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The Potential of Sugarcane Bagasse (*Saccharum officinarum* L.) as a Basic Ingredient for Making Cosmetics and Its Effectiveness as an Exfoliator and Skin Moisturizer

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ABSTRACT

Sugarcane bagasse (*Saccharum officinarum* L.) contains most of the phenolic compounds including gallic acid, ferulic acid, epicatechin, quercetin, and kaempferol. Various phenolic compounds contained in sugarcane bagasse, especially phenolic acids, have important bioactivity for the cosmetics industry. The aim of this research is to determine the potential of sugarcane bagasse as an active ingredient in cosmetics and its effectiveness as an exfoliator and skin moisturizer. This research method is experimental, using sugarcane bagasse samples with concentrations of 1%, 3% and 5%. The results of phytochemical screening showed that sugarcane bagasse contains phenolic compounds, flavonoids and phytosterols. Based on the research results, sugarcane bagasse exfoliating gel at concentrations of 1%, 3%, and 5% increased skin tone respectively, namely 1.00 ± 0.67; 0.40±0.49; and 0.30 ± 0.39. Sugarcane bagasse moisturizing gel at concentrations of 1%, 3%, and 5% had a percent increase in skin water content, respectively, namely 6.92 ± 11.094; 2.72±10.21; and 3.36 ± 6.49. Based on SPSS analysis, it is known that variations in the concentration of bagasse extract and the time of use have a significant effect on increasing skin tone. Meanwhile, variations in the concentration of bagasse extract did not have a significant effect on increasing skin water content. However, the time of use has a significant effect on the increase in skin water content. Therefore, it can be concluded that sugarcane bagasse extract has the potential to be an active ingredient in making cosmetics and is effective as an exfoliator and skin moisturizer.

1. Introduction

Indonesia is a country where the majority of the population earns their living as farmers. One of Indonesia's abundant agricultural products is sugarcane. The Central Statistics Agency (BPS) recorded that sugarcane production in Indonesia will reach 2.41 million tons in 2022. Of this amount, 32% of sugarcane bagasse is produced. As much as 60% of sugarcane bagasse is used as raw material for boilers, while the remaining 40% has not been utilized optimally because it is considered to have low economic value (Pangestuti, 2012). This is proven by the fact that in the field there is still bagasse remaining stored, and under certain conditions it can even catch fire due to the substances contained in it (Ariningsih, 2014).

Even though it is only a by-product of the sugar production process, bagasse contains bioactive compounds that have potential in cosmetics. Sugarcane bagasse contains free sugars (sucrose, glucose and fructose), starch, wax, amino acids, organic acids and most phenolic compounds (Zheng et al., 2017). Phenolic compounds contained in sugarcane bagasse include gallic acid, ferulic acid, epicatechin, quercetin, and kaempferol. Various phenolic compounds contained in sugarcane bagasse, especially phenolic acids, have important bioactivity for the cosmetics industry, namely antioxidant, antimicrobial and antiaging activity (Carvalho et al., 2021).

Antioxidants have the ability to slow down aging and brighten the skin with the presence of hydrogen electrons which can capture free radicals from UV rays, body metabolism and other external factors (Ria Friatna et al., 2011). The detrimental effects of free radicals can be overcome by using cosmetics that contain antioxidants to moisturize and soothe dry skin (Aryantini et al., 2020). The bioactive compound content in sugarcane bagasse has the potential to be formulated into cosmetic preparations in the form of exfoliating gel and moisturizing gel.

Gel is a semisolid system consisting of a suspension made from small inorganic particles or large organic molecules, penetrated by a liquid (Depkes RI, 2020). Exfoliation is the stage of removing dead skin cells, dust and dirt from the top layer of the skin (Abdassah et al., 2009). The exfoliation stage involves an exfoliator that works to break down the bonds that hold dull and dead skin cells on the surface of the skin. Therefore, exfoliation can make skin clean and healthy and improve skin tone (Packianathan & Kandasamy, 2011). Moisturizer is a preparation used to reduce evaporation or loss of water from the skin (Transepidermal Water Loos) by forming a thin layer of fat on the surface of the skin (Nopita et al., 2022). The term moisturizer describes the addition of water to the skin thereby reducing skin roughness or actively increasing the water content of the skin (Partogi, 2008).

Research conducted by Ratanasumarn & Chitprasert (2020) proves that sugarcane bagasse lignin extract in sunscreen preparations has an SPF value of 8.65 ± 0.21 with maximum protection type (SPF 8-15) thus providing broad spectrum protection against UVA and UVB and has the potential to be used as anti-aging, skin-whitening and sun-protection. Another study by Zhao et al., (2015) reported that sugarcane bagasse extract has antimicrobial activity against pathogenic bacteria such as Salmonella typhimurium and E. coli, with an effective concentration of 2.50 mg/mL, while inhibition of S. aureus was reported with 0.625 mg/mL and 1.25 for L. monocytogenes (Zhao et al., 2015). Research by Sitepu (2013) reported that skin lightening cream from sugarcane bagasse extract with a concentration of 5% showed stability during 12 weeks of storage, did not cause irritation and there was a significant difference in the benefit test. Meanwhile, there is no research that proves the effectiveness of sugarcane bagasse as an exfoliator and moisturizer (Sitepu, 2013)

2. Materials and Methods

2.1. Tools and Materials

The tools used in this research include: glassware, moisture analyzer, mortar and stamper, analytical balance, oven, pH meter, Brookfield viscometer, and water bath. The sample used was sugarcane bagasse (*Saccharum officinarum* L.) taken from Sukoharjo, Central Java. The ingredients used include: 70% methanol, $FeCl_3$, NaOH, HCl, chloroform, H_2SO_4, carbopol, propyl paraben, phenoxyethanol, triethanolamine, propylene glycol, mica powder, essential oil and distilled water.

2.2. Making Sugarcane Bagasse Simplicia

Making simplicia is done by separating the outer and inner parts of the bagasse. Then, weigh the inside of the bagasse and then dry it using an oven at ±40°C until dry and easy to crumble (Zheng, Su, Li, et al., 2017). Once dry, the simplicia is coarsely ground in a blender then stored in a clean and tightly closed container. Then, calculate %LoD using the formula:

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

2.3. Making Sugarcane Bagasse Extract

Sugarcane bagasse extract is made using the soxhletation method with 70% methanol solvent at a temperature of ±60°C and a ratio of 1:60 for 4 hours or 8 cycles or until the cycle droplets are no longer colored (Putra et al., 2022). The simplicia is then replaced with a new one and extracted in the same way until the solvent is concentrated. Once concentrated, the extraction results are evaporated over a water bath at a temperature of 50°C until a thick extract is obtained. Then calculate the % yield using the formula:

$$\%\text{Yield} = \frac{\text{Extract weight}}{\text{Simplicia weight}} \text{x } 100$$

2.4. Scrub Making

The scrub is made using a simple method, which has been coarsely sifted in a blender using a 30 mesh sieve. Then, sifted again using a 50 mesh sieve and the coarse part is taken.

2.5. Extract Evaluation

Organoleptic Test

Organoleptic testing is carried out using the five senses by describing color, smell and consistency as simply and objectively as possible (Depkes RI, 2000).

Water Content and Drying Shrinkage Test

Testing for water content and drying shrinkage is carried out using a moisture analyzer by adjusting the temperature and heating time. Water content requirements for extracts are: ≤10% (Depkes RI, 2000) and drying shrinkage conditions for the extract, namely ≤11% (Depkes RI, 2008).

2.6. Phytochemical Screening

Phenolic: A total of 0.2 g of extract was dissolved in 1 ml of distilled water and then 3-5 drops of 10% $FeCl_3$ were added. The results show positive for phenol if a green to blackish blue color forms (Hanani, 2015). **Flavonoids:** A total of 0.2 g of extract was dissolved in 1 ml of distilled water then added with 1 ml of 10% NaOH and a few drops of concentrated HCl. The results showed positive flavonoids with the disappearance of the yellow color (Shaikh & Patil, 2020). **Phytosterols:** A total of 0.2 g of extract was dissolved in 1 ml of distilled water and then 3-5 drops of concentrated sulfuric acid were added. The results show positive for phytosterols if a golden yellow color forms (Shaikh & Patil, 2020).

2.7. Preparation Formulation

Exfoliating Gel

Exfoliating gel is made by dispersing carbopol in 10x hot distilled water and leaving it for 30 minutes until it swells completely. Then, triethanolamine is added little by little while stirring until homogeneous. Then, propyl paraben is dissolved in propylene glycol and added to the expanded base. After that, add sugarcane bagasse extract and the remaining distilled water. Finally, add the bagasse scrub and essential oil and stir until homogeneous.

Table 1. Exfoliating Gel Formula

Material	Concentration (%)				Function
	F0	F1	F2	F3	
Sugarcane bagasse extract	-	1	3	5	Active substance
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

This formula has been slightly modified from (Putri et al., 2021)

Moisturizing Gel

Making moisturizing gel is done by dispersing carbopol in 10x hot distilled water and leaving it for 30 minutes until it swells completely. Then, triethanolamine is added to the expanded base and stirred until homogeneous. Then, propylene glycol is added little by little while stirring until homogeneous. Next, phenoxyethanol is added and stirred until homogeneous. After that, the bagasse extract was added and stirred until homogeneous. Then, add the tip of a spatula of mica powder which has been dissolved in 5 mL of distilled water and essential oil and stir until homogeneous. Finally, add the remaining distilled water and stir until homogeneous.

Table 2. Moisturizing Gel Formula

Material	Concentration (%)				Function
	F0	F1	F2	F3	
Sugarcane bagasse extract	-	1	3	5	Active substance
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

This formula has been slightly modified from (Okzelia *et al*., 2023)

Description:

qs = quantum satis/to taste
F0 = Formulation without sugarcane bagasse extract
F1 = Formulation with 1% sugarcane bagasse extract
F2 = Formulation with 3% sugarcane bagasse extract
F3 = Formulation with 5% sugarcane bagasse extract

2.8. Gel Evaluation

Organoleptic Test

Organoleptic testing is carried out using the five senses by describing the color, smell and consistency of the preparation (Zainal & Nisa, 2022).

Homogeneity Test

Homogeneity testing was carried out by applying 0.5 g of the preparation to a watch glass. Then observe whether the color is even and whether there are coarse particles in the preparation (Zainal & Nisa, 2022).

pH Test

pH testing is carried out by dipping the pH meter into the preparation. The number shown on the pH meter is the pH of the preparation. The pH requirements for gel preparations are 4.5 – 6.5 (Irianto et al., 2020).

Viscosity Test

Viscosity testing was carried out using a Brookfield viscometer with 4 spindles and a speed of 30 rpm. The test is carried out until the viscosity value is stable. The viscosity requirement for gel preparations is 2,000 – 50,000 cps (Zainal & Nisa, 2022).

Spreadability Test

Spreadability testing was carried out by weighing 0.5 g of the preparation and then placing it in the center of a scaled petri dish. Place the lid of the petri dish upside down on top of the preparation and leave it for 1 minute then measure the diameter of the spread. Then, a load of 50 g -250 g was added at every 1 minute interval and the spreading diameter was measured. The requirement for the spreadability of the gel preparation is 3-5 cm (Zainal & Nisa, 2022).

Adhesion Test

Adhesion strength testing was carried out by weighing 0.5 g of the preparation and then placing it on a glass plate and covering it with another glass plate. Next, a 500 g load was placed for 5 minutes. After that, release the 80 g load and calculate the time needed for the glass plate to come off. The adhesion requirement for the gel preparation is >1 second (Irianto et al., 2020).

Syneresis Test

The syneresis test was carried out by placing 5 g of the preparation in a clear pot and then placing it in a refrigerator at a temperature of ±2-8°C for 24, 48 and 72 hours. Next, the water above the

preparation is separated and the preparation is weighed again. Then, calculate the % syneresis of the preparation using the formula:

$$\%\text{Sineresis} = \frac{\text{Initial weight} - \text{Final weight}}{\text{Initial weight}} \text{x } 100\%$$

The conditions for syneresis of both gels are ≤1% (Banerjee & Bhattacharya, 2011).

Exfoliator Effectiveness Test

Testing the effectiveness of the exfoliator was carried out by measuring the condition of the respondent's skin before and after using the exfoliating gel using skin tone indicator paper. Respondents were asked not to apply topical products such as moisturizer, body lotion, sunscreen and antiaging formulas at the test location one week before and during testing. Testing was carried out on 20 respondents where every 5 respondents used 1 exfoliating gel formula. Testing was carried out for 2 weeks using exfoliating gel 3 times a week. The exfoliating gel was used by rubbing the preparation and leaving it for 15 minutes on the surface of the back of the respondent's hand and then rinsing. Changes in skin color to become brighter indicate that the exfoliating gel has potential as an exfoliator (Paradila et al., 2022).

Moisturizer Effectiveness Test

Testing the effectiveness of the moisturizer was carried out by measuring the water content of the respondent's skin before and after using the moisturizing gel using a skin analyzer. Respondents were asked not to apply topical products such as moisturizer, body lotion, sunscreen and antiaging formulas at the test location one week before and during testing. Testing was carried out on 20 respondents where every 5 respondents used 1 moisturizing gel formula. Testing was carried out for 5 consecutive days. Moisturizing gel was used by applying the preparation to the surface of the back of the respondent's hand and measuring the water content after 6 hours of use. Changes in the skin's water content increase, indicating that the moisturizing gel has the potential to act as a skin moisturizer (Okzelia, 2022).

2.9. Data Analysis

Data analysis was carried out descriptively and using IBM SPSS Statistics 26 software. Organoleptic and homogeneity test analyzes were carried out descriptively. Meanwhile, analysis of pH, viscosity, syneresis, spreadability, adhesiveness and effectiveness tests was carried out using SPSS software. The analysis carried out was normality and homogeneity tests. To see the relationship between treatment groups, a one-way analysis of variance (ANOVA) was carried out if the data was normally distributed and homogeneous. If the data is not normally distributed, a Kruskal-Wallis analysis is performed (Sayuti, 2015).

3. Results and Discussion

Sugarcane bagasse obtained from the Banaran, Grogol, Sukoharjo, Central Java areas is separated into the outer and inner parts. This is because the outside has a hard texture and is difficult to smooth. Sugarcane plants are determined to ensure the correct identity of the plants used. Based on the results of determination No: 019/A.E-I/LAB.BIO/VII/2023, it shows that the bagasse used in this research is from the *Gramineae* family and the species *Saccharum officinarum* L.

From 1,203.89 g of bagasse, 843.12 g of simplicia was obtained with a water content of 8.31% which met the requirements (<10%). Water content >10% will cause enzymatic processes and damage by microbes (Manoi, 2006). Sugarcane bagasse extraction is carried out using the soxhletation method using 70% methanol solvent at a temperature of ±60°C so that it will speed up the extraction process because of the heat and fresh solvent (Putra et al., 2022). Extraction of bagasse is carried out repeatedly until the solvent is concentrated. This aims to achieve solvent efficiency and maximize the compounds extracted.

The extraction results obtained a semi-viscous extract with a dark brown color and a distinctive smell with a yield of 16.44%, a water content of 7.15%, and a drying loss of 8.48%. This shows that the resulting extract meets the requirements for water content (<10%) and drying shrinkage (<11%) (Depkes RI, 2000, 2008). The pH of the extract was tested using a universal pH indicator and obtained a value of 4 which was included in the acid pH category.

Table 3. Phytochemical Screening Results

Compound Classes	Reagent	Results	Note
Phenol	$FeCl_3$ 10%	Blackish green	+
Flavonoids	NaOH 10% + Concentrated HCl	The yellow color disappears after adding concentrated HCl	+
Phytosterols	H_2SO_4	Golden yellow	+

Phytochemical screening was carried out to determine the content of secondary metabolite compounds in sugarcane bagasse extract. Based on the results of phytochemical screening, sugarcane bagasse extract positively contains alkaloids, flavonoids and phytosterols. The results of the phytochemical screening test can be seen in Table 3.

In the exfoliating gel formulation, carbopol 940 is used as a gelling agent, propyl paraben as a preservative, triethanolamine as a gel stabilizer, propylene glycol as a humectant, and essential oil as an odorant. Meanwhile, in moisturizing gel preparations, carbopol 940 is used as a gelling agent, phenoxyethanol as a preservative, triethanolamine as a gel stabilizer, propylene glycol as a humectant, essential oil as a corigen odoris, and mica power as a corigen coloris.

Carbopol 940 is used as a gelling agent because it can produce high viscosity at low concentrations and works effectively in a wide pH range. Triethanolamine is used as a gel stabilizer because it can neutralize carbopol and increase viscosity and produce a clear gel. Propylene glycol is used as a humectant because it can prevent water loss from the preparation so that the gel will be more stable. Phenoxyethanol is used as a preservative because it can reduce microbial activity in the concentration range of 0.5-1.0%. Propyl paraben is used as a preservative because it is effective in reducing microbial activity at pH 4-8 (Sheskey et al., 2017). Essential oil are used as corigen odoris to cover the unpleasant odor of sugarcane bagasse extract. Mica powder is used as a color agent so that the gel has an attractive color.

Table 4. Organoleptic Test Results, Homogeneity, pH, Viscosity, Spreadability and Stickiness of Exfoliating Gel

Evaluation	F0	F1	F2	F3
Organoleptic	White color, smell of grape essential oil, semi-solid consistency	Milk chocolate color, grape essential oil smell, semi-solid consistency	Mocha color, grape essential oil smell, semi-solid consistency	Brown color, smell of grape essential oil, semi-solid consistency
Homogeneity	Homogeneous	Homogeneous	Homogeneous	Homogeneous
pH	4.94 ± 0.33	5.20 ± 0.50	4.96 ± 0.19	4.75 ± 0.03
Viscosity (cPs)	20,171.87 ± 0.75	20,177.32 ± 2.70	19,010.04 ± 965.61	10,443.76 ± 1,293.64
Spreadability (cm)	3.88 ± 0.14	3.66 ± 0.10	3.70 ± 0.17	3.77 ± 0.22
Sticking Power (seconds)	0.80 ± 0.14	2.42 ± 0.86	1.08 ± 0.21	1.30 ± 0.27

Based on the evaluation results of the exfoliating gel, organoleptically all formulas show that there are differences in color and consistency, proportional to the concentration of the extract used. The greater the concentration of bagasse extract used, the browner and runnier the exfoliating gel. The homogeneity test shows that all formulas are homogeneous. A good preparation must have a homogeneous composition, even color and no coarse grains (Garg et al., 2002).

The pH test shows that the sugarcane bagasse exfoliating gel has a pH range of 4.75-5.20. This pH value is within the skin pH range, namely 4.5–6.5. The pH of a preparation that is too acidic will irritate the skin, while the pH of a preparation that is too alkaline will make the skin dry (Irianto et al., 2020). So that all formulas meet the pH requirements for exfoliating gel preparations. The pH test results data were analyzed using Kruskal Wallis and obtained a significance value of >0.05, namely 0.149, which means there was no influence between variations in the concentration of bagasse extract on the pH of the gel preparation.

The viscosity test shows that the sugarcane bagasse exfoliation gel has a viscosity range of 10,443.76–20,177.32 cPs. This viscosity value falls within the gel viscosity range, namely 2,000–50,000 cPs (Zainal & Nisa, 2022). The greater the concentration of bagasse extract, the smaller the viscosity of the preparation because the consistency of the extract is semi-viscous. The viscosity test results data were analyzed using Kruskal Wallis and obtained a significance value of <0.05, namely 0.000, which means that there is an influence between variations in the concentration of bagasse extract on the viscosity of the gel preparation.

The spreadability test shows that the sugarcane bagasse exfoliation gel has a spreadability range of 3.66-3.88 cm. The spreadability value is within the gel spreadability range, namely 3-5 cm (Zainal & Nisa, 2022). A gel that has good dispersing power will provide good distribution of medicinal ingredients so that the effects are more optimal (Naibaho et al., 2013). Spreadability is closely related to viscosity. The smaller the viscosity, the greater the spreadability of a dosage form (Sugihartini et al., 2020). Data from the spreadability test results were analyzed using Kruskal Wallis and a significance value of >0.05 was obtained, namely 0.068, which means there was no influence between variations in the concentration of bagasse extract on the spreadability of the gel preparation.

The adhesion test shows that the sugarcane bagasse exfoliating gel has an adhesion range of 0.80-2.42 seconds. The adhesion requirement for the gel preparation is >1 second (Irianto et al., 2020). So those that meet the adhesive power requirements are formulas 1, 2, and 3. The greater the concentration of bagasse extract, the smaller the adhesive power because the spreadability is greater (Irianto *et al*., 2020). However, there was data instability in all formulas which was possibly caused by human error, namely turning on the stopwatch too late during testing. Data from the adhesion test results were analyzed using Kruskal Wallis and obtained a significance value of <0.05, namely 0.000, which means that there is an influence between variations in the concentration of bagasse extract on the adhesion of the exfoliating gel preparation. The results of organoleptic tests, homogeneity, pH, viscosity, spreadability and stickiness of the exfoliating gel can be seen in Table 4.

Table 5. Exfoliating Gel Syneresis Test Results

Formulas	Syneresis hour to (%)			Average
	24	48	72	
F0	18.24 ± 0.03	34.00 ± 0.04	40.16 ± 0.06	30.80 ± 11.30
F1	5.09 ± 0.01	6.49 ± 0.01	7.27 ± 0.01	6.28 ± 1.10
F2	8.18 ± 0.03	8.82 ± 0.03	9.33 ± 0.03	8.78 ± 0.58
F3	2.62 ± 0.01	4.00 ± 0.01	4.73 ± 0.01	4.37 ± 0.52

The syneresis test shows that the sugarcane bagasse exfoliation gel has a syneresis range of 4.37-30.80%. The requirement for syneresis of gel preparations is <1% (Banerjee & Bhattacharya, 2011). So all formulas do not meet the syneresis requirements for gel preparations. The occurrence of syneresis is a sign that the preparation is physically unstable (Megawati et al., 2019). The lower the viscosity, the weaker the strength in binding water so that the gel easily experiences syneresis (Qolsum et al., 2020). However, from the test results, syneresis was not inversely proportional to viscosity and data instability occurred which was possibly caused by weighing the gel in the container while it was still cold. According to Utami, (2018) Temperature affects the reading value on a digital scale. Data from the syneresis test were analyzed using Kruskal Wallis and obtained a significance value of <0.05, namely 0.000 for the influence test on the formula and 0.042 for the influence test on storage time. So there is an influence between variations in the concentration of bagasse extract and storage time on the syneresis of exfoliating gel preparations. The results of the exfoliation gel syneresis test can be seen in Table 5.

Table 6. Exfoliator Effectiveness Test Results

Formulas	Increase in Skin Tone						Average
	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	
F0	0.20 ± 0.40	0.40 ± 0.50	0.60 ± 0.50	0.80 ± 0.40	1.60 ± 0.50	1.60 ± 0.50	0.87 ± 0.60
F1	0.20 ± 0.40	0.40 ± 0.50	0.80 ± 0.40	1.20 ± 0.40	1.40 ± 0.50	2.00 ± 1.00	1.00 ± 0.67
F2	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.40 ± 0.50	1.00 ± 0.00	1.00 ±0.00	0.40 ± 0.49
F3	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.20 ± 0.40	0.80 ± 0.40	0.80 ± 0.40	0.30 ± 0.39

The effectiveness test shows that the sugarcane bagasse exfoliating gel has an increase in skin tone during 6 days of use in the range of 0.30 – 1.00. The best formula that has the highest increase in skin tone is formula 1, followed by formula 0, formula 2, and formula 3.The exfoliation stage involves an exfoliator that works to break down the bonds that hold dull and dead skin cells on the surface of the skin. So exfoliation can improve skin tone (Packianathan & Kandasamy, 2011). An increase in skin tone that becomes brighter indicates that sugarcane bagasse exfoliating gel has the potential to act as an exfoliator. Increasing the concentration of sugarcane bagasse extract apparently reduces the potential of the preparation as an exfoliator to brighten the skin. The data from the effectiveness test was tested using Kruskal Wallis and obtained a significance result of <0.05, namely 0.000 for the effect test on the formula and 0.000 for the effect test on days of use. So there is an influence between variations in the concentration of bagasse extract and days of use on the effectiveness of exfoliating gel preparations. The results of the exfoliator effectiveness test can be seen in Table 6.

Table 7. Organoleptic Test Results, Homogeneity, pH, Viscosity, Spreadability and Stickiness of Moisturizing Gel

Evaluation	F0	F1	F2	F3
Organoleptic	White color, smell of grape essential oil, semi-solid consistency	Beige color, smell of grape essential oil, semi-solid consistency	Milk chocolate color, grape essential oil smell, semi-solid consistency	Latte color, grape essential oil smell, semi-solid consistency
Homogeneity	Homogeneous	Homogeneous	Homogeneous	Homogeneous
pH	5.16 ± 0.33	4.47 ± 0.22	4.30 ± 0.04	4.80 ± 0.09
Viscosity (cPs)	20,173.01 ± 3.84	20,176.38 ± 3.47	20,172.24 ± 1.77	13,636.92 ± 1,106.59
Spreadability (cm)	3.57 ± 0.12	3.41 ± 0.20	3.65 ± 0.19	3.52 ± 0.21
Sticking Power (seconds)	1.44 ± 0.94	1.82 ± 1.35	0.60 ± 0.17	0.62 ± 0.28

Based on the results of the evaluation of the moisturizing gel, organoleptically all formulas showed that there were differences in color and consistency, proportional to the concentration of the extract used. The greater the concentration of bagasse extract used, the browner and runnier the exfoliating gel. The homogeneity test shows that all formulas are homogeneous. A good preparation must have a homogeneous composition, even color and no coarse grains (Garg et al., 2002).

The pH test shows that the bagasse moisturizing gel has a pH range of 4.30-5.16. Increasing the concentration of sugarcane bagasse extract apparently reduces the pH value of the moisturizing gel preparation. This is because the pH value of the bagasse extract is acidic. However, in formula 3 there was an increase in pH which may have been caused by human error, namely the pH electrode had not been washed thoroughly after previous use. However, the formula pH values 0, 1, and 3 fall within the skin pH range, namely 4.5 – 6.5. The pH of a preparation that is too acidic will irritate the skin, while the pH of a preparation that is too alkaline will make the skin dry (Irianto et al., 2020). The pH test results data were analyzed using Kruskal Wallis and obtained a significance value of <0.05, namely 0.000, which means that there is an influence between variations in the concentration of bagasse extract on the pH of the moisturizing gel preparation.

The viscosity test shows that the bagasse moisturizing gel has a viscosity range of 13,636.92 - 20,176.38 cPs. This viscosity value falls within the gel viscosity range, namely 2,000-50,000 cPs (Zainal & Nisa, 2022). The greater the concentration of bagasse extract, the smaller the viscosity of the preparation because the consistency of the extract is semi-viscous. The viscosity test results data were analyzed using Kruskal Wallis and obtained a significance value of <0.05, namely 0.000, which means that there is an influence between variations in the concentration of bagasse extract on the viscosity of the moisturizing gel preparation.

The spreadability test shows that the bagasse moisturizing gel has a spreadability range of 3.41-3.65 cm. The spreadability value is within the gel spreadability range, namely 3-5 cm (Zainal & Nisa, 2022). A gel that has good dispersing power will provide good distribution of medicinal ingredients so that the effects are more optimal (Naibaho et al., 2013). Spreadability is closely related to viscosity. The smaller the viscosity, the greater the spreadability of a dosage form (Sugihartini et al., 2020).

However, data instability occurred which may have been caused by human errors, namely inaccuracies in calculating the diameter of the gel spread. The data from the spreadability test results were analyzed using Kruskal Wallis and a significance value of >0.05 was obtained, namely 0.055, which means that there was no influence between variations in the concentration of bagasse extract on the spreadability of the moisturizing gel preparation.

The adhesion test shows that the bagasse moisturizing gel has an adhesion range of 0.60-1.82 seconds. The adhesion requirement for the gel preparation is >1 second (Irianto et al., 2020). So what meets the adhesion requirements are formulas 0 and 1. The greater the concentration of bagasse extract, the smaller the adhesion power because the spreadability is greater *(*Irianto et al., 2020). However, there was data instability which was possibly caused by human error, namely turning on the stopwatch too late during testing. Data from the adhesion test results were analyzed using Kruskal Wallis and a significance value of <0.05 was obtained, namely 0.000, which means that there was an influence of differences in the concentration of sugarcane amps extract on the adhesion of the moisturizing gel preparation. The results of organoleptic tests, homogeneity, pH, viscosity, spreadability and adhesiveness of the moisturizing gel can be seen in Table 7.

Table 8. Moisturizing Gel Syneresis Test Results

Formulas	Syneresis hour to (%)			Average
	24	48	72	
F0	18.96 ± 1.64	35.05 ± 0.85	42.29 ± 1.23	32.10 ± 10.40
F1	3.16 ± 0.46	3.90 ± 0.99	5.44 ± 1.07	4.39 ± 1.21
F2	3.80 ± 1.45	5.22 ± 1.43	6.04 ± 0.97	6.70 ± 5.11
F3	1.13 ± 1.01	2.18 ± 0.80	3.18 ± 0.83	2.05 ± 1.24

The syneresis test shows that the sugarcane bagasse exfoliation gel has a syneresis range of 2.05-32.10%. The requirement for syneresis of gel preparations is <1% (Banerjee & Bhattacharya, 2011). So all formulas do not meet the syneresis requirements for gel preparations. The occurrence of syneresis is a sign that the preparation is physically unstable (Megawati et al., 2019). The lower the viscosity, the weaker the strength in binding water so that the gel easily experiences syneresis (Qolsum et al., 2020). However, from the test results, syneresis was not inversely proportional to viscosity and data instability occurred which was possibly caused by weighing the gel in the container while it was still cold. According to Utami, (2018) Temperature affects the reading value on a digital scale. Data from the syneresis test were analyzed using Kruskal Wallis and obtained a significance value of <0.05, namely 0.000 for the influence test on the formula and 0.004 for the influence test on storage time. So there is an influence between variations in the concentration of bagasse extract and storage time on the syneresis of moisturizing gel preparations. The results of the moisturizing gel syneresis test can be seen in Table 8.

The effectiveness test showed that sugarcane bagasse moisturizing gel had the highest percentage increase in water content in formula 1, followed by formulas 0, 2, and 3.Moisturizers work by adding water to the skin thereby reducing skin roughness or actively increasing water content in the skin (Partogi, 2008). An increase in the percentage of skin water content indicates that the bagasse moisturizing gel has potential as a moisturizer. Increasing the concentration of bagasse extract apparently reduces the potential of the preparation as a skin moisturizer. The data from the effectiveness test were tested using Kruskal Wallis and the significance results were obtained, namely 0.504 for the effect test on the formula and 0.020 for the effect test on days of use. So there is no effect of differences in the concentration of bagasse extract on the effectiveness of the moisturizer. However, there is an influence on the day of use on the effectiveness of the moisturizer. The results of the moisturizer effectiveness test can be seen in Table 9. Based on research results, sugarcane bagasse has been proven to have potential as a basic ingredient for making cosmetics and is effective as an exfoliator and moisturizer. Sugarcane bagasse offers more natural, organic and environmentally friendly benefits. Apart from that, through further research and innovation regarding the use of sugarcane bagasse, superior and high-quality cosmetic formulations can be created in the future.

Table 9. Moisturizing Effectiveness Test Results

Formulas	Increase in Water Content (%)					Average
	Day 1	Day 2	Day 3	Day 4	Day 5	
F0	9.80 ± 3.56	4.80 ± 5.12	4.00 ± 1.41	0.40 ± 4.56	5.40 ± 3.13	4.88 ± 4.63
F1	16.00 ± 19.96	9.80 ± 9.83	1.00 ± 3.29	2.80 ± 4.66	5.00 ± 5.00	6.92 ± 11.094
F2	8.00 ± 11.51	0.40 ± 8.47	-8.20 ± 10.08	10.00 ± 6.78	3.40 ± 3.97	2.72 ± 10.21
F3	7.40 ± 5.18	1.00 ± 7.48	5.40 ± 8.19	-0.60 ± 5.32	3.60 ± 2.41	3.36 ± 6.49

4. Conclusion

Based on the results of research conducted on exfoliating gel and moisturizing gel preparations from sugarcane bagasse extract (*Saccharum officinarum* L.), it can be concluded that, Sugarcane bagasse has the potential to be an active ingredient in exfoliating gel and moisturizing gel preparations. The best concentration of sugarcane bagasse extract for the physical properties of the exfoliating gel and the effectiveness of the exfoliator is formula 1 with an extract concentration of 1%. With a pH value of 5.20, viscosity of 20,177.32 cPs, spreadability of 3.66 cm, adhesion of 2.42 seconds, and an increase in skin tone 1 level brighter. The best concentration of sugarcane bagasse extract for the physical properties of the moisturizing gel and the effectiveness of the moisturizer is formula 1 with an extract concentration of 1%. With a pH value of 4.47, viscosity of 20,176.38 cPs, spreadability of 3.41 cm, adhesion of 1.82 seconds, and increase in water content of 6.69%.

Author Contributions

The research was thought of and designed by Iin Suhesti. Iin Suhesti carried out every data analysis. The results were evaluated by Fauziyah Oktofiani and Aprillia Nurul Janah and revised by Iin Suhesti and Yunita Dian Permata Sari. Writing the manuscript is Iin Suhesti. Iin Suhesti supervised the manuscript. The final manuscript was read and approved by all authors.

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Competing Interests

The authors declare no conflict of interest.

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