Effect of Distillation Methods on Citronella Oil (Cymbopogon nardus) Content

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Abstract. Citronella grass (Cymbopogon nardus) is a permanently growing grass belonging to Poaceae grass family. Which plant is native to the tropical region, especially the south-eastern Asia regions. The Citronella oil is used wildly in industrial product as insect repellent, perfumery, cosmetic, diffusion aromatherapy and health benefit. The aim of this study was investigated the efficiency of distillation methods on citronella oil content by laboratory scale, modified alcohol boiler and extractor machine. In addition, possibility of Citronella oil was reviewed to further product development. The three distillations processing were compared on essential oil content that found the distillation method significantly influenced essential oil content (p<0.05). The extractor machine showed highest yield 6.85 ± 0.07 ml/Kg followed by laboratory scale 4.55 ± 0.31 ml/Kg and modified alcohol boiler 2.35 ± 0.16 ml/Kg. The possibility of product development was found citronella oil using on mosquito repellent is recommended at a concentrations of 5-10% and massa ge oil should not higher than 1.0%. The strong concentration can cause skin sensitivity. Therefore, the optimized concentration should be observed in product development, and value investing.

1. The first section in your paper

The The citronella oil was obtained from citronella grass (Cymbopogon nardus) extraction. This plant is native growing in tropical and semitropical areas of Asia. Citronella essential oil is required for aromatherapy, medicinal treatment, food industry and insect repellent agent [1, 2]. The main compositions contain citronellol, citronellal and geraniol which had function of antifungal, antimicrobial, Anti-inflammatory, volatile, and well-being [3, 4, 5]. On previous research citronella oil has ability against 7 bacterial strains (Escherichia coli, Salmonella typhi, Pseudomonas aeruginosa, Gram-positive Streptococcus pneumonia, Bacillus cereus, Staphylococcus aureus, Bacillus subtilis) and 3 fungi strains (Aspergillus flavus, Candida albicans, Geotrichum candidum) on food applications. In addition, Sensory evaluation was performed non-significantly on adding essential oils [6].

Citronella oil is an option prevention for mosquito repellent which lead of malaria fever and danger fever [7]. Dengue Hemorrhagic Fever (DHF) have been importance illness in Laos. Local Daily Vientiane Times reported that total of dengue fever had 5,584 cases in 2016, 4,550 cases 2017 and 1,089 half year 2018 [8]. Thus, citronella oil is attractive for product development in local area. Hence, this
study aims to compare distillation methods on citronella oil (Cymbopogon nardus) content, moreover, its utilization and benefits of was also reviewed briefly.

2. Materials and Methods

2.1. Materials
The citronella grass (Cymbopogon nardus) was collected from the local area of Luangprabang and used as a raw material. The essential oil was distilled by hydro-stream by 3 methods differently (Laboratory scale, Extractor machine and Lao traditional alcohol boiler). The extractor machine (Dongbang, CO. KR, Korea) was supported by Lao-Korea Science and Technology Center (LKSTC). Traditional alcohol boiler was modified for essential oil distillation. Heat mantle was used for heat source of Laboratory scale distillation.

2.2. Essential oil distillation process
The leaves of citronella grass were cut in 20-25 cm for each method. The capacity of raw material was contained about 75-80% for boiler volume and the essential oil was distilled by hydro-stream in each process. Traditional alcohol boiler was used for citronella oil distillation which compared with laboratory distillation and extractor machine. The experimental condition was conducted in different distillation machine (Table 1). The yields of operation were compared on essential content to evaluate efficiency distillation methods. Essential oil contents were performed in triplicate and reported as mean + standard deviation.

Table 1. Conditions of distillation process

| No. | Distillation methods  | Citronella grass (Kg) | Temperature (°C) | Time (minutes) |
|-----|----------------------|------------------------|------------------|----------------|
| 1   | Extractor machine    | 10.00                  | 100              | 120            |
| 2   | Laboratory scale     | 0.25                   | 100              | 120            |
| 3   | Alcohol boiler       | 7.00                   | 100              | 120            |

Remark: Capacity input depend on boiler volume (Extractor machine 9-11 Kg, Laboratory scale 0.2-0.3 and Alcohol boiler 6-7 Kg)

2.3. Citronella oil utilization and possibility of product development in local market
The utilization and benefits of citronella oil were reviewed briefly for product development. Presently, citronella oil is one of a nature therapies for relievers and well-being. This review aims to study on citronella (Cymbopogon nardus) utilization in commercial and applications for product development in local market. In addition, citronella grass cultivation and chemical composition were also concluded in briefly reviews.
2.4. Statistical analysis
The effect of distillation methods on oil content was analyzed for significance (p<0.05) by using one-way analysis of variance (ANOVA) and Duncan's post hoc test. The statistical analysis was displayed using statistical software SPSS Ver.23 (Chicago, Illinois, USA). The citronella oil utilization was reviewed for possibility of product development in local area.

3. Results and Discussion

3.1 Effect of distillation methods on citronella oil content
Citronella oil content was distilled by Hydro-stream processes (extractor machine, Laboratory scale, alcohol boiler). The operation conditions were conducted at same temperature and time (100 °C for 2 h) in three replications. The result found that essential oil of citronella grass was significantly affected by the distillation method of uses (p < 0.05). The highest yields of essential oil content was distilled by extractor machine (6.85 ± 0.07 ml/Kg), following by laboratory distillation (4.55 ± 0.31 ml/Kg) and higher than that alcohol boiler distillation (2.35 ± 0.16 ml/Kg), respectively (Table 2). The lower yield of essential oil content distilled by alcohol boiler machine maybe due to heat convection system was not equilibrium inside the boiler which is leads to evaporate efficiency of volatile oil. While, the extractor machine and laboratory distillation provided steady heating and condenser cooling system which contrast to distillate by alcohol boiler machine.

Previous research reported that yield of citronella essential oil content distilled by laboratory distillation standard was 5.0-18.0 ml/Kg [9]. Incomparison, our experiment showed yield of citronella essential oil content distilled by laboratory distillation and alcohol boiler machine were lower. However, the yield of essential oil content distilled by extractor machine was range similarly to the reported of Oyen (1999) [9]. On the other hand, citronella oil recovery was also depended on various factors such as raw material state, harvest season, age of leave and soil fertilizer [10, 11]. Likewise, the steady of temperature in process was affected on essential oil content in operation. Yield and quality of essential oil was increased by pressure [12]. In addition, alcohol boiler distillation provided lower yield of citronella oil content of this experiment, which was due to equilibrium and leak of stream in distilled tank.

Table 2. Effect of distillation methods on citronella oil content

| No. | Distillation methods     | Raw material (Kg) | Yield of oil content (ml/Kg) |
|-----|-------------------------|-------------------|----------------------------|
| 1   | Extractor machine       | 10.00             | 6.85 ± 0.07                 |
| 2   | Laboratory scale        | 0.25              | 4.55 ± 0.31                 |
| 3   | Alcohol boiler          | 7.00              | 2.35 ± 0.16                 |

Note: The different superscript letters are significantly different at column (p < 0.05).

3.2 Citronella oil utilization and possibility of product development in local market
Plantation: citronella grass is native to the tropical region, especially the south-eastern Asia regions. The cultivation is popularly during May to June. Plantation period should be long term because of cultivation citronella grass remains harvesting for 5 to 7 years [11]. The suitable citronella cultivation requests well drained, fertile soil, pH~6-7, 150-700 m of sea level, temperature 20-38°C of climate and steady rainfall. In case of industry plantation land should limit and avoids of termite. Plant propagation is separated from old plant or called “Slips”. Distance of plantation is about 60x60 cm to 90x90 cm, the distance depends on soil fertilizer, weed control, irrigation and area [4, 11].

Harvesting: all parts of citronella grass carries essential commonly, but essential oil quality and yield are contained by leaves. Thus, citronella leaves should be harvested in plantation. The citronella leaves can harvest after farm installing 4-6 months, and every 3-4 months after first harvesting in new
plantation. The frequency of harvests is belonged to farmer-attention and climate. Moreover, number of cutting is lead to inferior essential oil [2, 13].

Citronella oil distillation: Hydro-distillation is traditional process to achieve essential oil from citronella leaves, this method is low investment cost and non-advanced technology. Stream distillation is used to extract citronella oil basically, fresh leaves was harvested form plantation and semi-dry making 12 to 24 hours on sunlight for moisture decreasing or extraction with fresh leaves, but oil content is lower more than semi-dry leaves. Distilled operation was taken for 4 hours by distiller machine then oil and water were separated by layer [2, 11]. Yield of citronella oil is dependent on various factors which are ranged from 5.0 – 18.0 ml/Kg. The application of supercritical extraction, ohmic heating, pressure and ultrasound were provided higher oil content [14, 15, 16, 17].

Utilization of Citronella Oil: citronella is used wildly product such as fragrances in perfumes, aromatherapy, traditional medication for anti-spasmodic, insect repellent, soaps, cosmetic and food product [14, 18]. In Laos citronella grass is native plant, it is used for herb and aromatherapy in Sapa. In commercially, citronella is natural repellents on the market, used at concentrations of 5-10%. Massage oil is should not higher than 1.0%. The higher concentration can effect on skin sensitivity. Although citronella oil is non-toxicity with human but pregnant and children should be avoided from citronella oil using [19, 20].

4. Conclusion
Methods of distillation process influenced all citronella oil content. Extractor machine showed best distilled efficiency of oil content. Traditional alcohol boiler shown lowest on oil content compared to extractor machine and laboratory distillation, however, this is the beginning of application with Lao traditional equipment, which lead to improve apparatus perfectly in future.

Citronella oil is used on different product as insect repellent, aromatherapy, medical, cosmetic and food product. However, citronella oil is still had various benefit and offered potential essential options which could be further applied to other applications.

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