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Chemical Compositions and Physico-chemical Properties of Three Varieties Essential oils of *Cymbopogon giganteus* Growing to the Spontaneous State in Benin

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ABSTRACT

Cymbopogon giganteus (Hochst.) Chiov., *Cymbopogon nardus* (L.) Rendle and *Cymbopogon schoen anthus* (L.) Sprend. Ssp. Proximus (Hochtst. Ex A. Rich.) Maire & Weiler plants are highly aromatic and reputed in traditional medicine in Benin. Physico-chemical studies and chemical composition of the essential oils (EO) extracted from the leaves of the three plants were realized by gas chromatography connected to a flame ionization detector (GC/FID) and by gas chromatography coupled to mass spectrometry(GC/MS). The major compounds (> 10%), marking the chemical profile of each of the essential oils studied, independently of the botanical variety considered, are constitued by the piperitone(62.9%), geraniol (29.9-34.5%), citronellal (27.9-32.3%), limonene (10.8%-19.4%), *cis*-mentha-1(7),8-dien-2-ol (18.4%), *trans*-mentha-1(7),8-dien-2-ol (17.0-19.9%), carvotanacetone (17.9%), *trans*-p-mentha-2,8-dien-1-ol(12.0-17.4%), *cis*-dihydrocarvone (10.1-17.2%), δ-2-carene (14.4%), myrtenol(11.9%)and citronellol(10.1-11.7%). The results of physico-chemical analyzes performed suggest a similarity between refractive index and density of the essential oil of *Cymbopogon giganteus* whose values are the highest. The values of the rotatory powers and acid index values did not remain homogeneous samples of essential oil of the same botanical species. They varied according to plant species studied and their origins.

Key words: *Cymbopogon,* geraniol, piperitone, citronellal, *cis*-mentha-1(7),8-dien-2-ol, Benin.

INTRODUCTION

The study of aromatic plants is still of current events considering the fact that the bioactive compounds of their essential oils focus in recent times, and effectively, the attention of researchers in the world of modern medicine. In Africa and in Benin in particular, the vegetation has a rich and diverse panel of aromatic plants species poorly explored for the developmentof plant biotechnology and high reach applications in cosmetics, pharmacy and food industries. *Cymbopogon* is an important genus of the Poaceae family and containing 120 species distributed in several varieties[1]. The three varieties, *Cymbopogon giganteus* (Hochst.) Chiov., *Cymbopogon nardus* (L.) Rendleet *Cymbopogons-choenanthus* (L.) Sprend. sp. Proximus (Hochtst. Ex A. Rich.) Maire & Weiler[2], are aromatic botanical species which grow in the savannas of the tropical regions of Africa. The literature indicates that *Cymbopogon giganteus* is a herbaceous, sustainable, large (2 to 2.5 m high), growing in tufts[2, 3]. Its leaves, long from 3 to 40 cm and wide 2 to 2.5 cm, are banded, glaucous, sheathing and having arounded base and an arrowed peak[2]. Alpha The edges are rough to the touch. The youngest are covered with a whitish pubescence described by some authors as floury[4]. The aqueous decoction of stems with leaves of *C.giganteus* associated with those of *Ocimum basilicum* is used to treat sickle cell disease. Used only in the state of decoction, *C. giganteus* calm quiet the epileptic fits[2]. Its aroma, a characteristic peppery flavor, is enjoyed through the food in Benin countrysides). *Cymbopogon nardus*, meanwhile, is a perennial herb growing in the wild. It grows in dense tufts and sometimes reaches 1.5 m in height with stems trimmed, purple color. Its spikelets geminateare more or less different according to their shape and their sex, one sessile, the other stalked, inserted on the articulated spine. The floral handle of this plant has many branches ending in greenish pellets ears. Concerning *Cymbopogon schoanenthus*, several studies have reported that it is a widespread species, especially in the dry areas of tropical Africa. Bushy perennial reaching a height of 90 cm, *Cymbopogon schoanenthus* carries linear leaves, fragrant and scabrouson margins. Inflorescences are panicles dense and contracted. The whole plant crushed, mixed with leaves of *Vitex simplicifolia* is used in the treatment of the madness in the form of aqueous decoction orally, in West Africa and in Ethiopia[2]. Several recent studies have focused on identifying of the chemical profile of the essential oil extracted from each of these plants. The works realized by Nyamador *et al.*[5] showed that the leaves of *Cymbopogon giganteus* collected in Togo are mainly composed of limonene(23.0%) followed by p-mentha-2,8-dien-1-ol split between the *trans* (5,63%) and the *cis* (14.3%) forms. Kétoh *et al.* identified a chemical composition of the essential oil of *Cymbopogon schoanenthus* leaves of Togo and the major components of this essential oil (piperitone: 68.0%, δ-2-carene: 16.48%)[6] were similars to those (piperitone: 60.0%, d-2-carene: 15%, elemol: 8.4%) identified by Ayedoun *et al.* in Benin[7]. In 2003, Nakahara *et al.* scrutinized the chemical composition of *Cymbopogon nardus* leaves essential oil from Tsukuba (Japan)[8]. The chromatographical analyzes performed by adding mass spectrometry showed six major oxygenates components: geraniol (35.7%), *trans*-citral (22.7%), *cis*-citral (14.2%), geranyl acetate (9.7%), citronellal (5.8%) and citronellol (4.6%)[8]. Vijender and Ali had also brought back from the essential oil of the leaves of New Dehli (India) the citronellal (29.7%), geraniol (24.2 %), #-terpineol (9.2 %), *cis*-sabinene hydrate (3.8%), (E)-nerolidol (4.8%), b-caryophyllene (2.2%) and germacren-4-ol (1.5%) [9]. All these volatile extracts, by means of the synergic effects of the constituents of their totum, had showed different biological effects[6,10-12]. The present work aims to study the chemical composition and physico chemical characteristics of the volatile extracts of *C. giganteus*, *C. nardus* and *C. schoenanthus* harvested in several villages of Benin.

EXPERIMENTAL

Plant material and essential oil extraction

Cymbopogon giganteus and *Cymbopogon nardus* leaves were collected in several localities in the south of Benin (Gbakpodji: F_1, Kétou: F_2andF_5,Tinou:F_3, Sèto: F_4,Ifangni: F_6 andF_7, Boukoumbé: F_8). The leaves of *Cymbopogon schoenanthus* were collected inanother region (Boukounbé) in northern of Benin. A voucher specimen of these diverse aromatic plants are deposited in Abomey-Calavi University National Herbarium. They were kept in the laboratory between 18 and 20°C in the shade during all the extractions period. Essential oils were extracted by hydrodistillation of the leaves(250g) for 3 to 4 hours using a Clevenger according to the method described in british pharmacopoeia[13]. The volatile extracts collected were dried over anhydrous sodium sulfate and analyzed by GC/MS.

Physico-chemical propertiesof essential oils

Physical parameters of the essential oils extracted from leaves *Cymbopogon* species of were determined using the methods described by AFNOR[5,6]. These parameters are the density, refractive index, refractive index, rotatory power and acid Index.

Density at 20°C

The density measure was carried out using a micro-pycno meteranda precision balance.

Refractive index at 20°C

The refractive index was determined by means of the refractometer Carl Zeiss Jena 234678.

Rotatory power at 20°C

The measurement was made by Carl Zeiss polarimeter 128291.

Acid index Ia

The material used to determine the acid index was constituted by phenolphtalein, neutralized ethanol, potassium hydroxide (0.05N) and a graduated burette. The index acid calculation was done using the following formula

$Ia = 5.61xV / m$.

V = Volume in mL of the ethanolic solution of potassium hydroxide

m = Mass measured in gram of essential oil charged.

Volatile components analysis

GC/FID

The extracts were analysed on a Hewlett-Packard gas chromatograph Model 6890, equiped with a DB5 MS column (30 m x 0.25 mm, 0.25 µm), programming from 50°C (5 min) to 300°C at 5°C/min, 5 min hold. Hydrogen as carrier gas (1.0 mL/min); injection in split mode (1:60); injector and detector temperature: 280 and 300°C respectively. Each extract is diluted in hexane: 1/30.

GC/MS

The extracts compositions were analysed on a Hewlett-Packard gas chromatograph Model 5890, coupled to a Hewlett-Packad MS model 5871, equipped with a DB5 MS column (30 m x 0.25 mm, 0.25 µm), programming from 50°C (5 min) to 300°C at 5°C/min, 5 min hold. Helium as carrier gas (1.0 mL/min); injection in split mode (1:30); injector and detector temperature, 250 and 280°C respectively. The MS working in electron impact mode at 70 eV; electronmultiplier: 2500 eV; ion source temperature: 180°C; mass spectra data were acquired in the scan mode in *m/z* range 33-450.

The compounds assayed by GC in the different essential oils were identified by comparing their retention indices with those of reference compounds in the literature and confirmed by GC-MS by comparison of their mass spectra with those of reference substances[14-16].

RESULTS AND DISCUSSION

The tableI shows thevalues of the fourphysico-chemical factorsmeasured. In the table IIare presentedthe results ofchromatographic analysis ofessential oils extracted fromleaves of *Cymbopogongig anteus*, *Cymbopogon nardus* and *Cymbopogonschoen anthus* from Benin.

Table 1: Physico-chemical properties of F_2, F_3, F_4, F_6, F_8 essential oilssamples

	Density	refractive Index (at 20°C)	Rotary power (at 20°C)	Ia (mg de KOH/g)
F_2	0.943	1.4845	- 44.87	2.562
F_3	0.941	1.4865	+ 21.70	5.452
F_4	0.948	1.4880	- 62.74	2.441
F_6	0.897	1.4759	- 3.70	0.805
F_8	0.928	1.4847	+ 37.20	2.026

F_2 = Kétou (11-07-07). F_3 = Tinou (15-07-07). F_4 = Sèto (02-07-06). F_6= Ifangni (25-04-07).
F_8 = Boukoumbé (28-09-06). Ia= Indice d'acide

Table 2: Yield andchemical compositionof essential oils from leaves of *C. giganteus*, *C. nardus* and *C. schoenanthus*

Yield (%)	KI	Cg				Cn			Cs
compounds identified		F_1 0.15	F_2 0.04	F_3 0.17	F_4 0.03	F_5 1.61	F_6 2.66	F_7 2.08	F_8 1.2
					(%)				
santene	880	0.2	-	-	-	-	-	-	-
α-thujene	926	0.4	-	-	-	-	-	-	-
α-pinene	934	4.1	-	-	-	-	-	-	-
camphene	951	0.1	-	-	-	-	-	-	-
thuja-2,4(10)-diene	954	0.4	-	-	-	-	-	-	-
sabinene	974	1.1	-	-	-	-	-	-	-
6-methylhept-5-en-2-one	981	-	-	-	-	-	0.1	-	-
dehydro-1,8-cineole	986	-	t	0.1	-	-	-	-	-
myrcene	991	-	-	-	-	-	0.1	-	-
δ-2-carène	996	-	-	-	-	-	-	-	14.4
meta-mentha-1(7),8-diene	999	-	0.1	0.1	-	-	-	-	-
α-phellandrene	1002	-	-	-	-	-	-	-	0.1
α-terpinene	1013	-	-	-	-	-	-	-	0.1
ortho-cymene	1021	-	t	0.3	0.3	-	-	-	-
para-cymene	1022	0.3	0.3	-	-	-	-	-	0.1
limonene	1030	7.8	12.9	10.8	19.4	0.6	1.8	1.7	2.4
(Z)-β-ocimene	1032	-	-	-	-	-	-	-	0.1
benzeneacetaldehyde	1041	-	-	0.1	-	-	-	-	-
(E)-β-ocimene	1043	-	-	-	-	0.2	0.1	-	0.1
para-cymenene	1086	0.1	0.2	0.2	0.2	-	-	-	-
fenchone	1087	-	-	-	-	-	-	-	0.1
6,7-epoxymyrcene	1093	-	0.4	0.2	0.2	-	-	-	-
linalool	1095	-	-	-	-	0.6	0.5	0.5	-
cis-para-menth-2-en-1-ol	1121	-	-	-	-	-	-	-	0.7
trans-para-mentha-2, 8-dien-1-ol	1126	17.4	-	16.3	12.0	-	-	-	-
cis-limoneneoxide	1129	-	19.2	-	-	-	-	-	-
cis-carvone oxide	1133	-	-	-	-	0.1	-	-	-
cis-para-mentha-2,8-dien-1-ol	1138	8.9	-	0.2	8.3	-	-	-	-
trans-para-menth-2-en-1-ol	1140	-	-	-	-	-	-	-	0.5
cis-verbenol	1143	-	9.6	-	-	-	-	-	-
trans-verbenolor*trans*-2-pinen-4-ol	1145	-	-	8.9	-	-	-	-	-
isopulegol	1146	-	-	-	-	1.6	0.8	0.7	-
trans-limoneneoxide	1149	-	-	-	0.1	-	-	-	-
neroloxide	1151	-	0.1	-	0.3	-	-	-	-
citronellal	1153	-	-	-	-	28.4	27.9	32.3	-
neo-3-thujanol	1154	-	-	-	-	-	-	-	-
iso-isopulegol	1155	-	0.2	-	-	-	-	-	-
3Z-nonen-1-ol	1157	-	-	0.3	-	-	0.3	-	-

neo iso-isopulegol	1163	-	-	-	-	0.5	-	-	-
verbenol	1164	-	0.4	-	-	-	-	-	-
thujan-3-ol	1168	-	0.3	-	-	-	-	-	-
cis-chrysanthenol	1169	-	-	-	0.1	-	-	-	0.5
trans-β-terpineol	1170	-	-	1.4	-	-	-	-	-
pinocarvone	1171	-	-	-	-	0.1	-	-	-
thuj-3-en-10-al	1177	-	-	-	-	0.2	-	-	0.2
para-methyl-acetophenone	1183	0.2	0.6	-	-	-	-	-	-
cis-dihydrocarveol	1186	-	-	-	-	-	-	-	0.1
thuj-3-en-10-al	1187	-	-	0.3	0.4	-	-	-	-
α-terpineol	1189	-	-	-	-	-	-	-	1.2
neodihydrocarveol	1192	-	-	-	6.2	0.1	-	-	-
cis-mentha-1(7),8-dien-2-ol	1193	18.4	-	-	-	-	-	-	-
myrtenol	1194	-	5.3	-	11.9	-	-	-	-
trans-mentha-1(7),8-dien-2-ol	1196	-	-	6.1	-	-	-	-	-
trans-dihydrocarvone	1198	0.2	-	-	0.3	-	-	-	-
cis-dihydrocarvone	1200	-	17.2	10.1	-	-	-	-	-
n-decanal	1202	-	-	-	-	0.1	-	-	-
cis-piperitol	1203	3.9	0.3	-	-	-	-	-	-
trans-piperitol	1206	1.4	2.4	0.2	5.4	-	-	-	0.3
4-methylene-isophorone	1214	-	0.6	1.6	1.3	-	-	-	-
trans-carveol	1217	5.1	-	-	-	-	-	-	-
cis-carveol	1221	-	-	1.0	6.4	0.1	-	-	-
citronellol	1225	-	-	-	-	11.5	11.7	10.1	-
nerol	1228	-	-	-	0.7	-	-	-	-
(Z)- ocimenone	1230	-	0.8	5.2	-	-	-	-	-
cis-para-mentha-1(7),8-dien-2-ol	1235	-	-	0.7	0.3	-	-	-	-
neral	1238	-	-	-	-	0.3	0.3	0.5	-
trans-mentha-1(7),8-dien-2-ol	1243	19.9	17.0	-	-	-	-	-	-
cis-3-hexnyliso-valerate	1244	-	0.2	-	-	-	-	-	-
carvotanacetone	1249	-	-	17.9	-	-	-	-	-
carvone	1250	2.6	3.2	-	2.8	-	-	-	-
trans-2-hydroxy-pinocamphone	1251	0.2	-	-	-	-	-	-	-
chavicol	1252	-	-	0.2	-	-	-	-	-
piperitone	1253	-	-	-	-	-	-	-	62.9
geraniol	1255	-	-	-	-	34.5	33.4	29.9	-
dec-9-en-1-ol	1256	-	0.1	-	-	-	-	-	-
geranial	1268	-	0.1	3.4	0.1	0.7	0.4	0.8	-
para-mentha-1,8-dien-7-al	1272	-	-	-	0.3	-	-	-	-
neo-isopulegol	1274	-	0.3	-	-	-	-	-	-
γ-terpin-7-al	1277	0.4	-	0.5	0.1	-	-	-	-
limonen-10-ol	1282	-	-	0.2	-	-	-	-	-
para-cymen-7-ol	1288	-	0.2	-	-	-	-	-	-
geranyl formate	1294	-	-	-	-	0.6	-	-	-
perillaalcohol	1299	-	0.2	0.1	0.1	-	-	-	-
dihydrocarveylacetate	1309	4.2	-	-	-	-	-	-	-

neo-dihydrocarveylacetate	1310	-	-	4.2	-	-	-	-	-
(E)-patchenol	1328	-	-	-	0.2	-	-	-	-
verbenylacetate	1342	-	-	-	-	0.2	-	-	-
néo iso carvomenthylacetate	1344	-	-	-	-	-	0.8	1.4	-
citronellylacetate	1346	-	0.3	0.9	-	0.4	-	-	-
eugenol	1348	-	-	0.4	-	0.7	0.7	0.6	-
geranylacetate	1373	-	-	-	-	0.6	1.5	3.0	-
β-bourbonene	1378	-	-	-	-	0.1	-	-	-
β-elemene	1386	-	-	-	-	1.3	1.1	0.9	0.5
β-caryophyllene	1418	-	-	-	-	-	-	-	0.8
nerylpropanate	1449	-	-	-	-	0.1	-	-	-
α-humulene	1454	-	-	-	-	-	0.1	-	0.1
allo-aromadendrene	1469	-	-	-	-	0.1	-	-	-
α-copaene	1472	-	-	-	-	-	0.1	-	-
germacrene-D	1479	-	-	-	-	0.9	1.2	1.4	0.1
b-selinene	1487	-	-	-	-	-	-	-	0.2
viridiflorene	1492	-	-	-	-	0.3	-	-	0.2
α-muurolene	1495	-	-	-	-	0.2	0.3	0.3	-
germacrene-A	1505	-	-	-	-	0.2	0.3	0.4	0.2
γ-cadinene	1510	-	-	-	-	1.1	0.2	0.2	0.1
δ-cadinene	1514	-	-	-	-	-	1.2	1.2	0.2
elemol	1546	-	-	-	-	7.4	7.0	6.6	5.0
longipinanol	1572	-	-	-	-	0.5	-	-	-
germacrene-D-4-ol	1574	-	-	-	-	-	2.0	2.1	-
caryophylleneoxide	1580	-	-	-	-	-	-	-	0.4
viridiflorol	1593	-	-	-	-	0.5	-	-	0.1
geranylisovalerate	1606	-	-	-	-	-	-	0.2	-
10-epi-γ-eudesmol	1620	-	-	-	-	-	-	-	0.1
γ-eudesmol	1628	-	-	-	-	0.6	0.6	0.7	1.7
epi-γ-cadinol	1640	-	-	-	-	-	0.5	0.3	-
epi-γ-muurolol	1641	-	-	-	-	0.4	-	0.6	0.2
α-cadinol	1653	-	-	-	-	2.6	2.6	2.8	-
β-eudesmol	1655	-	-	-	-	-	-	-	5.3
14-hydroxy-a-humulene	1705	-	-	-	-	0.3	-	-	-
(Z, Z)-farnesol	1709	-	-	-	-	-	0.4	0.5	-
cis-myrtanyloctanoate	1985	-	-	-	-	0.1	-	-	-
hydrogenatedmonoterpenes		14.5	13.5	11.4	19.9	0.8	1.8	1.7	17.3
oxygenatedmonoterpenes		78.6	78.5	75.3	57.2	79.4	76.3	75.4	66.5
hydrogenatedsesquiterpenes		-	-	-	-	4.5	4.5	4.4	2.4
oxygenatedsesquiterpenes		-	-	-	0.2	12.3	13.1	13.6	12.8
esters		4.2	0.5	5.2	0.1	2.0	2.3	4.6	-
Total		97.3	92.5	91.9	77.4	98.8	98.0	99.7	99.0

t = traces (< 0,05%) ; F_1 = Gbakpodji (18-09-08), F_2 = Kétou (11-07-07), F_3 = Tinou (15-07-07), F_4 = Sèto (02-07-06), F_5= Kétou (15-08-05), F_6 = Ifangni (25-04-07), F_7 = Ifangni (17-05-07), F_8 = Boukoumbé (28-09-06),*Cg*= *Cymbopogongiganteus*, *Cn*= *Cymbopogonnardus*, *Cs* = *Cymbopogonschoenanthus*,KI =Kovats index

The results ofphysico-chemical properties (density, refractive index, rotary power andacid index) of essential oils of *Cymbopogon* (F_2, F_3, F_4, F_6, F_8) presented in Table II revealed a major differences in accordence with sampling localities and variety.Theless densefractions ofessential oil sanalyzedis fromtheleaves of *Cymbopogonschoe nanthus*.The values of the rotatory power, refractive indexandacidindex aredifferent from a variety of *Cymbopogon*to another.In the case of *Cymbopogon schoenanthus*, physical parameters determined(density,refractive index,rotary power) are very different from thosefound byOnadja*et al*. in thevolatileextractof the same plantin Burkina Faso[17].

The three species of *Cymbopogon*each produced varied quantities of essential oil(TableII). The results indicate that*Cymbopogon nardus* (1.61-2.66%) contains more essential oil followed by *Cymbopogonschoen anthus* (1.20%) and *Cymbopogongig anteus* (0.03-0.17%). The values supplied by the calculation of volatile extract yield of the *Cymbopogon giganteus* leaves are lower than those obtained by Alitonou[18] from the leaves collected atSavalouand Sèto in Benin[18]. The yield of essential oil of *C. giganteus* collected at Sèto in 2006 is also lower compared to that obtained by Alitonou[18]. These differences should be due to the factors such as the influence of the harvest place and period, the composition, the harvest period, the vegetative stage of the plant and theclimatical factors inherent to the collectionzone.Different compounds (23 to 32)were identifiedand representing 77.4 to 97.3% of theessential oils (Table 2). In fact, theyare rich in oxygenated monoterpenes(57.2-78.4%) known for their biological efficiencies. In these volatileextracts, it was also noteda highoccurrence ofmonoterpenoic compoundsdominated bya high rate ofoxygenated monoterpenes(57.2-75.3%). However, theessential oilfromleaves growingin Setocontains less than60.0%of oxygenated monoterpenes. Sesquiterpene hydrocarbonwas not detected in plant species F_1, F_2, F_3andF_4. Similarly, volatile extracts from leaves collected to Gbakpodji, Kétou and Tinoudid not containoxygenated sesquiterpenes. On the over hand, a hardly unimportant percentage (0.2%)ofoxygenated sesquiterpeneswas notedin the sample ofessential oil from Setowitha relatively high proportion (19.9%) of hydrocarbon monoterpenes. However, this low rate of oxygenated sesquiterpenes (0.2%) would enhance the biological efficacy of sample F_4.The proportions of monoterpenehydro carbons inF_1, F_2, F_3volatileextracts samplesare respectively 8.2%, 13.5% and 11.4%.

The major compounds of the volatile extracts analyzed, regardless of their origin,were composedof limonene(7.8-19.4%), *trans*-para-mentha-2,8-dien-1-ol (12.0-17.4%), *cis*-limonene oxide(19.2%), *cis*-para-mentha-2,8-dien-1-ol (8.3-8.9%), *cis*-verbenol(9.6%), *trans*-verbenol (8.9%), dihydrocarveol(6.2%), *cis*-mentha-1(7),8-dien-2-ol (18.4%) myrtenol(5.3-11.9%), *cis*-dihydrocarvone (10.1-17.2%), *trans*-piperitol (5.4%), *trans*-carveol (5.1%), *cis*-carveol(6.4%), (Z)-ocimenone(5.2%), *trans*-mentha-1 (7),8-dien-2-ol (17.0-19.9%) and carvotanacetone(17.9%). These componentsare mostlyoxygenated compounds skeleton menthadiene like those studied by Sahouo[19] and Alitonou[18] as well as thoseextracted from flowers, leaves and stems acclimatedin Cameroon[20].

25 in 38 compounds were identified representing 64.6 to 99.7% of essential oils extracted from the leaves of *Cymbopogon nardus* collected at Kétou andIfangni (Table II). A high rate of oxygenated monoterpenes (> 75.0%) characterized the essential oils obtained from leaves of Kétou(F_5) and from Ifangni(F_6, F_7). To Ifangni, the rate is 42.4% and the major compounds of this essential oil, remained similar, in percentage, to those noted in F_1 and F_2. The main componentsaregeraniol(29.9- 34.5%), citronellal (27.9- 32.3%), citronellol(10.1 -11.7%) andelemol (6.6- 7.4%).This group compounds is similarto that determinedby Nakahara *et al.*, in Japan, which contained, except the geraniol (35.7%), citronellal(5.8%)and citronellol (4.6%).The isomers (*cis*: 14.2%and*trans*: 22.7%) of citralandgera-nylacetate (9.7%)were also identified[18]. The same observationwas made byBaranauskiéné[21] in the essential oil fromleavesof *Cymbopogon nardus* collected at Lithuania and also by Koba in Lomé (Togo)[22]. Bycons, these majors compoundswere quite differentfrom those identified (a-pinene4.4%, camphene 8.2%, limonene, 11.0% and geraniol: 18.0%)byParanagama*et al.*, in the volatile extracts of *C.nardus* leaves of Kelaniya in SriLanka[23].

Moreover,the analysis of results presented in the tableIIindicates that theabundant components identified in the essential oilof *Cymbopogonscho-anenthus*collected at Boukoumbéarepiperitone (62.9%),δ-2-carene (14.4%), elemol(5.0%). Also, Ayédoun*et al.* have reported in 1997, in Benin, these same monoterpenoic compounds (piperitone: 60.0%;δ-2-carene: 15.0%;elemol: 8.4%) punctuated with some differences between proportions[7].In Togo, nearby country of Benin, Koba *et al.*were reported twomajor componentsinrelatively higher proportions (piperitone: 68.0%),d-2-carene: 16.48%) in the essential[10]. On the other hand, the analysis by GC/MS and ^{13}C NMRof the essential oilfrom thisplant studiedin Tunisiain 2008byKhadri *et al.*[24] revealed major compoundsdifferentsto those obtained during the current investigation. Indeed, limonene (10.5-27.3%), β-phellandrene(8.2-16.3%), δ-terpinene(4.3-21.2%) and α-terpineol(6.8-11.0%) were the main componentsof this volatile extract[24].

CONCLUSION

The chemical compositions ofessential oils studiedhavevaried according to theplace of collection ofplant speciesand the varietyof *Cymbopogon*studied.The volatile extractsamples of *Cymbopogon nardus*exploredcontain lessthan 5.0% of hydrogenated terpenes. In *Cymbopogons-choenanthus* essential oil, hydrogenated sesquiterpenesare poorly represented (2.4%), while no trace ofthemwas observedin *Cymbopogongi-ganteus*volatile extracts investigated. In general,essential oilsof the three *Cymbopogon* varietiesinvestigatedare strongly dominated bymonoterpenoiccompounds. The evaluation of physico-chemical factorshad completed the chemical profiles of thesethree varieties of essential oil.The estimated physico-chemical factors will help in a better characterization of these three varieties of *Cymbopogon* essential oil.

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