Advances in Healthcare Research
Volume 3, Issue 2 (2025)
Website: https://advancesinresearch.id/index.php/AHR
OPEN ACCESS
e-ISSN: 2985-9808

Formulation and Antioxidant Activity Test of Micellar Water Extracted from Mangosteen Fruit Peel (Garcinia mangostana L.) Using the DPPH Method with Variations in the Concentration of PEG-7 Glyceryl Cocoate as a Surfactant

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ARTICLE HISTORY

Received: July 21, 2025
Revised: August 04, 2025
Accepted: August 12, 2025

DOI :
https://doi.org/10.60079/ahr.v3i2.588

ABSTRACT

Purpose: This study aims to determine the effect of PEG-7 glyceryl cocoate at concentrations of F1 0.2%, F2 0.4%, and F3 0.6% on the physical stability and cleaning power of micellar water preparations containing mangosteen peel extract. The best formulation was then tested for its antioxidant activity using the DPPH method.

Research Method: This study used a laboratory experimental method. The variations in PEG-7 glyceryl cocoate concentration used in the micellar water extract of mangosteen peel were F1 (0.2%), F2 (0.4%), F3 (0.6%), and negative control F0 (0%). Evaluations were conducted on physical stability tests (organoleptic, pH, homogeneity, and viscosity) and cleaning power. The best micellar water formulation was then tested for antioxidant activity using the DPPH method. The test results were analyzed using a One-Way ANOVA test.

Results and Discussion: The results of testing F3 micellar water, with the highest concentration of PEG-7 glyceryl cocoate, demonstrated that it was the best formula and exhibited the best cleaning ability. The results of the analysis using one-way ANOVA showed a p-value of < 0.05. The antioxidant activity of F3 was determined to have an IC50 of 103.81 µg/ml, which falls within the moderate category.

Implications: The results of this study indicate that PEG-7 glyceryl cocoate at a concentration of 0.6% can be used as a surfactant in micellar water preparations of mangosteen peel extract. Further research is needed to determine the long-term stability of the preparation.

Keywords: micellar water; mangosteen fruit peel (Garcinia mangostana L.); PEG-7 glyceryl cocoate; surfactant; antioxidant; DPPH.

Introduction

Facial cleansing is one of the most critical steps in a skincare routine. Keeping the skin clean from dirt or makeup residue is essential. Dirt, makeup, excess sebum, and oil on the skin's surface that

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are not properly removed can clog pores, which can affect metabolism and lead to premature aging. Proper facial cleansing not only removes dirt buildup but also indirectly helps hydrate the skin, keep it clean, and enhance the absorption of other skincare products (Blaak *et al.,* 2023). Choosing the right facial cleanser suited to your skin type is crucial for effective cleansing and maintaining skin safety.

One facial cleanser suitable for all skin types is micellar water (Hani Pratiwi *et al.,* 2024). Micellar water has excellent cleansing properties for removing makeup residue and dirt. It can dissolve, stabilize, and cleanse lipophilic impurities such as fats and oils, making it widely used in cosmetic formulations. Micellar water works by dissolving dirt, making it easy to clean and keeping the skin hydrated. Micellar water contains water, moisturizing, and surfactant formulas. In addition, micellar water is often combined with antioxidants (Dzakwan, 2020). Antioxidants have anti-free radical activity that can be added to cosmetic preparations.

Antioxidants in cosmetics can be synthetic or natural. Synthetic antioxidants such as butylated hydroxyanisole (BHA), butylated hydroxytoluene (BHT), and propyl gallate are widely used due to their relatively low production costs; however, research indicates that excessive use of synthetic antioxidants may pose health risks (Hoang *et al.,* 2021). Along with the growing consumer preference for organic products, the use of natural antioxidants derived from plants in cosmetics has increased in recent years and is expected to continue. Natural antioxidants from plants have gained popularity for both topical applications and consumption due to their significant ability to reduce photocarcinogenesis and aging caused by free radicals (Hussen *et al.,* 2025).

One plant with a high antioxidant content is the mangosteen (John *et al.,* 2021; Saristiana *et al.,* 2024; Widowati *et al.,* 2020). Mangosteen is a plant rich in antioxidant compounds known as xanthones found in the fruit peel. The fruit peel is often considered waste, but it contains high levels of antioxidants. The utilization of mangosteen peel in micellar water can produce a facial cleanser that not only cleanses but also provides antioxidant effects derived from the extract of mangosteen peel. Mangosteen peel contains several phenolic compounds, including xanthones, benzophenones, tannins, flavonoids, and anthocyanins. Xanthones are active flavonoid compounds that act as antioxidants (Widowati *et al.,* 2020). According to Partuti et al. (2021), the antioxidant activity of mangosteen peel extract, with an IC50 value of 7.33 ppm, is classified as very strong, as it is less than 50 ppm. Therefore, micellar water was produced from mangosteen peel extract using various formulations with varying concentrations of PEG-7 glyceryl cocoate. The best micellar water formulation was then tested for its antioxidant activity using the DPPH method.

Research Method

This research method uses a laboratory experimental method. The variations in PEG-7 glyceryl cocoate concentration used in the micellar water extract of mangosteen peel were F1 (0.2%), F2 (0.4%), F3 (0.6%), and negative control F0 (0%). This study was conducted at the Pharmacy Technology Laboratory of Muhammadiyah University of Kudus. The population in this study was mangosteen fruit peel (Garcinia mangostana L.) sourced from the Kalinyamatan District, Jepara Regency, Central Java, Indonesia. The peel was collected from fruits with purple and black skin color. The formulations were evaluated for physical stability (organoleptic, pH, homogeneity, and viscosity) and cleaning efficacy. The best micellar water formulation was then tested for antioxidant activity using the DPPH method. The test results were analyzed using a One-Way ANOVA test.

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Tools and Materials

The equipment required for this study includes a rotary evaporator, moisture balance (Ohaus), oven, reaction tubes, beaker glasses (Iwaki Pyrex), measuring flasks (Iwaki Pyrex), UV-Vis spectrophotometer (Shimadzu UV-1280), analytical balance (Ohaus), 1 ml measuring pipettes (Iwaki), pro pipettes, dropper pipettes, stirring rods, metal spoons, and measuring cups (Iwaki Pyrex). The materials used in this study were PEG-7 glyceryl cocoate, sodium gluconate, propylene glycol, glycerin, phenoxyethanol, lactic acid, distilled water, 96% ethanol, hydrochloric acid (HCl), magnesium powder (Mg), iron (III) chloride ($FeCl_3$), Mayer's reagent, Dragendroff's reagent, and mangosteen fruit peel (Garcinia mangostana L.).

Research Procedures

Preparation of Mangosteen Fruit Skin Samples

The sample used in this study was mangosteen peel (Garcinia mangostana L.). The preparation of the sample began with fresh mangosteen fruit being cleaned and separated from the flesh. The peel was then cut into small pieces and dried in an oven at 50°C for 72 hours. The resulting simplisia was ground into a powder using a blender and then sieved through a 20-mesh sieve to ensure uniform particle size. The resulting mangosteen fruit peel simplisia powder was stored in airtight containers protected from light until used for the subsequent extraction process.

Mangosteen Fruit Skin Maceration

Mangosteen peel powder was macerated using a ratio of 1:10. A total of 500 g of mangosteen peel powder was macerated using 5 L of 96% ethanol at room temperature for 3 days. Maceration was carried out in a closed container protected from sunlight, with stirring performed daily. The resulting solution was then filtered to separate the filtrate (liquid) from the residue. The filtrate was evaporated using a rotary evaporator at a temperature below 50°C until a concentrated mangosteen fruit peel extract was obtained.

Phytochemical Screening Test

- Alkaloid Test
  A total of 2 mL of extract was dissolved in 5 mL of 2N HCl. The solution was then divided into three test tubes. The first tube was used as a blank and mixed with dilute acid. The second tube was supplemented with three drops of Dragendorff's reagent, while the third tube was augmented with three drops of Mayer's reagent. The orange precipitate in the second tube and the yellow precipitate in the third tube indicate the presence of alkaloids (Nurdianti *et al.*, 2022).
- Flavonoid Test
  A total of 2 mL of extract was placed on a drop plate, and 10 drops of methanol were added. The mixture was then stirred with a spatula until it was dissolved. The mixture was then added with Mg powder and four drops of concentrated HCl. Flavonoids were identified by the presence of yellow, blue, orange, and red colors (Nurdianti *et al.*, 2022).

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- Saponin Test
  Two milliliters of extract were placed in a test tube and shaken vertically for 10 seconds. The formation of a stable foam 1-10 cm high identified the presence of saponin, and upon the addition of 1 drop of 2N HCl, the foam did not disappear (Depkes RI, 2014).
- Tannin Test
  A total of 2 mL of test extract was placed in a tube and reacted with the addition of 10% FeCl3 solution. Tannin compounds were identified by their characteristic dark blue or greenish-black color (Nurdianti *et al.,* 2022).

Preparation of Micellar Water

The process of making micellar water from mangosteen fruit begins with mixing PEG-7 glyceryl cocoate and extract to form phase A. Next, phase B is mixed, consisting of glycerin, propylene glycol, and lactic acid. In the next step, phenoxyethanol and sodium gluconate are each dissolved in distilled water and then added to phase B. The two prepared phases are then mixed and stirred until homogeneous. The final step involves adding distilled water to a total volume of 100 ml. The formulation used in this study is shown in Table 1.

Table 1. Formulation of Micellar Water from Mangosteen Fruit Peel Extract

Materials	Concentration (%)				Function
	F0	F1	F2	F3	
Mangosteen peel extract	1	1	1	1	Active ingredient (antioxidant)
PEG-7 glyceryl cocoate	0	0,2	0,4	0,6	Surfactant
Sodium gluconate	0,2	0,2	0,2	0,2	Preparation stabilizer
Propylene glycol	1,5	1,5	1,5	1,5	Humectant
Glycerine	0,25	0,25	0,25	0,25	Humectant
Phenoxyethanol	0,5	0,5	0,5	0,5	Preservative
Lactic acid	3 drops	3 drops	3 drops	3 drops	pH neutralizer
Aquades	Ad 100 ml				Solvent

Source: Processed primary data (2025)

Physical Stability Test

- Organoleptic Test
  Organoleptic testing was conducted to check the shape, smell, and color of micellar water using human senses (Hani Pratiwi *et al.,* 2024).
- pH test
  The test was conducted using a pH meter by dipping the electrode into the sample and allowing the device to display a constant pH value (Hani Pratiwi *et al.,* 2024). The pH range, according to the SNI 16-4380-1996 standard, is 4.5-7.8.
- Homogeneity Test
  The test was conducted with the aid of an object glass to ensure the homogeneity of the preparation. Good preparation is homogeneous and contains no visible particles (Rachmadani *et al.,* 2022).
- Viscosity Test

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Viscosity testing of preparations was performed using a Brookfield Viscometer by adjusting the spindle and speed. The viscosity standard was in the range of 0.24-30.60 cP (Hani Pratiwi *et al.,* 2024).

Clean Power Test

A cleaning power test was conducted to determine the efficiency of micellar water in removing dirt or makeup. To evaluate the cleaning power, the NIKKOL method was used with slight modifications, utilizing a Petri dish as the medium. The evaluation was conducted by applying lipstick over an area of 2x2 cm^2 and liquid foundation over an area of 4x3 cm^2 on the petri dish surface, then left to sit for 5 minutes. To assess the cleaning power, 0.5 mL and 1 mL of facial cleanser were dropped onto the petri dish, then wiped with a cotton pad or by hand, and the process was repeated by pouring 5 mL. Finally, the petri dish was immersed in water and immediately removed. Observations were made and compared through photos taken before and after applying the facial cleanser (Raknam, 2020).

Antioxidant Activity Test

The DPPH method for testing antioxidant activity includes (Nabilah *et al.,* 2023):

- Preparation of 1 mM DPPH solution
  A total of 39.432 mg of DPPH was weighed and placed in a 100 ml volumetric flask. The DPPH was then dissolved in ethanol to form a homogeneous solution. Afterward, the flask was covered with aluminum foil and stored in a dark place.
- Determination of the maximum wavelength of DPPH
  A total of 5 mL of DPPH solution was added to 3 mL of ethanol, and the mixture was stirred until a homogeneous solution was formed. The mixture was then incubated for 30 minutes at 27°C in the dark. Next, the absorbance of the DPPH solution was measured using a UV-Vis spectrophotometer over a wavelength range of 400–600 nm until the maximum absorbance was achieved. According to the observations by Emma et al. (2024), the maximum wavelength of DPPH using a UV-VIS spectrophotometer was ƛmax 517 nm.
- Determination of operating time
  The difference in the measured values of the constant absorbance can be used to determine the operating time. The operating time is used to determine the stable measurement time for soaking the DPPH free radicals.
- Preparation of micellar water sample solution
  - Preparation of 1000 ppm micellar water stock solution
    Place 0.025 mL of micellar water into a 25 mL volumetric flask, dissolve it using ethanol, and homogenize.
  - Preparation of standard series solutions
    A 1000 ppm stock solution is placed in a 10 mL volumetric flask to prepare a standard series solution with concentrations of 5 ppm, 10 ppm, 15 ppm, 20 ppm, and 25 ppm.
- Preparation of quercetin control solution
  - Preparation of 1000 ppm quercetin stock solution
    Place 2.5 mg of quercetin in a 25 mL volumetric flask and dissolve it in ethanol, then homogenize.
  - Preparation of standard series solutions

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A 1000 ppm stock solution is placed in a 10 mL volumetric flask to prepare a series of standard solutions with concentrations of 2 ppm, 4 ppm, six ppm, eight ppm, and 10 ppm.

- Antioxidant activity testing
  All standard solutions of micellar water and vitamin C were tested for their antioxidant activity by adding 1 mL to a test tube, followed by the addition of 1 mL of DPPH solution and 2 mL of ethanol. The solutions were then left to stand in the dark at room temperature for 30 minutes. Absorbance was measured at the maximum wavelength of DPPH 1 mM using a UV-Vis spectrophotometer. The parameter used was IC50. The IC50 value indicates the concentration of the compound required to inhibit DPPH intensity by 50%. The absorbance results obtained were used to calculate the % inhibition.

$$\%\ inhibisi\ = \frac{(control\ absorbance - sample\ absorbance)}{absorbance\ control} \times 100\%$$

Then, the inhibition percentage results obtained were used to find the IC50 value using the linear regression equation formula, namely:

$$y = b\ (x) + a.$$

Data Analysis Methods

The data obtained from physical stability tests, such as pH and viscosity tests, were subjected to normality and homogeneity tests. Normality tests were conducted to determine whether the data distribution was normal using the Shapiro-Wilk test. The data were considered normal if the p-value was greater than 0.05. Homogeneity tests were performed to ensure that the data groups came from the same sample using the Levene statistic test. Data is considered homogeneous if $p > 0.05$. If the data meet the criteria, a one-way ANOVA test is conducted. A p-value < 0.05 indicates that the variation in surfactants used has a significant effect on pH and viscosity values. The LSD method is then used, followed by a Post Hoc Tukey Test to determine which formulas differ significantly.

Results and Discussion

Analysis Result

Plant Determination

The mangosteen fruit peel used in this study underwent identification before being processed into crude extract. Identification was conducted at the Biology Laboratory, Faculty of Science and Applied Technology, Ahmad Dahlan University, on March 5, 2025, with identification number 175/Lab.Bio/B/III/2025. The identification results indicated that the sample used was mangosteen fruit peel, identified as Garcinia mangostana L.

Sample Processing

The drying of mangosteen fruit peel resulted in a reduction from 3,000 grams of fresh fruit peel to 500 grams of dried peel. The peel experienced a drying loss of 83.3% with a total moisture content of 3.48% as measured by a moisture balance. The moisture content of the peel was examined to determine the amount of moisture it contained. The moisture content of dried mangosteen peel

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typically ranges below 10% (Hasibuan & Mambang, 2022). Dried mangosteen peel with high moisture content can interfere with solvents during extraction and has a high risk of microbial contamination, which can cause the extract to deteriorate easily (Yuvanatemiya *et al.,* 2022).

Maceration

The extraction results from the concentrated extract of mangosteen peel were obtained through a maceration process. This extraction method was chosen because it is easy to use and can preserve the compounds contained within, preventing them from easily evaporating. Maceration was carried out by soaking the crude extract in a solvent until it was completely covered. The extraction process was conducted in a closed container and left to stand for at least three days, with regular stirring to ensure complete extraction. The extraction results were then separated into filtrate and solvent, which were subsequently evaporated using a rotary evaporator (Abubakar & Haque, 2020). The yields and total concentrated extracts obtained are presented in Table 2.

Table 2. Maceration results

Simplisia	Solvent	Thick Extract Weight	Randemen
Mangosteen peel 500 g	Etanol 96% 5l	83,61 gr	16,7%

Source: Processed primary data (2025)

The extraction of mangosteen peel yielded a reddish-brown extract with a slight purple hue and a distinctive aroma. Based on Table 2, 500 grams of mangosteen fruit peel crude material, macerated with 5 liters of 96% ethanol, yielded 83.61 grams of concentrated extract, corresponding to a total yield of 16.7%. The yield of the concentrated mangosteen fruit peel extract meets the requirements of the Indonesian Herbal Pharmacopoeia Edition II (2017), which stipulates a minimum yield of 7.8%.

Phytochemical Screening Test

Table 3. Maseration Results

No.	Compound Groups	Treatment	Observation Results		Description
			Before	After	
1.	Alkaloid	Extract + asam encer (blanko)	Reddish yellow without sediment	Reddish yellow without sediment	(+)
		Extract + dragendorf	Reddish yellow without sediment	Reddish yellow with orange deposits	(+)
		Extract + mayer	Reddish yellow without sediment	Reddish yellow with yellow deposits	(+)
2.	Flavonoid	Extract + powder Mg + HCl pekat	Reddish yellow	Red	(+)
3.	Saponin	Ekstrak + shaken + HCl 2N	Reddish yellow without foam	Stable foam	(+)
4.	Tanin	Extract + FeCl3	Reddish yellow	Dark green	(+)

Source: Processed primary data (2025)

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Phytochemical screening was conducted to identify the compounds contained in the extract, and was the initial stage to ensure that the extract obtained contained the desired compounds. The testing was performed using reagents as detectors for specific compound groups. The changes observed determine the compound content in the extract. Based on Table 3, phytochemical examination of mangosteen peel extract showed positive results in all tests. This indicates that mangosteen peel extract contains alkaloids, flavonoids, saponins, and tannins. These phytochemical screening results are consistent with the research conducted by Yayan Rizikiyan et al. (2022), which also found that mangosteen fruit peel extract contains these compounds.

Micellar Water Formula

The formulation of micellar water varied into four formulas with different percentages of surfactant in each formula. The surfactant concentration varied from F1 (0.2%), F2 (0.4%), F3 (0.6%), and F0, which served as a negative control without surfactant. The formulation was prepared using a dissolution method with a magnetic stirrer during the mixing process. The production process was divided into two phases, Phase A and Phase B, based on the solubility properties of the ingredients. PEG-7 glyceryl cocoate is a soluble surfactant in distilled water. Glycerin and propylene glycol function as humectants. In a study by Li et al. (2020), it was mentioned that the addition of humectants, emollients, and occlusives can reduce surfactant penetration into the skin or reduce the surfactant system's ability to damage skin lipids, thereby minimizing skin irritation. The addition of sodium gluconate is used to enhance formulation stability, while lactic acid is added to neutralize the pH of the formulation. The preservative chosen is phenoxyethanol because it does not cause damage to the endocrine glands, making it a safe option (Dzakwan, 2020). The fourth formula will undergo further testing to evaluate the resulting formulation. The fourth formula will undergo further testing to assess the resulting formulation.

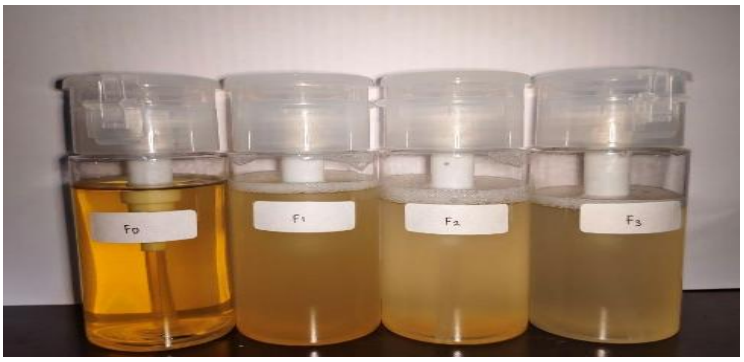

Figure 1. Micellar Water from Mangosteen Fruit Peel Extract

Physical Properties Test

Organoleptic Test

Organoleptic testing is a method that evaluates the appearance of a substance, including its color, odor, and shape. Based on the organoleptic testing conducted, all formulas have a characteristic odor similar to micellar water available on the market, which is unscented and in liquid form. However, the color of each micellar water formula varies. Differences among the formulas are observed in their clarity levels. F1 has a cloudy yellow color, F2 is slightly cloudy yellow, F3 is faintly cloudy yellow, and F0

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has a bright yellow color, indicating that surfactants can enhance clarity. The lower the surfactant concentration, the lower the clarity. This is because surfactants can penetrate the surface of oil or water particles, acting as a barrier to minimize or prevent the aggregation of dispersed particles (Wardana *et al.,* 2019).

pH test

pH testing was conducted to determine the acidity level of the micellar water formulation produced. This is crucial to ensure compliance with recommended standards, particularly since the formulation is intended for use on sensitive facial skin. The pH requirements for micellar water according to SNI 16-4380-1996 standards are 4.5–7.8.

Table 4. pH Test Results

Formula	Replication			Average ± SD	Requirements	Info
	1	2	3			
F0	4,56	4,58	4,59	4,57 ± 0,0152	4,5-6,5	Eligible
F1	4,83	4,78	4,85	4,82 ± 0,0360		
F2	5,02	4,99	5,08	5,03 ± 0,0458		
F3	5,26	5,27	5,20	5,24 ± 0,0378		

Source: Processed primary data (2025)

Based on Table 4, the results of pH testing on micellar water with varying surfactant concentrations showed that all formulations met the requirements. The test results showed an increase in pH values. The results for F3, which had the highest surfactant concentration, had a higher pH value than the other formulations. This is because PEG-7 glyceryl cocoate is a surfactant with basic properties (Wardana *et al.,* 2019); therefore, it can be stated that the higher the surfactant concentration, the higher the pH value.

The pH test data were further analyzed using SPSS. The results of the one-way ANOVA test on all pH formulations showed significant differences, with a p-value < 0.05. The test was continued with post hoc Tukey and LSD tests, which are follow-up tests after ANOVA to determine which formulations differ significantly. Based on the post hoc Tukey and LSD tests on all pH formulation samples, significant differences were found between the formulations, with p-values < 0.05. Therefore, it can be concluded that there are substantial differences between the formulation samples.

Homogeneity Test

Homogeneity testing was conducted to determine the degree of homogeneity in the preparations. Homogeneous preparations will ensure the expected effectiveness and maintain the stability and quality of the preparations (Wusono *et al.,* 2023). Based on the results of homogeneity testing on each formula, all micellar water formulas were found to be homogeneous, thus meeting the requirements.

Viscosity Test

Viscosity testing was conducted to determine the viscosity of the formulation. Viscosity testing was performed using a Brookfield Viscometer. Good viscosity results in a stable formulation because it has particle movement that tends to become increasingly complex (Puspita *et al.,* 2023). The viscosity

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requirements for facial cleanser formulations, as specified in SNI 16-4380-1996, range from 3 to 3000 cP. The pH test results are presented in Table 5.

Table 5. Viscosity Test Results

Formula	Replication			Average ± SD	Requirements	Info
	1	2	3			
F0	10,20	11,23	11,50	10,97 ± 0,6860	3-3000 Cps	Eligible
F1	15,80	16,00	15,50	15,76 ± 0,2516		
F2	20,05	19,50	19,00	19,50 ± 0,5252		
F3	29,00	27,00	30,00	28,66 ± 1,5275		

Source: Processed primary data (2025)

Based on Table 5, the viscosity test results for each formula have met the requirements. The test results showed that the highest viscosity was found in F3 and the lowest viscosity in F0. This is due to the surfactants contained in the formulation. Surfactants have a relatively high solution concentration; therefore, the higher the surfactant concentration used, the higher the solution concentration, resulting in a relatively higher viscosity (Wardana *et al.,* 2019).

The viscosity test data were then analyzed using SPSS. The results of the one-way ANOVA test on all formulations showed significant differences, with a p-value < 0.05. The test was continued with a post hoc Tukey and LSD test, which are follow-up tests after ANOVA to determine which formulations differ significantly. Based on the post hoc Tukey and LSD tests on all formulations, the viscosity of the formulations showed significant differences between formulations, with p-values < 0.05. Therefore, it can be concluded that there are substantial differences between the formulation samples.

Clean Power Test

A cleaning power test was conducted to determine the effectiveness of micellar water in removing dirt and makeup. To evaluate the cleaning power, the NIKKOL method was used with a Petri dish as the medium (Raknam, 2020). The results of the cleaning power test are shown in Table 6.

Table 6. Clean Power Test Results

Formula	Observation Results
F0	Not clean
F1	Not very clean
F2	Somewhat clean
F3	Clean

Source: Processed primary data (2025)

Based on Table 6, the results of testing various micellar water formulas showed that F3, with the highest surfactant concentration, had the best cleaning ability. This is due to the properties of surfactants. PEG-7 glyceryl cocoate, as a surfactant in micellar water, forms micelles. Micelles are small droplets that magnetically attract and trap skin impurities. The hydrophobic properties of the micelle's tail trap dirt, oil, and makeup, while the hydrophilic properties of the head allow the dirt to dissolve, making it easy to clean (Dzakwan, 2020).

Antioxidant Activity Test

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Antioxidant testing was conducted to assess the antioxidant activity of a compound against free radicals. The antioxidant testing was performed using the DPPH method on the third formulation, which exhibited the best physical evaluation and cleaning efficacy among the other formulations. The positive control used as a reference was quercetin. Quercetin was chosen as the positive control due to its well-established and vigorous antioxidant activity (Aiyuba *et al.,* 2023). The maximum wavelength was obtained at 517 nm with an absorbance of 0.843, which aligns with theoretical expectations, as the DPPH wavelength range is 400–600 nm (Emma *et al.,* 2024). The results of the clean power testing are presented in Table 7.

Table 7. Results of Antioxidant Activity Test

Sample	Average IC50 ± SD (µg/ml)	Info
Kuersetin	8,96 ± 0,0275	Very strong (<50 µg/ml)
Micellar water F3	103,81 ± 5,99	Medium (100-150 µg/ml)

Source: Processed primary data (2025)

Based on Table 7, the antioxidant activity results obtained from quercetin were higher than those from micellar water F3. Quercetin exhibited an antioxidant activity of 8.96 µg/ml, classified as very strong, while micellar water F3 had an antioxidant activity of 103.81 µg/ml, classified as moderate. According to Partuti et al. (2021), the antioxidant activity of mangosteen fruit peel extract yielded an IC50 value of 7.33 ppm, while in a study by Maulina et al. (2022), an IC50 of 35.80 ppm was obtained, and in a survey by Yayan Rizikiyan et al. (2022), an IC50 of 22.52 ppm was obtained. Based on these studies, the antioxidant activity of mangosteen fruit peel extract is below 50 ppm; thus, it can be categorized as having extreme antioxidant activity.

A decrease in antioxidant activity can occur when a formulation is prepared. Antioxidants are compounds that are highly susceptible to temperature changes, which can affect the antioxidant activity contained in the preparation (Hani Pratiwi *et al.,* 2024). The antioxidant mechanism of mangosteen peel is due to the content of xanthone and benzophenone, which donate hydrogen or electrons to free radicals.

Phenolic hydroxyl groups transfer hydrogen atoms to free radicals, thereby achieving stability. Stabilized compounds can stop free radicals from causing damage (Tran *et al.,* 2021). Antioxidant content can combat harmful free radicals and neutralize reactive molecules, thereby protecting cells from external and internal stress and helping to extend their lifespan and vitality.

Conclusion

Based on the research results, it can be concluded that micellar water extracted from mangosteen peel with a surfactant concentration of PEG-7 glyceryl cocoate F3 (0.6%) has better results than formulas F1 (0.2%) and F2 (0.4%). The physical stability of all formulas met the requirements. Test results, obtained using one-way ANOVA, post hoc Tukey, and LSD analysis, showed significant differences in pH and viscosity between the formulations. The test results yielded a p-value of <0.05. The cleaning efficacy test results indicated that only F3 (0.6%) had the best cleaning ability.

The antioxidant activity of quercetin was higher than that of micellar water F3. Quercetin exhibited an antioxidant activity of 8.96 µg/ml, classified as very strong, while micellar water F3 had an

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antioxidant activity of 103.81 µg/ml, classified as moderate. A decrease in antioxidant activity may occur after formulation into a preparation.

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