Formulation And Physical Stability Testing Of Exfoliating Gel And Moisturizing Gel From Sugarcane Bagasse Extract

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Abstract.

Sugarcane bagasse extract (Saccharum officinarum Linn.*) has high antioxidant activity due to its phenolic compounds, which are beneficial for moisturizing dry skin, smoothing the skin, and combating free radicals. This study aimed to evaluate the physical stability of exfoliating and moisturizing gel formulations containing sugarcane bagasse extract at concentrations of 1%, 3%, and 5% using the cycling test method over six cycles (12 days) at temperatures of ±4°C and ±40°C. Parameters tested included organoleptic properties, homogeneity, pH, viscosity, spreadability, and adhesiveness. The results showed that the formulations without extract (control) and those with 1% extract concentration met the physical stability parameters and remained stable throughout the cycling test, with viscosity ranging from 13,665.7 to 20,180.6 cPs, pH between 4.76 and 5.43, spreadability from 3.25 to 5.64 cm, and adhesiveness from 0.42 to 1.52 seconds. In contrast, formulations with 3% and 5% extract concentrations exhibited physical instability, such as changes in pH, viscosity, and spreadability, failing to pass the stability test cycles.*

Keywords: *Exfoliating Gel, Moisturizing Gel and Sugarcane Bagasse Extract.*

I. INTRODUCTION

Indonesia is home to various factories spread across its regions, one of which is the sugar factory. These factories use sugarcane as raw material, which is milled to produce sugar, leaving behind a by-product that is often discarded. Annually, sugar factories generate approximately 1.8 million tons of sugarcane bagasse waste, which is disposed of through open dumping without further processing, leading to environmental issues and unpleasant odors. Therefore, optimal utilization of this waste is crucial (Pamungkas & Evandani, 2021). Although sugarcane bagasse is merely a by-product of sugar production, it contains bioactive compounds valuable for cosmetic formulations. These compounds include free sugars (sucrose, glucose, and fructose), starch, wax, amino acids, organic acids, and predominantly phenolic compounds (Zheng et al., 2017). The phenolic compounds found in sugarcane bagasse, such as gallic acid, epicatechin, quercetin, ferulic acid, and kaempferol, demonstrate significant antioxidant potential (Carvalho, Oliveira, Pedrosa, Pintado, & Madureira, 2021).

Antioxidants are stable compounds capable of donating electrons or hydrogen to free radicals, inhibiting free radical chain reactions, and reducing cellular damage through their free radical-scavenging properties (Ibroham et al., 2022). The negative effects of free radicals can be mitigated by using cosmetics containing antioxidants, which function as moisturizers and soothe dry skin (Aryantini et al., 2020). A study by Suhesti et al. (2024) indicated that sugarcane bagasse (Saccharum Officinarum) at concentrations of 1%, 3%, and 5% has antioxidant activity that combats free radicals. This antioxidant content was innovated in the form of exfoliating gel and moisturizing gel. Gel is a semi-solid or thick product made from a mixture of extract (active substances) with a suitable base, providing the ability to hydrate the skin (Setyawan et al., 2023). Exfoliators are used for the removal of dead skin cells, dust, and dirt from the top layer of the skin (Purwandari et al., 2018). Based on the formula researched by Suhesti et al. (2024), the author will conduct a physical stability test to assess the impact of varying concentrations of sugarcane bagasse extract in exfoliating and moisturizing gel formulations. Stability testing aims to determine a product's ability to maintain its physical, chemical, microbiological, and toxicological quality, as well as ensure its safety and durability to meet established requirements (Oktami et al., 2021).

II. METHODS

2.1. Equipment and Materials

The equipment used in this study includes glassware, mortar and pestle, analytical balance, refrigerator, oven, pH meter, Brookfield viscometer, and water bath. The sample used is sugarcane bagasse (Saccharum officinarum Linn) obtained from Sukoharjo, Central Java. The materials used include 70% methanol, FeCl3, NaOH, HCl, chloroform, H2SO4, Carbopol 940, propyl paraben, phenoxyethanol, triethanolamine, propylene glycol, mica powder, essential oils, and aquades.

2.2. Preparation of Sugarcane Bagasse Simplisia

Simplisia is prepared by separating the outer part from the inner part of the sugarcane bagasse. The inner part of the bagasse is then weighed and dried in an oven at a temperature of approximately ±40°C until it is dry and easily crushed (Zheng et al., 2017). The dried simplisia is then coarsely blended and stored in a clean, tightly sealed container. Next, the simplisia is calculated for its % Loss on Drying (LoD) using the following formula:

$$\%\text{LoD} = \frac{\text{Wet sample weight} - \text{Dry sample weight}}{\text{Wet sample weight}} \text{x } 100\%$$

2.3. Preparation of Sugarcane Bagasse Extract

The sugarcane bagasse simplisia is extracted using the Soxhlet extraction method with 70% methanol as the solvent at 60°C, with a ratio of 1:60, for 4 hours or 8 cycles until the drops are colorless (Putra et al., 2022). The simplisia is replaced with fresh simplisia for re-extraction until the solvent becomes concentrated. Once the solvent is concentrated, the extract is further concentrated using an evaporator at 50°C until the desired thick extract is obtained. The yield percentage (% rendemen) is then calculated using the following formula:

$$\%\text{Yield} = \frac{\text{Weight of extract obtained}}{\text{Weight of dry simplisia use}} \text{x } 100$$

2.4. Preparation of Scrub

The preparation of the scrub is carried out by first coarsely blending the simplisia, then sieving it using a mesh size of 30. The material is sieved again using a mesh size of 50, and the coarse part is collected (Suhesti et al., 2024).

2.5. Extract Evaluation

Organoleptic Test

The organoleptic physical properties test includes the evaluation of shape, odor, and color, which are observed using human senses (Shintyawati et al., 2024).

Moisture Content and Drying Loss Test

The moisture content and drying loss are tested using a moisture analyzer by adjusting the temperature and heating time. A good extract should meet the moisture content requirement of ≤ 10% and the drying loss of ≤ 11% (Depkes RI, 2008).

2.6. Phytochemical Screening

Phenolic Compounds

The phenolic test is performed by weighing 0.2 grams of extract, dissolving it in 1 ml of aquadest, and adding 3-5 drops of 10% FeCl3. A positive result for phenolic compounds is indicated by a color change to green, purple, blue, or black (Hanani, 2015).

Flavonoids

The flavonoid test is conducted by weighing 0.2 grams of extract, dissolving it in 1 ml of aquadest, adding 1 ml of 10% NaOH, and 2 drops of concentrated HCl. A positive result for flavonoids is indicated by the disappearance of the yellow color (Shaikh & Patil, 2020).

Phytosterols

The phytosterol test is carried out by weighing 0.2 grams of extract, dissolving it in 1 ml of aquadest, and adding 3-5 drops of concentrated H2SO4. A positive result for phytosterols is indicated by a color change to golden yellow (Shaikh & Patil, 2020).

2.7. Formulation of Preparations

Exfoliating Gel

The preparation of the exfoliating gel is carried out by dispersing carbopol into hot aquadest in a ratio of 1:10, then allowing it to swell for 30 minutes until fully expanded. Next, triethanolamine is added gradually to the base and stirred until homogeneous. Propyl paraben is dissolved in propylene glycol, and the mixture is then added to the expanded base. After that, sugarcane bagasse extract and the remaining aquadest are added. Finally, the sugarcane bagasse scrub and essential oils are incorporated and stirred until homogeneous.

Table 1. Exfoliator Gel Formulation

Ingredients	Concentration (%)				Function
	F0	F1	F2	F3	
Bagasse extract	-	1	3	5	Active ingredient
Bagasse	-	0,5	0,5	0,5	Scrub
Carbopol 940	1	1	1	1	Gelling agent
Propyl paraben	0,1	0,1	0,1	0,1	Preservative
Triethanolamine	0,5	0,5	0,5	0,5	Gel stabilizer
Propylene glycol	2	2	2	2	Humectant
Essential oil	qs	qs	qs	qs	Corigen odoris
Aquadest ad	100	100	100	100	Solvent

Moisturizing Gel

The moisturizing gel is prepared by placing carbopol into a beaker and dispersing it in 10 times the amount of hot water at 80°C until it fully expands. Next, triethanolamine is added gradually while stirring until homogeneous. Then, propylene glycol is added slowly into a mortar and stirred until homogeneous. After that, phenoxyethanol is added and mixed until homogeneous. The sugarcane bagasse extract is then added to the mortar and stirred until well-mixed. Next, mica powder is added with the tip of a spatula, dissolved in 5 mL of water, and essential oil is dropped in and stirred until homogeneous. Finally, the remaining aquadest is added and stirred until homogeneous.

Table 2. Moisturizing Gel Formulation

Ingredients	Concentration (%)				Function
	F0	F1	F2	F3	
Bagasse extract	-	1	3	5	Active ingredient
Carbopol 940	1	1	1	1	Gelling agent
Triethanolamine	0,5	0,5	0,5	0,5	Gel stabilizer
Propylene glycol	5	5	5	5	Humectant
Phenoxyethanol	0,5	0,5	0,5	0,5	Preservative
Essential oil	qs	qs	qs	qs	Corigen odoris
Mica powder	qs	qs	qs	qs	Corigen coloris
Aquadest ad	100	100	100	100	Solvent

2.8. Evaluation of the Preparation

Organoleptic Test

The organoleptic test is performed by visually observing or using sensory evaluation to assess the color, odor, and consistency of the gel preparation (Zainal & Nisa, 2022).

Homogeneity Test

The homogeneity test is conducted by applying 0.5 g of the preparation onto a watch glass. The sample is then observed to check if the color is even and if there are any coarse particles present in the preparation (Zainal & Nisa, 2022).

pH Test

The pH test is performed by immersing a pH meter into the preparation. The value displayed on the pH meter indicates the pH of the preparation. The gel base preparation should have a pH that matches the skin's pH, which is between 4.5–6.5 (Setyawan et al., 2023).

Viscosity Test

Viscosity is tested using a Brookfield viscometer with a 4 mm spindle at 30 rpm. A gel preparation that meets the requirements should have a viscosity between 2,000–50,000 cps (Zainal & Nisa, 2022).

Spreadability Test

For the spreadability test, 0.5 g of the preparation is weighed and placed at the center of a graduated Petri dish. The dish is covered upside down and left for 1 minute to measure the spread diameter. Then, additional weights ranging from 50 g to 250 g are added every 1-minute interval, and the spread diameter is measured. The spreadability of the gel preparation should be between 3–5 cm (Zainal & Nisa, 2022).

Adhesion Test

In the adhesion test, 0.5 g of the preparation is weighed and placed on a glass plate, which is then covered with another glass plate. A 500 g weight is placed on top for 5 minutes. Afterward, a 80 g weight is removed, and the time taken for the glass plates to separate is measured. The adhesion time for the gel preparation should be more than 1 second (Irianto et al., 2020).

Stability Test

The stability test is performed using the cycling test method. The exfoliating gel is stored at ±4°C for 24 hours and then at ±40°C for 24 hours. The test is conducted for 6 cycles or 12 days. During each cycle, physical changes in the cream are observed, including organoleptic properties, homogeneity, pH, spreadability, and adhesion (Natalia Lumetut, Hosea Jaya Edy, 2020).

2.9. Data Analysis

Data analysis is conducted descriptively using SPSS software. Descriptive analysis is used for the organoleptic and homogeneity tests. For the pH, viscosity, spreadability, adhesion, and stability tests, analysis is done using SPSS. The analysis includes tests for normality and homogeneity. If the data is normally and homogeneously distributed, one-way analysis of variance (ANOVA) is used to assess the relationship between groups. However, if the data is not normally distributed, Kruskal-Wallis analysis is performed (Sayuti, 2015).

III. RESULT AND DISCUSSION

This study was conducted to evaluate the stability of sugarcane bagasse extract in exfoliating gel preparations. The sugarcane bagasse used in this study was sourced from Banaran, Grogol, Sukoharjo, Central Java. The preparation of the sugarcane bagasse involved separating the outer and inner parts, as the outer part has a hard texture and is difficult to crush. The plant identification was carried out to confirm the species used. Based on the identification results conducted at the Biology Laboratory of Muhammadiyah University of Surakarta, it was confirmed that the sugarcane bagasse belongs to the Poaceae family and the species *Saccharum officinarum Linn.* A total of 1,203.89 g of sugarcane bagasse produced 843.12 g of dried simplicia with a moisture content of 8.31%, which meets the requirement (<10%).

The sugarcane bagasse extract was prepared using the Soxhlet extraction method with 70% methanol solvent at a temperature of approximately 60°C, with a 1:60 ratio for 4 hours or 8 cycles, until the solvent drops were colorless (Putra et al., 2022). The extraction was repeated until the solvent became concentrated. This approach was used for solvent efficiency and to maximize the amount of compounds extracted (Suhesti et al., 2024).The result of the sugarcane bagasse extraction produced a dark brown extract with a characteristic odor and semi-viscous consistency. The viscous extract was tested for yield, moisture loss, and water content. The yield was 16.44%, moisture loss was 8.48%, and the water content was 7.15%. These results indicate that the extract meets the required moisture content and drying loss criteria, which are <10% and <11%, respectively (Depkes RI, 2000, 2008). The extract was tested using a universal pH indicator, and a pH of 4 was obtained, indicating that the extract is acidic in nature.

Table 3. Phytochemical Screening Results

	Reagent	Result	Description
Fenol	$FeCl_3$ 10%	Blackish green	+
Flavonoids	NaOH 10% + Concentrated HCl	Disappearance of yellow color after addition of concentrated HCl	+
Fitosterol	H_2SO_4	Golden yellow	+

Phytochemical Screening

Phytochemical screening was conducted to identify secondary metabolite compounds in sugarcane bagasse extract. The results showed that the extract contains alkaloids, flavonoids, and phytosterols. The results of the phytochemical screening are presented in Table 3.

Formulation of Exfoliator Gel and Moisturizing Gel

In the formulation of the exfoliator gel and moisturizing gel, Carbopol 940 was used as the gelling agent because it is neutral, provides stable viscosity, and has resistance to microbes. Triethanolamine was used as a stabilizer for the gel, as it can neutralize Carbopol and increase viscosity to produce a transparent gel. Propylene glycol acted as a humectant to maintain the moisture of the gel preparation by reducing water evaporation. Propylparaben was selected as a preservative due to its ability to inhibit microbial growth within a pH range of 4 to 8 (Sheskey et al., 2017). Essential oil was used to improve the scent of the gel. Mica powder was used as a colorant to give an attractive color to the moisturizing gel preparation.The exfoliator and moisturizing gel preparations were made in four formulas with three replications. Stability testing was then carried out using the cycling test method. The cycling test is an accelerated test by storing the preparation at a cold temperature (4-8°C) for 24 hours and then transferring it to an oven at 40°C for 24 hours in one cycle (Natalia Lumetut, Hosea Jaya Edy, 2020). This process was repeated for six cycles or 12 days, and the preparation was evaluated at each cycle.

Organoleptic Testing

The organoleptic test aimed to observe the gel preparation in terms of color, odor, and consistency (Eugresya, 2017). The results of the organoleptic observations for the exfoliator gel over the six cycles are shown in Table 4.

Table 4. Organoleptic Test Results of Exfoliator Gel

		Cycle						
		0	**1**	**2**	**3**	**4**	**5**	**6**
F0	Color	White	White	White	White	White	White	White
	Smell	Grape essential oil	Grape essential oil	Grape essential oil	Grape essential oil	Grape essential oil	Grape essential oil	Grape essential oil
	Texture	Semisolid	Semisolid	Semisolid	Semisolid	Semisolid	Semisolid	Semisolid
F1	Color	Milk chocolate	Milk chocolate	Milk chocolate	Milk chocolate	Milk chocolate	Milk chocolate	Milk chocolate
	Smell	Grape essential oil	Grape essential oil	Grape essential oil	Grape essential oil	Grape essential oil	Grape essential oil	Grape essential oil
	Texture	Semisolid	Semisolid	Semisolid	Semisolid	Semisolid	Semisolid	Semisolid
F2	Color	Mocca	Mocca	Mocca	Mocca	Mocca	Mocca	Mocca
	Smell	Grape essential oil	Grape essential oil	Grape essential oil	Grape essential oil	Grape essential oil	Essential oil grape	Essential oil grape
	Texture	Semisolid	Semisolid	Semisolid	Semisolid	Semisolid	Liquid	Liquid
F3	Color	Chocolate	Chocolate	Chocolate	Chocolate	Chocolate	Chocolate	Chocolate
	Smell	Grape essential oil	Grape essential oil	Grape essential oil	Grape essential oil	Grape essential oil	Grape essential oil	Grape essential oil
	Texture	Semisolid	Semisolid	Semisolid	Liquid	Liquid	Liquid	Liquid

Based on the observations conducted over six cycles, the exfoliator gel preparation did not undergo any changes in color or odor. The color of formulas 0, 1, 2, and 3 were white, milk brown, mocha, and brown, respectively, with a characteristic grape essential oil scent. The differences in color and texture between formulas 0, 1, 2, and 3 were in accordance with the concentration of the sugarcane bagasse extract present in each formula. The higher the concentration of the sugarcane bagasse extract used, the more intense the color variation.The texture of formulas 0 and 1 did not experience any changes. However, formula 2 showed significant changes in texture during cycles 5 and 6. Formula 6 also showed texture changes in cycles 2, 3, 4, 5, and 6. These changes may have been influenced by factors such as temperature, humidity, and the concentration of the sugarcane bagasse extract used.

Table 5. Organoleptic Test Results of Moisturizing Gel

		Cycle						
		0	**1**	**2**	**3**	**4**	**5**	**6**
F0	Color	White	White	White	White	White	White	White

	Smell	Essential Grape fruit	Essential Grape fruit	Essential Grape fruit	Essential Grape fruit	Essential Grape fruit	Essential Grape fruit	Essential Grape fruit
	Texture	Semisolid	Semisolid	Semisolid	Semisolid	Semisolid	Semisolid	Semisolid
F1	Color	Beige	Beige	Beige	Beige	Beige	Beige	Beige
	Smell	Essential Grape fruit	Essential Grape fruit	Essential Grape fruit	Essential Grape fruit	Essential Grape fruit	Essential Grape fruit	Essential Grape fruit
	Texture	Semisolid	Semisolid	Semisolid	Semisolid	Semisolid	Semisolid	Semisolid
F2	Color	Milk Chocolate	Milk Chocolate	Milk Chocolate	Milk Chocolate	Milk Chocolate	Milk Chocolate	Milk Chocolate
	Smell	Essential Grape fruit	Essential Grape fruit	Essential Grape fruit	Essential Grape fruit	Essential Grape fruit	Essential Grape fruit	Essential Grape fruit
	Texture	Semisolid	Semisolid	Semisolid	Semisolid	Semisolid	Liquid	Liquid
F3	Color	Latte	Latte	Latte	Latte	Latte	Latte	Latte
	Smell	Essential Grape fruit	Essential Grape fruit	Essential Grape fruit	Essential Grape fruit	Essential Grape fruit	Essential Grape fruit	Essential Grape fruit
	Texture	Semisolid	Semisolid	Semisolid	Semisolid	Semisolid	Liquid	Liquid

Based on Table 5 above, the results of the organoleptic test for all formulas (F0, F1, F2, and F3) showed differences in color and consistency, which are consistent with the concentrations of the extract used in the formulations. The higher the concentration of the extract, the darker the color and the more liquid the gel preparation.

Homogeneity

The homogeneity test aims to determine whether there are any particles that have not been evenly mixed. A good gel preparation should be homogeneous and free from clumping particles (Pratasik et al., 2019). The results of the homogeneity test for both the exfoliator gel and the moisturizer gel over six cycles can be seen in Table 6.

Table 6. Results of Homogeneity Test of Exfoliator Gel and Moisturizing Gel

	Cycle						
	0	**1**	**2**	**3**	**4**	**5**	**6**
F0	Homogeneous	Homogeneous	Homogeneous	Homogeneous	Homogeneous	Homogeneous	Homogeneous
F1	Homogeneous	Homogeneous	Homogeneous	Homogeneous	Homogeneous	Homogeneous	Homogeneous
F2	Homogeneous	Homogeneous	Homogeneous	Homogeneous	Homogeneous	Homogeneous	Homogeneous
F3	Homogeneous	Homogeneous	Homogeneous	Homogeneous	Homogeneous	Homogeneous	Homogeneous

The results of the homogeneity test over six cycles showed that both the exfoliator gel and the moisturizer gel with sugarcane bagasse extract were homogeneous, as there were no particles that remained unmixed when applied to the watch glass.

pH Test

The purpose of the pH test is to determine the acidity level of the preparation, ensuring it falls within the same pH range as skin, which is 4.5-6.5 (Slamet, Anggun, & Pambudi, 2020). A preparation with a pH that is too acidic can cause skin irritation, while one that is too alkaline can make the skin dry (Zaky, Balqis, & Pratiwi, 2020). The results of the pH measurements can be seen in Table 7 and Table 8.

Table 7. Results of pH Test Exfoliator Gel

	Cycle						
	0	**1**	**2**	**3**	**4**	**5**	**6**
F0	5,11±0,09	5,53±0,33	5,41±0,08	5,41±0,06	5,39±0,03	5,44±0,07	5,28±0,03
F1	5,23±0,07	5,25±0,16	5,29±0,13	5,20±0,08	5,45±0,11	5,31±0,14	5,14±0,08
F2	5,12±0,04	5,10±0,04	5,15±0,31	5,01±0,07	4,96±0,27	4,71±0,25	4,67±0,43
F3	5,19±0,21	5,21±0,22	5,13±0,35	4,85±0,20	4,99±0,10	4,66±0,22	4,51±0,17

Based on the pH test over six cycles, the exfoliator gel with sugarcane bagasse extract showed a pH range of 4.66-5.53. This value falls within the skin's pH range of 4.5-6.5. A pH that is too acidic can cause skin irritation, while a pH that is too alkaline can dry out the skin (Irianto et al., 2020). Therefore, all formulas meet the required pH for the exfoliator gel. As the concentration of the extract increases, the pH value becomes more acidic.The pH test data were analyzed using the Kruskal-Wallis test, and a significance value of <0.05 (0.000) was obtained, indicating that there is an effect of the varying concentrations of extract on the pH value. The stability test results showed that the pH value becomes more acidic as the storage

duration increases. This data was also analyzed using the Kruskal-Wallis test, with a significance value of <0.05 (0.000), indicating that the storage duration significantly influences the pH value.

Table 8. Results of Moisturizing Gel pH Test

	Cycle						
	0	**1**	**2**	**3**	**4**	**5**	**6**
F0	5,24±0,09	5,23 ± 0,20	5,43±0,09	5,38±0,08	5,40±0,05	5,25±0,04	5,26±0,04
F1	4,76±0,11	5,20 ± 0,03	5,23±0,06	5,18±0,09	5,11±0,02	5,00±0,04	4,87±0,08
F2	5,15±0,06	5,29 ± 0,11	5,06±0,07	5,14±0,11	5,14±0,12	5,14±0,10	5,13±0,12
F3	5,10±0,19	5,04 ± 0,21	4,82±0,18	4,91±0,16	4,96±0,15	4,94±0,16	4,83±0,14

Based on the observations, the pH test results show that formulas F0, F1, and F2 have pH values between 4.76-5.43, indicating that as the concentration of the extract increases, the pH of the preparation becomes more acidic. However, for formula F3, an increase in pH was observed, which could be influenced by human error, such as the pH meter not being properly cleaned after previous use.The data from the pH test, which were analyzed using the Kruskal-Wallis test, showed a significance value of <0.05 (0.000), indicating that there is an effect of the varying extract concentrations on the pH value. Meanwhile, the stability test results from the pH analysis also showed a significance value of <0.05 (0.007), indicating that the storage duration significantly affects the pH value.

Viscosity Test

The viscosity measurement of the exfoliator gel aims to assess the thickness or consistency of the gel. The results of the viscosity test can be seen in Tables 9 and 10.

Table 9. Results of Exfoliator Gel Viscosity Test

	Cycle						
	0	**1**	**2**	**3**	**4**	**5**	**6**
F0	20172,37± 1,79	20173,53± 0,64	20173,53± 0,64	20175,87± 1,33	20177,40± 0,00	20176,27± 1,15	20177,43± 1,15
F1	20177,87± 0,81	20177,87± 0,81	20177,87± 0,81	20177,20± 0,35	20177,20± 0,35	20178,60± 1,20	20180,17± 0,64
F2	20180,90± 0,00	20180,13± 1,33	20179,50± 1,57	20180,17± 0,64	20180,53± 0,64	16362,37± 6599,78	16294,87± 6716,69
F3	20179,37± 1,789786	20175,07± 2,020726	20010,47± 294,2518	18807,67± 2108,696	16036,23± 3818,977	10582,20± 5124,808	8048,70± 5124,808

Based on the viscosity test results conducted over six cycles, the exfoliator gel made from sugarcane bagasse exhibited a viscosity range of 8,048.70 to 20,180.90 cPs. This viscosity value falls within the acceptable range for gel viscosity, which is between 2,000 and 50,000 cPs (Zainal & Nisa, 2022). The data indicates that as the concentration of sugarcane bagasse extract increases, the viscosity of the formulation decreases, likely due to the semi-viscous consistency of the extract.The data from the viscosity test, which were analyzed using the Kruskal-Wallis test, revealed a significance value of <0.05 (0.000), indicating that there is a significant effect of varying extract concentrations on the viscosity of the gel formulation. However, the results of the stability test on viscosity showed a significance value of >0.05 (0.535), meaning that the duration of storage does not have a significant effect on the viscosity over time.

Table 10. Results of Moisturizing Gel Viscosity Test

	Cycle						
	0	**1**	**2**	**3**	**4**	**5**	**6**
F0	20172,37± 1,79	20173,53± 0,64	20173,53± 0,64	20175,87± 1,33	20177,40± 0,00	20176,27± 1,15	20177,43± 1,15
F1	20177,87± 0,81	20177,87± 0,81	20177,87± 0,81	20177,20± 0,35	20177,20± 0,35	20178,60± 1,20	20180,17± 0,64
F2	20180,90± 0,00	20180,13± 1,33	20179,50± 1,57	20180,17± 0,64	20180,53± 0,64	16362,37± 6599,78	16294,87± 6716,69
F3	20179,37± 1,789786	20175,07± 2,020726	20010,47± 294,2518	18807,67± 2108,696	16036,23± 3818,977	10582,20± 5124,808	8048,70± 5124,808

Based on the observations, the viscosity test results of the sugarcane bagasse gel showed a viscosity range of 13,665.7 - 20,180.6 cPs, which meets the viscosity test requirements. The higher the concentration of the extract used, the lower the viscosity value. Data analysis of the viscosity test using Kruskal-Wallis

resulted in a significance value of < 0.05, which is 0.000, indicating a significant effect between the variation in extract concentration and the viscosity value. However, the stability test results for viscosity, analyzed using Kruskal-Wallis, showed a significance value of > 0.05, which is 0.163, meaning there is no significant effect between storage time and the changes in viscosity values.

Spreadability Test

The spreadability test aims to determine the ability of the exfoliator gel to spread on the skin surface. The wider the spread, the larger the area on the skin that can receive therapeutic effects (Putri, 2021). The spreadability test results can be seen in Table 11 and Table 12.

Table 11. Results of the Exfoliator Gel Spreading Power Test

	Cycle						
	0	**1**	**2**	**3**	**4**	**5**	**6**
F0	3,96±0,36	4,10±0,29	3,61±0,14	3,28±0,33	3,51±0,08	3,29±0,27	3,55±0,27
F1	3,47±0,22	3,54±0,09	3,51±0,18	3,17±0,15	3,34±0,36	3,29±0,24	3,42±0,14
F2	3,44±0,24	3,38±0,15	3,39±0,27	3,44±0,19	3,41±0,17	3,43±0,14	3,32±0,21
F3	3,07±0,44	3,37±0,16	3,24±0,24	3,33±0,20	3,27±0,28	3,69±0,45	3,93±0,50

Based on the spreadability test results, during 6 cycles, the sugarcane bagasse exfoliator gel had a spreadability range between 3.07 - 4.10 cm, which meets the gel spreadability range of 3-5 cm (Zainal & Nisa, 2022). A gel with good spreadability can distribute the active ingredients optimally, resulting in more effective therapeutic effects (Naibaho et al., 2013). Spreadability is closely related to viscosity; the lower the viscosity, the greater the spreadability of a formulation (Sugihartini et al., 2020).The spreadability test data analysis using Kruskal-Wallis resulted in a significance value of < 0.05, which is 0.001, indicating that there is an effect between the variation in sugarcane bagasse extract concentration and the spreadability of the gel formulation. The stability test results for spreadability showed that the longer the storage time, the higher the spreadability. This data was analyzed using Kruskal-Wallis with a significance value of < 0.05, which is 0.010, meaning that there is a significant effect between the storage duration and the resulting spreadability.

Table 12. Table 12. Moisturizing Gel Spreading Power Test Results

	Cycle						
	0	**1**	**2**	**3**	**4**	**5**	**6**
F0	3,29±0,13	3,25±018	4,61±0,18	4,06±0,13	4,44±0,14	4,45±0,19	4,60±0,18
F1	3,87±0,38	4,32±0,22	4,68±0,18	4,47±0,11	4,44±0,24	4,77±0,16	4,87±0,26
F2	4,63±0,15	4,59±0,24	4,88±0,22	4,91±0,27	5,16±0,34	5,12±0,20	4,93±0,20
F3	4,97±0,22	5,09±0,43	5,64±0,19	5,56±0,15	5,52±0,20	5,59±0,24	5,56±0,22

Based on the observations, the spreadability of the sugarcane bagasse extract gel has a range between 3.25 to 5.64 cm. The spreadability value is inversely related to viscosity, where the lower the viscosity, the higher the spreadability of the formulation (Sugihartini, Jannah, & Yuwono, 2020). The spreadability test results analyzed using Kruskal-Wallis showed a significance value of < 0.05, which is 0.000, indicating a significant effect between the variation in extract concentration and spreadability values. Additionally, the stability test results for spreadability, analyzed using Kruskal-Wallis, showed a significance value of < 0.05, which is 0.000, indicating a significant effect between the storage duration and spreadability values.

Adhesion Test

For the adhesive strength test, this aims to determine how long the exfoliator gel can adhere to the skin. A gel with good adhesive strength will stay on the skin longer, allowing the desired effects to be achieved without easily detaching (Pratasik et al., 2019). The adhesive strength test results will provide further insight into the durability of the gel formulation on the skin during use.

Table 13. Results of Exfoliator Gel Adhesion Test

	Cycle						
	0	**1**	**2**	**3**	**4**	**5**	**6**
F0	0,69±0,12	0,65±0,07	0,79±0,09	0,85±0,09	1,05±0,15	1,07±0,15	1,17±0,16
F1	0,99±0,18	0,95±0,14	0,90±0,11	1,06±0,13	1,04±0,13	1,05±0,12	1,12±0,10
F2	1,27±0,24	1,06±0,12	1,07±0,09	1,13±0,12	1,25±0,13	1,05±0,09	1,10±0,13
F3	1,13±0,21	1,17±0,11	1,10±0,08	1,10±0,08	1,21±0,12	1,00±0,15	1,06±0,09

Based on the results of the adhesion test during 6 cycles, the exfoliator gel made from sugarcane bagasse showed an adhesion range of 0.65-1.27 seconds. The standard for gel adhesion is >1 second (Irianto

et al., 2020). Therefore, only Formula 0 in cycles 4, 5, and 6 meets the adhesion requirement. Formula 1 meets the requirement in cycles 3, 4, 5, and 6, while Formulas 2 and 3 also meet the requirement. As the concentration of sugarcane bagasse extract increases, the adhesion time decreases because the spreadability increases (Irianto et al., 2020). However, there was instability in the data for all formulas, possibly due to human error, such as delayed starting of the stopwatch during the test.The adhesion test data were analyzed using Kruskal-Wallis, resulting in a significance value of <0.05 (0.000), indicating that there is an influence of varying concentrations of sugarcane bagasse extract on the gel's adhesion. The stability test results indicate that the longer the storage period, the lower and more unstable the adhesion value becomes. The data were also analyzed using Kruskal-Wallis, yielding a significance value of <0.05 (0.000), indicating a significant effect of storage duration on the gel's adhesion.

Table 14. Moisturizing Gel Adhesion Test Results

	Cycle						
	0	**1**	**2**	**3**	**4**	**5**	**6**
F0	0,81±0,34	0,87±0,16	0,64±0,08	0,72±0,09	0,89±0,09	1,07±0,37	0,68±0,02
F1	0,88±0,11	0,42±0,19	0,82±0,31	1,50±0,05	1,33±0,16	1,32±0,08	1,48±0,20
F2	1,51±0,16	1,41±0,03	1,36±0,14	1,40±0,08	1,37±0,05	1,52±0,10	1,32±0,03
F3	1,49±0,16	1,33±0,12	1,35±0,02	1,52±0,02	1,33±0,07	1,35±0,10	1,16±0,01

Based on the results of the adhesion test, the sugarcane bagasse extract gel showed an adhesion range of 0.42 – 1.52 seconds. The required adhesion time for gel preparations is >1 second (Irianto, Purwanto, & Mardan, 2020). The results of the adhesion test for formulas 2 and 3 met the requirement. As the concentration of the extract increases, the adhesion time decreases and the spreadability of the gel increases. The data from the adhesion test were analyzed using Kruskal-Wallis, and the significance value was <0.05 (0.000), indicating that there is an influence of extract concentration variation on the adhesion value. The stability test results for the adhesion showed a significance value of <0.05 (0.034), meaning that there is an influence of storage duration on the adhesion value.

Stability Test

The stability test is conducted to determine the shelf life of a preparation over a specific period. The results of the stability test conducted over 6 cycles can be seen in Table 15.

Table 15. Results of 6 cycle stability test

Exfoliator Gel and Moisturizer Gel Preparation	Stability Test Results
F0 without extract	6 Cycles
F1 extract concentration 1%	6 Cycles
F2 extract concentration 3%	4 Cycles
F3 extract concentration 5%	2 Cycles

Based on the stability test results, the exfoliator gel and moisturizer gel with sugarcane bagasse extract were found to be stable in formula 0 without extract and formula 1 with a 1% sugarcane bagasse extract concentration. However, formula 2 with a 3% sugarcane bagasse extract concentration and formula 3 with a 5% sugarcane bagasse extract concentration were considered unstable as they could not withstand the 6 cycles (Rasyadi, 2021).

IV. CONCLUSION

1. Based on the results of the stability tests on the sugarcane bagasse extract exfoliator gel and moisturizer gel using the cycling test method for 6 cycles, the following conclusions can be made:
2. Sugarcane bagasse has the potential to be used as an active ingredient in exfoliator and moisturizer gel formulations with concentrations of 1%, 3%, and 5%, and exhibits antioxidant activity.
3. The exfoliator gel and moisturizer gel formulations F0 (without sugarcane bagasse extract) and F1 (with 1% sugarcane bagasse extract) produced stable gels that met the requirements for good topical formulations, both before and after the 6-cycle cycling test.
4. The exfoliator gel formulation F2 with 3% sugarcane bagasse extract and F3 with 5% sugarcane bagasse extract were found to be unstable as they could not withstand all 6 cycles.

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