Review

Cymbopogon Species; Ethnopharmacology, Phytochemistry and the Pharmacological Importance

Opeyemi Avoseh 1, Opeoluwa Oyedeji 1,*, Pamela Rungqu 1, Benedicta Nkeh-Chungag 2 and Adebola Oyedeji 3

1 Chemistry Department, University of Fort Hare, 5700 Alice, South Africa; E-Mails: seavoseh@gmail.com (O.A.); 200800815@ufh.ac.za (P.R.)
2 Department of Zoology, Walter Sisulu University, 5099 Mthatha, South Africa; E-Mail: bnkehchungag@wsu.ac.za
3 Department of Chemistry, Walter Sisulu University, 5099 Mthatha, South Africa; E-Mail: aoyedeji@wsu.ac.za

* Author to whom correspondence should be addressed; E-Mail: ooyedeji@ufh.ac.za; Tel.: +27-764260280.

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Abstract: Cymbopogon genus is a member of the family of Gramineae which are herbs known worldwide for their high essential oil content. They are widely distributed across all continents where they are used for various purposes. The commercial and medicinal uses of the various species of Cymbopogon are well documented. Ethnopharmacology evidence shows that they possess a wide array of properties that justifies their use for pest control, in cosmetics and as anti-inflammation agents. These plants may also hold promise as potent anti-tumor and chemopreventive drugs. The chemo-types from this genus have been used as biomarkers for their identification and classification. Pharmacological applications of Cymbopogon citratus are well exploited, though studies show that other species may also useful pharmaceutically. Hence this literature review intends to discuss these species and explore their potential economic importance.

Keywords: Cymbopogon; ethnopharmacology; secondary metabolites; terpenes; chemo-types
1. Introduction

The presence of secondary metabolites in plants is characterized by their ability to provide defenses against biotic and abiotic stress [1]. The mechanism of defense varies from plant to plant, their environmental conditions and climatic variations. However, the presence of these metabolites in plant are usually in minimum amounts though several molecular techniques are available to either increase or decrease the quantity of a particular metabolite by blocking competitive pathways and enriching metabolites of choice [2]. Terpenes, alkaloids (N-containing compounds) and phenolics constitute the largest groups of secondary metabolites. The shikimic acid pathway is the basis of the biosynthesis of phenolics while the terpenes which are comprised of isoprene units arise from the mevalonate pathway [3]. Aspirin (1) from white willow, quinine (2) from the cinchona plant and artemisinin (3) from *Artemisia annum* are all plant secondary metabolites. The biological application of these metabolites as therapeutic agents for a broad spectrum of ailments and the microbial infections has been salutary in human history.

The genus *Cymbopogon* is widely distributed in the tropical and subtropical regions of Africa, Asia and America. Comprised of 144 species, this genus is famous for its high content of essential oils which have been used for cosmetics, pharmaceuticals, and perfumery applications [4]. Two main species, *C. flexuosus* and *C. citratus* (lemongrass) are commercially cultivated in the Democratic Republic of Congo (DRC), Madagascar, and the Comoros Island. However, the leading exporter of these plants is Guatemala, trading about 250,000 kg per year and while the USSR sells about 70,000 kg per year [5].

The commercial value of some *Cymbopogon* species is further enhanced by their ability to grow in moderate and extremely harsh climatic conditions [6]. In environments where they are not used for cosmetics, drug or perfumery, such as in the Eastern Cape Province of South Africa, these plants have found a good application as roof thatches and grass brooms [7].

2. Ethnopharmacology of *Cymbopogon* Species

Traditional applications of *Cymbopogon* genus in different countries shows high applicability as a common tea, medicinal supplement, insect repellant, insecticide, in flu control, and as anti-inflammatory and analgesic. Table 1 shows the common names of some species, their relevance and how they are applied. *C. citratus* is ranked as one of the most widely distributed of the genus which is used in every part of the world. Its applications in Nigeria include cures for upset stomach, malaria therapy, insect repellent and as an antioxidant (tea) [8]. *C. citratus* and *C. flexuosus* are the prevailing species in Eastern and Western India and have been used locally in cosmetics, insecticides, and for the treatment of digestive disorders and fevers [9,10].
Table 1. Several *Cymbopogon* species, common name, regions, plant part used and the uses.

| Species                  | Region                  | Common Name       | Parts                  | Medicinal Uses                                                                 | References |
|--------------------------|-------------------------|-------------------|------------------------|---------------------------------------------------------------------------------|------------|
| *C. nardus (L.) Rendle*  | India                   | Citronella oil    | Leaves                 | Insect repellent and as perfumes                                                | [11]       |
| *C. parkeri Stapf*       | Pakistan                | Lemon grass       | Aerial                 | Antiseptic and stomachic treatment                                              | [12]       |
| *C. excavatus Hoscht*    | South Africa            | Bread-leavened    | Sheaths                | Used as insecticides                                                            | [13]       |
| *C. olivieri (Boss)*     | Pakistan                | Pputar            | Aerial                 | Pyretic, vomit, diuretic, rheumatism, and as anti-malaria condiment.            | [14,15]    |
| *C. validus (Stapf)*     | Eastern and Southern    | African bluegrass | Essential oils         | skin toner, anti-ageing in men, fumigant and for rodent control                 | [16]       |
| *C. winterianus (Jowitt)*| Brazil                  | Java grass        | Fleshy leaves          | Treatment of epilepsy and anxiety                                               | [17]       |
| *C. marginatus (Steud.)* | South Africa            | Lemon-Scented grass | Root                   | They are used as moth repellent                                                 | [18]       |
| *C. citratus Stapf*      | India                   | Lemon grass       | Aerial                 | Fever, digestive disorders                                                      | [9]        |
|                         | Nigeria                 | Lemon grass       | Leaves                 | Diabetes, inflammation and nerve disorders                                       | [8]        |
|                         | Argentina               | Limonaria         | Leaves                 | Against cold and flu, and digestive complaints, stomach                        | [19]       |
|                         | Cuba                    | Cana Santa        | Leaves                 | upsets and as decoction with other plants for malaria                          | [20]       |
|                         | Costa Rica              | Grass tea         | Leaves                 | To relieve cough, carminative, expectorant and depurative                      | [21]       |
|                         | Colombia                | Limonaria         | Rhizome                | It is chewed and used as toothbrush and for pest control.                      | [22,23]    |
|                         | Brazil                  | Capimsanto        | Leaves                 | Anxiolytic and anti-hypertensive                                               | [24]       |
|                         | Trinidad & Tobago       | “fever grass”     | Grass and rhizomes     | The teas from it are used to treat cold, flu, fever and diabetes               | [24]       |
| *C. giganteus* (Hochst.)| Cameroon                | Tsauri grass      | decoctions of leaves and flowers | Cough and arterial hypertension                                      | [25]       |
| *C. ambiguous* (Hack.) A. Camus.* | Australia           | Native Lemon Grass | Leaves and stems       | Headache remedy, chest infections, muscle cramp and Scabies                  | [26,27]    |
| *C. procerus* (R.Br.) Domin | Australia            | Scent grass       | Leaves and stems       | Leaves and stem are pounded and used as medicinal body wash; used for headache| [28]       |
| *C. flexuosus* (Nees ex Steud.) Wats.* | India                | Lemon grass       | Leaves                 | Cosmetics, antiseptic and for treatment of fever                             | [10]       |
| Species                        | Region           | Common Name       | Parts            | Medicinal Uses                                                                 | References |
|-------------------------------|------------------|-------------------|------------------|-------------------------------------------------------------------------------|------------|
| *C. pendulus* (Nees ex Steud.) Wats. | India            | Jammu             | Leaves           | Antiseptic and for perfumery                                                  | [29]       |
| *C. scheonanthus* (L.) Spreng | Saudi Arabia     | Ethkher           | Leaves           | Antidiarrheal, to treat fever, treatment of jaundice and tonic                 | [30]       |
| *C. obtectus* (S.T. Blake)     | Central Australia| Silky-heads       | Mixture          | Cold and flu, headaches, fever and sore throat                                | [27]       |
| *C. proximus* (Stapf.)         | Egypt            | Halfabar          | Leaves           | Expulsion of renal and ureteric calculi                                      | [31]       |
| *Cymbopogon refractus* (R.Brown) A. Camus. | Australia        | Barbed wire grass | Leaves           | Feed for animals                                                              | [32]       |
| *C. densiflorus* (Steud.) Stapf | Congo            | Lemongrass        | Leaves and rhizome | Employed against asthma, epilepsy, abdominal cramps and pains and also for interpreting dreams by witch doctors. | [33,34]   |
| *C. jwarancusa* (Jones) Schult. | Egypt            | Thé Limon        | The whole plant  | Condiment and for medicinal purpose                                           | [35]       |
In the Middle East, *C. Olivieri* and *C. Parkeri* are more predominant, and they are used as antiseptics, anti-malarial condiments, diuretics and also to cure rheumatism [12,14,15]. The high amounts of volatile compounds from these species are responsible for their diverse uses.

**Figure 1.** Flavonoids and triterpenoids from *Cymbopogon* species.
3. Phytochemistry

The enormous information gathered from the ethno-pharmacological applications of *Cymbopogons* begged the investigation of its chemical constituents. These studies have led to the isolation of alkaloids, volatile and non-volatile terpenoids, flavonoids, carotenoids and tannins from every part of these plants. Figure 1 displays some of the compounds isolated from *Cymbopogon* species.

3.1. Alkaloids

The rhizome of *C. citratus* from Nigeria was reported to contain about 0.52% alkaloids from 300 g plant material [36].

3.2. Flavonoids

This class of compounds has potent antioxidant properties. Some of the flavonoids isolated from *Cymbopogon* species are presented in Figure 1. Isoorientin (4) and tricin (5) were isolated from the dichloromethane extract of *C. parkeri* [37], evaluation of these two compounds revealed their muscle relaxation activity [38]. Isolation of luteolin (6), luteolin 7-O-glucoside (cynaroside) (7), isoscoparin (8) and 2"-O-rhamnosyl isoorientin (9) from the leaves and rhizomes of *C. citratus* has been reported. Other flavonoid compounds isolated from the aerial parts of *C. citratus* are quercetin (10), kaempferol (11) and apigenin (12) [39], isolated elimicin (13), catechol (14), chlorogenic acid (15), caffeic acid (16) and hydroquinone (17) from the aerial parts of the same species. Isolation of 4-phenylpropanoids from Australian species of *C. ambiguus* has been reported. These compounds are eugenol (4-allyl-2-methoxyphenol) (18); elemicin (5-allyl-1,2,3-trimethoxybenzene) (19); eugenol methylether (4-allyl-1,2-dimethoxybenzene) (20) and *trans*-iso-elemicin (1,2,3-trimethoxy-5-(1-propenyl) benzene) (21) and all these isolates exhibited good inhibition activity against ADP-induced human platelet serotonin release which is associated with headaches [26].

3.3. Cymbopogon Terpenoids

3.3.1. Non-Volatile Terpenoids

Plants in the *Cymbopogon* genus contain large amounts of volatile terpenoids though a few species from this genus are reported to contain non-volatile terpenoids as well. Bottini et al. [40] isolated a novel bis-monoterpenoid named cymbodiacetal (22) from *C. martinii*. The triterpenoids cymbopogone (23) and cymbopogonol (24) (Figure 1) were also reported from the leaves of *C. citratus* [41].

3.3.2. Volatile Terpenoids of Cymbopogon Species

Different chemotypes of *Cymbopogon* species contain varying major compounds such as citral, geraniol, citronellol, piperitone and elemin (Table 2). In the literature, the majority of the *C. citratus* analysed showed a remarkably high percentage of neral (25) and geranial (26). Analysis of *C. citratus* species from Brazil [42], India [43], West and Eastern Africa [43–49] and Asia [50] showed the high value of neral and geranial chemotypes. A special distinguishing feature between *C. citratus* of African origin is the high amount of myrcene observed in them [44–49]. High occurrence of piperitone (27)
characterizes the oils of *C. parkeri* and *C. olivieri* from Iran. Jiroveltz *et al.* [25] reported a significant presence of cis-p-mentha-1(7),8-dien-2-ol (28) and its isomer trans-p-mentha-1(7),8-dien-2-ol (29) in the oils of *C. giganteus* from Cameroon [25]. Predominant components observed in other *Cymbopogon* species essential oils from around the world include δ-2-carene (30) in *C. proximus* from Cameroon [51], linalool (31) from Malaysia’s *C. nardus* [52], limonene (32) in *C. schoenanthus* (Tunisia) and *C. giganteus* (Burkina Faso) [46] and elemicin (33) from the oils of *C. pendulus* from India [53]. Observation of the oil of *C. winterianus* from different parts of Brazil showed two major chemotypes based on the amount of geraniol (34) and citronellal (35) [17,54–56].

Table 2. Major components observed in some *Cymbopogon* species.

| Compound                              | Species       | Country/Region        | Major % | References |
|---------------------------------------|---------------|-----------------------|---------|------------|
| cis-p-mentha-1(7),8-dien-2-ol (C10H16O) | *C. giganteus* | Cameroon              | 22.8    | [25]       |
|                                       |               | Burkina Faso          | 12.0    | [46]       |
|                                       |               | Madagascar            | 19.0    | [57]       |
| trans-p-mentha-1(7),8-dien-2-ol       | *C. giganteus* | Cameroon              | 26.5    | [25]       |
|                                       |               | Burkina Faso          | 14.2    | [46]       |
|                                       | *C. densiflorus* | Zambia              | 11.1    | [57]       |
|                                       | *C. giganteus* | Madagascar            | 22.4    | [56]       |
| Limonene (C10H16)                     | *C. viridis*  | Cameroon              | 7.4     | [25]       |
|                                       | *C. viridis*  | Burkina Faso          | 42.0    | [46]       |
|                                       | *C. proximus* | Burkina Faso          | 3.9     | [51]       |
|                                       | *C. schoenanthus* | Tunisia            | 24.2    | [58]       |
| Elemicin (C12H16O3)                   | *C. pendulus* | India                 | 53.7    | [53]       |
| α-Pinene (C10H16)                     | *C. pendulus* | India                 | 6.1     | [53]       |
| Camphene (C10H16)                     | *C. pendulus* | India                 | 9.1     | [53]       |
|                                       | *C. viridis*  | India                 | 8.0     | [59]       |
| Geranial (C10H16O)                    | *C. flexuosus* | China (Kumauon region)  | 33.1    | [60]       |
|                                       |               | India (Bilhar)         | 42.4    | [43]       |
|                                       | *C. citratus* | Benin republic         | 27.04   | [62]       |
|                                       |               | Nigeria                | 33.7    | [44]       |
|                                       |               | Angola                 | 40.55   | [63]       |
|                                       |               | Congo Brazzaville      | 48.88   | [45]       |
|                                       | *C. winterianus* | S.E. Brazil        | 8.05    | [55]       |
| Compound                     | Species  | Country/Region         | Major % | References |
|------------------------------|----------|------------------------|---------|------------|
| Neral (C10H16O)              | C. flexuosus | Brazil (North)       | 30.1    | [42]       |
|                              |          | Egypt                  | 34.98   | [61]       |
|                              |          | Zambia                 | 29.4    | [47]       |
|                              |          | Kenya                  | 33.31   | [48]       |
|                              | C. giganteus | Benin republic    | 19.93   | [62]       |
|                              |          | Nigeria                | 26.5    | [44]       |
|                              |          | Angola                 | 28.26   | [63]       |
|                              |          | Malaysia               | 50.81   | [64]       |
|                              |          | Congo Brazzaville      | 36.24   | [49]       |
|                            | C. citratus | Brazil             | 4.53    | [17]       |
|                              |          | Ivory Coast            | 32.5    | [45]       |
|                              |          | Mali                   | 26.3    | [45]       |
|                              |          | Iran                   | 30.95   | [50]       |
| Geranyl acetate (C12H20O2)   | C. flexuosus | India              | 12.0    | [60]       |
| Linalool (C10H18O)           | C. flexuosus | India             | 2.6     | [60]       |
|                              | C. winterianus | India           | 1.5     | [59]       |
|                              | C. martini   | India                | 2.0     | [65]       |
|                              | C. nardus     | Malaysia             | 11.0    | [52]       |
| Geraniol (C10H18O)           | C. winterianus | India      | 23.9    | [59]       |
|                              | C. martini    | India                | 84.16   | [65]       |
|                              | C. winterianus | Brazil        | 32.82   | [17]       |
|                              |          | Brazil (para state)   | 16.2    | [54]       |
|                              | C. winterianus | S.E. Brazil      | 40.06   | [55]       |
| Citronellal (C10H18O)        | C. winterianus | India      | 32.7    | [59]       |
|                              | C. nardus     | Malaysia             | 29.6    | [52]       |
|                              | C. winterianus | Brazil       | 36.19   | [17]       |
|                              |          | Brazil (para state)   | 26.5    | [54]       |
|                              | C. winterianus | S.E. Brazil    | 27.44   | [55]       |
| Citronellol (C10H2O2)        | C. winterianus | India       | 15.9    | [59]       |
|                              | C. winterianus | Brazil      | 11.34   | [17]       |
|                              | C. winterianus | Brazil (Para state) | 7.3     | [54]       |
|                              | C. winterianus | S.E. Brazil    | 10.45   | [55]       |
| Myrcene (C10H16)             |          | Burkina Faso          | 11.0    | [46]       |
|                              | C. citratus   | Egypt                | 15.69   | [61]       |
|                              |            | Zambia                | 18.0    | [47]       |
|                              | C. citratus   | Benin republic        | 27.83   | [62]       |
|                              | C. citratus   | Nigeria              | 25.3    | [44]       |
|                              | C. citratus   | Angola                | 10.57   | [63]       |
|                              |            | Ivory Coast           | 18.1    | [45]       |
|                              |            | Mali                  | 9.1     | [45]       |


| Compound                  | Species      | Country/Region | Major % | References |
|---------------------------|--------------|----------------|---------|------------|
| Selina-6-en-4-ol (C_{15}H_{26}O) | C. citratus  | Brazil         | 27.8    | [42]       |
| α-Cadinol (C_{13}H_{26}O)  | C. citratus  | Brazil         | 8.2     | [42]       |
| Piperitone (C_{10}H_{16}O) | C. olivieri  | Iran           | 72.8    | [14]       |
|                           | C. parkeri   | Iran           | 80.8    | [12]       |
|                           | C. proximus  | Burkina Faso   | 59.1    | [51]       |
| 4-Carene (C_{10}H_{16})   | C. olivieri  | Iran           | 11.8    | [12]       |
| Germacrene-D (C_{13}H_{22}) | C. parkeri  | Iran           | 5.1     | [11]       |
| δ-2-Carene (C_{10}H_{16}) | C. proximus  | Burkina Faso   | 22.3    | [51]       |
| β-Phellandrene (C_{10}H_{16}) | C. schoenanthus | Tunisia     | 13.4    | [58]       |

### 3.4. Tannins

A literature search on the phytochemical screening of *C. citratus* also reveals the presence of tannins, however, very little effort has been made in the isolation of these compounds despite the appreciable amounts reported through quantitative phytochemical tests. Figueirinha et al. fractionated extracts of the species collected from Portugal and reported about 10 mg dry weight of hydrolysable tannins (prothocyanidins) [66] while *C. citratus* from Nigeria showed about 0.6% of tannins [36]. *C. citratus* is the single species of *Cymbopogon* which is most exploited for its tannin content.

### 4. Pharmacology

Several bioassays have confirmed the potency of *Cymbopogon* species for their several uses (Table 3). *C. citratus* was found to have chemoprotective activity by preventing of diethylnitrosamine (DEN)-initiated hepatocellular lesions in rats [67]. In South Africa, extract from *C. citratus* was applied for treatment of oral thrush in patients who tested positive to HIV/AIDS and proved effective [68].

Insecticidal activity is one of the biological effects of most plant of the *Cymbopogon* genus; it is either applied as pest control for stored crops or as mosquito repellent/insecticide. The essential oils of *C. martinii* have been studied and found to display high anthelmintic activity against *Caenorhabditis elegans* at ED_{50} value of 125.4 µg/mL, *C. schoenanthus*, *C. giganteus* and *C. citratus* essential oils from Benin Republic in West Africa all displayed about 100% mortality rate against adult *Anopheles gambiae* [69]. The essential oil from *C. winterianus* caused a dose dependent mortality of *Culex quinquefasciatus* with LC_{50} of 0.9% [70].

The anticancer properties of *Cymbopogon* species have also been studied. The essential oils of *C. flexuosus* was effective in inhibiting the growth and killing of Ehrlich and Sarcoma-180 tumors cells. In this study, it was discovered that at a dose of 200 mg/kg, Ehrlich solid tumor inhibition was about 57.83% compared to the 45.23% inhibition observed with 5-fluorouracil (22 mg/kg) [71]. Inhibition of early phase of hepatocarcinogenesis was also observed in *C. citratus* [67]. Positive results in several other bioassays such as antiprotozoal, anti-inflammatory, antimicrobial, anti-bacterial, anti-diabetic, anticholinesterase, molluscidal, antifungal and larvicidal activity are also prominent with *Cymbopogon* species as outlined in Table 3.
Table 3. Pharmacological evidence of some *Cymbopogon* species.

| Cymbopogon Species | Pharmacology                  | Activity                                                                 | References |
|--------------------|-------------------------------|--------------------------------------------------------------------------|------------|
|                    | Cytotoxicity                  | Shows high toxicity against Chinese Hamster Ovary (CHO) cells (IC\textsubscript{50} = 10.63 µg/mL) and moderately toxic against human fibroblast cell line 138 (W138) cells (IC\textsubscript{50} = 39.77 µg/mL). | [72]       |
| C. citratus        | Insecticidal                  | LC\textsubscript{50} of 48.6 µL/L against housefly larvae                | [43]       |
|                    | Neurobehavioral effects       | Ability to be active as sedative, anxiolytic and anticonvulsant agent    | [73]       |
|                    | Antitrypanosomal              | Modest activity against *Trypanosoma brucei* IC\textsubscript{50} = 1.837 ± 0.13 µg/mL | [72]       |
|                    | Anti-diabetic                 | Shows activity against poloxamer-407 induced type 2 diabetic (T2D) in Wistar rats | [43]       |
|                    | HIV/AIDS                      | As a highly effective control for oral thrush in HIV/AIDS victims in South Africa | [68]       |
|                    | Larvicidal activity           | It shows high inhibition and mortality rate against larva of *A. aegypti* | [74]       |
|                    | Chemopreventive activity      | Inhibits the early phase of hepatocarcinogenesis in rats                | [67]       |
|                    | Anti-inflammations            | Hexane extract inhibited iNOS (inducible nitric oxide synthase) expression, NO (nitric oxide) production and various LPS (lipopolysaccharide)-induced pathways | [75]       |
|                    | Antioxidant(DPPH)             | 36%–73.8% activity per 2 µL of oil                                       | [58]       |
| C. schoenanthus    | Acetylcholinesterase inhibitory | IC\textsubscript{50} = 0.26 ± 0.03 mg mL\textsuperscript{−1}               | [58]       |
|                    | Insecticidal activity         | 2.7 µL/L obtained for LC\textsubscript{50} against *Callosobruchus maculatus* | [76]       |
|                    | Moluscidal                    | LC\textsubscript{50} = 97.0mg/L and LC\textsubscript{50} = 54.0 mg/L       | [54]       |
| C. winterianus     | Larvicidal                    | LC \textsubscript{50} = 181.0mg/L                                       | [54]       |
|                    | Anti-fungal                   | Inhibited the growth of 15 strains of *Candida albicans* at concentrations of 625 µg/mL and 1250 µg/mL | [77]       |
|                    | Antimicrobial                 | High activity against gram \textsuperscript{+}ve and gram \textsuperscript{−}ve bacteria | [25]       |
|                    | Cytotoxicity                  | Low cytotoxicity against CHO cells and the human non cancer fibroblast cell line (W138) | [72]       |
| C. giganteus       | Anti-trypanosomal             | IC\textsubscript{50} = 0.25 ± 0.11 µg/mL against *Trypanosoma brucei*    | [72]       |
|                    | Antiplasmodial                | High activity with an IC\textsubscript{50} ≤ 20 µg/mL                    | [72]       |
|                    | Antifungal                    | Strong activity against *Microsporum audouinii, Trichophyton rubrum* and *Epidermophyton floccosum* at 100% for all the species | [78]       |
| C. pendulus        | Chemopreventive               | Potent *in vivo* activity against Ehrlich and Sarcoma-180 tumors.         | [71]       |
| C. flexuosus       | Antibacterial                 | Gram-negative bacteria. MICs were found to be between 250 and 500 ppm for the Gram-positive and between 500 and 1000 ppm for the Gram-negative bacteria | [79]       |
| C. densiflorus Stapf | Inflammatory                 | Inhibition of ADP-induced human platelet serotonin release in the cell.   | [26]       |
| C. ambiguus        | Antibacterial                 | MIC values ranged from 0.244 µg/mL to 0.977 µg/mL when tested against the bacterial isolates | [52]       |
| C. nardus          | Molluscidal activity          | It inhibits *Biomphalaria pfeifferi* at LD\textsubscript{50} of 213.099 ppm dose dependent | [80]       |
| C. nervatus        | Antimicrobial activity        | Exhibited excellent antimicrobial activity against gram \textsuperscript{±}ve organisms | [14]       |
5. Conclusions

*Cymbopogon* species have been used as traditional medicine in many countries. Of all the species reviewed, *C. citratus* and *C. flexuosus* are the most widely used in traditional and in conventional medicine due to the pharmacological potential of their phytochemicals. The majority of these species contain a voluminous amount of essential oils which have shown several biological activities such as insecticidal, anti-protozoan, anticancer, anti-HIV, anti-inflammatory and anti-diabetes effects.

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Author Contributions

Opeyemi Avoseh carry out the literature survey and wrote part of first draft of the manuscript. Pamela Rungqu investigated the essential oil composition of *Cymbopogon* species found in the Eastern Cape and wrote part of the first draft of the manuscript. Opeoluwa Oyedeji, Benedicta Nkeh-Chungag and Adebola Oyedeji are supervisors to the above authors on the chemistry and inflammatory studies of the essential oils. They also contributed editorial to the writing and editing of the final manuscript.

Conflicts of Interest

The authors declare no conflict of interest.

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