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COMPARATIVE STUDIES OF ESSENTIAL OILS FROM *ZINGIBER OFFICINALE* GROWN IN NIGERIA

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ABSTRACT

Zingibe officinale Rosc. (Ginger) is widely used as a spice, and it has been used in folk medicine for thousands of years. Ginger is a very important spice for both culinary and medicinal uses. **Aim:** The study is aimed at the comparative analysis of the oils extracted from the fresh and the dried rhizomes of the plant. **Methodology:** The oils were obtained by hydro-distillation distillation of the dried and fresh rhizomes and analyzed using GC-MS. **Result:** The total components detected in the oil from fresh sample were 62 while in the oil from the dried sample were 68. The major compounds in the dried ginger sample were verbernol (7.76%), eucalyptol (7.52%), borneol (6.26) nerol (5.01%), α-terpineol (5.12), citral (3.82%), linalool (4.52%), fernesene (3.89%), camphene (3.05%) and curcumene (3.46%) while the major compounds in the fresh ginger sample were citral (6.09%), verbernol (4.90%), borneol (4.07%), eucalyptol (3.67%), linalool (3.64%), α-selinene (3.42%) and camphene (2.62%). **Discussion:** There were more components detected in the dried than the fresh rhizomes and the percentage composition of the common components was more in the dried than the fresh samples. The compound α-selinene was found in the oil from the fresh sample but was absent in the oil from the dried sample and nerol was present in the dried sample but absent in the fresh sample.

KEY WORDS: Ginger, Oil, Hydro-distillation, GC-MS, Chemical composition, Nigeria.

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INTRODUCTION

Zingiber officinale Rosc. (Ginger) is a flowering plant of the Zingiberaceae family. Its rhizome (root) is widely used as a spice, and it has been used in folk medicine for thousands of years. Ginger has long been known for over 2000 years as one of the most versatile medicinal plants having a wide spectrum of biological activity and a condiment for various foods and beverages (1). The health benefits of ginger essential oil are nearly identical to the medicinal health benefits of fresh ginger; in fact, the most potent form of ginger is the essential oil. Ginger is used in a variety of foods because of its flavoring compounds. Ginger rhizomes are a rich source of carbohydrates, vitamins, mineral and iron (2). Ginger originated from south East Asia; it has been cultivated for thousands of years as spice and also for its medicinal purposes. Currently, India and China are the dominant suppliers of the world market (2). The climate in Nigeria is favorable for the production of ginger and Nigeria also has massive land for its production. Ginger is marketed in Nigeria in fresh or split dried form and exported to Asia and the Middle East but poor quality is a hindrance. The fresh or dried forms are also consumed locally, it is a potential high value crop and also in high demand in the country.

There is a renewed interest in ginger and several scientific investigations aimed at its isolation, identification of active constituents, scientific verification of its pharmacological actions for the treatment of several diseases and conditions such as diarrhea, nausea, stomach problems, cough, palpitation, inflammation, and loss of appetite, constipation, swellings and asthma (3). The rhizome of ginger has shown to be effective in a wide range of bacterial, viral, fungal and parasitic diseases in humans. It is known that the essential oils from aromatic and medicinal plants possess biological activity and anti-bacterial and antioxidant properties, due to the growing interest in the use of essential oils in both food and pharmaceutical industries. A systematic study of the plant extracts has become very important. Ginger rhizome and ginger essential oils are gaining popularity for their preservative, flavoring, keeping away pests and as perfumery capabilities (4).

Today, ginger essential oil is used to treat stomach upset and it also supports digestion (5). Ginger oil reduces stress and nausea after surgical procedures (6); and heals infections as an antiseptic agent that kills

infections caused by microorganisms and bacteria (7). It aids respiratory problems (8) and reduces inflammation (9; 10). It strengthens heart health (11) and has high levels of antioxidants (12). Natural aphrodisiac (13) and relieves anxiety (14; 15). It improves liver function (16). It is also known to bring on feelings of courageousness and self-assurance, which is why it is known as "the oil of empowerment".

Compounds like verbenol, borneol, eucalyptol, terpineol, linalool, citral, nerol and many others have been isolated from ginger rhizomes. These compounds have a variety of uses: (S)-cis-verbenol may be a useful therapeutic agent due to its anti-oxidative and anti-inflammatory activities (17). The clinical application of central nervous system (CNS) drugs is limited by their poor bioavailability due to the blood–brain barrier (BBB). Borneol is a naturally occurring compound in a class of 'orifice opening' agents often used for resuscitative purposes in traditional Chinese medicine. A growing body of evidence confirms that the 'orifice-opening' effect of borneol is principally derived from opening the BBB. Borneol is therefore believed to be an effective adjuvant that can improve drug delivery to the brain (18). Patients with chronic diseases such as cardiovascular diseases, chronic respiratory diseases, and neurological diseases have been shown to benefit from treatments such as aromatherapy in addition to medication. Most chronic diseases are caused by chronic inflammation and oxidative stress as well as harmful factors. Eucalyptol (1,8-cineole), a terpenoid oxide isolated from *Eucalyptus* species, is a promising compound for treating such conditions as it has been shown to have anti-inflammatory and antioxidant effects in various diseases, including respiratory disease, pancreatitis, colon damage, and cardiovascular and neurodegenerative diseases, eucalyptol can pass the blood-brain barrier and hence can be used as a carrier to deliver drugs to the brain via a micro emulsion system. (19). α-Terpineol plays an important role in the industrial field. It has a pleasant odor similar to lilacs and it is a common ingredient in perfumes, cosmetics, and aromatic scents. In addition, α-terpineol attracts a great interest as it has a wide range of biological applications as an antioxidant, anticancer, anticonvulsant, antiulcer, antihypertensive, anti-nociceptive compound. It is also used to enhance skin penetration, and also has insecticidal properties (20). Linalool has antifungal and antimicrobial activities.

Linalool and the corresponding acetate play a major role in the anti-inflammatory activity displayed by the essential oils containing them, and provide further evidence suggesting that linalool and linalyl acetate-producing species are potentially anti-inflammatory agents (21). The mechanism by which the anti-inflammatory effect occurs remains to be determined, although several observations suggest possible involvement of NMDA receptors. Indeed, linalool is a competitive NMDA receptor antagonist (22) and the administration of excitatory amino acid receptor antagonists selectively attenuates carrageenin-induced behavioral hyperalgesia in rats (23). Citral is an aromatic compound used in perfumery for its *citrus* effect. Citral has been extensively tested, with no known genotoxicity or carcinogenic effect. Citral belongs to fragrances which should not be used separately but only in mixtures with substances depressing the sensitizing effect of the substance (23).

MATERIALS AND METHODS

Plant material:

Fresh rhizomes/roots were purchased from Kwoi, (Jabba Local Government) Kaduna state, (North Central) Nigeria. Some of the roots were dried in an airy place at room temperature 30^{o}C – 40^{o}C for 2 weeks in January, 2019. Thin, light yellow oil was obtained by hydro-distillation using a Clevenger apparatus which was used for the GC-MS analysis.

Extraction of the essential oil:

Essential oil was obtained from the fresh and dried rhizomes by hydro-distillation method employing Clavenger-type apparatus. The experiment was carried out for four hours and the essential oil obtained was analyzed by GCMS using Shimadzu QP-2010 GC with QP-2010 mass selective detector [MSD, operated in the EI mode (electron energy =70Ev), scan range =45-400 amu, and scan rate = 3.99 scan/sec], and Shimadzu GCMS solution data system. The GC column was HP-5MS fused silica capillary with a 5% phenyl-polymethylIsililoxane stationary phase, length 30 m, internal diameter 0.25 mm and film thickness 0.25 µm. The program used for GC oven temperature was isothermal at 60^{o}C, increased from 60^{o}C to 180^{o}C at rate of 10^{o}C/min, held at 180^{o}C for 2 minutes; increased from 180^{o}C at a rate of 15^{o}C/min, then held at 280^{o}C for 4 minutes. The injection port temperature was 250^{o}C. The ionization of sample components was performed in the electron impact mode (70eV). Injector temperature was 250^{o}C

while detector temperature was 280°C. Helium was used as carrier gas at a flow rate of 1.61 ml/min. 1.0 µl of diluted essential oil (1/100 in hexane, v/v) was injected using auto sampler. Split ratio was 10:90 (24).

Qualitative and quantitative analysis:

Components of the essential oil were identified by searching NIST Mass Spectral Library (NIST 11) and referring to compounds known in literature33. The percentage of each component was reported as raw percentage based on the total ion current without standardization. The essential oil constituents of the dried and fresh rhizomes are shown in Table 1 and 2 respectively. The Gas chromatography profiles of the essential oil of the dried and fresh rhizomes of *Zingiber officinale* are shown in Fig. 1 & 2 respectively while the major components in the fresh and dried ginger is on Table 3.

RESULTS

The Chromatographic profiles of the essential oil of dried and fresh rhizome of *Zingiber officinale* are shown in Fig. 1 and 2 while the chemical constituents are in Tables 1 and 2 respectively. The fresh sample had 62 components while dried sample had 68 compounds. The major constituents of the Nigeria ginger essential oil were: verbernol, eucalyptol, borneol, nerol, citral, linalool, fernesene, selinene, camphene and curcumene (Tables 1 and 2). Structures of some major components of ginger oil from Nigeria are in Figure 3.

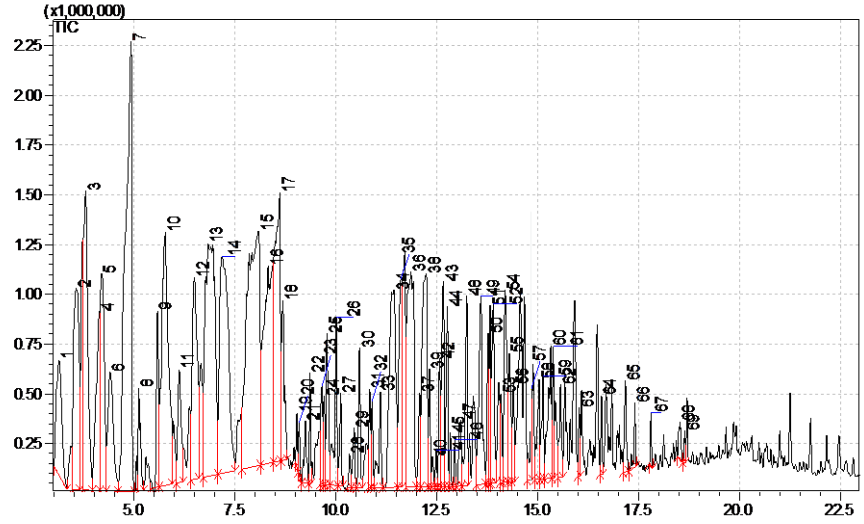

Figure 1. Chromatographic profile of the essential oil of dried rhizome of *Zingiber officinale*

Table 1. Chemical Constituents of the dried rhizome of *Zingiber officinale*

S/N	Compound[a,b]	MF[c]	RT[d]	% Composition on[e]
1.	2-Heptanol	$C_7H_{16}O$,	3.132	1.56
2.	alpha.-Pinene	$C_{10}H_{16}$	3.559	2.82
3.	Camphene	$C_{10}H_{16}$	3.795	3.05
4.	2,3-Pinanediol	$C_{10}H_{18}O_2$	4.125	1.86
5.	beta.-Myrcene	C10H16	4.189	2.33
6.	Linaly propanoate	$C_{13}H_{22}O_2$	4.401	1.75
7.	Eucalyptol	C10H18O	4.921	7.52
8.	2-Octenal (E)	$C_8H_{14}O$	5.112	0.65
9.	(+)-4-Carene	$C_{10}H_{16}$	5.573	1.03
10.	Linalool	$C_{10}H_{18}O$	5.765	4.52
11.	trans-2-Pinanol	$C_{10}H_{18}O$	6.113	1.09
12.	Citronellal	C10H18O	6.491	2.74
13.	endo-Borneol	$C_{10}H_{18}O$	6.831	6.26
14.	alpha.-Terpieol	$C_{10}H_{18}O$	7.167	5.12
15.	Verbenol	$C_{10}H_{16}O$	8.081	7.76
16.	Nerol	$C_{10}H_{18}O$	8.317	5.01
17.	alpha.-Citral	$C_{10}H_{16}O$	8.605	3.82
18.	2-Undecanone	$C_{11}H_{22}O$	8.681	1.19
19.	2,3-Pinanediol	$C_{10}H_{18}O_2$	9.025	0.19
Norbornane, 2-isobutyl		$C_{11}H_{20}$	9.083	0.20

20.	11-Octadecynoic acid, mwthyl ester			
21.	Citronellyl acetate	$C_{12}H_{22}O_2$	9.354	0.36
22.	4-n-Propyl-trans-3-oxabicyclo[4.4.0]decane	$C_{12}H_{22}O$	9.647	0.56
23.	Cubenol	$C_{15}H_{26}O$	9.702	
24.	Geraniol acetate	$C_{12}H_{20}O_2$	9.772	0.98
25.	beta.-Elemene	$C_{15}H_{24}$	10.005	1.11
27.	Zingiberene	$C_{15}H_{24}$	10.115	0.43
28.	Verbenone	$C_{10}H_{14}O$	10.334	0.17
29.	Caryophyllene	$C_{15}H_{24}$	10.448	0.33
30.	Germacrene B	$C_{15}H_{24}$	10.580	0.66
31.	beta.-Farnesene	$C_{15}H_{24}$	10.833	0.51
32.	Alloaromadendrene	$C_{15}H_{24}O$	11.097	0.64
33.	Curcumene	$C_{15}H_{22}$	11.435	3.46
34.	alpha.-Cedrene	$C_{15}H_{24}$	11.600	1.87
35.	Farnesene	$C_{15}H_{24}$	11.856	3.89
36.	Epi-bicyclosesquiphellandrene	$C_{15}H_{24}$	12.067	0.56
37.	beta.-Sesquiphellandrene	$C_{15}H_{24}$	12.238	2.88
38.	Patchouli alcohol	$C_{15}H_{26}O$	12.312	0.50
39.	Farnesol	$C_{15}H_{26}O$	12.387	0.15
40.	beta.-Vatirenen	$C_{15}H_{22}$	12.481	0.15
41.	Elemol	-	12.562	0.64
42.	trans-Nerolidol	$C_{15}H_{26}O$	12.658	1.34
43.	gamma.-Elemene	$C_{15}H_{24}$	12.758	0.98

44.	beta.-Cedren-9-.alpha.-ol	$C_{15}H_{24}O$	12.833	0.19
45.	Germacrene D-4-ol	$C_{15}H_{26}O$	12.943	0.16
46.	alpha.-Bisabolol	$C_{15}H_{26}O$	13.082	0.46
47.	Longipinocarveol, trans-	$C_{15}H_{24}O$	13.238	1.16
48.	gamma.-Eudesmol	$C_{15}H_{26}O$	13.587	1.72
49.	Carotol	$C_{15}H_{26}O$	13.758	0.78
50.	gamma.-Gurjunene	$C_{15}H_{24}$	13.818	0.69
51.	alpha.-Cadinol	$C_{15}H_{26}O$	13.892	1.18
52.	beta.-Eudesmol	$C_{15}H_{26}O$	14.083	0.43
53.	Globulol	$C_{15}H_{26}O$	14.192	1.55
54.	Spathulenol	$C_{15}H_{24}O$	14.288	0.91
55.	Longifolenaldehyde	$C_{15}H_{24}O$	14.393	0.48
56.	Farneso	$C_{15}H_{26}O$	14.833	0.52
57.	Nuciferol	$C_{15}H_{22}O$	15.029	0.70
58.	trans, trans-Farnesal	$C_{15}H_{24}O$	15.129	0.56
59.	6,10-Dimethyl-5,9-undecadien-1-yne	$C_{13}H_{20}$	15.318	1.25
60.	Caryophyllene oxide	$C_{15}H_{24}O$	15.381	0.51
61.	Widdrol	$C_{15}H_{26}O$	15.559	0.58
62.	1,3,12-Nonadecatriene-5,14-diol	$C_{19}H_{34}O_2$	16.023	0.29
63.	2,6-Dimethyl-2,6-undecadien-10-ol	$C_{13}H_{24}O$	16.579	0.30
64.	Palmitic acid	$C_{16}H_{32}O_2$	17.169	0.49
65.	Cedr-8-en-13-o	$C_{15}H_{24}O$	17.401	0.25
66.	Nerolidyl acetate	$C_{17}H_{28}O_2$	17.802	0.16
67.	Octadec-9-enoic acid	$C_{18}H_{34}O_2$	18.525	0.23

68.	Ethyl geranate	$C_{12}H_{20}O_2$	18.633	0.12

[a]Compounds listed in order of retention time (RT) from a HP-5ms column; [b]identification; [c]Molecular formula; [d]Retention time in minutes, GC-MS, gas chromatography-mass spectroscopy; [e]Components percentage composition were calculated from peak areas

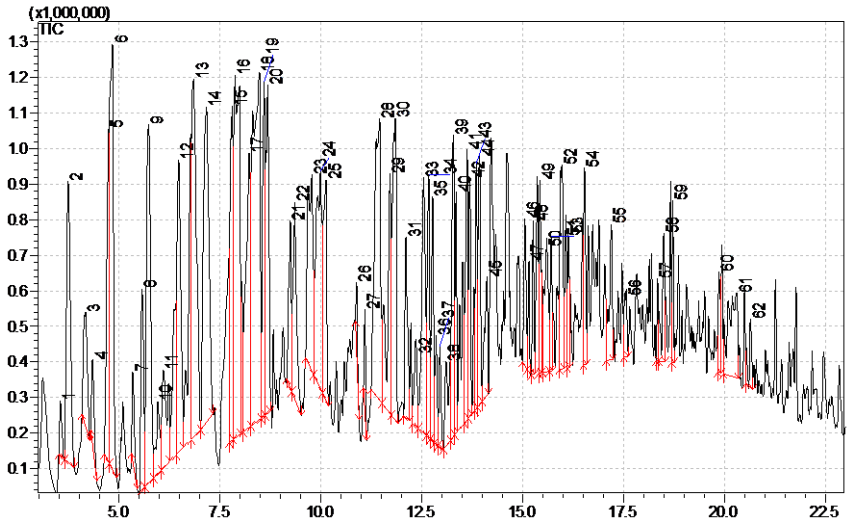

Figure 2. Chromatogram of the essential oil of fresh rhizome of *Zingiber officinale*

Table 2. Chemical Constituents of the Fresh rhizome of *Zingiber officinale*

S/N	Compound[a,b]	MF[c]	RT[d]	% Composition[e]
1.	alpha.-Pinene	$C_{10}H_{16}$	3.533	0.30
2.	Camphene	$C_{10}H_{16}$	3.734	2.64
3.	beta.-Myrcene	$C_{10}H_{16}$	4.164	1.05
4.	Octanal	$C_8H_{16}O$	4.333	0.48
5.	Limonene	$C_{10}H_{16}O$	4.733	2.01
6.	Eucalyptol	$C_{10}H_{18}O$	4.835	3.67

7.	Linalool oxide	$C_{10}H_{18}O_2$	5.335	0.48
8.	2-Nonanone	$C_9H_{18}O$	5.563	1.35
9.	Linalool	$C_{10}H_{18}O_2$	5.725	3.64
10.	Borneol	$C_{10}H_{18}O$	5.950	0.68
11.	4-Isopropyl-1-methyl-2-cyclohexen-1-ol	$C_{10}H_{18}O$	6.092	1.24
12.	(-)-Camphor	$C_{10}H_{16}O$	6.472	2.75
13.	Borneol	$C_{10}H_{18}O$	6.840	4.07
14.	alpha.-Terpineol	$C_{12}H_{17}F_3O_2$	7.158	4.22
15.	alpha.-Citronellol	$C_{10}H_{20}O$	7.795	2.43
16.	Verbenol	$C_{10}H_{16}O$	7.868	4.90
17.	Geranyl ethyl ether 1	$C_{12}H_{22}O$	8.208	3.30
18.	Alpha-Citral	$C_{10}H_{18}O$	8.476	6.09
19.	Epoxy-linalooloxide	$C_{10}H_{18}O_3$	8.591	2.07
20.	Penderol	$C_7H_{16}O_2$	8.677	2.31
21.	7-Isopropenyl-2,2,6-trimethyl-1,5- cyclooctanedione	$C_{14}H_{22}O_2$	9.237	1.01
22.	Decahydro-2,7-naphthalenediol	$C_{10}H_{18}O_2$	9.348	1.31
23.	alpha.-Amorphene	$C_{15}H_{24}$	9.771	2.37
24.	beta.-Elemene,	$C_{15}H_{24}$	9.985	3.03
25.	Geranic acid	$C_{10}H_{16}O_2$	10.125	1.56
26.	beta.-Cedrene	$C_{15}H_{24}$	10.880	0.19
27.	Alloaromadendrene	$C_{15}H_{24}O$	11.085	0.29
28.	Curcumene	$C_{15}H_{22}$	11.451	3.94
29.	alpha.-Selinene	$C_{15}H_{24}$	11.708	3.42

30.	beta.-Bisabolene	$C_{15}H_{24}$	11.838	2.84
31.	Cedrene	$C_{15}H_{24}$	12.104	1.17
32.	Hydroxy citronellal	-	12.367	0.61
33.	Alloaromadendrene oxide	$C_{15}H_{24}O$	12.538	2.31
34.	Cubenol	$C_{15}H_{26}O$	12.668	1.50
35.	Lauric acid	$C_{12}H_{24}O_2$	12.768	1.40
36.	alpha.-Bisabolol	$C_{15}H_{26}O$	12.852	0.49
37.	Dihydrocurcumene	$C_{15}H_{24}$	12.946	0.49
38.	Epiglobulol	$C_{15}H_{26}O$	13.092	0.88
39.	Cuparene	$C_{15}H_{22}$	13.280	1.98
40.	Guaiene	$C_{15}H_{24}$	13.346	0.86
41.	Farnesene epoxide	$C_{15}H_{24}O$	13.617	1.63
42.	beta.-Maaliene	-	13.684	0.99
43.	Ledene oxide-(I)	$C_{15}H_{24}O$	13.848	1.01
44.	3-Methyldiadamantane	$C_{15}H_{22}$	13.922	1.43
45.	beta.-Eudesmol	$C_{15}H_{26}O$	14.107	0.87
46.	Nuciferol	$C_{15}H_{22}O$	15.052	0.78
47.	Ar-Curcumene	$C_{15}H_{22}$	15.148	0.36
48.	trans, trans-Farnesal	$C_{15}H_{24}O$	15.254	0.56
49.	9,12-Octadecadiynoic acid, methyl ester	$C_{19}H_{30}O_2$	15.422	0.82
50.	Cedr-8-en-15-ol	$C_{15}H_{24}O$	15.600	1.26
51.	Dihydro iso-jasmone	$C_{11}H_{18}O$	15.703	0.66
52.	Larixol	$C_{20}H_{34}O$	15.973	1.58
53.	3-Eicosyne	$C_{20}H_{38}$	16.126	0.47

54.	n-Pentadecanol	$C_{15}H_{32}O$	16.527	0.90
55.	Corymbolone	$C_{15}H_{24}O_2$	17.191	1.01
56.	Widdrol	$C_{15}H_{26}O$	17.567	0.41
57.	Terpinyl formate	$C_{11}H_{18}O_2$	18.340	0.27
58.	3-Cyclopentylpropionic acid, hexyl ester	$C_{14}H_{26}O_2$	18.491	0.88
59.	Ethyl geranate	$C_{12}H_{20}O_2$	18.716	0.50
60.	9-Cyclohexylbicyclo(3.3.1)nonan-9-ol	$C_{15}H_{26}O$	19.850	0.64
61.	Nerylacetone	$C_{13}H_{22}O$	20.297	1.84
62.	2-Hexadecanoyl glycerol	$C_{19}H_{38}O_4$	20.640	0.41

[a]Compounds listed in order of retention time (RT) from a HP-5ms column; [b]Identification; [c]Molecular formula; [d]Retention time in minutes, GC-MS, gas chromatography-mass spectroscopy; [e]Components percentage composition were calculated from peak areas.

Table 3. Percentage Composition of the major component of Dry and Fresh oil extracts of *Zingiber officinale* from Nigeria

S/No.	Compound	% composition (Dry sample)	% composition (Fresh sample)
1.	Verbenol	7.67	4.90
2.	Eucalyptol	7. 52	3.67
3.	Borneol	6.26	4.07
4.	Citral	3.82	6.09
5.	Alpha-Terpineol	5.15	4.22
6.	Linalool	4.52	3.64
7.	Farnesene	3.89	1.63
8.	Nerol	5.01	-
9.	Curcumene	3.46	0.36
10.	Camphene	3.05	2.63
11.	Alpha-Selinene	-	3.42

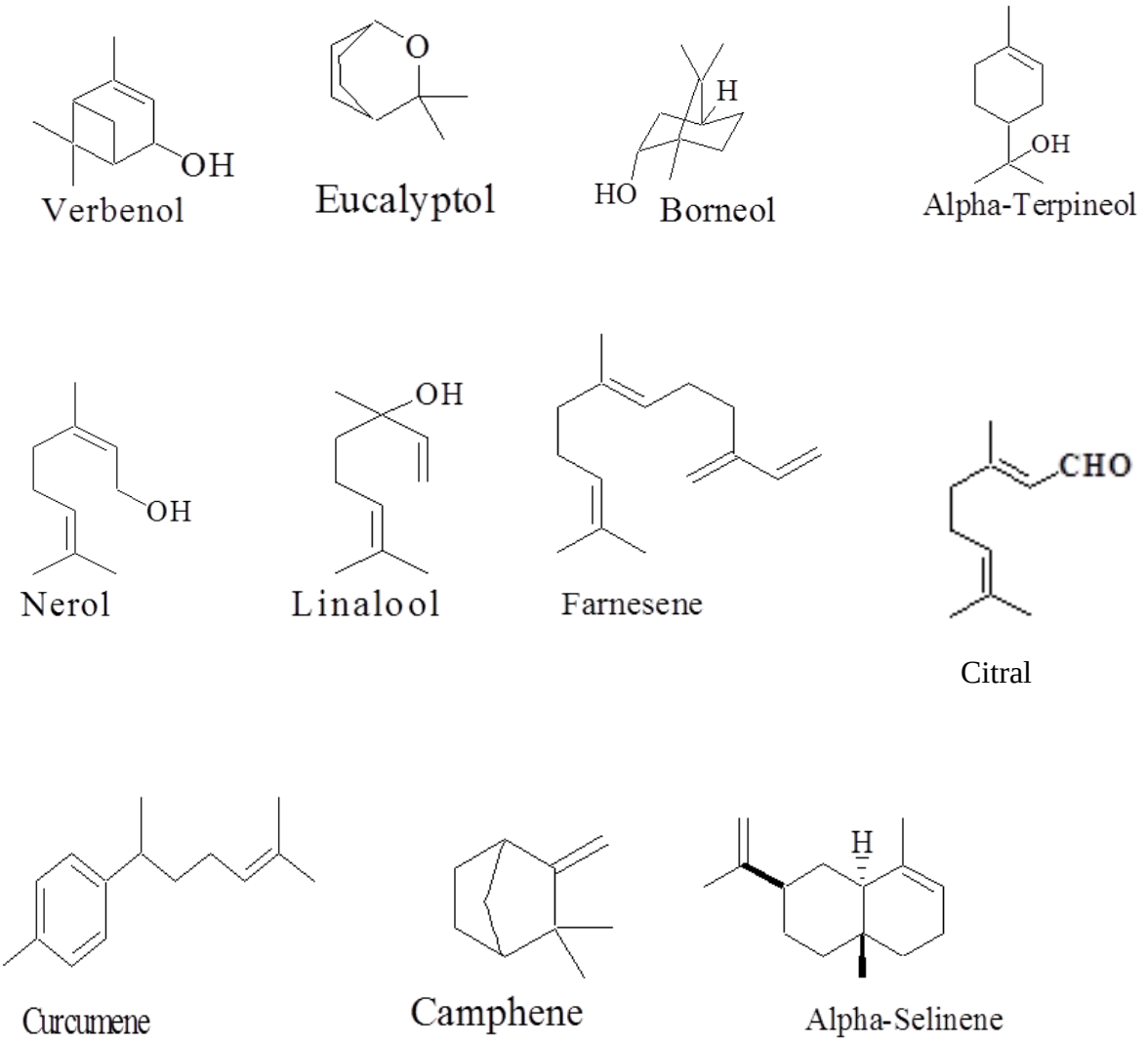

Figure 3. Structures of some major components of Ginger oil from Nigeria

DISCUSSION

The GC-MS analysis of the fresh oil sample had 62 compounds while that of the dried sample had 68 compounds. Nerol was present in the dry but not in the fresh samples (Table 1 and 3). The major constituents of Chinese ginger essential oil were: zingiberene, ar-curcumene, β-Sesquiphellandrene, β-Bisabolene, camphene, β-Phellandrene, borneol, 1, 8-cineole (eucalyptol), α-pinene and β-elemene (25). Comparing the Chinese and the Nigerian ginger oils, it was observed that eucalyptol, ar-curumene, camphrene, borneol, α-pinene, β-elemene, β-

Sesquiphellandrene, β-Phellandrene were present in both the Chinese and Nigerian oils. β-Phellandrene was present in the oil from the fresh sample and β-Sesquiphellandrene was present in the dry oil sample of the Nigeria oil. β-Phellandrene was only present in the Chinese ginger oil and not the Nigerian oil sample. Zingiberene which was present in the Chinese ginger oil was only present in a small quantity (0.43%) in the dry ginger of the Nigerian oil sample.

CONCLUSION

The isolation of the various components detected by the GCMS analysis can be used for the formulation of drugs which will be used to treat ailments like: respiratory diseases, pancreatitis, colon damage, cardiovascular and neurogenerative diseases; useful therapeutic agent due to its anti-oxidative and anti-inflammatory agent, anti-cancer, anti-convulsant, anti-ulcer anti-hypertensive, anti-nociceptive, anti-fungal and anti-microbial drugs.

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