300 ppm of the fruit oil (Gardini et al., 2009). Furthermore, in paper disk diffusion assay with 10 µL per paper disk, the fruit neat essential oil displayed extensive inhibition zone diameters of 12.5-20.5 mm against various human pathogen bacteria, compared to penicillin G® displaying 9.5-30 mm at 2000 ppm. At a 10% concentration of the fruit oil, diameters of inhibition zones were still 7.5-9 mm (Ngassoum et al., 2003). The fruit essential oil showed in addition activity against the food poisoning bacteria *Salmonella typhimurium* and

Bacillus subtilis displaying MICs of 0.26 and 0.52 μL/mL, respectively, compared to the antibiotic kanamycin with 0.52 and 0.53 μL/mL, respectively (Misra et al., 2013).

Activity of the roots applied in Cameroonian traditional medicine against sickle cell anaemia and some plant parts against haemolysis of red blood cells in patients with malignant neoplastic diseases and cancers might be further investigated by appropriate *in vitro/in vivo* assays.

Comparing fruit essential oils of *Zanthoxylum leprieurii* and *Zanthoxylum xanthoxyloides*, their main compound pattern appears completely different, and it is suggested that the more pronounced anticancer activity of *Zanthoxylum xanthoxyloides* as well as its antibacterial potential may be related to the main compounds citronellol, geraniol and (*Z*)-β-farnesene or their synergistic action (Table 5).

3.9. Verbenaceae

3.9.1. *Lantana camara* L.

3.9.1.1. Traditional use

Leaves are reported to be used in Cameroon for the treatment of skin itch, ulcers and hepatitis (Bouda et al., 2001). Infusion of leaves is applied against asthma and colds, while the whole plant is considered as be antifever and antimalarial (Adjanohoun et al., 1988; Oliver-Bever, 2009; Watt and Breyer-Brandwijk, 1962). In Nigeria, the leaves are applied against fever, as antiseptic and antispasmodic (Odugbemi, 2008).

3.9.1.2. Bioactivities

3.9.1.2.1. Leaf

In an insecticidal assay employing impregnated maize grains, the leaf essential oil gave a LD_{50} value of 0.16% against the maize weevil *Sitophilus zeamais* after 24 h feeding (Bouda et al., 2001).

3.9.2. *Lippia adoensis* Hochst.

Common names

Big sage, wild sage, red sage, white sage, tickberry, Spanish flag, bush lantana (English), ewon-agogo, kimbar (Nigeria), Wandelröschen (German).

Fig. 31. The photograph of leaves and flowers of *Lantana camara* L.

3.9.2.1. Traditional use

The essential oil of the plant (Fig. 31) is used in Cameroon in general crude drug medicines, while in Ethiopia, the plant is applied for the treatment of eczema and superficial fungal infections. The dried leaves powdered together with barely are eaten to get relief from stomach complaints Buli et al., 2015; Gemeda et al., 2015; Mazarin et al., 2016). The plant is as well reported to be a children´s remedy for fever and constipation, and he leaves are used as decoction in the treatment of skin disorders, bronchitis and cough, while roots or leaves are applied against ophthalmia (Quattrocchi, 2012).

3.9.2.2. Bioactivities

3.9.2.2.1. Leaves

The leaf essential oil and major compounds triacetin, *para*-cymene, thymol-acetate and thymol were tested against the stored product beetle *Callosobruchus maculatus* showing that the oil and its constituents had strong toxicity against eggs, larvae and adults. Significant synergistic interaction of major constituents were reported, although lower than that of the oil itself. Data on behaviour at death, like turning around, agitation and hyperactivity suggested that the oil may be neurotoxic (Akami et al., 2016). 100% inhibition of

Table 5
Comparison of main fruit essential oil compounds produced by two *Zanthoxylum* species from the Western/Littoral Province.

Compounds	*Zanthoxylum leprieurii*		*Zanthoxylum xanthoxyloides*	
	Dschang, Western Highlands	Douala, Littoral Province	Dschang, Western Highlands	Douala, Littoral Province
Myrcene	**28.6%**			
(*E*)-β-Ocimene	**29.4%**	**77.36%**		
Limonene	**13.60%**			
Citronellol			**29.9%**	**40.0%**
Geraniol			**11.5%**	**9.0%**
(*Z*)-β-Farnesene				**10.08%**

Common names

Gambey tea bush, Gambian tea bush (English).

Fig. 31. The photograph of leaves and flowers of *Lippia adoensis* Hochst.

Common names

Gossolhi (Cameroon).

Fig. 32. The photograph of leaves and flowers of *Lippia rugosa* A. Chev.

mycelial groth and spore germination was reached by the leaf oil at 2 µL/mL against *Aspergillus flavus*, *Aspergillus parasiticus*, *Aspergillus niger* and *Aspergillus fumigatus*. The oil was found to be superior to the chemical synthetic preservative sodiumbenzoate: while the MIC of *Aspergillus fumigatus* was best with 1.00 mg/mL, compared to sodium benzoate with 8.00 mg/mL, other strains displayed 2.00 mg/mL, compared to sodium benzoate displaying 16.00 mg/mL or values above (Gemeda et al., 2015). Moreover, the leaf essential oil was shown to display an LC_{50} of 47.1 µg/mL against larvae of *Aedes aegypti*, the immature stage of the primary vector of dengue. (Massebo et al., 2009).

3.9.3. *Lippia rugosa* A. Chev.

3.9.3.1. Traditional use

In Cameroon, the plant (Fig. 32) is applied against indigestion, rheumatism, fever, cough and jaundice, as well as for the preservation of food items (Illiassa, 2004).

3.9.3.2. Bioactivities

3.9.3.2.1. Leaf

A two weeks storage test on samples of maize infested by the plant pathogen fungus *Aspergillus flavus* as well as maize co-infested by the maize weevil *Sitophilus zeamais* resulted in 95% inhibition of of *A. flavus*, *A. flavus* conidia and the maize weevil *S. zeamais* at 310 µL of leaf essential oil/200 g of maize grains. Furthermore, mycelium growth of *A. flavus* ATCC 46283 on leaf oil supplemented medium was totally inhibited at 1000 mg/L within 8 days, and on leaf oil supplemented SMKY broth, aflatoxin synthesis by *A. flavus* was inhibited at 1000 mg/L also within 8 days (Tatsadjieu et al., 2008). However, in agar dilution method, the leaf essential oil delivered low MICs of 300-1.300 µg/mL against various plantpathogen *Aspergillus*, *Fusarium* and *Penicillium* fungal strains (Aoudou et al., 2010, 2011). Concerning stored products weevils, the leaf essential oil gave LD_{50s} of 70.67, 354.63 and 348.47 ppm against second-, third-stage and young adults of the red flour weevil *Tribolium castaneum*, respectively (Kouninki et al., 2007).

3.9.3.2.2. Flower

In a chronic toxicity assay, the flower essential oil reduced the oviposition of the maize weevil *Sitophilus zeamais* from 19 to 2 eggs, and attacks of maize grains when coated with the oil from 37 to 18 after 100 days of rearing, indicating loss of appetite (Ngamo et al., 2007c).

Entire plant. The oil gave LD50s of 119.63, 117.00 and 348.25 µg/mL towards the plant weevils *Sitophilus zeamais*, *Sitophilus oryzae* and *Tribolium castaneum*, respectively, after 24 h of exposure to contact/inhalation assays carried out on filter paper in petri dishes (Ngamo et al., 2007c).

3.10. Zingiberaceae

3.10.1. *Aframomum citratum* (C. Pereira) K. Schum.

3.10.1.1. Traditional use

In Cameroon, the fruit (Fig. 33) is used to treat sterility in women as well as schizophrenia, and is believed to have a positive effect on the sympathetic nervous system (Tane et al., 2005). There is a general agreement between local Cameroonian populations that the plant brings strength and peace to families with twins (Nguikwie et al., 2013). Fruits, bark and leaves are applied against fever, intercostals pains, as tonic and as aphrodisiac (Kuete et al., 2011; Tane et al., 2005).

3.10.1.2. Bioactivities

3.10.1.2.1. Seeds

The essential oils displayed MICs of 0.40, 1.15, 1.10, 0.50 and 4.75 mg/mL towards the human pathogen bacteria *Staphylococcus aureus* ATCC 9144, *Escherichia coli* ATCC 25922, *Proteus mirabilis* ATCC 29906,

Common names

Mvonlo, mbak, bakim, etutu (Cameroon), akia mbego dibo (Mpiemo, East Cameroon), maniguette odorante (French).

Fig. 33. The photograph of fruits of *Aframomum citratum* (C. Pereira) K. Schum.

Common names

Tondo (Bibaya, South Cameroon), akia sonji nkali (Mpiemo, East Cameroon).

Fig. 34. The photograph of fruits of *Aframomum dalzielii* Hutch.

Klebsiella pneumoniae ATCC 10031, *Pseudomonas aeruginosa* ATCC 27853 and the dermatophyte *Candida albicans* ATCC 10231 in macro dilution assay, but was inactive towards *Pseudomonas aeruginosa* ATCC 27853 displaying an MIC > 9 mg/mL (Chalchat et al., 1997).

3.10.2. *Aframomum dalzielii* Hutch.

3.10.2.1. Traditional use

Not further specified parts of the plant (Fig. 34) are applied in Cameroon against stomachache Quattrocchi, 2012). There is a general agreement between local Cameroonian populations that the plant brings strength and peace to families with twins (Nguikwie et al., 2013).

3.10.2.2. Bioactivities

3.10.2.2.1. Seeds + pericarps + leaf + rhizomes

The essential oil displayed MICs of 0.9 and 0.19, from pericarps 25 and 1.56, from leaves 25 and 1.56, and from rhizomes 12 and 0.19 µL/mL against the non pathogen bacterium *Micrococcus luteus* and the human pathogen bacterium *Escherichia coli*, respectively, measured by broth dilution assay. Values for pure compounds were for sabinene MICs of 50 and 1.56, β-pinene 3.12 and 0.19, 1,8-cineole 12.3 and 0.78, linalool 0.19 and 0.19, (*E*)-β-caryophyllene > 50 and 50, α-humulene > 50 and 6.25, (*R*)-(*E*)-nerolidol 0.19 and 0.19, and caryophyllene oxide 12.5 and 25 µL/mL, respectiverly. It was concluded that the strong activity of the seed essential oil against both microorganisms might be attributed to its high content of (*R*)-(*E*)-nerolidol (Nguikwie et al., 2013).

3.10.3. *Aframomum daniellii* (Hook. f.) K. Schum.

3.10.3.1. Traditional use

In Western Africa, roots and seeds are used as vermifuge (Burkill, 1985), while the seeds are applied as laxative and antihelmintic and the root as purgative (Bouquet, 1969). In addition, the plant (Fig. 35) is employed to treat several parasitic and other microbial infections, as well as to control populations of arthropod pests (Adegoke et al., 2016; Adegoke and Skura, 1994; Ahua et al., 2007; Karunamoorthi and Hailu, 2014; Pavela et al., 2016).

3.10.3.2. Bioactivities

3.10.3.2.1. Seeds + pericarp + leaf

The seed, pericarp and leaf essential oil was investigated by larvicidal toxicity assay using larvae of the filariasis and West Nile virus vector *Culex quinquefasciatus*. Tests resulted in LC_{50s} of 106.5, 65.5 and 73.6 µL/L, respectively. It was suggested that larvicidal activity of pericarp and leaves may be justified by the presence of sabinene and linalool that were previously proven to be effective against *Anopheles stephensi*, *Aedes aegypti* and *Culex quinquefasciatus* (Pavela et al., 2016). Sabinene, β-pinene and (*E*)-caryophyllene were assayed against the parasite Trypanosoma brucei TC 221 causing African sleeping sickness, resulting in IC_{50s} of 5.96, 11.4 and 8.25 µg/mL, respectively, compared to the positive control suramin with 0.0286 µg/mL (Kamte et al., 2017). Being ingredients of seeds, pericarp and leaf, results from theses pure compounds add to bioactivities reported by Pavela et al. (2016).

3.10.3.2.2. Fruit

The fruit essential oil was reported to display 90-

Common names

African cardamom, bastard melegueta (English).

Fig. 35. The photograph of fruits of *Aframomum daniellii* (Hook. f.) K. Schum.

100% mortality at 0.02-0.04% against the fourth instar larvae of *Aedes aegypti*, *Anopheles gambiae* and *Culex pipiens fatigans* (Adebayo et al., 1999).

3.10.3.2.3. Leaf

The leaf essential oil was assayed against the parasite *Trypanosoma brucei brucei* TC 221 causing African sleeping sickness, resulting in an IC_{50} of 7.65 μg/mL, compared to the positive control suramin with 0.0286 μg/mL. Furthermore, in mouse embryonic fibroblast cell line Balb/3t3, ATCC/CCL 163, the IC_{50} was > 100 μg/mL, giving a favourable selectivity index (SI) of > 13.1 (Kamte et al., 2017).

3.10.3.2.4. Seeds

10% of the seed essential oil in food, traditionally prepared from a mixture of sorghum and millet grains, resulted in 76% reduction in mycotoxin fumonisin B1 infestation. Seeds for the assay had been purchased at Ibode market in Ibadan, Nigeria. Its oil composition is very similar to the Cameroonian one, with main components being β-pinene with 14.77% 1,8-cineole with 56% and α-terpineol with 11.46% (Olosunde et al., 2015). Furthermore, the seed essential oil was assayed by inhibition of α-amylase activity, α-glucosidase activity, angiotensin I converting enzyme (ACE) inhibition activity, inhibition of Fe^{2+}/SNP - induced lipid peroxidation in rat pancreas homogenates, radicals NO/OH scavenging ability and Fe^{2+} chelating ability. EC_{50s} were recorded with 165.43, 114.65, 48.73, 111.23, 162.83, 343.87, 145.94 and 263.85 μL/L, respectively. Above parameters were suggested to play a role in diabetes II and hypertension development. However, the Nigerian oil employed differed significantly from the Cameroonian one, containing 51.14% of eugenol (Adefegha et al., 2017). The Cameroonian seed essential was reported to have broad spectrum antimicrobial effects on food spoilage yeasts *Candida tropicalis*, *Hansenula anomala* and *Kluveromyces thermotolerans* and mycotoxin-producing molds *Aspergillus flavus* and *Aspergillus parasiticus* (Adegoke et al., 2016).

3.10.3.2.5. Seeds + leaf + rhizome

DPPH radical scavenging activity was measured for the leaf, seed and rhizome essential oil resulting in IC_{50s} of 58.5 g/mL, 45.5 g/mL and 72.0 g/mL, respectively, while ascorbic acid showed 20.5 g/mL. The ferri-reducing potential activity was reported with 1.305, 1.376 and 1.454 at 100 μg/mL absorbance at 700 nm, respectively, compared to the positive control ascorbic acid with 1.995 μg/mL (Essien et al., 2017).

3.10.4. *Aframomum letestuanum* Gagnep.

3.10.4.1. Traditional use

Common names

Ndidim (Cameroon), dedem (Yemba, Cameroon), Sia-ndidi (Bangwa, Cameroon).

Fig. 36. The photograph of fruits of *Aframomum letestuanum* Gagnep.

In the Menoua area, West Cameroon, the seeds are taken orally for the treatment of nausea and vomiting, swelling of legs and ankles as well as problems connected with pregnancy, like bleeding during pregnancy, faciliation of delivery, retained placenta, postpartum abdominal pain and postpartum haemorhagic fever (Yemele et al., 2015). In a recipe, 100 g of stem decoction is prepared with 50 mL of water and is taken in doses of two spoons twice a day to cure diarrhea; in an other prescription, stem bark is crushed and the extract is administered in doses of 20-30 mL twice a day for one to three days to cure dysentery (Khan and Khanum, 2008).

Furthermore, in Cameroon, seeds are masticated for their tranquillizing effects and widely eaten by women who consider them to favor conception of a male child. Seeds are as well applied against female sterility (Tane et al., 2005). There is a general agreement between local Cameroonian populations that the plant brings strength and peace to families with twins (Nguikwie et al., 2013).

3.10.4.2. Bioactivities

3.10.4.2.1. Seeds + pericarps + leaf + rhizomes

In a broth dilution assay, the essential oil from seeds displayed MICs of 0.39 and 0.39 μL/mL, from pericarps 25 and 0.19 μL/mL, from leaves 0.78 and 0.78 μL/mL, and from rhizomes 12.5 and 1.56 μL/mL against *Micrococcus luteus* and the human pathogen bacterium *Escherichia coli*, respectively. Values for pure compounds were for sabinene MICs of 50 and 1.56, β-pinene 3.12 and 0.19, 1,8-cineole 12.3 and 0.78, linalool 0.19 and 0.19, (*E*)-β-caryophyllene > 50 and 50, α-humulene > 50 and 6.25, (*R*)-(*E*)-nerolidol 0.19 and 0.19, and caryophyllene oxide 12.5 and 25 μL/mL. (Nguikwie et al., 2013).

3.10.5. *Afromomum melegueta* K. Schum.

3.10.5.1. Traditional use

In Western Africa, seeds are used as ingredients of preparations for the treatment of snakebites, stomachache and diarrhea (Ilic et al., 2010). They are further used as pain killer, against pulmonary troubles, to improve the skeletal structure, against tumors and cancers, while the root is applied in stomach troubles, against cholera and as antidote against venomous stings and bites. The fruit (Fig. 37) is taken for the treatment of veneral diseases (Burkill, 1985).

3.10.5.2. Bioactivities

3.10.5.2.1. Stem + leaf + rhizome

Essential oil from the stem, leaf and rhizome was submitted to acetyl-cholinesterase (AChE) inhibition assay by Ellmann colorimetric method leading to IC_{50s} of 15.27, 16 and 28.97 µg/mL, compared to the positive control galatamine displaying 6.62 µg/mL (Owokotomo et al., 2015).

3.10.5.2.2. Leaf

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

3.10.5.2.3. Seeds

The seed essential oil was assayed by inhibition of α-amylase activity, α-glucosidase activity, ACE activity, inhibition of Fe^{2+}/SNP - induced lipid peroxidation in rat´s pancreas homogenates, radicals NO/OH scavenging ability and Fe^{2+} chelating ability. EC_{50s} were recorded with 139.00, 91.83, 65.53, 126.98, 131.76, 370.64, 128.46 and 297.62 µL/L, respectively. Above parameters were suggested to play a role in diabetes II and hypertension development (Adefegha et al., 2017).

It should be noted that the seed essential oil composition of the assayed sample was harvested at the Akure main market, southwest Nigeria, and differs widely from the Cameroonian sample containing 82.2% of eugenol. In addition, activity of the seeds applied in Cameroonian traditional medicine against tumors and cancer might be further investigated by appropriate *in vitro/in vivo* assays.

Common names

Guinea grains, Guinea pepper, grains of paradise, alligator pepper (English), poivre de Guinée, malaguette, maniguette (French).

Fig. 37. The photograph of fruits of *Aframomum letestuanum* Gagnep.

Common names

Cardamom (Cameroon), Sia-ndidi (Bangwa, Cameroon), bereifter Kardamom, Kamerun-Kardamom (German).

Fig. 38. The photograph of fruits of *Aframomum pruinosum* Gagnep.

3.10.6. *Aframomum pruinosum* Gagnep.

3.10.6.1. Traditional use

In Cameroon, seeds of this plant (Fig. 38) are masticated for their tranquilizing effects and widely eaten by women who consider them to favor conception of a male child. Seeds are as well applied against female sterility (Tane et al., 2005). There is a general agreement on their properties to bring strength and peace in families with twins (Nguikwie et al., 2013).

3.10.6.2. Bioactivities

3.10.6.2.1. Seeds + pericarp + leaf + rhizomes

In a broth dilution assay, the essential oil from seeds displayed MICs of 0.78 and 0.19 µL/mL, from pericarps 12.5 and 0.78 µL/mL, from leaves 25 and 1.56 µL/mL, and from rhizomes 50 and 0.19 µL/mL against the bacteria *Micrococcus luteus* and *Escherichia coli*, respectively. Values for pure compounds were for sabinene MICs of 50 and 1.56, β-pinene 3.12 and 0.19, 1,8-cineole 12.3 and 0.78, linalool 0.19 and 0.19, (*E*)-β-caryophyllene > 50 and 50, *α*-humulene > 50 and 6.25, (R)-(E)-nerolidol 0.19 and 0.19, and caryophyllene oxide 12.5 and 25 µL/mL (Nguikwie et al., 2013).

Bringing the abundant data reported by Nguikwie et al. (2013) on the essential oil composition of *Aframomum dalzielii*, *Aframomum letestuanum* and *Aframonum pruinosum* together into one table focusing on most abundant essential oil components, parts of plants can be clearly distinguised by their main essential oil ingredient: While rhizomes and pericarps of all three species are characterized by a high β-pinene content (> 29.0%), seeds uniformely display a huge (*E*)-nerolidol content (> 88%). However, species significantly differ by their most abundant leaf oil component, which is (*E*)-β-caryophyllene with 81.4%, caryophyllene oxide with

Table 6
Most abundant essential oil compounds within rhizome, pericarp, seed and leaf of three *Aframomum* sister species, collected during the raining period in Mbouda and Fontem.

Part of plant	***Aframomum dalzielii***				***Aframomum letestuanum***				***Aframonum pruinosum***			
	A	B	C	D	A	B	C	D	A	B	C	D
Rhizome	**37.9**				**32.9**				**34.3**			
Pericarp	**42.3**				**38.2**				**29**			
Seeds		**91.2**				**88**				**95.1**		
Leaves			**81.4**					**23.7**			**47.7**	

A=β-pinene, B=(*E*)-Nerolidol, C=(*E*)-β-Caryophyllene, D=Caryophyllene oxide; values in%

23.7% and (*E*)-β-caryophyllene with 47%, respectively. Taken together, species seem to be genetically closely related. In fact, DNA investigation reported an unusually low level of sequence variation in the internal transcribed spacer of *Aframomum*, suggesting a very rapid development of new species under conditions of Pleistocene climatic change in tropical Africa, supported by effective dispersal of seeds by primates (Harris et al., 2000) (Table 6).

3.10.7. *Curcuma longa* L.

3.10.7.1. Traditional use

The plant is used in general Cameroonian medicines (Gardini et al., 2009). Furthermore, the rhizome is applied in Western Africa for nasopharyngeal affections, as vermifuge, for liver and kidney complaints, for the treatment of cutaneous and subcutaneous parasitic infections, and against menstrual cycle problems (Burkill, 1985). In Western Africa, the rhizome is as well used against inflammation and as eyewash for conjunctivitis, while in Eastern Africa, the rhizome (Fig. 39) is powdered and applied on the forehead against head ache. It is also applied on the body of smallpox patients, and the patients are made to stay outside in the sun.

3.10.7.2. Bioactivities

3.10.7.2.1. Rhizome

With the aim to evaluate the possible slowing effect on the growth of food poisoning bacteria, the rhizome essential oil was tested against *Salmonella enteritidis* 155A, *Listeria monocytogenes* Scott A and *Staphylococcus aureus* SR231. However, low antimicrobial activity against all three strains was reported (Gardini et al., 2009).

It should be noted that tumerone, *ar*-tumerone and curlone are essential oil compounds not reported from any other Cameroonian plant family so far.

Common names

Tumeric (English), curcuma, safran des Indes (French).

Fig. 39. The photograph of fruits of *Aframomum pruinosum* Gagnep.

3.10.8. *Zingiber officinale* Roscoe

3.10.8.1. Traditional use

The rhizome (Fig. 40) is widely used in Cameroonian as spice and in local medicine (Grimaldi and Bikia, 1977; Pelé and Le Berre, 1966; Purseglove, 1972). Furthermore, rhizomes are used in Western Africa as a stimulant, pain killer, eye treatment, against naso-pharyngeal affections and stomach troubles, as fabrifuge, antidote for venomous stings and bites, against paralysis, epilepsy, convulsions, spasms and insanity (Burkill, 1985).

The plant is an important ingredient in Chinese, Ayurvedic and Tibb-Unani herbal medicines for the treatment of catarrh, rheumatism, nervous diseases, gingivitis, toothache, asthma, stroke, constipation and diabetes (Awang, 1992; Tapsell et al., 2006; Wang and Wang, 2005). It is as well applied in pain, inflammation, arthritis, urinary infections, female diseases and gastrointestinal disorders (Shukla et al., 2012).

3.10.8.2. Bioactivities

3.10.8.2.1. Whole plant

Common names

Ndjindja (Cameroon), Ginger (English), gingembre (French).

Fig. 40. The photograph of fruits of *Zingiber officinale* Roscoe.

In an agar dilution assay for antifungal activity, the essential oil of the fresh whole plant was shown to be moderately effective, completely inhibiting the growth of several strains of the plant pathogen fungi *Fusarium moniliforme*, *Aspergillus fumigatus* and *A. flavus*, however at a high concentration of 800 ppm, 2000 ppm, and 2500 ppm, respectively. For three less sensitive strains of *A. flavus*, growth reduction of 92%, 87% and 75%-92% was noted at 2500 ppm (Nguefack et al., 2004b).

3.10.8.2.2. Leaf

In an agar well dilution assay for antibacterial activity, the essential oil of the leaves was shown to be low effective against the food spoiling bacteria *Listeria innocua*, *L. monocytogenes* and *Staphylococcus aureus* (Nguefack et al., 2004a).

3.10.8.2.3. Rhizome

The rhizome 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. In macro dilution assays, MICs of 0.63, 1.25, 0.63 and 0.63 mg/mL, repectively, for inhibition of bacterial growth, and 0.75, 0.75 mg/mL for inhibition of spore germination of *Bacillus cereus* and *Bacillus megaterium*, respectively, were reported (Voundi et al., 2015). Furthermore, activity of the oil was tested against the fungal pathogens of oranges, namely *Penicillium italicum*, *Penicillium digitatum*, *G. indicum*, *Alternaria alternata*, *Colletotrichum gleosporioides* and *Phomopsis citri* by poison food technique, showing 100% inhibition of mycelial growth at 100, 100, 200, 500, 500 and 500 ppm, respectively. In addition, 100% inhibition at 500 ppm was reported against most common fruit and vegetable rotting fungi *Aspergillus niger*, *Botrytis cinera*, *Botryodiplodia theobromae*, *Ceratocystis paradoxa*, *Fusarium roseum*, *Monilinia fructicola*, *Mucor piriformis*, *Macrophomina phaseolina*, *Penicillium expansum* and *Rhizopus stolonifer*. For above assays, positive controls benzimidazole, diphenylamine, phenylmercuric acetate and zincdimethyl dithiocarbamate were found to result in 100% growth inhibition between 300 and 700 ppm (Tripathi, 2016). Moreover, the rhizome essential oil from Brazilian material, with camphene as major compound with 16.4% compared to the Cameroonian sample displaying 9.6%, was submitted to cytotoxicity assays employing 4,5-dimethylthiazol-2-yl)-2,5-diphenyltetrazolium bromide (MTT) and 3-amino-7-dimethylamino-2-methylphenazine (NR) method, resulting in IC_{50s} of 141.4 and 635.1 µg/mL against human cervical cancer cell line HeLa and human liver cell line HepG2, respectively, for MTT analysis and 129.9 and 635.1 µg/mL, respectively, for NR analysis. Selectivity indices (SIs) were calculated with 4.330 and 4.489, respectively (Santos et al., 2016). Interestingly, α-zingiberene present in the Cameroonian sample with 7.6% displayed IC_{50s} of 60.6, 46.2, 172.0 and 80.8 µg/mL against cervix cancer cell line HeLa, cervix cancer cell line SiHa, breast cancer cell line MCF 7 and leukemia cell line HL 60, compared to cisplatin showing 28.2, 56.2, 31.2 and 31.1 µg/mL (Lee, 2016).

3.11. Correlation traditional use with bioactivity *in vitro*

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, reserarchers do not yet fully understand the mechanisms of bioactive ingredients and their synergistic action within the essential oil.

The leaves of *Eucalyptus saligna* (Myrtaceae) are used in the Western highlands of Cameroon to protect stored grains from insect infestation (Tapondjou et al., 2000). The leaf essential oil displayed strong toxicity against the cowpea weevil *Callosobruchus maculatus*, the maize grain weevil *Sitophilus zeamais* and the red flour beetle *Tribolium confusum*. In addition, at 100 µL/40g grain, the oil produced 100% reduction in adult emergence of *Sitophilus zeamais* and *Tribolium confusum* (Tapondjou et al., 2005).

In Cameroon, fruits of *Piper guineense* (Piperaceae) are applied in respiratory infections (Noumi et al., 1998), probably for sedative effect. In an inhalation test in mice model, the fruit essential oil showed significant sedative activity and potent anxiolytic effect, the latter as potent as the essential oil of *Lavandula angustifolia* (Lamiaceae) (Tankam and Ito, 2013).

Some Baka pygmies living in the Cameroonian rain forest apply a decoction of the stem bark of *Phyllanthus muellerianus* (Phyllantaceae) as a remedy for tetanus (Brisson, 1999). In a micro dilution assay with the tetanus model bacterium *Clostridium sporogenes*, the stem bark oil diplayed a very significant MIC value of 13.5 µg/mL, compared to the positive control amphothericin B® showing 0.7 µg/mL (Brusotti et al., 2012). Moreover, the Nigerian population uses the whole plant against skin diseases (Odugbemi, 2008). The activity of the stem bark essential oil was shown to be twice as effective as amphothericin B® against the dermatophytic fungus *Trichophyton rubrum* causing infection of nail and ringworm or tinea, which is caused by a fungal infection on the skin (Brusotti et al., 2012).

Powdered seeds of *Piper guineense* (Piperaceae) are used in the Western highlands of Cameroon for the protection of stored grains (Tchoumbougnang et al., 2009a). In a contact toxicity assay with the maize grain weevil *Sitophilus zeamais*, the fruit essential oil displayed 50% mortality with a 1% solution, compared to Poudrox® showing 100% mortality with a 5% solution (Tchoumbougnang et al., 2009a).

Extracts of *Cymbopogon citratus* (Poaceae) are

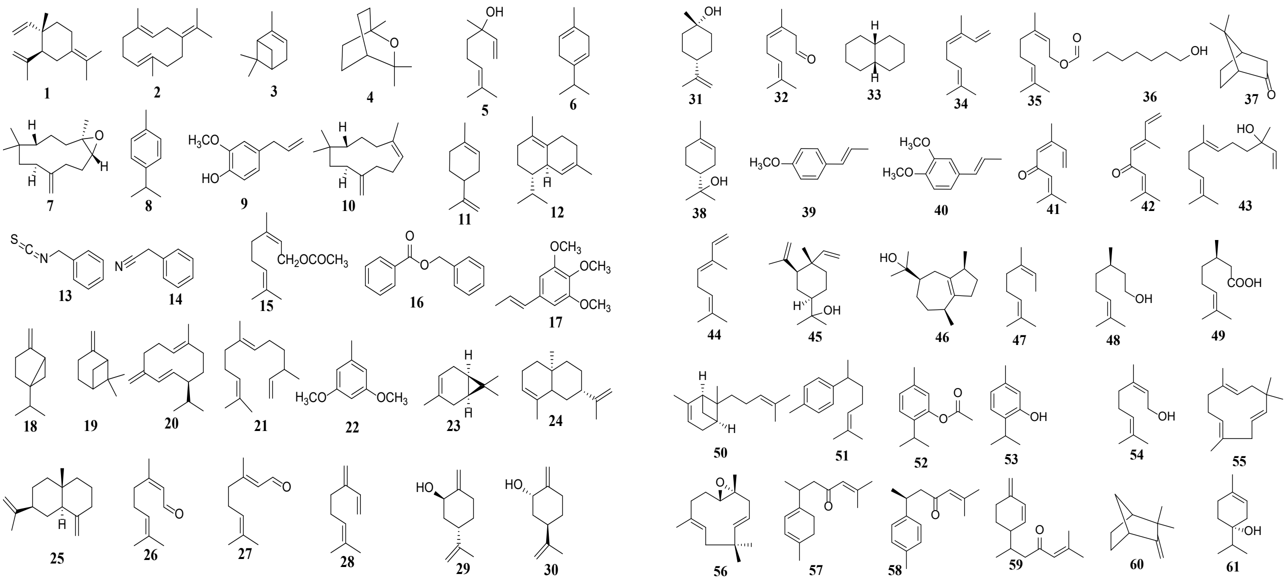

Fig. 41. Structures of main essential oil components.

applied in Cameroon and Nigeria traditionally for the treatment of malaria, where a decoction of the leaves is administered (Odugbemi, 2008; Saotoing et al., 2011). The leaf oil was shown to display very significant activity against the chloroquine® resistant *P. falciparum* strain FcB1/Colombia of *P. falciparum* with an IC_{50} of 4.2 µg/mL (Akono et al., 2014).

Leaves of *Cymbopogon giganteus* (Poaceae) are applied in Western African countries against fever and cough (Popielas et al., 1991; Sidibé et al., 2001), the plant is also used prophylactic against fever (Haerdi et al., 1964; Kerharo, 1973; Kerharo and Adam, 1963, 1974). The leaf essential oil was 10 times more active against the human pathogen bacteria *Staphylococcus aureus*, *Enterococcus faecalis*, *Escherichia coli*, *Proteus vulgaris*, *Pseudomonas aeruginosa*, *Salmonella* sp. , *Klebsiella pneumoniae* and *Salmonella* sp. than ciproxin®, lidaprim® and tetracycline hydrochloride®, and in addition, lidaprim® was not higher active against *Proteus vulgaris* and *Salmonella* as the oil (Jirovetz et al., 2007)

Dried leaves of *Clausena anisata* (Rutaceae) are used by some farmers of the Cameroonian Western highlands to protect their stored products against insect infestations (Tapondjou et al., 2000). Significant leaf oil activity was recorded against the mung bean pest *Callosobruchus maculatus* and the green peas pest *C. chinensis* as well as complete inhibition of their F1 progeny production after low dose (Tapondjou et al., 2002); for the common bean weevil *Acanthoscelide obtectus*, no progeny was produced after low dose treatment with the leaf oil, and the pure oil evoked high fumigant toxicity (Ndomo et al., 2008); the leaf oil was twice as toxic against the red flour beetle *Tribolium castaneum* as imidacloprid®, and the insect could acquire resistance to imidacloprid® five times faster than to the leaf essential oil (Goudoum et al., 2010).

In Nigeria, *Zanthoxylum xanthoxyloides* (Rutaceae) is used for the treatment of cancers (Olowokudejo et al., 2008; Odugbemi, 2008). In MTT assay, the fruit essential oil displayed significant IC_{50s} of 35.4, 18.2, 47.6 and 27.8 µg/mL against human glioblastoma cell line T98G, human breast adenocarcinoma cell line MDA-MB 231, human malignant melanoma cell line A375 and human colon carcinoma cell line HCT116, respectively, compared to cisplatin® with 2.3, 2.1, 0.2 and 2.6 µg/mL (Fogang et al., 2012).

In Western Africa, *Zanthoxylum xanthoxyloides* (Rutaceae) is widely used to bathe wounds, against diarrhoea, urinary tract infections and fever (Iwu, 2014; Neuwinger, 2000; Ngassoum et al., 2003; Noumi, 1984; Oliver-Bever, 2009). In a paper disk agar diffusion assay with 10 µL per paper disk, the fruit essential oil displayed extensive inhibition zone diameters of 12.5-20.5 mm against various human pathogen bacteria, compared to penicillin G® displaying 9.5-30 mm at 2000 ppm. At a 10% concentration of the fruit oil, diameters of inhibition zones were still 7.5-9 mm (Ngassoum et al., 2003). It showed very significant antimicrobial activity against *Salmonella typhimurium* and *Bacillus subtilis* with MICs of 0.26 and 0.52 µL/mL, compared to kanamycin with 0.52 and 0.53 µL/mL, respectively (Misra et al., 2013).

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

Reviewing Cameroonian essential oils, 80 plant species belonging to twenty-two families were found to have been analyzed for essential oil composition, 40 of which are presented in this part II of the compilation. Moreover, a huge number of bioassays *in vitro* and *in* *vivo* on essential oils as well as - increasingly within the last decade - on major and minor compounds presented by the oils have been published. From above data, it is strongly suggested that the oils´ bioactive potential is mainly controlled by major essential oil ingredients, often acting in a synergistic manner with other oil ingredients. However, isolation of compounds from essential oils is difficult and often impossible. It is suggested that once the compound profile is available, commercial compounds may be employed in bioassays for follow up work including synergistic action between compounds. The goal is to improve effectivity and doses calculation for traditional essential oil medicines and agricultural products, to be applied in Cameroon and other Subsaharan countries.

Conflict of interest

The authors declare that there is no no conflict of interest.

Acknowledgement

Jean Duplex Wansi wishes to thank the European Commission for awarding Marie Curie Fellowship 2014-2016 as well as Return Fellowship 2016-2017.

References

Adam, J.G., 1954. Note sur les graminées fourragères de la presqu'île du Cap-Vert (Sénégal): observations et renseignements sur leurs répartition, écologie et valeur fourragère. Rev. Elev. Med. Vet. Pays Trop. 7(2), 87-101.

Adebayo, T.A., Gbolade, A.A., Olaifa, J.I., 1999. Comparative study of toxicity of some essential oils to larvae of three mosquito species. Nig. J. Nat. Prod. Med. 3(1), 74-76.

Adefegha, S.A., Olasehinde, T.A., Oboh, G., 2017. Essential oil composition, antioxidant, antidiabetic and antihypertensive properties of two *Afromomum* species. J. Oleo. Sci. 66(1), 51-63.

Adegoke, G.O., Skura, B.J., 1994. Nutritional profile and antimicrobial spectrum of the spice *Aframomum danielli* K. Schum. Plant. Foods Hum. Nutr. 45(2), 175-182.

Adegoke, G.O., Evwiehurhoma, F.O., Afolabi, M.O., 2016. African Cardamom (*Aframomum danielli*) Oils, in: Preedy, V.R. (Ed.), Essential Oils in Food Preservation. Academic Press, London, pp. 161-170.

Adjanohoun, E.J., Aké Assi, L., 1972. Plantes Pharmaceutiques de Côte d'Ivoire. Centre National de Floristique, Abidjan, Ivory Coast.

Adjanohoun, E.J., Ahyi, L.M.R., Ake-Assi, L., Baniakina, J., Chibon, P., Cusset, G., Doulou, V., Enzanza, A., Eyme, J., Goudote, E., Keita, A., Mbemba, C., Mollet, J., Moutsambote, J.-M., Mpati, J., Sita, P., 1988. Contribution aux Etudes Ethnobotaniques et Floristiques en Républic Populaire du Congo. Mission ACCT, Paris, France.

Ahua, K.M., Ioset J.-R., Ioset, K.N., Diallo, D., Mauel, J., Hostettmann, K., 2007. Antileishmanial activities associated with plants used in the Malian traditional medicine. J. Ethnopharmacol. 110(1), 99-104.

Ainslie, J.R., 1937. A List of Plants Used in Native Medicine in Nigeria. Imperial Forestry Institute, University of Oxford, Oxford, United Kingdom.

Akami, M., Niu, C., Chakira, H., Chen, Z., Vandi, T., Nukenine, E.N., 2016. Persistence and comparative pesticidal potentials of some constituents of *Lippia adoensis* (Hochst. ex Walp.) (Lamiales: Verbenaceae) essential oil against three life stages of *Callosobruchus maculatus* (Fab.) (Coleoptera: Bruchidae). British Biotechnol. J. 13(4), 1-16.

Akono, N.P., Baldovini, N., Mouray, E., Mambu, L., Belong, P., Grellier, P., 2014. Activity of *Ocimum basilicum*, *Ocimum canum* and *Cymbopogon citratus* essential oils against *Plasmodium falciparum* and mature-stage larvae of *Anopheles funestus* s.s. Parasite 21(33), 1-8.

Akono, P.N., Dongmo, P.M.J, Tonga, C., Kouotou, S., Kekeunou, S., Magne, G.T., Lehmann, L.G., Menut, C., 2015. Larvicidal activity of essential oils from pericarps of ripe *Citrus* fruits cultivated in Cameroon on pyrethroids sensitive and resistant strains of *Anopheles gambiae* Giles, 1902. J. Entomol. Zool. Stud. 3(4), 334-339.

Akono, P.N., Mbida, J.A.M., Dongmo, P.M.J., Tonga, C., Tchamga, L.A.D., Mounbain, F., Magne, G.T., Mache, P.N., Kekeunou, S., 2016a. Chemical composition and insecticidal activity of essential oils of *Cinnamomum zeylanicum*, *Citrus grandis*, *Citrus medica* and *Citrus sinensis* leaves from Cameroon on *Anopheles gambiae* Giles, 1902. J. Entomol. Zool. Stud. 4(6), 17-23.

Akono, P.N., Tonga, C., Dongmo, P.M.J., Kekeunou, S., Tedongmo, N.L., Lehman, L.G., 2016b. Influence of urbanization on the sensitivity of female adults of the *Anopheles gambiae* complex to essential oils of some plants from the Littoral region of Cameroon. Int. J. Mosq. Res. 3(6), 45-53.

Aliberti, L., Caputo, L., De Feo, V., De Martino, L., Nazzaro, F., Souza, L.F., 2016. Chemical composition and *in vitro* antimicrobial, cytotoxic, and central nervous system activities of the essential oils of *Citrus medica* L. cv. "*liscia*" and *C. medica* cv. "*rigosa*" cultivated in Southern Italy. Molecules 21(9), 1244-1258.

Ampofo, O., 1983. First Aid in Plant Medicine. Ghana Rural Reconstruction Movement, Mampong-Akwapim, Ghana.

Anonymous, 1956. The Wealth of India: Raw Materials and Industrial Products. Vol. IV. Council of Scientific and *Industrial* Research, New Delhi, India.

Aouadhi, C., Simonin, H., Prévost, H., de Lamballerie, M., Maaroufi, A., Mejri, S., 2013. Inactivation of *Bacillus sporothermodurans* LTIS27 spores by high hydrostatic pressure and moderate heat studied by response surface methodology. LWT-Food Sci. Technol. 50(1), 50-56.

Aoudou, Y., Tatsadjieu, N.L., Jazet, D.P.M., Etoa, F.X., Mbofung, C.M., 2010. Antifungal properties of essential oils and some constituents to reduce foodborne pathogen. J. Yeast Fungal Res. 1(1), 1-8.

Aoudou, Y., Tatsadjieu, N.L., Mbofung, C.M., 2011. Mycelia growth inhibition of some *Aspergillus* and *Fusarium* species by essential oils and their potential use as antiradical agent. Agric. Biol. J. N. Am. 2(11), 1362-1367.

Awang, D.V.C., 1992. Ginger. Can. Pharm. J. 125(7), 309-311.

Benelli, G., Bedini, S., Cosci, F., Toniolo, C., Conti, B., Nicoletti, M., 2015. Larvicidal and ovideterrent properties of neem oil and fractions against the filariasis vector *Aedes albopictus* (Diptera: Culicidae): a bioactivity survey across production sites. Parasitol. Res. 114(1), 227-236.

Betti, J.L., 2004. An ethnobotanical study of medicinal plants among the Baka pygmies in the Dja biosphere reserve, Cameroon. Afr. Stud. Monogr. 25(1), 1-27.

Bouda, H., Tapondjou, L.A., Fontem, D.A., Gumedzoe, M.Y.D., 2001. Effect of essential oils from leaves of *Ageratum conyzoides*, *Lantana camara* and *Chromolaena odorata* on the mortality of *Sitophilus zeamais* (Coleoptera, Curculionidae). J. Stored Prod. Res. 37(2), 103-109.

Boudries, H., Loupassaki, S., Ladjal, E.Y., Souagui, S., Bachir, B.M., Nabet, N., Chikhoune, A., Madani, K., Chibane, M., 2017. Chemical profile, antimicrobial and antioxidant activities of *Citrus reticulata* and *Citrus clementina* (L.) essential oils. Int. Food Res. J. 24(4), 1782-1792.

Bouquet, A., 1969. Féticheurs et Médecines Traditionnelles du Congo (Brazaville). Office de la Recherche Scientifique et Technique Outre-Mer, Paris, France.

Bouquet, A., Debray, M., 1974. Plantes Médicinales de la Côte d'Ivoire. Office de la Recherche Scientifique et Technique Outre-Mer, Paris, France.

Boyom, F.F., Ngouana, V., Zollo, P.H.A., Menut, C., Bessiere, J.M., Gut, J., Rosenthal, P.J., 2003. Composition and anti-plasmodial activities of essential oils from some Cameroonian medicinal plants. Phytochemistry 64(7), 1269-1275.

Brisson, R., 1999. Mythologie des Pygmées Baka (Sud-Cameroon). Etudes Pygmées. Peeters-Selaf, Paris, France.

Brown, D., 1995. Encyclopedia of Herbs and Their Uses. Dorling Kinderslay, London, United Kingdom.

Brusotti, G., Cesari, I., Gilardoni, G., Tosi, S., Grisoli, P., Picco, A.M., Caccialanza, G., 2012. Chemical composition and antimicrobial activity of *Phyllanthus muellerianus* (Kuntze) Excel essential oil. J. Ethnopharmacol. 142(3), 657-662.

Btissam, R., Rajae, R., Hassane, G., Naima, B., Mohamed, N., 2017. Protocol implementation for the detection of advanced glycation end products and screening of natural extracts involved in the prevention of diabetic complications. J. Med. Plants 5(3), 4-15.

Buli, G.A., Duga, A.G., Dessalegn, E., 2015. Antimicrobial activity of *Lippia adoensis* var. *koseret* against human pathogenic bacteria and fungi. Am. J. Clin. Exp. Med. 3(3),118-123.

Burkill, H.M., 1985. The Useful Plants of West Tropical Africa. Royal Botanical Gardens, Kew, United Kingdom.

Burkill, I., Birtwistle, W., Foxworthy, F.W., Scrivenor, J.B., Watson, J.G., 1966. A Dictionary of the Economic Products of the Malay Peninsula, 2nd ed. Published on Behalf of the Governments of Malaysia and Singapore by the Ministry of Agriculture and cooperatives. Ministry of Agriculture and Co-operatives, Kuala Lumpur, Malaysia.

Carvalho de Oliveira, M.A., Borges, A.C., Brighenti, F.L., Salvador, M.J., Gontijo, A.V.L., Koga-Ito, C.Y., 2017. *Cymbopogan citratus* essential oil: effect on polymicrobial caries-related biofilm with low cytotoxicity. Braz. Oral Res. 31, 1-12.

Chalchat, J.-C., Garry, R.-P., Menut, C., Lamaty, G., Malhuret, R., Chopineau, J., 1997. Correlation between chemical composition and antimicrobial activity. VI. Activity of some African essential oils. J. Essent. Oil Res. 9(1), 67-75.

Chopra, R.N., Nayar, S.L., Chopra, I.C., 1956. Glossary of Indian Medicinal Plants. Council of Scientific and Industrial Research, New Delhi, India.

Conduzorgues, J.-P., Sincholle, D., 2000. Composition pour la prévention et le traitement de la cellulite. Brevet WO/00/30604; PCT/FR99/028571.

Dalziel, J.M., Hutchinson, J., 1937. The Useful Plants of West Tropical Africa, First Ed. Crown Agents for the Overseas Colonies, London, United Kingdom.

Danga, Y.S.P., Nukenine, E.N., Esimone, C.O., Lame, Y., 2014. Larvicidal and pupicidal toxicities of *Plectranthus glandulosus* and *Callistemon rigidus* leaf essential oils against three mosquito species. J. Mosq. Res. 4(2), 5-14.

Debjit, B., Kumar, K.P.S., Yadav, A., Srivastava, S., Paswan, S., Dutta, A.S., 2012. Recent trends in Indian traditional herbs *Syzygium aromaticum* and its health benefits. J. Pharmacogn. Phytochem. 1(1), 13-22.

Dongmo, P.M.J., Ngoune, L.T., Dongmo, B.N., Kuate, J., Zollo, P.H.A., Menut, C., 2008. Antifungal potential of *Eucalyptus saligna* and *Eucalyptus camaldulensis* essential oil from Cameroon against *Phaeoramularia angolensis*. Eur. J. Sci Res. 24(3), 348-357.

Dongmo, J.P.M., Tatsadjieu, L.N., Ndongson, B.D., Kuate, J., Zollo, P.H.A., Menut, C., 2009. Correlation between chemical composition and antifungal properties of essential oils of *Callistemon rigidus* and *Callistemon citrinus* of Cameroon against *Phaeoramularia angolensis*. J. Med. Plants Res. 3(1), 9-15.

Dounias, E., 2008. *Pentadiplandra brazzeana* Baill., in: Schmelzer, G.H., Gurib-Fakim, A., (Eds.), Prota 11(1): Medicinal Plants/Plantes Médicinales, PROTA, Wageningen, pp. 453-456.

Duke, J.A., 1985. CRC Handbook of Medicinal Herbs. CRC Press, Florida, United States of America.

Ekanem, A.P., Udoh, F.V., Oku, E.E., 2010. Effects of ethanol extract of *Piper guineense* seeds (Schum. and Thonn) on the conception of mice (*Mus musculus*). Afr. J. Pharm. Pharmacol. 4(6), 362-367.

Epaulard, O., Saint-Raymond, C., Villier, C., Charles, J., Roch, N., Beani, J.-C., Leccia, M.-T., 2010. Multiple agressive squamosa cell carcinomas associated with prolonged voriconazole therapy in four immunocompromised patients. Clin. Microbiol. Infect. 16(9), 1362-1364.

Essien, E.E., Thomas, P.S., Oriakhi, K., Choudhary, M.I., 2017. Characterization and antioxidant activity of volatile constituents from different parts of *Aframomum danielli* (Hook) K. Schum. Medicines 4(2), 29.

Fankem, P.M., Kwanga, S.N., Sameza, M.L., Tchoumbougnang, F., Tchabong, R., Ngoué, L.T., Dongmo, P.M.J., 2017. Antioxidant and antifungal activities of cocoa butter (*Theobroma cacao*), essential oil of *Syzygium aromaticum* and a combination of both extracts against three dermatophytes. Am. Sci. Res. J. Engin. Technol. Sci. 37(1), 255-272.

Fogang, H.P.D., Tapondjou, L.A., Womeni, H.M., Quassinti, L., Bramucci, M., Vitali, L.A., Petrelli, D., Lupidi, G., Maggi, F., Papa, F., Vittori, S., Barboni, L., 2012. Characterization and biological activity of essential oils from fruits of *Zanthoxylum xanthoxyloides* Lam. and *Z. leprieurii* Guill. and Perr., two culinary plants from Cameroon. Flav. Fragr. J. 27(2), 171-179.

Galani, Y.J.H., Nguefack, J., Dakole, D.C., Fotio, D., Petchayo, T.S., Fouelefack. F.R., Avam Zollo, P.H., 2013. Antifungal potential and phytochemical analysis of extracts from seven Cameroonian plants against late blight pathogen *Phytophthora infestans*. Int. J. Curr. Microbiol. App. Sci. 2(5), 140-154.

Gardini, F., Belletti, N., Ndagijimana, M., Guerzoni, M.E., Tchoumbougnang, F., Zollo, P.H.A., Micci, C., Lanciotti, R., Kamdem, S.L.S., 2009. Composition of four essential oils obtained from plants from Cameroon, and their bactericidal and bacteriostatic activity against *Listeria monocytogenes*, *Salmonella enteritidis* and *Staphylococcus aureus*. Afr. J. Microbiol. Res. 3(5), 264-271.

Gemeda, N., Woldeamanuel, Y., Asrat, D., Debella, A., Belete, Y., 2015. Assessment of *Lippia adoensis* Hochst. var. *koseret*, *Rosmarinus officinalis* L. and *Ruta chalepensis* L. essential oils as a potential source of fungitoxic and mycosporicidal activity against toxigenic *Aspergillus* species. Pharmacologyonline 2, 85-94.

Gerhäuser, C., Klimo, K., Heiss, E., Neumann, I., Gamal-Eldeen, A., Knauft, J., Liu, G.-Y., Sitthimonchai, S., Frank, N., 2003. Mechanism-based *in vitro* screening of potential cancer chemopreventive agents. Mut. Res. 523-524, 163-172.

Ghalem, B.R., Mohamed, B., 2008. Antibacterial activity of leaf essential oils of *Eucalyptus globulus* and *Eucalyptus camaldulensis*. Afr. J. Pharm. 2(10), 211-215.

Goh, S.H., Chuah, C.H., Mok, J.S.L., Soepadmo, E., 1995. Malaysian Medicinal Plants for the Treatment of Cardiovascular Diseases. Pelanduk Publications Sdn Bhd, Selangor Darul Ehsan, Malaysia.

Goldbeck, J.C., do Nascimento, J.E., Jacob, R.G., Fiorentini, A.M., da Siva, W.P., 2014. Bioactivity of essential oils from *Eucalyptus globulus* and *Eucalyptus urograndis* against planktonic cells and biofilms of *Streptococcus mutans*. Ind. Crops Prod. 60, 304-309.

Goudoum, A., Ngamo, L.S.T., Ngassoum, M.B., Tatsadjieu, L.N., Mbofung, C.M., 2010. *Tribolium castaneum* (Coleoptera: Curculionidae) sensitivity to repetitive applications of lethal doses of imidacloprid and extracts of *Clausena anisata* (Rutaceae) and *Plectranthus glandulosus* (Lamiaceae). Int. J. Biol. Chem. Sci. 4(4), 1242-1250.

Goyal, P.K., Jain, R., Jain, S., Sharma, A., 2012. A Review on biological and phytochemical investigation of plant genus *Callistimon*. Asian Pac. J. Trop. Biomed. 2(3), 1906-1909.

Grimaldi, J., Bikia, A., 1977. Le grand livre de la cuisine camerounaise. Orstrom, Yaoundé.

Guest, A., Jackson, J. R., James, S.P., 1982. Toxicity of benzyl cyanide in the rat. Toxicol. Lett. 10(2-3), 265-272.

Gutiérrez, R.M.P., Mitchell, S., Solis, R.V., 2008. Psidium guajava: a review of its traditional uses, phytochemistry and pharmacology. J. of Ethnopharm. 117(1), 1-27.

Haerdi, F., Kerharo, J., Adam, J.G., 1964. Afrikanische Heilpflanzen: Plantes médicinales africaines. Die Eingeborenen-Heilpflanzen des Ulanga-Distriktes Tanganjikas (Ostafrika). Acta Trop. Suppl. 8, 1-278.

Harkat-Madouri, L., Asma, B., Madani, K., Said, Z.B.-O.S., Rigou, P., Grenier, D., Allalou, H., Remini, H., Ajaoud, A., Boulekbache-Makhlouf, L., 2015. Chemical composition, antibacterial and antioxidant activities of essential oil of *Eucalyptus globulus* from Algeria. Ind. Crops Prod. 78, 148-153.

Harris, D.J., Poulsen, A.D., Frimodt-Møller, C., Preston, J., Cronk, Q.B., 2000. Rapid radiation in *Aframomum* (Zingiberaceae): evidence from nuclear ribosomal DNA internal transcribed spacer (ITS) sequences. Edinburgh J. Bot. 57(3), 377-395.

Hojjati, M., Barzegar, H., 2017. Chemical composition and biological activities of lemon (*Citrus limon*) leaf essential oil. Nutr. Food Sci. Res. 4(4), 15-24.

Hsouna, A.B., Halima, N.B., Smaoui, S., Hamdi, N., 2017. *Citrus lemon* essential oil: chemical composition, antioxidant and antimicrobial activities with its preservative effect against *Listeria monocytogenes* inoculated in minced beef meat. Lipids Health Dis. 16(1), 146-146.

Hutchinson, J., Dalziel, J.M., Keay, R.W.J., 1954. Flora of West Tropical Africa. Crown Agents, London, United Kingdom.

Ilic, N., Schmidt, B.M., Poulev, A., Raskin, I., 2010. Toxicological evaluation of grains of paradise (*Aframomum melegueta*) [Roscoe] K. Schum. J. Ethnopharmacol. 127(2), 352-356.

Illiassa, N., 2004. Analyse de la gestion post-récolte de *Vigna unguiculata* (Walp.) et évaluation de l'importance insecticide des huiles essentielles de trois plantes aromatiques. Mémoire de maîtrise en Biologie Animale. Faculté des Sciences, Université de Ngaoundéré.

Irvine, F.R., 1961. Woody Plants of Ghana With Special Reference to Their Uses. Oxford University Press, Oxford, United Kingdom.

Islam, M.R., Ahamed, R., Rahman, M.O., Akbar, M.A., Al-Amin, M., Alam, K.D., Lyzu, F., 2010. *In vitro* antimicrobial activities of four medicinally important plants in Bangladesh. Eur. J. Sci. Res. 39(2), 199-206.

Iwu, M.M., 1993, 2014. Handbook of African Medicinal Plants. CRC, Press Boca Raton.

Jaramillo, M.A., Callejas, R., Davidson, C., Smith, J.F., Stevens, A.C., Tepe, E.J., 2008. A phylogeny of the tropical genus *Piper* using ITS and the chloroplast intron psbJ-petA. Syst. Bot. 33(4), 647-660.

Ji, T., 2009. Traditional Chinese medicine pills for treating hemorrhoid. J. Chin. Med. CN 101352524 A, 20090128.

Jirovetz, L., Buchbauer, G., Eller, G., Ngassoum, M.B., Maponmetsem, P.M., 2007. Composition and antimicrobial activity of *Cymbopogon giganteus* (Hochst.) Chiov. Essential flower, leaf and stem oils from Cameroon. J. Essent. Oil Res. 19(5), 485-489.

Kamtchouing, P., Mbongue, F.G.Y., Dimo, T., Jatsa, H. B., 2002. Evaluation of androgenic activity of *Zingiber officinale* and *Pentadiplandra brazzeana* in male rats. Asian J. Androl. 4(4), 299-302.

Kamte, S.L.N., Ranjbarian, F., Campagnaro, G.D., Nya, P.C.B., Mbuntcha, H., Woguem, V., Womeni, H.M., Tapondjou, L.A., Giordani, C., Barboni, L., Benelli, G., Cappellacci, L., Hofer, A., Petrelli, R., Maggi, F., 2017. *Trypanosoma brucei* inhibition by essential oils from medicinal and aromatic plants traditionally used in Cameroon (*Azadirachta indica, Aframomum melegueta, Aframomum daniellii, Clausena anisata, Dichrostachys cinerea and Echinops giganteus*). Int. J. Environ. Res. Public Health 14(7), 737-753.

Karunamoorthi, K., Hailu, T., 2014. Insect repellent plants traditional usage practices in the Ethiopian malaria epidemic-prone setting: an ethnobotanical survey. J. Ethnobiol. Ethnomed. 10(1), 22.

Kennett, M.J., Hook Jr., R.R., Franklin, C.L., Riley, L.K., 1999. *Acanthamoeba castellanii*: characterization of an adhesin molecule. Exp. Parasitol. 92(3), 161-169.

Kerharo, J., 1973. Pharmacognosy of some Senegalese grasses. Bull. Soc. Med. Afr Noire Lang. Fr. 18(1), 1-13.

Kerharo, J., Adam, J.G., 1963. Deuxième inventaire des plantes médicinales et toxiques de la Casamance (Sénégal). Ann. Pharm. Franc. 21, 853-870.

Kerharo, J., Adam, J.G., 1964. Note sur quelques plantes médicinales des Bassari et des Tandanke du Senegal oriental. Bull. Inst. fr. Afr. noire 26, 403-37.

Kerharo, J., Adam, J.C., 1974. La Pharmacopeé Sénégalaise Traditionnelle - Plantes Médicinales et Toxiques. Editions Vigot frères, Paris, France.

Kerharo, J., Bouquet, A., 1950. Plantes Médicinales et Toxiques de la Côte d´Ivoire-Haute Volta. Editions Vigot frères, Paris, France.

Kerharo, J., Paccioni, J.P., 1974. Considérations d´actualité sur un vieux remède sénégalais tombé dans l'oubli: le remède de Joal («garab u djoala» ou «garab diafan»). J. Agric. Trop. Bot. Appl., 21(10/11/12), 345-350.

Khan, I.A., Khanum, A., 2008. Herbal medicine for human diseases. J. Herb. Med. 4, 133.

Kimutai, A., Ngeiywa, M., Mulaa, M., Njagi, P.G.N., Ingonga, J., Nyamwamu, L.B., Ombati, C., Ngumbi, P., 2017. Repellent effects of the essential oils of *Cymbopogon citratus* and *Tagetes minuta* on the sandfly, *Phlebotomus duboscqi*. BMC Res. Notes 10(1), 98-107.

Kirtikar, K.R., Basu, B.D., 1975. Indian Medicinal Plants. Vol. I. Lalit Mohan Basu and Co, Allahabad, India.

Kouninki, H., Ngamo, L.S.T., Hance, T., Ngassoum, M.B., 2007. Potential use of essential oils from local Cameroonian plants for the control of red flour weevil *Tribolium castaneum* (Herbst.) (Coleoptera: Tenebrionidae). Afr. J. Food Agric. Nutr. Dev. 7(5), 1-15.

Kuete, V., Krusche, B., Youns, M., Voukeng, I., Fankam, A.G., Tankeo, S., Lacmata, S., Efferth, T., 2011. Cytotoxicity of some Cameroonian spices and selected medicinal plant extracts. J. Ethnopharmacol. 134(3), 803-812.

Lee, Y., 2016. Cytotoxicity evaluation of essential oil and its component from *Zingiber officinale* Roscoe. Toxicol. Res. 32(3), 225-230.

Lewis, J.J., 1949. Diabetes and the insulin administration problem. Physiol. Rev. 29(1), 75-90.

Lü, J., 2017. Effect of *Citrus reticulata* Blanco essential oil on *Cryptolestes ferrugineus* (Stephens) adults. J. Food Prot. 80(12), 2090-2093.

Mahanta, S., Khanikor, B., Sarma, R., 2017. Potentiality of essential oil from *Citrus grandis* (Sapindales: Rutaceae) against *Culex quinquefasciatus* Say (Diptera: Culicidae). J. Entomol. Zool. Stud. 5(3), 803-809.

Makumbelo, E., Lukoki, L., Paulus, J., Luyindula, N., 2008. Stratégie de valorisation des espèces ressources des produits non ligneux de la savane des environs de Kinshasa:II. Enquête ethnobotanique (aspects médicinaux). Tropicult. 26(3), 129-134.

Malar, M.S., Jamil, M., Hashim, N., Kiong, L.S., Jaal, Z., 2017a. Repellency effect of white flesh *Citrus grandis* Osbeck fruit peel extracts against *Aedes aegypti* (Linn.) mosquitoes. Int. J. Mosq. Res. 4(4), 88-94.

Malar, M.S., Jamil, M., Hashim, N., Kiong, L.S., Jaal, Z., 2017b. Toxicity of white flesh *Citrus grandis* Osbeck fruit peel extracts against *Aedes aegypti* (Linnaeus) larvae and its effect on non-target organisms. Int. J. Mosq. Res. 4(4), 49-57.

Mapi, J., 1988. Contribution à l'Etude Ethnobotanique et Analyse Chimique de Quelques Plantes Utilisées en Médecine Traditionnelle Dans la Région de Nkongsamba (Moungo). Thèse de doctorat. Université de Yaoundé, Yaoundé, Cameroon.

Martins, M.H.G., Fracarolli, L., Vieira, T.M., Dias, H.J., Cruz, M.G., Deus, C.C.H., Nicolella, H.D., Stefani, R., Rodrigues, V., Tavares, D.C., Magalhaes, L.G., Crotti, A.E.M., 2017. Schistosomicidal erffects of the essential oils of *Citrus limonia* and *Citrus reticulata* against *Schistosoma mansoni*. Chem. Biodiv., 14(1), 1-8.

Massebo, F., Tadesse, M., Bekele, T., Balkew, M., Gebre-Michael, T., 2009. Evaluation on larvicidal effects of essential oils of some local plants against *Anopheles arabiensis* Patton and *Aedes aegypti* Linnaeus (Diptera, Culicidae) in Ethiopia. Afr. J. Biotechnol. 8(17), 4183-4188.

Mazarin, A., Nukenine, E.N., Niu, C., Vincent, F.V., 2016. Synergistic effects of wood ash and essential oil on fecundity, pupal eclosion and adult mortality of *Callosobruchus maculatus* (Cleoptera: Bruchidae) cowpea seed weevil. Am. J. Exper. Agric. 11(6), 1-12.

Mehdi, S.M., Reza, S.A., Mahnaz, K., Reza, A.M., Abbas, H., Fatemweh, M., Hassan, V., 2010. Phytochemistry and larvicidal activity of *Eucalyptus camaldulensis* against malaria vector, *Anopheles stephensi*. Asian Pac. J. Trop. Med. 3(11), 841-845.

Metsoa Enama, B., Yaouba, A., Nyaka Ngobiosa, A., Beyegue Djonko, H., 2017. Antifungal activities of essential oils against *Rigidoporus lignosus*, causative agent of white root-rot disease of the rubber tree in Cameroon. EPH Int. J. Agric. Environ. Res. 2(1), 1-10.

Miller, A., Chodos, R.B., Emerson, C.P., Ross, J.F., 1956. Studies of the anemia and iron metabolism in cancer. J. Clin. Invest. 35(11), 1248-1262.

Mirzaei-Najafgholi, H., Tarighi, S., Golmohammadi, M., Taheri, P., 2017. The effect of *Citrus* essential oils and their constituents on growth of *Xanthomonas citri* subsp. *citri*. Molecules 22(4), 591-615.

Misra, L.N., Wouatsa, N.A.V., Kumar, S., Kumar, R.V., Tchoumbougnang, F., 2013. Antibacterial, cytotoxic activities and chemical composition of fruits of two Cameroonian *Zanthoxylum* species. J. Ethnopharmacol. 148(1), 74-80.

Mohammadhosseini, M., 2017. The ethnobotanical, phytochemical and pharmacological properties and medicinal applications of essential oils and extracts of different *Ziziphora* species. Ind. Crops Prod. 105, 164-192.

Mohammadhosseini, M., Sarker, S.D., Akbarzadeh, A., 2017. Chemical composition of the essential oils and extracts of *Achillea* species and their biological activities: A review. J. Ethnopharmacol. 199, 257-315.

Mohammadhosseini, M., Venditti, A., Sarker, S.D., Nahar, L., Akbarzadeh, A., 2019. The genus *Ferula*: Ethnobotany, phytochemistry and bioactivities – A review. Ind. Crops Prod. 129, 350-394.

Musa, D.A., Nwodo, F.O.C., Ojogbane, E., 2011. Phytochemical, antibacterial and toxicity studies of the aqueous extract

Eucalyptus camaldulensis Dehnh. Asian J. Plant Sci. Res. 1(3), 1-10.

Ndomo, A.F., Ngamo, L.T., Tapondjou, L.A., Tchouanguep, F.M., Hance, T., 2008. Insecticidal effects of the powdery formulation based on clay and essential oil from the leaves of *Clausena anisata* (Willd.) J.D. Hook ex. Benth. (Rutaceae) against *Acanthoscelides obtectus* (Say) (Coleoptera: Bruchidae). J. Pest Sci. 81(4), 227-234.

Ndomo, A.F., Tapondjou, A.L., Tendonkeng, F., Tchouanguep, F.M., 2009. Evaluation des propriétés insecticides des feuilles de *Callistemon viminalis* (Myrtaceae) contre les adultes d'*Acanthoscelides obtectus* (Say) (Coleoptera; Bruchidae). Tropicult. 27(3), 137-143.

Ndomo, A.F., Tapondjou, L.A., Ngamo, L.T., Hance, T., 2010. Insecticidal activities of essential oil of *Callistemon viminalis* applied as fumigant and powder against two bruchids. J. Appl. Entomol. 134(4), 333-341.

Ndoye, F., 2001. Thèse de Doctorat, Université Montpellier 2, Montpellier, France.

Ndoye, M.-C.N.F, Tchinang, T.F.K., Nyegue, A.M., Abdou, J.-P., Yaya, A.J.G., Tchinda, A.T., Essame, J.-L.O., Etoa, F.-X., 2016. Chemical composition, *in vitro* antioxidant and anti-inflammatory properties of essential oils of four dietary and medicinal plants from Cameroon. BMC Complement. Altern. Med. 16(1), 117-129.

Neuwinger, H.D., 2000. African Traditional Medicine: A Dictionary of Plant Use and Applications. Medpharm Scientific Publishers, Stuttgart, Germany.

Ngamo, T.S.L., Ngassoum, M.B., Mapongmestsem, P.M., Noudjou, W.F., Malaisse, F., Haubruge, E., Lognay, G., Kouniki, H., Hance, T., 2007a. Use of essential oils of aromatic plants as protectant of grains during storage. Agric. J. 2(2), 204-209.

Ngamo, T.S.L., Noudjou, W.F., Ngassoum, M.B., Mapongmestsem, P.M., Boubakary, A.B.A., Malaisse, F., Haubruge, E., Lognay, G., Hance, T., 2007b. Investigations on both chemical composition and insecticidal activities of essential oils of *Vepris heterophylla* (Rutaceae) from two localities of northern Cameroon towards *Tribolium castaneum* (Herbst) (Coleoptera: Tenebrionidae). Res. J. Biol. Sci. 2(1), 57-61.

Ngamo, T.L.S., Goudoum, A., Ngassoum, M.B., Mapongmetsem, P.M., Lognay, G., Malaisse, F., Hance, T., 2007c. Chronic toxicity of essential oils of 3 local aromatic plants towards *Sitophilus zeamais* Motsch. (Coleoptera: Curculionidae). Afr. J. Agric. Res. 2(4), 164-167.

Ngane, A.N., Biyiti, L., Amvam Zollo, P.H., Bouchet, P., 2000. Evaluation of antifungal activity of extracts of two Cameroonian Rutaceae: *Zanthoxylum leprieurii* Guill. et Perr. and *Zanthoxylum zanthoxyloides* Waterm. J. Ethnopharm. 70(3), 335-342.

Ngassoum, M.B., Yonkeu, S., Jirovetz, L., Buchbauer, G., Schmaus, G., Hammerschmidt, F.-J., 1999a. Chemical composition of essential oils of *Lantana camara* leaves and flowers from Cameroon and Madagascar. Flav. Fragr. J. 14(4), 245-250.

Ngassoum, M.B., Jirovetz, L., Buchbauer, G., Schmaus, G., Hammerschmidt, F.-J., 1999b. Chemical composition and olfactory evaluation of the essential oils of leaves and seeds of *Clausena anisata* (Willd.) J.D. Hook. ex. Benth. from Cameroon. J. Essent. Oil Res. 11(2), 231-237.

Ngassoum, M.B., Essia-Ngang, J.J., Tatsadjieu, L.N., Jirovetz, L., Buchbauer, G., Adjoudji, O., 2003. Antimicrobial study of essential oils of *Ocimum gratissimum* leaves and *Zanthoxylum xanthoxyloides* fruits from Cameroon. Fitoter. 74(3), 284-287.

Ngassoum, M.B., Ngamo, T.L.S., Ngatanko, I., Tapondjou, L.A., Lognay, G., Malaisse, F., Hance, T., 2007. Chemical composition, insecticidal effect and repellent activity of essential oils of three aromatic plants, alone and in combination, towards *Sitophilus oryzae* L. (Coleoptera: Curculionidae). Nat. Prod. Commun. 2(12), 1229-1232.

Ngouana, V., Fokou, P. V. T., Foudjo, B.U.S., Ngouela, S.A., Boyom, F. F., Zollo, P.H.A., 2011. Antifungal activity and acute toxicity of stem bark extracts of *Drypetes gossweileri* S. Moore-Euphorbiaceae from Cameroon. Afr. J. Trad. Complement. Altern. Med. 8(3), 328-333.

Ngoula, F., Tekam, M.G., Kenfack, A., Tchingo, C.d´A.T., Nouboudem, S., Ngoumtsop, H., Tsafack, B., Teguia, A., Kamtchouing, P., Galeotti, M., Tchoumboue, J., 2017. Effects of heat stress on some reproductive parameters of male cavie (*Cavia porcellus*) and mitigation strategies using guava (*Psidium guajava*) leaves essential oil. J. Therm. Biol. 64, 67-72.

Nguefack, J., Leth, V., Amvam Zollo, P.H., Mathur, S.B., 2004a. Evaluation of five essential oils from aromatic plants of Cameroon for controlling food spoilage and mycotoxin producing fungi. Int. J. Food Microbiol. 94(3), 329-334.

Nguefack, J., Budde, B.B., Jakobsen, M., 2004b. Five essential oils from aromatic plants of Cameroon: their antibacterial activity and ability to permeabilize the cytoplasmic membrane of *Listeria innocua* examined by flow cytometry. Lett. Appl. Microbiol. 39(5), 395-400.

Nguefack, J., Torp, J., Leth, V., Dongmo, J.B.L., Fotio, D., Amvam Zollo, P.H., 2007a. Effects of plant extracts and chemical fungicide in controlling a rice seed-born fungus under laboratory and in irrigated cropping system in Ndop-Cameroon. Afr. Crop Sci. Conf. Proceed. 8, 791-796.

Nguefack, J., Nguikwie, S.K., Fotio, D., Dongmo, B., Amwam Zollo, P.H., Leth, V., Nkengfack, A.E., Poll, L., 2007b. Fungicidal potential of essential oils and fractions from *Cymbopogon citratus*, *Ocimum gratissimum* and *Thymus vulgaris* to control *Alternaria padwickii* and *Bipolaris oryzae*, two seed-borne fungi of rice (*Oryza sativa* L.). J. Essent. Oil Res. 19(6), 581-587.

Nguefack, J., Leth, V., Lekagne Dongmo, J.B., Torp, J., Amvam Zollo, P.H., Nyasse, S., 2008. Use of three essential oils as seed treatments against seed-borne fungi of rice (*Oryza sativa* L.). Am. Euras. J. Agric. Environ. Sci. 4(5), 554-560.

Nguefack, J., Lekagne Dongmo, J.B., Dakole, C.D., Leth, V., Vismer, H.F., Torp, J., Guemdjom, E.F.N., Mbeffo, M., Tamgue, O., Fotio, D., Amvam Zollo, P.H., Nkengfack, A.E., 2009. Food preservative potential of essential oils and fractions from *Cymbopogon citratus*, *Ocimum gratissimum* and *Thymus vulgaris* against mycotoxigenic fungi. Int. J. Food Microbiol. 131(2/3), 151-156.

Nguefack, J., Tamgue, O., Lekagne Dongmo, J.B., Dakole, C.D., Leth, V., Vismer, H.F., Amvam Zollo, P.H., Nkengfack, A.E., 2012. Synergistic action between fractions of essential oils from *Cymbopogon citratus*, *Ocimum gratissimum* and *Thymus vulgaris* against *Penicillium expansum*. Food Control 23(2), 377-383.

Nguefack, J., Wulff, G.E., Dongmo, J.B.L., Fouelefack, F.R., Fotio, D., Mbo, J., Torp, J., 2013. Effect of plant extracts and an essential oil on the control of brown spot disease, tillering, number of panicles and yield increase in rice. Eur. J. Plant Pathol.

137(4), 871-882.

Nguikwie, S.K., Nyegue, M.A., Belinga, F.N.-F., Ngane, R.A.N., Romestand, B., Kouzayha, A., Casabianca, H., Zollo, P.H.A., Menut, C., 2013. The chemical composition and antibacterial activities of the essential oils from three *Aframomum* species from Cameroon, and their potential as sources of (*E*)-(*R*)-nerolidol. Nat. Prod. Commun. 8(6), 829-834.

Nlôga, A.M.N., Saotoing, P., Tchouankeu, J.C., Messi, J., 2007. Effect of essential oils of six local plants used as insecticide on adults of *Anopheles gambiae*, Giles 1902. J. Entomol. 4(6), 444-450.

Nordeng, H., Al-Zayadi, W., Diallo, D., Ballo, N., Paulsen, B.S., 2013. Traditional medicine practitioners' knowledge and views on treatment of pregnant women in three regions of Mali. J. Ethnobiol. Ethnomed. 9(1), 67-76.

Norris, E.J., Gross, A.D., Dunphy, B.M., Bessette, S., Bartholomay, L., Coats, J.R., 2015. Comparison of the insecticidal characteristics of commercially available plant essential oils against *Aedes aegypti* and *Anopheles gambiae* (Diptera: Culicidae). J. Med. Entomol. 52(5), 993-1002.

Noumi, E., 1984. Les Plantes à Epices, à Condiments et à Aromates du Cameroun. Doctoral Dissertation. The University of Yaoundé, Yaoundé, Cameroon.

Noumi, E., Amvan Zollo, P.H., Lontsi, D., 1998. Aphrodisiac plants used in Cameroon. Fitoter. 69(2), 125-134.

Noumi, E., Dibakto, T.W., 2000. Medicinal plants used for peptic ulcer in the Bangangte region, western Cameroon. Fitoter. 71(4), 406-412.

Noumi, E., Snoussi, M., Hajlaoui, H., Trabelsi, N., Ksouri, R., Valentin, E., Bakhrouf, A., 2011. Chemical composition, antioxidant and antifungal potential of *Melaleuca alternifolia* (tea tree) and *Eucalyptus globulus* essential oils against oral *Candida* species. J. Med. Plant Res. 5(17), 4147-4156.

Nundkumar, N., Ojewole, J.A.O., 2002. Studies on the antiplasmodial properties of some South African medicinal plants used as antimalarial remedies in Zulu folk medicine. Methods Find. Exp. Clin. Pharmacol. 24(7), 397-402.

Nurdjannah, N., Bermawie, N., 2001. Clove. Handbook of Herbs and Spices. CRC Press New York, Wood Head Publishing Ltd., Cambridge, United Kingdom.

Nyegue, M., Ndoyé, F., Amvam Zollo, P.-H., Etoa, F.-X., Agnaniet, H., Menut, C., 2008. Chemical and biological evaluation of essential oil of *Pentadiplandra brazzeana* (Bail.) roots from Cameroon. Adv. Phytother. Res. 91-107.

Nyegue, M.A., Ndoyé-Foe, F.M.-C., Essama, R.S., Hockmeni, T.C., Etoa, F.-X., Menut, C., 2014. Chemical composition of essential oils of *Eugenia caryophylla* and *Mentha* sp cf *piperita* and their in vitro antifungal activities on six human pathogenic fungi. Afr. J. Tradit. Complement. Altern. Med. 11(6), 40-46.

Nyegue, M.A., Del Florence, M.N.E., Ndoyé-Foe, F., Etoa, F.-X., Menut, C., 2017. Bioactivity of essential oils from medicinal plants of Cameroon and their combination against infant diarrhea induced by bacteria. Afr. J. Trad. Complement. Altern. Med. 14(6), 27-37.

Odugbemi, T., 2008. A Textbook of Medicinal Plants from Nigeria. University of Lagos Press, Lagos, Nigeria.

Ogunwande, I., Olawore, N.O., Adeleke, K.A., Ekundayo, O., Koenig, W.A., 2003. Chemical composition of the leaf volatile oil of *Psidium guajava* L. growing in Nigeria. Flav. Fragr. 18(2), 136-138.

Okoh, S.O., Oyewole, A.O., Ishola, R.O., Odusote, A.D., Okoh, O.O., Igwe, C.C., Elemo, G.N., 2015. Antioxidant and free radical scavenging capacity of crude and refined oil extracted from *Azadirachta indica* A. Juss. Int. J. Biol. 7(2), 78-85.

Okunade, A.L., Olaifa, J.I., 1987. Estragole: an acute toxic principle from the volatile oil of the leaves of *Clausena anisata*. J. Nat. Prod. 50(5), 990-991.

Oliver, B., 1960. Medicinal Plants in Nigeria. University of Ibadan Press, Ibadan, Nigeria.

Oliver-Bever, B., 2009. Medicinal Plants in West Africa. Cambridge University Press, Cambridge, United Kingdom.

Olosunde, O.O., Adegoke, G.O., Abiodun, O.A., 2015. Composition of sorghum-millet flour, *Aframomum danielli* essential oil and their effect on mycotoxins in kunu zaki. Afr. J. Food Sci. 9(7), 411-416.

Olowokudejo, J.D., Kadiri, A.B., Travih, V.A., 2008. An ethnobotanical survey of herbal markets and medicinal plants in Lagos State of Nigeria. Ethnobot. Leaflets 12(1), 851-865.

Ousman, A., Ngassoum, M.B., Essia-Ngang, J.J., Ngamo, L.S.T., Ndjouenke, R., 2007. Insecticidal activity of spicy plant oils against *Sitophilus zeamais* in stored maize in Cameroon. Agric. J. 2(2), 192-196.

Owokotomo, I.A., Ekundayo, O., Abayomi, T.G., Chukwuka, A.V., 2015. In-vitro anti-cholinesterase activity of essential oil from four tropical medicinal plants. Toxicol. Rep. 2, 850-857.

Oyedeji, O.O., Lawal, O.A., Shode, F.O., Oyedeji, A.O., 2009. Chemical composition and antibacterial activity of the essential oils of *Callistemon citrinus* and *Callistemon viminalis* from South Africa. Molecules 14(6), 1990-1998.

Patil, J.R., Jayaprakasha, G.K., Murthy, K.N.C., Tichy, S.E., Chetti, M.B., Patil, B.S., 2009. Apoptosis-mediated proliferation inhibition of human colon cancer cells by volatile principles of *Citrus aurantifolia*. Food Chem. 114(4), 1351-1358.

Pavela, R., Maggi, F., Mbuntcha, H., Woguem, V., Fogang, H.P.D., Womeni, H. M., Tapondjou, L.A., Barboni, L., Nicoletti, M., Canale, A., Benelli, G., 2016. Traditional herbal remedies and dietary spices from Cameroon as novel sources of larvicides against filariasis mosquitoes? Parasitol. Res. 115(12), 4617-4626.

Pavela, R., Maggi, F., Lupidi, G., Mbuntcha, H., Woguem, V., Womeni, H.M., Barboni, L., Tapondjou, L.A., Benelli, G., 2018. *Clausena anisata* and *Dysphania ambrosioides* essential oils: from ethno-medicine to modern uses as effective insecticides. Environ. Sci. Pollut. Res., 25(11) 10493-10503.

Pavunraj, M., Ramasubbu, G., Baskar, K., 2017. *Leucas aspera* (Willd.) L.: Antibacterial, antifungal and mosquitocidal activities. Trends Phytochem. Res. 1, 135-142.

Pelé, J., Le Berre, S., 1966. Les Aliments d´Origine Végétale au Cameroun. Orstrom, Yaoundé, Cameroon.

Phasomkusolsil, S., Soonwera, M., 2011. Comparative mosquito repellency of essential oils against *Aedes aegypti* (Linn.), *Anopheles dirus* (Peyton and Harrison) and *Culex quinquefasciatus* (Say). Asian Pac. J. Trop. Biomed. 1(1), S113-S118.

Popielas, L., Moulis, C., Keita, A., Fourasté, I., Bessière, J.-M., 1991. The essential oil of *Cymbopogon giganteus*. Planta Med. 57(6), 586-687.

Purseglove, J.W., 1972. Tropical Crops. Dicotyledons.

Longman, London, United Kingdom.

Quattrocchi, U., 2012. CRC World Dictionary of Medicinal and Poisonous Plants: Common Names, Scientific names, Eponyms, Synonyms, and Etymology 1-5, CRC Press, Boca Raton, United States of America.

Raponda-Walker, A., Sillans, R., 1961. Les Plantes Utiles du Gabon. Lechevalier, Paris, France.

Reisch, J., Adesina, S.K., Bergenthal, D., 1985. Constituents of *Zanthoxylum leprieurii* fruit pericarps. CIII: Natural product chemistry. Pharmazie 40(11), 811-812.

Saeb, S., Amin, M., Gooybari, R.S., Aghel, N., 2016. Evaluation of antibacterial activities of *Citrus limon*, *Citrus reticulata* and *Citrus grandis* against pathogenic bacteria. Int. J. Enteric Pathog. 4(4), 1-5.

Said, Z.B.-O.S., Haddadi-Guemghar, H., Boulekbache-Makhlouf, L., Rigou, P., Remini, H., Adjaoud, A., Khoudja, N.K., Madani, K., 2016. Essential oil composition, antibacterial and antioxidant activities of hydrodestillated extract of *Eucalyptus globulus* fruits. Ind. Crops Prod. 89, 167-175.

Sameza, M.L., Tchameni, S.N., Ekoué, J.D.A., Jazet, P.M.D., Tchoumbougnang, F., 2016. Growth inhibition of stored fish (*Ethmalosa fimbriata*) fungus *Aspergillus* flavus, exposed to extracted essential oils from *Callistemon citrinus* and *Ocimum canum*. Afr. J. Microbiol. Res. 10(30), 1164-1172.

Santos, P.A.S.R., Avanço, G.B., Nerilo, S.B., Marcelino, R.I.A., Janeiro, V., Valadares, M.C., Machinski, M., 2016. Assessment of cytotoxic activity of rosemary (*Rosmarinus officinalis* L.), turmeric (*Curcuma longa* L.), and ginger (*Zingiber officinale* R.) essential oils in cervical cancer cells (HeLa). Sci. World J., 1-8.

Saotoing, P., Vroumsia, T., Tchobsala, D., Tchuenguem, F.F.-N., Njan Nlôga, A.-M., Messi, J., 2011. Medicinal plants used in traditional treatment of malaria in Cameroon. J. Ecol. Nat. Environ. 3(3), 104-117.

Shagal, M.H, Kubamarawa, D., Tadzabia, K., Dennis, K.I., 2012. Evaluation of phytochemical and antimicrobial potentials of roots, stem-bark and leaves extracts of *Eucalyptus camaldulensis*. Afr. J. Pure Appl. Chem. 6(5), 74-77.

Shinde, P.R., Patil, P.S., Bairagi, V.A., 2012. Pharmacognostic, phytochemical properties and antibacterial activity of *Callistemon citrinus viminalis* leaves and stems. Int. J. Pharm. Pharm. Sci. 4(4), 406-408.

Shrestha, S., Poudel, A., Satyal, P., Dosoky, N.S., Chhetri, B.K., Setzer, W.N., 2015. Chemical composition and biological activity of the leaf essential oil of *Callistemon citrinus* from Nepal. Am. J. Essent. Oils Nat. Prod. 2(5), 29-33.

Shukla, R., Singh, P., Prakash, B., Dubey, N.K., 2012. Antifungal, aflatoxin inhibition and antioxidant activity of *Callistemon lanceolatus* (Sm.) sweet essential oil and its major component 1,8-cineole against fungal isolates from chickpea seeds. Food Control 25(1), 27-33.

Shukla, Y., Singh, M., 2007. Cancer preventive properties of ginger: a brief review. Food Chem. Toxicol., 45(5), 683-690.

Sidibé, L., Chalchat, J.-C., Garry, R.-P., Lacombe, L., Harama, M., 2001. Aromatic plants of Mali (IV): chemical composition of essential oils of *Cymbopogon citratus* (DC) Stapf and *C. giganteus* (Hochst.) Chiov. J. Essent. Oil Res. 13(2), 110-112.

Silva, J., Abebe, W., Sousa, S.M., Duarte, V.G., Machado, M.I.L., Matos, F.J.A., 2003. Analgesic and anti-inflammatory effects of essential oils of *Eucalyptus*. J. Ethnopharm. 89(2/3), 277-283.

Sofowora, A., 1984. Medicinal Plants and Traditional Medicine in Africa. John Wiley and Sons Ltd., New York, United States of America.

Sokamte, T.A., Jazet, D.P.M., Tatsadieu, N.L., 2016. In vitro activity of *Syzygium aromaticum* against food spoilage fungi and its potential use as an antiradical agent. J. Microbiol. Res. 6(1), 1-7.

Steele, V.E., Hawk, E.T., Viner, J.L., Lubet, R.A., 2003. Mechanisms and applications of non-steroidal anti-inflammatory drugs in the chemoprevention of cancer. Mut. Res. Fundam. Mol. Mech. Mutagen. 523-524, 137-144.

Tagne, A., Feujio, T.P., Sonna, C., 2008. Essential oil and plant extracts as potential substitutes to synthetic fungicides in the control of fungi. ENDURE Int. Conf. La Grande-Motte, France.

Talla, E., Bealem, A., Tatsadjieu, N.L., Ngassoum, M.B., Mbafor, T.J., 2013. Phytochemical screening, chemical composition and antimicrobial activity of *Zingiber officinale* essential oil of Adamaoua region (Cameroon). J. Chem. Pharm. Res. 5(7), 296-301.

Tane, P., Tatsimo, S.D., Ayimele, G.A., Connolly, J.D., 2005. Bioactive Metabolites from Aframomum Species. 11th NAPRECA Symposium. Book of Proceedings, Antananarivo, Madagascar.

Tankam, J.M., Ito, M., 2013. Inhalation of the essential oil of *Piper guineense* from Cameroon shows sedative and anxiolytic-like effects in mice. Biol. Pharm. Bull. 36(10), 1608-1614.

Tapondjou, A.L., Bouda, H., Fontem, D.A., Zapfack, L., Lontsi, D., Sondengam, B.L., 2000. Local plants used for traditional stored product protection in the Menoua devision of the Western highlands of Cameroon. Integr. Prot. Stored Prod. IOBC Bull. 23(10), 73-77.

Tapondjou, A.L., Adler, C., Bouda, H., Reichmuth, C., 2002. Ability of products derived from the leaves of *Clausena anisata* to protect stored legumes from attack by *Callosobruchus maculatus* and *C. chinensis* (Coleoptera: Bruchidae). Integr. Prot. Stored Prod. IOBC Bull. 25(3), 153-160.

Tapondjou, A.L., Adler, C., Fontem, D.A., Bouda, H., Reichmuth, C., 2005. Bioactivities of cymol and essential oils of *Cupressus sempervirens* and *Eucalyptus saligna* against *Sitophilus zeamais* Motschulsky and *Tribolium confusum* du Val. J. Stored Prod. Res. 41(1), 91-102.

Tapsell, L.C., Hemphill, I., Cobiac, L., Patch, C.S., Sullivan, D.R., Fenech, M., Roodenrys, S., Keogh, J.B., Clifton, P.M., Williams, P.G., Fazio, V.A., Inge, K.E., 2006. Health benefits of herbs and spices: the past, the present, the future. Med. J. Austr. 185(4), S1-S24.

Tatsadjieu, N.L., Etoa, F.-X., Mbofung, C.M.F., Ngassoum, M.B., 2008. Effect of *Plectranthus glandulosus* and *Ocimum gratissimum* essential oils on growth of *Aspergillus flavus* and aflatoxin B_1 production. Tropicult. 26(2), 78-83.

Tatsadjieu, N.L., Dongmo, P.M.J., Ngassoum, M.B., Etoa, F.-X., Mbofung, C.M.F., 2009. Investigations on the essential oil of *Lippia rugosa* from Cameroon for its potential use as antifungal agent against *Aspergillus flavus* Link ex. Fries. Food Control 20(12), 161-166.

Tatsadjieu, N.L., Yaouba, A., Nukenine, E.N., Ngassoum, M.B., Mbofung, C.M.F., 2010. Comparative study of the simultaneous action of three essential oils on *Aspergillus flavus* and *Sitophilus zeamais* Motsch. Food Control 21(2), 186-190.

Tchameni, S.N., Mbiakeu, S.N., Sameza, M.L., Jazet, P.M.D., Tchoumbougnang, F., 2017. Using *Citrus aurantifolia* essential oil for the potential biocontrol of *Colocasia esculenta* (taro) leaf blight caused by *Phytophthora colocasiae*. Environ. Sci. Poll. Res., 1-7.

Tchoumbougnang, F., Amvam Zollo, P.H., Dagne, E., Mekonnen, Y., 2005. In vivo antimalarial activity of essential oils from *Cymbopogon citratus* and *Ocimum gratissimum* on mice infected with *Plasmodium berghei*. Planta Med. 71(1), 20-23.

Tchoumbougnang, F., Jazet, D.P.M., Sameza, M.L., Ndifor, F., Wouatsa, N.A.V., Amvam Zollo, P.H., Menut, C., 2009a. Comparative essential oils composition and insecticidal effect of different tissues of *Piper capense* L., *Piper guineense* Schum. et Thonn., *Piper nigrum* L. and *Piper umbellatum* L. grown in Cameroon. Afr. J. Biotechnol. 8(3), 424-431.

Tchoumbougnang, F., Dongmo, P.M.J., Sameza, M.L., Mbanjo, E.G.N., Fotso, G.B.T., Zollo, P.H.A., Menut, C., 2009b. Larvicidal activity against *Anopheles gambiae* Giles and chemical composition of essential oils from four plants cultivated in Cameroon. Biotechnol. Agron. Soc. Environ. 13(1), 77-84.

Ticzon, R., 1997. Herbal Medicine Encyclopaedia. Romeo R. Ticzon Publishing, Philippines.

Titanji, V.P.K, Zofou, D., Moses, N., Ngemenya, M.N., 2008. The antimalarial potential of medicinal plants used for the treatment of malaria in Cameroonian folk medicine. Afr. J. Tradit. Complement. Altern. Med. 5(3), 302-321.

Tofel, K.H., Kosma, P., Stähler, M., Adler, C., Nukenine, E.N., 2017. Insecticidal products from *Azadirachta indica* and *Plectranthus glandulosus* growing in Cameroon for the protection of stored cowpea and maize against their major insect pests. Ind. Crops Prod. 110, 58-64.

Tripathi, P., 2016. Efficacy of essential oil of *Zingiber officinale* (Rosc) in preservation of orange (*Citrus sinensis* (L.) Osbec) fruit against rotting fungi. Int. J. Curr. Agric. Sci. 6(9), 108-114.

Troupin, G., 1983. Flore Des Plantes Ligneuses du Rwanda. Musée Royal de l´Afrique Centrale Turuven, Belgium.

Uchida, N.S., Silva-Filho, S.E., Aguiar, R.P., Wiirzler, L.A.M., Cardia, G.F.E., Cavalcante, H.A.O., de Souza Sila-Comar, F.M., Becker, T.C.A., Silva, E.L., Bersani-Amado, C.A., Cuman, R.K.N., 2017. Protective effect of *Cymbopogon citratus* essential oil in experimental model of acetaminophen-induced liver Injury. Am. J. Chin. Med. 45(3), 515-532.

Uzun, A., Yesiloglu, T., 2012. Genetic Diversity in *Citrus*, in: Caliskan, M. (Ed.), Genetic Diversity in Plants, Tech: Rijeka, Croatia, pp. 213-230.

Vergiat, A.-M., 1970. Plantes magiques et médicinales des Féticheurs de l'Oubangui (Région de Bangui). J. d´Agric. Trop. Bot. Appl. 17(1-4), 60-91.

Vigo, E., Cepeda, A., Perez-Fernandez, R., Gualillo, O., 2004. *In vitro* anti-inflammatory effect of *Eucalyptus globulus* and *Thymus vulgaris*: nitric oxide inhibition in J774A.1 murine macrophages. J. Pharm. Pharm. 56(2), 257-263.

Vijaylakshmi, P., Radha, R., 2015. An overview: *Citrus maxima*. J. Phytopharm. 4(5), 263-267.

Villiers, J.-F., 1973. Flore du Cameroun. Muséum National d'Histoire Naturelle. Laboratoire de Phanérogamie, Paris 5e, vol 15, 263.

Voundi, S.O., Nyegue, M., Lazar, I., Raducanu, D., Ndoye, F.F., Stamate, M., Etoa, F.-X., 2015. Effect of essential oils on germination and growth of some pathogenic and spoilage spore-forming bacteria. Foodborne Pathog. Dis. 12(6), 551-559.

Walker, A.R., Sillians, R., 1961. Les Plantes Utiles du Gabon. Tournon. 6è Ed. Paris, France.

Wang, W.H., Wang, Z.M., 2005. Studies of commonly used traditional medicine-ginger. Chin. J. Chin. Mat. Med. 30(20), 1569-1573.

Watt, J.M., Breyer-Brandwijk, M.G., 1962. The Medicinal and Poisonous Plants of Southern and Eastern Africa, 2nd edn. Livingstone, London, United Kingdom.

Weldemariam, Y., Abadi, K., Gebremariam, G., Brhane, G., 2015. Phytochemical screening, anthelmintic and antioxidant activity of *Eucalyptus globulus* essential oils: Local cough remedy plant. World J. Pharm. Pharm. Sci. 4(1), 52-60.

Wong, W., 1976. Some folk medicinal plants from Trinidad. Econ. Bot. 30(2), 103-142.

Xiao, D., Vogel, V., Singh, S.V., 2006. Benzyl isothiocyanate-induced apoptosis in human breast cancer cells is initiated by reactive oxygen species and regulated by Bax and Bak. Mol. Canc. Ther. 5(11), 2931-2945.

Yamashiro, S., Noguchi, K., Matsuzaki, T., Miyagi, K., Nakasone, J., Sakanashi, M., Sakanashi, M., Kukita, I., Aniya, Y., Sakanashi, M., 2003. Cardioprotective effects of extracts from *Psidium guajava* L. and *Limonium wrightii*, Okinawan medicinal plants, against ischemia-reperfusion injury in perfused rat hearts. Pharmacol. 67(3), 128-135.

Yaouba, A., Tatsadjieu, L.N., Dongmo, P.M., Etoa, F.X., Mbofung, C.M., Zollo, P.H., Menut, C., 2011. Evaluation of *Clausena anisata* essential oil from Cameroon for controlling food spoilage fungi and its potential use as an antiradical agent. Nat. Prod. Commun. 6(9), 1367-1371.

Yemele, M.D., Telefo, P.B., Lienou, L.L., Tagne, S.R., Fodouop, C.S.P., Goka, C.S., Lemfack, M.C., Moundipa, F.P., 2015. Ethnobotanical survey of medicinal plants used for pregnant women' s health conditions in Menoua division-West Cameroon. J. Ethnopharmacol. 160, 14-31.

Yeung, H.C., 1985. Handbook of Chinese Herbs and Formulas. Institute of Chinese Medicine, Los Angeles, United States of America.

Zouaghi, G., Najar, A., Chiboub, O., Sifaouio, I., Abderrabba, M., Morales, J.L., 2017. The effect of viroid infection of citrus trees on the amoebicidal activity of 'Maltese half-blood' (*Citrus sinensis*) against trophozoite stage of *Acanthamoeba castellanii* Neff. Exper. Parasitol., 183, 182-186.