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FORMULATION AND PHYSICAL EVALUATION OF SHAMPOO CONTAINING MAHKOTA DEWA (PHALERIA MACROCARPA (SCHEFF.) BOERL.) LEAF EXTRACT USING CARBOXYMETHYL CELLULOSE

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ABSTRACT
Shampoo is a cosmetic preparation used to cleanse the hair and scalp. The incorporation of plant-based ingredients into shampoo formulations has gained increasing attention, including the use of mahkota dewa (Phaleria macrocarpa (Scheff.) Boerl.) leaves, which contain secondary metabolites with potential antimicrobial properties. This study aimed to formulate and evaluate the physical characteristics of shampoo containing mahkota dewa leaf extract with varying concentrations of sodium carboxymethyl cellulose (Na-CMC). This laboratory experimental study used the maceration method with 96% ethanol as the extraction solvent. Three shampoo formulations were prepared using Na-CMC at concentrations of 0.50% (F1), 0.75% (F2), and 1.00% (F3). Physical evaluation included organoleptic characteristics, homogeneity, pH, and foam height. Phytochemical screening of the mahkota dewa leaf extract indicated the presence of alkaloids, flavonoids, saponins, tannins, and steroids. All formulations exhibited homogeneous characteristics. The pH of all formulations was 4, which was within the acceptable range for shampoo preparations. The foam height remained stable for up to 15 minutes. Among the formulations, F3 containing 1.00% Na-CMC showed the most favourable physical characteristics based on the evaluated parameters. Mahkota dewa leaf extract can be formulated into a shampoo preparation using Na-CMC as a thickening agent. The formulation containing 1.00% Na-CMC demonstrated the most favourable results in terms of homogeneity, pH, and foam stability.

Keywords: foam; homogeneity; Na-CMC; phaleria macrocarpa; phytochemical; shampoo

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INTRODUCTION

Indonesia has a predominantly hot climate, which may contribute to conditions that support microbial growth and the occurrence of various hair and scalp problems. Consequently, many people seek hair and scalp care products that are considered safe and have fewer adverse effects than conventional chemical-based treatments. The increasing interest in herbal medicine has encouraged the utilisation of natural ingredients in healthcare and cosmetic preparations in Indonesia. One of the medicinal plants that has been reported to have potential for addressing hair and scalp problems is mahkota dewa (Phaleria macrocarpa (Scheff.) Boerl.) (Fitriani, 2024).

Dandruff is a common scalp problem experienced by the community. It is often accompanied by itching, which may cause discomfort and reduce self-confidence, leading individuals to seek clean and healthy scalp conditions (Sukara et al., 2023). Dandruff is a scalp condition characterised by excessive shedding of dead skin cells, which generally appears as white or yellowish flakes. Although dandruff may occur in areas such as the eyebrows, it is most commonly observed on the scalp and represents one of the prevalent dermatological problems in the community (Widowati et al., 2020).

The prevalence of dandruff is estimated at approximately 15–20% of the global population, with approximately 50% of cases occurring among adults. This prevalence indicates that dandruff is a

common scalp disorder that requires appropriate attention to maintain hair and scalp health (Nasution, 2021). In Indonesia, the number of individuals experiencing dandruff has been estimated at 43,833,262 among a total population of 238,452,952. Based on these estimates, Indonesia has been reported to have a relatively high number of individuals affected by dandruff globally, ranking fourth after China, India, and the United States (Yusuf et al., 2020).

Mahkota dewa (Phaleria macrocarpa (Scheff.) Boerl.) is a medicinal plant originating from Indonesia, particularly Papua, and has traditionally been utilised by local communities because of its potential health benefits. Traditional applications of this plant include the management of various health conditions, including skin disorders, diabetes, allergies, dysentery, heart disease, kidney disorders, respiratory problems, cancer, hypertension, influenza, and gout. These traditional uses are associated with the presence of various secondary metabolites found in different parts of the plant, including the stems, leaves, seeds, fruit pulp, and fruit peel (Dania, 2021).

The phytochemical constituents reported in Phaleria macrocarpa (Scheff.) Boerl. include alkaloids, flavonoids, saponins, tannins, and steroids. These secondary metabolites are considered important contributors to the biological activities of the plant. Previous studies have reported that the secondary metabolites of Phaleria macrocarpa may exhibit pharmacological activities, including antioxidant, antiviral, antibacterial, antifungal, and other biological effects. Therefore, mahkota dewa has potential for further development as a natural ingredient in medicinal and pharmaceutical preparations, including the utilisation of its leaf extract as an active ingredient in skin and hair care formulations (Dania, 2021).

Shampoo is a cosmetic preparation intended to cleanse the hair and scalp from impurities such as dust, excess oil, and dead skin cells without causing irritation. Gel-based shampoo preparations are generally designed to provide convenient application and may reduce the potential for irritation when appropriately formulated. Carboxymethyl cellulose (CMC), particularly sodium carboxymethyl cellulose (Na-CMC), is a polymer that can be incorporated as an excipient in cosmetic preparations such as shampoo. Na-CMC is a relatively biodegradable polymer and may therefore contribute to the development of more environmentally sustainable formulations. In shampoo formulations, its hydrophilic properties enable it to function as a thickening or viscosity-enhancing agent, thereby improving the consistency of the preparation, providing a comfortable texture during application, and potentially increasing the adhesion of active ingredients to the hair (Fitriani, 2024).

The incorporation of Na-CMC into shampoo containing mahkota dewa leaf extract may also contribute to the physical stability and usability of the preparation. Its hydrophilic characteristics can support the maintenance of product texture and improve shampoo viscosity without substantially altering the chemical properties of the main ingredients. In addition, Na-CMC may improve the consistency and application characteristics of shampoo, thereby supporting the production of a stable and acceptable cosmetic preparation (Fitriani, 2024).

The use of natural ingredients in anti-dandruff shampoo formulations may be further supported by antifungal activity against Malassezia furfur, a microorganism associated with dandruff. (Sari et al., 2025) reported that a gel shampoo containing pandan leaf juice demonstrated inhibitory activity against Malassezia furfur. Similarly, mahkota dewa leaf extract has shown potential antifungal activity. (Harahap et al., 2024) reported that mahkota dewa leaf extract was capable of inhibiting the growth of Candida albicans using the agar disc diffusion method. These findings support the potential application of mahkota dewa leaf extract in scalp care preparations; however, its direct effectiveness in reducing dandruff requires further investigation.

In addition to its potential antifungal activity, mahkota dewa leaf extract has also been investigated for its anti-inflammatory properties. (Shofiah et al., 2025) reported that Phaleria macrocarpa (Scheff.) Boerl. leaf extract has potential anti-inflammatory activity, which may support its application in scalp care preparations. Such activity may be relevant to inflammatory processes associated with scalp disorders, including dandruff. Nevertheless, the effectiveness of mahkota dewa leaf extract specifically in managing dandruff and reducing associated symptoms such as itching and erythema requires further investigation, particularly through studies focusing on scalp applications.

Based on the potential of mahkota dewa leaf extract and the functional properties of Na-CMC in shampoo formulations, optimisation of the Na-CMC concentration is important to obtain a preparation with appropriate physical characteristics. However, the effect of different Na-CMC concentrations on the physical properties of shampoo containing mahkota dewa leaf extract requires further evaluation. Therefore, this study investigated the differences in Na-CMC concentrations in three shampoo formulations, namely Formula 1 (0.50%), Formula 2 (0.75%), and Formula 3 (1.00%), and evaluated their effects on the physical characteristics of the preparations. The study also aimed to determine the formulation demonstrating the most favourable physical characteristics and to develop a shampoo preparation containing mahkota dewa (Phaleria macrocarpa (Scheff.) Boerl.) leaf extract with acceptable physical properties.

METHOD

Study Design and Setting

This study employed a laboratory experimental design to formulate and evaluate the physical characteristics of shampoo containing mahkota dewa (*Phaleria macrocarpa* (Scheff.) Boerl.) leaf extract with different concentrations of sodium carboxymethyl cellulose (Na-CMC). The study was conducted at the Integrated Laboratory, Sekolah Tinggi Ilmu Kesehatan (STIKES) Papua. The research was conducted from July 2025 to March 2026. The formulations consisted of three Na-CMC concentrations: 0.50% (F1), 0.75% (F2), and 1.00% (F3). Physical evaluation included organoleptic characteristics, homogeneity, pH, and foam height.

Plant Material and Sample Preparation

Fresh, green, and undamaged mahkota dewa leaves were collected in the morning before 08:00 from Klamono District, Sorong Regency, Southwest Papua, Indonesia. A total of 10,000 g of fresh leaves was collected. The leaves were subjected to wet sorting, washed under running water, cut into smaller pieces, and air-dried away from direct sunlight. The dried leaves were subjected to dry sorting, weighed, pulverised using a blender, and sieved through a 40-mesh sieve. The resulting simplicia powder was stored in a sealed container with silica gel to minimise moisture and fungal contamination.

Extraction Procedure

Mahkota dewa leaf extract was prepared using the maceration method with 96% ethanol. A total of 1,850 g of powdered simplicia was placed in a glass container and macerated using 10 L of 96% ethanol in three extraction cycles. The simplicia was initially moistened with the solvent and allowed to absorb the solvent before additional ethanol was added until the material was completely immersed. The container was closed and protected from direct sunlight for three days, with occasional stirring. The extract was subsequently filtered, and the residue was re-macerated twice. All filtrates were combined and concentrated using a water bath at 60°C until a thick extract was obtained.

Phytochemical Screening

Phytochemical screening was conducted to identify alkaloids, flavonoids, saponins, tannins, and steroids in the ethanol extract of mahkota dewa leaves. Alkaloids were identified using

Dragendorff's and Mayer's reagents following acidification with hydrochloric acid. Flavonoids were assessed using magnesium powder and hydrochloric acid. Saponins were identified based on the formation of persistent foam. Tannins were detected using 10% ferric chloride, while steroids were identified using acetic anhydride and concentrated sulphuric acid. The tannin content of the extract was additionally examined using thin-layer chromatography (TLC) on silica gel GF254 plates. The mobile phase consisted of *n*-butanol acid (4:1:5), with gallic acid used as a reference standard. The developed plate was sprayed with ferric chloride to visualise tannin-positive spots.

Shampoo Formulation

Three shampoo formulations containing 5% mahkota dewa leaf extract were prepared using different concentrations of Na-CMC. Sodium lauryl sulphate (10%) was used as a surfactant, methyl paraben (0.2%) as a preservative, propylene glycol (6%) as a humectant, and menthol (0.2%) as a flavouring agent. Purified water was added to a final volume of 100 mL. The formulation composition is presented in Table 1.

Table 1.
Shampoo formulations containing mahkota dewa leaf extract

Ingredient	Function	F1 (%)	F2 (%)	F3 (%)
Mahkota dewa leaf extract	Active ingredient	5.0	5.0	5.0
Na-CMC	Thickening agent	0.50	0.75	1.00
Sodium lauryl sulphate	Surfactant	10.0	10.0	10.0
Methyl paraben	Preservative	0.20	0.20	0.20
Propylene glycol	Humectant	6.0	6.0	6.0
Menthol	Flavouring agent	0.20	0.20	0.20
Purified water	Solvent	ad 100 mL	ad 100 mL	ad 100 mL

Shampoo Preparation

Na-CMC was gradually dispersed in a portion of purified water and stirred until hydrated and homogeneous (mass 1). Sodium lauryl sulphate was separately dissolved in a portion of purified water and mixed until homogeneous (mass 2). Methyl paraben and menthol were dissolved in 96% ethanol, followed by the addition of propylene glycol. Masses 1 and 2 were then combined and mixed until homogeneous. The methyl paraben–menthol–ethanol–propylene glycol mixture was added gradually with continuous stirring. Mahkota dewa leaf extract was subsequently incorporated and mixed until homogeneous. Purified water was added gradually to obtain a final volume of 100 mL. The finished preparations were transferred into shampoo bottles.

Physical Evaluation

The physical characteristics of each shampoo formulation were evaluated through organoleptic, homogeneity, pH, and foam height tests.

1. Organoleptic evaluation. The colour, odour, and physical form of each formulation were observed and recorded.
2. Homogeneity test. A sample of each shampoo formulation was spread on a glass slide and examined for the presence of particles or components that were not uniformly dispersed.
3. pH test: The pH of each formulation was measured using universal pH paper. The acceptable pH range used in this study was 4–6.
4. Foam height test. A 10-mL sample of shampoo was placed in a graduated cylinder and shaken for five minutes. Foam height was measured immediately after shaking and subsequently at 5 and 15 minutes to assess foam stability.

Data Analysis

The data were analysed descriptively by organising and interpreting the results according to the observed characteristics of each formulation. The data included phytochemical screening results and physical evaluation results consisting of organoleptic characteristics, homogeneity, pH, and foam

height. The results were presented in tables to facilitate comparison among the three Na-CMC concentrations.

RESULT

Simplisia Processing and Extract Yield

The processing of mahkota dewa (*Phaleria macrocarpa* (Scheff.) Boerl.) leaves produced 2,100 g of dried simplicia from 10,000 g of fresh leaves, corresponding to a drying yield of 21%.

Table 2.
Yield of mahkota dewa leaf simplicia

Plant material	Fresh weight (g)	Dried weight (g)	Drying yield (%)
Mahkota dewa leaves	10,000	2,100	21.0

Extraction of 1,850 g of dried simplicia using 96% ethanol yielded 237 g of concentrated extract, corresponding to an extract yield of 12.8%.

Table 3.
Yield of mahkota dewa leaf ethanol extract

Simplicia powder (g)	Concentrated extract (g)	Extract yield (%)
1,850	237	12.8

Phytochemical Screening

Phytochemical screening demonstrated the presence of five secondary metabolite groups in the mahkota dewa leaf extract: alkaloids, flavonoids, saponins, tannins, and steroids. Positive reactions were indicated by characteristic colour changes or precipitate/foam formation according to the respective qualitative tests.

Table 4.
Phytochemical screening of mahkota dewa leaf extract

Phytochemical group	Test/reagent	Observation	Result
Alkaloids	Dragendorff's and Mayer's reagents	Orange-red colour and white-to-yellowish precipitate	+
Flavonoids	Magnesium powder + HCl	Red colour development	+
Saponins	Hot distilled water + HCl	Foam formation	+
Tannins	10% $FeCl_3$	Greenish-black colour	+
Steroids	Acetic anhydride + H_2SO_4	Green colour development	+

The qualitative identification of tannins was further confirmed by thin-layer chromatography (TLC). The mahkota dewa leaf extract produced a greenish-black spot after spraying with $FeCl_3$, with an Rf value of 0.85. The gallic acid reference standard produced an Rf value of 0.87. The similar migration values supported the presence of tannin compounds in the extract.

Table 5.
TLC identification of tannins in mahkota dewa leaf extract

Sample	Reference	Visualisation reagent	Rf	Spot colour	Interpretation
Mahkota dewa leaf extract	Gallic acid	$FeCl_3$	0.85	Greenish-black	Positive for tannins
Gallic acid	—	$FeCl_3$	0.87	—	Reference

Shampoo Formulation

Three shampoo formulations were prepared using 5% mahkota dewa leaf extract, while Na-CMC concentrations were varied at 0.50% (F1), 0.75% (F2), and 1.00% (F3). The concentrations of sodium lauryl sulphate, methyl paraben, propylene glycol, and menthol were maintained at 10%, 0.20%, 6%, and 0.20%, respectively, in all formulations.

Table 6.
Shampoo formulations containing mahkota dewa leaf extract

Ingredient	Function	F1 (%)	F2 (%)	F3 (%)
Mahkota dewa leaf extract	Active ingredient	5.0	5.0	5.0
Na-CMC	Thickening agent	0.50	0.75	1.00
Sodium lauryl sulphate	Surfactant	10.0	10.0	10.0
Methyl paraben	Preservative	0.20	0.20	0.20

Propylene glycol	Humectant	6.0	6.0	6.0
Menthol	Flavouring agent	0.20	0.20	0.20
Purified water	Solvent	ad 100 mL	ad 100 mL	ad 100 mL

Physical Characteristics of Shampoo

Organoleptic characteristics. All formulations exhibited a greenish-brown colour and a characteristic aroma of mahkota dewa leaves and menthol. The main difference among the formulations was texture. F1 showed a liquid texture, F2 exhibited a moderately viscous texture, and F3 produced the thickest preparation. The increasing consistency corresponded with the increasing concentration of Na-CMC.

Table 7.
Organoleptic characteristics of shampoo formulations

Formula	Na-CMC (%)	Texture	Colour	Aroma
F1	0.50	Liquid	Greenish-brown	Characteristic of mahkota dewa and menthol
F2	0.75	Moderately viscous	Greenish-brown	Characteristic of mahkota dewa and menthol
F3	1.00	Viscous	Greenish-brown	Characteristic of mahkota dewa and menthol

Homogeneity. All three formulations showed positive homogeneity results. No lumps or coarse particles were observed in F1, F2, or F3.

Table 8.
Homogeneity of shampoo formulations

Formula	Homogeneity	Observation
F1	+	No lumps
F2	+	No lumps
F3	+	No lumps

pH. All formulations had a pH value of 4. Thus, the three formulations showed the same measured pH despite differences in Na-CMC concentration.

Table 9.
pH of shampoo formulations

Formula	Na-CMC (%)	pH
F1	0.50	4
F2	0.75	4
F3	1.00	4

Foam height. Differences in foam height and stability were observed among the formulations. F1 produced an initial foam height of 41 mL, remained at 41 mL after 5 minutes, and decreased to 36 mL after 15 minutes. F2 produced 45 mL initially and after 5 minutes, decreasing to 41 mL at 15 minutes. F3 produced the highest foam height, at 57 mL initially and after 5 minutes, and maintained 57 mL after 15 minutes.

Table 10.
Foam height of shampoo formulations

Formula	Na-CMC (%)	Initial (mL)	5 min (mL)	15 min (mL)
F1	0.50	41	41	36
F2	0.75	45	45	41
F3	1.00	57	57	57

Overall, increasing the Na-CMC concentration was associated with increased shampoo consistency and greater foam stability. F3, containing 1.00% Na-CMC, produced the highest and most stable foam height among the three formulations.

DISCUSSION

Processing of Mahkota Dewa Leaves and Extraction

The preparation of mahkota dewa (*Phaleria macrocarpa* (Scheff.) Boerl.) leaves involved wet sorting, washing, cutting, drying, dry sorting, pulverisation, and storage before extraction. The extraction was performed using maceration with 96% ethanol for 3 × 24 h, followed by filtration and concentration at 60°C using a water bath. This process was intended to obtain a concentrated extract containing secondary metabolites that could subsequently be incorporated as the active ingredient in the shampoo formulation.

The drying process reduced the fresh leaf weight from 10,000 g to 2,100 g, corresponding to a drying yield of 21%. The 79% reduction in weight was primarily associated with the removal of water from the fresh plant material. Fresh plant materials generally contain substantial amounts of water, and drying is therefore important for reducing moisture content, limiting microbial growth and enzymatic activity, and helping to minimise degradation of bioactive compounds (ElGamal et al., 2023). The drying yield obtained in this study was consistent with the reported general range of 70–90% weight reduction for fresh plant materials, depending on the plant species, plant part, and drying method (Kementerian Kesehatan Republik Indonesia, 2017).

The extraction of 1,850 g of powdered simplicia produced 237 g of concentrated extract, corresponding to an extraction yield of 12.8%. This result indicates that 96% ethanol was capable of extracting constituents from mahkota dewa leaves. The yield was relatively comparable with the 14.58% yield reported by (Lestari et al., 2023) for ethanol extraction of mahkota dewa leaves. Differences in extraction yield may occur because of variations in plant material, solvent-to-sample ratio, particle size, extraction duration, and extraction conditions.

Phytochemical Profile of Mahkota Dewa Leaf Extract

Phytochemical screening identified alkaloids, flavonoids, saponins, tannins, and steroids in the mahkota dewa leaf extract. The positive reactions were indicated by characteristic precipitates, colour changes, or foam formation. The presence of these secondary metabolites provides preliminary evidence of the chemical constituents of the extract and supports its potential application as a natural ingredient in topical and hair-care formulations.

The alkaloid tests using Dragendorff's and Mayer's reagents produced positive reactions. The formation of an orange-red precipitate with Dragendorff's reagent is associated with the interaction between alkaloids containing nitrogen atoms and potassium tetraiodobismuthate, resulting in the formation of a coloured precipitate (Marbun et al., 2024). Similarly, the white-to-yellowish precipitate observed with Mayer's reagent is associated with the formation of a poorly soluble alkaloid complex in an acidic medium (Safdar et al., 2025). The detection of alkaloids is consistent with findings reported by (Andriyani et al., 2025), who identified alkaloids in ethanol extracts of mahkota dewa leaves and reported antibacterial activity against *Staphylococcus epidermidis*. These findings provide a chemical basis for further investigation of mahkota dewa leaf extract in scalp-care preparations; however, antibacterial activity was not directly evaluated in the present study.

Flavonoids were detected by the development of a red colour following the addition of magnesium powder and hydrochloric acid, corresponding to the Shinoda reaction. This reaction is associated with the reduction of flavonoid structures by magnesium under acidic conditions, resulting in coloured flavilium derivatives. Flavonoids are also recognised for their antioxidant potential through their ability to scavenge free radicals (Lestari et al., 2023). The detection of flavonoids therefore further supports the presence of bioactive secondary metabolites in the extract, although antioxidant activity was not directly measured in this study.

The positive saponin test was indicated by the formation of stable foam. Saponins possess hydrophilic and hydrophobic structural components and consequently exhibit surfactant-like properties that facilitate foam formation when agitated in aqueous media (Sinaga & Wulandari, 2024). This finding is particularly relevant to the present formulation because saponins may contribute to the foaming characteristics of the shampoo. Saponins have also been reported to possess antibacterial activity, partly through interactions with microbial cell membranes (Chen et al., 2024). Nevertheless, the present study only established the presence of saponins through qualitative screening and did not directly assess their antimicrobial activity.

Tannins were detected by the development of a greenish-black colour after the addition of 10% ferric chloride. This reaction is associated with the interaction of ferric ions with phenolic hydroxyl groups in tannins, producing a characteristic dark complex (Hariyanti et al., 2024). Tannins are polyphenolic compounds that may interact with proteins and interfere with microorganisms through mechanisms involving protein binding, enzyme inhibition, and membrane disruption (Hosseini et al., 2025). In the context of the present study, these findings support the chemical characterisation of the extract but should not be interpreted as direct evidence of antimicrobial efficacy of the formulated shampoo.

Steroids were also detected based on the green colour reaction obtained using acetic anhydride and concentrated sulphuric acid. This reaction corresponds to the Liebermann–Burchard test, which is commonly used for the qualitative identification of steroidal and triterpenoid compounds (Irawan et al., 2025). Overall, the phytochemical profile observed in this study was consistent with the findings of (Andriyani et al., 2025), who reported alkaloids, flavonoids, tannins, saponins, phenols, and steroids in 96% ethanol extracts of mahkota dewa leaves.

TLC Identification of Tannins

TLC analysis provided additional qualitative evidence for the presence of tannins in the mahkota dewa leaf extract. Using silica gel GF254 as the stationary phase and *n*-butanol acid (4:1:5) as the mobile phase, the extract produced an Rf value of 0.85, whereas the gallic acid reference produced an Rf value of 0.87. The difference of 0.02 indicates a relatively close migration pattern under the experimental conditions.

The greenish-black spot observed after spraying with $FeCl_3$ further supported the presence of phenolic compounds associated with tannins. The result was comparable with Firsty *et al.* (2023), who reported Rf values of 0.88 for the extract and 0.87 for gallic acid. Similar TLC conditions using *n*-butanol acid (4:1:5), gallic acid as a reference, and $FeCl_3$ as a visualisation reagent have also been reported by (Lihawa, 2023). Thus, the TLC findings in the present study provide supportive, rather than definitive, evidence for the presence of tannins in the extract.

Effect of Na-CMC Concentration on Shampoo Characteristics

The three shampoo formulations contained the same concentration of mahkota dewa leaf extract and other excipients, while Na-CMC concentration was varied from 0.50% (F1) to 0.75% (F2) and 1.00% (F3). This design allowed the physical characteristics of the shampoo to be compared according to the concentration of the thickening agent. Na-CMC is a hydrophilic cellulose derivative that can increase viscosity through the formation of a polymeric network and can contribute to the physical stability of liquid cosmetic formulations (Costa et al., 2022). Sodium lauryl sulphate (SLS) served as the primary surfactant, while propylene glycol, methyl paraben, menthol, and purified water functioned as a humectant, preservative, fragrance/cooling agent, and solvent, respectively (Samadi et al., 2025; Zendrato et al., 2025; Fitriani, 2024).

Increasing the Na-CMC concentration resulted in progressively thicker preparations. F1 produced the most fluid consistency, F2 showed intermediate viscosity, and F3 produced the thickest preparation. This pattern is consistent with the function of Na-CMC as a hydrophilic thickening agent. Increasing the polymer concentration increases the interaction between polymer chains and water, resulting in greater viscosity. (Pratiwi et al., 2025) similarly reported that increasing Na-CMC concentration can increase viscosity and contribute to the physical stability of shampoo preparations.

The organoleptic findings further demonstrated that the colour and aroma were relatively consistent across formulations, whereas texture changed according to Na-CMC concentration. The greenish-brown colour was associated with the mahkota dewa leaf extract, while the characteristic aroma was

associated with the extract and menthol. Texture is an important organoleptic parameter because it is related to viscosity, physical stability, and consumer acceptability (Dabbaghi et al., 2021). The differences in consistency observed among F1, F2, and F3 therefore demonstrate the expected contribution of Na-CMC to the physical properties of the shampoo.

Homogeneity and pH

All three formulations demonstrated good homogeneity, with no visible coarse particles or lumps. This finding indicates that the extract and excipients were adequately dispersed throughout the shampoo base. Uniform distribution is important because it supports consistent distribution of the active ingredient within the formulation and is an essential parameter in the assessment of physical quality (Bautista et al., 2025).

All formulations showed a pH of 4. This value was within the pH range of 4–6 used in the study for scalp-compatible shampoo preparations. Products intended for cleansing the skin are generally formulated within an acidic range to help maintain the physiological acidic environment of the skin surface (Blaak et al., 2023). The identical pH values across F1, F2, and F3 suggest that varying Na-CMC concentration within the tested range did not produce an observable difference in the measured pH. However, because only descriptive analysis was performed, this observation should not be interpreted as evidence of a statistically non-significant effect.

Foam Height and Stability

Foam height differed among the three formulations. F1 produced an initial foam height of 41 mL, which decreased to 36 mL after 15 min. F2 produced 45 mL initially and decreased to 41 mL after 15 min. In contrast, F3 produced 57 mL and maintained this height throughout the 15-min observation period. Thus, F3 demonstrated the greatest foam height and the highest observed foam stability among the tested formulations.

Foam formation is primarily associated with the presence of SLS, which reduces surface tension and facilitates the formation of air–liquid interfaces. The saponins detected in mahkota dewa leaf extract may also contribute to foam formation because of their surfactant-like properties. (Samadi et al., 2025) reported that saponin-containing shampoo preparations demonstrated surface activity and good foam-forming and foam-stabilising characteristics. Therefore, both the fixed concentration of SLS and the saponins present in the extract may have contributed to the formation of foam in the present formulations.

The differences in foam stability among formulations may be associated with the increasing concentration of Na-CMC. As a viscosity-enhancing polymer, Na-CMC can increase the viscosity of the continuous phase and reduce liquid drainage from foam films. Reduced drainage may delay bubble collapse and consequently improve foam stability. (Li et al., 2024) reported that increased Na-CMC concentration can reduce liquid drainage and bubble coarsening, thereby improving foam stability. A similar mechanism has been described for saponin-containing systems, in which increased viscosity can delay drainage from foam structures (Chae et al., 2025).

The present findings therefore suggest that the higher foam height and stability observed in F3 were more appropriately associated with the increased Na-CMC concentration rather than with differences in extract concentration, because the concentration of mahkota dewa leaf extract and SLS was identical across all formulations. The saponins in the extract may have supported foam formation, whereas Na-CMC may have contributed more directly to foam retention by increasing the viscosity of the continuous phase. This distinction is important when interpreting the effect of the formulation variables.

Overall Formulation Performance

Overall, increasing Na-CMC concentration produced observable differences in the physical characteristics of mahkota dewa leaf extract shampoo, particularly in texture and foam stability. F3 containing 1.00% Na-CMC produced the thickest consistency, remained homogeneous, had a pH of 4, and maintained a foam height of 57 mL for 15 min. On the basis of the physical parameters evaluated in this study, F3 can therefore be considered the most favourable formulation among the three tested formulations. This finding is consistent with the general role of Na-CMC in improving viscosity and physical stability in liquid cosmetic preparations (Costa et al., 2022; Pratiwi et al., 2025).

Nevertheless, the interpretation of F3 as the optimal formulation is limited to the parameters evaluated in the present study. Instrumental viscosity measurement, long-term stability testing, and irritation testing were not performed. In addition, the present study did not directly evaluate antifungal activity against *Malassezia furfur* or other microorganisms. Therefore, although the phytochemical findings and previous literature indicate that mahkota dewa leaf extract has potential biological activity, the formulated shampoo cannot yet be concluded to have anti-dandruff or antifungal efficacy based solely on the present physical evaluation. Further studies should investigate rheological properties, stability during storage, skin or scalp irritation, and relevant antimicrobial activity to establish the safety, stability, and functional efficacy of the formulation.

CONCLUSION

The formulation of mahkota dewa (Phaleria macrocarpa (Scheff.) Boerl.) leaf extract shampoo with varying Na-CMC concentrations resulted in different physical consistencies, ranging from liquid (F1), moderately viscous (F2), to viscous (F3). Among the formulations, F3 containing 1% Na-CMC showed the most favourable physical characteristics based on organoleptic properties, homogeneity, pH, and foam height. Phytochemical screening of the mahkota dewa leaf extract indicated the presence of alkaloids, flavonoids, saponins, tannins, and steroids. Overall, the 1% Na-CMC formulation demonstrated the most favourable characteristics among the formulations evaluated in this study.

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