Study on the formula to produce shampoo derived from Lemongrass *(Cymbopogon citratus (D.C.) Stapf.)* essential oil

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Abstract. Facing the proliferation of unnatural fragrance personal care products by their convenience and affordability. However, facing the immediate benefits is the insecurity of prolonged exposure to odors, the vast majority of which may exceed the allowable or unknown uses. Therefore, we research the production process of shampoos derived from natural essential oils. In this study, we use lemongrass oil originating from Tan Phu Dong commune, Tien Giang province to conduct steam distillation with optimum efficiency of 0.29%. The general formula for making a shampoo product is based on basic factors such as detergent, humectant, foaming agent, etc. The product evaluation is based on the results of the assessment of foaming ability, degree foam stability, and product stability under different storage conditions. Results showed that shampoo products derived from lemongrass oil gave good evaluation results, scalable, and developed to conduct commercialization.

1. Introduction
Currently, the demand for personal care in men and women is increasing. At the same time, people are also increasingly understanding the close connection between health and beauty. Therefore, the gentle and friendly ingredients is becoming the keyword that is more concerned than ever. Skin-care products are from natural sources, so they get more and more attention from the beauty community, especially valuable and rare ingredients [1]. In the past, beauty technologies were favored with cosmetics due to the rapid effects [2]. Recently, the trend of beauty with natural extracts is the most preferred. Chemical compounds have been gradually replaced by pure and natural materials such as Essential oils of herbs, fruits, pearls, seaweeds, honey, and so on. Natural extracts without chemical treatment do not contain artificial ingredients, colorings, alcohol should ensure safety for users [3].

Natural oils are a complex mixture of many precious and unique compounds [4]. Essential oils are extracted from several plant organs including flowers, leaves, branches, seeds, fruit, roots, wood, or bark...
are valuable natural products [5]. Besides, concerns about the production of natural, high-value, chemical-free products and residues of solvents or additives, for these reasons, are used as essential oils. Ingredients for many products including food flavors, additives, and flavorings used in the tobacco industry and a mixture of cosmetics and perfumes [6]. They are also used in air cooling and deodorization and in all medical disciplines such as pharmaceuticals, balneology, massage, and homeopathy. In addition to being safe, some naturally derived scents also have beneficial biological effects, such as essential oils extracted from natural herbs. The most popular are essential oils extracted from lemongrass, lemon, tea tree, wind Melaleuca, eucalyptus. Citral has the antibacterial and deodorizing effect [7–14].

Lemongrass essential oil is an essential oil extracted from lemongrass components such as lemongrass leaves, lemongrass root. The scientific name is Cymbopogon citratus. Currently, there are about 55 species [5]. The main lemongrass product is the essential oil accumulated in the leaves, with the oil content varying from 0.4 to 2.0% depending on the variety, ecological conditions and care [14–16]. Lemongrass essential oil has many attractive aromatic compounds that can relieve pain due to minor pain and fight cancer (myrcene and limonene) and some compounds have strong deodorizing, antibacterial properties (citral and geraniol). Lemongrass has been applied in many types of food, medicine, and industry [17–20]. Lemongrass essential oil is a pale yellow, strong smell of lemon odor, usually extracted by distillation directly with an aqueous solvent. The main components of lemongrass essential oils are citral, geraniol, citronellol, nerol, limonene, geranyl, and acetate, linalool, lemongrass have high index [21–25]. We endeavored to formulate a herbal shampoo from Lemongrass essential oil. The prepared formulas were evaluated for foam volume and stability in comparison to a commercial brand.

2. Materials and methods

2.1. Raw materials and chemicals

Lemongrass essential oil used in this study was extracted by steam distillation. The material used to remove the essential oil is lemongrass leaves, which originated from Tan Phu Dong district, Tien Giang province, Vietnam. Lemongrass oil is removed with a capacity of 300 kg to 750 kg of raw material per batch for 3 hours, with a distillation efficiency of 0.29%. Next, the mixture of essential oils and water is filtered to obliterate water. Finally, lemongrass oil is dried on anhydrous sodium sulfate and stored in a sealed glass container. Chemicals used: Sodium Lauryl Ether Sulphate (SLES), EDTA, PEG-7 Glycerin Cocoate (PEG-7), Coco Amido Propyl Betaine (CAPB), Coco Diethanolamidine (CDE), Carbopol thickener, Glycerin, Polyquaternium-10, D-panthenol are purchased at Nguyen Ba Trading Production Co., Ltd, Tan Binh District, Ho Chi Minh city.

2.2. The process of mixing shampoo from lemongrass oil

The process is as follows: Main detergent, copper detergent, hair conditioner, preservative, and a part of water are dissolved together, stirring and heating. At the same time, the viscosity enhancer is dispersed in water, lightly heated to swell, and mixed with the mixture. Continue to increase foaming, opaque substance, lemongrass oil, emulsifier, antioxidants emulsified with water, and then slowly turn into the mix. Add electrolyte and dissolved pH adjustment solution to the system. Finally, conduct cooling to obtain shampoo products from lemongrass oil.

2.3 The evaluation and test methods

Foamability: The sense of use is expressed by the ability to foam 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, shaking with a moderate force until the amount of foam generated is maximum (foam volume does not change).
The formula calculates foamability: $\varepsilon_f = \frac{V_{\text{foam}} - V_{\text{liquid}}}{V_{\text{foam}}}$, where $\varepsilon_f$: foaming level; $V_{\text{foam}}$: foam volume after shaking; and $V_{\text{liquid}}$: 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 separated.

A number of several influencing factors during storage and transportation of products are also simulated for evaluation. During the storage process, it is inevitable that the denaturation of the product is under the influence of environmental agents, so it is necessary to find the best solution to preserve the product. Products are packed in sealed bottles and stored in different conditions: room temperature, temperature 45°C, and conditions of thermal shock. Carry out observation of the following characteristics: state, color, smell.

3. Result and discussion
3.1. The effect of detergent content on the foaming ability and foaming strength
Based on the reference formula and the goal of creating products with appropriate foam strength and durability, we surveyed selected main active ingredients: SLES 70 and EDTA replaced with SLS and lauric acid. Based on figure 1a, we found that when SLES was the main cleaning agent, the foam was higher (0.4505) than SLS (0.3590) and lauric acid (0.3421). The difference in foam strength is also evident with the most effective agent, SLES (25.3 minutes). The results were similar when the EDTA agent used. Besides, the comparison of experimental samples with market products (TT sample) also shows the foaming ability and foam durability more effectively of the model. It is understood that, for the same type of surfactant, the lower the critical micelle concentration (CMC), the higher the foaming capacity, the longer the foam lasts. Bisedes, compared to the effectiveness of using SLES, it makes the product feel smoother and less irritating to the skin and eyes, creating a soothing and parallel feeling, that is also the cheaper active ingredient compared to SLS lauric acid. The combination of SLES with EDTA and the increase in cleaning ability, also helps stabilize emulsions and isolate metal ions so that they do not affect other compounds, thereby contributing to increase durability for the product. We selected the main detergents in the product, SLES, and EDTA, for subsequent experiments from the above results. The experiment further assessed the foaming and foam strength at different concentrations of active substances SLES and EDTA. Continue based on the results in figure 1; in general, we see that the foaming rate and foam resistance time are different when changing the content using SLES and EDTA. For SLES, foaming reached the highest value at 18% (0.4565) compared to the lowest of 12% (0.3590), and durability reached 24.95 minutes. Similarly, 0.15% of EDTA content had the best foam level of 0.4624 (24.85 minutes), while at 0.05% it was only 0.1935 (17.36 minutes). From the above results, SLES, EDTA with 18% and 0.15% contents, respectively, were used for the next experiments.

3.2. Evaluate the influence and content of copper detergent on foaming ability and foam strength
Evaluation of the foaming ability and foam strength of surfactants is carried out through a comparison test of the active ingredients Minocol and PEG-7. In terms of foaming, PEG-7 showed significantly higher results (0.4363) than Minocol (0.1667) (figure 2(a)). Besides, the foam durability time of PEG-7 is also superior to (24.93 minutes) minocol (15.13 minutes) and products on the market (TT sample) (22.05 minutes). In terms of properties, PEG-7 is neutral, non-volatile, and well compatible with cationic surfactants (SLES), thereby increasing and stabilizing the foaming level of the model. PEG-7 is an easy-to-use, hypoallergenic, smooth-feeling but non-greasy feeling, suitable for general personal care products. From the above survey, select PEG-7 to conduct an appropriate content evaluation to use the base formula. The survey results showed that the content of 1.2%, the foaming reached the best value (0.4589) compared to 1.8% (0.3243). Foam retention time peaks at 23.18 minutes and begins to decrease with increasing content. From here, PEG-7 with 1.2% content was selected to conduct the next experiments.
Figure 1. The effect of surface-active agents on the foam generation and foam resistance time.

Figure 2. Influence of surface-active co-agents, the content of use on foaming and foam durability time (a) PEG-7 and other surfactants; (b) PEG-7 content.

3.3. The assessment effect of foaming agents concentration on the foaming ability and foam stability

Experimental results are shown in figure 3, showing that using the CAPB and CDE mixture gives the best foaming (0.4559) compared to using only CAPB (0.3289) and CDE (0.3865). The foaming effect of CAPB and CDE blends is also higher than that of market products (TT sample) (0.4069). Considering the foam durability time, the CAPB and CDE mixture proved its ability to maintain foam stability for 24.95 minutes, higher than the product’s value on the market. Based on the above results, the experiments to survey the content of CAPB and CDE use were conducted at different values. For CAPB (figure 3(b)), the foaming level peaked when the active ingredient content was 7% (0.4635), in parallel, the CDE agent also showed the best foaming effect at 2% (0.4540) (figure 3(c)). Corresponding results were recorded at foam resistance time. In fact, CAPB is a commonly used raw material because of its
foaming properties and its ability to reduce surface tension, combined with CDE, which helps stabilize foam, increase emulsification and sensitization. Pleasing sensation to skin and hair. Thereby increasing the sensory value as well as the effective use of the product. Thus, the use of CAPB and CDE with 7%, 2% content is suitable for the next survey.

Figure 3. Influence of foaming agents, use content to foaming and foam strength of: (a) Mixtures of CAPB, CDE and other surfactant co-agents; (b) CAPB content; (c) CDE content.

3.4. The effect of foaming agents’ concentration on the foaming ability and foam resistance time
The results of the solid agent survey are presented in figure 4(a). Easily found, the foaming and foam durability time when using carbopol is higher (0.4624 / 24.38 minutes) than CMC (0.3243 / 14.23 minutes), HEC (0.4013 / 18.66 minutes) and Xanthangum (0.2857 / 16.36 minutes) respectively. Besides, the foaming effect when using carbopol as the main thickening agent also gives better results than products on the market (TT sample). Considering the actual production, the active ingredients CMC, HEC, and xanthangum tend to form blocks in high humidity. Hence, they are easy to clump when working with water, resulting in a lot of time preparing of raw materials. Therefore, we choose carbopol to conduct a detailed survey of the content used in the background formula. The result shows that the foam content of carbopol is in amount of 22% (0.4553), which is the largest compared to 20% (0.2857) (figure 4(b)). The results of the foam strength evaluation showed similar results. With the ability to thicken the surface-active system, enhance viscosity, increase the components’ cohesion, prevent silicon deposition, thereby limiting layer separation and retaining durability for the product, Carbopol was selected as the key solidity agent for the next experiments.
3.5. The effect of humectants on the foaming ability and foam strength

The ability and durability of foam in different humidifying agents are assessed and shown in figure 5(a). Based on the figure, we see that glycerin has a higher level of foaming (0.4635) than sodium lactate (0.3954), dipropylene glycol (0.3498), and products on the market (TT sample). In parallel, the longest foam resistance when using glycerin (24.21 minutes) and the lowest for dipropylene glycol (16.31 minutes). When evaluating the content of use, 1% glycerin gives the best foaming and foam resistance (0.4898 / 24.49 minutes), while at higher values tends to reduce the foam and their stability. In terms of cost, sodium lactate and dipropylene glycol are less economical than glycerin. On the other hand, glycerin is a benign active substance suitable for all scalp types. It has high stability and good foaming ability, so the use of this agent in the product is appropriate for the original purpose of the research.

![Figure 5](image)

**Figure 5.** Effect of moisturizing agents, the content used on the foaming and foam strength of:
(a) Glycerin and other surfactants; (b) Glycerin content.

3.6 The effect of smoothing concentration on the foaming ability and foam strength

Based on the survey results presented in figures 6a, it is found that the smoothing agents have a significant effect on foaming and foam strength, most notably the two PEG-10 (0.4253 / 20.08 minutes) and D-panthenol (0.3976 / 21.50 minutes). However, the combination of all three active ingredients PEG-10, D-panthenol, and 3140E gave better results (0.4505 / 24.32 minutes) compared to a single active ingredient and compared to the product market (TT sample). Conduct experiments to survey the content of active ingredients used each active ingredient’s formula, obtaining the highest foaming and foam stability results at 0.35% (figure 6(b)), 0.2% (figure 6(c)), 2% (figure 6(d)) correspond to PEG-10, D-panthenol and 3140E. Selecting all three active ingredients based on their specific properties,
PEG-10 is compatible with protein-based surfaces (skin, hair, etc.), reducing static electricity, thereby improving the texture of fibers. Hair is damaged by physical or chemical causes. Besides, 3140E and D-panthenol are added to protect, moisturize, and increase smoothness, helping to overcome inflammation and irritation, helping to promote the proliferation of fibroblasts in the class. The epidermis, where damage to the skin and hair forms. Therefore, with the smoothing agent group, we chose the combination of PEG-10, D-panthenol, and 3140E for the next experiment.

![Graph showing the effects of smoothing agents and levels on foaming and foam strength.](image)

**Figure 6.** Effects of smoothing agents and levels on foaming and foam strength: (a) Smoothing agents; (b) PEG-10; (c) D-panthenol; (d) 3140E.
3.7 The effect of antioxidants and content on the foaming ability and foam strength

The effects of antioxidants are shown in figures 7. Accordingly, we surveyed in two different conditions (nano and non-nanochemical) using two preservatives, BHT, BHA, and a mixture of BHT and BHA. The results showed that all 8 studied samples achieved better foaming and durability than market samples (TT sample). It is easy to see that, for 4 non-nano particles, the sample with BHT is the main antioxidant which has little change compared to the remaining samples, the same perception was also seen in 4 nanosized samples. Therefore, we selected samples containing BHT with nanoization to continue evaluating their appropriate usage. Figure 3.7 shows the influence of antioxidants on shampoo products from lemongrass oil. As we can see, the foaming results achieved the best at concentration of 0.2% (0.4623), tended to decrease to close to the market sample gradually, the durability of the sample at the concentration of 0.2% was assessed to meet the requirements. For the purpose of commercializing shampoo products. Therefore, we choose the BHT active ingredient with 0.2% content to be nanosized for further research.

Figure 7. Effect of antioxidants and content on foaming and foam durability (1. Essential oil; 2. BHT; 3. BHT; 4. BHA + BHT; 5. Essential oils + Nanoization; 6 BHA + BHT + Nanoization; 7. BHT + Nanoization; 8. BHA + BHT + Nanoization)

3.8. The effect of Lemongrass Essential oil in the foaming ability and foam durability

The influence of the oil content is shown in figure 8. Thereby, we surveyed 5 levels of content ranging from 0.1% to 0.5%. The results showed that all samples had better foaming and durability than market samples (TT sample). Therefore, it shows that increasing the content of lemongrass oil in the range of 0.1 - 0.5 (%) does not affect the product’s properties. However, when deploying a larger scale, it is necessary to assess in detail the economics of use. In terms of appearance, there is no big difference in the milestones using essential oils. Besides, when assessing the scent, at 0.4% content for a pleasant aroma, no harshness, no discomfort, and good fragrance. In a nutshell, we use lemongrass oil with a 0.4% content for the general formula of the product.

Figure 8. Influence of lemongrass oil content on product appearance.
3.9. **The effect of storage conditions on the scent of lemongrass essential oil in products**

Figure 9 shows the effect of changing storage conditions on the foaming properties and the foam retention time of shampoo products. The results showed that, when changing the storage conditions did not affect the foaming and foam durability time of the product, the survey samples did not have a big difference compared with the market sample (TT sample). Assessing the appearance, the accelerated sample has a slight yellowing, but does not affect too much the product’s appearance. This can be handled thoroughly after the product is colored.

![Figure 9](image.png)

**Figure 9.** The effect of storage conditions on foam generation and foam strength.

4. **Conclusion**

Factors affecting the production process are found and optimized for the process including: detergents (EDTA, 70% SLES), co-cleaning agents (PEG-7 glyceryl cocoate), humectants (Glycerin), foaming agents (CAPB, CDE), thickeners (Polygel 1.4%), smoothing agents (Polyquaterium-10, D-panthenol, 3140E), antioxidants (BHT), additives (citric acid 30%), plantacare 1200, NaOH, NaCl), lemongrass oil. From the results of the experiment, it has been shown that the shampoo derived from lemongrass oil has high cleaning efficiency, there is no significant difference compared to existing products on the market. From this, the results can be used to conduct in-depth research and apply products to commercialization in practice.

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