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CHEMICAL VARIABILITY OF *TITHONIA DIVERSIFOLIA* (HEMSL.) A. GRAY LEAF AND STEM OIL FROM CÔTE D'IVOIRE

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Tithonia diversifolia, Asteraceae, Essential oil composition, α-pinene, sabinene, β-pinene, limonene, (Z)-β-ocimene, thymol and spathulenol

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ABSTRACT: *Tithonia diversifolia* was collected from 27 localities of Côte d'Ivoire. The oils of the leaves and stems obtained by hydrodistillation using Clevenger-type apparatus have been studied by GC and GC-MS. The identified components accounted for 91.4% - 96.9% of leaves and 93% – 95.6% of stems. The content of the main components varied from sample to sample. α-pinene (0.9 – 47.4%), limonene (0.5 – 65.5%), (Z)-β-ocimene (0.0 – 35.9%) and 3-methyl-2 (2-methylbuthenyl) furan (0 – 94%) were noted as major components of the oil from the leaves. Whereas, the stem oil was rich in α-pinene (5.8 – 89.8%), sabinene (0. – 5.2%), β-pinene (0.3 – 10.5%), limonene (1.3 – 36.5%), (Z)-β-ocimene (0 – 39.3%), thymol (0 – 4%) and spathulenol (0.1 – 11.8%). Due to the chemical polymorphisme, the results of oil obtained from leaves and stems were submitted to hierarchical cluster, principal components analysis and discriminant factoriel analysis which allowed the distinction of two groups within the oil samples of each organ. According to the essential oil from the leaves, the composition of the oils of the first group (10 samples) was predominated by α-pinene, limonene and (Z)-β-ocimene, when the second group (17 samples) was rich in α-pinene, limonene, (Z)-β-ocimene and 3-methyl-2 (2-methylbuthenyl) furan. Concerning the stems oil, the group I (7 samples) was characterized by α-pinene, sabinene, β-pinene, limonene, (Z)-β-ocimene, thymol and spathulenol. The group II was dominated by α-pinene, limonene, (Z)-β-ocimene, β-pinene and sabinene.

INTRODUCTION: *Tithonia diversifolia* (Hemsl.) A. Gray (Asteraceae), Mexican sunflower or Mexican tournesol is native to the lowlands of Southearstern of Mexico and Central America [1]. The large family of Asteraceae comprising more than 1000 genera and 25000 species [2, 3]. Nowadays, it is spread all over the world; it is found in Africa, Central and South America, in Asia and Australia [4].

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In Côte d'Ivoire, this fast-growing perennial or annual herb found in dense clumps along roadsides generally. It is a bushy reaching 3m in height, characterized by leaves usually three to five lobed, 15 – 17cm long and 9 – 13 cm wide. Flowers are bright yellow and solitary on the stalks [5, 6].

The infusion of aerial parts of the plant was reportedly used for treatment of malaria [7, 8] while decoction from the flowers, leaves and stem were used to cure hepatitis in Taiwan, Kenya, Thaïland [9], haematomas, measles, skin eczema and gastrointestinal disorders [10-12]. In Southwestern Nigeria, the decoction of various parts of this Asteraceae has been used in the amelioration and

treatment of diabetes mellitus, sore throat and liver pains [13]. *Tithonia diversifolia* has been exhaustively studied and possesses several biological activities including the following: anti-inflammatory, analgesic, antimalarial, antiviral, antidiabetic, antidiarrhoeal [6, 14-17]. This plant is important due to its substantial use within traditional medicine in several countries [18].

From chemical point of view, flavonoids and sesquiterpenoid lactones including 8-(2-methylbutanoyl)-3, 10-epoxy-3,8-dihydroxyl-4,11,13-germacradien-12, 6-olide, tagitinin isomers,, diversifolol, diversifolin, tirotudin and hispidulin [17,19-21] have been isolated from the non-volatile fractions of this plant. The chemical composition of essential oils of *Tithonia diversifolia* have been the subject of only four studies previously published. The literature reveals several chemotypes. (Z)-β-ocimene (40.2%), α-pinene (25%) and limonene (13.9%) were the major components of leaf and flower oils from Cameroon [22]. While, Menut et *al.* [23] also reported that the flower oils of *Tithonia diversifolia* harvested to Cameroon contain α-pinene (50.8–60.1%), (Z)-β-ocimene (15.5–21.4%) and limonene (5.4– 6.4%) as the principal components. The leaf oil from Nigeria is found to have α-pinene (32.9%), β-caryophyllene (20.8%), germacrene D (12.6%), β-pinene (9.5%) and 1, 8-cineole (9.1%), while germacrene D (20.3%), β-caryophyllene (20.1%) and bicyclogermacrene (8.0%) were identified in the flower oil of this Asteraceae [13]. Oladipupo et *al.* [24] have described α-pinene (60.9– 75.7%), β-pinene (7.2– 11.0%) and limonene (0.9– 4.3%) as the major components of leave, flower, stem and root oils from South Africa. However, there is no report on the oil component of this plant from Côte d'Ivoire.

The present study reports for the first time, the comparative analyses of the essential oils obtained from *Tithonia diversifolia* collected from different localities of Côte d'Ivoire.

MATERIALS AND METHODS:

Plant Material and Extraction:

Aerial part of wild plant of *Tithonia diversifolia* were collected between January 2008 and December 2010 from different localities of Côte d'Ivoire. Fractions of 500g of fresh vegetal material were submitted to hydrodistillation for 3h using Clevenger apparatus. The oils obtained by decantation dried over anhydrous sodium sulfate and then stored in sealed vial protected from -20°C before gas chromatographic.

Analysis of the Essential Oil:

GC: The essential oil were analyzed on the AGILENT gas chromatograph Model 6890 equipped with a DB5 MS column (30m X 0.25 mm; 0.25 µm), programming from 50°C (5 min) to 300°C/min, 5 min hold. Hydrogen as carrier gas (1.0 ml/min); injection in split mode (1: 60), injector and detector temperature were 280 and 300°C respectively. The essential oil is diluted in acetone or hexane 1/3.

GC/MS: The essential oil were analyzed on a AGILENT gas chromatograph Model 7890, coupled to a AGILENT ms Model 5975 equipped with a DB5 MS column (20m X 0,20 mm, 0,20 µm) programming from 50°C (5 min) to 300°C at 8°C/min, 5 min hold. Helium as carrier gas (1.0 ml/min), injection in split mode (1: 250); injector and detector temperature were 250 and 280°C respectively. The MS working in electron impact mode at 70 eV; electron multiplier, 1500V; ion source temperature, 230°C; mass spectra data were acquired in the scan mode in *m/z* range 33-450.

Compounds were identified by computer search using their mass spectra either with known compounds or published spectra [25] and by comparison of their retention indices with those of known compounds [26].

Statistical Analysis:

The factorial discriminant analysis was performed with Xlstat-Pro7.5.2 (Adinsoft, France).

RESULTS AND DISCUSSION: The essential oils from leaves and stems of *Tithonia diversifolia* were light yellow color with yields of 0.01 – 0.94% and 0.01 – 0.06% (*w*/*w*) respectively. **Table 1** and **2** show the results of qualitative and quantitative oils analyses listed in order of elution DB5 MS column. In total, 83 components were identified by GC and GC/MS analyses accounting for 93.9–96.7%.

FIG.1: SAMPLING LOCALITIES OF *TITHONIA DIVERSIFOLIA* AERIAL PART FROM CÔTE D'IVOIRE

There are 35 monoterpenes hydrocarbons, 5 linear compounds, 48 sesquiterpenes and 5 diterpenes. Although the occurrence of various constituents was observed in all the investigated samples, their proportion varied drastically from sample to sample. The essential oils of aerial part of *Tithonia diversifolia* are predominated by monoterpene hydrocarbons (2.3 – 96.3%) characterized by α-pinene (0.9 – 89.8%), limonene (0.2 – 65.5%) and (Z)-β-ocimene (0 – 39.3%). Other compounds present at appreciable contents were caryophyllene oxide (up to 22.6%), spathulenol (up to 20.4%), (E)-nerolidol (up to 13.6%), ar-curcumene (up to 11.4%), germacrene D (10.6%), α-copaene (up to 9.5%), thymol (up to 5.7%). It should be noted that the presence of the 3-methyl-2 (2-methylbuthenyl) furan is firstly described in the oil of *Tithonia diversifolia* when taking account the literature.

Statistical Analysis:

All the 27 and 16 oil compositions from leaves and stems respectively were subjected to standard methods of statistical analysis such as hierarchical cluster (HCA, **Fig. 2**) and principal components (PCA, **Fig. 3**). The dendrogram shown in **Fig. 2** suggested the presence of two groups within the *Tithonia diversifolia* leaves essential oils. This partitioning was agreed with the result of PCA, in which the third and five axes accounted for 13% and 7% respectively. Therefore, the mean content and standard deviation of the major constituents were calculated for Groups I and II are reported in table and **Fig. 4.**

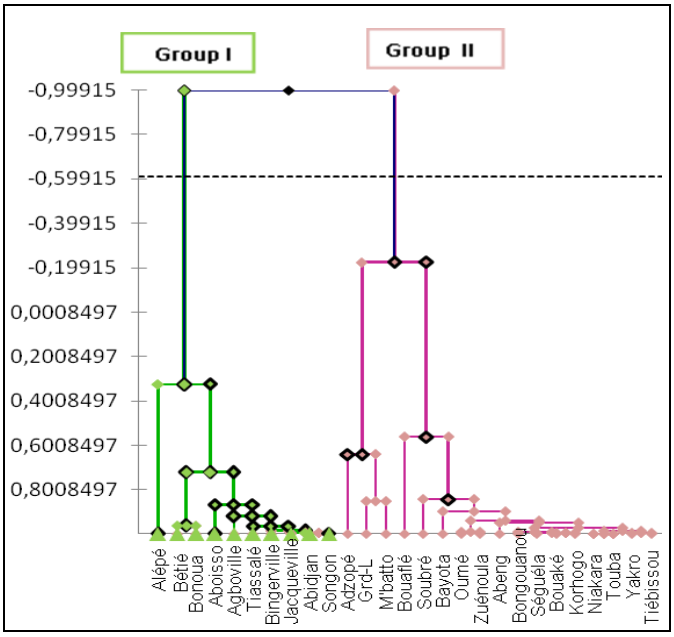


FIG.2: DENDROGRAM OBTAINED BY HIERAICHICAL CLUSTER ANALYSIS OF THE 27 SAMPLES LEAF-OIL FROM TITHONIA DIVERSIFOLIA

The composition of the two groups of samples presented an important percentage in monoterpene hydrocarbons, respectively 70.1% for the group I; 73.0% for the group II. We have also sesquiterpene hydrocarbons at appreciable proportion, 13.1% for the group I and 7.3% for the group II. In the samples of the group I (37% of the samples), the chemical composition was comprised of an abundance of α-pinene (23.8 ± 15.9%), limonene (22.8 ± 17.8%) and (Z)-β-ocimene (16.7 ± 12%). The group I constituted the samples collected in South and South-east from Côte d'Ivoire.

TABLE 1: CHEMICAL VARIABILITY OF THE LEAF ESSENTIAL OILS FROM *TITHONIA DIVERSIFOLIA*

Compound name	RI	Content (%)	
		Group I (10 samples)	Group II (17 samples)
α- thujene	925	0.1 ± 0.1	0.1 ± 0.1
α-pinene	932	23.8 ± 15.9	24.1 ± 11.4
camphene	943	0.1 ± 0.1	0.1 ± 0.1
sabinene	972	2.9 ± 2.2	3.7 ± 2.5
β-pinene	976	3.0 ± 2.6	3.6 ± 1.9
mentha-1(7),8-diene para	1001	0.1 ± 0.1	0.2 ± 0.1

α- terpinene	1015	0.1 ± 0.1	-
para cymene	1023	0.2 ± 0.2	0.1 ± 0.1
limonene	1027	22.8 ± 17.7	28.1 ± 14.3
β- phellandrene	1029	0.1 ± 0.3	-
eucalyptol	1031	0.1 ± 0.4	0.1 ± 0.2
(Z)-β-ocimene	1036	16.6 ± 11.9	12.7 ± 8.4
(E)-β-ocimene	1045	0.1 ± 0.1	0.1 ± 0.1
γ- terpinene	1057	0.1 ± 0.1	-
3-methyl-2(2methylbutenyl) furan	1090	0.1 ± 0.1	5.6 ± 22.8
camphenone	1095	0.1 ± 0.1	-
Linalool	1097	0.1 ± 0.1	-
trans hydrate sabinene	1099	0.1 ± 0.1	0.1 ± 0.2
6-methyl-hepta-3,5-dien-2-one	1104	0.1 ± 0.1	-
(E)-4,8-Dimethyl-1, 3, 7-nonatriene	1111	0.1 ± 0.1	-
α- fenchol (endo)	1118	0.1 ± 0.1	-
cis menth-2-en-1-ol	1123	0.1 ± 0.1	-
cis epoxy ocimene	1137	0.1 ± 0.1	-
allo-ocimene	1143	0.2 ± 0.2	0.1 ± 0.1
trans verbenol	1146	0.1 ± 0.1	0.1 ± 0.1
endo borneol	1173	0.1 ± 0.1	-
terpinene-4-ol	1182	0.4 ± 0.4	0.2 ± 0.1
2,6-dimethyl-3,5,7-octatriene-2-ol	1202	0.2 ± 0.6	0.1 ± 0.1
Verbenone	1209	0.2 ± 0.1	0.1 ± 0.1
3-methyl-non-2-en-4-one	1213	0.1 ± 0.1	0.1 ± 0.1
trans carveol	1231	0.1 ± 0.2	-
thymolmethylether	1228	0.1 ± 0.1	-
neral	1235	0.1 ± 0.1	-
geraniol	1253	0.1 ± 0.1	0.1 ± 0.2
geranial	1271	0.1 ± 0.1	0.2 ± 0.4
aldehyde perillique	1276	0.1 ± 0.2	0.1 ± 0.1
thymol	1291	1.4 ± 2.1	0.3 ± 0.8
cavacrol	1300	0.1 ± 0.1	0.1 ± 0.3
Bicycloelemene	1336	0.1 ± 0.1	-
α- cubebene	1349	0.1 ± 0.1	0.1 ± 0.1
iso-geranial	1365	0.1 ± 0.1	-
isoledene	1372	0.1 ± 0.2	-
α-copaene	1380	2.1 ± 2.7	1.3 ± 1.1
β-elemene	1389	0.1 ± 0.1	0.1 ± 0.1
β-cubebene	1392	0.1 ± 0.3	-
italicene	1409	0.2 ± 0.6	-
β- caryophyllene	1426	3. 6 ± 2.1	2.8 ± 2.5
Trans- α- bergamotene	1436	0.1 ± 0.1	-
cadina-4,11-diene	1455	0.1 ± 0.1	-
α -humulene	1461	0.3 ± 0.3	0.2 ± 0.2
allo aromadendrene	1462	0.1 ± 0.1	0.1 ± 0.1
γ- curcumene	1479	0.1 ± 0.3	-
germacrene-D	1481	1.6 ± 3.2	0.3 ± 0.6
ar-curcumene	1485	1.2 ± 3.6	-
β-selinene	1492	0.6 ± 0.5	0.4 ± 0.3
α- selinene	1494	0.3 ± 0.5	0.1 ± 0.4
bicyclogermacrene	1495	0.9 ± 0.9	1.0 ± 1.0
δ- amorphene	1500	0.5 ± 0.7	-
(Z)-α -bisabolene	1506	0.1 ± 0.1	-
β -bisabolene	1508	0.1 ± 0.1	0.2 ± 0.2
γ- cadinene	1511	0.1 ± 0.1	-
δ -cadinene	1522	0.5 ± 0.7	-
(E)-nerolidol	1565	2.6 ± 4.0	1.2 ± 1.1
spathulenol	1584	2.6 ± 2.8	2.6 ± 4.8
Caryophyllene oxide	1585	1.7 ± 1.9	2.3 ± 5.3
eudesma-4(15),7-diene-3β-ol	1586	0.4 ± 0.7	0.3 ± 0.3

β- copaen-4-α-ol	1591	0.1 ± 0.1	0.1 ± 0.1
cuminul butyrate (33,12)	1605	0.2 ± 0.2	0.1 ± 0.1
humulene-1,2-epoxide	1617	0.1 ± 0.1	0.1 ± 0.1
10-epi-γ-eudesmol	1624	0.1 ± 0.1	0.2 ± 0.2
valerenol	1632	0.2 ± 0.3	-
isospathulenol	1638	0.1 ± 0.1	-
caryophylla-4(12), 8(13)-diene-5-β-ol	1644	0.1 ± 0.1	0.1 ± 0.1
epi -α- cadinol	1647	0.1 ± 0.1	0.2 ± 0.2
α- cadinol	1662	0.3 ± 0.3	0.3 ± 0.3
neo intermdeol	1665	0.4 ± 0.4	0.4 ± 0.4
14-hydroxy-9-epi-(E)- caryophyllene	1673	0.1 ± 0.2	-
cadalene	1676	0.2 ± 0.5	0.1 ± 0.1
α- Bisabolol	1688	0.1 ± 0.2	0.1 ± 0.5
(Z)-trans -α -bergamotol	1694	0.3 ± 1.0	-
flacarinol	2031	0.1 ± 0.1	0.1 ± 0.1
phytol	2108	0.1 ± 0.2	0.1 ± 0.2
Monoterpene hydrocarbons		70	72.7
Oxygenated monoterpenes		3.7	7.2
Sesquiterpenes hydrocarbons		9.2	6.6
Oxygenated sesquiterpenes		9.7	8.1
Oxygenated diterpenes		0.2	0.2
Linear compound		0.7	0.2
Total identified		93.5	95

Order of elution and contents determinated on the apolar column. Retention index determinated on the apolar column. Contents are given as mean ± standard deviation. Contents determinated by GC-FID data.

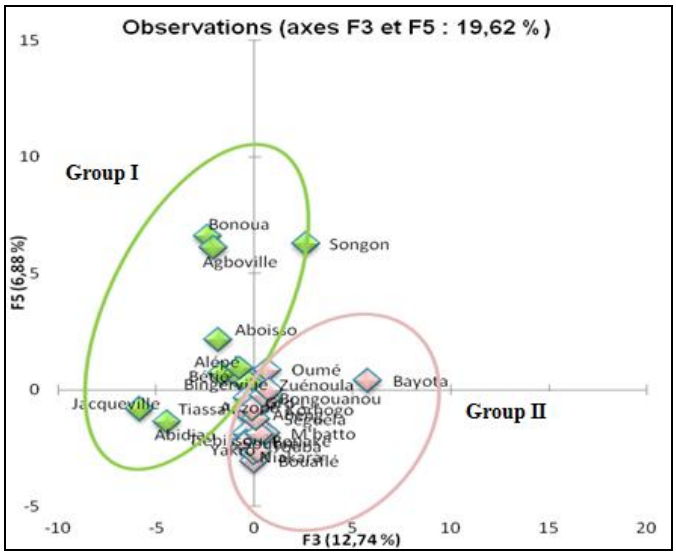


FIG.3: PRINCIPAL COMPONENT ANALYSIS OF THE 27 *TITHONIA DIVERSIFOLIA* LEAF-OIL SAMPLES

The samples belonging to Group II (63% of the samples) were characterized by limonene (28.1± 14.3%), α-pinene (24.1±11.4%), (Z)-β-ocimene (12.7±8.4%) and 3-methyl-2(2methylbutenyl)furan (5.6 ± 22.8%). Sabinene (3.7 ± 2.5%), β-pinene (3.6±1.9%), β- caryophyllene (2.8± 2.5%), spathulenol (2.6±4.8%) and Caryophyllene oxide (2.3±5.3%) were present at appreciable contents. It is noteworthy that 3-methyl-2(2methylbutenyl) furan which represented 94% of essential leaf-oil from Bouaflé (Centre-west) was firstly described in the oil of *Tithonia diversifolia*.

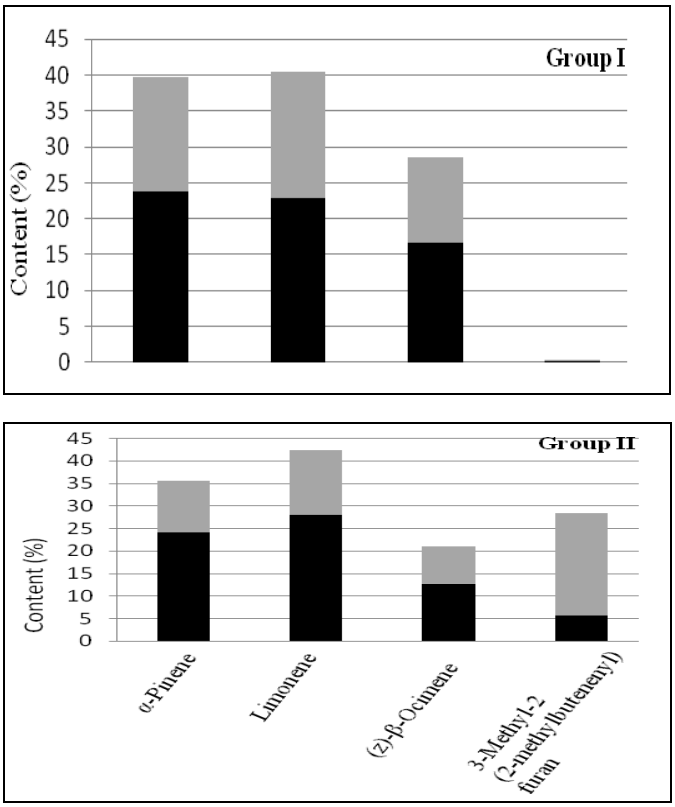


FIG.4: CONTENT OF MAJOR COMPONENTS OF THE *TITHONIA DIVERSIFOLIA* LEAF-OIL SAMPLES OF GROUPS I AND II.
Black, mean content; gray standard deviation.

The dendrogram based on hierarchical cluster (HCA, **Fig. 5**) has showed the presence of two groups concerning to the 16 stem-oil samples. That confirmed by result obtained from principal components analyses, in which the first two axes accounted for 26 and 14% variability respectively (PCA, **Fig. 6**).

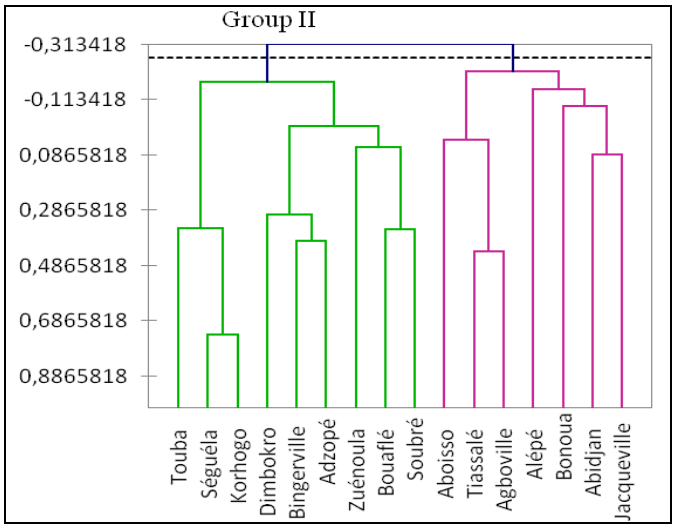


FIG.5: DENDROGRAM OBTAINED BY HIERAICHICAL CLUSTER ANALYSIS OF THE 16 *TITHONIA DIVERSIFOLIA* STEM-OIL SAMPLES

The first group (37.5% of the samples) consisted of samples collected at Jacqueville, Abidjan, Bonoua, Alépé Agboville, Tiassalé and Aboisso in the south and south-east of Côte d'Ivoire. These localities were characterized by α-pinene (44.3 ± 28.4%), limonene (10.1 ± 7.6%) and (Z)-β-ocimene (7.9 ± 6.9%), accompanied by spathulenol (2.8 ± 4.5%), sabinene (2.5 ± 1.4%) and thymol (2.3 ± 1.6%).

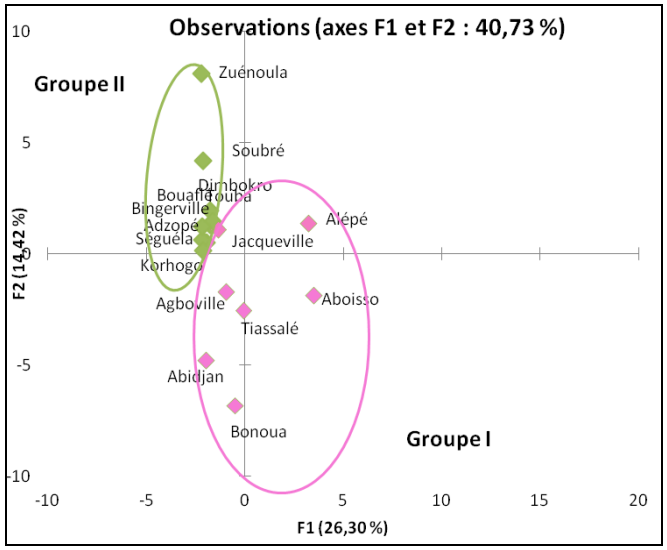


FIG.6. PRINCIPAL COMPONENT ANALYSIS OF TITHONIA DIVERSIFOLIA STEM-OIL SAMPLES

The second group (62.5% of the samples) formed by the samples collected at Soubré, Bouaflé, Zuénoula, Adzopé, Bingerville, Dimbokro, Korhogo, Séguéla and Touba. The chemical composition of this group is predominated by α-pinene (59.5 ± 20.1%), accompanied by limonene (14.1 ± 10.1%), (Z)-β-ocimene (10.3 ± 10.8%), β-pinene (5.0 ± 3.7%) and sabinene (2.2 ±1.3%).

TABLE 2: CHEMICAL VARIABILITY OF THE STEM ESSENTIAL OILS ISOLATED FROM *TITHONIA DIVERSIFOLIA*

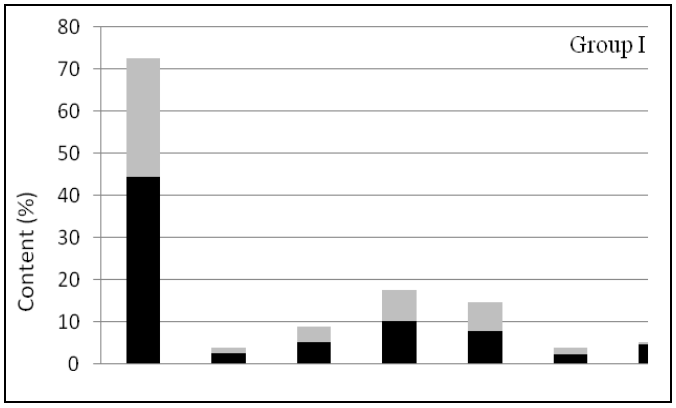
Compound name	RI	Content (%)	
		Group I (7 samples)	Group II (9 samples)
α- thujene	925	0.1 ± 0.1	0.1 ± 0.1
α-pinene	932	44.3 ± 28.3	59.5 ± 20
camphene	943	0.1 ± 0.1	0.1 ± 0.2
sabinene	972	2.5 ± 1.4	2.2 ± 1.3
β-pinene	976	5.1 ± 3.7	5.0 ± 3.7
myrcène	988	0.1 ± 0.1	-
mentha-1(7),8-diene para	1001	-	0.1 ± 0.1
para cymene	1023	0.3 ± 0.2	0.1 ± 0.1
limonene	1027	10.1 ± 7.5	14.0 ± 10.9
eucalyptol	1031	1.0 ± 1.5	-
(Z)-β-ocimene	1036	7.8 ± 6.9	10.3 ± 10.7
(E)-β-ocimene	1045	0.1 ± 0.1	0.1 ± 0.1
γ- terpinene	1057	0.1 ± 0.1	-
terpinolene	1083	0.1 ± 0.1	-
3-methyl-2(2methylbutenyl)furan	1090	0.1 ± 0.1	-
camphenone	1095	0.1 ± 0.1	-
Linalool	1097	0.1 ± 0.1	-
trans hydrate sabinene	1099	0.2 ± 0.4	-
6-methyl-hepta-3,5-dien-2-one	1104	0.1 ± 0.1	-
(E)-4,8-Dimethyl-1,3,7-nonatriene	1111	0.1 ± 0.1	-

cis menth-2-en-1-ol	1123	0.2 ± 0.2	0.1 ± 0.1
myroxyde (Z)	1129	0.2 ± 0.3	-
neo allo-ocimene	1143	0.3 ± 0.6	-
trans verbenol	1146	1.0 ± 1.5	-
Cis chrysanthenol	1163	0.2 ± 0.6	-
terpinene-4-ol	1182	0.8 ± 0.5	0.3 ± 0.2
cryptone	1191	0.4 ± 0.9	-
α-terpineol	1196	0.6 ± 0.9	0.2 ± 0.1
Verbenone	1209	0.1 ± 0.1	0.1 ± 0.1
3-methyl-non-2-en-4-one	1213	0.4 ± 1.0	0.1 ± 0.1
trans carveol	1231	0.1 ± 0.1	-
thymol	1291	2.3 ± 1.6	0.1 ± 0.2
cavacrol	1300	0.6 ± 1.4	-
δ-elemene	1339	0.2 ± 0.4	-
α- cubebene	1349	0.1 ± 0.2	-
eugenol	1353	0.1 ± 0.2	-
iso-geranial	1365	0.1 ± 0.1	-
isoledene	1372	0.1 ± 0.2	-
α-copaene	1380	0.4 ± 0.4	0.3 ± 0.1
isodauca-4,6-diene	1386	0.4 ± 0.7	-
β- caryophyllene	1426	0. 5 ± 0.8	0.5± 0.7
Trans- α- bergamotene	1436	0.1 ± 0.1	-
Geranyl acetone	1445	0.2 ± 0.4	-
germacrene-D	1481	0.1± 0.1	0.1 ± 0.1
β-selinene	1492	0.1 ± 0.1	0.4 ± 0.3
α- selinene	1494	0.9 ± 0.7	-
bicyclogermacrene	1495	0.6 ± 1.2	0.3 ± 0.8
(Z)-α -bisabolene	1506	0.1 ± 0.2	-
γ- cadinene	1511	0.2 ± 0.5	-
δ -cadinene	1522	0.1 ± 0.1	0.1 ± 0.1
(E)-nerolidol	1565	0.8 ± 0.6	0.2 ± 0.2
Dendrosalin (clausena anisata)	1570	0.1 ± 0.1	-
spathulenol	1584	2.8 ± 4.5	0.6 ± 0.6
Caryophyllene oxide	1585	1.1 ± 1.5	0.1 ± 0.1
eudesma-4(15),7-diene-3β-ol	1586	0.2 ± 0.2	0.2 ± 0.2
β- copaen-4-α-ol	1591	0.3 ± 0.8	0.1 ± 0.1
humulene-1,2-epoxide	1617	0.4 ± 0.8	-
10-epi-γ-eudesmol	1624	0.1 ± 0.1	0.1 ± 0.1
epi -α- cadinol	1647	-	0.1 ± 0.1
cubenol	1653	0.1 ± 0.1	-
α- cadinol	1662	0.3 ± 0.3	0.1 ± 0.1
neo intermdeol	1665	0.3 ± 0.5	0.1 ± 0.1
α- Bisabolol	1688	0.1 ± 0.1	-
(Z)-trans -α -bergamotol	1694	0.3 ± 0.5	-
Benzyl benzoate	1765	0.3 ± 0.6	-
Methyl hexadecanoate	1924	0.2 ± 0.2	-
isophytol	1944	0.9 ± 2.1	-
flacarinol	2031	0.5 ± 0.4	0.3 ± 0.2
abiatatriene	2057	0.2 ± 0.4	-
phytol	2108	0.1 ± 0.2	0.1 ± 0.2
Monoterpene hydrocarbons		70.7	91.5
Oxygenated monoterpenes		7.8	0.9
Sesquiterpenes hydrocarbons		3.9	1.7
Oxygenated sesquiterpenes		7.2	1.6
Diterpenes hydrocarbons		0.2	0.3
Oxygenated diterpenes		1.5	0.1
Linear compound		1.3	0.1
Total identified		92.6	96.2

Order of elution and contents determinate on the apolar column. Retention index determinate on the apolar column. Contents are given as mean ± standard deviation. Contents determinate by GC-FID data.

We noted that chemical composition of the two group samples have commonly constituted by α-pinene, limonene, (Z)-β-ocimene, β-pinene and sabinene as major component. The presence of the thymol (aromatic compound) and the spathulenol (oxygenated sesquiterpene) in the first group (samples collected in Sud and Sud-east localities) marked the difference. We have noted that samples collected in West (Zuenoula, Soubré, Bouaflé) and Nord (Séguéla, Touba, Korhogo) of the country are mainly characterized by monoterpene hydrocarbons (91.5%) namely α-pinene (59.5 ± 20.0%), limonene (14.0 ± 10.9%), (Z)-β-ocimene (10.3 ± 10.7%) and β-pinene (5.0 ± 3.7%).

According to the literature, there is one report concerning the description of stem-oil of *Tithonia diversifolia*. The main constituents were α-pinene (61.4%) and β-pinene (11.0%) [18]. In effect, it's important to note that thymol and spathulenol chemotype which are described in our investigation is a significant result for this Asteraceae study.



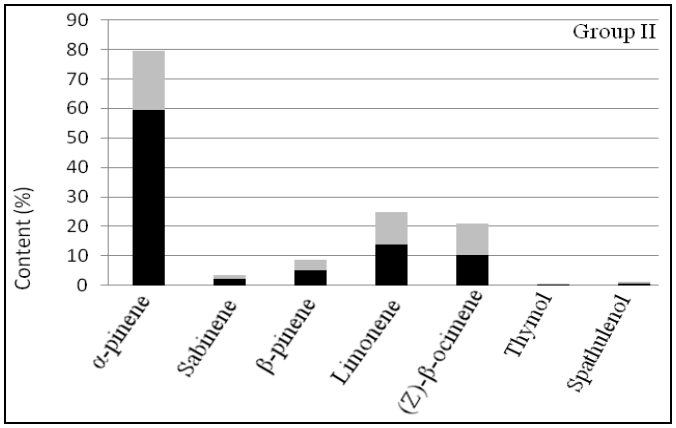


FIG.7. CONTENT OF MAJOR COMPONENTS OF THE *TITHONIA DIVERSIFOLIA* STEM-OIL SAMPLES OF GROUPS I AND II.

Black, mean content; gray standard deviation

CONCLUSIONS: Chemical composition of essential oils of aerial part (leaf, stem) of *Tithonia diversifolia* predominated by monoterpene hydrocarbons such as α-pinene, limonene and (Z)-β-ocimene. Nevertheless, spathulenol, (E)-nerolidol, caryophyllene oxide (oxygenated sesquiterpenes) appear in chemical composition of certain samples at appreciable proportion. We also noted the presence of 3-methyl-2(2methylbutenyl) furan as new compound in leaf oil at 94%. Thymol which is also an aromatic compound is present in our samples.

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