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Article

The Potential of Sugarcane Bagasse Lignin as Biosurfactant for Used Cooking Soap Enhanced with Lime Peel Extract to Optimize Local Waste in Support of SDGs 2030

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ABSTRACT

The need for sugar production continues to grow every year along with the increasing population in Indonesia. Sugar cane (*Saccaharum officinarum*) is a plantation crop that can be processed into sugar. One of the large sugar cane centres in East Java is in the Tebu Ireng area, Jombang. According to BPS East Java in the last one year in 2021, the production of sugar cane produced in the area reached 59,120 tonnes, so the high production of sugar cane will produce a lot of bagasse waste. While lime peel is a waste with bioactive compounds that can still be utilised. Making soap made from used cooking oil fortified with lime peel extract is expected to have an impact on the environment in the form of waste reduction. In general, soap uses synthetic chemical surfactants which certainly have a negative impact on the environment. Therefore, it is necessary to develop natural surfactants, one of which is lignin-based. Sugarcane bagasse contains 24.2% lignin which has the potential to be developed as a biosurfactant to improve environmentally friendly soap made from used cooking oil and lime peel. Based on this, this research aims to process bagasse waste into soap biosurfactants to optimise the potential of local waste in order to support the SDGs 2030 programme. This research is an experimental study that is analysed descriptively based on formulation tests with parameters of the physical properties of soap. Based on the results of the analysis, the addition of bagasse lignin biosurfactant affects the physical properties of orange peel extract-fortified used cooking soap.

INTRODUCTION

Sugarcane (*Saccaharum officinarum L.*) is a plantation crop that can be processed as the main raw material for making sugar. The Central Bureau of Statistics (BPS) noted that the total area of sugarcane plantations in Indonesia reached 449,008 hectares in 2021. The need for sugar production continues to grow every year in line with the increasing population in Indonesia. National sugar production in 2021 amounted to 2.35 million tons until it increased in 2022 to reach 6.48 million tons. One of the largest sugarcane plantation centers in East Java is Tebu Ireng, Jombang. In 2020 to 2021, Jombang district experienced an increase in sugarcane production of 8,095 tons from the initial total production of 51,025 tons to 59,120 tons (BPS Jatim, 2021). The high production of cane sugar will produce a lot of bagasse waste at Tebu Ireng, Jombang, East Java. Bagasse waste is a by-product of the sugar processing process that is usually just thrown away and burned. If not handled properly it will be very concerning for the surrounding environment, for example burning bagasse will cause air pollution. On the other hand, bagasse has potential and more value if utilized optimally.

The content of bagasse based on chemical analysis includes 48-52% water, 2.5 ± 6% sugar, 44 - 48% fiber, 3.28% ash, 1.81% juice, 27.97% pentosan, 3.01% SiO_2, 40-50% cellulose, 23-35% hemicellulose and 18-24% lignin (Wulandari, 2018). Lignin is a polymeric organic compound that is abundant and important in the plant world besides cellulose. Lignin is found inside and outside the cell wall and causes woody plants to be hard and stiff. Lignin has a structural framework containing several units, namely, aromatic, phenolic hydroxyl, hydroxyl alcohol, and methoxy. The existence of these functional groups provides opportunities for lignin to undergo oxidation, reduction, hydrolysis, acylation, amination and other reactions. Lignin contained in bagasse can be utilized as a biosurfactant (Wulandari, 2018).

The manufacture of surfactants can be done through two reactions, namely hydrolysis and sulfonation. Hydrolysis is the reaction of breaking the lignin/lignosulfonate molecule (polymer) into smaller molecules. With this molecular breakdown, the lignosulfonate can dissolve in water. Meanwhile, sulfonation is a reaction between bisulfite ions and lignin molecules (Sukmawati, 2021). Surfactants themselves are one of the main components in household soaps and detergents. Surfactants in soap function as active ingredients that can reduce the surface tension between water and oil. So far, the surfactants used in soap are chemical or synthetic surfactants which have a negative impact on the environment. Therefore, by utilizing bagasse lignin can be used as a natural biosurfactant as a substitute for chemical surfactants so that it is more environmentally friendly.

Sugarcane bagasse lignin biosurfactant can be applied to soap made from used cooking oil with lime extract fortification. Used cooking oil is the residual oil from frying that has been used repeatedly. The use of cooking oil more than once can cause the fatty acids contained will be increasingly saturated and unhealthy if consumed by the community. So that used cooking oil waste is common as household waste. Therefore, in order not to become waste, used cooking oil can be utilized in making soap. The development of used cooking oil soap has been done by many previous researchers. In this study, innovation was carried out by adding biosurfactants from bagasse lignin and also fortified using lime peel extract.

Lime is a citrus that is often used as a drink and is often sold in food stalls. Of course, this produces waste in the form of lime peels that have not been maximally utilized. Lime peel contains flavedo and albedo. Flavedo contains chloroplasts, carotenoids, and oil glands (where essential oils accumulate). While albedo contains a lot of cellulose, hemicellulose, lignin, pectate and hesperiodes such as hesperin and nagirin and limonin compounds that are more than flavedo (Iryani, 2018). Lime peel can be extracted to produce lime peel essential oil, which can be developed into an essential oil-based liquid dish soap product.

Therefore, in the manufacture of used cooking oil soap, lime extract is added as an antimicrobial. Making soap made from used cooking oil fortified with lime peel extract is expected to have an impact on the environment in the form of reducing waste and air pollution. Based on this background, this study aims to determine how to process bagasse waste into biosurfactants and determine the effect of the addition of bagasse lignin biosurfactants on the physical properties of used cooking oil soap fortified with lime peel extract. To optimize the potential of local waste in order to support the SDGs 2030 program.

METHODS

This research was conducted from Tuesday, January 17, 2023 to Tuesday, February 7, 2023 at the Science Laboratory of the Ponorogo State Islamic Institute. This research was conducted by direct experimentation and the research data was analyzed descriptively qualitatively supported by literature studies. The method in writing this article uses a qualitative approach with an explanatory descriptive model that intends to provide a detailed description related to the making of used cooking oil soap fortified with lime peel and bagasse lignin as a natural surfactant. The tools used in this soap making research are a glass jar, evaporation cup, electric stove, electric centrifuge, blender, stirrer, thermometer, pipette, funnel, waterbath, mortar and pestle, sieve, cloth sieve, universal indicator paper, scales, scissors, mixer, ruler and stopwatch. The materials used are bagasse, lime peel, distilled water, KOH, NaOH, activated carbon, NaCl, dye, used cooking oil, ethanol, methanol, sodium bisulfate, HCL, fhenolhtalein, Mg powder, sulfuric acid, ferric chloride 5%.

RESULTS AND DISCUSSION

Soap is one of the cleaning agents that is commonly used by communities such as restaurants, hotels, industries, mosques and especially household environments. The use of soap as an auxiliary tool for washing activities on the other hand the remaining washing water containing detergents can cause environmental pollution. Soap containing active ingredients such as ABS or LAS surfactants derived from petroleum can have a negative impact on the environment and living things because they are difficult to decompose by microorganisms and can pollute the environment (Isma, 2020). Some soap products circulating in the community generally contain artificial surfactants in helping to remove oil, stains or dirt that stick and make it easier to remove.

Surfactants generally contain active ingredients that can pollute the environment, such as used soap wash water that flows into settlements, rice fields, and waters. Efforts to overcome the environmental pollution that occurs can use natural surfactant alternatives (biosurfactants). Biosurfactants can be found from surrounding natural materials that contain surfactant properties, namely saponins which also function as foam producers. Natural materials that can function as biosurfactants include bagasse waste. *Bagasse* contains 18-24% lignin.

Lignin content can be used in the process of making natural surfactants. Making biosurfactants from bagasse lignin can go through a sulfonation process to produce lignosulfonates that have an amphipathic structure. In addition to biosurfactants made from bagasse lignin, in the making of used cooking oil soap in this study, lime peel extract was also added. The following are the steps in making soap from used cooking oil fortified with lime peel and sugar cane bagasse lignin as a natural surfactant is as follows:

a. Purification of used cooking oil

The refining of used cooking oil uses the same method as in the research of Arlofa, et. all in his research entitled Making Solid Soap from Used Cooking Oil (Arlofa, 2021).There are three stages, the first, Despicing (seasoning removal), namely the seasoning removal process is carried out by mixing used cooking oil and distilled water in a ratio of 1: 1, then heated using a waterbath with a temperature of 100 ° C. Heating is carried out until the distilled water remains half. Heating is carried out until the condition of the distilled water remains half. After that, the used cooking oil is filtered using a cloth filter.Second, Neutralization, namely the neutralization process is carried out by mixing the results of the oil that has finished despicing with NaOH. NaOH used in the neutralization process is 15% NaOH with a ratio of NaOH and oil 40: 3. NaOH is added after the oil reaches a temperature of 40°C. Then stirred until two layers of different colors were formed. After forming 2 layers, the oil is filtered using a cloth. Third, bleaching is the last process of refining used cooking oil. This process is done by mixing oil and activated charcoal. The ratio of oil and activated charcoal is 20: 1 (oil in units of ml, activated charcoal in units of grams).

b. Making used cooking oil soap

Used cooking oil that has undergone a purification process will then be processed into liquid soap with the following steps: First mix the refined used cooking oil with 60% KOH (30 grams/20 ml) in a ratio of 7.5: Then, stirring the mixture of oil and KOH using a mixer until it turns thick like soap, stirring time ± 3 minutes at low speed. Next, mix the soap base with distilled water which has been given a dye with the ratio of soap base and water is 1: 2 (gram / ml). Then mixed using a mixer for ± 1 minute at low speed. Finally, the mixture of soap and distilled water is added with NaCl solution with the ratio of NaCl and distilled water is 1: 4 (gram/ml), the mixture was stirred using a mixer for ± 30 seconds at low speed. The purpose of adding NaCl is to accelerate the thickening process of liquid soap.

c. The process of making bagasse lignin as a biosurfactant for used cooking liquid soap

First, the separation of lignin from bagasse (Delignification) is carried out on bagasse that has been dried, the dried bagasse is cut into small pieces and mashed using a blender until it reaches ± 80 mesh. The mashed bagasse was then cooked using 10% NaOH in a ratio of 1:15 (gram/ml). Cooking was carried out at 90°C for 5 hours. The ratio of bagasse powder and NaOH, NaOH content, time, and temperature were obtained after studying various references and development was carried out according to the results that had been obtained from various previous experiments. After the cooking of bagasse powder and NaOH was complete, it was filtered and the liquid was taken, which was then titrated using concentrated sulfuric acid and distilled water until it reached pH 2. After the pH reached 2, it was allowed to stand for ± 10 hours until a precipitate appeared under the glass jar. To take the existing precipitate, filtering was carried out using an Electric centrifuge with a speed of 1000 Rpm. The filtered precipitate was then dried in the sun. The dried precipitate was then ground to form a powder. The resulting brown powder is what is called lignin.

Second, Sulfonation of Lignin. Lignin in the form of flour from the previous process is put into a round-neck flask of 250 ml size as much as 2 grams with distilled water added as much as 60 ml. Then add Sodium Metabisulfite as much as 1.2 grams which is put into a round-neck flask and adjust the pH of the suspension solution to pH 7 by adding NaOH little by little. The mixture was then heated in a waterbath at 95°C for 3.5 hours. Control the temperature using a thermometer, adding distilled water little by little if there is an increase in temperature of more than 95°C. Third, purification of Lignin Sulfonation. The sulfonation results were then distilled to evaporate the water still contained in the sulfonation results at 100°C until a concentrated solution was obtained. The distilled concentrated solution is then filtered with filter paper. The result of this stage is a filtrate in the form of Sodium lignosulfonate which still contains lignin and sodium bisulfite. The filtrate obtained is then added to methanol and then shaken vigorously until a bisulfite precipitate is obtained and filtered again using an Electric centrifuge at 1000 Rpm. The filtrate precipitate obtained is then dried in the sun until sodium lignosulfonate is obtained and converted into lignin powder.

d. The process of making lime peel extract

To make lime peel extract using the maceration technique, first the lime peel is dried until completely dry and crushed using a blender. The lime peel powder is then soaked in ethanol until everything is completely submerged and stirred for 10 minutes. The soaked lime peel powder is left for 24 hours, then filtered. The filter results are then evaporated using an evaporation cup in a water bath until a precipitate forms and thickens. The thickened sediment is then dried in the sun until dry.

e. Alkaline free test process

After the soap has been made, several tests need to be carried out, one of which is the alkali test. Alkaline testing is carried out by adding 5 grams of soap without & with biosurfactant dissolved in the PP indicator liquid and 100 ml of neutral alcohol. After that, it is heated for 30 minutes, if the resulting color is still the same after heating, so that the color changes to red, titration must be carried out with 0.1 M KOH. The way to calculate the free alkali content in soap is using the following formula:

$$\text{Free Alkali Level (\%)} = \frac{V \times N \times BM}{M \times 1000} \times 100\%$$

Information :
V = HCl Titration Volume (ml)
N = Normality of HCl (0.1 N)
BM = Molecular Weight of Lauric Acid (200)
M = Weight of Soap (grams)

f. Foam durability test process

Foam stability testing was carried out by dissolving 1 gram of soap from each formula and control into 5 ml of distilled water in each test tube. After that, it was shaken together for the same time, in this study it was shaken for 1 minute. After that, the height was calculated after leaving it for 10, 20 and 30 minutes. To calculate foam stability, you can use the following formula:

$$\text{Foam Test} = \frac{\textit{Final Foam Height}}{\textit{Initial Foam Height}} \times 100\%$$

g. pH test process

pH testing is carried out by inserting universal indicator paper into each soap formula. After that, the colors are equalized to determine the pH.

h. Test active compounds

Flavoid compounds can be identified by changing the color of the lime extract solution with the addition of HCl and Mg powder which produces an orange color. Phenolic compounds can be identified by changing the color of the lime extract solution with the addition of 5% $FeCl_3$, producing a bluish or purple color. Meanwhile, saponin compounds can be identified by the appearance of foam in the lime extract solution with the addition of distilled water and shaking for 1 minute.

From the soap testing procedure above, the test results will be discussed below. The addition of lime peel extract contains flavonoid, phenol and saponin compounds that function as antimicrobials. Flavonoids, phenols, and saponins contained in lime peel extract in previous studies have been shown to inhibit bacterial growth based on variations in concentration, it can be seen that the difference in the content of antibacterial substances contained.

Table 1. Test for active compounds in lime peel extract

Type of Bioactive Compound Content Test	Treatment	Condition Before	After Condition	Description
Flavonoids	HCl + Mg powder	Yellowish Green	Oren	+
Phenol	5%	Yellowish Green	Bluish/Purple	+
Saponins	Distilled water and shaking	No foam	Foaming	+

Based on the test results in this study, it is proven that lime peel extract contains flavonoids, phenols, and saponins. The colour change that occurs in flavonoid and phenol testing occurs due to the formation of flavilium salts (Anggraini, 2021). The saponin test, which originally had no foam after adding distilled water and shaking, immediately appeared foam, indicating that there was saponin content in the lime peel extract. So that the used cooking liquid soap also has a good foam from the saponin content of the lime peel extract. The presence of flavonoids and phenols that contain antioxidants and antimicrobials can add value to the used cooking liquid soap. Therefore, the addition of lime peel extract and bagasse lignin biosurfactant to the used cooking liquid soap can change the physical and chemical properties of the soap. The following are the different characteristics of used cooking liquid soap:

Table 2. Comparison of physical characteristics of used cooking liquid soap

Characteristics	Without biosurfactant and lime extract (Soap + 5ml distilled water)	With biosurfactant and lime extract (Soap + Lignin 0.05 gram + (Lime peel extract 0.5 gram + Solvent 5 ml))
Colour	Tosca green	Light green
Smell	Smells of oil	Extract odour
Foam	A little	Many
Texture	Viscous	Liquid

Figure 1. Soap Colour Difference

In addition to observations on the physical properties of the soap, the following parameters were tested:

a. pH test

Based on the results of the pH test of liquid soap from used cooking oil with and without the addition of biosurfactants and lime peel extracts, it is 10 and 11. The following is a graph of the difference in pH of used cooking oil liquid soap:

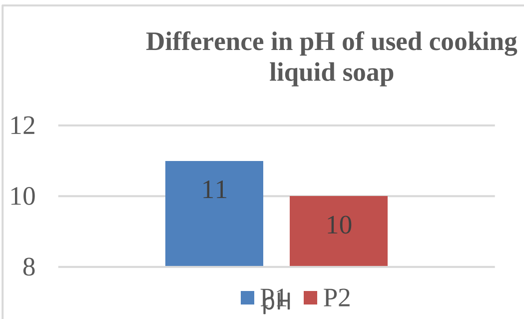

Figure 2. pH difference of used cooking liquid soap

The degree of acidity or pH serves to express the level of basicity of a solution, one of which is soap. Good soap pH standards based on SNI No.06-4085-1996 range from 8-11 (Anggraini, 2021). So that used cooking oil soap with or without the addition of biosurfactants and lime peel extract is in accordance with SNI standards. Liquid soap that is not adjusted by the pH of the skin will cause skin problems, one of which is skin irritation. The skin has the capacity to resist products that have a pH of 8-10.8 (Dewi, 2021). Therefore, in terms of pH, used cooking oil liquid soap with the addition of biosurfactants and lime peel extract which has a pH of 10 is better than soap without any addition which has a pH of 11. The difference in ph in soap with added surfactants is due to the reaction between surfactants and soap, causing the ph of the soap to rise.

b. Free Alkali Test

	P1	P2
HCl Titration Volume (ml)	4,5	2,5
Free Alkali Content (%)	0,02%	0,01%

Figure 3. The difference in the free alkali content of the used cooking liquid soap

The free fatty acid or free alkali test aims to determine the free fatty acids that are in the soap sample, but are not bound as sodium or triglyceride (mineral fat) compounds. While free alkali shows the amount of alkali in soap that is not bound as a compound (Rinaldi, 2021). The free alkali test is carried out to determine the presence or absence of free alkali in liquid soap. According to SNI, the maximum free alkali in a liquid soap preparation is 0.1% (Persada, 2020).

Tests carried out on soap formula 1 (P1) required 4.5 ml of HCl for titration. While in soap formula 2 (P2) 2.5 ml of HCl is required. According to SNI, the maximum free alkali in a liquid soap preparation is 0.1% (Hutauruk, 2020). Based on the research, the free alkali content obtained in each soap P1 = 0.018% and P2 = 0.010%. This shows that the used cooking soap is proven to be in accordance with the standards set by SNI. In addition, it can also be concluded that the lower the percentage of free alkali content in the soap, the better the soap because the amount of alkali used is closely related to the pH level of the soap produced. The quality of soap is good if the free alkali contained in it is in low quantities, so that the resulting pH is also in accordance with the pH of the skin (Sriwening, 2022). Therefore, P2 soap with the addition of lime peel extract and bagasse lignin biosurfactant is better than P1 soap without any addition.

c. Foam Stability Test

Foam stability testing aims to determine the foam resistance contained in the soap in each formula. The following are the results of the foam stability test calculation on each soap formula:

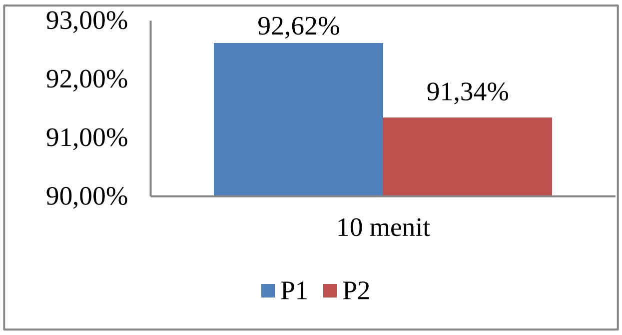

Figure 4. Differences in foam stability

Description: Data taken based on 3 repetitions

Foam stability is a foam resistance to maintain the size or rupture of the film layer of foam bubbles. According to previous research, it is stated that the stability of soap foam meets the standard if shaken for 10 minutes the percentage is at 60-100% (Rosmainar, 2022). The more and more stable the foam on the soap, the more people are interested in using the soap. From the research, it was found that the stability of used cooking liquid soap with the addition of lime peel extract and bagasse lignin biosurfactant was 91.34%. So that the used cooking liquid soap with the addition of lime peel extract and bagasse lignin biosurfactant has met the standard. In addition, it can be enjoyed by users because it has high foam stability. So that this soap can meet the SDGs 2030, because it is in great demand by users.

d. Organoleptic Test

Limited organoleptic testing was conducted by observing texture, aroma, and colour using the senses of sight and smell. This test assesses the panellists' liking of used cooking oil soap with added biosurfactants and without biosurfactants. This organoleptic test was conducted by 15 untrained panelists. The following table shows the results of organoleptic testing on 15 untrained panellists.

Table 3. Organoleptic test results of non-biosurfactant soap

Non-biosurfactant soap (P1)				
Variables	Favourability Level			
	Liked very much	Like	Regular	Dislike
Texture	0	6	7	2
Aroma	0	8	7	0
Colour	0	2	5	8
Total Value		48	38	10
Interpretation		Regular		96

Table 4. Organoleptic test results of biosurfactant soap

Soap with biosurfactant (P2)				
Variables	Favourability Level			
	Liked very much	Like	Regular	Dislike
Texture	6	5	3	1
Aroma	4	9	2	0
Colour	0	9	6	0
Total Value	40	69	22	1
Interpretation		Like		132

Table 5. Interpretation of organoleptic results

Total Value	Interpretation
45≤ ST≤ 78.5	Dislike
78.5≤ ST≤ 112.5	Regular
112.5≤ ST≤ 146.25	Like
146.25≤ ST≤ 180	Liked very much

Table 3 illustrates the level of public liking for non-biosurfactant soap is quite good in terms of texture, colour, and aroma (Fuadah, 2022). The overall liking score of 15 panellists was 96. This shows that the level of acceptance and liking of panellists for non-biosurfactant soap is in the usual category. Meanwhile, table 4 can illustrate the level of public liking for used cooking oil soap with biosurfactants is very good in terms of texture, colour, and aroma. The overall liking value of 15 panellists is 132.

The colour produced by biosurfactant soap has a more attractive colour because it is light green and lighter than soap without biosurfactant. The aroma of used cooking oil in biosurfactant soap has been minimised by the aroma produced from lime peel extract and the texture of this soap is more liquid than soap without biosurfactant. This shows that the level of acceptance and liking of panellists towards used cooking oil soap with biosurfactants is in the category of liking and can be well received. Based on the organoleptic test data, it can be concluded that both in terms of texture, colour, and aroma have the potential to be accepted and liked by the community as an environmentally friendly soap.

CONCLUSION

The manufacture of used cooking oil liquid soap fortified with lime peel extract and bagasse lignin biosurfactant goes through several long processes. Starting from making bagasse lignin, making lime peel extract, and making soap from used cooking oil which was previously purified first.The biosurfactant content of bagasse lignin and lime peel extract can change the physical and chemical properties of used cooking liquid soap.The added lime peel extract is proven to contain active flavonoid and phenol compounds as antioxidants and antimicrobials. It also contains saponins that can add natural foam to the used cooking liquid soap.The pH test results of soap P1 = 11 and soap P2 = 10, this proves that the used cooking liquid soap is in accordance with SNI standards so it is safe to use for the skin. The free alkali content obtained in each soap P1 = 0.018% and P2 = 0.010%, proved to be in accordance with the standards set by SNI. P2 soap with the addition of lime peel extract and bagasse lignin biosurfactant is better than P1 soap without any addition, because it has lower free alkali levels.

The stability of used cooking liquid soap with the addition of lime peel extract and bagasse lignin biosurfactant is 91.34%, has met the standard and is classified as high. So that this soap can welcome SDGs 2030 as a soap that has high foam stability and can be of interest to many users.Organoleptic testing was carried out by observing texture, aroma, and colour using the senses of sight and smell by 15 untrained testers. Based on the test results, the value of non bisurfactant soap was 96 and that of bisurfactant soap was 132.With the use of bagasse waste in the manufacture of oil soap fortified with lime peel extract, it can reduce the amount of waste, especially in Tebu Ireng, Jombang, East Java and as a form of participation in welcoming SDGs 2030.

AKNOWLEDGMENT

This research is indeed not perfect, so further research needs to be done to determine the effectiveness of liquid cooking oil soap fortified with lime extract and bagasse lignin bisurfactant and other soap standardisation tests.

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