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Environmentally Friendly Emergency Lighting System Using Bio Batteries from Pineapple Skin Waste as Energy Source

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ABSTRACT

This study examines the use of bio batteries from pineapple skin paste as an energy source. Bio-battery is a battery with a paste derived from natural materials that are environmentally friendly. The bio-battery is capable of generating electrical power by using a pineapple peel electrolyte paste and copper (Cu) and zinc (Zn) electrodes arranged in series. Parameters measured are voltage, current and duration of the LED (Light Emitting Diode) light. The pasta variations used were pure pasta, pasta with the addition of sodium bicarbonate, pasta with the addition of salt and pasta fermented using LEDs with the total of 6 pieces arranged in parallel and the implementation using pasta with the addition of 0.75 gr salt and 4 LEDs. The research results reveal that the pure paste produces a maximum voltage of 2.410 volts, a maximum current of 0.12 mA with a 14-hour LED light; paste added with sodium bicarbonate produces a maximum voltage of 2,342 volts, a maximum current of 0.21 mA with LED lights on for 12 hours; paste added with salt produces a maximum voltage of 2.432 volts, a maximum current of 0.33 mA with an LED lamp on for 13 hours; and the fermented pasta produced a maximum voltage of 2.542 volts, a maximum current of 0.91 mA. The results showed that bio-battery with pineapple skin paste can produce electrical power that can be used as an energy source for emergency lights.

1. INTRODUCTION

Commercially available batteries generally contain heavy metals such as mercury, lead, cadmium and nickel which are hazardous chemicals. The use of single-use primary batteries causes environmental pollution as the result of manganese as the most abundant element in these batteries (Sobianowska-Turek et al., 2016). The manganese element can pollute the environment, for example water pollution (Oktiawan, 2007). This chemical pollution needs to be reduced, so innovation is needed to overcome it. One of the innovations made is by utilizing waste from fruits and vegetables as a substitute for chemicals in batteries. This type of battery is also known as a bio-battery. Bio-battery is a battery with electrolyte in the form of a paste derived from natural materials that are environmentally friendly and do not contain harmful chemicals.

Research on bio-batteries has been carried out by (Anshar, 2021; Aziz, 2020; Salafa, 2020; Sitanggang, 2021) who analyzed the electrical properties of Citrus Fruit Peel, cassava peel, pineapple peel, Orange Peel and Tamarind. This research generally analyzes liquid electrolytes. The results showed that the fruits and vegetables used in the manufacture of bio-batteries were acidic fruits. These fruits also contain substances such as ascorbic acid, citric acid and NADH (Nicotinamide Adenosine Dinucleotide Hydrogen, which produces energy cells) acting as electrolytes and can be utilized as alternative renewable energy sources (Fauzia, 2019). The results of the study (Atina, 2015) showed five types of fruit that have great potential to be used as electrolytes in bio-batteries, one of which is pineapple.

Riau is one of the largest pineapple-producing provinces in Indonesia, based on data from the Central Statistics Agency (BPS). Pineapple production in Riau reaches 8000 tons/year (BPS, 2018). The amount of pineapple production is directly proportional to the increase in the amount of pineapple waste produced, especially the skin and fruit weevil. Pineapple has high sugar and acid content, so it has the potential to be used as a bio-battery (Toygar, 2018).

Utilization of pineapple peel waste into bio-battery can be an innovative solution for handling pineapple waste in Riau Province, while also reducing hazardous chemical waste from primary batteries. This bio-battery utilizes pineapple peel waste as a substitute for primary battery electrolyte and uses Zn-Cu and Al-Cu electrodes. Zn-Cu and Al-Cu electrodes are materials with high conductivity, easy to obtain and relatively cheap (Susanto, 2017; Kar, 2014). Electrolytes from pineapple waste are made in solid or paste form. This aims to avoid the occurrence of rapid corrosion on the electrode surface. Bio-battery paste is also added with citric acid to prevent oxidation process and sodium bicarbonate to inhibit corrosion rate. Bio-battery has great potential to be developed because it is made from natural materials that are widely available and the electrodes used are cheap and can be used as a renewable alternative energy. Therefore, this bio battery is used as an energy source for emergency lighting, by adding LED lights to the bio battery.

2. METHOD

The implementation of this research was carried out in several stages, namely, Pasta Production, Prototype of Bio-battery and bio-battery testing.

2.1 Pasta Production

Pineapple skin waste is obtained from pineapple traders in the markets of Pekanbaru City and pineapple traders who sell on the streets. The process of making pineapple paste is as follows:

1. Pineapple skin waste is weighed as much as 600 grams for each variation of pineapple peel paste.
2. Pineapple skin waste is cut into pieces with a size of approximately 1 cm using a knife.
3. The pineapple skin waste is pureed using a blender until it is shaped like a paste.
4. Smooth pineapple peel paste has a wet texture, so it is necessary to reduce the water content of pineapple peel waste. Furthermore, pineapple peel waste is squeezed using a fruit squeezer until the water content reaches 10-20%. Then the pineapple peel paste that has been smooth is put into the container provided, as shown in Figure 1.
5. The paste is added with citric acid from lime fruit to prevent the oxidation process (Tritanti, 2015) and added sodium bicarbonate to inhibit the corrosion rate**.** (Marlina , 2013).
6. After being squeezed, the pineapple peel paste is treated with the following variations:
   a. Pure pineapple skin paste
   b. Pineapple skin paste added sodium bicarbonate 0.3 g, 0.6 g and 0.9 g.
   c. Pineapple skin paste added NaCl 0.25 gr, 0.50 gr and 0.75 gr.
   d. Pineapple peel paste is fermented with free air for 24 hours, 36 hours and 48 hours.

2.2 Prototype of Bio-battery

The next step is to prepare a container for pineapple peel paste made from used batteries as many as 21 pieces which will be tested for electrical characteristics. The battery used is a dry cell battery type ABC R20S IEC/UM-1/D with a voltage of 1.5 volts with a diameter of 34.2 mm and a height of 61.5 mm. Used batteries must be cleaned before use. The variation of the pineapple peel paste treatment that has been made is then put into a clean and empty battery and then closed. Pineapple peel paste that has been varied as much as 35 grams into a clean battery. This study uses a copper (Cu) electrode which functions as a positive electrode (cathode) and zinc (Zn) as a negative electrode (anode). Batteries work by utilizing the oxidation-reduction process. The anode will undergo an oxidation reaction so that the electrons on the Zn surface will be released and carried by electrolyte ions to Cu. The transfer of electrons by these electrolyte ions will then produce a voltage difference and an electric current. Each battery will be connected in series. In addition to batteries, this study also uses Cu-Zn electrodes, copper (Cu) serves as the positive electrode and zinc (Zn) as the negative electrode.

Figure 1. Pineapple Peel Paste

2.3 Bio-battery Testing Stage

Testing the characteristics of pineapple peel waste aims to determine the relationship between voltage and electric current generated on variations in the length of time for fermentation of pineapple peel waste, pineapple peel waste without the addition of salt and with variations in the addition of salt. This characteristic test is carried out in the following ways:

1. Connect the alligator clip with the second end of the battery to the digital multimeter.
2. Furthermore, the measurement of voltage and electric current is carried out using a digital multimeter
3. Then from the sample, it is tested how long the lights are on with the addition of 5 LEDs arranged in parallel. The LED lamp used is of the bright white type with a voltage value specification of (2.3-3.5) volts.
4. The test process is repeated for different variations of pineapple peel waste.

2.4 System Assembly Emergency lighting

Emergency lighting system assembly activities are making emergency lighting packaging and implementing bio-battery. The bio-battery that is implemented in this emergency light is a bio-battery that has good electrical properties based on previous tests. The type of lamp used in this emergency light is a white SMD LED lamp with 2 lights, 3 lights and 4 lights.

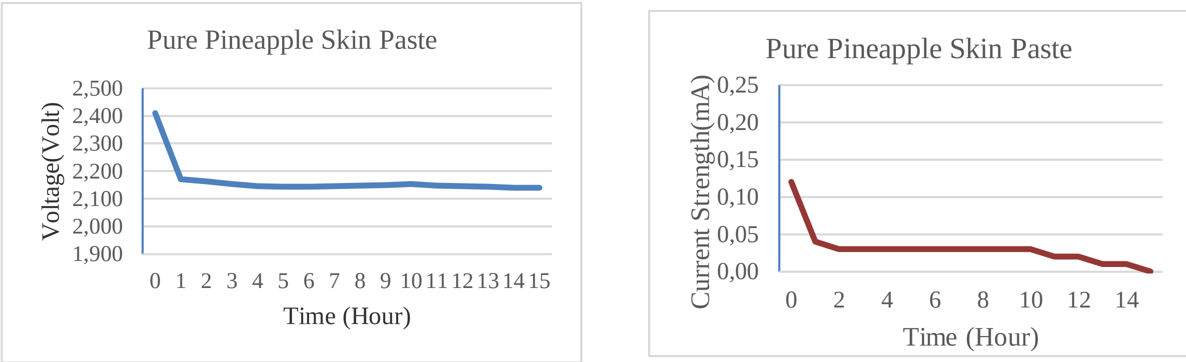
3. RESULT AND DISCUSSION

3.1 Electrical Characteristics of Pineapple Skin Waste Bio Battery

3.1.1 Relationship of Voltage and Current with Time for Pure Paste

Figure 2 (a) is the relationship between voltage and time on a pure pineapple skin paste bio-battery. The voltage value obtained is the maximum voltage of 2,410 volts and the minimum voltage of 2,139 volts. The graph trend shows a decrease in the value of the voltage with time. Testing the length of time the LED light is on is for 15 hours.

The relationship between current strength and time using pure pineapple skin paste can be seen in Figure 2 (b) The results of the current strength are 0.12 mA maximum and 0.00 mA minimum. From the graph it can be seen that there is a decrease in current strength with time. The current value obtained is proportional to the voltage value, in line with research (Ia, 2020). To increase the output voltage, the bio-battery system must be arranged in series. Meanwhile, to increase the current, bio-batteries are arranged in parallel (Ansanay, 2019).

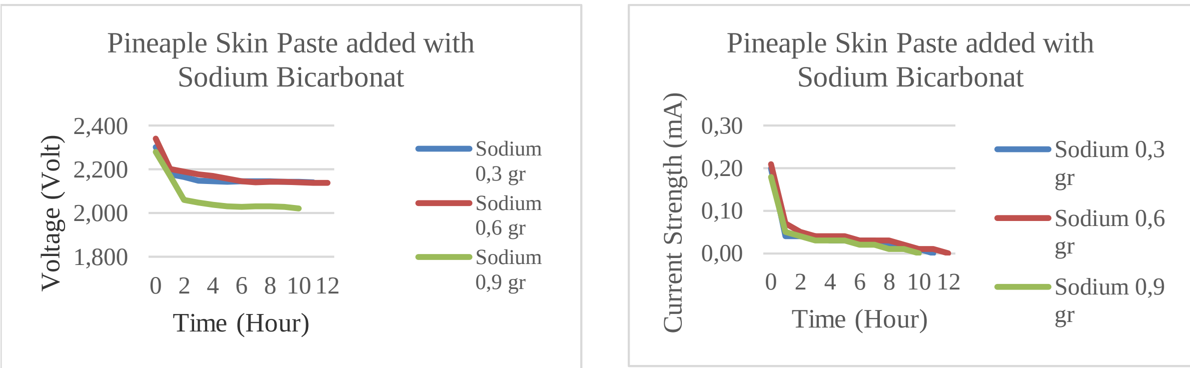


(a) **(b)**

Figure 2 (a) Graph of Voltage-Time Relationship for Pure Pineapple Skin Paste **(b)** Graph of Current Strength-Time Relationship for Pure Pineapple Skin Paste

3.1.2 Comparison of Voltage and Current Strength on Variation of Pineapple Skin Paste added with Sodium Bicarbonate

Figure 3 (a) shows that the more sodium bicarbonate is added, the lower the resulting voltage value. This is because the water content decreases presumably due to the nature of sodium bicarbonate which is able to produce CO2. The decrease in water content is in line with the results of (Nandhani, 2015) research. The more sodium bicarbonate concentration added to cookies, the more CO2 is produced, so that more cavities or pores are formed. The more cavities or pores that are formed, the greater the surface area of the material so that the water in the material will easily come out.



(a) **(b)**

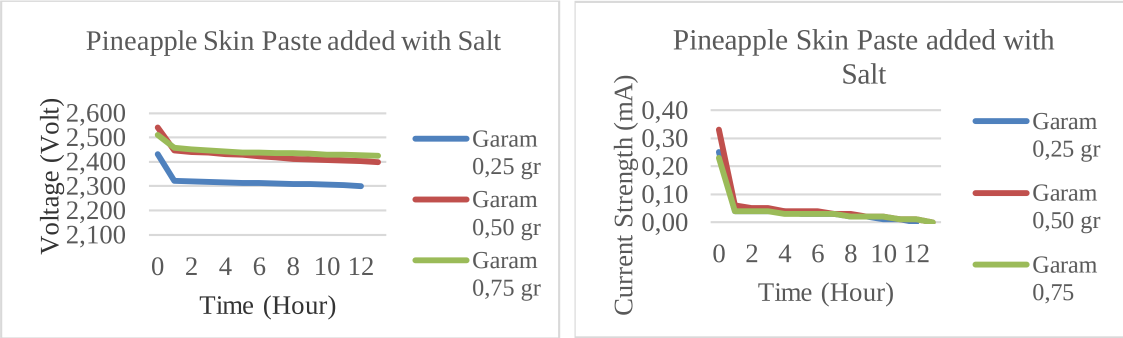
Figure 3 (a) Graph of Voltage Values Comparison from Variation of Pineapple Skin Paste Added with Sodium Bicarbonate. **(b)** Graph of Current Strength Values Comparison from Pineapple Skin Paste Variations Added with Sodium Bicarbonate

The current produced for each addition of sodium bicarbonate, namely 0.3 g, 0.6 g and 0.9 g, can be seen in Figure 3 (b) The graph shows that the more addition of sodium bicarbonate used to carry out the test, the stronger the current decreases with time. The decrease in the value of this current occurs because of the alkaline nature of sodium bicarbonate.

3.1.3 Comparison of Voltage and Current Strength in Variations of Pineapple Skin Paste Added with Salt

Figure 4 (a) shows the highest voltage value, namely in pasta with the addition of 0.50 gr salt. This is in accordance with research of (Fadilah, 2015) that the more salt (NaCl) is added, the higher the voltage value produced because salt (NaCl) is a type of strong electrolyte.

The value of the current strength produced from pasta with variations in the addition of salt, namely 0.25 gr, 0.50 gr and 0.75 gr can be seen in Figure 4 (b) The graph shows that the highest current strength value is found in pasta with the addition of 0.50 gr salt. This is because the addition of 0.50 g of salt to the pineapple peel waste paste is the optimum point, to produce voltage and current.



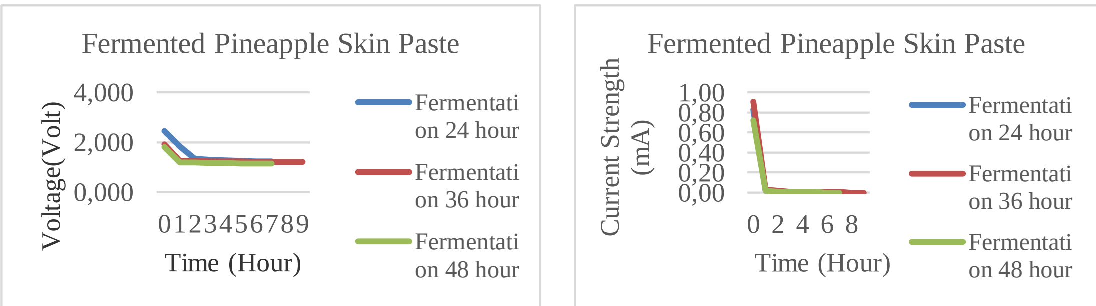
(a) **(b)**

Figure 4 (a) Graph of Comparison of Voltage Values of Pineapple Skin Paste Variations added with Salt
(b) Graph of Comparison of Current Strength Values of Pineapple Skin Paste Variations added with Salt

3.1.4 Comparison of Voltage and Current Strength in Variation of Fermented Pineapple Skin Paste

The voltage value from the test results of bio-battery paste with variations in the length of fermentation time from Figure 5 (a) shows that the highest voltage value at 24-hour fermentation time is 2.452 volts and the minimum voltage value at 48-hour fermentation time is 1.806 volts. The decrease in voltage with time is also influenced by the temperature in the fermentation process. Pineapple skin paste that is fermented in free air will be easily affected by the temperature conditions in the surrounding environment. This is in accordance with the research of (Kumaunang, 2011) that in pineapple skin there is an enzyme bromelain which functions to catalyze the hydrolysis reaction of proteins that affect the electrolyte quality of the pineapple skin, and the higher temperature increases can damage the structure of the enzyme so that the function of the enzyme can be reduced. The reduced function of the enzyme will certainly affect the quality of the electrolyte produced by the pineapple skin, so that the electrical properties of the pineapple skin will decrease.

Figure 5 (b) is a comparison graph of the current strength value of the variation in the length of fermentation time. The graph shows that the highest current strength value at 36 hours fermentation time is 0.91 mA while the lowest current strength at 48 hours fermentation time is 0.72 mA. This indicates that the optimum ion reaction that occurs in the pasta is found in the variation of the 36 hour fermentation time, while at 48 hours the ion reaction has decreased so that the voltage and current values decrease.



(a) **(b)**

Figure 5 (a) Graph of Comparison of Voltage Values of Pineapple Skin Paste Variations with Fermentation Time. (b) Graph of Comparison of Current Strength Value of Pineapple Skin Paste Variations with Fermentation Time Duration

3.2 Lifetime of Bio-battery

Bio-battery endurance testing is done by observing the LED connected to the battery. The test results showed that the bio-battery of the pure paste ignites for 15 hours. Bio-battery with Pineapple Peel Paste added Sodium Bicarbonate ignites for 10-12 hours. Bio-battery with Pineapple Skin Paste added Salt lit for 12-13 hours, while bio-battery with Pineapple Skin Paste which is fermented ignites for 6-8 hours. The results of testing the battery life of 4 pasta variations showed that the bio-battery with pure paste had the longest durability. Stable acidity of pure pineapple peel paste affected the flame of the LED lamp used. This is in accordance with research (Shittu, 2018) which reveals that the higher the acidity and the size of the fruit, the higher the stress produced.

3.3 Implementation of Bio-battery in Emergency Lighting

Based on testing the electrical properties of the variation of the type of bio-battery paste used, the longest voltage value and LED light are variations of pineapple peel paste added with 0.50 gr salt. The test result data is used as a reference as the implementation of the system. The LED lamps used in the system implementation test are white SMD (Surface Mounted Device) LED lamps of 2 lamps, 3 lamps and 4 lamps. The test is carried out by connecting a digital multimeter to measure the voltage and electric current, while measuring the LED light length of time is using a stopwatch. Comparison of voltage values and current strength from Implementation Test of 2 SMD LED Lamps, 3 SMD LED Lamps and 4 SMD LED Lamps can be seen in Tables 1 and 2. The emergency lighting system can be seen in Figure 6

The resulting voltage table in Table 1 is a table of the results of the implementation test using three types of tests, namely 2 SMD LED lights, 3 SMD LED lights and 4 SMD LED lights. The table shows the value of the voltage that decreases with time. Judging from the resulting table, the maximum voltage value is 2,681 volts, the minimum voltage is 1,992 volts.

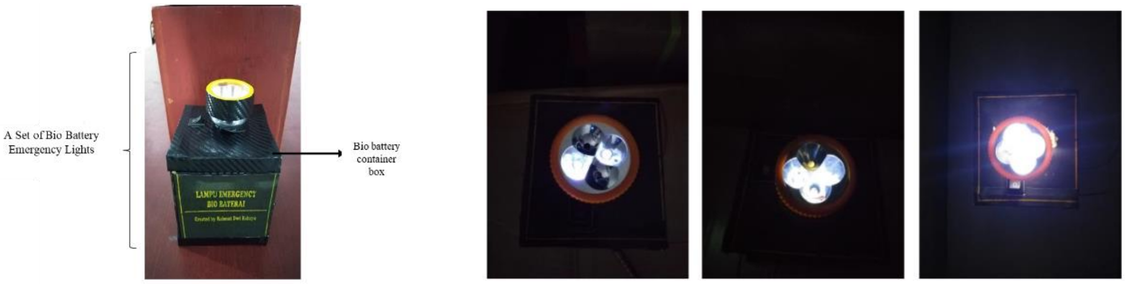
Table 1 Comparison of Voltage Values from Implementation Test of 2 SMD LED Lamps, 3 SMD LED Lamps and 4 SMD LED Lamps

Lamp Length (minutes)	Number of LED Lights		
	Rated Voltage of 2 LEDs (Volt)	Rated Voltage of 3 LEDs (Volt)	Rated Voltage of 4 LEDs (Volt)
0	2,542	2,681	2,598
15	2,023	2,042	2,051
30	2,018	2,033	2,031
45	2,014	2,030	2,027
60	2,012	2,028	2,026
75	2,010	2,027	2,024
90	2,009	2,025	2,022
105	2,006	2,023	2,018
120	2,004	2,020	2,016
135	2,001	2,018	2,014
150	1,997	2,017	2,013
165	1,994	Off	Off
180	1,992	Off	Off
195	Off	Off	Off

Table 2 is a comparison of the current strength of the implementation test results using three types of tests, namely 2 SMD LED lights, 3 SMD LED lights and 4 SMD LED lights. It can be seen from the table that there is a decrease with time. The maximum current value is 0.62 mA and the minimum electric current is 0.00 mA. Testing the longest flame length using 2 SMD LED lights is for 180 minutes, while the fastest light is using 3 and 4 SMD LED lights for 135 minutes.

Table 2 Comparison of Current Strength Values from Implementation Test of 2 SMD LED Lamps, 3 SMD LED Lamps and 4 SMD LED Lamps

Lamp Length (minutes)	Number of LED Lights		
	2 LED Current Strong Value (Volt)	3 LED Current Strong Value (Volt)	4 LED Current Strong Value (Volt)
0	0,62	0,51	0,49
15	0,06	0,07	0,06
30	0,04	0,05	0,05
45	0,03	0,05	0,04
60	0,03	0,04	0,03
75	0,03	0,03	0,03
90	0,03	0,02	0,02
105	0,02	0,01	0,01
120	0,02	0,01	0,01
135	0,02	Off	Off
150	0,01	Off	Off
165	0,01	Off	Off
180	Off	Off	Off



(a) (b)

Figure 6 (a) Emergency Lights (b) Comparison of 2 SMD LED Lights, 3 SMD LED Lights and 4 SMD LED Lights

4. CONCLUSION

From the results of the research conducted, it can be concluded that pineapple skin waste can be used as an environmentally friendly bio-battery. The value of the electric voltage produced from the pure pineapple skin paste variety is 2.410 volts and the value of the resulting current is 0.12 mA. The best voltage test results from the four variations of pineapple skin paste are pineapple skin paste added with 0.50 gr salt for 2,541 volts. The best current strength test results from four variations of pineapple skin paste, namely pineapple skin paste with 0.91 mA. The results of testing show that the longest LED light from four variations of definite types of pineapple skin is pure pineapple skin paste for 15 hours. Testing the implementation of the best system using 4 bio-batteries applied to 2 SMD LED lamps produces a voltage of 2.542 volts, an electric current of 0.62 mA and the lamp burning for 180 minutes. This bio battery has the potential to be used as an emergency light because it has a long enough endurance of 3 hours. In addition, it also has great potential to be developed because it is made from natural materials which are widely available and the electrodes used are cheap, so it can be used be used as a renewable alternative energy.

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