INTERNATIONAL JOURNAL OF ENGINEERING TECHNOLOGY AND SCIENCES (IJETS)
ISSN: 2289-697X (Print); ISSN: 2462-1269 (Online) Vol.5 (1) June 2018

DOI: http://dx.doi.org/10.15282/ijets.5.1.2018.8.1094

A Review: The extraction of active compound from *Cymbopogon sp.* and its potential for medicinal applications

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Abstract- Cymbopogon citratus and Cymbopogon nardus are plants categorized under the family of Poaceae that have been recognized with high demand in pharmaceutical industry for its wide range of pharmacological activities. The potential bioactive compounds can be obtained either through traditional or conventional methods. The plant extracts are commonly used in numbers of products for culinary, pesticides and cosmetic purposes for its flavours and fragrances. Besides, bioactive compounds extracted from both species possess good biological activities that can be applied in the pharmaceutical field.

Indexed Terms- Cymbopogon sp., Extraction, Bioactive Compounds, Biological Activities

I. INTRODUCTION

1.1 Cymbopogon species

Cymbopogon is a tall perennial grass which is natively grown in a tropical region within warm temperate [1]. This plant is originated in Asia and Australia besides being well distributed in Africa, Indian, South America, Australia, Europe and North America [1]–[3]. The genus of *Cymbopogon* belongs to a family known as *Graminae* (Poaceae) and its taxonomy position is as listed in Table 1. Generally, 55 species of Cymbopogon have been identified. There are two common species available in Malaysia which are *Cymbopogon citratus* and *Cymbopogon nardus*.

Table 1: The taxonomic position of *Cymbopogon sp.*

KINGDOM	PLANTAE
Sub-Kingdom	Tracheobionta
Superdivision	Spermatophyta
Division	Magnoliophyta
Class	Liliopsida
Sub-class	Commelinidae
Order	Cyperales
Family	Poaceae
Genus	*Cymbopogon*

C. citratus (DC.) Stapf is well-known as a lemongrass and it is typically identified as West Indian lemongrass [1], [4]–[7]. West Indian lemongrass is believed to have originated either in Malaysia or in Sri Lanka. Then, it is widely distributed and grown in India, Thailand, Bangladesh, Madagascar and China, America and Africa [3], [4], [8], [9]. In contrast, *C. nardus* is known as Citronella. *C. nardus* (L) Rendle is classified in cultivated types named as Ceylon Citronella [1], [4], [5]. This plant has probably originated from Sri Lanka and then introduced in Java around 1899 [1], [10]–[12]. Subsequently, Java becomes a major producer of citronella in the world. Furthermore, *C. nardus* is also growing wild in most tropical Asian countries including Malaysia.

1.2 Cultivation, harvesting and the processing of *Cymbopogon sp*.

Cymbopogon sp. has been commonly cultivated as a ratoon crop and well grown in a wide range of soils and climatic conditions [1]. For example, *C. citratus* and *C. nardus* have vigorous growth conditions in both tropical and subtropical climate [1], [5]. Meanwhile, the optimum growths of both sp. are warm and humid climate. Both plants require direct exposure to sunlight and an average rainfall per annum needed is in between 250 to 330 cm [5], [7]. The temperature that is suitable for growth is ranging in between 20 to 30^{o}C. *C. citratus* is flourished in well-drained sandy loam which is from rich loam to poor laterite [1], [4]–[7]. Similar to *C. nardus* where it is well planted on most soil types ranging from sandy, mineral to organic soils[5], [13]. Hence, this plant also grows abundantly in most places including mountain and hillside area [1]. The optimum of growth conditions had resulted specific morphological features for each species. Both of the species are classified as an aromatic tall grass, growing to approximately 1m in height with long and thin leaves [5], [12]–[15]. However, some of the features for both sp. are different. *C. citratus* have short stems and fibrous roots meanwhile its leaves are narrow and linear. In contrast, *C. nardus* has whitish stems and sometimes with magenta-tinged while the leaves are smaller with rough surface [1].

C. citratus is first harvested in the range of four to six months upon plantation followed by subsequent harvests in the interval of two to three months [4], [16]. Likewise, *C. nardus* is ready for harvest after six to eight months of planting but the subsequent harvesting can be done within 90 to 120 days [14], [17], [18]. Nevertheless, the numbers of harvest for both species are subject to the growth of plants.

The lemongrass can be divided into several parts including leaves, aerials and rhizomes [2], [5], [19]–[21]. These parts are subjected to a drying process in which dried material is prepared for further processing because it reduces the moisture content of fresh materials for long storage. Besides, drying process capable to preserve the sample from further deterioration by microorganisms and preserve its biochemical constituents. In dry part there is no further enzymatic or metabolic reaction of dried plants and all compounds can be recovered in a natural without altered form [22]–[25]. However chloroplast and active metabolic are presence in fresh green leaves of *Cymbopogon* sp. besides remains a possibility of formation of new compounds such as intermediates and secondary metabolites [26]. There are two common methods used in the drying process of *Cymbopogon* plants which are sun drying, air drying and oven drying [10], [22]–[31]. The chemical composition of *Cymbopogon* extracts are influence by a variety of drying methods. For example, the crude essential oil extracted from *C. citratus* are resulted highest percentage yield (2.45%) using oven drying compared to air drying (2.12%) and sun drying methods (2.10%) [30]. Meanwhile, *C. nardus* dried using oven drying methods obtained 9.40% of percentage yield of crude essential oil [30]. The dried herbs are then ground into small pieces typical in the size of 0.3mm to 2.0mm. Traditionally the grinding process is performed in various ways such as using mortar and pestle, crushing, blending and grinding [31], [32]. The extraction process usually take parts after raw material already dried and reduce in particle size. There are two common approaches in the extraction process, firstly through a traditional approach, secondly through a conventional approach [10], [29]–[34].

II. EXTRACTION PROCESS

2.1 Extraction methods for traditional processes

Decoction and infusion are common classical methods involve in extraction process [2], [35]–[36]. Basically, during the decoction process, stable constituents of a crude drug will be extracted in hot water soluble [37]. This process will be subject to boiling in water for 15 minutes, cooling, and straining before passing the sufficient cold water which contains a liquid extract [37]. In contrast with infusion methods where soluble components extract from the plants were immersed in hot water without continuous boiling [2], [3], [35], [38]. The solution will be cooling before straining [2], [35], [39]. This method normally applied in lemongrass tea processing where lemongrass is immersed in hot water [5], [39]–[42]. It is mostly taken in the form of tea as a remedy for a cough, flu, headache, pneumonia, malaria, digestive problems, diarrhea, stomach ache and vascular disorders [5], [27], [39]–[42], [27]. However, traditional process is difficult to optimize due to inaccurate of dosage extract. Hence, boiling sample at boiling point of water is able to reduce the amount of plant extract. Therefor the efficacy of herbal extract as alternative medicine also reduce.

2.2 Extraction method for conventional processes

Current practices involve the use of general methods of extraction that have been well developed due to the application of advanced technology. These extraction methods are known as Soxhlet extraction [43]–[45], microwave-assisted extraction [22], [44]–[50], ultrasound extraction [33], [34], [51], supercritical fluid extraction [11], [20], [27], [52], [53], hydrodistillation [22], [24], [44], [49], [54], [55] and steam distillation [14], [52], [56]–[62], [63], [64]. Each process is unique in terms of the process principal and process parameters, however the selection basis is generally depending on the yield of the process [52], [59], [65]. Hence, conventional extraction methods have many advantages where the process is flexible, allows modulation selection of solvent extract besides polluting organic solvent can be eliminated during the extraction process. Hence, the amount of plant extract can be optimized. For example, the yield of essential oil extracted using distillation process can be optimize either increase the raw material use or prolong the extraction time. Figure 1 shows the simple process flow of steam distillation process including the sample preparation, pretreatment process and extraction process.

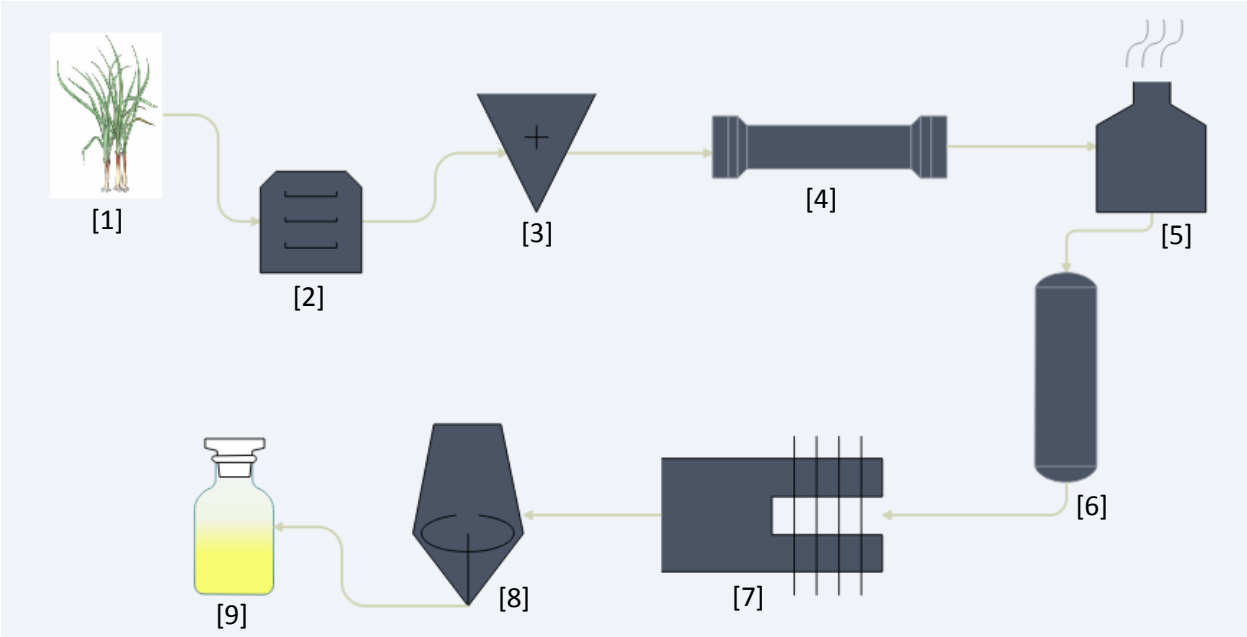

Figure 1: Simple flow diagram of steam distillation process to extract lemongrass oil; [1] Raw material collection [2] Drying process [3] Grinding process [4] Pretreatment process [5] Boiling process to generate steam [6] Oil extract using steam distillation process [7] Condensation process [8] Plant extract collection [9] Lemongrass oil is produced

2.3 The plant extract

The extracts from *Cymbopogon* normally exist in several forms, liquid [36], [39] and oil [4], [10], [16], [22]–[28], [33], [34]. The oil-based extract is normally known as essential oil and this product has been widely used as insect repellent to kill the Aedes mosquitoes [5], [26], [31], [32], [37], [40], [51] alternative medicines [2], [35], [59], [66] aromatherapy and cosmetic [2], [10], [27], [33]– [35], [39], [67]–[69]. Due to its nice odour, *Cymbopogon sp*. is widely used as a flavouring ingredient in number of products such as soaps, perfume, candle and insects repellent [69]. In spite of, the liquid extract of *Cymbopogon* sp. traditionally used to produce an aromatic drink by incorporated the whole plant in a water whereas the stems often used in cooking. The essential oil that is obtained from plants extracts is formerly known as crude essential oil. The extracts are relatively a complex mixture of metabolites presence in liquid form intended for oral and external uses [20], [43], [44], [62], [66]. During the extraction, solvents diffuse into the solid plant material and solubilize the compounds with similar polarity [33], [34], [67], [68], [70], [71].

The quality of the plant extract can be influenced by several factors including the plant part used as raw material to extract, choice of solvent used during the extraction process and the procedure of extraction [33], [34], [70], [71]. The phytochemical constituents of *Cymbopogon sp.* extracts are varying according to extraction time, temperature and concentration used, selection of extraction method, part of the plant used, the polarity of solvent used, geographical of plant origin and harvesting period. Despite the quality, the yield of crude essential oil is one of the important parameters. The yield can be identified according to the relation between the essential oil mass obtained and the raw material used in the extraction. The summary of percentage yield is calculated using the formula as follow:

$$Percentage\ of\ yield\ (\%) = \frac{Y_i}{Y_0} \times 100\%$$

where;

Yi = Actual mass
Yo = Calculated mass

Basically, the average oil content is about 1% on the basis of fresh leaves within 2 to 3 hours of distillation [5], [57], [58]. The oil extracted from *Cymbopogon* sp. consists higher of volatile compounds. The determination of bioactive compounds obtained from plant extract is largely dependent on the type of solvent used during the extraction. The selection of solvent used during extraction is dependent on some factors such as toxicity level, the ability of solvent to evaporate at low heat, inability to produce a complex extract, a rapid absorption of the extract, and good as preservative action. [33], [34], [70]. For example, water is universal solvent and widely use in plant extraction for some purpose such as antimicrobial activity. Water is non-toxic and able to reduce the health hazards potential of the extractants.

The bioactive compounds extractive from lemongrass oil is useful in some health concern. In order to obtain the valuable aromatic compound, essential oil is necessary to extract from the plant herbs. Besides, the different method extraction will provide vary optimum condition to extract maximum crude essential oil [14], [17]. Hence, the chemical constituents and yield obtained will vary due to several factors such as time extraction, method extraction and also raw material preparation. The active compound extracted from lemongrass oil can be identified using Gas Chromatography Mass Spectrometry (GCMS).

III. CHEMICAL ANALYSIS

3.1 Gas Chromatography

The aromatic compound of essential oils is generally performed quantitatively and qualitatively by Gas Chromatography (GC) and Gas Chromatography Mass Spectrometry (GCMS) [20], [60]. Gas Chromatography is used to identify a volatile compounds using gas phase. In gas chromatography, the mobile phase known as carrier gas, usually used as inert gas such as helium and nitrogen. The stationary phase is a polymer or liquid microscopic layer on an inert solid support located inside a column. As a result, the compound in gas phase subject to total amount of vapour. Retention times and Kovats index were used to compare the percentage of main compounds using a mass spectrometry detector [4], [16]. Besides, good chromatogram can be obtained by consider numerous conditions during the process of analysis using GC and GCMS which including the sample preparation, column type and dimensions size, carrier gas flow rate during the analysis process and temperature programming including injector, detector and column temperature [72]. On the other hand, the molecules structurally similar like stereo-isomeric compounds of essential oils which are difficult to separate by GC instruments can be analyzed by 13C NMR [73]. Therefore, this technique is also applied to identify the quality control of volatile compounds of essential oils. Mass Spectrometry is normally used to identify and elucidate the structure and chemical properties of molecules include unknown compounds. Besides, the MS Spectrum able to determine the molecular weight of the sample.

3.2 Infrared Spectroscopy

Infrared Spectroscopy is used to determine the functional group present in the sample. This instrument able to measure the wavelength and intensity of the absorption of mid-infrared light by a sample [70]. IR spectroscopy also used to confirm the identity of a particular compound beside capable to determine the newly synthesized molecule. The IR wavelength shows the characteristics of specific types of chemical bonds. An addition, IR spectroscopy is useful for qualitative analysis of organic and organometallic molecules. For example, citral is major compound in *C. citratus* extract. In the IR spectrum analysis, the functional groups of citral were observed. In the vibrations at 2968 cm^{-1}, asymmetric stretching of -CH3 is observed corresponding to an alkyl saturated aliphatic group and at 2915 and 2857 cm^{-1} [29]. At 1671 cm^{-1} of intense band is observed due to vibrations of C=C (cis and trans). The presence double bonds (C=C-CHO) in citral showed as acyclic monoterpenes. The list of detector used in each instrument for qualitative and quantitative analysis are summarized in Table 2.

Table 2: Qualitative and quantitative analysis involves in the identification of *Cymbopogon* extract

INSTRUMENT USE	DETECTOR USE IN INSTRUMENT	PURPOSE OF DETECTION	REFERENCES
Fourier Transform Infrared Spectroscopy (FTIR)	Infrared Spectroscopy (IR)	To identify the functional groups present in the active compounds	[70]
Gas Chromatography (GC)	Mass Spectrometry (MS)	To determine the molecular weight of the volatile compound	[1], [4], [16], [22]–[25], [70], [72], [73]
	Flame Ionization Detector (FID)	To measure the essential oil concentration using a gas stream	
Nuclear Magnetic Resonance Spectroscopy (NMR)	^{13}C-NMR and ^{1}H-NMR	To identify carbon atoms and hydrogen atoms that present in the single compound	[33], [34], [70]

IV. A POTENTIAL BIOACTIVE COMPOUNDS

4.1 Phytochemical constituents of Cymbopogon extract

The *Cymbopogon* extract contains some chemical substances that produce physiological and biochemical actions in the human body. Most of the bioactive constituents attributed to *Cymbopogon* extract are derived from its leaves, stem, and rhizomes, and their secondary metabolites. Despite these differences, a number of classes of compounds are reproducibly found, including phytonutrients, mineral contents and essential oils. The list of phytonutrients exists in *Cymbopogon sp.* are shown in Table 3 such as tannins, phenolics, saponins, flavonoids, steroids, carbohydrates, glycosides, protein and amino acid. The class of aromatic compound is tabulated in Table 4 meanwhile Table 5 had shown that numerous mineral contents appear in *Cymbopogon* extract [2], [39], [35], [71]. Despite these differences, the crude of essential oil extract from *Cymbopogon* plant consists a number of classes volatile compounds such as hydrocarbon terpenes, alcohols, ketones, esters and mainly aldehydes. The molecular structure of some active compounds namely as Linalool (1), Geraniol (2), Nerol (3), Geranial (4), Myrcene (5), Citronellal (6), Neral (7), Citronellol (8), Limonene (9), Elemol (10) are shown in Figure 2.

Table 3: Phytonutrients reported in *Cymbopogon sp.*

GROUP OF PYTOCHEMICALS	BIOACTIVE COMPOUNDS	NAME OF METHOD USE	REFERENCES
Terpenoids and essential oils	Ketones, aldehyde, alcohol groups, hydrocarbon, terpenes, esters	Distillation method	[1], [2], [5], [10], [14]–[18], [27], [28], [33]–[39], [52], [57], [58], [63], [64], [67], [70]

Table 4: Essential oil of *Cymbopogon* extract contains a numerous aromatic compound

GROUP OF PHYTO-CHEMICALS	BIOACTIVE COMPOUNDS	NAME OF TEST USE	REFERENCES
Mineral contents	Sodium (Na) Calcium (Ca) Iron (Fe) Phosphorus (P) Potassium (K) Magnesium (Mg) Zinc (Zn)	Qualitative and quantitative using: • Instrumental Neutron Activation Analysis • Atomic Absorption Spectrophotometer	[33], [34], [39], [67], [68], [71]

Table 5: Mineral content reported in *Cymbopogon sp.*

GROUP OF PHYTO-CHEMICALS	BIOACTIVE COMPOUNDS	STRUCTURAL FEATURES	NAME OF TEST USE	REFERENCES
Phytonutrients	Phenolics	C3 side chain, -OH groups, phenol ring	Lead acetate test,	[2], [5], [10], [27], [28], [35], [40] [42], [66]–[68], [71], [74]
	Tannins	Polymeric phenols (molecular weight: 500-3000)	Ferric chloride test	
	Flavanoids	Phenolic structure, one carbonyl group, hydroxylated phenols, 3-hydroxyl group	Lead acetate test	
	Steroids	Organic compound with 4 rings	Salkowski test	
	Saponins	Amphipathic glycosides	Honeycomb test, Foam test	
	Carbohydrates	Biological molecule form of monosaccharides consists of H, C, and O atom	Fehlings test, Benedicts test	
	Glycosides	Sugar with non-carbohydrate moiety	Glycosides test	
	Protein and amino acids	Linked together through peptides bonds and cross-linked chains by hydrogen bonds	Biuret test, Kjedahl method, Ninhydrin test	

The phytochemicals that present in *Cymbopogon* extract is presented in Table 6. The constituents of essential oil extracted from *C. citratus* and *C. nardus* using different extraction method were analyzed by GCMS and summarize in Table 7 [10], [14], [17], [22]–[28], [63], [64]. Several research works have been reported that the chemical composition of the essential oil of *C. citratus* and *C. nardus* varies according to the geographical origin [63], [64]. In addition, the different percentage of essential oil composition is might be affected by several factors such as climate, the age of plantation and efficiency of distillation method [10], [27], [28]. For example, *C. citratus* contains a high percentage of citral, which is a mixture of terpenoids neral and geranial [16], [75]. Besides, this high citral content justifies the large scale commercial cultivation of *C. citratus* in several countries and it is responsible for the lemony odor and serves as an aroma compound and used in perfumery. However, the younger *C. nardus* leaves were found to have a higher content of citronellal and citronellol while the older leaves were found to have a higher content in geraniol. As mentioned earlier, the *Cymbopogon sp.* has lemony scent ordour due to citral was found in high percentage in the older *C. nardus* leaves. This could be the main compound that contributed to the differences in smell and appearance of *Cymbopogon* extract. Citral extracted from *Cymbopogon sp.* are valuable for pharmacology activities such as antimicrobial activity, antimutagenicity effect, antioxidants, hypocholesterolemic, and anti-nociceptive effects.

Table 6: Potential active compounds reported in lemongrass oil and citronella oil

PLANT TYPE		ACTIVE COMPOUND
Cymbopogon citratus [2], [35]		citral, α-terpinol, β-*O*-cimene, α-pinene oxide, *t*-muurolol, 1-Octyn-3-ol, neral, geranial, citronellol, γ-muurolene, α-farnesene, δ-cadinene, β-myrcene, linalool, citronellal, nerol, geranyl-acetate, *t*-cadinol
Cymbopogon nardus [10], [27], [28]	Ceylon type	Camphene, dipentene, citronellal, geraniol, geranyl acetate, nerol, citronellol, farnesol, linalool, borneol and methyl eugenol
	Java type	Limonene, citronellal, citral, geraniol, citronellol, citronellal, eugenol, chavicol, elemol, citronellyl oxide, δ-cadinene, γ-cadinene, methyl eugenol, and vanillin

Table 7: The chemical compositions of oil extracted from *Cymbopogon citratus* and *Cymbopogon nardus* using various method of distillation and analyze by GCMS

Method Use	Steam Distillation	Microwave Hydro - distillation	Hydro – distillation		Steam Distillation	Unknown Method		Hydro-distillation
Plant Species	*Cymbopogon citratus*				*Cymbopogon nardus*			
Plant Origin (Variety)	Unknown	Unknown	Malaysia	Malaysia	Malaysia	Malaysia (Ceylon)	India (Java)	India (Ceylon)	Malaysia (Ceylon)
References	[57], [58]	[52]	[24]	[24]	[64]	[14], [18]	[27]	[27]	[14]
Compound (% of mass)									
β- mycrene	6.80	10.20	3.96	9.91	2.09	-	-	0.30	-
Linalool	-	0.58	0.48	-	1.37	-	1.50	1.20	-
Citrnonellal	35.90	0.20	-	-	0.33	20.99	32.70	5.20	22.09
Citronellol	5.20	-	0.50	-	-	13.64	15.90	8.40	12.26
Nerol	-	32.40	-	-	5.49	-	7.70	0.90	-
Neral	-	-	35.69	9.91	-	4.94	-	-	7.97
β-citral	-	-	-	-	23.77	-	-	-	-
geraniol	20.90	5.50	-	-	12.05	42.43	23.90	18.00	41.48
geranial	1.50	45.20	50.81	49.46	32.43	4.39	-	-	8.39
δ-cadinene	2.10	0.95	-	-	0.24	1.35	-	-	-
elemol	-	0.60	-	-	0.17	-	6.00	1.70	-
caryophyllene oxide	-	0.18	-	-	0.46	-	-	-	-
α-gurjene	-	0.45	-	-	1.76	-	-	-	-
δ-limonene	1.80	-	-	-	-	-	1.30	9.70	-
citronellyl acetate	2.90	-	-	-	-	2.13	3.00	1.90	1.37
geranyl acetate	4.00	-	-	-	-	7.74	-	-	4.73

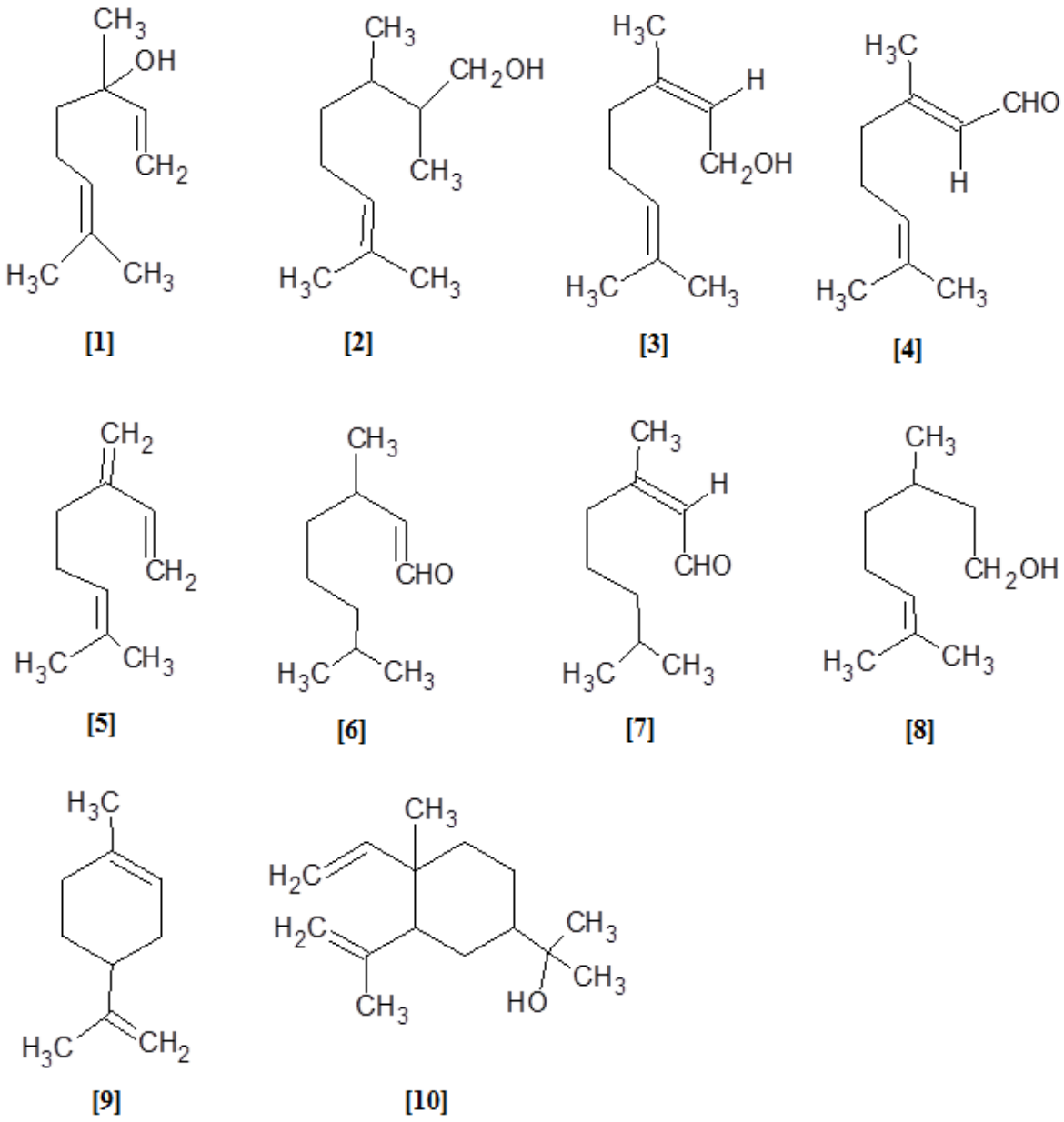

Figure 2: Molecular structure of aromatic compound extract from *Cymbopogon* plant

V. BIOLOGICAL ACTIVITIES

5.1 Biological activities of *C. citratus* and *C. nardus*

The *Cymbopogon* extract is good as traditional herbal remedies and have the ability to treat several diseases such as gastrointestinal problems, fever and hypertension [2], [5], [76]. For example, the product extract of *C. citratus* is known as a folk remedy for such treatment such as a cough, consumption, flu, headache, pneumonia, malaria, digestive problems, diarrhea, stomach ache and vascular disorders [2], [3], [5], [76]. It is mostly taken in the form of tea as a remedy. Other than that, *C. citratus* has been widely used as carminative and insect repellent besides contributes good scent flavour in the culinary process for food preparation. *C. nardus* extract has similar application and traditionally used for postpartum bath. This plant will be boiled and used externally during the shower for confinement lady. In addition, *C. nardus* extracts is well used as body massage at body spa center. Meanwhile, in Chinese culture, the leaves of *C. nardus* specifically use for rheumatism and commonly uses in the treatment of fever, digestive problem, intestinal parasites, and menstrual problems.

It has been documented in various literature that the active compound obtained from both of *C. citratus* and *C. nardus* possess several biological activities, such as antimicrobial activity, antimutagenicity effect, anti-inflammatory effect, anti-nociceptive effect, hypocholesterolemic effect and antioxidant [1], [4], [77]. A number of studies have found that *C. citratus* extract able to exhibit inhibition against several isolates bacterial such as *Staphylococcus aureus*, *Streptococcus bovies*, *Salmonella typhi* and *Escherichia coli* [78]. The active compound of *C. citratus* was extracted using the different type of solvent which are methanol and aqueous extract. The results obtained showed that microbial growth was greater in methanol extract as compared to aqueous extract [78]. Furthermore, the essential oil that has been extracted from *C. nardus* has high potential to function as antibiotic for the use against systemic bacteria which have been isolated from the internal organs of aquatic animals [62]. Minimum inhibitory concentration (MIC) of the essential oil tested against bacteria isolated from these aquatic animals were determined by using two-fold broth microdilution method with kanamycin and eugenol as positive controls [62], [79]. The MIC values of the citronella against isolated bacterial such as *Edwardsiella spp.* (n = 21), *Vibrio spp.* (n = 6), *Aeromonas spp.* (n = 2), *Escherichia coli* (n = 2), *Salmonella spp.* (n = 2), *Flavobacterium spp.* (n = 1), *Pseudomonas spp.* (n = 1) and *Streptococcus spp.* (n = 1) ranged from 0.244 µg/ml to 0.977 µg/ml [62].

Also, the chemical constituents of *C. nardus* demonstrated strong antimutagenic effect towards *S. typhimurium* strains TA98 and TA100 [80], [81]. Results obtained from mutagenic testing evaluate that ethanol and water extract of *C. nardus* extracted were not mutagenic to both strains of *S. typhimurium* [80]. In particular, methanolic extracts of *C. citratus* such as alkaloids, steroids, flavonoids, tannins, saponins and carbohydrates possess moderate analgesic activity as well as exhibited significant anticancerous activity [5], [82]. In addition, an aqueous root extract of *C. citratus* possesses to treat anxiety disorders at different dose levels in comparison to standard and normal saline group. Essential oils obtained from *Cymbopogon* extract have folk medicine properties due to the presence of citral compound. Citral compound has a significant pharmacological evidence as antidiabetic by reducing the effect of Type 2 diabetes with multiple targets in Wistar rats [4], [83], [84]. In other investigation, highest dosage of lemongrass oil has indicated a useful effect of reducing the cholesterol level in the blood [4], [85]. In addition, inhalation of citronellol compound presence in citronella oil has an indirect role to promote weight loss by reducing the appetite for food intake without affecting the liver [85].

The main aromatic compound possesses high biological activity had summarized in Table 8. Although a lot of pharmacological investigations have been carried out based on the ingredients present, a lot more can still be explored, exploited and utilized.

Table 8: Biological properties of *Cymbopogon sp.*

Component	Biological activities	References
mycrene	Antibacterial activity	[2], [27], [33], [35], [59],
citral	Antibacterial activity	[68], [75], [86]
α-citral (geranial)	Antinociceptive activities	[59], [66], [75], [86], [87],
	Antimicrobial activity	[88]
β-ciral (neral)	Antinociceptive	[65]
geraniol	Antiviral activity	[66], [88]
limonene	Antioxidant activity	[5], [8], [22]–[25], [33],
		[34], [41], [42], [71]
methyl heptenone	Anti-diabetic activity	[5], [15], [57], [58], [65],
	Anxiolytic properties	[77], [79]
	Antinociceptive activity	
	Antifungal activity	
citronellol	Antifungal activity	[2], [10], [38], [75], [90]

VI. CONCLUSION

It can be concluded that liquid and oil extract for both *Cymbopogon sp*. have therapeutic constituents and widely used in numerous industry includes agriculture, medicinal and perfumery industries. The conventional methods of extraction process are widely used such as by distillation process to produce a good yield of lemongrass oil extract. The choice of solvent will be influence the result of product extract. Water is the best solvent extract to lower the toxic effect. Gas Chromatography with Mass Spectrometry detector is practical quantitatively and qualitatively in order to identified the chemical constituents of volatile compound in essential oil. Most of the compounds reported in *Cymbopogon* extract are neral, geranial, geraniol, citral, citronellal, citronellol and mycrene. This mainly aromatic compound is reported to be high potential to treat a numerous disease and proven by a variety of biological activities.

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