Formulation of the Lemongrass (*Cymbopogon citratus*) essential oil-based eco-friendly diffuse solution

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Abstract. One of the most challenging issues associated with the use of artificial scent is the harmful effects not always visible to the eyes. To meet the growing consumer demand for the natural active ingredients of household products, the team looked for new, rich ingredients that have ample amount of compound that create scents and exhibit high antibacterial activities. The main objective of this study was to formulate a diffused product by replacing the harmful synthetic ingredients with safe natural ingredients. After applying the hydrodistillation method for the extraction process, lemongrass essential oil obtained with optimum efficiency of 0.29%. The process and formula of diffused products are optimized through the process of influencing parameters such as platform oil, emulsifier, solvent, Tween 80 and essential oil. The results indicate that lemongrass essential oil can be used as an eco-friendly alternative, which can add up the aromatic and deodorizing properties to the synthesized fragrance. The research into the application of lemongrass essential oils in many products will provide insight into the potential development of essential oils in the field of home care products.

1. Introduction

Today, essential oils are the subject of many scientific studies and also attract the attention of the cosmetics and pharmaceutical industries due to their potential as aromatic compounds or natural preservatives [1–5]. The wide variety of natural compounds and biological properties that make them attractive to many new and unexplored industries and applications. Regardless of the sensory properties of essential oils, the antibacterial, antifungal and especially aromatic activities of each essential oil are the goals of the study [6–10]. A promising new area of application of essential oils for flavoring and enhancement of preservatives from nature in cosmetics has been investigated [11–15].

Lemongrass has the scientific name of *Cymbopogon citratus* currently has about 55 species. It is one of the plants with a sweet and attractive scent, is applied in much cosmetic technology (e.g. perfume, perfume and bath soap) and food (e.g. tea, baking spices). Lemongrass is a year-round plant with thin, long leaves, is one of the most widely used medicinal plants and is also the most oil-extracted plant in
tropical countries like Asia, Africa, and America. The aroma of citronella is due to the composition of the components in the essential oil, they create a gentle fragrance and long-lasting, an important aroma of high-class cosmetics [16, 17]. A number of previously published reports have revealed the presence the compounds identified in citronella are mainly terpenes, alcohols, ketones, aldehydes, and esters. Essential oils contain Citral, Citral, Nerol Geraniol, Citronellal, Terpinolene, Geranyl acetate, Myrcene, and Terpinol Methylheptenone [18–23].

Nowadays, the natural lemongrass essential oil is very expensive. Despite the higher prices, many people still switch to using natural essential oil products instead of synthetic essential oils. However, the determination of the essential oil component serves the production technology of essential oil applications has not been focused yet. There is no method to satisfy the requirements set forth about the efficiency and quality of citronella oil.

Lemongrass essential oil has been studied and applied widely for centuries ago, in many countries around the world [24–28]. Particularly in our country, the research of citronella oil, as well as the ability to apply research results, have been almost neglected. In addition, the safety of cosmetics is always of special interest to researchers and manufacturers, as the influence of microorganisms can lead to product degradation and endanger human health. Diffused products now commonly marketed are mainly blended with aromas to create a fragrance for products that contain products mixed with essential oils to create the fragrance, repel mosquitoes, insects, and deodorants. Besides, the price of these products is quite high, it mainly processed in Vietnam or imported from other countries such as Japan, Indonesia and Malaysia.

To create diffused products in the form of a solution of lemongrass essential oils, several factors such as solute/emulsifier of essential oils, the percentage of essential oils in the product to the highest aroma at a low cost should be taken into consideration. Furthermore, large-scale and low-quality production of essential oil may also do harm to consumer health, as well as the environment by disposing a significant amount of waste, toxic chemicals and non-recyclable containers [29]. For these reasons, research and preparation of environmentally friendly diffusing products made from lemongrass essential oils are essential, taking advantage of available raw materials in Vietnam with competitive prices.

2. Materials and methods

2.1. Raw materials and chemicals

Lemongrass materials were collected and selected in Tan Phu Dong district, Tien Giang province, Vietnam in the spring of 2019. The leaves are cut 20 cm away from the root, pick up and remove withered leaves, stored in a cool, convenient place during production for a few days. The extraction of essential oils is carried out by the hydro distillation system with an industrial scale of inputting about 200–750 kg. 710 kg of lemongrass leaves have been steam distilled with temperature of 100°C and steam flow rate of 110–130 L per hour for 3 hours to obtain essential oils. The addition of sodium sulfate has been done to remove excess water left in the essential oil, then the oil stored in a closed vial.

Chemicals used: Dipropyliden glycol and paraffin are purchased at Nguyen Ba Trading Production Co., Ltd, Tan Binh District, Ho Chi Minh City. Tween 80 and ethanol were obtained from Xilong Group (China). Coconut oil was from Luong Quoi Coconut Co., Ltd and Borges Extra Virgin Olive Oil from Spain.

2.2. Product blend process

Lemongrass essential oil is first dissolved with a vegetable oil, antioxidants and emulsifiers are stirred to form a homogeneous mixed solution in phase 1. Then water, ethanol and isopropanol are separately stirred in phase 2 forming a homogeneous mixture. After a period of 30 minutes, the phase 1 mixture is slowly added to phase 2, continue stirring for 2–3 hours. After adding colors and different flavors, we will get a diffusion solution.
Table 1. Table of formulation of lemongrass essential oil.

| Ingredients          | %  |
|----------------------|----|
| Tween 80             | 2–12|
| Lemongrass essential oil | 2–6 |
| Coconut oil          | 0–4 |
| Ethanol              | 0–20|
| BHT                  | 0.1–0.5|
| Water                | just enough|

2.3. Evaluation methods

2.3.1. Method of assessing the appearance of products

*Homogeneity and clarity:* the product is contained in a transparent jar and visually observes against a white background under light to assess its homogeneity and clarity.

*Color:* visual observation, color identification and uniformity for preliminary evaluation. If the accurate determination is required, a colorimetric method may be carried out using a colorimeter.

*Odor:* describes the perceived odor.

*pH:* measured by using a Consort pH meter (Consort C3010, Belgium)

2.3.2. Methods of evaluating product durability

Products are stored in airtight bottles and stored under different conditions: room temperature, acceleration and thermal shock. The diffusion ability of essential oil was evaluated.

2.3.3. Methods of assessing the volatility of products

Place 2 ml of the sample solution on a petri dish, observe the evaporation time. Weigh the samples before and after leaving it at room temperature for 1 h, 2 h and 3 h. Record the clear aroma diffusion content at each time interval.

3. Results and discussion

3.1. The effect of platform oil contents on diffusion solutions

The influence of the oil on the background of the diffusion solution product is shown in figures 1 and 2. The results showed that the physical appearance of the product when using a coconut oil give the best result in terms of clarity, uniformity, fragrance, pH of the solution. For olive and paraffin oils, the solution is cloudy and small particles of oil appear on the surface. Similarly, when dipropylene glycol is used as a platform oil, the solution shows a clear separation and the oil layer will float up. Figure 1 shows the effect of the oil on the diffusion of the mosquito repellent solution. The results showed that the use of coconut oil as a platform oil resulted in a much higher degree of diffusion than when using paraffin oil, in which, with a survey time of 3 hours, the obtained diffusion level was the highest (1.045). Figure 2 shows the effect of coconut oil content on diffused products. The results showed that with the content of coconut oil increased from 0–1%, the level of product diffusion increased from 0.871 to 0.925. However, when the content of coconut oil increased to 1.5 and 2%, the level of product diffusion decreased from 0.853 to 0.783. This could be explained by the fact that coconut oil is enriched in triglycerides; thus its addition of at high concentration would increase the solution viscosity, limiting the diffusity of the product [30]. Similar to the conductive oil survey experiment, when the time increases from 1–3 hours, the diffusion of the product increases. In particular, the level of product diffusion at 3 hour intervals soared compared to 1 h and 2 h. Therefore, using a sample of coconut oil with a content of 1% for the next survey.
Table 2. The influence of platform oil on diffusion solutions.

| Platform oil | Coconut oil | Olive oil | Paraffin | Dipropylene glycol |
|--------------|-------------|-----------|----------|-------------------|
| Physical appearance | Slightly turbid | Turbid | Turbid | Turbid |
| Uniformity | Uniformity | Small oil particles float on the surface of the solution | Oil floating on the surface of the solution | Oil floating on the surface of the solution |
| Fragrance | Pleasant | Pleasant | Pleasant | Pleasant |
| pH | 6–7 | 6–7 | 6–7 | 6–7 |

Figure 1. The effect of platform oil on the background of the diffusion solution.

Figure 2. The effect of coconut oil contents on the background of the diffusion solution.

3.2. The effect of Lemongrass essential oil contents on diffusion solutions

The physical appearance of the product using different concentrations of essential oils is presented in table 2. The analysis showed that the content of lemongrass oil is proportional to the turbidity of the product, besides the high content of lemongrass also affects the smell of the product, causing a strong
odor when use. The influence of the oil content on the evaporation of the solution is shown in figure 3. Lemongrass essential oil has many attractive aromatic compounds (myrcene and limonene) and some compounds capable of deodorizing and strong antibacterial activity (citral and geraniol) should be used as the main ingredient in mosquito repellent solution. The volatility of the solution increases with the concentration of essential oil from 2 to 4% after 1 hour and 2 hours and 3 hours, when the concentration of 5 and 6% increases, the sample changes to a slightly cloudy state, slightly lower than the 4% sample. Therefore, the content of lemongrass essential oil using 4% is suitable for diffusion products.

| Table 3. The influence of lemongrass essential oil contents on diffusion solutions. |
|---------------------------------|----|----|----|----|----|
| Lemongrass essential oil contents | 1% | 1.5% | 2% | 2.5% | 3% |
| Physical appearance              | Slightly turbid | Slightly turbid | Slightly turbid | Turbid | Turbid |
| Uniformity                        | Uniformity     | Uniformity     | Uniformity     | Uniformity     | Uniformity     |
| Fragrance                         | Very light     | Light          | Pleasant       | Pungent       | Very pungent   |
| pH                               | 6–7           | 6–7           | 6–7           | 6–7           | 6–7           |

**Figure 3.** The effect of lemongrass essential oil contents on the background of the diffusion solution.

### 3.3. The effect of emulsifier on diffusion solutions

The physical appearance of the product when using different types of emulsifiers is shown in table 4. The results showed that, when using emulsifiers such as tween 20, tween 80, the solution was more opaque when using the emulsifier type PEG-40. Regarding the degree of homogeneity, observing the separation of the essential oil in the product base when using emulsion is Tween 20 and when using the other two emulsifiers, the phenomenon does not appear. The effect of emulsifier on the evaporation of the product is shown in figure 4. The results show that the emulsifiers Tween 20 (1.45) and Tween 80 (1.43) have the best evaporation than PEG-40 (1.16). However, in terms of appearance, Tween 20 appears the separation of essential oils. Therefore, Tween 80 is selected as the main emulsifier in the solution for the next survey.

The influence of the content of Tween 80 on the background of the sample solution is shown in figure 5. The results showed that Tween 80 surfactant accounted for 4% of the obtained solution with high stability and low viscosity. The reason is that the amount of surfactant just enough to break the emulsion up to micrometer size [31], while 10% and 12% of the large emulsifier makes the spray of odorant liquid...
difficult to use. Conversely, when using 2, 4, and 6% low emulsion content leads to unstable system, there is phenomenon of delamination, so use 8% content to investigate the next factor.

**Table 4.** The influence of emulsifier on diffusion solutions.

| Emulsifier | Tween 20 | Tween 80 | PEG-40 |
|------------|----------|----------|--------|
| Physical appearance | Turbid | Turbid | Slightly pure |
| Uniformity | Oil floating on the surface of the solution | Uniformity | Uniformity |
| Fragrance | Pleasant | Pleasant | Pleasant |
| pH | 6–7 | 6–7 | 6–7 |

**Figure 4.** The effect of emulsifier contents on the background of the diffusion solution.

**Figure 5.** The effect of Tween 80 contents on the background of the diffusion solution.
3.4. The effect of solvent on diffusion solutions
The physical appearance of the product using different types of solvents is presented in Table 4. The results showed that with ethanol the diffusion solution obtained was more transparent when using isopropanol. The diffuse solution used ethanol has a pleasant aroma, while with the isopropanol, the diffuse solution has a strong odor caused by the solvent vapor. The evaporation of diffusion solutions using different types of solvents is shown in Figure 6. The results showed that the evaporation of the diffusion solution using ethanol is much higher than that of isopropanol. After a period of 2 hours and 3 hours, the evaporation of ethanol is 0.768–1.053 compared with isopropanol 0.666–0.913 respectively. At the same time, with the specific characteristics of isopropanol when used as a solvent in the solution, it will have a slightly pungent odor, reducing the aroma of essential oils. Therefore, ethanol is used as a solvent for diffusion products.

The evaporation rate of the solution depends mainly on the amount of solvent used, the difference between the concentrations is shown in Figure 7. According to the observation results, the percentage 5% and 10% volatility after 3 hours 1.253–1.179, respectively. Additional amount of solvent content to 15%, 20% of the evaporation gradually increases with the solvent content of 1.289–1.315 after 3 hours. Although, the ethanol content of 15% and 20% has a higher diffusion than the remaining sample, but the solution appears a separation state between the two phases of oil and water, the oil layer separates and floats on surface of solution. Therefore, use 5% ethanol for the subsequent survey of factors.

Table 5. The influence of solvent on diffusion solutions.

| Solvent   | Ethanol | Isopropanol |
|-----------|---------|-------------|
| Physical appearance | Slightly turbid | Turbid |
| Uniformity | Uniformity | Uniformity |
| Fragrance | Pleasant | Very pungent (smell of solvent) |
| pH        | 6–7     | 6–7         |

Figure 6. The effect of solvent contents on the background of the diffusion solution.
3.5. The effect of antioxidants on diffusion solutions

The appearance of the product when using different antioxidants is shown in Table 5. The results showed that, with BHA preservative the solution obtained was clear but separated. In contrast, with the antioxidant BHT, the solution is cloudy without separation. The influence of the antioxidants used in the sample to the diffusion is shown in Figure 8. In terms of evaporation after 3 hours, the BHA 0.995 sample and the BHT 1.247 sample, proving that the BHT model evaporates a lot better. Although the properties of BHT are similar to BHA's, they are more heat-resistant. However, BHT has a lower antioxidant effect than BHA because the space structure of BHT is more bulky than BHA (because in the molecule of BHT, there are 2 groups of tert - butyl around the group - OH). Therefore, use BHT as an antioxidant in solution samples.

The influence of antioxidant content on the background of the product of diffusion solution is shown in Figure 9. The volatility between different concentrations does not have much difference, the sample reaches the highest value at the content of 0.1% (1.145). For antioxidant content at 0.2, 0.3, 0.4, 0.5%, the diffusion ability of lemongrass essential oil is also relatively reduced. However, when high levels of antioxidants are used, the sample of the solution becomes more opaque than the rest of the samples, due to its unique properties. Therefore, the use of an antioxidant BHT with a concentration of 0.1% is suitable for diffusion products.

Figure 10 shows the effect of storage conditions (room temperature, acceleration, thermal shock) on the amplification of the solution. The solution sample, when stored under three conditions does not have much difference in the diffusion ability of the sample. On the other hand, samples stored under accelerated conditions and heat shocks turn into a more opaque state than samples under normal conditions. However, the component that accounts for the highest content of lemongrass essential oil is Citral (accounting for more than 80% of the content of lemongrass oil), which is very unstable, easily oxidized and denatured by external conditions such as light, heat which lead to changes in the quality of the diffusion solution [32,33]. This is the disadvantage that we do not expect of lemongrass essential oil because when the Citral component is denatured it will create another structure that leads to changes in the odor or loss of the characteristic smell of citronella oil in the sample.

Table 6. The influence of antioxidants on diffusion solutions.

| Antioxidants | BHA | BHT |
|--------------|-----|-----|
| Physical appearance | Turbid | Slightly turbid |
| Uniformity | Oil floating on the surface of the solution | Uniformity |
| Fragrance | Pleasant | Pleasant |
| pH | 6–7 | 6–7 |
Figure 8. The effect of antioxidants contents on the background of the diffusion solution.

Figure 9. The effect of BHT contents on the background of the diffusion solution.

Figure 10. The influence of storage conditions on the background of the diffusion solution.
4. Conclusion
Research has proven that the replacement of citronella essential oil to diffused liquid formulations is an important factor that contributes to the quality of the product, significantly reducing the irritation of scents and improve the safety of products used. The ingredients in the formula are investigated at different levels and select the appropriate content to add to the product. The result is a diffuse product with main ingredients: Coconut oil (1%), Lemongrass essential oil (4%), Ethanol (5%), Tween 80 (8%) as emulsifier and BHT antioxidant (0.1%). The resulted lemongrass essential oil requires room temperature and minimal temperature change to maintain its diffusion quality.

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