VOLATILE PROFILES AND BIOLOGICAL PROPERTIES OF CYMBOPOGON CITRATUS, CYMBOPOGON GIGANTEUS, CYMBOPOGON SHOENANTHUS, AND THEIR ISOLATED COMPOUNDS: A REVIEW

Annick Flore Arlette Dohoué BOSSOU1,2, Gbédossou Sophie Reine BOGNINOU1, Cokou P. AGBANGNANAOSA1, Houmannkpon YEDOMONHAN2, Félicien AVLESSI1, Dominique C. K. SOHOUNHLOU2

1Laboratory of Study and Research in Applied Chemistry, Polytechnic School of Abomey-Calavi, University of Abomey-Calavi, Abomey-Calavi, Benin
2Laboratory of Botanic and Plant Ecology, Faculty of Sciences and Techniques, University of Abomey-Calavi, Abomey-Calavi, Benin

Article Info: Received 04 January 2019; Accepted 26 January. 2020
DOI: https://doi.org/10.32553/jbpr.v9i1.711
Address for Correspondence: Annick Flore Arlette Dohoué BOSSOU
Conflict of interest statement: No conflict of interest

ABSTRACT:

Essential oils are worldwide used for their several biological properties. As such, the genus Cymbopogon is an interesting source of essential oils. Among the genus Cymbopogon, the most studied plant species, especially in West Africa, are C. citratus, C. giganteus and C. Schoenanthus. The essential oils extracted from these plants are sought for their various properties such as their insecticidal, analgesic, anti-inflammatory, antioxidant, hypotensive properties. Their anti-leishmaniasis, antimicrobial, antiplasmodial anti-acetylcholinesterase, anti-trypanosomal, anti-nociceptive and anticonvulsant potentials were also noted. These different properties are related to the presence of secondary metabolites in these essential oils. It follows that, the Cymbopogon species as well as the volatile compounds contained in their essential oils constitute interesting sources of new bioactive substances likely to fight against several types of resistance phenomena. Thus this literature review constitutes a scientific basis which can contribute to the economic valorization of the genus Cymbopogon.

Keywords: Cymbopogon species, volatile profiles, biological properties, cytotoxicity.

1. INTRODUCTION

Cymbopogon citratus is a perennial grass with short rhizome up to 2 m high. Fertile culms are rare and the leaves are highly aromatic [1]. The flowers are bisexual or unisexual and the fruit is a dry indehiscent caryopsis with a thin pericarp [2]. C. giganteus is a perennial grass, 2.5 meters high, with slightly aromatic glaucous leaves. Its dense panicles are narrow and its flowers appear throughout the year [1]. C. schoenanthus is an aromatic vivacious herb of drier parts of tropical Africa that can reach 60 to 80 cm high. This plant species possesses linear and fragrant leaves and its inflorescences are contracted in panicles [1]. Many other species, not as studied as the previous three species also belong to the genus cymbopogon. These plant species are traditionally used in many area were they occur, mainly to fight against several diseases. Moreover, scientists are studied this genus to offer scientific bases to traditionally uses. The present review was conducted to highlight the traditional and scientifically demonstrated uses of cymbopogon species.

2. TRADITIONAL USES OF CYMBOPOGON SPECIES

Cymbopogon species are worldwide traditionally used for several purposes especially in Africa. In Benin [3] and in Nigeria [4], C. citratus leaves are used to treat malaria, fever and to repel mosquitoes. The decoction of the leaves and the roots of Securidaca longepedunculata is administered orally in the treatment of snakebites and in the treatment of edema, jaundice and anemia [1]. In Congo, the leaves decoction of Cymbopogon citratus is used for its hypotensive properties [5]. The decoction of the leaves of Cymbopogon giganteus and Ocimum basilicum, is used in the treatment of drepanocytosis and the decoction of leafy stems in case of epilepsy crises [1, 6]. Cymbopogon citratus and Cymbopogon giganteus are traditionally used in Congo, for their anti-ulcerative potential [7]. In Burkina-Faso, the fresh roots decoction is used against toothache, gingivitis and sores in the mouth, the tongue and on the lips [8]. In Congo, the infusion of roots and leaves is drunk against stomachaches [7]. In Benin, the whole plant is burnt for its repellency property against mosquitoes [3]. In Benin, C. schoenanthus is used as insect repellent and natural insecticide [3]. The whole plant, crushed and mixed with...
leaves of *Vitex simplicifolia* is indicated in traditional medicine against schizophrenia [1]. In Tunisia, *Cymbopogon* is eaten in salads and used to prepare traditional meat recipes [9]. In Congo-Brazaville the infusion of the leaves is used to treat stomachache [7].

3. **CHEMICAL COMPOSITION**

3.1. **Volatile profile of Cymbopogon citratus**

Table 1: Main volatile compounds of *Cymbopogon citratus*

<table>
<thead>
<tr>
<th>Countries</th>
<th>Extracts</th>
<th>Main volatile compounds</th>
<th>References</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brazil</td>
<td>Essential oil (fresh leaves)</td>
<td>myrcene (11.1%), neral (31.5%), geranial (47.5%)</td>
<td>[10]</td>
</tr>
<tr>
<td>Brazil</td>
<td>Essential oils (blades, sheaths and rhizomes)</td>
<td>Blades: Neral (30.1%), geranial (39.9%); Sheats: Neral (27.8%), geranial (50.0%); Rhizome: selina-6-en-4-ol (27.8%), α-cadinol (8.2%), neointermediol (7.2%), eudesma-7(11)-en-4-ol (5.3%).</td>
<td>[11]</td>
</tr>
<tr>
<td>Burkina- Faso</td>
<td>Essential oil (leaves)</td>
<td>myrcene (10.7%), neral (33.0%), geranial (44.6%)</td>
<td>[12]</td>
</tr>
<tr>
<td>Burkina- Faso</td>
<td>Essential oil (leaves)</td>
<td>geranial (48.1%), neral (34.6%), myrcene (11.0%)</td>
<td>[13]</td>
</tr>
<tr>
<td>Burkina- Faso</td>
<td>Essential oils (leaves)</td>
<td>geranial/citral A (48.18%), neral/citral B (34.37%).</td>
<td>[14]</td>
</tr>
<tr>
<td>Portugal</td>
<td>Essential oil (aerial parts)</td>
<td>myrcene (11.5%), neral (32.5%), geranial (45.7%)</td>
<td>[15]</td>
</tr>
<tr>
<td>Cameroon</td>
<td>Essential oil (leaves)</td>
<td>myrcene (11.4%), neral (30.2%), geranial (32.8%), geraniol (8.2%)</td>
<td>[16]</td>
</tr>
<tr>
<td>Benin</td>
<td>Essential oil (leaves)</td>
<td>myrcene (12.4%), neral (33.1%), geranial (44.3%)</td>
<td>[17]</td>
</tr>
<tr>
<td>Benin</td>
<td>Essential oil (leaves)</td>
<td>geranial (27.04%), neral (19.93%), myrcene (27.04 %)</td>
<td>[18]</td>
</tr>
<tr>
<td>Benin</td>
<td>Essential oil (leaves)</td>
<td>geranial (39.5%), neral (35.5%), β-pinene (10.1%), cis-geraniol (4.3%)</td>
<td>[19]</td>
</tr>
<tr>
<td>Brazil</td>
<td>Essential oil (leaves)</td>
<td>geranial (51.46%), neral (19.83%), myrcene (16.5%), geraniol (1.28%)</td>
<td>[20]</td>
</tr>
<tr>
<td>Togo</td>
<td>Essential oil (leaves)</td>
<td>myrcene (67%) et geranial (12%)</td>
<td>[21]</td>
</tr>
<tr>
<td>Togo</td>
<td>Essential oil (aerial parts)</td>
<td>geranial (45.2%), neral (32.4%) and myrcene (10.2%)</td>
<td>[22]</td>
</tr>
<tr>
<td>Peru</td>
<td>Essential oil (leaves)</td>
<td>geranial (49.9%), neral (30.9%), geraniol (10.4%)</td>
<td>[23]</td>
</tr>
<tr>
<td>Mali</td>
<td>Essential oil (aerial parts)</td>
<td>myrcene (6.2%-9.1%), neral (21.3-32.5%), geranial (45.3%-56.2%)</td>
<td>[24]</td>
</tr>
<tr>
<td>Ivory-Coast</td>
<td>Essential oil (aerial parts)</td>
<td>myrcene (8.1%-22.6%), neral (23.6-26.3%), geranial (30.5%-34.0%)</td>
<td>[24]</td>
</tr>
</tbody>
</table>

3.2. **Volatile profile of Cymbopogon giganteus** Chiov (Poaceae)

The volatile profile of *C. giganteus* was characterized by the presence of a set of monoterpene alcohols, namely *E*-mentha-1(7),8-dien-2-ol (14.2%), *Z*-mentha-1(7),8-dien-2-ol (12%), *E*-mentha-2,8-dien-1-ol (5.6%) and *Z*-mentha-2,8-dien-1-ol (5.2%) (Table 2).

Table 2: Main volatile compounds of *Cymbopogon giganteus*

<table>
<thead>
<tr>
<th>Countries</th>
<th>Extracts</th>
<th>Main volatile compounds</th>
<th>References</th>
</tr>
</thead>
<tbody>
<tr>
<td>Burkina- Faso</td>
<td>Essential oils (leaves)</td>
<td>limonene (42%) and a set of monoterpene alcohols, namely <em>E</em>-mentha-1(7),8-dien-2-ol (14.2%), <em>Z</em>-mentha-1(7),8-dien-2-ol (12%), <em>E</em>-mentha-2,8-dien-1-ol (5.6%) and <em>Z</em>-mentha-2,8-dien-1-ol (5.2%)</td>
<td>[13]</td>
</tr>
<tr>
<td>Burkina- Faso</td>
<td>Essential oils (leaves)</td>
<td>Limonene (19.33%), <em>Z</em>-Mentha-1(7),8-dien-2-ol (17.34%), <em>E</em>-Mentha-1(7),8-dien-2-ol (13.95%), <em>E</em>-p- Mentha-2,8-diene-ol (13.91%) et <em>Z</em>-p-Mentha-2,8-diene-1-ol (8.10%)</td>
<td>[14]</td>
</tr>
</tbody>
</table>
| Benin       | Essential oils                  | *E*-mentha-1(7),8-dien-2-ol (19.6%), *E*-mentha-2,8-dienol (19.3%), *Z*-p-
3.4. Main volatile compounds of other Cymbopogon species

The other species of *cymbopogon* are characterized by other main compounds such as piperitone, citronellal α-eudesmol, geranial, and neral etc... (Table 4).
Table 4: Volatile profile of other Cymbopogon species

<table>
<thead>
<tr>
<th>Plante species</th>
<th>Countries</th>
<th>Extracts</th>
<th>Main volatile compounds</th>
<th>References</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cymbopogon jawarancusa</td>
<td>India</td>
<td>Essential oil (aerial part)</td>
<td>piperitone (58.6%), elemol (18.6%)</td>
<td>[36]</td>
</tr>
<tr>
<td>Cymbopogon Olivieri Boissi</td>
<td>Iran</td>
<td>Essential oil (aerial part)</td>
<td>δ-3 carene (22.46%), piperitone (44.90%), α-eudesmol (13.33%).</td>
<td>[37]</td>
</tr>
<tr>
<td>Cymbopogon nardus.</td>
<td>Togo</td>
<td>Essential oil (aerial part)</td>
<td>citronellal (35.5%), geraniol (27.9%), citronellol (10.7%)</td>
<td>[22]</td>
</tr>
<tr>
<td>Cymbopogon nardus.</td>
<td>Benin</td>
<td>Essential oil (leaves)</td>
<td>β-citronellal (35.9%), nerol (24.3%), β-citronellol (11.6%), elemol (9.0%), limonene (2.2%)</td>
<td>[19]</td>
</tr>
<tr>
<td>Cymbopogon martinii</td>
<td>Brazil</td>
<td>Essential oil</td>
<td>geraniol (81.4%), Isomenthyl isomenthyl acetate (10.1%), Linalool (2.6%), Geranial (2.1%)</td>
<td>[30]</td>
</tr>
</tbody>
</table>

4. BIOLOGICAL PROPERTIES OF CYMBOPOGON SPECIES

4.1. Biological properties of Cymbopogon citratus (DC.) Stapf (Poaceae)

The biological properties of Cymbopogon citratus have been demonstrated in various domains. Indeed the essential oil extracted from C. citratus in Brazil revealed to be active against larvae of Aedes aegypti with LC50 (0.28 μg/mL) and LC90 (0.56 μg/mL) [38]. When tested against larvae of Culex tritaeniorhynchus and Anopheles subpictus, a good repellency and larvicidal activity was observed and the lethal concentrations LC50 and LC90 were 136.58 ppm and 243.18 ppm for Cx. Tritaeniorhynchus; 77.24 ppm and 128.39 ppm for A. subpictus [39]. Larvicidal, insecticidal and repellent activities have been detected against A. arabiensis with LC50 = 74.02 ppm and LC90 = 158.20 ppm [40, 41], and Tribolium castaneum with a mean repellent dose after 4 hours exposure of 0.021 m/L [42]. Insecticidal properties against Sitophilus oryzae by topical application assays was noticed with the essential oil extracted from the fresh leaves of C. citratus. LC50 = 0.027 μL mL⁻¹ and 70% and 100% mortality recorded respectively after 24 h and 48 h were obtained [10]. This leaves essential oil has also demonstrated its insecticidal properties against Anopheles funestus larvae with LC50 = 35.5 ppm and 34.6 ppm, respectively, for larval stages III and IV after 6 h of exposure [16]. It adulticidal activity again Tribolium castaneum, by fumigation, with LC50 value of 4.2 m/L air after 24 h, was reported. Following WHO test procedures for insecticide resistance monitoring in malaria vector mosquitoes, a diagnostic dose of 0.77% for C. citratus compared to permethrin 0.75%, was obtained against the resistant strain of Anopheles gambiae {17]. Anti-Leishmanina activity of C. citratus essential oil and a mixture of its main compounds obtained from 40% neral and 60% geranial, has been noticed against L. infantum, L. tropica and L. major. IC50 concentrations ranged from 25 to 52 μg/ml for C. citratus essential oil, and from 34 to 42 μg/mL for the mixture of citral were obtained [15]. By topical application assays, the essential oil of C. citratus demonstrated a strong toxicity (LC50 = 0.027 μL mL⁻¹) at a short exposure. After 24 h and 48 h, 70% and 100% mortality of S. oryzae was noticed, respectively [10].

A potent antimicrobial activity has been demonstrated against various microorganisms. The minimal inhibitory concentrations obtained were 1.0 mg/ml for Enterococcus faecalis, 2.1 mg/ml for Salmonella enteric and 2.5 mg/ml for S. typhimurium [13]. Moreover the essential oil of C. citratus, originating from Congo, has shown interesting antibacterial activity against 17 different bacteria species [43]. The in vitro antiplasmodial activity against the resistant strain of Plasmodium falciparum was observed with an IC50 value of 4.2 ± 0.5 μg/mL [16]. Moreover, the aqueous extract of C. citratus at 310 mg/kg/day was more effective as bood schizonticide against Plasmodium berghei (71.4% of suppression of parasitaemia), compared to chloroquine (22.5%). Its efficiency was closed to that of sulphadoxine/pyrimethamine (79.7%) [44].

C. citratus lipid- and essential oil-free leaves infusion, and its polyphenolic compounds, were shown to be natural and safe sources of new anti-inflammatory drugs [45]. Other antioxidant, antiradical and anti-inflammatory properties were also noticed, as well [12, 45-47]. Indeed, C. citratus has demonstrated nitric oxide (NO) scavenging activity and has inhibited inducible NO synthase (iNOS) protein expression [46]. Beside the inhibition of iNOS expression and NO production, the polyphenolic compounds extracted from C. Citratus has also inhibited various lipopolysaccharide (LPS)-induced pathways like p38 mitogen-activated protein kinase (MAPK), c-jun NH2-terminal kinase (JNK) 1/2 and the transcription nuclear factor (NF)-KB [45]. Lemongrass pretreatment has demonstrated a cardio-protective activity at a dose of 200 mg/kg b.wt, by decreasing activity of cardiac markers in serum, and the toxic events of lipid peroxidation (TBARS) in both serum and
heart tissue. The consequence is the increasing of cardiac markers in heart homogenate, the level of enzymatic antioxidants and non-enzymatic antioxidants in both heart homogenate and serum sample [48]. Its property to reduce the blood cholesterol level was reported as well [20]. When tested by formol-induced edema in the animals, *C. citratus* essential oil has demonstrated an anti-inflammatory activity by reducing the edema over time in a dose dependent manner and a preventive effect at 3,000 mg/kg of animal weight [18]. The promising in vitro antitrypanosomal properties of *C. citratus* against *Trypanosoma brucei brucei* with IC\(_50\) values of 1.837±0.13 μg/mL, was demonstrated, compared to the standard compound (suramine) with IC\(_50\) was 0.11±0.02 μg/mL [19].

4.2. Biological properties of *Cymbopogon giganteus* Chiov. (Poaceae)

Concerning the biological activities, *C. giganteus* essential oil has shown insecticidal, larvicidal and ovicidal activity against *Callosobruchus maculatus* through the destruction of growing eggs or larvae [25], against *C. maculatus* and *C. subinnotatus* with an oviposition reduction of 91% in *C. subinnotatus* population at 5 μL/L versus 81% in *C. maculatus* population [27]. The hight antimicrobial properties of essential oils extracted from flowers, leaves and stems of *Cymbopogon giganteus* against Gram-(+)- and Gram-(--)-bacteria as well as the yeast *Candida albicans* was shown [29].

The high in vitro antitrypanosomal property of essential oil extracted from *C. giganteus* against *Trypanosoma brucei brucei* with IC\(_50\) values of 0.25±0.11 μg/mL compared to the standard compound(suramine) with IC\(_50\) was 0.11±0.02 μg/mL, was reported [19].

4.3. Biological properties of *Cymbopogon schoenanthus* (L.) Spreng. (Poaceae)

The insecticidal activity of *C. schoenanthus* essential oil and its main constituent, piperitone has been demonstrated on *Callosobruchus maculatus* with LC\(_50\) values of 1.6 μL/L and 2.7 μL/L, respectively [32]. Its adulticidal activity against *Dinarmus basalis* has been also reported [31]. The insecticidal activity of *C. schoenanthus* by fumigation against *Tribolium castaneum*, with the LC\(_50\) values after 24 h, of 2.1 mL/L air, and a mortality of 72% was reported [49]. Its activity against ovine trichostrongylids and gastrointestinal nematodes (*Haemonchus contortus* and *Trichostrongyulus spp.* ) has been demonstrated [30].

The antimalarial, antioxidant and antiacetylcholinesterase properties of *C. schoenanthus* have been shown as well [9, 33, 50]. Indeed *C. schoenanthus* essential oil was effective against *Escherichia coli*, *Staphylococcus aureus*, methicillin-sensitive (MSSA) *S. aureus* (MRSA) and *Klebsiella pneumonia* with the following MIC values of 9.37 μg/mL for *E. coli* 4.69 μg/mL for *S. aureus* (MRSA), 2.34 mg/mL for MSSA and 2.34 μg/mL for *K. pneumonia* [35].

The good antioxidant activity of the proanthocyanidin extract, by DPPH test, and the methanol extract, by b-carotene/linoleic acid test, of *C. schoenanthus* was demonstrated with IC\(_50\) of 17.1 μg/mL and 0.11 mg/mL, respectively. Its moderate acetylcholinesterase inhibition activity was reported as well with IC\(_50\) ranged between 0.23 and 0.75 mg/mL [50].

The goog in vitro antitrypanosomal property of essential oil extracted from *C. schoenanthus* against *Trypanosoma brucei brucei* with IC\(_50\) values of 2.10±0.89 μg/mL was revealed [19].

4.4. Biological properties of other *Cymbopogon* species

*Cymbopogon martini* and *Cymbopogon flexuosus* essential oils originated from Colombia were more effective as repellents than the commercial repellent IR3535. Indeed the percentages of repellency obtained at 0.002 μL/cm\(^2\), 0.02 μL/cm\(^2\), 0.2 μL/cm\(^2\), were 51%, 82% and 94% for *Cymbopogon flexuosus* and 73%, 89% and 95% for *Cymbopogon martini*, after two hours of exposure, compare to IR3535, for which 39%, 50% and 72% of repellency were recorded [51].

The good in vitro antitrypanosomal property of *C. nardus* against *Trypanosoma brucei brucei* with IC\(_50\) values of 5.71±1.40 μg/mL, was shown. The promising acaricide property of the essential oil extracted from the dry sample of *C. nardus* against *Anocentor nitens* larvae, was reported as 0.0%, 90.8%, 100.0%, and 100.0% at the concentrations of 6.25%, 12.5%, 25.0%, and 50.0%, respectively [52].

When evaluated by Sulphorhadamine-B assay, *Cymbopogon javarancusa* has demonstrated a potent cytotoxic effect against human cancer cell lines THP-1 (leukemia), A-549 (lung), HEP-2 (liver) and IGR-OV-1 (ovary) with the following IC\(_50\): 6.5 μg/mL (THP-1), 6.3 μg/mL (A-549), 7.2 μg/mL (HEP-2) and 34.4 μg/mL (IGR-OV-1). Its antioxidant potential, using DPPH assay was demonstrated as well with a IC\(_50\) of 48.9 μg/mL [36].

The good larvicidal potential of the essential oil extracted from *Cymbopogon olivieri* (Boiss.) Bar., has been attested against *Anopheles stephensi* with a LD\(_50\) value of 321.902 p.p.m. [37]

4.5. Biological properties of some isolated compounds of Essential oils extracted from *Cymbopogon* Species

Major and minor compounds from essential oils have exhibited variable biological properties. Indeed the antinociceptive effect of essential oil have been demonstrated and correlated with their major/minor compounds [53]. Moreover several of these...
major/minor compounds have demonstrated potential therapeutic alternatives for synthetic drugs. Several compounds of essential oil are effective as an analgesic compound in various pain models. Indeed, 3-tetradecanone is among chemical compounds present in essential oil that exhibiting anti-inflammatory and antioxidant activities [54]. Citronellal has the property to attenuate the mechanical noiception mediated by the NO-iGMP-ATP sensitive K channel pathway in mice [55]. By intraperitoneal injection, citronellal provoked the reduction of spontaneous activity, ataxia, analgesia, and sedation. In pentobarbital induced hypnosis, citronellal 50, 100, and 200 mg/kg (i.p.) significantly increased sleeping time (88.0±11.4, 100.2±16.4, and 119.5±20.9 min) when compared to vehicle solution injections (43.0±6.1). It can also reduce at 100 and 200 mg/kg, i.p., by central analgesic properties, the number of writhes (66.4 and 81.9%) in a writhing test, the number of paw licks in phase 1 (47.0 and 66.8%) and phase 2 (71.1 and 79.2%) of a formalin test [56]. These results were confirmed by Melo et al. (2011), which research has demonstrated the anti-inflammatory (50, 100, 200 mg/kg) and relox protective activities (200mg/kg) by inhibiting the enzymes involve in the arachidonic acid pathway [57]. Citronellal is also an alternative for the management and the treatment of orofacial pain since the intraperitoneal injection of citronellal exhibited significant antioxidant activity at the doses of 0.1 and 1 mg/mL, and antinoceptive property in a capscium and glutamate tests [58, 59].

Citroneoll has demonstrated antinoceptive and anti-inflammatory properties, by the inhibition of peripheral mediators as well as central inhibitory mechanisms related to its strong antioxidant effect. Indeed citronellol (25, 50 and 100 mg/kg, i.p.) reduced the amount of writhing compared to the control group in mice, when evaluated against acetie-acid-induced abdominal writhing. Citronellol inhibited both the early (neurogenic pain) and the late (inflammatory pain) phases of formalin-induced licking when tested in the formalin test. Moreover when tested in a thermal model of pain, Citronellol (100 mg/kg, i.p.) caused a significant increase in the latency response on the hot-plate test [60]. The hypotensive and vasorelaxant effect of citronellol was demonstrated in rats by the antagonism of the contraction induced by the 10 μM phenylephrine or 20 mM caffeine [61]. Citronellol has also reduced nociceptive and inflammatory activities in rodents linked with the inhibition of peripheral mediators as well as central inhibitory mechanisms. It also demonstrated anticonvulsant activity by reducing convulsion induced by pentylentetrazol and eliminating the extensor reflex of a maximal electroshock-induced seizures test in about 80% of experimental animals [62]. The good insecticidal activity of citronellal, by fumigation with a LC50 of 1.2 mL/L air was reported. After 24 hours, at 2.1 mL/L air, a mortality of 82% was recorded as well [49]. The antinoceptive activity of R-(-)-limonene has been demonstrated related to peripheral analgesia [63]. 1,8-cineole (eucalyptol) is a compound extracted from essential oils which is able to attenuate the cerulean-induced acute pancreatitis through an anti-inflammatory mechanism and to fight against oxidative stress [64-66].

The significant anticonvulsant potential of terpinen-4-ol has been demonstrated since at 100-200 mg/kg, it produced a significant dose-dependent increase in the duration of sleeping in mice, inhibited the induced seizures of picrotoxin at 200-300 mg/kg and decreased at 300 mg/kg the tonic hind convulsions percentage [67]. Moreover the complex α-terpineol and β-cyclodextrin has demonstrated a reduction of the hyperalgesia followed by the chronic muscle pain model, using the descending inhibitory pain system, specifically through opioid and serotoninergic receptors [68]. α-terpinene (p.o.) has demonstrated an antinoceptive effect in the formalin, capsain, and glutamate tests through the cholinergic and opioid systems involvement [69]. The antioxidant potential of α-terpineol was discovered since it was proven that it autoxidizes rapidly compared to other compounds [70].

Isopulegal and neo-isopulegal have demonstrated a sedative property in the pentobarbital-induced sleep test [71]. The gastroprotective and antioxidant properties of isopulegal was demonstrated both in ethanol- and indomethacin- induced ulcer models, mediated by endogenous prostaglandins, KATP channel opening [72]. Other research has suggested the anticonvulsant and bioprotective effects of isopulegal against pentylentetrazole-induced convulsions related to the positive modulation of benzodiazepine-sensitive GABA receptors and to its antioxidant properties [73]. Moreover isopulegal (25 and 50 mg/kg) presented depressant and anxiolytic-like effects with no effect on the motor coordination of animals in the rota rod test unlike to diazepam (2 mg/kg) [74].

When the antioxidant potential of p-cymene was evaluated in the hippocampus of mice by determining the levels of thiobarbituric acid reactive substances, nitrite content, activity of catalase and superoxide dismutase, it showed an antioxidant potential in vivo [75]. Moreover p-cymene possess analgesic and anti-inflammatory properties which are increased by β-cyclodextrin [75].

The potent in vivo anti-inflammatory activities of synthesized methyl salicylate derivatives were demonstrated against xylol-induced ear edema and carrageenan-induced paw edema in mice [76].
Piperitone has demonstrated its insecticidal activity against Tribolium castaneum. Indeed by fumigation after 24 hours, the LC50 values of 0.5 mL/L and a mortality of 100% at 2.4 mL/L air, were noticed [49]. By contact “no choice” test, after 72 hours, a mortality of 87% was recorded with piperitone at 4.7% w/v [49].

5. CYTOTOXICITY OF CYMBOPOGON SPECIES

The low cytotoxicity of extracts from Cymbopogon species was demonstrated since the in vitro cytotoxicity bioassays on human epidermic cell line HaCaT was shown with IC50 of 150 μL mL-1 for C. citratus oil and 450 μL mL-1 for essential oil extracted from C. nardus [22]. The in vitro cytotoxicity tests against the Chinese Hamster Ovary (CHO) cells and the human non cancer fibroblast cell line (WI38), had demonstrated the low cytotoxicity of Cymbopogon giganteus, Cymbopogon nardus and Cymbopogon schoenanthus (IC50 >50 μg/mL). In contrary, the cytotoxic property of Cymbopogon citratus essential oil against CHO cells (IC50=10.63 μg/mL) and WI38 cells (IC50=39.77 μg/mL) was shown [19]. Other compounds such as neral and geranial (citol) was toxic against CHO cells (IC50=20.62 μg/mL) and moderately toxic against WI38 cells (IC50=39.48 μg/mL) [19]. But, the safety of the use of Cymbopogon species at the doses used in folk medicine, was noticed since a high lethal dose (LD50) of C. citratus was revealed to be (≈3500 mg/kg by 24 h) [20].

CONCLUSION

The present review has focused on the volatile profiles and biological properties of cymbopogon species mainly Cymbopogon citratus, Cymbopogon giganteus and Cymbopogon schoenanthus. Essential oils extracted from species of the genus Cymbopogon, have demonstrated a wide range of biological properties in relation to their volatile profiles. These findings have validated the several traditional uses of these plant species.

REFERENCES

2. Prota: Plant Resources of Tropical Africa [http://www.prota4u.info/]


55. de Santana MT, de Oliveira MGB, Santana MF, De Sousa DP, Santana DG, Camargo EA, de Oliveira AP,


67. de Sousa DP, Nóbrega FFF, de Morais LSC, de Almeida RN: Evaluation of the Anticonvulsant Activity of Terpinen-4-ol *Z Naturforsch* 2009, 64 c.


