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Composition Analysis and Antibacterial Efficacy of Essential Oils Extracted from *Cola argentea* Mast (*Sterculiaceae*) Leaf, Stem Bark, and Fruit

I[1*]. Ante, S[2]. Aboaba, H[3]. Siddiqui & M.I[3]. Choudhary
[1]Department of Chemistry, Joseph Sarwuan Tarka University, Makurdi, Nigeria.
[2]Department of Chemistry, University of Ibadan, Ibadan, Nigeria.
[3]H.E.J Research Institute of Chemistry, International Center for Chemical and Biological Sciences, University of Karachi, Karachi-75270, Pakistan
*Correspondence E-mail: ante.iniobong@uam.edu.ng

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Abstract
Essential oils from Cola argentea Mast (Sterculiaceae) were extracted via hydrodistillation and analyzed using GC-MS to evaluate their composition across leaf, stem bark, and fruit, building on the family's known antibacterial, anti-anemic, and radical scavenging properties. The antibacterial activities of the oils were tested using gram (+) and gram (-) bacteria, and were also assayed for their multidrug resistance (MDR) properties. The leaf oil, stem-bark oil and fruit oil afforded 81, 50 and 44 compounds representing 98.83%, 99.83% and 99.41% of the oils. The main constituents in the leaf oil were diterpenes, sesquiterpenes and monoterpenes with significant quantities of 6-isopropenyl-4,8a-dimethyl-1,2,3,5,6,7,8,8a-octahydro-naphthalen-2-ol (13.30%), phytol (8.12%), decane (7.81), kaur-16-ene (7.20%), 2(1H) napthalenone, 3,5,6,7,8,8a-hexahydro-4,8a-dimethyl-6-(1-methyl ethenyl-1-(7.08%), m-xylene (6.90%). The most abundant compounds in the stem-bark oil are non-terpene compounds, m-xylene (64.1%), ethyl benzene (12.09%) and hydrofol (7.72%). Prominent compounds in the fruit oil are o-xylene (52.48%), m-xylene (17.51%), ethyl benzene (14.07%), escalol 557 (2.60%) and squalene (1.69%) which are essentially non-terpene constituents. The leaf oil showed low activity in *Pseudomonas aeruginosa* and Epidemic Methicillin Resistant Staphylococcus Aureus (EMRSA-16), but moderate activity in *Escherichia coli* and *Salmonella typhi*. The stem-bark oil displayed low activity to EMRSA-16 and also moderate activity to *Escherichia coli* and *Salmonella typhi*. The fruit oil exhibited low activity to *Pseudomonas aeruginosa* and EMRSA-16 but was moderately active to *Escherichia coli*, *Salmonella typhi* and Epidemic Methicillin Resistant Staphylococcus Aureus EMRSA-17.
Keywords: *Cola argentea*, GC-MS, Essential oil, multidrug-resistant

Introduction

Cola argentea (*Sterculiaceae*) is a forest shrub or small tree up to 5 m high with characteristic red flowers and fruiting carpels about 4 inches long. It is of the lowland humid rain forest in southern Nigeria and Western Cameroon [1].

Ita, 2011 [2] investigated selected physiochemical parameters, total phenolics, flavonoids and free radical scavenging activity of honey samples from the northern savannah region and southern rainforest ecosystems of Nigeria. Moisture and ash content of most samples were within acceptable limits with *Cola argentea* a honey sample from the Southern rainforest (Cross river state).

Mansonia altissima (A.chev) (*Sterculiaceae)* has been reported to be used in treating leprosy, use as an aphrodisiac and against yaws, scabies and syphilis [3,4,5].

Salem et al., 2014 [6] reported the fatty acid methyl ester component alongside the antibacterial, antifungal and antioxidant activities of *Brachychiton diversifolius* (*Sterculiaceae*). The antibacterial and anaemic properties of the *Waltheria indica* L. (*Sterculiaceae*) leaf have been reported. The main constituents were anthraquinones, saponins, tannins, cardiac glycosides. At the same time, the bark of *Threbroma cacoa* (*Sterculiaceae*) had all the constituents mentioned above besides alkaloids, polyphenol-protein complex, and amino acids. [7,8,9]. The leaf and stem-bark of *Hildegardia populifolia* (Roxb) Schott & Endl (Sterculiaceae) also possessed bioactive compounds and antifungal activity [10]. Here we report the composition of essential oils from leaf, stem bark and fruit of *Cola argentea* their antibacterial activity against the resistant

Bacteria *S. aureus*, which has little published information in the literature.

Materials and Methods

Plant materials

The leaf, stem bark and fruit samples of *C. argentea* were collected in Abak Local Government Area, Akwa-Ibom State, Nigeria. All collections were done between August and September 2013. The plant was identified and authenticated at the herbarium, Department of Botany and Ecological Studies, University of Uyo, Uyo, Akwa-Ibom State, Nigeria where voucher samples were deposited (UUH3414).

Isolation of Essential oils

Air-dried samples were grounded and batches (300 g) were hydro-distilled for three hours in an all-glass Clevenger-type apparatus. The resulting essential oil was kept refrigerated at 4 °C until it was analyzed.

Analyses of the Oils

Gas Chromatography-Mass Spectrometry Analysis (GC-MS)

The volatile oil samples were subjected to GC-MS analyses performed on an Agilent system consisting of a model 7890A Gas chromatography interfaced with an Agilent system Triple quadruple 7000 mass spectrometer, operating at 70 eV, with an ion source temperature of 250 °C The column was an Agilent 19091S-433 HP-5 MS fused silica capillary with a (5% Phenyl) - methyl polysiloxane stationary phase, film thickness of 0.25 µm, a length of 30 m and internal diameter of 0.25 mm. The carrier gas was helium with a column head pressure of 9.3508 psi and of 1.1 mL/min flow rate. The G.C. oven's initial temperature was 60 °C held for 5 minutes, and then the temperature was increased to 180 °C at a rate of 5 °C /min and held again for 10 minutes, after that temperature was further increased to 280 °C at the rate of 10 °C /min for 30 minutes. The split ratio was 10:1.

Identification of compounds

Identification of each constituent of the essential oils was achieved using Agilent Mass Hunter Qualitative Analysis B.04.00 software based on their retention indices (determined using a homogenous series of normal alkenes), and by comparison of their mass spectra fragmentation patterns with a preinstalled NIST MS search 2.0 data based, with data previously reported in the literature.

Antibacterial Assay

Micro-organism

Cultures of five human pathogenic bacteria namely: *Escherichia coli* (ATCC 2592), *Shigella flexenari* (ATCC 12022), *Staphylococcus aureus* (NTCC 6571), *Pseudomonas aeruginosa* (NTCC 10662) *Salmonella typhi* (ATCC 23857) were used for the antibacterial assay. For the multidrug-resistant properties, the following M.D.R strains were employed: Epidermic Methilicin Resistant Staphylococcus Aureus (EMRSA-17), EMRSA-16, MRSA-252, Pakistani clinical isolate *Staphylococcus aureus* and drug-resistant *Pseudomonas aeruginosa*. The strains used for the antibacterial studies were clinical isolates purchased from American Type Cultures Collection (ATCC) and National Collection of Type Culture (NTCC), U.K. EMRSA-17, EMRSA-16 and MRSA-252 were also purchased from NCTC, hpa, U.K. Pakistani Drug resistant clinical isolate of *Staphylococcus aureus* was purchased from OJHA campus, Dow, University of Health Sciences, Karachi and M.D.R *Pseudomonas aeruginosa* is a drug-resistant clinical isolate from a 73-year-old hospitalized patient in north of England that was arranged and purchased from the National Collection of type Culture (NCTC), hpa, U.K. All were screened in the International Center for Chemical and Biological Sciences (ICCBS) laboratory, University of Karachi, Pakistan.

Antibacterial Activity Determination

Micro-plate Alamar Blue Assay (MABA)

Antibacterial susceptibility testing was performed in a 96-well microplate. Organisms were grown in Mueller-Hinton medium. Inoculums were adjusted to 0.5 McFarland turbidity index. The stock solutions of the essential oils were prepared in DMSO in a 1:1 concentration, the stock solutions were serially diluted in Mueller-Hinton broth to obtain the concentration of 20 µg/ mL. Furthermore, the 96 well plates' volume was made up to 200 µL. 5 × 106 bacterial cells were added in each of the 96-well plate. The plate was then sealed and incubated at 37°C for 18-20 hrs. Alamar blue dye (10%) was dispensed in each well and shaken at 80 R.P.M in a shaking incubator at 37°C for 3-4 hrs. Ampicillin was used as the positive control for the bacteria isolates, Vancomycin for the M.D.R- *S. aureus* and Sulbactum for U.K drug resistant clinical isolate of *P. aeruginosa* (DMSO showed no cidal effect on the growth of the bacterial cells). All experiment was done in triplicate. The change in the colour of Alamar dye from blue to pink indicated the growth of bacteria strains. The ELISA reader recorded Absorbance at 570 and 600 nm by the ELISA reader (SpectraMax M2, Molecular Devices, CA, U.S.A). Percentage difference in reduction of Alamar Blue between treated and control cells were calculated using the formula:

$$\% = \frac{(\varepsilon_{ox})\lambda_2 A\lambda_1 - (\varepsilon_{ox})\lambda_1 A\lambda_2}{(\varepsilon_{ox})\lambda_2 A'\lambda_1 - (\varepsilon_{ox})\lambda_1 A'\lambda_2} \times 100$$

Where (εox) λ2 = molar extinction coefficient of Alamar blue oxidized form at 600 nm

(εox) λ1= molar extinction coefficient of Alamar blue oxidized form at 570 nm

A λ1 = Absorbance of test wells at 570 nm

A λ2 = Absorbance of test wells at 600 nm

A' λ1= Absorbance of control well at 570 nm

A' λ2= Absorbance of control well at 600 nm

Results and Discussion

The compositions of the investigated oils are reported in Table 1.

The leaf oil, stem-bark oil and fruit oil afforded eighty-one (81), fifty (50) and forty-four (44) compounds with percentage yields of 0.05, 1.03, and 0.07 representing 98.83%, 99.83% and 99.41% of the oils respectively. The main constituents in the leaf oil were 6-isopropenyl-4,8a-dimethyl-1,2,3,5,6,7,8,8a-octahydro-naphthalen-2-ol (13.30%), phytol (8.12%), decane (7.81), kaur-16-ene (7.20%), 2(1H) napthalenone, 3,5,6,7,8,8a-hexahydro-4,8a-dimethyl-6-(1-methyl ethenyl-1-(7.08%), m-xylene (6.90%), verticillol (5.89%), (8E)-8-heptadecene (4.63%), hexahydrofarnesyl acetone 93.49%), squalene (3.67%). The most abundant compounds in the stem-bark oil are m-xylene (64.1%), ethyl benzene (12.09%) and hydrofol (7.72%). Prominent compounds in the fruit oil are o-xylene (52.48%), m-xylene (17.51%), ethyl benzene (14.07%), escalol 557 (2.60%) and squalene (1.69%). The profile of the essential oils of the leaf, stem-bark and fruits of *Cola argentea* revealed the presence of diterpenes, Sesquiterpenes, monoterpenes and non-terpene compounds. As mentioned above, the individual oils had various compositions constituting their respectively major components. The common constituents in the leaf, stem-bark and fruits oil samples with their respective percentages are octane (0.27, 1.15, 1.14), ethyl benzene (1.39, 12.09, 14.07), m-xylene (6.90, 64.1, 17.51), cumene (0.07, 0.54, 0.58), decane (7.81, 0.72, 1.08), hemimelitene (0.04, 0.06, 0.07), D-limonene (0.20, 0.37, 0.67) and +-δ-cadinene (1.01, 0.42, 0.51). The profile of the leaf essential oil showed the presence of diterpenes in high quantity; kaur-16-ene and phytol which have been reported to be of biological importance [11,12,13,14]. Phytol for example is recommended as a diterpene compound that might act as an antimicrobial, anti-cancer, anti-inflammatory and diuretic. The compound 6-isopropenyl-4,8a-dimethyl-1,2,3,5,6,7,8,8a-octahydro-naphthalene-2-ol is a sesquiterpenoid and stereoisomer of eudesma-4,11-diene-2-ol and found to exhibit cytotoxic properties [15], 2(1H) napthalenone,3,5,6,7,8,8a-hexahydro-4,8a-dimethyl-6-(1-methyl ethenyl-1) also present in the leaf essential oil was characterized as one of the dominant constituents in *Cordia refusa* (Boraginaceae) [16]. The stem-bark and fruit oil however were dominated by non-terpenes compounds and minor terpene constituents (cumene, 1,4-cineole, cymene, α-terpineol, α-cyclocitral, safranal, tau-camphor, δ-cadinene, β-caryophyllene, eudesmane, spathulenenol. It is worth noting that these terpene compounds even in minor quantities could exhibit significant fragrance, odour and therapeutic properties in the host plant. Ordaz et al., 2011 [17] earlier reported that the principal component in *Helicteres guzumifolia* (Sterculiaceae) essential oil comprises 30.28% of non-terpenoids volatile secondary metabolites.

Table 1: Essential Oil Composition of *Cola argentea* (leaf, stem-bark and fruit)

Peak No.	RI	COMPOUNDS	CAL#	CAS#1	CAF#2
1	816	Octane	0.27	1.15	1.14
2	839	5-tert-Butyl-1,3-cyclopentadiene	0.30	-	-
3	842	trans-1,3-dimethylcyclohexane	0.05	0.09	-
4	852	Isonanane	-	-	0.09
5	880	Ethylcyclohexane	0.06	0.32	-
6	893	Ethyl benzene	1.39	**12.09**	**14.07**
7	907	o-xylene	-	-	**52.48**
8	907	m-xylene	**6.90**	**64.1**	**17.51**
9	916	Nonane	0.09	0.34	-
10	920	m-pyrol	-	0.17	-
11	928	Cumene	0.07	0.54	0.58
12	938	2-methyl-2-hepten-6-one	0.10	-	-
13	958	Cyanobenzene	-	-	0.18
14	982	Benzaldehyde	0.65	-	-
15	992	1,5,5-Trimethyl-6-methylene-1-cyclohexene	-	-	0.38
16	1006	p-Ethyl toluene	-	-	0.49
17	1006	m-Ethyl toluene	-	0.50	-
18	1007	5-Ethyl-2,2,3-trimethylheptane	-	-	0.49
19	1012	1,4-cineole	-	-	0.07
20	1015	Decane	**7.81**	0.72	1.08
21	1018	D-limonene	0.20	0.37	0.67
22	1020	Psi-cumene	-	-	0.07
23	1020	Mesitylene	-	-	0.43
24	1020	Hemimelitene	0.04	0.06	0.07

25	1040	2-Amylifuran	0.29	1.97	-
26	1042	β-cymene	-	0.17	0.19
27	1083	caprylic acid methyl ester-	-	-	0.08
28	1092	2-Isopropenyl-5-methylhex-4-enal	0.25	-	-
29	1095	1-methylene-1H-indene	-	-	0.13
30	1097	β-Isophrone	0.08	-	-
31	1104	Nonanal	0.46	1.05	-
32	1115	Undecane	-	0.21	0.19
33	1131	trans-3(10)-caren-2-ol	0.07	-	-
34	1131	Isopinocarveol	-	0.13	-
35	1133	Durene	-	-	0.05
36	1143	(-)-α-Terpineol	0.15	-	-
37	1151	2-Decanone	-	0.36	-
38	1156	2,3,5,8-Tetramethyldecane	-	-	0.23
39	1164	Cis linalool oxide	0.63	0.04	-
40	1175	α-Cyclocitral	0.14	-	-
41	1183	Methyl nonanoate	-	0.13	0.56
42	1184	Longiycyclene	-	-	0.05
43	1186	Safranal	0.19	-	-
44	1189	1,6-methano[10]annulene	0.07	0.33	-
45	1197	(3E)-2,6-Dimethyl-3,7-octadiene-2,6-diol	0.18	-	-
46	1204	β-cyclocitral	0.08	-	-
47	1204	Decanal	0.21	0.31	-
48	1212	(E)-2-Decenol	0.16	-	-
49	1225	Quinolene	-	-	1.19
50	1231	Tar-camphor	0.44	1.36	-
51	1239	(1E)-1-Ethylene-7a-methyloctahydro-1H-indene	0.17	-	-
52	1255	Epoxylinalol	-	0.07	-
53	1281	(2Z)-2-(3,3-Dimethylcyclohexylidene) ethanol	0.06	-	-
54	1281	Isoaromadendrene epoxide	-	0.27	-
55	1303	2,6,6-Trimethyl-1-cyclohexene-1-acetaldehyde	0.17	-	-
56	1320	(5E)-5,9-Dimethyl-5,8-decadien-2-one	0.14	-	-
57	1320	2,6,11-Trimethyldodecane	-	-	0.50
58	1320	Farnesane	-	-	0.33
59	1325	8-hydroxylinalool	0.12	-	-
60	1325	2,4,4,6,6,8,8-Heptamethyl-1-nonene	-	-	0.17
61	1339	(-)-β-Bourbonene	1.85	-	-
62	1342	Edulan 1, dihydro-	0.05	-	-
63	1345	α-methylnapthalene	-	0.38	-
64	1386	(+)-Aromadendrene	2.06	0.18	-
65	1393	2-Butyloctanol	-	-	0.11
66	1398	Cedrene	0.22	-	-
67	1398	(-)-β-Elemene	0.55	0.28	-
68	1398	(+)-Longifolene	-	-	0.08
69	1403	β-Gurjunene	0.42	-	-
70	1413	Tetradecane	-	-	0.12
71	1414	α-Ionene	0.06	-	-
72	1416	4-(2,2-dimethyl-6-methylenecyclohexl-2-butanone	0.19	-	-
73	1419	Viridiflorene	-	0.07	-
74	1420	Geranyl acetone	2.55	0.22	-
75	1424	trans-1,10-Dimethyl-trans-9-decalinol	1.27	-	-
76	1424	γ-Ionone	-	-	0.05
77	1426	4(2,6,6-Trimethyl-cyclohex-1-enyl-)butan-2-ol	0.15	-	-
78	1429	α-Ionone	2.09	0.04	-
79	1457	β-Ionone	2.55	0.20	-
80	1458	1,7-dimethyl naphthalene	-	0.25	-
81	1458	2,6-dimethyl naphthalene	-	0.22	-
82	1462	Aromadendrene oxide-(1)	-	0.08	-

83	1469	(+)-δ-Cadinene	1.01	0.42	0.51
84	1472	S-Guaiazulene	-	0.29	-
85	1474	α-Selinene	0.62	-	-
86	1494	β-caryophyllene	0.49	-	0.09
87	1494	α-Himachalene	0.75	-	-
88	1502	2-isopropenyl-4a,8-dimethyl-1,2,3,4,4a,5,6,7-octahydro naphthalene	1.84	-	-
89	1507	Eudesma-3,7(11)-diene	0.44	-	-
90	1519	2,6,10-trimethyltetradecane	0.26	-	0.13
91	1523	β-Guaiene	-	0.10	-
92	1530	Epiglobulol	0.43	-	-
93	1530	Palustrol	0.54	-	-
94	1530	Viridiflorol	0.53	-	-
95	1530	Globulol	0.17	-	-
96	1536	Spathulenenol	-	0.29	-
97	1555	2,4-Di-tert-butylphenol	-	-	0.21
98	1563	Hexahydrofarnesol	0.24	-	-
99	1614	1-Isopropyl-4,8-dimethylspiro[4.5]dec-8-7-one	0.85	0.10	-
100	1635	(-)-Isolongifolol	2.58	-	-
101	1635	1-(4-Bromobutyl)-2-piperidinone	-	-	0.06
102	1651	Niddrol	-	0.11	-
103	1673	2(1H) Napthalenone,3,5,6,7,8,8a-hexahydro-4,8a-dimethyl-6-(1-methyl ethenyl-)-	**7.08**	-	-
104	1690	6-Iso propenyl-4,8a-dimethyl-1,2,3,5,6,7,8,8a-octahydro-napthalen-2-ol	**13.30**	-	-
105	1706	Cadalene	-	-	0.14
106	1719	(8E)-8-Heptadecene	**4.63**	-	-
107	1754	Hexahydrofarnesyl acetone	**3.49**	-	-
108	1769	Myristic acid	-	0.49	-
109	1782	Phenanthrene	-	0.13	-
110	1789	Kaur-16-ene	**7.20**	-	-
111	1808	(7Z)-7-hexadecanal	0.07	0.10	-
112	1852	2,6,10,15,-Tetramethylheptadecane	-	-	0.07
113	1869	Pentadecanoic acid	-	0.30	-
114	1902	Farnesyl acetone	1.60	-	-
115	1910	Nonodecane	-	-	0.27
116	1968	Hydrofol	-	**7.72**	-
117	2021	1-Benzoyloxy-2-formoxybenzene	0.33	-	-
118	2045	Phytol	**8.12**	-	-
119	2088	Escalol 557	-	0.16	**2.60**
120	2190	Verticillol	**5.89**	-	-
121	2228	Oleamide	0.12	-	-
122	2241	E,E,Z-1,3,12-Nonadecatriene-5,14-diol	0.31	-	-
123	2258	5-methyl-5-(4,8,12 trimethyltridecyl) dihydro-2(3H) furanone	0.22	-	-
124	2336	2-Cis-9-Octadecenyl oxy ethanol	0.13	-	-
125	2370	Phthalic acid, Isobutyl octyl ester	-	-	0.15
126	2374	Cis-13-Eicosenoic acid	0.11	-	-
127	2652	Methylene cholestan-3-0l	0.29	-	-
128	2704	Diisooctyl phthate	0.19	0.05	-
129	2705	Heptacosane	0.93	-	0.13
130	2714	Sistenone	-	0.39	-
131	2914	Squalene	**3.67**	-	**1.69**
132	3942	1-Heptatriacotanol	0.66	-	-
133	4395	Tetratetracontane	1.28	-	-
		TOTAL	**98.83**	**99.83**	**99.41**

RI: Retention Indices

CAL#: *Cola argentea* (leaf)
CAS#[1]: *Cola argentea* (stem bark)
CAF#[2]: *Cola argentea* (fruit)

Table 2: Antibacterial activity of the Essential oils

Bacteria	**Part of plant**	**% Inhibition of sample (20 µg/ml)**	**Ampicillin (20 µg/ml)**
Escherichia coli	Leaf	21.286	73.406
	Stem bark	23.412	73.408
	Fruit	25.284	73.408
Shigella flexenari	Leaf	-	65.869
	Stem bark	-	65.869
	Fruit	-	65.869
Staphylococcus aureus	Leaf	-	64.675
	Stem bark	-	64.675
	Fruit	-	64.675
Pseudomonas aeruginosa	Leaf	8.204	76.873
	Stem bark	-	76.873
	Fruit	1.203	76.873
Salmonella typhi	Leaf	18.995	64.675
	Stem bark	35.108	64.675
	Fruit	32.966	64.675

The leaf, stem-bark and fruit oils all showed moderate activity (Table 2) to *Escherichia coli* with the percentage inhibition of 21.286, 23.412 and 25.284 respectively. At the same time, 73.408 was the percentage inhibition of the standard drug, ampicillin. Similarly, the oils were all moderately significant to *Salmonella typhi* with the respective percentage inhibition of 18.995, 35.108, 32.966 while that of ampicillin the standard drug used was 64.675. The leaf and fruit oil were weakly active in *Pseudomonas aeruginosa* with 8.204 and 1.203 as their respective percentage of inhibition while 76.873 was the percentage inhibition of the standard drug ampicillin. None of the tested oils showed activity to *Staphylococcus aureus* and *Shigella flexenari*. Other standard drugs employed for the above multidrug resistant bacterial strains of *Staphylococcus aureus* were oxacillin, streptomycin and clindamycin but they all had no inhibition. Also, tetracycline had no inhibition of the U.K drug-resistant clinical isolates of *P. aeruginosa.* The fruit oil showed very significant activity (Table 3) to EMRSA-17 with a percentage inhibition of 17.357 while comparing it to that of the standard drug used vancomycin which was 20.700

Table 3: Antibacterial Activity of the Essential oils against MDR-*Staphylococcus aureus*

Bacterial strain	Part of plant	% Inhibition of sample (20 µg/ml)	Vancomycin (20 µg/ml)
EMRSA-17	Leaf	-	20.700
	Stem-bark	-	20.700
	Nut	17.357	20.700
EMRSA-16	Leaf	2.012	23.720
	Stem-bark	0.579	23.720
	Nut	4.310	23.720
MRSA-252	Leaf	-	18.600
	Stem-bark	-	18.600
	Nut	-	18.600
Drug-resistant clinical isolate of *S. aureus*	Leaf	-	40.400
	Stem-bark	-	40.400
	Nut	-	40.400
			Sulbactum
			(20 µg/ml)
Drug-resistant clinical isolates of *P. aeruginosa*	Leaf	-	20.000
	Stem-bark	-	20.000
	Nut	-	20.000

The leaf, stem-bark and fruit oils showed weak activity to EMRSA-16 with 2.012, 0.579, and 4.310 as their respective percentage inhibition while 23.720 was the observed percentage inhibition for vancomycin. It was observed that none of the test oils showed activity to MRSA-252, drug resistant isolate of *S.aureus* or drug-resistant clinical isolate of *P. aeruginosa*. The observed antibacterial variations between the essential oils may be attributed to the fact that the biological activity of an essential oil is linked to its chemical composition and at times to the major chemical constituents within. [18,19]. In addition, synergistic effect between the minor and major components in essential oils contributes to the antibacterial activity [20].

Conclusion

The leaf, stembark and fruit essential oils of *Cola argentea* Mast (Sterculiacea) have been isolated, characterized and investigated against mutidrug resistant (M. D. R) bacteria. The characterization of the studied essential oils is being reported for the first time to the best of our knowledge.

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