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Kepok Banana Peel Extract (*Musa Paradisiaca*) as Antibacterial and Renewable-Biodegradable Surfactant in Liquid Detergent

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ABSTRACT

Kepok banana peel contains tannin as antibacterial activity and saponin acts like a surfactant. Detergent is a cleaning agent commonly used by the community. Banana peel is extracted with ethanol solvent to produce antibacterial activity and can be used as a bioadditive. Knowing the antibacterial activity, the extract requires incubation. Because the nature of saponin is the same as surfactant, banana peel extract can be compared with mes surfactant to make liquid detergent. This study was conducted to identify tannin and saponin in banana peel extract, obtain the best banana peel extract yield with the best solvent concentration and the best incubation time for bacterial inhibition, and the best formulation with the addition of extract to the liquid detergent application. The banana peel extraction process with ethanol uses the Ultrasonic Bath Extraction method. The independent variables in this study were the concentration of extraction solvent (50%, 60%, 70%, 80% and 96%) and the formulation of adding banana peel extract (0%, 5%, 10%, 15% and 20%). The best extraction results were obtained with a solvent concentration of 96% which produced a brown liquid with a strong aroma containing tannins and saponins with the best yield of 11.27% and the best antibacterial activity test with a time of 72 hours, then the extract was made into a liquid detergent formulation as a surfactant and compared with MES surfactant so that the best formulation was obtained in formulation F2 (5% banana peel extract 15% methyl ester sulfonate surfactant) and formulation F3 (10% banana peel extract 10% methyl ester sulfonate surfactant).

Introduction

Banana peel is one part of the banana plant that has been neglected. The use of banana peel waste as food processing has been widely used, but the use of banana peels in terms of components the active compounds contained therein are still limited [1-7]. Phytochemical screening of ethanol extract of kepok banana peel contains alkaloids, saponins, flavonoids, and tannins. Tannins in banana peels can act as antimicrobials while saponins that have a non-polar triterpenoid or steroid chain structure are natural foam-producing compounds that can be used in the detergent, soap and shampoo industries [8-10]. Detergents are cleaning agents commonly used by the public, both by households, industries, hotels, restaurants, and others [11]. Conventional detergents are made from various chemical compounds such as builders, artificial fragrances, and the most dangerous are surfactants [12-16]. Surfactants are petroleum-derived compounds that

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function to lower the surface tension of water or make the surface wetter so that it is easier to interact with shampoo oil and fat [17-18]. Detergents containing active ingredients such as LAS surfactants derived from petroleum can have negative impacts on the environment and living things because they are difficult to decompose by microorganisms and can pollute the environment [19-21]. To overcome this pollution problem, vegetable-based surfactants can be used that can be degraded by microorganisms compared to petroleum-based surfactants. The vegetable surfactant used is methyl ester sulfonate, which is environmentally friendly and easy to degrade because it is made from vegetable oil. Natural compounds that have characteristics like surfactants are saponins [20-24]. Saponins are natural foam-producing compounds that can be used in the detergent, soap and shampoo industries [25-27]. In addition to saponins, there are surfactants from vegetable oil, namely Methyl Ester Sulfonate (MES). MES is an anionic surfactant as an active ingredient in detergents that has been widely developed because it shows good dispersion, good saponification properties especially in water with high hardness levels, and is easily degraded [8]. Ultrasonic-assisted extraction (UAE) is one of the extraction methods ultrasonic assisted. The extraction method using ultrasonic waves is a more effective and efficient alternative [28]. Ethanol is a solvent commonly used in pharmaceutical and cosmetic preparations. Ethanol is a universal solvent that can attract all types of compounds including polar, semi-polar and nonpolar. This research was conducted to determine whether tannins can be antibacterial and saponins can be surfactants in the manufacture of liquid detergent.

Methods

Materials

Kepok Banana Peel, $FeCl_3$, HCl, H_2SO_4, Ethanol, Bacterial Culture, KMnO4 0.1 N,Oxalic acid, Anisaldehyde, Nutrient Agar, STPP, HPMC, BHT, Decyl Glucoside, Lauryl Gkucoside, Pafrum, Aquadest.

Sample Preparation

The raw material of banana peel is washed using running water. Then dry the banana peel using an oven at a temperature of 500°C for 2-3 days.The dried banana peel is ground using a blender until it becomes powder.

Banana peel extraction

Banana peel powder is weighed 50 grams using an analytical scale and then put into a 500 ml Duran bottle. Ethanol is added according to the specified ratio. then stirred until homogeneous. The banana peel powder solution is extracted using an ultrasonic bath, after being extracted with an ultrasonic bath it is then filtered using whatman paper, the filtrate obtained is then evaporated. Evaporation is carried out with a rotary vacuum evaporator with a pressure of 100 mbar, a temperature of 40oC and a rotation of 100 rpm. The thick extract obtained is weighed and calculated. The yield of this extract will be obtained as the yield/yield of banana peel ethanol extract. The yield can be calculated using the formula (1).

Yield:

$$\frac{\text{extract mass}}{\text{simplisia mass}} x\ 100\% \quad (1)$$

Banana peel extract analysis

Organoleptic Test

The extract that has been obtained is then identified organoleptically. Organoleptic testing is carried out by directly observing the color, shape, and smell of the extract that is formed.

Flavonoid Test

The extract that has been reacted with ethanol, then HCl is added, forms an orange color indicating the presence of flavone compounds.

Tannin Identification Test

To 1 ml of sample, 2-3 drops of 1% FeCl3 solution are added. If the solution produces a blackish or ink blue color, then the material contains tannin.

Saponin Identification Test

Samples were taken as much as 0.5 g plus 10 ml of hot distilled water, cooled and then shaken for 10 minutes. The formation of stable foam (lasting a long time) indicates positive saponin.

Tannin Content Test

Determination of Maximum Wavelength

The maximum wavelength of gallic acid was determined by measuring a gallic acid solution with a concentration of 50µg/ml in the wavelength range of 400-800nm using a UV-Vis spectrophotometer.

Making a Standard Curve

Gallic acid concentrations of 20 µg/ml, 30 µg/ml, 40 µg/ml, 50 µg/ml, and 60 µg/ml were made by pipetting from a standard solution of gallic acid with a concentration of 1000 µg/ml, then 0.4 ml of

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Folin Ciocalteau reagent was added, shaken and left for 4-8minutes. Added 4.0ml of 1% NaOH solution, shaken until homogeneous. Then added with distilled water up to 10ml and measured the absorbance at the maximum wavelength.

Determination of Total Tannin Content

Weigh 10mg of banana peel extract then dissolve it with 10ml of 96% ethanol, pipette 1ml of the solution, then add 0.4ml of Folin Ciocalteau reagent, shake and leave for 4-78 minutes then add 4.0ml of 1% NaOH, shake until homogeneous. Add enough water to 10ml, and let stand for 1 hour at room temperature. Then measure the absorbance at the maximum wavelength

Saponin Level Test

Weight for 1.5-2.0 grams of extract sample carefully into an Erlenmeyer flask. Add 25 mL of 0.5N potassium hydroxide-ethanol solution and reflux for 30 minutes and occasionally rotate. Add 1 mL of phenolphthalein indicator. Titrate with 0.5N standardized HCl solution. Calculation formula (2):

$$Saponification = \frac{(Vblanko - Vsample)\, x\ 56{,}11\ x\ 0{,}5}{\text{Weight of Sample (g)}} \qquad (2)$$

Antibacterial Activity Test

Antibacterial activity test was carried out using the Cylinder Method.The inoculated suspension bacteria are mixed into the media and poured evenly into a sterile petri dish and waited until dry, then placed several cylinders made of glass or stainless steel on top of agar media that has been inoculated with bacteria. Each cylinder is placed so that it stands on the agar media, filled with banana peel extract based on the concentration of the extraction solvent using a pipette, Incubated in an incubator at 32°C for 24, 48, 72, 120, and 168 hours, observe and measure the diameter of the clear zone formed around the hole using a vernier caliper.

Liquid Detergent Making

Weigh all raw materials according to the formula. Prepare the equipment to be used. Dissolve the extract with HPMC into distilled water (1). Dissolve BHT into ethanol until homogeneous (2). MES surfactant and Mixture (2) are added with distilled water at a temperature of 40-60◦C then stirred until homogeneous (3). Mixture (3) is added to Mixture (1) then added Sodium Tripolyphos phate (STPP) solution then stirred until homogeneous. Add fragrance then add distilled water. Stir until homogeneous. Let stand for 24 hours.

Liquid Detergent Analysis

pH test

At pH using a pH meter tool using an indicator electrode. The electrode is inserted into the sample to be examined. Let stand until the number shows a constant value. The value shown is recorded as the pH.

Specific Gravity (Density) Test

In density, the principle of measuring the specific gravity of liquid detergent preparations with a pycnometer is to weigh the weight of the empty pycnometer and record it, then fill the pycnometer with distilled water, then weigh and record it, then put the liquid detergent preparation into the pycnometer, then weigh and record the results, then calculate the density..

$$Density = \frac{Weight\ of\ banana\ peel\ extract}{Weight\ of\ water} \qquad (3)$$

Test Foam Stability

A total of 0.1 g of sample was dissolved in 10 mL of distilled water, then the solution was put into a graduated tube from the wall. The tube was then closed and vortexed for two minutes. The height of the foam produced was observed and then the height of the foam was recorded with a measurement scale of 0.1 cm at minutes 0 and 5. The difference in foam height at minutes 0 and 5 is the value of foam resistance.

$$Foam\ stability = \frac{\text{final foam height}}{\text{initial foam height}}\ x\ 100\% \qquad (4)$$

Test Detergency

The ability of the extract as a surfactant was tested through a dirt removal test. White cloth was stained with soy sauce (protein) and then left to dry by letting it sit for four hours. The dried cloth was washed using a liquid detergent containing the extract. This detergency test was carried out qualitatively.

BOD and COD Test

Prepare the sample to be analyzed. Pipette 2 mL of sample. Insert the sample into a tube containing the reagent. Heat at 150oC for 2 hours. Let the sample stand for 5 minutes until the sample is cooler. Analyze using the DR 900 instrument.

Results and Discussion

Banana Peel Extract

Extraction needs to be done to separate the contents contained in banana peel extract. In addition to dissolving, extraction can also be interpreted as

separating materials with appropriate solvents. So to get the contents in the banana peel, it is necessary to start with the extraction process. In this study, banana peel extraction used an ultrasonic extraction process, then concentrated using a rotary evaporator. This is because ultrasonic extraction is a fairly good extraction in the extraction results. Ultrasonic waves cause the formation of cavitation waves in the cell walls of plants. The rupture of cavitation waves causes an increase in the pores of the cell walls. This is what triggers why the sonication extraction method or the extraction method using ultrasonic waves is faster than other extraction methods [21]. The results of the calculation of the banana peel extract yield can be seen in **Table 1**.

Table 1. The percentage of banana peel yield

	Solvent concentration				
	50%	60%	70%	80%	96%
Banana peel extract	4.18%	6.12%	9.30%	9.97%	11.27%

In **Table 1,** the results of the percentage of banana peel yield increased because ethanol is a polar solvent that has a hydroxyl group (OH) that is able to attract the necessary compounds such as flavonoids, alkaloids, tannins, terpenoids and saponins and is able to attract more chemical compounds compared to water and methanol, if the concentration is higher which means the less the mixture with water, the more extract is obtained. In Devianti's research, determining the quality of pectin from banana peel waste with variations in solvent volume that the solvent volume is directly proportional to the amount of pectin successfully extracted from banana peels, the pectin yield obtained during the extraction process with a material/solvent ratio of 1:40 and 1:50 is 9.88% and 10.68%.

Banana Peel Extract Analysis

Organoleptic Test

In the extracts produced from solvent concentrations of 50%, 60%, 70%, 80% and 96% after concentration, the extracts were liquid, brown in color and had a strong banana aroma.

Flavonoid Test

The resulting banana peel extract was tested for flavone compounds by adding solvents. Concentrated HCl as many as 6 drops and the color changes to orange on the amyl alcohol layer which indicates the presence of flavone compounds in each banana peel extract produced.

Tannin Test

Identification of tannins in banana peel extract by adding solvents3 drops of 1% $FeCl_3$ into each extract, each extract changes color to blackish green which indicates the positive presence of tannin in each extract. The formation of a blackish color in the extract after adding $FeCl_3$ is because tannin will form a complex compound with $FeCl_3$.

Saponin Test

Identification of saponins in banana peel extract, each banana peel extract result was added 2 mL of water is then shaken vigorously and produces foam and waited for 10 minutes to ensure stable foam and what happens is positive stable foam indicating that there is a saponin compound in each extract produced.

Tannin Content Test

Table 2.Test results for tannin content of banana peel extract

Variation of ethanol solvent concentration (%)	Tannin content results
50	10.11%
60	10.49%
70	11.05%
80	11.98%
96	12.04%

Based on **Table 2**. Results of the tannin content test of banana peel extract. The concentration of the solvent can affect the tannin content in the extract obtained because ethanol is a polar solvent that can attract tannin compounds, so the greater the concentration, the greater the tannin content obtained in the extract.

Saponin Level Test

Table 3. Saponin content test results

Variation of ethanol solvent concentration (%)	Saponin content results
50	29.21%
60	32.91%
70	34.48%
80	40.30%
96	43.64%

Based on **Table 3**. Results of saponin content tests, Saponin is a nonionic surfactant found in natural materials and can function as a cleaning agent. The higher the saponin content produced in biosurfactants, the higher the potential of the material to be used as a natural detergent. This is because saponin can reduce water tension and is able to lift dirt. According to [15] The higher the

detergency obtained indicates that the saponin content in the extract can function well in lifting dirt that sticks to the fabric.

Antibacterial Activity Test

Table 4. The results of the banana peel extract inhibitory power test

Incubation time (hours)	Bacterial Inhibition Zone Diameter (mm)				
	50%	60%	70%	80%	96%
24	10.00	18.85	17.74	14.52	12.72
48	10.57	19.01	18.60	15.66	13.26
72	11.44	19.12	19.60	16.70	14.00
120	11.01	17.24	17.73	14.40	12.22
168	9.39	10.23	12.05	11.01	9.32

Based on **Table 4**, the inhibition zone formed, antibacterial activity can be classified into several groups, namely weak antibacterial inhibition zone <5 mm, moderate inhibition zone between 5-10 mm, strong inhibition zone between 10-20 mm, and very strong (inhibition zone> 20 mm). From the results that have been observed and referring to the statement, the inhibitory power of the banana peel extract is included in the category of moderate to strong inhibition zone, namely the diameter of the zone obtained is 9-20 mm. According to research (makatambah, 2020) that the fractions of n-hexane, chloroform and ethyl acetate concentrations of 3%, 4%, 5% and 6% are able to inhibit the growth of S. mutans bacteria with the diameter of the inhibition zone in the three fractions of n-hexane, chloroform and ethyl acetate, namely >10 mm and classified in the strong category.

Liquid Detergent Analysis

pH Test

The pH test is performed to see if there is any effect of detergent when it comes into contact with the skin.

Table 5. Results of pH analysis of liquid detergent

Formula Variations	pH value
I	5.92
II	6.96
III	8.04
IV	9.33
V	10.03

According to SNI 06-4075-1:2017 liquid detergent tends to have a basic pH of 6-8. Based on Table 5. Results of liquid detergent pH analysis. the results of liquid detergent pH testing in the table above show that the pH values produced are 5.92; 6.96; 8.04; 9.33; and 10.03, where the pH in formulas 1 to 3 is included in the basic category and is safe for the skin because it is close to neutral pH. Liquid detergents F2 and F3 are expected to help the cleaning process and do not cause negative effects in the form of irritation to the user's skin during the washing process using hands. This is supported by research by [25], pH values ranging from 6-8 are safe for the skin so that the liquid detergent produced can be used safely and does not cause skin irritation.

Specific Gravity Test

Table 6. Results of analysis of specific gravity of liquid detergent

Formula Variations	Specific Gravity Value (g/mL)
I	1,0039
II	1,0077
III	1.0015
IV	1.0102
V	1,0043

Based on SNI quality requirements, the density of liquid detergent products ranges between 1.0–1.3 g/mL. The density value of the liquid detergent produced ranges between 1.0015–1.0102 g/mL and meets SNI quality requirements.

Foam Stability Test

The test results must show that the foam produced from the liquid detergent product must also be stable so that it can last a long time during the washing process.

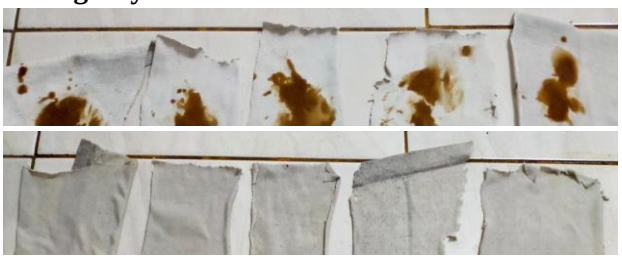
Table 7. Results of liquid detergent foam stability analysis

Formula Variations	Foam stability value (%)
I	93.33
II	81.82
III	72.73
IV	90.91
V	92.31

The criteria for good foam stability are, if within 5 minutes the foam stability range is between 60-70% [20]. Based on the calculation results, the foam stability values of the five liquid detergent formulas were respectively 93.33%, 81.82%, 72.73%, 90.91%, 92.31% where the third formula is closest to the threshold value. Basically, the higher the foam

stability of the detergent, the more optimal the washing power is, because the foam produced can prevent stains from sticking back to clothes. The foam produced by the detergent is expected not to have a negative effect on the environment because the MES surfactants and natural surfactants used are easily degraded naturally by microorganisms in the environment and are more environmentally friendly.

Detergency Test



I II III IV V

Figure 1. Detergency test results

Visually, the fabric washed using the extract has a color level that is not much different from commercial surfactants, so that starfruit plants have the potential to be developed as a source of raw materials for surfactants for detergent applications.

BOD Test

Table 8. BOD results of detergent waste

Formula Variations	Quality Standard (mg/L)	BOD (mg/L)
Commercial Detergent	150	112
I	150	72
II	150	85.5
III	150	109.5
IV	150	110
V	150	121.5

BOD (Biochemical Oxygen Demand) is a measure of how much oxygen is used by microorganisms in the Aerobic oxidation process in water where the BOD process can be used by bacteria to oxidize into inorganic materials. According to the Liquid Waste Qualification Standards set by the government, the BOD of liquid waste is 150 mg/L [27]. The BOD value produced in liquid detergent waste still meets the liquid waste qualification standards.

COD (Chemical Oxygen Demand) Test

Table 9.COD results of detergent waste

Formula Variations	Quality Standard (mg/L)	COD (mg/L)
Commercial Detergent	300	340
I	300	178
II	300	191
III	300	209
IV	300	221
V	300	243

COD or often called Chemical Oxygen Demand is the amount of oxygen needed to chemically oxidize organic matter in water [3]. According to the Liquid Waste Qualification Standards set by the government [23] the COD of liquid waste is 300 mg/L. The COD value of detergent waste above still meets the liquid qualification standards.

One Way ANOVA Analysis

One Way ANOVA Test decision making guidelines:

If the Sig (Significance) value > 0.05 then H0 is accepted, If the Sig (Significance) value < 0.05 then H0 is rejected.

Table 10. ANOVA test data on the inhibitory power of banana peel extract

Incubation time (hours)	Bacterial Inhibition Zone Diameter (mm)				
	50%	60%	70%	80%	96%
24	10.00	18.85	17.74	14.52	12.72
48	10.57	19.01	18.60	15.66	13.26
72	11.44	19.12	19.60	16.70	14.00
120	11.01	17.24	17.73	14.40	12.22
168	9.39	10.23	12.05	11.01	9.32

H0 = incubation time affects the antibacterial activity test

Anova: Single Factor

SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*
Row 1	5	73,83	14,766	13,12128
Row 2	5	77,1	15,42	12,81155
Row 3	5	80,86	16,172	11,95752
Row 4	5	72,6	14,52	8,83175
Row 5	5	52	10,4	1,3275

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	101,1224	4	25,2806	2,630678	0,064891	2,866081
Within Groups	192,1984	20	9,60992			
Total	293,3208	24				

Obtained value *P-value* (0.06) > 0.05 then the variance between data groups is the same (homogeneous). It can be seen in the ANOVA test above that the F value is smaller than the F crit value and the P-Value is > 0.05, so, **H0 is accepted, there is an effect of incubation time during the inhibitory power test on banana peel extract.**

Table 11. ANOVA test data of liquid detergent formulation

Formulation Detergent	Response Analysis				
	pH	Specific gravity (g/mL)	Foam stability (%)	COD (mg/L)	BOD (mg/ L)
I	5.92	1,0039	93.33	178	72
II	6.96	1,0077	81.82	191	85.5
III	8.04	1.0015	72.73	209	109.5
IV	9.33	1.0102	90.91	221	110
V	10.03	1,0043	92.31	243	121.5

Anova: Single Factor

SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*
Row 1	5	316,2539	63,25078	3665,809
Row 2	5	376,2877	75,25754	6006,683
Row 3	5	410,2715	82,0543	7910,502
Row 4	5	452,2502	90,45004	8972,912
Row 5	5	467,8443	93,56886	9664,584

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	2981,833	4	745,4583	0,102906	0,980182	2,866081
Within Groups	144882	20	7244,098			

Obtained value *P-value*(0.98) > 0.05 then the variance between data groups is the same (homogeneous). It can be seen in the ANOVA test that the F value is smaller than the F crit value and the P-Value is > 0.05, so **H0 is accepted, Banana peel extract can be a surfactant with a comparison of MES surfactants**.

Conclusions

The results of this study can be concluded that the solvent concentration affects the yield of banana peel extract, the best yield is produced at a solvent concentration of 96%, which is 11.27%, positive containing tannins and saponins. Based on the One Way ANOVA analysis on the data of banana peel extract inhibition test, incubation time affects antibacterial activity and in the liquid detergent formula test data, banana peel extract can be a surfactant with a comparison of MES surfactant in liquid detergent.

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Author Contributions

The authors' contributions to the paper are as follows: study conception, design, analysis, and interpretation of results: RAN, ASR; data collection: SP; draft manuscript preparation: RJH. All authors have reviewed the results and approved the final version of the manuscript.

Conflicts of Interest

All authors declare that they have no conflicts of interest.

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