Online ISSN: 2249-4626
Print ISSN: 0975-5896

Global Journal

of Science Frontier Research: B

Chemistry



Contaminated Air Force

Evaluation of Accumulation ability

Highlights

Activity of Eucalyptus Globules

Variability of Anibarosaeodora Oils

Discovering Thoughts, Inventing Future

VOLUME 15 ISSUE 5 VERSION 1.0

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Volume 15 Issue 41 was originally issued as B5

Global Journal of Science Frontier Research: B
Chemistry

Volume 15 Issue 41
Originally issued as B5

Global Journal of Science Frontier Research: B
Chemistry

Volume 15 Issue 5 (Ver. 1.0)

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Global Journal of Science Frontier Research: B
Chemistry
Volume 15 Issue 5 Version 1.0 Year 2015
Type : Double Blind Peer Reviewed International Research Journal
Publisher: Global Journals Inc. (USA)
Online ISSN: 2249-4626 & Print ISSN: 0975-5896

Determination of Phytochemical Constituents and Insecticidal Activity of Eucalyptus Globules Against Cactus Pests

By Yohannes Weldemariam & Shishay Welderufael
Adigrat University, Ethiopia

Abstract- Cactus pear is widely distributed in Tigray and South Amhara Regional state and is the integral part of the economy of the people. It is commonly used as a famine food, feed for livestock, bee forage, a source of cash income and short time occupation, soil and water conservation, live fences etc. However, cactus is been gradually destroyed. The peoples relied on cactus are suffering from the destruction. The effect of the insect *cochineal* has been an alarm around the region. The intention of this research was to find a solution to insects and pests on cactus. Insecticidal activity was done on *Eucalyptu* soil extracts and on three commercial pesticides. At all concentrations the oils terminate the cochineal insects of all ages. Especially, the male cochineals (adult and young) and young female were more sensitive to the oils respectively. Findings from spray test are promising with 80-90% inhibition in average.

Keywords: opnitiaficusindica, eucalyptus globulus, hydro distillation, essential oil, phytochemical screening, physicochemical constants, insecticidal activity.

GJSFR-B Classification : FOR Code: 259999p



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Determination of Phytochemical Constituents and Insecticidal Activity of Eucalyptus Globules Against Cactus Pests

Yohannes Weldemariam [α] & Shishay Welderufael [σ]

Abstract- Cactus pear is widely distributed in Tigray and South Amhara Regional state and is the integral part of the economy of the people. It is commonly used as a famine food, feed for livestock, bee forage, a source of cash income and short time occupation, soil and water conservation, live fences etc. However, cactus is been gradually destroyed. The peoples relied on cactus are suffering from the destruction. The effect of the insect *cochineal* has been an alarm around the region. The intention of this research was to find a solution to insects and pests on cactus. Insecticidal activity was done on *Eucalyptu s*oil extracts and on three commercial pesticides. At all concentrations the oils terminate the cochineal insects of all ages. Especially, the male cochineals (adult and young) and young female were more sensitive to the oils respectively. Findings from spray test are promising with 80-90% inhibition in average.

Keywords: opnitiaficusindica, eucalyptus globulus, hydro distillation, essential oil, phytochemical screening, physicochemical constants, insecticidal activity.

I. Introduction

Unlike those edible vegetable oils essential oil(ethereal oil) is a concentrated, hydrophobic liquid that contains hundreds of aromatic compounds, organic constituents, and other natural elements found in dried or fresh leaves, stems, flowers, bark, wood, roots or other elements of a plant(Buchbauer2010). Essential oils has been used for psychological and physical wellbeing since long timein China and Egypt. Yet, its medicinal potential was known only during the earlier part of the 20thCentury as discovered by French Chemist Rene-Maurice Gattefosse(Buchbauer2010,Taylor and Francis Group 2010,Cipolca2005, Celikel and Kavas 2008).

Essential oils can be used for treating burned skin or to heal wounds due to their anti-inflammatory properties (Derwich et al. 2010). They also bear role to play in the protection of crops against mould, mildew and wood root fungi and plants against various insects (Isman 2000). In addition, when applied in a vapor form, essential oil has potential to manage weeds, especially as its toxicity appears to be harmful to the insects. Since essential oils are a complex mixture of chemical components their synergetic effect is promising. Most of them work in the same way as:

- Repellents which drive the insects away from the plant by their smell or taste
- Anti- feed ants which cause insects feeding on the plants to reduce their food intake until they die from starvation
- Ovipositor deterrents which prevent insects from laying eggs
- Inhibitors which stop the development of different stages of the insect(Isman 2000, Hussain2009, Can Baser and Buchbauer 2010).

Globules oil *from Eucalyptus* genus can control aphids, Piercing-Sucking insect pests associated with Faba bean *Viciafaba by* reducing the population of leafhoppers and planthoppers (Mousa et al. 2013). Data from insecticidal activity of this plant indicates it is lethal to female Pediculushumanuscapitis De Geer insect (Yang et al. 2004).On another study it has lethal effect to Sternechus subsignatus, Rhyssomatussubtilis and Lutzomyialongipalpis, with significant mortality (contact toxicity (LD50 = 0.40 and 0.84 μL/cm^2 for S. pinguis and R. subtilis respectively) two important pest of soybean (Maciel et al.2010).

Cactus pear is widely distributed in Tigray Regional State and is the integral part of the economy of the people. Fruits are very sweet and have many essential components comparable to mostly used fruits and known in the countries over the entire world where cactus grows. Young cladodes are edible as fresh or cooked vegetable in the origin county Mexico and other countries. As reported in one study done on uses of cactus as livestock feed in Northern Ethiopia it revealed many uses such as famine food, feed for livestock, bee forage, a source of cash income and short time occupation, soil and water conservation, live fences etc (Gebretsadik2013). With regard to its medicinal application it is used to lower fever and relieves chest pains, as a healing pad in cases of rheumatic and asthmatic symptoms of the chest, liver trouble, earaches, against diabetes and neuro protective effects. However, here in Tigray its production and quality as compared to its potential is very low. One of

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the main reasons is damage of insect and disease. This fruit crop can be affected by disease such as Phyllosticta pad spot, Anthracnose, *Echinocereus, Pythium*, Sammons'virus, Bacterial necrosis and insects like *Scyphophorusacupunctatus*, Cochineal scale, Cactus longhorn beetle, Coccid scale etc. despite of this fact, there are no research reports on the control methods of these insects and diseases which hindering its production and quality (Buchbauer2010, Derwich et al. 2010, Isman 2000, Mousa et al. 2013).The aim of this research project was to extract essential oil from one eucalyptusspecies as an pesticide specifically with focus to Cochineal insect. This is the first project to try to eliminate cochineal insects in natural chemical pesticide.

II. Methodology

a) Materials and Methods

i. *Materials*

a. *Chemicals and Solvent*

Glacial acetic acid, acetic anhydride, ammonium solution, conc. hydrochloric acid, sodium hydroxide, potassium hydroxide, sodium mercuric chloride , potassium iodide , calcium hydroxide ($Ca(OH)_2$), iodine, potassium iodide, ferric chloride ($FeCl_3$), picric acid, concentrated sulphuric acid, dilute ammonia solution, n-hexane, diethyl ether, acetone, benzene, ethyl acetate, and ethanol.

b. *Instruments and Equipment*

Thermometer, distiller, pestle and mortal, vacuum pump, separatory funnel. pipettes, burettes, Clevenger apparatus, round bottom flask, fridge, electrode beam balance were the major instruments used in this work.

ii. *Methods*

a. *Extraction of Essential Oil*

Fresh collected samples were washed with tap water, to eliminate soil and other surface contaminants and shade dried at room temperature for 8 -10days.The dried sample was crashed to increase surface area using pestle and mortal(Saim et al. 2008).The essential oil was then extracted from samples of *Eucalyptus* using hydro distillation in Clevenger type apparatus through the following procedure; first 300g of the sample was measured using beam balance and put in to 5000 ml three-necked round bottom flask using spatula. Then ¾ of flask was filled with distilled water. The round bottom flask was then placed on heating mantle and using metal clamps it was connected with the Clevenger apparatus and condenser. Then the flask was heated for 3-4hours. While it was heating the oil and water evaporated as stem. The oil appears at the top of the water. The essential oil was obtained by removing the water until it riches the layer of the oil. The obtained essential oil was purified and stored under refrigerator for further use (Maciel et al. 2010, Saim et al. 2008, Fabiane et al. 2007).

The percent yields of essential oil extracted was calculated as;

Percent yields = weight of the oil/weight of the sample used(Fabiane et al. 2007,Tiwari et al 2011)

b. *Insecticidal activity*

In order to test the toxicity of essential oil on the insects of different age (young and adult). Ten adults were put into the 2500 ml glass jars. Essential oil was then applied on a filter-paper strip measuring 3 x 3 cm attached to the lower side of the jar's lid. Doses was calculated and assumed 100% volatilization of the oils in the exposure vessels. The same procedure was repeated with only difference in the number of treatment groups that 30 young insects were used in both male and female. The first insecticidal activity experiments was conducted at constant temperature (27 ± 1°C), photoperiod (14L: 10D) and relative humidity (60% ± 5) for 24 h. While for the sake of obtaining the exact death and time of paralysis the second experiment was done out of the incubator. In either case insects of both ages were exposed to essential oil vapors (100, 80, 60, 40, 20, 10, 5, 3, 1 μl/l air). A dose-mortality line was developed depending on the exposure time(s), and the lethal concentration of essential oil needed to kill 50% of the pest population (LC50) was also determined. Three replicates were set up for each dose and exposure time. In a small designed field containing six cladodes spraying was also done for three consecutive days with all the treatment groups at (100, 200, 300, 400, 500, 600 μl/l air). All replicates were run simultaneously during the experiments. A complete set of controls was also be maintained and replicated three times for each treatment (Mousa et al. 2013, Yang 2004 et al, Macielet al2010).

III. Result and Discussion

a) Essential oil yield

From fresh leaf samples of *Eucalyptus globulus* 1.56(%w/w) of oil was obtained.

b) Phytochemical screening findings

For a plant to have phytochemical constituents means that the plant is promising to be used in as herbal medicine. Some of those determined here have clear mechanism of action with respect to the strains. The phenols are expected to be toxic though they absent from the essential oil. Alkaloids are known to act in central nervous system of the insects while tannins complex with proteins through so-called nonspecific forces such as hydrogen bonding and hydrophobic effects, as well as by covalent bond formation. They inactivate microbial adhesions, enzymes, and cell envelope transport etc (Jeyachandran et al. 2009, Kashiwada1992, Paiva et al. 2003, Jagessarand Cox, 2010, Schulzet al. 2004)Condensed tannins act by

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binding to cell walls of for instance ruminal bacteria resulting in declining growth weakened activity. In the case of insects tannins specifically those condensed ones are expected to act the same.

Table 1 : Phytochemical constituents of *Eucalyptus globulus and Eucalyptus camaldulensis* leaf and oil.

S/No	Phytochemicals	*Eucalyptus globulus(oil)*	*Eucalyptus globulus(leaf)*
1	Phenol	-	+
2	Alkaloids	++	-
3	Free anthraquinones	-	+
4	Flavonoids	-	-
5	Tannins	++	++
6	Steroids	++	++
7	Terpenoids	++	++
8	Saponins	ND	+
9	Cardiac glycosides	+	+
10	Volatile oil	++	++

Key: (++)=strong presence, (+)=presence,(-)= absence, (ND)=not determined

c) *Insecticide activity on cochineal insect*

In Cochineal insect taxonomy the female is about five times bigger than the male and it lacks wings. Equal sizes of both adult and young female as well as male were collected carefully in glass and plastic bottles from the most infected area near to the research laboratory. Since the insects are host specific that it is impossible to grow them from egg level. We tried to collect them along with the cactus cladode. Insecticidal tests were also done while the insects are in the cladode and in isolated manner. The problem is the females are fixed to the cladode attached by their mouth. For the first time cochineal female and male (young and adult) were also tested with the treatment groups in an incubator for 24 hours. The next day none of the insects survive in the jars containing them. But we were also interested at determining the exact time when the insects will die and follow how they behave towards the oil from the beginning. Thus, we tested the insects in open but protected environment in the laboratory. The recorded data are as follows.

i. *Eucalyptus globulus*

The oils of this specific species of eucalyptus tend to paralyze and kill the insects. At all concentrations the recorded activity was dose dependent. At the highest concentration(100μL/air) young cochineal male paralyzed and dead at 29±9 and 49±12 respectively while, the females are bigger and stronger than the males that they get paralyzed and killed at some longer time(58±19 and 89±18). In the same sex the adult tend to resist more than the young. Because of this 30 young cochineal was included in each jar. Even at this number, the oils paralyze and kill with less time compared to the adult insects. Table 2 and table 3 display this finding.

Table 2 : Paralysis and death time of *Eucalyptus globulus* essential oils over young cochineal insect male and female

S/No	Treatment groups	Concentration(μL)	Cochineal Male		Cochineal Female	
			Age(young)			
			Time(in minuets)			
			Paralysis	Death	Paralysis	Death
1	*Eucalyptus globulus*	100	29±9	49±12	58±19	89±18
		80	33±11	50±14	70±24	99±17
		60	39±10	58±11	87±20	107±21
		40	51±20	75±17	97±25	126±38
		20	60±7	87±20	100±18	124±34
		10	77±11	99±18	107±23	142±30
		5	94±8	108±21	144±54	157±33
		3	121±25	148±37	164±43	189±41
		1	140±22	166±41	191±48	217±55

- *Results on this biological study were reported as mean ± Standard deviation by formula. n= 30 in each group.*

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Table 3 : Paralysis and death time of *Eucalyptus globulus* essential oils over adult cochineal insect male and female

S/No	Treatment groups	Concentration	Cochineal Male		Cochineal Female	
			Age(adult)			
			Time(in minuets)			
			Paralysis	Death	Paralysis	Death
1	*Eucalyptusglobulus*	100	38±11	69±17	68±21	200±55
		80	45±7	88±12	100±30	185±33
		60	45±8	100±16	122±40	199±34
		40	62±14	99±14	200±39	253±64
		20	66±13	107±19	220±33	308±56
		10	82±11	134±20	267±68	552±80
		5	91±8	158±38	388±84	608±88
		3	111±21	197±36	441±55	789±91
		1	139±18	254±31	710±98	920±105

- *Results on this biological study were reported as mean ± Standard deviation by formula. n= 10 in each group.*

ii. *Commercial pesticides*

In case of an emergency there is a habit in many people all around the world to use these pesticides to manage mainly infections at house level. The aim of this specific assay was not to compare and contrast the activity of the essential oils with these pesticides considering them as reference standards. Rather it is to show the effect of the pesticides to the insects as well as to the plants taking them as single individual treatment agent. The time they took for paralysis and death of the insects is lower but comparable to the essential oils. So, they can also be recommended to be used. The major side effect seen was the outer layer of the cladode turned yellow sometime after of the spray. Since they are all chemicals they leave residue this can then affect the plant time from time. The effect to the animals after eating those sprayed cladodes any time after the spray is another major concern. As shown in the table below, males are eliminated at less time before females. The inhibition was dose dependent that with increasing concentration paralysis and death decreased. Yong cochineal insect of both sex tend to be moresusceptible than corresponding adult.

Table 4 : Paralysis and death time of Drusban (48%), Malathion(48%), Ventazion /Diainon(60%) over young cochineal insect male and female

S/No	Treatment groups	Concentration(μL)	Cochineal Male		Cochineal Female	
			Age(young)			
			Time(in minuets)			
			Paralysis	Death	Paralysis	Death
1	Drusban (48%)	100	36±16	55±11	71±14	96±13
		80	52±13	68±9	88±15	104±22
		60	42±16	77±9	101±10	125±24
		40	72±17	88±16	98±8	108±14
		20	100±10	111±12	128±21	150±20
		10	99±24	124±22	167±17	188±35
		5	145±33	154±25	164±20	185±35
		3	148±17	166±31	174±41	201±16
		1	172±33	204±38	225±19	263±44
2	Malathion(48%)	100	56±23	77±10	84±21	89±25
		80	68±14	94±14	88±15	102±28
		60	75±17	89±15	103±32	124±18
		40	86±24	97±32	138±14	158±46
		20	94±25	107±34	118±23	157±34
		10	125±16	142±26	188±28	209±31
		5	144±39	175±28	195±35	244±33
		3	164±47	180±31	211±43	239±26

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		1	177±21	186±23	208±51	254±46
3	Ventazion /Diainon(60%)	100	68±22	75±16	96±28	130±42
		80	81±32	98±16	116±26	129±27
		60	92±27	105±15	110±20	145±34
		40	118±26	149±22	141±32	156±27
		20	133±42	150±24	179±19	188±26
		10	166±29	187±37	208±44	238±46
		5	195±25	206±38	258±17	277±56
		3	222±24	228±33	219±25	286±46
		1	232±19	248±44	304±49	337±55

- *Results on this biological study were reported as mean ± Standard deviation by formula. n= 30 in each group.*

Table 5 : Paralysis and death time of Drusban (48%), Malathion(48%), Ventazion /Diainon(60%) over adult cochineal insect male and female

S/No	Treatment groups	Concentration(µL)	Cochineal Male		Cochineal Female	
			Age(adult)			
			Time(in minuets)			
			Paralysis	Death	Paralysis	Death
1	Drusban(48%)	100	71±17	86±28	99±24	119±18
		80	84±27	108±19	97±22	127±32
		60	83±16	101±29	121±11	142±22
		40	79±24	91±36	140±18	160±17
		20	84±14	98±18	109±30	148±33
		10	102±18	116±36	108±26	138±42
		5	97±23	122±20	147±20	164±46
		3	104±17	128±32	130±31	161±22
		1	134±44	158±42	178±37	211±48
2	M alathion(48%)	100	84±23	96±21	94±24	108±23
		80	98±21	99±24	102±18	144±27
		60	111±22	128±22	148±39	155±15
		40	126±24	136±41	138±27	162±19
		20	137±23	149±19	172±44	187±34
		10	156±19	169±28	200±36	257±54
		5	148±34	170±11	204±35	266±38
		3	199±53	239±42	259±33	277±32
		1	222±32	256±21	247±46	271±31
3	Ventazion /Diainon(60%)	100	102±34	118±19	109±28	134±33
		80	122±22	139±29	128±19	159±29
		60	124±31	138±22	142±17	168±37
		40	128±16	133±32	153±22	168±27
		20	161±50	174±36	201±11	241±18
		10	164±29	194±19	189±53	266±37
		5	184±42	193±28	184±52	246±29
		3	237±58	249±48	276±33	298±26
		1	258±29	269±39	296±56	328±38

- *Results on this biological study were reported as mean ± Standard deviation by formula. n= 10 in each group*

d) Lethal concentration of treatment groups

For the sake of complying with statistical validity of the data, lethal concentration at 50% inhibition (LC50) values were calculated from graph in Microsoft excel. The equations for these graphs are shown in (Table 12). When the equations are worked out for "X" value the results are correlated to LC50values. The R^2 values confirm the validity of the data in the graph. Because R^2 values > 0.7 are statically valid in such controlled experiments.

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Table 6 : Lethal concentration of treatment groups needed to kill 50% of the insects

S/N	Agents	Cochineal insects		LC50	R^2	Equation
		Sex	Age			
1	Eucalyptus globulus	Male	Young	46.1	0.7299	y = -0.97x + 127.75
			Adult	40.97	0.6132	y = -1.268x + 178.95
		Female	Young	66.6	0.713	y = -0.975x + 173.44
			Adult	33.1	0.6706	y = -6.225x + 666.65
4	Drusban (48%))	Male	Young	47.32	0.788	y = -1.2096x + 159.21
			Adult	114.58!	0.4783	y = -0.417x + 126.78
		Female	Young	55.86	0.7182	y = -1.286x + 203.34
			Adult	184.39!	0.1847	y = -0.3144x + 163.4
5	Malathion(48%)	Male	Young	70.28	0.6997	y = -0.9894x + 162.51
			Adult	60.45	0.7167	y = -1.290x + 205.98
		Female	Young	65.02	0.8906	y = -1.627x + 232.79
			Adult	76.23	0.8787	y = -1.6545x + 261.6
6	Ventazion /Diainon(60%)	Male	Young	59.04	0.885	y = -1.5534x + 215.7
			Adult	72.03	0.6958	y = -1.204x + 221.23
		Female	Young	57.82	0.7633	y = -1.8349x + 274.6
			Adult	70.37	0.8284	y = -1.692x + 283.08

e) Present inhibition of cochineal insect on spray

Considering the loss of aroma of the oils in an open environment 100-600μl oils were sprayed to each of the experimental cladodes for three days. As shown in the figure below (Fig. 4.1.) the results of all treatment groups are promising. Compared to the laboratory findings the less effectiveness (taking the three days in to account) of the treatment groups can be explained in many ways. The female attaches to the cladodes by their moths and the oils may not effectively get their heads until they blown or diluted by the air. The cladodes contain more than 200 insects of all ages. During each spray all of the species may not receive the treatment. The oil is too much volatile. And probably the insects may die quickly when they are starved. In literature of the carmine die producing company it was revealed that they are environment sensitive (Weniger1991).The environment of the laboratory could have contribution to the effect here.

i. *Percent of inhibition*

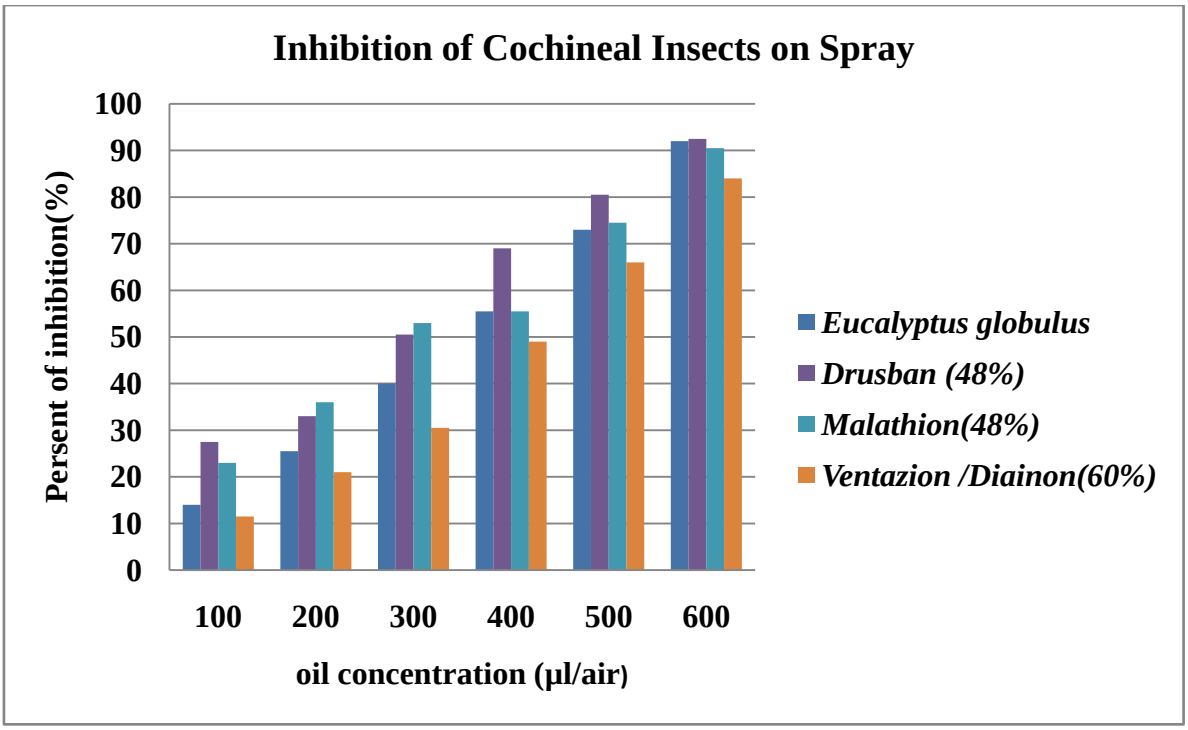


Fig. 1 : Inhibition of Cochineal Insects on Spray

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ii. *Lethal concentration (LD50)*

Table 7 : Lethal concentration (LD50), Equation and R^2 values of treatment groups on spray

S/N	Treatment groups	LD50	R^2	Equation
1	*Eucalyptus globulus*	349.936	0.9932	y = 0.1566x - 4.8
4	Drusban (48%)	286.299	0.9852	y = 0.1389x + 10.233
5	Malathion(48%)	308.4804	0.9786	y = 0.1301x + 9.8667
6	Ventazion /Diainon(60%)	393.03	0.9814	y = 0.1474x - 7.9333

IV. Conclusion

If a plant possesses an essential oil it is believed by local peoples that it is medicinal plant. The aroma character of most of the plants used by traditional healers confirms this idea. Most insects are sensitive to plant aroma that they will be either attracted or repelled. Eucalyptus oils have strong aroma and irritating character capable of repelling the insects. The composite chemical nature of the oil is another big matter. The plants have many of these phytochemicals known for their inhibition towards microorganisms, insects and other foreign invaders. In addition, the oils tend to contain organic constituents, including hormones, vitamins and other natural elements with their own major role in the inhibition. This all could be the reason for the promising activity of the oils. In the in vitro assay in almost each jar the inhibition was dose dependent. Reasonable data was also recorded with respect to age and sex. A field test of course not in a big area as recommended by research works on insecticide was also done in six cladodes at six different concentrations. Elimination of the males both young and adult was very clear in three days of spray. Young female were also seen while getting dries out. However, the adult females are not mobile; their very small heads is mostly suck to the cladode that make it difficult to conclude whether or not they are lifeless. In general, it can be concluded that the oils from this variety of eucalyptus can repel and eliminate the cochineal insects. If the males of any age are eliminated the number of the colony will be too much decreased. There is no male insect means there is no way the insect will lay its 250 eggs in each cycle. There is no young female also means there is no adult female. Hence the adult female can be out of concern.

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Global Journal of Science Frontier Research: B
Chemistry
Volume 15 Issue 5 Version 1.0 Year 2015
Type : Double Blind Peer Reviewed International Research Journal
Publisher: Global Journals Inc. (USA)
Online ISSN: 2249-4626 & Print ISSN: 0975-5896

Evaluation of Accumulation Ability for Pb, Cr, Ni, and Mn in Native Plants Growing on a Contaminated Air Force Shooting Range, Kaduna

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Abstract- The concentrations of Pb, Cr, Ni and Mn were determined in *Sida veronicifolia, Chrystanthelum americanum, Cassia rotundifolia* and *Borreria filifolia* samples using Atomic Absorption spectrophotometry at the Air Force shooting range, Kaduna. The heavy metals (Pb, Cr, Ni and Mn) concentrations in *Borreria filifolia* shoot were found to be (229.29 ± 0.03, 33.26 ± 0.00, 200 ± 0.01, and 142.51 ± 0.01 mg/kg respectively while those of *Sida veronicifolia* samples in shoot are 189.27 ± 0.04, 170.56 ± 0.03, 111.9 ± 0.04 and 158.71 ± 0.01 mg/kg respectively for Pb, Cr, Ni and Mn. In *chrystanthelum americanum* samples in shoot are found 112.31 for Pb, 41.14 ± 0.01 mg/kg for Cr, 176.64 ± 0.00 mg/kg of Ni and 228.80 ± 0.02 mg/kg of Mn. *Cassia rotundifolia* gave 112.23 ± 0.00 mg/kg for Pb, 41.09 ± 0.01 mg/kg for Cr, 176.56 ± 0.05 mg/kg for Ni while 228.71 ± 0.03 mg/kg in Mn. The translocation factor (TF) indicates that the plants accumulated these metals (Cr, Ni and Mn) more in the shoots than in the roots. *S. veronicifolia and B. filifolia* can be used to decontaminate soil contaminated with (Cr and Mn) studied because TF is greater than one (TF > 1) while other plants can only be used for decontamination of soil polluted with selected metals where (TF>1).

Keypoint: *heavy metals, shooting range, translocation factor and native plants.*

GJSFR-B Classification : *FOR Code: 259999*



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Keypoint: heavy metals, shooting range, translocation factor and native plants.

I. Introduction

Heavy metals are currently of much environmental concern globally. They are harmful to humans, animals and plants. The threat that heavy metals pose to human and animal health is aggravated by their long-term persistence in the environment. They are introduced into the environment through mining and smelting of metal ores, industrial emissions and applications of insecticides and fertilizers (Alloway, 1994). Pb has been found to be responsible for quite a number of ailments in human such as chronic neurological problems (Awofolu, 2005) and mental retardation in children (Huge *et al*., 1980). Pb, Sb, As and Ni are common contaminants in areas adjacent to the impact bern of military shooting ranges (Robinson *et al*., 2007). High exposure to chromium can cause spinal joints degeneration, depressed immune system and lymphatic swelling (Roth, 2009). Long term exposure to Ni can cause decreased body weight, liver damage, lungs and nasal sinus cancers and skin irritation. Manganese effect occurs in the respiratory track and in brain. Symptoms of Mn poisoning are hallucination, forgetfulness and nerve damage (Abdullahi, 2006).

The persistence of heavy metals in soils is a big environmental problem. This could have long-term implications for the biological, chemical and physical properties of agricultural and forest soil and its fertility as well as productivity (Nicholson *et al*., 2003). The heavy metals Cr, Cd, Pb, Ni, Cu and Zn take part in the biological turnover and their excess or lack of disturbance of the metabolism and inhibited vegetation (Adomaitis *et al.,*2000; Jaakkola, 1994). Metals may bioaccumulate in living organisms and be transferred into the food chain (Bogaert *et al*., 2000).

It is a confirmed fact that the major parts (75-80%) of heavy metals get into human organisms with vegetable diet when plants take it from the soil (Willaert *et al*., 1985).

Several technologies are available to remediate soils that are contaminated by heavy metals. However, many of these technologies are costly (e.g excavation of contaminated material and chemical/physical treatment) (Lorestani, *et al.,* 2011). The development of phytoremediation technologies for plant based cleanup of contaminated soil is therefore of significant interest (USEP, 2001). Phytoremediation is the use of plant to remove, detoxify or immobilize environmental contaminant in a growth matrix (soil, water or sediment) through the natural biological or chemical processes of plants (Curia *et al*., 2005). Several plants have been identified in the last two decades as highly effectively in absorbing and accumulating various toxic heavy metals. High heavy metal accumulating ability has been reported for cereal crops such as maize, sorghum and alfafa (*Medicago saliva L*) (Vijayarengan, 2005). Plants like Indian mustard, tobacco and spinach show high tolerance to heavy metals and are therefore used in phytoremediation studies (Schmidt, 2003, Tang *et al*., 2003).

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Military grounds are territories of specific purpose. Such areas have special stationary structures necessary for exercises, defence infrastructure; moreover exercises involving shooting real cartridges are held and heavy military war materials such as ammunitions and explosives are used there. Therefore soil in military grounds is very often polluted with heavy metals from spent bullets. These contaminations can create environmental and occupational health problems during range operation and maintenance.

Military training exercises lead to the release of heavy metals in the environment (Sanderson *et al.,* 2010, Johnson *et al*., 2005 and Robinson *et al*., 2008). It was reported that Air Force shooting range in Kaduna is contaminated with heavy metals as a result of shooting exercise (Nwaedozie *et al*., 2015). In this work therefore, some local plants (*Sida veronicifolia, Chrystanthalum americanum, Cassia rotundifolia and Borreria filifolia*) found growing in the shooting range were evaluated for their accumulation ability with a bid of using them as phytoremediators.

II. Materials and Method

a) Sampling

The plant samples used in this study were collected from the Nigerian Air Force shooting range located in Kaduna, Northern Western Nigeria. The entire area was divided into five (5) sections.

For sampling, four (4) different plants of each species, namely *S.veronicifolia, C. americanum*, *C. rotundifolia and B. filifolia* and three (3) samples of each plant species were collected at different points in a given section. Each plant sample was uprooted to include the roots and soil samples were also collected from the point of sampling. The samples were sorted according to species, collection points and labeled accordingly.

b) Plant Analysis

The plant samples were first separated into roots, stems and leaves, then washed with distilled water and oven dried at 70°C for 2hrs (Larry and Morgan, 1986). They were ground into fine powder sieved and stored in a labeled bottle until analysis. 0.5g of prepared plant samples were digested with 5.0cm^3 of concentrated $HN0_3$ and 5.0cm^3 of 70% $HCl0_3$ and placed on a hot plate for 5 minutes after which 20cm^3 of deionised water was added on cooling, the digest was filtered into 100.0cm^3 volumetric flask and made up to the mark with deionised water (Horwitz, 1980). Total concentrations of Pb, Cr, Ni and Mn in the prepared samples were determined by Shimadzu model Atomic Absorption spectrophotometer (AAS).

III. Results and Discussions

The Table 3.1 shows the mean total metal concentrations in plants in Air Force shooting range, Kaduna.

Table 3.1 : Heavy Metal Concentrations (mg/kg) in Plant Parts Collected at the Shooting Range of Air Force, Kaduna

Plant Species	Pb	Cr	Ni	Mn
S. veronicifolia$_{shoot}$	189.226±0.04	170.56±0.03	119.906±0.04	158.706±0.01
S. veronicifolia$_{root}$	52.422±0.04	137.358±0.04	129.692±0.04	57.818±0.04
C.rotundifolia$_{soot}$	112.226±0.00	41.086±0.01	176.562±0.05	228.71±0.03
C.rotundifolia$_{root}$	172.432±0.04	18.522±0.00	129.294±0.04	27.968±0.04
C.americanum$_{shoot}$	112.306±0.04	41.14±0.01	129.344±0.00	228.80±0.02
C.americanum$_{root}$	172.476±0.04	18.572±0.04	129.344±0.02	28.01±0.00
B. filifolia$_{shoot}$	229.29±0.03	33.26±0.00	200.00±0.01	142.51±0.01
B. filifolia$_{root}$	241.47±0.00	12.878±0.01	65.262±0.03	61.292±0.04
H. annus$_{shoot}$	500.31±0.06	25.11±0.01	41.28±0.03	423.12±0.02
H. annus$_{root}$	2213.85±0.04	21.01±0.04	16.15±0.00	103.385±0.04

Key: SV = S. veronicifolia, CR = C. rotundifolia, CA = C. americanum, HA = H. annus

The Table 3.1 showed that SV accumulated Pb, Cr and Mn more in the shoot than in the root while BF contained Cr, Ni and Mn higher in the shoot than in the root. The same pattern was observed in the case of CR and CA with more Ni and Mn in the shoot than in the root. This may imply that these metals absorbed by the plants are not stored in the root but fairly distributed to all parts of the plants. CA, CR and BF showed deviation in the accumulation of Pb where it is accumulated more in the roots than in the shoot. This implied that most of the Pb absorbed by CR, CA and BF from soil is stored in the roots and lesser percentage is transported to the shoot. This is same for absorbed Ni by SV. *H. annus* the control plant accumulated Pb, Cr, Ni and Mn more in the shoot than in the root. In 95% of the plant samples, the root Pb concentration were much greater than those of shoot Pb contents, indicating low mobility of Pb from the roots to the shoots and immobilization of heavy metals in the roots. This pattern was in agreement with observation of Yoon *et al*., 2006.

The results of translocation factor (TF) for all the heavy metals are reported in Table 3.2 below.

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Table 3.2 : Translocation factor of SV, CR, CA and BF for Heavy Metals (Pb, Cr, Ni and Mn) in the native plants

Plant Species	Pb	Cr	Ni	Mn
S. veronicifolia	3.610	1.242	0.863	2.745
C. americanum	0.651	2.238	1.366	8.169
C. rotundifolia	0.651	2.218	1.365	9.178
B. filifolia	1.951	2.215	0.410	2.325
H.annus (Control)	1.678	1.195	2.500	4.077

The translocation factor values for heavy metals are presented on Table 3.2. The TF values for metals within the plants were calculated as the concentration of the metals in the shoot divided by the concentration in the root (Baker and Brooks, 1989). The TF highest for Pb was 3.61 for SV and lowest 0.651 for CA and CV. The TF values were greater than one for Pb in SV and BF; SV, CA, CR and BF for Mn. The control result (*H.annus*) shows TF greater than one for all the plants. A plants ability to translocate metals from the roots to the shoots is measured using the TF. TF greater than one represents that translocation of metals effectively was made to the shoot from the root (Baker and Brooks, 1989). The data presented indicate that metals (Cr and Mn) accumulated by plants species (SV, CA, and CR) were largely transported to the shoots from the roots as shown by general TF values which is greater than one (Table 3.2). Exceptions occurred in SV for Ni (TF<1), CA for Pb (TF<1) and BF for Ni (TF<1).

All the four plants studied have both TF greater than one for Cr and Mn. Therefore these plants can be used to remove these metals from the environment.

IV. Conclusion

Based on the results obtained in this study, it can be concluded that:

- All the plants studied (*S, veronicifolia, C. rotundifolia, C. amricanum and B. filifolia)* can be suitable phytoremediator for Cr and Mn.

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Global Journal of Science Frontier Research: B
Chemistry
Volume 15 Issue 5 Version 1.0 Year 2015
Type : Double Blind Peer Reviewed International Research Journal
Publisher: Global Journals Inc. (USA)
Online ISSN: 2249-4626 & Print ISSN: 0975-5896

Chemical Variability of *Aniba rosaeodora* Oils

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Abstract- The scarcity of natural populations of *Anibarosaeodora* in Brazil is well known and it has been attributed to the over-exploitation for extraction of its trunk wood essential oil for perfumery industry. The leaves of cultivated trees of this species could be a new source for future sustainable exploitation for the same purpose. Leaf oils from 35 trees of *A. rosaeodora* ("pau-rosa") obtained by hydrodistillation were analyzed by gas chromatography/mass spectrometry. High variation in yields (1.15% to 4.21%) and in linalool content (38.48% to 71.05%) were observed. Additionally, leaf oils of *A. parviflora* ("macacaporanga"), commonly confused as *A. rosaeodora*were analized. Linalool was the major compound in *A. parviflora* essential oils, but in considerable smaller amount (21.30% and 12.64%) when compared to *A. rosaeodora*. *Anibaparviflora* oils were different from those of *A. rosaeodora*, showing a high amount of β-phellandrene (21.06% and 23.60%), and lacking the presence of α-, β- and γ-eudesmol, and 7-*epi*-α- and 10-*epi*-γ-eudesmol.

Keywords: aniba rosaeodora, a. parviflora, leaves, linalool, β-phellandrene.

GJSFR-B Classification : FOR Code: 030199



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Chemical Variability of *Aniba rosaeodora* Oils

Maria das Graças Bichara Zoghbi [α], Selma Toyoko Ohashi [σ], Rafael de Paiva Salomão [ρ] & Giselle Maria Skelding Pinheiro Guilhon [ω]

Abstract- The scarcity of natural populations of *Aniba rosaeodora* in Brazil is well known and it has been attributed to the over-exploitation for extraction of its trunk wood essential oil for perfumery industry. The leaves of cultivated trees of this species could be a new source for future sustainable exploitation for the same purpose. Leaf oils from 35 trees of *A. rosaeodora* ("pau-rosa") obtained by hydrodistillation were analyzed by gas chromatography/mass spectrometry. High variation in yields (1.15% to 4.21%) and in linalool content (38.48% to 71.05%) were observed. Additionally, leaf oils of *A. parviflora* ("macacaporanga"), commonly confused as *A. rosaeodora*were analized. Linalool was the major compound in *A. parviflora* essential oils, but in considerable smaller amount (21.30% and 12.64%) when compared to *A. rosaeodora*. *Aniba parviflora* oils were different from those of *A. rosaeodora*, showing a high amount of β-phellandrene (21.06% and 23.60%), and lacking the presence of α-, β- and γ-eudesmol, and 7-*epi*-α- and 10-*epi*-γ-eudesmol.

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I. Introduction

Lauraceae comprises 52 genera and approximately 3,000 species, distributed throughout tropical and subtropical regions (Chanderbali et al., 2001). Twenty four genera and about 441 spp. of this family occur in Brazil, mostly in wet forests, sandbanks and "cerrado" (a tropical savanna ecoregion of Brazil) (Quinet et al., 2015). *Aniba rosaeodora* Ducke, popularly known as "pau-rosa" (rosewood), is endemic to Brazil, and occurs in the States of Amapá, Amazonas and Pará (Quinet et al., 2013). According to Marques (2001), besides *A. rosaeodora*, 12 other species belonging to the genus *Aniba* are known as "pau-rosa", including *A. parviflora*(Meisn.) Mez. *Aniba parviflora* is locally known as "macacaporanga" and is frequently confused with *A. rosaeodora* due to the similarities of their morphological aspects. An essential oil, dominated by linalool (3,7-dimethyl-1,6-octadien-3-ol) and known as rosewood oil, is extracted by steam distillation from the trunk wood of *A. rosaeodora*, Rosewood oil is widely used in fragrances for perfumery industry, mostly due to the fragrance of linalool. When populations of *A. rosaeodora*(Syn: *A. duckei* Kostermans) from French Guiana disappeared due to destructive exploitation, Brazilian populations of *A. rosaeodora* came to meet a high market demand. The search for another oil rich in linalool, but possessing a close bouquet of rosewood oil, prompted many researchers to study the leaf oil of *A. rosaeodora* from Brazil and French Guiana (Gottlieb and Mors, 1958; Araujo et al., 1971; Ohashi et al., 1997; Maia et al., 2007; Chantraine et al., 2009; Fidelis et al., 2012; Cunha, 2011). These studies showed that *A. rosaeodora* leaf oils also were dominated by linalool. Analysis of this oil using a two-dimensional (GC x GC) analytical technique was able to separate and identify more compounds when compared to gas chromatography (GC) (Fidelis et al., 2012). Very few studies were reported dealing with the volatiles of *A. parviflora* (Syn.: *Aniba fragrans* Ducke). Leaves and fine branches oils containing limonene, linalool and spathulenol as major compounds was reported (Maia et al., 2000). A study conducted by Tranchida et al. (2008) and focused on the use of a comprehensive 2D GC methodology, led to the identification of 84 compounds in the leaf essential oil, but unfortunately, the authors did not furnish the relative percentual contribution of each compound.

The aim of this paper was to analyze the chemical composition of 35 leaf essential oils obtained from *A. rosaeodora* cultivated trees in the State of Pará, in the North Brazil. Additionally, two samples of *A. parviflora* leaf oils were analyzed.

II. Experimental Botanical Material

Thirty five samples of *A. rosaeodora* leaves (AR) were collected for essential oil extraction. Numbering followed the collections numbers. Samples AR-3 and AR-4 were collected in a smallholder rural property, in the municipality of Tomé-Açu. Samples AR-36, AR-37 and AR-38 were collected in Curuá-Una, municipality of Santarém, from of an experimental plantation cultivated since 1974. Samples AR-5 to AR-35 were collected from an experimental 17 years old plantation in the research campus of Universidade Federal Rural da Amazônia (UFRA), in the city of Belém. All samples were collected in October, 2008. Both samples of *A. parviflora* (AP-2 and AP-21) were collected in the same place of samples AR-3 and AR-4. Botanical identification was carried out by comparison with the vouchers MG-53,318 (*A. rosaeodora*) and MG-30,053 (*A. parviflora*) deposited in the Herbarium MG of MuseuParaenseEmílioGoeldi

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(MPEG). The samples were dried for 7 days in an air-conditioned room (at low humidity) and then ground.

III. Extraction of Volatile Compounds

The dry plant material was hydrodistilled for 3 h, using a Clevenger-type apparatus with refrigeration water at 15°C. The oils obtained were centrifuged for 5 min (3,000 rpm), dried over Na_2SO_4, and centrifuged again in the same conditions. A hexane solution (1 mL) containing 2 μL of the oil was submitted to GC-MS analysis. The total oil yield was expressed in percentage (volume·mass^{-1}) on the basis of dried material. The amount of water was measured using infrared light on a Marte ID-50 device.

IV. Analysis of Volatile Compounds

The oils were analyzed using a Shimadzu GC/MS Model QP-2010 Plus, equipped with a Rtx-5MS (30 m × 0.25 mm; 0.25 µm film thickness) fused silica capillary column. Chromatographic conditions included helium as carrier gas at 1.2 mL·min^{-1}; splitless injection of 1 µL of hexane solution; injector and interface temperature at 250°C; oven temperature program 60-240°C at 3°C·min $^{-1}$. EIMS: electron energy, 70 eV; ion source temperature at 200°C. Identification of the compounds were made by comparison of their GC mass and retention data with those in NIST-05 library, and cited in the literature (Fidelis et al., 2018; Adams, 2007; Qiao et al., 2008). Retention indices were calculated using *n*-alkane standard solutions (C8-C26) available from Fluka S. A., in the same chromatographic conditions.

V. Results and Discussion

GC/MS analysis of the essential oils of *A. rosaeodora* obtained from the leaves of 35 trees led to the identification of a total of 48 different compounds, while 81 compounds were identified in two oils of *A. parviflora*. Tables 1 – 3 show the identified compounds in sequence of their retention indices together with the yields. Yields of *A. rosaeodora* essential oils ranged from 1.15% to 4.21%. The samples of *A. parviflora* furnished oils with 0.92% and 1.29% yields. High yields in oil of *A. rosaeodora* were obtained from the samples collected in Curuá-Una (AR-36: 3.85%, AR-37: 3.97% and AR-38: 4.21%), followed by samples taken in Tomé-Açu (AR-3 and AR-4: 2.92% and 2.69%, respectively). Comparison of the results with those reported by Chantraine et al. (2009) for the leaf oils of *A.rosaeodora* from French Guiana (0.18% to 0.55%) reveals a great difference. The trees cultivated in the campus of UFRA (AR-3 to AR-20 and AR-22 to AR-38), all of the same age (17 years old), provided yields that ranged from 1.15% to 3.05%. These results are in accordance with Chantraine et al. (2009) that obtained yields that were practically independent of the tree ages.

The content of linalool in the 35 *A. rosaeodora* oils ranged from 38.48% to 71.05%. Other compounds identified in the leaf oils of *A. rosaeodora* in amount ≥ 1% were α-pinene, *cis*-linalool furanoxide, *trans*-linalool furanoxide, α-copaene, β-elemene, β-cayophyllene, β-selinene, α-selinene, spathulenol, cayophyllene oxide, humulene epoxide II, selin-11-en-4α-ol and benzyl benzoate. Five linalool derivatives were found (dihydro-2,6,6-trimethyl-6-vinyl-2H-pyran-3(4H)-one, *cis*-linalool furanoxide, *trans*-linalool furanoxide, *cis*-linalool pyranoxide and *trans*-linalool pyranoxide). Pyranoxide derivatives of linalool were identified only in a small percentage (traces-0.29%). Benzyl benzoate was detected in *A. rosaeodora* and in *A. parviflora*, while benzyl salicylate was identified only in *A. parviflora*. Comparison of the present results to those previously reported by Maia et al. (2007) reveals some similarities in the chemical composition, but 1,8-cineole, β-chamigrene, α-muurolol and α-cadinol were not detected. In the same way, several compounds identified by Fidelis et al. (2012) in the leaf oil of *A. rosaeodora* by gas chromatography-quadrupole mass spectrometry, such as 1,8-cineole, hotrienol, myrcenol and ocimenol, were not detected in all 35 samples. No significant qualitative differences between individual chemical components of the samples of *A. rosaeodora* taken in Curuá-Una (Samples AR-36 – AR-38) and Tomé-Açu (AR-3 and AR-4) have been observed. However, considerable quantitative variation was noted in the linalool content (48.10% to 55.91%).

Linalool was present in leaf oils of *A. parviflora* in a smaller amount (21.30% and 12.64%) when compared to those encountered in *A. rosaeodora*. Besides linalool, AP-2 and AP-21 oils were characterized by a high amount of β-phellandrene (21.06% and 23.60%). The leaf and fine branch oil of *A. parviflora* (cited as *A.fragrans*), also collected in Curuá-Una, was reported by Maia et al. (2000) to contain linalool (32.40%), spathulenol (19.1%) and limonene (14.5%) as major compounds. Limonene was not detected in both analyzed samples; spathulenol was present in a small content, as well α- and β-eudesmol. Comparison of the chemical composition of the oils of *A. parviflora* with those previously reported by Tranchida et al.[13] reveals similarity on the presence of linalool as the major compound, but in both analyzed oils, β-phellandrene, instead of α-phellandrene, was detected in a high amount.

In order to investigate the chemical variability, all identified compounds in all studied oils were included in the multivariate analysis using Minitab 14 software for Hierarchical Component Analysis (HCA). HCA led to two-well defined clusters of essential oils: Cluster I, composed by the samples from *A. parviflora* characterized by the presence of linalool and β-phellandrene, and Cluster II, composed by the samples of *A. rosaeodora*, rich in linalool (Figure 1).

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A study conducted by Chantraine et al. (2009) with the essential oil of *A. rosaeodora* trunk wood revealed that the age of the trees, season and phenological stages had no influence on the amount of linalool; but yield changes considerably. A large variation in the linalool content and in yields were observed, although the majority of the samples (Samples AR-3 to AR-20, and AR-22 to AR-38) were of the same age and they were collected in the same environment, date and Amazonian climate period (dry season);additionally, all trees were free from injuries caused by microorganisms. The chemical variability in *A. rosaeodora* is particularly important due to its potential to be used by perfumery industry.

VI. Conclusions

This study shows that the leaves of *A. rosaeodora* furnish essential oils with a high variation in linalool content and yield. It also shows that the chemical composition of essential oils could be an important tool in distinguishing *A. rosaeodora* and *A. parviflora*.

VII. Acknowledgments

The authors are gratefull to ALCOA-JURUTI/Project - Conservation and management of *Anibarosaeodora*, *Dicypelliumcaryophyllaceum*, *Bertho-lletiaexcelsa* and *Manilkara* spp.; municipalityof Juruti, State of Pará, by financial support.

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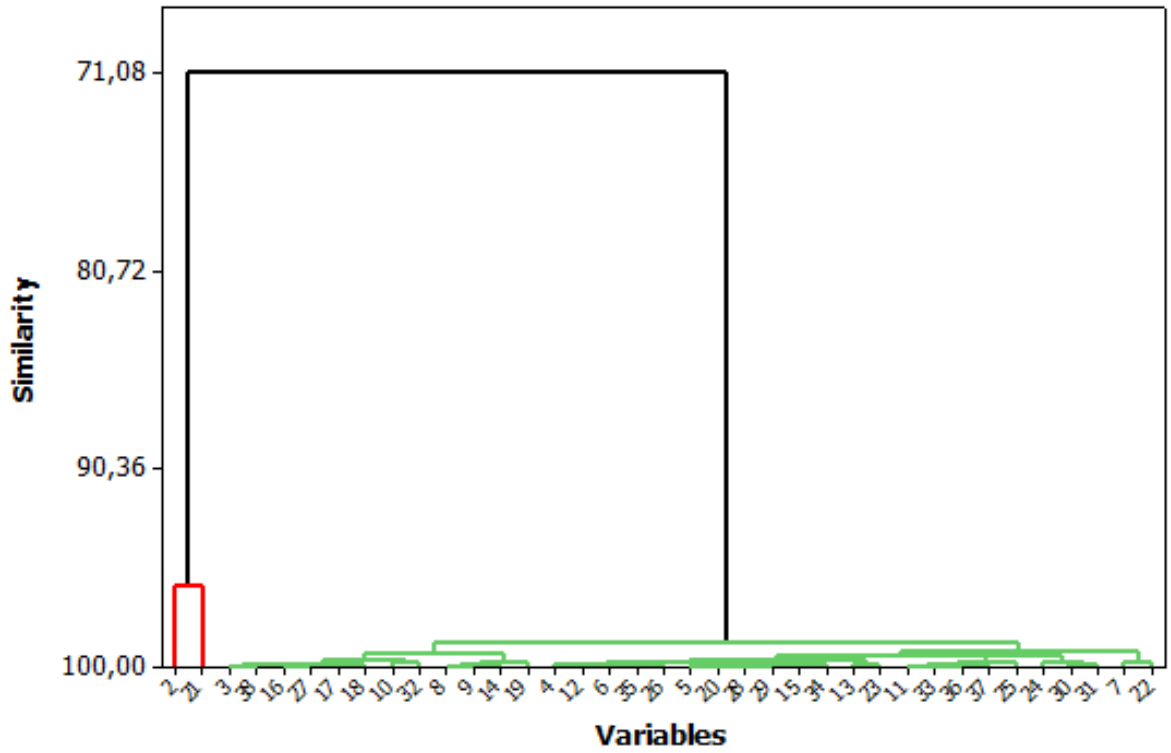


Figure 1 : Hierarchical Component Analysis (HCA) of *Aniba rosaeodora* and *A. parviflora* plants collected in the experimental plantation of Universidade Federal Rural da Amazônia, Belém, State of Pará, Brazil

Table 1 : Chemical constituents (%) identified in the essential oils of *Anibarosaeodora* leaves (AR).

Constituents/yields (%)	RI*	AR-3	AR-4	AR-5	AR-6	AR-7	AR-8	AR-9	AR-10	AR-11	AR-12	AR-13	AR-14
		2.92	2.69	2.39	2.19	1.15	1.81	1.55	2.17	2.06	1.68	2.39	2.05
(*Z*)-hexen-3-ol	857	tr	tr	tr	tr	tr	tr	-	tr	-	0.13	Tr	tr
hexanol	870	tr	tr	tr	tr	tr	tr	tr	tr	tr	0.74	Tr	tr
α-pinene	937	tr	0.87	-	tr	-	-	-	-	-	2.68	0.98	-
β-pinene	981	-	0.40	-	tr	-	-	-	-	-	0.80	0.38	-
myrcene	995	0.55	0.93	0.59	0.67	0.45	0.43	0.54	0.52	0.64	0.98	0.56	0.43
p-cymene	1027	-	-	-	-	-	-	-	-	-	-	Tr	tr
limonene	1031	0.63	0.63	tr	tr	tr	tr	tr	tr	tr	0.54	Tr	tr
(*Z*)-β-ocimene	1039	tr	-	tr	tr	tr	tr	tr	tr	tr	0.22	Tr	tr
(*E*)-β-ocimene	1050	0.31	0.42	0.27	0.31	tr	tr	0.25	tr	0.31	0.37	0.21	tr
cis-linaloolfuranoxide	1074	1.77	5.59	3.55	4.21	1.04	1.51	1.29	1.05	0.90	4.28	3.20	2.05
trans-linaloolfuranoxide	1091	1.42	4.43	2.70	3.30	0.80	1.12	0.93	0.79	0.64	2.94	2.48	1.53
linalool	1103	50.81	55.91	51.75	57.17	43.02	42.61	45.28	42.67	52.22	55.10	43.96	44.66
dihydro-2,2,6-trimethyl-6-vinyl-2H-pyran-3(4H)-one[a]	1113	0.59	0.84	0.85	0.76	0.40	0.45	0.54	tr	0.49	0.62	0.72	0.57
allo-ocimene	1131	-	tr	tr	tr	tr	tr	tr	tr	tr	tr	Tr	tr
borneol	1169	-	-	-	-	-	-	-	-	-	tr	-	-
cis-linaloolpyranoxide	1170	0.08	0.17	0.08	0.19	tr	tr	tr	tr	tr	tr	0.09	tr
trans-linaloolpyranoxide	1177	tr	0.29	0.14	0.33	0.01	0.06	tr	tr	tr	0.12	0.17	tr
α-terpineol	1194	0.24	0.3	0.15	0.18	0.12	0.16	0.16	0.15	0.14	0.47	0.21	tr

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nerol	1231	tr	0.08	tr	tr	tr	tr	tr	tr	tr	0.08	Tr	tr
geraniol	1257	0.11	0.17	0.12	0.14	0.09	0.11	0.12	0.10	0.11	0.19	0.11	0.09
δ-elemene	1340	0.05	-	tr	-	-	tr	tr	0.06	tr	-	Tr	-
α-cubebene	1353	tr	-	tr	-	tr	tr	tr	-	tr	-	Tr	tr
α-copaene	1380	1.57	1.67	3.39	2.33	3.10	2.77	2.80	1.96	2.59	0.95	3.51	2.23
β-elemene	1395	1.68	0.32	0.41	0.29	0.50	1.06	0.78	1.52	1.07	0.20	0.60	0.79
β-caryophyllene	1424	0.75	tr	0.53	0.30	0.35	0.94	0.95	2.43	1.48	tr	0.35	0.42
α-guaiene	1443	0.19	0.08	0.09	0.12	0.14	0.21	0.22	0.38	0.15	0.08	0.17	0.13
α-humulene	1458	0.20	tr	0.11	tr	0.06	0.17	0.16	0.44	0.24	tr	0.08	0.11
allo-aromadendrene	1467	-	-	-	-	-	-	-	-	-	tr	-	-
4,5-di-*epi*-aristolochene	1474	0.17	0.11	0.15	0.11	0.24	0.21	0.21	0.19	0.13	0.11	0.22	0.23
γ-selinene[b]	1489	0.89	0.53	0.59	0.52	0.85	0.92	0.89	0.81	0.78	0.40	0.91	0.97
β-selinene	1492	4.35	3.43	3.79	3.37	5.84	5.23	5.11	4.88	4.24	3.34	5.25	5.40
α-selinene	1501	4.06	2.63	2.75	2.58	4.19	4.26	4.11	4.13	3.53	2.2	4.24	4.49
α-muurolene	1505	-	-	-	-	-	-	-	-	-	0.01	-	-
α-bulnesene	1510	0.23	-	tr	-	-	0.21	0.20	-	0.19	-	0.20	0.21
γ-cadinene	1519	tr	tr	tr	tr	tr	tr	tr	tr	tr	tr	tr	tr
7-*epi*-α-selinene	1522	0.14	0.09	0.09	0.09	0.16	0.16	0.15	0.14	0.12	0.08	0.16	0.17
δ-cadinene	1527	0.13	0.11	0.21	0.14	0.21	0.19	0.18	0.18	0.14	0.08	0.23	0.13
(*E*)-nerolidol	1563	0.28	0.20	0.31	0.34	0.28	0.49	0.42	0.42	0.26	tr	0.22	0.24
spathulenol	1580	4.46	2.67	3.82	3.92	4.46	3.32	3.01	7.20	1.48	4.25	3.51	1.33
caryophyllene oxide	1585	0.75	0.28	1.1	1.33	1.05	1.45	1.26	2.45	1.41	0.30	0.93	1.08
guaiol	1597	-	-	0.51	-	-	0.51	-	0.61	0.47	-	0.51	0.71
humuleneepoxide II	1611	0.86	0.56	0.84	0.66	0.87	0.96	0.92	1.02	0.75	0.53	0.86	0.91
selina-6-en-4-ol	1616	0.48	0.35	0.40	0.30	0.48	0.53	0.50	0.41	0.29	0.34	0.50	0.53
iso-spathulenol	1631	0.16	0.16	0.29	0.16	0.37	0.38	0.34	0.28	0.15	0.25	0.37	0.37
caryophylla-4(12),8(13)-dien-5-ol[c]	1641	0.53	0.13	0.38	0.40	0.46	0.55	0.48	0.87	0.32	0.18	0.42	0.27
selina-3,11-dien-6α-ol	1651	0.34	0.25	0.34	0.24	0.46	0.53	0.50	0.42	0.40	0.24	0.42	0.57
selin-11-en-4α-ol	1660	2.09	1.35	1.76	1.37	2.58	2.35	2.19	2.08	1.57	1.60	2.20	2.46
n.i.	1717	2.45	1.70	2.08	1.77	3.00	3.28	3.16	2.63	3.18	1.69	2.59	3.49
n.i.	1728	3.61	2.80	3.81	3.16	6.14	5.87	5.69	4.81	5.40	3.59	4.49	6.06
n.i.	1732	4.41	3.35	4.23	3.58	6.45	6.49	6.24	5.33	5.98	3.92	5.12	6.87
benzylbenzoate	1773	1.16	0.60	1.47	0.77	3.49	1.04	1.04	0.99	1.01	1.26	1.21	0.85

**RI on HP-5MS; [a]Ref. 10; [b]Ref 14; [c]Correct isomer not characterized; tr = traces (< 0.01%); RI = 1717, m/z (rel. int.): 220 [M⁺](39), 202(27), 187(41), 173(12), 159(45), 145(81), 133(100), 119(61), 105(84), 93(93), 79(43), 67(30), 55(34), 41(46); RI = 1728, m/z (rel. int.): 220 [M⁺](21), 205(47), 202(42), 187(28), 177(13), 165(19), 159(52), 145(48), 133(53), 119(61), 105(90), 93(100), 79(70), 67(56), 55(50), 41(57); RI = 1732, m/z (rel. int.): 220 [M⁺](61), 205(23), 202(16), 187(32), 177(19), 159(47), 145(46), 133(50), 121(64), 107(81), 93(100), 81(88), 71(73), 55(55), 43(65).*

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Table 2 : Chemical constituents (%) identified in the essential oils of Anibarosaeodora leaves (AR)

Constituents/yields (%)	IR	AR-15	AR-16	AR-17	AR-18	AR-19	AR-20	AR-22	AR-23	AR-24	AR-25	AR-26	AR-27
		2.25	2.85	1.63	3.04	2.72	2.04	1.22	2.47	2.34	2.20	2.90	3.52
(*Z*)-hexen-3-ol	857	tr	-	-	tr	tr	-	-	-	-	-	-	-
hexanol	870	tr	tr	-	0.55	0.23	-	tr	tr	-	tr	-	tr
α-pinene	937	1.71	-	-	-	-	-	-	1.57	0.82	1.11	0.38	-
β-pinene	981	0.85	-	-	-	-	-	-	0.68	0.54	0.51	0.24	-
myrcene	995	0.87	0.58	0.55	0.52	0.38	0.42	0.45	0.55	0.72	0.97	0.70	0.67
p-cymene	1027	-	-	-	-	-	-	-	-	-	-	tr	tr
limonene	1031	0.55	tr	tr	0.22	0.22	tr	tr	tr	0.62	0.69	0.45	tr
(*Z*)-β-ocimene	1039	0.21	tr	tr	0.13	0.11	tr	tr	-	-	tr	tr	tr
(*E*)-β-ocimene	1050	0.34	0.27	0.24	0.23	0.18	tr	tr	0.21	0.31	0.42	0.30	0.31
cis-linaloolfuranoxide	1074	4.79	1.21	1.90	2.96	1.09	2.84	2.66	3.68	1.15	2.43	2.86	1.73
trans-linaloolfuranoxide	1091	3.75	0.89	1.41	2.34	0.80	2.21	2.01	2.84	0.90	1.81	2.21	1.32
linalool	1103	56.29	52.72	46.90	49.24	38.48	47.49	45.41	45.99	57.22	64.26	52.68	49.93
dihydro-2,2,6-trimethyl-6-vinyl-2H-pyran-3(4H)-one[a]	1113	1.14	0.62	0.56	0.46	0.44	0.63	0.62	0.59	0.81	1.25	0.73	0.61
allo-ocimene	1131	tr	tr	tr	tr	tr	tr	tr	tr	tr	tr	-	tr
borneol	1169	tr	tr	-	-	-	-	-	tr	tr	tr	-	-
cis-linaloolpyranoxide	1170	0.14	tr	tr	0.09	0.02	0.10	0.09	0.13	tr	tr	0.09	0.06
trans-linaloolpyranoxide	1177	0.25	tr	tr	0.16	0.03	0.17	0.17	0.23	tr	0.07	0.14	tr
α-terpineol	1194	0.36	0.18	0.18	0.14	0.08	0.14	0.19	0.28	0.17	0.25	0.17	0.14
Nerol	1231	0.07	0.06	-	0.04	0.03	tr	tr	tr	tr	0.07	0.06	0.05
Geraniol	1257	0.17	0.16	0.15	0.10	0.07	0.12	0.10	0.12	0.10	0.16	0.12	0.13
δ-elemene	1340	-	-	-	0.01	0.01	-	0.01	-	-	-	-	-
α-cubebene	1353	-	tr	tr	0.03	0.03	tr	tr	tr	-	tr	tr	0.01
α-copaene	1380	3.37	2.46	2.26	3.45	2.21	3.20	3.65	5.06	5.48	3.27	1.51	2.64
β-elemene	1395	0.13	0.85	0.43	0.59	0.91	0.34	0.45	0.35	0.76	0.10	0.29	1.20
β-caryophyllene	1424	0.19	0.38	0.37	0.39	0.96	0.47	0.27	0.11	0.18	0.11	0.15	0.63
α-guaiene	1443	0.14	0.20	0.17	0.22	0.21	0.13	0.20	0.11	0.20	0.11	0.15	0.18
α-humulene	1458	tr	0.17	0.11	0.13	0.19	0.10	0.07	0.06	0.17	-	0.07	0.16
allo-aromadendrene	1464	tr	tr	tr	0.04	tr	tr	tr	tr	tr	tr	tr	tr
4,5-di-*epi*-aristolochene	1474	0.10	0.15	0.21	0.14	0.31	0.15	0.16	0.15	0.07	0.08	0.16	0.13
γ-selinene[b]	1480	0.55	0.80	0.86	0.72	1.24	0.69	0.64	0.70	0.52	0.49	0.75	0.71
β-selinene	1497	3.07	4.00	4.92	4.09	6.41	4.02	4.31	4.04	2.21	2.68	4.19	3.89
α-selinene	1501	2.39	3.69	4.07	3.44	5.58	3.10	3.10	3.17	2.27	2.11	3.46	3.19
α-muurolene	1505	-	-	-	0.07	tr	tr	tr	tr	tr	tr	tr	tr
α-bulnesene	1510	-	0.19	0.23	0.19	0.18	0.17	0.11	0.09	0.24	0.12	0.19	0.25
γ-cadinene	1519	tr	tr	tr	tr	tr	tr	0.08	tr	0.10	tr	tr	tr
7-*epi*-α-selinene	1522	0.08	0.13	0.16	0.13	0.23	0.11	0.13	0.11	0.09	0.06	0.12	0.12
δ-cadinene	1527	0.19	0.21	0.2	0.23	0.15	0.20	0.30	0.36	0.29	0.15	0.12	0.16
(*E*)-nerolidol	1563	0.12	0.33	0.22	0.23	0.45	0.37	0.28	0.30	0.14	0.12	0.23	0.46
spathulenol	1580	3.87	5.12	4.53	6.47	1.54	2.79	4.70	2.62	6.53	3.26	4.56	4.44
caryophyllene oxide	1585	0.22	0.55	0.84	0.94	1.59	1.26	0.59	0.36	0.35	0.19	0.39	0.88
guaiol	1597	0.11	0.71	0.58	0.33	0.24	0.47	0.39	0.34	0.44	0.11	0.47	0.61

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humuleneepoxide II	1611	0.42	0.67	0.80	0.82	1.04	0.88	0.77	0.72	0.89	0.38	0.69	0.76
selina-6-en-4-ol	1616	0.26	0.41	0.52	0.39	0.63	0.42	0.46	0.41	0.23	0.23	0.25	0.34
iso-spathulenol	1631	0.13	0.24	0.33	0.26	0.32	0.26	0.39	0.34	0.20	0.08	0.22	0.25
caryophylla-4(12),8(13)-dien-5-ol[c]	1641	0.24	0.71	0.51	0.58	0.35	0.55	0.52	0.26	0.99	0.26	0.50	0.56
selina-3,11-dien-6α-ol	1651	0.16	0.33	0.41	0.36	0.56	0.45	0.40	0.40	0.25	0.14	0.33	0.40
selin-11-en-4α-ol	1660	1.21	2.07	2.33	1.51	2.59	1.90	1.94	1.84	0.80	1.15	1.99	1.64
n.i.	1717	1.24	2.43	2.74	2.21	3.84	2.97	2.10	2.51	1.54	1.12	2.26	2.73
n.i.	1728	2.18	3.87	4.88	3.40	5.66	5.23	4.37	4.40	2.43	2.04	3.77	4.67
n.i.	1732	2.57	4.51	5.40	4.32	7.12	5.53	4.69	5.10	2.81	2.34	4.54	5.39
benzylbenzoate	1773	2.61	1.91	2.30	0.88	0.85	1.58	6.25	1.96	1.59	2.38	0.96	1.36

**RI on HP-5MS; [a]Ref. 10; [b]Ref 14; [c]Correct isomer not characterized; tr = traces (< 0.01%); RI = 1717, m/z (rel. int.): 220 [M⁺](39), 202(27), 187(41), 173(12), 159(45), 145(81), 133(100), 119(61), 105(84), 93(93), 79(43), 67(30), 55(34), 41(46); RI = 1728, m/z (rel. int.): 220 [M⁺](21), 205(47), 202(42), 187(28), 177(13), 165(19), 159(52), 145(48), 133(53), 119(61), 105(90), 93(100), 79(70), 67(56), 55(50), 41(57); RI = 1732, m/z (rel. int.): 220 [M⁺](61), 205(23), 202(16), 187(32), 177(19), 159(47), 145(46), 133(50), 121(64), 107(81), 93(100), 81(88), 71(73), 55(55), 43(65).*

Table 3 : Chemical constituents (%) identified in the essential oils of Anibarosaeodora (AR) and A. parviflora (AP) leaves

Constituents/yields (%)	IR	AR-28	AR-29	AR-30	AR-31	AR-32	AR-33	AR-34	AR-35	AR-36	AR-37	AR-38	AP-2	AP-21
		1.78	2.77	1.85	2.19	3.05	2.23	1.96	2.71	3.85	3.97	4.21	0.92	1.29
(*Z*)-hexen-3-ol	857	-	-	-	-	-	tr	tr	-	-	-	-	-	-
hexanol	870	tr	-	tr	-	tr	tr	tr	tr	-	-	-	-	-
α-thujene	928	-	-	-	-	-	-	-	-	-	-	-	0.30	0.36
α-pinene	937	0.88	tr	2.61	1.37	-	-	1.74	-	-	-	-	2.53	1.61
camphene	951	-	-	-	-	-	-	-	-	-	-	-	1.95	0.90
β-pinene	981	0.35	0.23	1.39	0.74	-	-	0.81	-	-	-	-	1.54	0.76
myrcene	995	0.95	0.50	1.03	1.01	0.63	0.90	1.10	1.47	1.01	0.92	0.51	3.66	3.53
α-phellandrene	1009	-	-	-	-	-	-	-	-	-	-	-	7.25	2.26
α-terpinene	1020	-	-	-	-	-	-	-	-	-	-	-	0.02	0.25
p-cymene	1027	-	-	-	-	-	-	-	-	-	-	-	0.01	0.01
limonene	1031	0.60	tr	0.80	tr	tr	-	0.43	0.38	tr	0.68	tr	-	-
β-phellandrene	1033	-	-	-	-	-	-	-	-	-	-	-	21.06	23.60
(*Z*)-β-ocimene	1039	-	-	-	-	-	-	0.28	0.41	-	-	-	-	-
(*E*)-β-ocimene	1050	0.40	tr	0.36	tr	0.29	0.45	0.45	0.75	0.50	0.46	0.24	2.95	2.12
γ-terpinene	1061	-	-	-	-	-	-	-	-	-	-	-	0.75	0.78
cis-linaloolfuranoxide	1074	3.18	2.81	2.79	1.29	1.62	2.24	3.13	3.35	2.27	2.24	1.69	0.25	0.13
trans-linaloolfuranoxide	1091	2.29	2.21	2.14	1.06	1.32	1.66	2.38	2.60	1.91	1.71	1.35	-	-
terpinolene	1092	-	-	-	-	-	-	-	-	-	-	-	0.66	0.27
linalool	1103	51.87	54.36	71.05	70.3	43.66	50.32	48.39	61.96	55.09	55.93	48.10	21.30	12.64
dihydro-2,2,6-trimethyl-6-vinyl-2H-pyran-3(4H)-one	1113	0.95	0.83	1.10	0.57	tr	0.71	0.83	-	0.62	0.77	0.63	-	-
cis-p-menth-2-en-1-ol	1124	-	-	-	-	-	-	-	-	-	-	-	0.15	0.28
allo-ocimene	1131	tr	tr	tr	tr	tr	tr	tr	tr	tr	tr	tr	0.11	0.04
trans-p-menth-2-en-1-ol	1142	-	-	-	-	-	-	-	-	-	-	-	0.10	0.17
borneol	1169	-	-	-	-	-	-	-	-	-	-	-	0.84	0.21
cis-linaloolpyranoxide	1170	0.07	0.08	tr	tr	0.08	tr	0.08	0.09	tr	tr	0.05	-	-

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trans-linaloolpyranoxide	1177	0.13	0.13	0.09	tr	tr	tr	0.13	0.13	0.08	tr	0.10	-	-
terpinen-4-ol	1181	-	-	-	-	-	-	-	-	-	-	-	0.66	1.09
cryptone	1190	-	-	-	-	-	-	-	-	-	-	-	0.17	0.33
α-terpineol	1194	0.24	0.14	0.27	0.21	0.13	0.12	0.26	0.13	-	-	-	-	2.30
α-phellandreneepoxide (tent)	1205	-	-	-	-	-	-	-	-	-	-	-	0.17	0.12
trans-piperitol	1211	-	-	-	-	-	-	-	-	-	-	-	0.04	0.10
trans-carveol	1222	-	-	-	-	-	-	-	-	-	-	-	0.01	0.02
nerol	1231	0.07	tr	tr	tr	0.05	0.06	0.07	0.11	0.07	0.06	0.01	0.05	-
cuminaldehyde	1243	-	-	-	-	-	-	-	-	-	-	-	-	0.03
carvone	1248	-	-	-	-	-	-	-	-	-	-	-	-	0.02
geraniol	1257	0.16	-	0.10	0.11	0.11	0.14	0.16	0.22	0.13	0.13	0.08	0.05	-
piperitone	1258	-	-	-	-	-	-	-	-	-	-	-	-	0.10
phellandral	1279	-	-	-	-	-	-	-	-	-	-	-	0.04	0.07
δ-elemene	1340	tr	tr	tr	tr	0.06	-	tr	-	-	-	tr	1.62	0.76
α-cubebene	1353	tr	0.06	tr	tr	tr	-	-	tr	0.09	tr	0.04	0.07	0.03
α-ylangene	1376	-	-	-	-	-	-	-	-	-	-	-	0.08	-
isoledene	1377	-	-	-	-	-	-	-	-	-	-	-	-	0.24
α-copaene	1380	2.46	3.95	2.90	2.07	2.92	2.88	3.73	0.82	2.82	1.65	1.80	0.22	0.07
hexylhexanoate	1388	-	-	-	-	-	-	-	-	-	-	-	-	0.04
β-elemene	1395	0.28	0.38	0.10	0.20	1.10	1.66	0.27	0.43	0.74	0.37	1.24	0.64	0.52
methyleugenol	1408	-	-	-	-	-	-	-	-	-	-	-	0.02	-
α-gurjunene	1415	-	-	-	-	-	-	-	-	-	-	-	0.06	0.24
β-caryophyllene	1424	0.20	0.15	0.18	0.39	0.54	0.85	0.13	0.20	0.78	0.72	0.79	2.55	3.84
β-gurjunene	1433	-	-	-	-	-	-	-	-	-	-	-	-	0.27
β-copaene	1434	-	-	-	-	-	-	-	-	-	-	-	0.20	-
γ-elemene	1438	-	-	-	-	-	-	-	-	-	-	-	0.07	0.87
α-guaiene	1443	0.07	0.11	0.13	0.23	0.34	0.12	0.07	0.11	0.17	0.09	0.19	-	-
aromadendrene	1445	-	-		-	-	-	-	-	-	-	-	0.69	3.08
(Z)-β-farnesene	1447	-	-	-	-	-	-	-	-	-	-	-	0.23	-
α-humulene	1458	-	0.06	tr	0.14	0.26	0.18	-	tr	0.19	0.14	0.22	0.46	0.89
allo-aromadendrene	1467	-	-	-	-	-	-	-	-	-	-	-	-	0.53
4,5-di-*epi*-aristolochene	1474	0.16	0.15	-	-	0.28	0.14	0.13	0.10	0.16	0.13	0.19	0.03	-
γ-selinene	1480	0.63	0.68	0.27	0.46	1.23	0.74	0.52	0.52	0.89	0.68	0.97	-	0.01
γ-muurolene	1486	-	-	-	-	-	-	-	-	-	-	-	0.37	0.20
germacrene D	1487	-	-	-	-	-	-	-	-	-	-	-	1.08	-
β-selinene	1497	4.12	4.13	1.74	2.31	6.29	4.22	3.55	3.10	4.49	3.79	4.81	0.44	2.72
cis-β-guaiene	1497	-	-	-	-	-	-	-	-	-	-	-	0.08	-
δ-selinene	1497	-	-	-	-	-	-	-	-	-	-	-	-	0.24
α-selinene	1501	2.89	3.11	1.36	2.14	5.79	3.50	2.54	2.49	4.14	3.18	4.51	-	-
bicyclogermacrene	1504	-	-	-	-	-	-	-	-	-	-	-	4.31	3.42
α-muurolene	1505	tr	tr	tr	-	tr	tr	0.05	tr	tr	tr	tr	tr	tr
α-bulnesene	1510	-	-	-	0.19	0.28	0.01	-	0.18	0.20	-	0.24	-	-
(*E,E*)-α-farnesene	1511	-	-	-	-	-	-	-	-	-	-	-	0.63	-
α-curcumene	1515	-	-	-	-	-	-	-	-	-	-	-	-	0.33

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γ-cadinene	1519	tr	tr	tr	tr	tr	tr	tr	tr	tr	tr	0.07	0.11	0.08
7-*epi*-α-selinene	1522	0.11	0.10	-	-	0.23	0.12	0.09	0.09	0.15	0.10	0.19	-	0.37
δ-cadinene	1527	0.15	0.20	0.13	0.13	0.24	0.17	0.25	0.08	0.15	0.09	0.17	0.32	0.35
selina-3,7(11)-diene	1546	-	-	-	-	-	-	-	-	-	-	-	0.44	0.19
elemol	1552	-	-	-	-	-	-	-	-	-	-	-	-	1.16
germacrene B	1561	-	-	-	-	-	-	-	-	-	-	-	0.04	0.32
(*E*)-nerolidol	1563	0.28	0.38	0.06	-	0.23	0.41	0.32	0.11	0.23	0.21	0.27	0.88	0.54
palustrol	1570	-	-	-	-	-	-	-	-	-	-	-	-	0.42
spathulenol	1580	2.63	2.36	3.73	6.2	6.18	0.56	3.15	3.75	1.99	0.55	4.62	3.75	4.73
caryophyllene oxide	1585	0.42	0.29	0.20	0.36	1.31	0.69	0.45	0.30	0.88	2.11	0.90	1.19	2.88
globulol	1594	-	-	-	-	-	-	-	-	-	-	-	0.26	0.79
guaiol	1597	-	-	-	0.21	0.70	0.36	0.10	0.01	0.39	0.42	0.33	0.26	1.37
rosifoliol	1602	-	-	-	-	-	-	-	-	-	-	-	0.09	0.94
humuleneepoxide II	1611	0.64	0.61	0.26	0.35	0.97	0.75	0.74	0.52	0.72	0.73	0.95	-	0.58
selina-6-en-4-ol	1616	0.43	0.33	0.12	0.15	0.55	0.35	0.42	0.29	0.33	0.36	-	-	-
10-*epi*-γ-eudesmol	1623	-	-	-	-	-	-	-	-	-	-	-	0.19	-
iso-spathulenol	1631	0.25	0.16	-	-	0.30	0.22	0.31	-	0.11	0.18	-	-	-
γ-eudesmol	1636	-	-	-	-	-	-	-	-	-	-	-	-	1.35
caryophylla-4(12),8(13)-dien-5-ol[c]	1641	0.28	0.24	0.26	0.76	0.72	0.18	0.28	0.26	0.24	0.21	0.62	-	-
selina-3,11-dien-6α-ol	1651	0.36	0.29	0.09	0.12	0.37	0.38	0.49	0.21	0.24	0.21	0.41	-	-
β-eudesmol	1657	-	-	-	-	-	-	-	-	-	-	-	0.71	2.05
α-eudesmol	1660	-	-	-	-	-	-	-	-	-	-	-	0.92	2.30
selin-11-en-4α-ol	1660	1.68	1.60	0.63	0.67	2.53	1.64	1.77	1.19	1.48	1.67	2.29	-	-
7-*epi*-α-eudesmol	1664	-	-	-	-	-	-	-	-	-	-	-	0.13	-
bulnesol	1674	-	-	-	-	-	-	-	-	-	-	-	0.23	1.07
(*Z*)-α-santalol	1678	-	-	-	-	-	-	-	-	-	-	-	0.22	0.48
eudesm-7(11)-en-4-ol	1705	-	-	-	-	-	-	-	-	-	-	-	-	0.08
n.i.	1717	2.17	2.24	0.65	0.80	2.47	2.98	2.30	1.55	2.42	2.66	2.90	-	-
n.i.	1728	4.21	4.16	1.24	1.34	3.98	5.04	4.68	2.57	3.39	4.10	4.32	-	-
n.i.	1732	4.75	4.70	1.45	1.63	4.88	5.65	5.19	2.99	4.43	5.11	5.23	-	-
benzylbenzoate	1773	1.6	2.35	1.15	0.49	0.85	0.90	1.38	0.83	0.62	0.79	0.50	0.48	0.66
benzylsalycilate	1878	-	-	-	-	-	-	-	-	-	-	-	0.06	-

**RI on HP-5MS; [a]Ref. 10; [b]Ref 14; [c]Correct isomer not characterized; tr = traces (< 0.01%); RI = 1717, m/z (rel. int.): 220 [M$^+$](39), 202(27), 187(41), 173(12), 159(45), 145(81), 133(100), 119(61), 105(84), 93(93), 79(43), 67(30), 55(34), 41(46); RI = 1728, m/z (rel. int.): 220 [M$^+$](21), 205(47), 202(42), 187(28), 177(13), 165(19), 159(52), 145(48), 133(53), 119(61), 105(90), 93(100), 79(70), 67(56), 55(50), 41(57); RI = 1732, m/z (rel. int.): 220 [M$^+$](61), 205(23), 202(16), 187(32), 177(19), 159(47), 145(46), 133(50), 121(64), 107(81), 93(100), 81(88), 71(73), 55(55), 43(65).*

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"

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References	Complete and correct format, well organized	Beside the point, Incomplete	Wrong format and structuring

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