Formulation and Physical Stability Evaluation of Bitter Melon (Momordica charantia L.) Leaf Extract Shampoo

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Abstract. Shampoo is a cosmetic preparation used to cleanse the scalp, and its effectiveness can be enhanced by incorporating natural ingredients**.**Bitter melon leaves (Momordica charantia L.) contain active flavonoids and alkaloids that have the potential provide beneficial effects on hair and scalp health. This study aimed to determine the physical characteristics and stability of bitter melon leaf extract shampoo preparations with varying concentrations of the gelling agent carbopol 940. This was an experimental study using a completely randomized, one-factor design, where variations in carbopol 940 concentration affected the physical characteristics of the shampoo preparations. The formulations were evaluated for organoleptic properties, pH, viscosity, foam height, and mechanical stability.and mechanical stability tests using centrifugation at 3,600 rpm for 30 minutes. Statistical analysis was performed using normality and homogeneity tests, followed by ANOVA and post hoc tests or Kruskal-Wallis and Mann-Whitney tests with a 95% confidence level (α=0.05). The results showed that increasing the concentration of carbopol 940 significantly increased the specific gravity (0.9821–1.0240 g/mL) and viscosity (520–3.440 cPs). The Kruskal-Wallis test showed a P value <0.05 for the specific gravity (P = 0.027) and viscosity (P = 0.020), indicating a significant difference between the formulas. All formulas met SNI 06-2692-1992 for pH (9.0), foam height (4.5 cm), and organoleptic parameters. Stability tests showed reversible phase separation, thus all three formulas were declared stable. In conclusion, the concentration of carbopol 940 significantly affected the specific gravity and viscosity and exhibited reversible stability.

Keywords: Shampoo, bitter melon leaves, physical stability, physical characteristics, Carbopol 940.

INTRODUCTION

Shampoo is one of the most commonly used hair care products to clean dirt and oil from the hair and scalp. It consists of primary ingredients, such as surfactants or detergents, and additional ingredients, including antioxidants, pH stabilizers, dispersing agents, preservatives, colorants, and fragrances, which function to ensure the quality and stability of the product (Rashati, 2019). Epidemiological data show that the prevalence of dandruff among male respondents is 20.7%, while among female respondents it is 12.8%. This difference occurs because men have higher androgen hormone levels, which can trigger the development of dandruff (Bergler-Czop and Brzezińska-Wcisło, 2013). Consequently, consumers frequently seek effective treatments for dandruff.

One common approach to managing dandruff is using commercial shampoo products. However, these commercial products often present drawbacks, as they are dominated by harsh synthetic chemicals, such as Sodium Lauryl Sulfate (SLS) or other artificial cleansing agents. Continuous use of these chemicals can cause side effects, including scalp irritation, dryness, and hair breakage. Therefore, safer hair care alternatives with minimal side effects are needed to avoid these risks, such as formulating shampoos from natural ingredients like bitter melon leaves (*Momordica charantia* L.). Previous studies have shown that bitter melon leaf extract exhibits antifungal activity at a concentration of 1% against *Microsporum canis*, producing an inhibition zone of 13 mm (Soares *et al.*, 2015). To facilitate the use of bitter melon leaf extract as an anti-dandruff agent, it needs to be developed into a shampoo formulation.

In this study, shampoo formulations will be prepared using varying concentrations of carbopol as a gelling agent at 0.2%, 0.3%, and 0.4%. Subsequently, physical characteristic and stability tests will be conducted to determine whether the quality and performance of the formulations comply with established standard specifications.

METHODS

This study employed an experimental research design using a single-factor Completely Randomized Design (CRD). The factor evaluated was the variation in Carbopol concentration on the physical characteristics and stability of the shampoo formulation containing bitter melon leaf extract (*Momordica charantia* L.). The formulation was replicated three times. The steps in this study included:

Extraction

A total of 200 g of bitter melon leaf powder was weighed, and 1,500 mL of 96% ethanol was added. The container was covered with aluminum foil to prevent evaporation. The mixture was allowed to stand at room temperature and was stirred once a daily. After 3 days, it was filtered using a flannel cloth to obtain the first filtrate. Subsequently, a repeated extraction was performed using 500 mL of 96% ethanol, which was left at room temperature for 1 day, then filtered to obtain the second filtrate. The combined filtrates were concentrated using a rotary evaporator, followed by evaporation in a water bath (Andayani and Widarta, 2021)

Formulation.

The formulation of the bitter melon leaf extract shampoo was a modification of the study by Kartikasari *et al.* (2017). The modification involved adding Carbopol as a gel base in gradually increasing concentrations and adding triethanolamine to form a clear gel. The formulations are detailed in Table 1.

Table 1. Formulation of Bitter Melon Leaf Extract Shampoo

Materials	Concentration (%)			Function
	I	II	III	
Bitter melon leaf extract	1	1	1	Active Ingredient
Carbophol	0,2	0,3	0,4	Gelling agent
PVP K-30	4	4	4	Film forming agent
Glycerin	6	6	6	Emollient
Propilenglycol	5	5	5	Humectant
Methylparaben	0,15	0,15	0,15	Preservative
Triethanolamin	1,5	1,5	1,5	Alkalizing agent
Cocamide DEA	10	10	10	Foaming agent
Jasmine Essence	qs	qs	qs	Fragrance
Aquadest ad	100	100	100	Carrier

*Each formulation was prepared to a total volume of 150 mL.

Shampoo Preparation

All required ingredients were weighed according to the formula. Methylparaben was weighed and dissolved in boiling water. Carbopol was swelled in the preservative solution; once swollen, triethanolamine (TEA) was added gradually and stirred until a gel base was formed. PVP was then swelled, and cocamide DEA was added gradually to the mixture. Next, glycerin was added to the mixture and stirred until homogeneous. Bitter melon leaf extract was introduced into the mixture gradually while stirring until homogeneous, and distilled water was added to reach the desired weight. Jasmine essence was added and stirred until homogeneous (Kartikasari *et al.*, 2017). The shampoo formulation was poured into bottles for physical characteristics and stability testing.

Physical Characteristics Test

a. Organoleptic: The organoleptic test was conducted by observing the form, color, and odor of the shampoo.
b. pH: A pH indicator paper was dipped into the formulation, and the pH value—ranging between 5.0 and 9.0—was observed on the pH indicator scale.
c. Viscosity: A 100 mL sample of the shampoo formulation was poured into a beaker glass, and the spindle was lowered until it was fully immersed in the sample. The device was turned on by pressing the ON button. A spindle No. 64 was used at a speed of 30 rpm.
d. Foam Height: A total of 0.1 g of shampoo was weighed, placed into a test tube, mixed with 5 mL of distilled water, and sealed. The mixture was shaken for 20 seconds by regularly inverting the test tube. The height of the formed foam was then measured (Rowe *et al.*, 2000).

Stability Test

The stability test was performed by introducing 15 mL of the bitter melon leaf extract shampoo formulation into a centrifuge tube. The centrifuge was operated at a speed of 3,600 rpm for 30 minutes. The product was considered stable if phase separation occurred but could readily remix into a homogeneous state upon shaking (Arisanti *et al.*, 2021)

Analysis

The research data were analyzed descriptively and statistically. Descriptive data were presented in the form of tables and figures, then compared with reference standards or previous studies. Statistical analysis was conducted using normality and homogeneity tests. If the data were normally distributed and homogeneous, the analysis was proceeded with ANOVA and Post Hoc tests. If the homogeneity or normality requirements were not met, the Kruskal-Wallis and Mann-Whitney tests were used, with a 95% confidence level.

RESULTS AND DISCUSSION

Extraction

The extraction method employed in this study was maceration. This method was selected because bitter melon (*Momordica charantia* L.) leaf simplicia contains flavonoid compounds that are susceptible to thermal degradation; therefore, a cold extraction method was considered more appropriate. The extraction process yielded 11.2%, indicating that the extract fulfilled the minimum yield requirement for herbal simplicia (≥10%) (Indonesian Herbal Pharmacopoeia, 2017).

Qualitati3ve Flavonoid Test

The obtained extract was subjected to a qualitative flavonoid analysis. A positive result was indicated by the appearance of a yellow coloration in the sample solution. The formation of the yellow color following the addition of magnesium (Mg) powder and concentrated hydrochloric acid (HCl) confirmed the presence of flavonoid compounds, particularly flavones or chalcones. Chemically, this reaction involves the reduction of the benzopyrone nucleus by hydrogen gas generated from the exothermic reaction between metallic magnesium and concentrated hydrochloric acid, leading to the formation of colored flavilium salts.

The yellow coloration indicates that the flavonoid structure in the bitter melon leaf extract possesses a specific substitution pattern on the C-ring, resulting in absorption within the complementary visible spectrum. This finding is consistent with the principle of the Shinoda test, which states that color intensity, ranging from yellow to orange and red, is influenced by the position of hydroxyl groups and the degree of saturation within the flavonoid core structure after reduction (Prasetya *et al.,* 2021). The qualitative flavonoid test results are presented in Figure 1**.**

Figure 1. Flavonoid test results

Shampoo Preparation

During shampoo formulation, Carbopol 940 was first dispersed in distilled water to allow complete swelling and formation of the gel base. Subsequently, triethanolamine (TEA) was added gradually until a clear gel was obtained. Stirring was performed carefully to minimize foam formation during preparation. The foam generated during mixing was attributed to the presence of Cocamide DEA, which functions as the foaming agent in the formulation. The resulting shampoo formulations were then evaluated for their physical characteristics and compared with standard shampoo quality requirements. The evaluations included organoleptic properties, pH, foam height, viscosity, and accelerated stability testing using a centrifuge. The shampoo formulation is shown in Figure 2.

Figure 2. Bitter melon leaf extract shampoo

Physical Characterization of the Shampoo

a. Organoleptic Evaluation

The organoleptic evaluation was conducted to assess the appearance, color, and odor of the bitter melon (*Momordica charantia* L.) leaf extract shampoo formulations. The organoleptic characteristics of the formulations are presented in Table 2.

Table 2. Organoleptic test result

Formula	Appearance	Color	Odor
I	Thin Liquid	Brown	Jasmine
II	Viscous Liquid	Yellowish-brown	Jasmine
III	Viscous Liquid	Yellowish-brown	Jasmine

As the concentration of Carbopol 940 increased, the consistency of the shampoo changed from a low-viscosity liquid to more viscous liquid. This change indicates the formation of a stronger three-dimensional polymer network resulting from increased viscosity. The brown to yellowish-brown color remained relatively consistent across all formulations, suggesting that variations in the concentration of the gelling agent did not affect the color stability of the bitter melon leaf extract or the fragrance contributed by the excipients used in the formulation.

b. pH Evaluation

The pH values of each shampoo formulation are presented in Table 3**.**

Table 3. pH test result

Formula	pH
I	9
II	9
III	9

According to the Indonesian National Standard (SNI 06-2692-1992), the acceptable pH range for shampoo is 5.0–9.0. Carbopol 940 is inherently acidic when dispersed in water. Therefore, triethanolamine (TEA) was incorporated to neutralize the carboxyl groups of Carbopol 940, converting them into their salt form and facilitating the formation of a clear, viscous gel. The relatively high concentration of TEA (1.5%) was sufficient to neutralize the acidic nature of Carbopol 940 while increasing the pH of the formulation to 9.0. The pH was also influenced by the presence of 10% Cocamide DEA, a nonionic surfactant that naturally exhibits a slightly alkaline character (approximately pH 8–10 in a 1% solution). At this concentration, Cocamide DEA contributed substantially to maintaining the formulation at pH 9.0 through its buffering effect (Lestari, 2020). All shampoo formulations complied with the SNI requirements, indicating that variations in the formulation did not significantly affect the pH values obtained.

c. Viscosity Evaluation

The viscosity test was performed to determine the thickness of the shampoo formulations. The results are presented in Table 4.

Table 4. Viscosity test result

Formula	Viskositas (Cps)
I	520
II	1886
III	3440

The highest viscosity was observed in Formula III, with a value of 3,440 cP, demonstrating that Increasing the Carbopol 940 concentration significantly increased the viscosity of the shampoo formulations of the shampoo. Wati (2021) reported that a formulation containing 0.5% Carbopol 940 produced a viscosity of 2,340 cP. Although the Carbopol 940 concentration used in the present study was only slightly different, the resulting viscosity was considerably higher. This difference may be attributed to the incorporation of 15% Cocamide DEA, which acts as a secondary thickening agent and works synergistically with Carbopol 940 to produce a denser gel network. Despite differences in absolute viscosity values, both studies demonstrated a linear increase in viscosity with increasing concentrations of the gelling agent, confirming that the consistency of the shampoo formulations in the present study was consistent with the theoretical mechanism of polymer matrix formation. Higher concentrations of Carbopol 940 resulted in greater viscosity of the shampoo formulation.

d. Foam Height Evaluation

The foam height test was conducted to evaluate the foaming ability of the shampoo formulations in water (Utami & Anwarudin, 2021). According to the Indonesian National Standard (SNI 06-2692-1992), the acceptable foam height for shampoo ranges from 1,3 to 22 cm. Foam height is a crucial quality parameter because consumers generally associate abundant foam with effective cleansing performance (Erwiyani *et al.*, 2023). This test was used to assess the ability of the surfactant system to generate foam. All formulations (Formula I, II, and III) produced a foam height of 4.5 cm, which complied with the SNI requirements. The foam height results are presented in Table 5**.**

Table 5. Foam Height Test Results

Formula	Tinggi busa (cm)
I	4,5
II	4,5
III	4,5

The foaming ability of the shampoo formulations was primarily attributed to the incorporation of 10% Cocamide DEA, which functions as both a foam booster and foam stabilizer. Mechanistically, Cocamide DEA reduces the surface tension of water and reinforces the liquid film surrounding air bubbles, thereby producing a more stable foam that is less susceptible to collapse. The identical foam height values (4.5 cm) observed across all formulations also indicate a high degree of homogeneity during the mixing process. These findings demonstrate that the bitter melon (*Momordica charantia* L.) leaf extract shampoo formulations exhibited stable foaming properties and met the quality requirements for hair-cleansing products (Pravitasari *et al.*, 2021).

Stability Test

Mechanical stability testing was performed using the centrifugation method at 3,600 rpm for 30 minutes**.** This accelerated stability test was employed to simulate the gravitational stress experienced by the formulations during approximately one year of normal storage. The results are presented in Table 6.

Table 6. Stability Test Results

Formula	Parameter	Pre-centrifugation observation	Post-centrifugation observation	Description
I	Phase Separation	No Phase Separation	Phase separation occurred; returned to a homogeneous state after gentle shaking	Stable
II	Phase Separation	No Phase Separation	Phase separation occurred; returned to a homogeneous state after gentle shaking	Stable
III	Phase Separation	No Phase Separation	Phase separation occurred; returned to a homogeneous state after gentle shaking	Stable

Based on the observations presented in Table 6, all formulations (F1, F2, and F3) exhibited phase separation after centrifugation. This phenomenon occurred because the centrifugal force accelerated the separation of formulation components with different densities, resulting in sedimentation or creaming

(Wati *et al.*, 2021). Despite the observed phase separation, all formulations were classified as stable, as the separated phases readily returned to a homogeneous state after gentle shaking. The ability of the formulations to recover their homogeneity indicates that the dispersed system possessed reversible physical stability. Furthermore, Carbopol 940 played a crucial role in maintaining formulation stability by forming a flexible three-dimensional polymer network. Although the polymer matrix was temporarily disrupted under high mechanical stress during centrifugation, it recovered its original structure without undergoing permanent damage, thereby preserving the overall physical stability of the shampoo formulations.

CONCLUSION

Variations in Carbopol 940 concentration significantly affected the physical characteristics of the shampoo formulations, particularly viscosity. The stability test altered the consistency of the formulations from a low-viscosity liquid to a more viscous liquid. However, variations in Carbopol 940 concentration did not affect color stability, odor, pH, or foam height. All formulations demonstrated good stability in the centrifugation test at 3,600 rpm. Although temporary phase separation occurred, the formulations remained stable because they readily returned to a homogeneous state after gentle shaking, indicating reversible physical stability.

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