Formulation of a Floor Cleaning Product using Lemongrass (Cymbopogon citratus) Essential Oil and Evaluation of Foamability and Foam Durability

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Abstract. The growing demand for natural products has spurred the idea of replacing synthetic fragrances with essential oils with antibacterial properties. Essential oils distilled from commercially valuable Cymbopogon citratus species has citral as a major component and finds a wide range of application such as flavors and aromas in perfumes, cosmetics, soaps, and detergents and in the pharmaceutical industry. Via hydrodistillation, the extraction yield of essential oil reached 0.29%. The components for formulation of the cleaning product were determined through a survey of active ingredients: 4.5% Sodium Lauryl Ether Sulphate (SLES), Ethylenediamin Tetraacetic Acid (EDTA-2Na), 0.7% Coco Amido Propyl Betaine (CAPB), 1% Hydroxyethylcellulose (HEC), Sodium Benzoate, 0.3% Butylated hydroxyanisole (BHA), 0.1% NaCl and 0.2% lemongrass essential oil. The finished product was evaluated based on the foaming ability and durability of the emulsion. At the same time, samples stored at different conditions (e.g. room temperature, acceleration, thermal shock) were evaluated for its durability. The results show that citronella oil can be used as a valuable cosmetic material, an antibacterial agent, while not adversely affecting the usability of floor cleaning liquid.
1. Introduction
The use of essential oils has been a long-established practice in the prevention and treatment of food and cosmetics across the country [1-3]. Apart from aroma-therapies, cosmetics, flavouring and spiritual use, essential oil can be used as a fragrance for cleaning products [4-7]. Essential oils are a mixture of numerous compounds such as saturated and unsaturated hydrocarbons, alcohols, aldehydes, esters, ethers, ketones, phenolic oxides and terpenes, which can produce a characteristic natural aroma that is less harmful to consumers’ health, as compared to synthetic fragrances [16-25].

A typical example for this case would be lemongrass (Cymbopogon citratus). Lemongrass essential oil is one of the most important essential oils and is widely used to produce citral, which is one of the main components in essential oils [26]. Lemongrass essential oil is often used as a fragrance in soap, detergents and various technical products due to its abundance in valuable components including citral, geraniol, citronellol, nerol, limonene, geranyl, acetate, linalool, and citronellal, creating distinction when being mixed into product formulations [27-31]. Previous studies have shown that these compounds can exhibit, antibacterial activity against different bacterial strains which are Desulfovibrio alaskensis, Ampylobacter jejuni, Escherichia coli, Listeria monocytogenes and Bacillus cereus [32-35]. Taking advantage of the soil conditions in the Southwest, Vietnam is focusing on exploiting the potentials of C. citratus and the area of C. citratus cultivation. This urges for further development in utilizing this source as input materials and then diversifying its products to boost income for growers, as well as improve the brand recognition.

This study aims to formulate a floor cleaning product with lemongrass essential oils to reduce the amount of harmful synthetic fragrance used in the products. The content of lemongrass essential oil, detergent, foaming agent, thickener, electrolyte and suitable storage conditions were determined.

2. Materials and Methods
2.1. Plant material and chemicals
Lemongrass essential oil were obtained from lemongrass leaves harvested in in Tan Phu Dong district, Tien Giang province, Vietnam in March 2019. The extraction process is done on industrial-scale hydrodistillation equipment with 710kg of input material capacity with a time of 3 hours. Essential oil mixture after extraction was put into a funnel to separate from water and was anhydrous with sodium sulfate. The maximum extraction efficiency achieved 0.29%.

Chemicals used: Sodium Lauryl Ether Sulphate (SLES), Ethylendiamin Tetraacetic Acid (EDTA-2Na), Coco Amido Propyl Betaine (CAPB), Hydroxyethylcellulose (HEC), Natri Benzoat, Butylated hydroxyanisole (BHA), NaCl were purchased at Nguyen Ba Trading Production Co., Ltd, Tan Binh District, Ho Chi Minh city.

2.2. Product preparation process
First, the main detergent SLES, co-detergent, EDTA-2Na and preservatives were dissolved in water, heated and stirred to form a homogeneous mixture. Then CAPB was added to the mixture, followed by gentle stirring. HEC thickener was soaked, heated and stirred separately in the aqueous phase and was added to the mixture. The mixture was stirred and allowed to cool. The homogeneous mixture was then added with lemongrass essential oil to produce lemongrass floor cleaning liquid. Lastly, different colorants were added to diversify products.

2.3. The evaluation and test methods
The parameters used to evaluate the formulated floor cleaning product were referred to previous studies [36-38] as well as the formulation of such products which are being sold in the local market.

Foamability: Usability is expressed by the foaming ability of the product. This study uses the shaking test to measure foaming. The liquid is diluted 100 times and then 2 ml of solution is put into a stoppered tube, followed by shaking with a moderate force until the amount of foam generated is maximum (constant foam volume).

Foamability is calculated by the formula: \[ \varepsilon_f = \frac{V_{\text{foam}} - V_{\text{liquid}}}{V_{\text{foam}}} \]
\( \varepsilon_f \): foaming level; \( V_{\text{foam}} \): foam volume after shaking; \( V_{\text{liquid}} \): original volume of liquid

The durability of the emulsion: The cleaning effect is expressed through the time of emulsification, that is, the emulsifying ability of the product with selected paraffin oil (simulated for dirt). A volume of 2 ml of diluent is added to 2 g of paraffin oil, then shake to produce an emulsion. The use of a stopwatch is used to determine the lifetime of the system when a 1 ml volume of oil is clearly separated.

Products are packed in sealed bottles and stored in different conditions: room temperature, temperature 45°C, and conditions of thermal shock. Characteristics such as state, color, and smell were observed.

3. Results and discussion

3.1. Effect of detergent content

The ability to clean is an important factor with a high-quality floor cleaning product. We first investigated the effect of different cleaning agents including SLES, ethoxylate and alkyl polyglucoside on foamability and emulsion durability. The results are shown in Figure 1.

![Figure 1](image)

**Figure 1.** The influence of detergent on foamability and durability of the emulsion: (A) Detergent, (B) SLES contents

The results indicate that SLES is the best detergent with the highest foamability (0.523) in 20.28 minutes of durability of the emulsion, while such ability declined when using ethoxylate (0.484 and 18.51 minutes) and alkyl polyglucoside (0.464 and 17.38 minutes). When used in cosmetics, the Lauryl ether (SLES) is considered safe for users, as the foam produced by SLES is quite durable and thick with high foam density and low surface activity, making the agent less harmful to the skin [39]. In addition, SLES is widely used because it is highly active and particularly inexpensive [40]. The result of Figure 1b shows the effect of SLES content on the foaming and durability of the emulsion of the samples. The foaming rate and the durability of the emulsion were highest at 4.5% with 0.507 and 22.42 minutes. Therefore, use 4.5% content as the value of the next survey of other agents.
3.2. **Effect of foaming content**

![Figure 2](image)

**Figure 2.** The influence of foaming contents on foamability and durability of the emulsion

The assessment of foaming ability and durability of the emulsion was carried out and reported in Figure 2. Depending on the content of the foaming agent CAPB used in the sample, differences in foam between the samples could be observed. The foaming level increases gradually from 0.5 to 0.7% CAPB, tends to decrease with increasing CABP content to 0.8% and 0.9% and reaches the highest value at 0.7% CABB content with a foaming rate of 0.534. In addition, the durability of the emulsion of the sample added with 0.7% CAPB was relatively longer than the remaining samples, reaching approximately 23.5 minutes. CAPB has thickening and foaming properties that should be used as a common ingredient in personal and family care products [41]. If there are two liquids that are difficult to dissolve, CAPB will be able to increase the contact area of the two substances, making the cleaning process faster and easier due to the foaming and increasing viscosity and anti-static [42]. Therefore, a 0.7% CAPB content was used to investigate the next experiment.

3.3. **Effect of thickener and thickener content**

![Figure 3](image)

**Figure 3.** The influence of thickener on foamability and durability of the emulsion: (A) Thickener and (B) HEC contents

The influence of the thickener is shown in Figure 3. For a general cleaning product, the last factor to be investigated to form the finished product is the choice of thickener. There are many different thickeners, which can thicken the product with electrolytes or polymers [43]. In some cases, the combination of multiple thickeners should be performed to produce the desired consistency [44]. Therefore, in the study, the suitable product thickeners were selected and examined. After experimenting on Xanthan Gum, HEC and CMC thickening agents, the foaming and emulsion consistency of the sample was determined. Based on the results of Figure 3a), results on foamability
and foam durability of samples treated with Xanthan Gum (0.5 and 21.41 minutes), HEC (0.533 and 24.37 minutes) and CMC (0.362 and 15.55 minutes) were shown. Clearly, HEC achieved the highest foamability and foam durability and were selected as the main thickener. On the other hand, the use of Xanthan Gum and CMC to thicken the product requires the pre-stirring of the substance to prevent insolubility and lumps from affecting the substrate. In addition, when using Xanthan Gum, the substrate is not transparent but slightly cloudy (Figure 3.8b), while when using CMC for the product, the foam is limited compared to HEC and Xanthan Gum (Figure 3A). Survey results of HEC content affecting the foaming and the durability of the emulsion are shown in Figures 3B). The foaming level of HEC reached the highest value at the content of 1% (0.464), corresponding with the durability of the emulsion of 23.31. HEC does not precipitate under high temperatures and has good solubility and viscosity change over a wide pH range. HEC attains low viscosity within the pH range of 2-12 and decrease when the pH is outside this limit. The best viscosity is 4800-6000 cps with pH of 8.0 (1% in water). Another unique advantage of HEC is that it will turn into colloidal when heated, enabling a wide range of applications [45]. In comparison with other substances, HEC is more hygroscopic, thickening and has better stabilizing properties [46]. As a non-ionic surfactant, other properties of HEC may also include thickening, emulsifying, adhesion, film-forming, dispersing, and water retention [47]. It can coexist in other water-soluble polymers in solutions with a high concentration of electrolytes [48]. Therefore, HEC was selected for the subsequent investigation

3.4. Effect of electrolyte content

![Figure 4. The influence of electrolyte on foaming and durability of the emulsion: (A) Electrolytes and (B) NaCl contents](image)

The electrolyte will reduce the solubility concentration of surface agents resulting in increased adsorption at the interfaces [49]. The electrolytes will reduce the CMC because the electrolytes in the detergent solution will prevent the formation of micelles, leading to a decrease in micelle concentration and an increase in foam [50]. The influence of the electrolyte on the foaming and emulsifying time is shown in Figure 4. It was found that the three electrolyte agents have a significant effect on foaming and durability of the emulsion. The electrolyte is also a relatively important factor determining a product base. Considering the foamability, foam durability results and the popularity of electrolytes, NaCl is used as the main electrolyte [51]. NaCl and its compounds help increase the thickness and viscosity of cosmetics, buffering and neutralizing acids found in personal and family care products [52]. Performing further experiment with NaCl electrolyte at different NaCl contents resulted in the highest foaming and durability of the emulsion at 0.521 and 21.49 minutes, respectively. Therefore, use 0.1% NaCl content for the next survey experiment.
3.5. **Effect of Lemongrass essential oil content**

The influence of lemongrass essential oil on the visual quality, foam and emulsion durability of the product is shown in Figure 5. The foaming level and the durability of the emulsion achieved between the contents showed only small differences. The most prominent foamability and durability (0.481 and 24.51 minutes) were achieved at the essential oil concentration of 0.2%. In terms of sensory characteristics, the survey sample products have the scent of lemongrass essential oil and the scent gets intensified with increasing amount of added essential oil. However, the higher the content of the essential oil, the more likely it is that the sample will change in color over time. This is because of the instability of Citral, accounting for more than 80% of the citronella oil content [53]. Citral is also easily oxidized and denatured by external conditions such as light, heat, degrees, and pH, negatively affecting the quality and preservability of the sample [54]. Figure 5 shows that samples of products containing essential oils when stored at 45 °C after 20 days had the phenomenon of discoloration to pale yellow. The discoloration was most evident at the essential oil content of 0.4% and 0.5%. Therefore, it is necessary to add antioxidants to prevent the transformation process from occurring and to select the content of 0.2% lemongrass essential oil for the next experimental survey.

3.6. **Effect of antioxidant content**

The influence of antioxidants and the content of antioxidants on product characteristics are shown in Figures 6. The survey was conducted on two substances, BHT and BHA. BHT has the same properties as BHA but is more heat resistant. However, BHT has a lower antioxidant effect than BHA.

![Figure 5](image1.png)

**Figure 5.** The effect of Lemongrass essential oil content on foaming and durability of the emulsion

![Figure 6](image2.png)

**Figure 6.** The effect of antioxidant content on foaming and durability of the emulsion: (A) Antioxidants and (B) BHA contents
because the spatial structure of BHT is bulkier than BHA due to BHT molecule having 2 groups of tert-butyl around the group - OH. Besides, when using BHT, the appearance of the product will be opaquer than the background of sample using BHA. In terms of foaming and durability of the emulsion, BHA (0.528 and 25.38 minutes) was superior to BHT (0.268 and 15.44 minutes). Therefore, BHA was selected as the antioxidant agent for the next experiment evaluating the appropriate antioxidant content in the product. The survey results shown in Figure 6b) show that at the 0.3% BHA content, the foaming and the durability of the emulsion reached the highest value (0.485 and 23.416 minutes). Although the BHA content of 0.4% and 0.5% are better in preventing denaturation of essential oils, the content of 0.3% has met the requirements of oxidation resistance, foaming, durability time, color and scent of the product and would be selected for the final experiment.

3.7. Evaluate the impact of storage conditions on floor cleaning products

The influence of changing storage conditions on foaming and foam durability of floor cleaning products is shown in Figure 7. The results indicated that, heat shock and heated conditions did not greatly affect the foaming and durability of the emulsion of the products, compared to the sample in normal conditions. However, in terms of appearance, the accelerated sample showed a slight yellowing after the tested storage time due to oxidation of essential oil. Foamability and foam durability of samples stored under thermal shock conditions were not altered significantly.

![Figure 7. The effect of storage condition on foaming and durability of the emulsion](image)

4. Conclusions

Natural essential oils are favorably as a alternative fragrance for harmful synthetic ones in daily products. In this study, lemongrass essential oil was used to formulate a floor cleaning product. By varying different agents used and their contents, a complete formulation was determined. Main ingredients of the cleaning product were selected as follows: 4.5% Sodium Lauryl Ether Sulphate (SLES), Ethylenediamin Tetraacetic Acid (EDTA-2Na), 0.7% Coco Amido Propyl Betaine (CAPB), 1% Hydroxyethylcellulose (HEC), Sodium Benzoate, 0.3% Butylated hydroxyanisole (BHA), 0.1% NaCl and 0.2% lemongrass essential oil. The obtained products were tested and evaluated based on different quality indicators such as foamability, foam durability, discoloration effect of storage conditions to ensure a product quality.

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