Chemical composition of *Cymbopogon nardus* essential oil and its broad spectrum benefit

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Abstract. Investigation was conducted to determine the chemical composition of *Cymbopogon nardus* oil (CNO). Firstly, the leaves of CNO was characterized on its macro nutrient. Distillation was carried out on *C. nardus* leaves which were air dried conditioning for previous 24 hours. CNO was then analyzed using GCMS Pyrolysis Type Shimadzu QP2010. The nutrient laboratory test found that *C. nardus* leaves have water content 11.15%, C organic 25.30%, total N 0.77%, C/N ratio (33.00%), total P (0.40%) and total K (1.08%). Literature study on benefit uses were carried on previous study. A total of 29 active compounds have been identified and quantified by GCMS Shimadzu QP2010. Predominant constituent among them: ammonium carbamate (18.26%), carbinol (13.57%), neophytadiene (11.65%), trans-geraniol (6.92%), phenol-methoxy (6.15%), norolean (4.93%), benzofuran (3.9%), guaiacol (3.23%), hexadecen-phytol (3.1%), beta-citronellol (2.69%), trans-caryophyllene (2.61%), alpha-humulene (2.45%) and valerol (2.38%). A diverse spectrum benefit among: bactericidal activity (BA), anti-fungal, anti-free radicals, waste degradation (agricultural, faecal), insect repellents and natural staple preservation. The constituents of CNO active compound varied related habitat, distillation and analysis method. Agreement among researchers on predominant compounds: citral, citronellal, geranyl acetate, geraniol and citronellol to be responsible compounds on a broad of benefit.

1. Introduction

Essential oil become natural material that attract industry related the content of active compounds within. The active compounds of essential oils can be used as food preservative, antioxidants, bactericidal, antifungal, and others spectrum benefit. These active compounds come from secondary metabolism which is stored in all parts of the plant: roots, stems, bark, branch and leaf. Secondary metabolism has an important role as a plant's self-defense against pests, naturally. One source of essential oil is lemongrass (*Cymbopogon nardus*).

* C. nardus* belongs to Panicodiaceae family of Graminales [1] and well known as one of the traditional medicinal plants. The characteristics of *C.nardus* plant are green and purplish red stems, green leaf color to bluish green, flat elongated leaves resembling reeds, if the leaves are squeezed it will smell a distinctive aroma, adventitious roots and growth clumpy [1]. *C. nardus* can grow at an altitude of 200-1,100 m AMSL, however *C. nardus* is well growth at of 300-600 m AMSL. Lemongrass cultivation techniques are not too difficult and can be planted in the garden yard.

The essential oil from *C. nardus* is obtained by distilling part of plant: roots, stems or leaves, yet the yield and the best quality originated the leaves. In general, the harvested leaves are left in air
condition, waving purposes [2–4]. The principle of distillation is to separate oil and water through low-pressure steam, water distillation [5]. Distillation technique may use a kettle, even local people adopt as a local wisdom, traditionally. C. nardus essential oil is widely used as a mixture of traditional medicine appertain active compound. Hence, this study aims to investigate the composition of active compounds of C. nardus essential oil and discuss on its broad benefits spectrum.

2. Materials and Methods

2.1. Raw materials
Leaves of C. nardus were obtained from KPHP XIII Lakitan Bukit Cogong-South Sumatera. Geographically located between 102°46'12" to 103°15'36" East Longitude and 02°45'00" to 03°16'48" South Latitude. Materials were one of species within the scope of joint research between Forest Products Research and Development Center and Peat Restoration Agency. C. nardus planted on drained peatlands, meanwhile restoration forest area apply agroforestry.

![Figure 1](image-url)  
**Figure 1.** (a) *Cymbopogon nardus* plant; (b) agroforestry mechanism in restoration forest area

2.2. Methods

2.2.1. Raw materials preparation
After harvesting, C. nardus leaves were package and transported of 20 kg sack. C. nardus leaves were air dried for 24 hours in a depot. The material was inserted into distiller without being chopped, 50 kg distillation capacity and as long as 5.5-hour processing.

2.2.2. Characterization of raw materials
Macro nutrient analysis using titration method as stated below.

| No | Parameter     | Root (%) | Leave (%) |
|----|---------------|----------|-----------|
| 1  | Water content | 5.48     | 11.15     |
| 2  | C organic     | 18.12    | 25.30     |
| 3  | N total       | 0.36     | 0.77      |
| 4  | C/N ratio     | 50.00    | 33.00     |
| 5  | P Total       | 0.28     | 0.40      |
| 6  | K Total       | 1.15     | 1.08      |
2.2.3. GCMS Analysis
Identification and analysis of organic chemical compounds of *C. nardus* oil (CNO) using Gas Chromatography-Mass Spectrometry (GCMS) Pyrolysis Type Shimadzu QP2010. GCMS condition: helium as a carrier gas; linear speed of 23.7 cm. second⁻¹; column and injection temperature 280°C; pyrolizer temperature 400°C; pressure of 101.0 kPa; and contact time for 50 minutes

3. Results and Discussions

3.1. Chemical composition
A total of 29 active compounds were identified and quantified by GCMS Shimadzu QP2010. The organic chemical and its percentage were listed in Table 2. Most constituents in this study have similarity with previous research including groups of valerol, citronellol, geraniol, e-citral and neryl acetate, a mutual agreement in lemongrass oil. In the present study we have found CNO predominant compound consist of: ammonium carbamate (18.26%), carbinol (13.57%), neophytadiene (11.65%), trans-geraniol (6.92%), phenol-methoxy (6.15%), norolean (4.93%), benzofuran (3.9%), guaiacol (3.23%), hexadecen-phytol (3.1%), beta.-citronellol (2.69%), trans-caryophyllene (2.61%), alpha-humulene (2.45%) and valerol (2.38%). Previous studies announced the constituent of CNO consists of 17 compounds [6], 37 compounds [7], 53 compounds [8] and 33 compounds [9].

| Peak # | Retention Time (minutes) | Concentration (%) | Compounds                      |
|--------|--------------------------|-------------------|--------------------------------|
| 1      | 3.462                    | 18.26             | ammonium carbamate             |
| 2      | 13.588                   | 3.23              | guaiacol                       |
| 3      | 13.898                   | 13.57             | carbinol                       |
| 4      | 14.684                   | 2.38              | valerol                        |
| 5      | 14.854                   | 2.69              | citronellol                    |
| 6      | 15.157                   | 6.92              | geraniol                       |
| 7      | 15.342                   | 1.09              | e-citral                       |
| 8      | 15.429                   | 3.9               | benzofuran                     |
| 9      | 15.567                   | 1.57              | p-ethylguaiacol                |
| 10     | 15.976                   | 6.15              | Phenol                         |
| 11     | 16.233                   | 1.2               | neryl acetate                  |
| 12     | 16.335                   | 1.96              | 2,6-dimethoxyphenol            |
| 13     | 16.483                   | 0.67              | (-).beta.-elemene              |
| 14     | 16.842                   | 2.61              | trans-caryophyllene            |
| 15     | 17.152                   | 2.45              | .alpha.-humulene               |
| 16     | 17.633                   | 1.91              | .delta.-cadinene               |
| 17     | 17.941                   | 0.73              | elemol                         |
| 18     | 18.224                   | 0.98              | endo-1-bourbonanol             |
| 19     | 19.193                   | 1.22              | 4-allyl-2,6-dimethoxyphenol     |
| 20     | 19.759                   | 11.65             | neophytadiene                  |
| 21     | 19.931                   | 0.94              | neophytadiene                  |
| 22     | 20.063                   | 3.1               | phytol                         |
| 23     | 20.327                   | 0.79              | 14-methyl-8-hexadecen-1-ol     |
| 24     | 20.566                   | 0.69              | 3,7-dimethyl-2,6-octadienyl     |
| 25     | 20.766                   | 1.45              | palmitic acid                  |
3.2. Bactericidal activity
CNO believed to have BA as reported previous study. CNO effective against *Streptococcus mutans* and *Streptococcus sobrinus* with inhibition zones of 52.15±0.21 mm and 52.50±0.28 mm, respectively [10]. Detailed observations were conducted by testing the BA of CNO and comparing it with commercial geraniol. Gram-positive and gram-negative bacteria from the groups of *Staphylococcus aureus*, *Staphylococcus epidermidis*, *Enterococcus faecalis*, *Streptococcus pyogenes*, *Pseudomonas aeruginosa* and *Escherichia coli* were determined as targeted bacteria. Commercial geraniol has the positive effect of inhibiting halos within the groups [6], yet not all bacteria respond the same to CNO. The bacteria *P. aeruginosa* and *E. coli* were rejecting CNO treatment.

Consistent result of CNO demonstrated against 4 gram-positive and 2 gram-negative bacteria. Gram-positive selected: *Staphylococcus aureus* ATCC6538, *Bacillus subtilis* ATCC6633, *Bacillus cereus* ATCC11778 and *MRS*A, while gram-negative bacteria were *Pseudomonas aeruginosa ATCC9027* and *Escherichia coli ATCC8939*. The minimum level of inhibitory concentration (MIC) used ranges from 125 µg mL⁻¹ – 2,000 µg mL⁻¹ [8]. The highest value was 2,000mg. mL⁻¹ of MRS*A and *Pseudomonas aeruginosa*, following *Staphylococcus aureus* and *Bacillus subtilis* of 1,000 µg mL⁻¹, *Escherichia coli* 500 µg. mL⁻¹ and the minimal value was 125 µg. mL⁻¹ of *Bacillus cereus*, respectively.

Particular study was conducted with CNO as BA through *Pseudomonas* spp: *Pseudomonas agglomerans*, *P. antarctica*, *P. brassicaevarum*, *P. frederiksbergensis*, *P. koreensis*, *P. lundensis*, *P. mandelii*, *P. proteolytica*, *P. synxantha* and *P. veronii* [11]. Observation of BA was stage out using a method for diffusion discs and MIC. CNO has successfully suppressed the growth of *Pseudomonas spp*, yet *Cinnamomumzeylanicum* superior agent has been concluded [11].

3.3. Anti-fungal activity
CNO has been tested for antifungal, *Candida spp*, which is in chronic diabetic wounds. The in vitro study was conducted using mice to see CNO's activities in more detail. Giving 100 µg mL⁻¹ of CNO, was announced to inhibit the growth of *C. albicans* (65±2.2 mm), *C. glabrata* (56±1.8mm) and *C. tropicalis* (44±1.1mm) at 7, 14 and 21 days of experimental [7]. More detailed observation made by [9] on hyphae species: *C. albicans* (CA-ATCC 90028, CA2, CA3, CA4); *C. krusei* (CK-ATCC 6258, CK2, CK3, CK4); *C. glabrata* (CG-ATCC 2001, CG2, CG3, CG4); *C. tropicalis* (CT-ATCC 13803, CT2, CT3, CT4), *parapsilosis complex-C. parapsilosis* (CP-ATCC 22019), and *C. orthopsilosis* (CO-ATCC 96141). *C. albicans* ATCC 10231. A scientific evident that CNO has anti-fungal properties, even compared to commercial citronellals [9].

3.4. Anti-oxidant agent
1, 1-diphenyl-2-picrylhydrazyl (DPPH) used as free radical in the study. DPHH is the easiest and fastest method in testing anti-free radical activity. The results show that CNO was effective against DPHH with EC50% 2.44 µg/mL⁻¹ [8]. Similar results showed by [11] for 2,2-diphenyl-1-picrylhydrazyl (DPPH) free radicals. CNO compound to be responsible for anti-oxidant activity was citral, pre assumption.

3.5. Agricultural residue degradation
Herbicide and insecticide residue caused problems in aquatic, as hazardous substance. Among them, 2,4-Dichlorophenoxyacetic Acid (2,4-D), have found in modern agricultural application. 2,4-D
exposure suspected to harm liver and nervous system of humans. In fact, farmers prefer to use fertilizers/herbicides/chemical insecticides rather than organics, increasing the risk of exposure. A study was conducted to minimize the effect. Novel simultaneous ultrasonic-hydro distillation (UAE-HD) technique was carried out to produce CNO. CNO products were then used as silver nanoparticles (Ag) synthesis media. In the result, green synthesis successfully degrades harmful residues (2,4-D), thanks to the phenol content in CNO [12].

3.6. Staple preservation
Potato staple foods have extensive product variants. But the problem lies in storing potatoes in the warehouse related growing sprouts. At the current conditions, potato preservation using air humidity control and the use of synthetic chemicals is well known technique. A triggering of the environmental pollution and chemical residue problems. Previously, low temperatures would cause a decreasing in sugar levels caused by cold conditions. Forcefully, asparagine was used as artificial sweetener to maintain the potatoes taste. This fact attracted the interest of researchers to carry out critical study, exploring natural preservatives. One potential ingredient is CNO with rich organic chemical compound. CNO constituents: citronellol, citronellal, geraniol, myrcene, citral and eugenol believed in reducing potato sprouts in the storehouse. The experiment was carried out by giving 30 µg. L⁻¹ CNO, gauze containing 0.6 mL CNO placed in the base of a plastic box. The result, CNO treatment extended the potato dormancy period to 60 days at the temperature of 10°C [13].

3.7. Antiparasitic on poultry
Ascaridiagalli is a parasite that infects livestock, boilers. This endoparasyte disrupts the growth and productivity performance of poultry. In fact, some farmers report digestive disorders and drastic weight loss. An initiative study was carried out to investigate the effect of CNO against A. galli growth. Geraniol-based CNO thought to have an effect on the development of A. galli. The study material used CNO ethanol extract and CNO powder extract. The treatment applied was by mixing CNO extract with 0.25, 0.50 and 1% distilled water as much as 100mL of solution. The solution was then poured into a petri containing A. galli. Mortality rates were evaluated at the level of 30, 60 and 90 minutes. A result shows that CNO was suppress A. galli, even kill it [14].

3.8. Environmental management
Waste management in the surface water become critical issue in developing countries concerning water consumption. Among parameters: BOD, COD, phosphorus and organism activity are used as parameters to measure consumption water quality. One of pollutant that become special attention is human faecal. Management of sewage were directing disposed to the river, without treatment. This condition will have a negative impact to the quality of surface water. A means before disposal procedures is applied to reduce the problem, one of which is by planting herbaceous plants. The combination of C. nardus (CN) and Andropogon gayanus (AG) plants were predicted to overcome environmental issues in faecal management. Dissolved oxygen content was increasing at CN (3.08 mgL⁻¹) and AG (2.92 mgL⁻¹) compared to controls of 0.81mgL⁻¹[15]. Negative relationships stated for COD and BOD parameters, decreasing compared to controls. Increasing dissolved oxygen and a decreasing in COD-BOD were in a condition of water quality improvement. The degree of pH water changes from alkali to neutral. Planting 5 clumps .m⁻² may reduce pH from 8.03 to 7.5-7.7, a remarkable result. The effectiveness of coliform reduction from AG is higher than CN; 197 mgL⁻¹ and 260 mgL⁻¹[15]. Thus, AG and CN plantation has a positive impact on improving the quality of surface water.

Environmental temperature has a strong influence on the development of livestock. Stress temperatures are very critical for newly hatched broilers. Variable broilers: nutrition, growth and sexual maturity are strongly influenced by broiler responses to heat, especially at the beginning of broiler growth. Provision of essential oils on drinking water has been done to observe the effect on broilers. Essential oil-mixture (EOM): Eucalyptus globulus, Thymus vulgaris, Cymbopogon nardus
and *Syzygium aromaticum* were given to broilers for 42 days, and fatty acid was monitored for 42 days of the study period. In 36°C conditions, critical heat stress, EOM reduce saturated fatty acids (SFA) and increase unsaturated fatty acids (MUFA and PUFA) [16].

Previously, a study has been conducted to control American cockroaches, household insects (*Periplaneta americana* L). CNO has been proven to effectively expose *P. americana* insects at level of 80%, but it was under the superior *Cymbopogon citratus*.

4. Conclusion

The study stated consistent with local wisdom, where CNO has been used as a traditional medicine, related its bactericidal activity. Study packages scientifically prove the culture of CNO in Indonesian society along active compound within. The predominant constituents of CNO: citral, citronellal, geranyl acetate, geraniol, and citronellol reported to have a broad-spectrum benefit including: BA, antifungal, anti-free radicals, staple preservation, cattle health, environmental improvement (agriculture and faecal mass) and eradicate insects’ risk.

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