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Optimization and evaluation of the physical stability of shampoo preparations containing virgin coconut oil and aloe vera extract

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ABSTRACT

Background: Hair is crucial for both aesthetic appearance and protection against sun damage. Shampoo is vital in hair care, often formulated with natural ingredients to enhance its effectiveness. Virgin coconut oil (VCO) and aloe vera extract are two ingredients known for their roles as moisturizers and conditioners, as well as nutrients and emollients.

Objective: The study aimed to evaluate and optimize the stability and physical characteristics of shampoo containing VCO and aloe vera.

Methods: The primary surfactant, sodium lauryl sulfate (SLS), was tested in concentrations of 2%, 4%, 6%, 8%, and 10%. The shampoos were prepared using an emulsification method and were evaluated based on organoleptic properties, homogeneity, pH, specific gravity, and viscosity. The formula that met all Indonesia National Standard (SNI) requirements was selected for further testing, including a cycling test to assess stability.

Results: The findings indicate that the formula 5 (F5) containing 10% sodium lauryl sulfate exhibited optimal physical characteristics. Throughout six rounds of cycling tests, no phase separation was observed in F5, underscoring its stability.

Conclusion: The optimized shampoo formula containing VCO and aloe vera (F5) demonstrated compliance with the required physical characteristics and stability standards. This formula presents a viable option for effective hair care, combining the beneficial properties of its natural ingredients with chemical stability.

Keywords: shampoo, virgin coconut oil, aloe vera extract, sodium lauryl sulphate, emulsion

Introduction

Hair is essential for humans as it shields the scalp from sun damage and improves appearance. However, individual hair health varies and can be influenced by factors such as blow-drying, straightening, perming, and using unclean water for washing. These practices can lead to hair that appears greasy, dull, and frizzy. One solution for maintaining healthy hair involves using natural active ingredients that nourish the hair, such as virgin coconut oil (VCO) [1].

VCO is versatile and often included in hair care products due to its hydrating properties, which stem from its rich content of unsaturated and saturated fatty acids [2]. Additionally, VCO contains beneficial components such as lauric acid, iron, vitamin E, and vitamin K, which contribute to hair thickening [3]. Similarly, aloe vera is another potent natural ingredient [4], known for its conditioning and moisturizing properties due to its content of vitamins A, B, and E, polysaccharides, and amino acids [5]. Aloe vera also includes saponin, an effective cleansing agent [6].

Despite their benefits, aloe vera and VCO cannot be directly applied to the scalp as they may leave an uncomfortable, greasy residue. Therefore, in this study, they were incorporated into a shampoo formulation.

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Table 1. Optimization of shampoo based on sodium lauryl sulfate concentration

Ingredients	Formula (%)					Function
	F1	F2	F3	F4	F5	
Virgin coconut oil	25	25	25	25	25	Active ingredient
Aloe vera extract	7.5	7.5	7.5	7.5	7.5	active ingredient, conditioner
Sodium lauryl sulfate	2	4	6	8	10	Surfactant
Cocomide DEA	12	12	12	12	12	Surfactant
HPMC	1.5	1.5	1.5	1.5	1.5	Viscosity enhancer
Methyl paraben	0.1	0.1	0.1	0.1	0.1	Preservative
Propyl parabene	0.01	0.01	0.01	0.01	0.01	Preservative
Menthol	0.5	0.5	0.5	0.5	0.5	Freshener
Bubble gum	0.5	0.5	0.5	0.5	0.5	Fragrance
Aquadest	Ad to 100 ml	Ad to 100 ml	Ad to 100 ml	Ad to 100 ml	Ad to 100 ml	Solvent

Shampoo was chosen as the medium since it is a daily personal hair care product. A key characteristic of a high-quality shampoo is its physical stability, which ensures the product remains stable during storage. This stability is evident through its appealing appearance, color, odor, and other physical properties and the absence of creaming or phase separation [7].

An essential factor in shampoo formulation is the concentration of the emulsifier. This research aimed to optimize the concentration of sodium lauryl sulfate (SLS) in shampoo containing VCO and aloe vera extract. The evaluation included testing physical characteristics and conducting a cycling test involving freezing and thawing to assess emulsion stability. The formation of ice crystals during freezing causes oil droplets to converge, potentially disrupting the emulsion's interfacial layers upon thawing [8,9].

Methods

Shampoo formulation

Hydroxypropyl methylcellulose (HPMC) was dispersed in cold water at temperatures ranging from 30-40°C for 10 minutes, followed by stirring at 500-600 rpm using a stirrer bar on a hotplate for 60 minutes. SLS was dissolved in water at 40°C for 10 minutes and then added to the HPMC solution. This mixture was stirred at 500-800 rpm for 60 minutes at 50°C until homogeneous. Subsequently, methyl paraben and propyl paraben were dissolved in menthol for 5 minutes; this was followed by the addition of aloe vera extract for another 5 minutes. Cocamide diethanolamine (DEA) was then incorporated, and the solution was maintained at 50°C, gradually increasing to 70°C over 30 minutes to form a base. Virgin coconut oil (VCO) was heated to 50-70°C in a separate beaker for 10 minutes. Once both mixtures reached 70°C, the VCO was blended into the aqueous phase and stirred at 1000 rpm for 15 minutes. After cooling, bubble gum fragrance was added to counteract the undesirable odors of the other chemicals in the formulation [10], such as surfactants [11], and to enhance consumer appeal due to its mood-lifting properties [12,13].

Optimization of shampoo preparations

The shampoo formulations were optimized using a one-factor-at-a-time (OFAT) approach [14], a commonly employed method before applying more complex experimental designs such as response surface methodology [15-17]. The optimization focused on varying concentrations of the primary surfactant, SLS, at 2%, 4%, 6%, 8%, and 10% (Table 1). Each formulation was evaluated for physical quality and stability through a cycling test.

Physical quality evaluation of shampoo preparations

A homogeneity test was conducted to determine if the shampoo was evenly dispersed. This test involved sandwiching a sample of the shampoo preparation between two glass slides, pressing them together, and then evaluating the sample for coarse particles or inhomogeneities [18]. A shampoo is considered homogeneous if it appears evenly dispersed

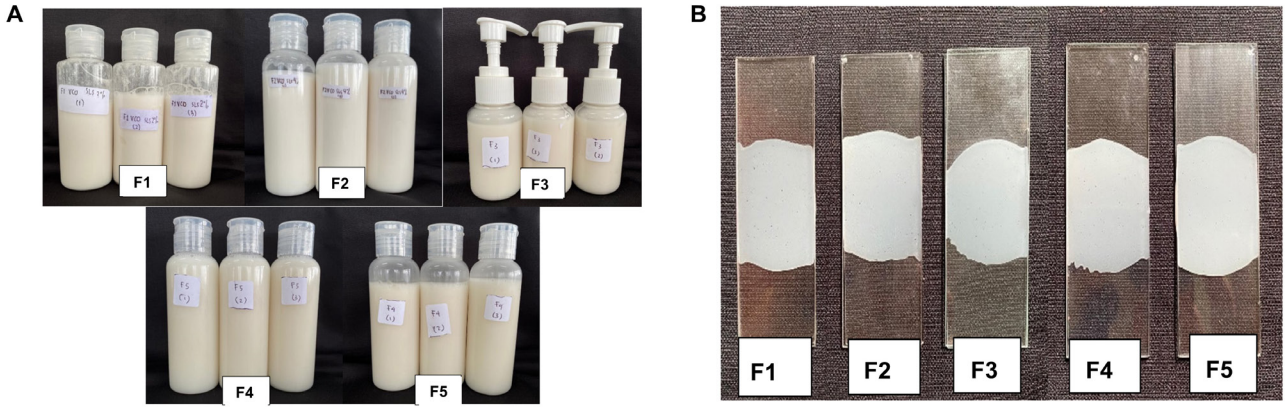

Figure 1. Physical characteristic results of shampoo. A. Appearance, B. Homogeneity

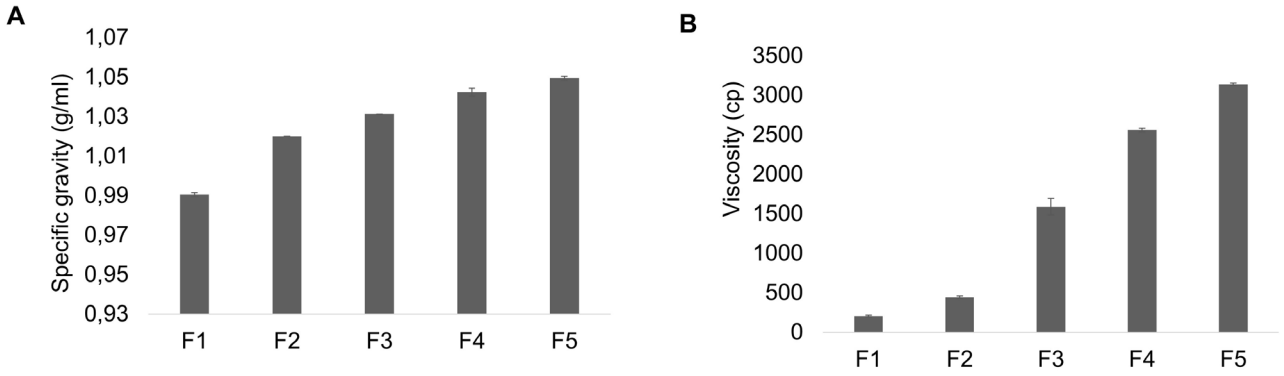

Figure 2. Specific gravity and viscosity of shampoo preparations. A. Specific gravity, B. Viscosity. ANOVA analyzed significant differences with Tukey's pairwise post hoc test at $p<0.05$

across the glass [19]. Additionally, the pH level of the preparation was measured using a Benchtop pH/Mv-meter. The specific gravity was determined using a pycnometer, and the viscosity was measured with a Brookfield Viscometer [20]. Specific gravity is defined as the ratio of the density of the substance to the density of a reference substance; equivalently, it is the ratio of the mass of a substance to the mass of a reference substance for the same volume [21,22]. Both specific gravity and viscosity are crucial for assessing the concentration and characterizing the product [21,22].

Cycling test

The ideal shampoo recipe was subjected to a stability test involving a cycling temperature regimen: the product was stored at 4°C for 24 hours, followed by 24 hours at 40°C per cycle, for a total of six cycles. The stability of the shampoo was evaluated by observing any physical changes, such as phase separation, that occurred during these cycles [23].

Data analysis

The optimized formula was selected based on the Standar Nasional Indonesia (SNI) [24]. Visual examinations were conducted to assess appearance and homogeneity. The results for specific gravity were statistically analyzed using one-way ANOVA, with a confidence level of 95%, to identify significant differences between the formulations [25].

Results

Various tests are conducted to optimize SLS for shampoo stability, including assessments of viscosity, pH, specific gravity, homogeneity, and organoleptic properties. The results of these physical evaluations are presented in Figure 1. The organoleptic test reveals that each formula exhibits a bubble gum scent and a milky white semisolid appearance.

The homogeneity test confirms that the shampoo formula is uniformly dispersed without any coarse particles. This uniformity is attributed to the effective pre-emulsification of the oil and water phases and the

subsequent stirring at 1000 rpm for 15 minutes, which was adequate to homogenize the emulsion.

The pH levels of the five shampoo formulations range from 6.6 to 7.5. The specific gravity for formulations F1 to F5 ranges from 0.99 to 1.05 g/mL, as shown in Figure 2. Statistical analysis indicates a significant increase (sig. 0.00 < 0.05) in specific gravity with each increment in SLS concentration, demonstrating a strong correlation (0.970) between specific gravity and SLS concentration.

Viscosity measurements for formulations F1 through F4 ranged from 205 to 3154 cps, with a significant increase (sig. 0.00 < 0.05) observed from F1 to F4. Correlation tests further reveal a substantial relationship (0.984 correlation value) between the viscosity of the shampoo and increasing SLS content, indicating a 98.4% correspondence.

Discussion

Virgin coconut oil (VCO) offers multiple benefits in hair cosmetic preparations, notably due to its content of both saturated and unsaturated fatty acids. These components allow VCO to serve as an emollient, moisturizing the scalp and hair. Moreover, VCO contains lauric acid, iron, vitamin E, and vitamin K, which are beneficial as hair nutrients [3].

Aloe vera is another essential natural ingredient, enriching hair with vitamins A, B, and E, polysaccharides, amino acids, and saponins, the latter of which are effective cleansing agents [4-6]. Thus, incorporating both VCO and aloe vera in shampoo formulations is expected to enhance both cleansing and moisturizing properties.

Test results for pH, homogeneity, and organoleptic properties for the shampoos containing VCO and aloe vera extract indicate that all formulations meet the requirements. However, only formulas F2 through F5 passed the viscosity and specific gravity tests, with F1 failing these assessments. The optimized formula selection focused on F2-F5, taking into account that the ideal pH range according to SNI requirements is 5.0-9.0, with F3-F5 nearing a neutral pH [24]. Ultimately, F5 was selected due to its superior viscosity and specific gravity, suggesting greater stability during storage [25-27]. Higher viscosity is linked to enhanced emulsion stability, which helps in reducing the rate of creaming [26].

F5, with its 10% sodium lauryl sulfate (SLS) content, emerged as the optimal formulation, meeting all physical criteria set by SNI. Its strong bubble gum scent was also noted to improve consumer acceptance. Fragrance plays a crucial role in customer satisfaction, with specific scents like bubble gum eliciting emotional responses and increasing joy due to associations with childhood [11-13]. Alternative fragrances such as thyme, lavender, peppermint, and rose oil are potential additions to explore in future formulations [28].

The stability of F5 was confirmed after six cycles of freeze-thaw testing, indicating that it can effectively function as a moisturizing and conditioning shampoo. The freeze-thaw stability is influenced by various factors, such as the type of lipids and surfactants used, as well as the specifics of the homogenization and thermal processes [29].

Conclusion

The optimized shampoo formula containing virgin coconut oil and aloe vera extract, with a 10% concentration of sodium lauryl sulfate (F5), has demonstrated excellent physical stability and meets required standards through extensive testing, including a 6-cycle cycling test. Further research is necessary to assess the shampoo's performance on human hair.

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Conflict of interest

Authors declare no conflict of interest.

Author contributions

OM, TLN, ES, and NA wrote the initial script; and all authors contributed to data interpretation and final approval of the manuscript.

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