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UTILIZATION O F CASSAVA PEEL (*Manihot esculenta*) AS BIO-BATTERY

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ABSTRACT
Cassava peel (*Manihot esculenta*) is the result of the chip manufacturing industry which has been considered as a by-product so that it can only be a waste that can be recycled. Cassava peel has a carbon content of 59.31%. Based on the carbon content data, this study aims to prove that cassava peel waste can be used as a biobattery and to determine the voltage and current generated. The measurement of voltage and electric current is based on a function of the distance of the electrode and the surface area of the electrode. The electric voltage as a function of the surface area of the electrodes and a function of the distance between the electrodes determines the flow solidity and the electrical voltage. This research showed the voltage was 0.563 V and the current was 0.014 mA. The test was carried out by replacing the carbon in the battery with activated charcoal and cassava peel juice was able to light up on a wall clock for 8 hours. So, cassava peel waste can be used as alternative energy to replace batteries or bio-batteries.
Keywords: *Manihot esculenta*, Battery, Electric Voltage, and Electric Current Strength.
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INTRODUCTION

One of the most important applications of electrochemistry is the storage and conversion of energy. A device that can store and convert chemical energy into electrical energy is a battery. A battery can be composed of one or more voltaic cells.[1] The battery is a device that is an application of the concept of a voltaic cell or galvanic cell. Voltaic cells in everyday life are in the form of batteries.[2] Batteries are chemical electrical devices that store energy and release energy in the form of electricity.[3] Batteries have become an alternative energy source that is widely used in the community. The batteries used are batteries that are sourced from chemicals in the form of heavy metals. So, there is a need for innovations in dealing with the problem of battery content so as not to pollute the environment.[4] One way to deal with this problem is through the use of alternative energy derived from materials that are available and have not been used more widely. Alternative energy is used in the form of bio-battery. Researchers have developed bio-batteries derived from organic and environmentally friendly materials along with the times. So, bio-battery is a solution for conventional batteries that are environmentally friendly. Decomposing fruits and vegetables are juicy. Vegetables other than fruits and vegetables are very potential to generate electricity. Research on fruits and vegetables as an alternative to batteries has been widely carried out, including the potential for electrical energy and the acidity of lime and starfruit.[5] Another study on enzymatic glucose biobatteries showed an increase in the efficiency and performance of enzymatic biofuel cells.[6] Other bio-batteries that have been investigated are microbial-based on a bio-battery.[7] From this basic concept, fruits and vegetables can be used as electrolytes to replace batteries as biobatteries such as cassava.[8] In the manufacture of bio-batteries, we can use natural materials, one of which is cassava peel waste. Cassava is a plant that can be found in all regions of Indonesia. In 2019 the cassava production in Palu City reached 1083 tons,[9] located on Jalan Kalora, Palu City, Central Sulawesi. The cassava chip manufacturing industry processes about 1 ton of cassava to make chips, and the waste generated is around 300 kg/week. Cassava peel waste is only left and thrown away, and this can be seen in Fig.-1.

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In this study, cassava contains 60% water, 3.5% starch, 2.5% raw fiber, 0.5% oil, and 1% cinder. Cassava peel is underutilized, especially by consumers of cassava fruit. Generally, consumers only eat the flesh of the fruit and discard the skin. If properly processed, cassava peel has enormous potential. So, research is needed to utilize cassava peel as a bio-battery.[10]

Fig.-1: Cassava Peel Waste

EXPERIMENTAL

This research is a laboratory experimental research conducted to utilize cassava peel waste as a biobattery. The cassava peel waste used is the white inner bark taken directly from the cassava chips manufacturing industry on Kalora street, Palu City. Before analyzing the cassava waste, it is first tested for its electrical power and then made into activated charcoal which will later be used as a substitute for carbon in the battery.

Tools and Materials

The equipment used in this research includes a digital multimeter, M2000 nail clipper, screwdriver, Miyako blender, knife, 1.5 Volt ABC used battery, resistor, alligator clip cable, 100 mL beaker, copper plate (Cu) and zinc (Zn) plate, thermometer, paper scissors, 100-ohm load, plastic, 100 mesh sieve, cutting board, 1000 mL beaker, 10 ml measuring cup, 500 mL beaker, dropper, spatula, stirring rod, Erlenmeyer 250 mL, separating funnel, ruler, furnace, pH meter, and oven. The materials used in this study include cassava peel, aqua dest, 100 mL NaOH 0.1N, 100 mL HCl 0.1N, filter paper, and label paper.

Experiment Work Steps

The research was carried out through several stages as follows:

Electric Current Test Stage

Preparation of Electrodes

The electrodes used are copper plate as cathode and zinc plate as anode with a length of 7 cm and a width of 2 cm. Then washed and sanded.

Make Cassava Peel Juice and pH Measurement

Peel in a blender until smooth, then squeeze and strain. The filter results (juice) were put into a 100 mL beaker and then the pH was measured. Measurements were carried out three times.

Measurement of Voltage Against Electrode Distance

Cassava peel juice in a beaker covered with a plastic tool. The plastic cap was previously given a hole with a distance of 0.5cm; 1cm; and 1.5cm, up to a distance of 4 cm (a total of eight holes) as a place to insert the electrodes. At each of these distances, the electrical voltage was measured using an electrode surface area of 5 cm^2. Measurements were carried out three times at each distance. The stress test is carried out as shown in Fig.-2.

Measurement of Electric Current on the Surface Area

Cu and Zn electrodes which had been previously marked with a distance of 0.5 cm were put into cassava peel juice in a beaker. The electric current is measured from the electrode depth of 0.5 cm to a distance of 4 cm by using a circuit that is loaded with 100 ohms. The distance between the copper and zinc electrodes is 1.5 cm. Measurements were made three times on the same surface area. The electric current test is carried out as shown in Fig.-3.

Fig.-2: Voltage Measurement

Fig.-3: Electric Current Measurement

Making of Cassava Bark Activated Charcoal as Media

Preparation of Sample

Small pieces of cassava peel are dried in the sun for two days[11] and have been washed and separated from the outer skin after drying, then heated at a temperature of 400ºC for 1 hour until it becomes charcoal. It was then filtered at 100 mesh.

Cassava Peel-Activated Charcoal

Cassava peel-activated charcoal was prepared by soaking it in 0.1 N Na OH (60 minutes), then washed with H Cl, distilled and filtered, and then heated at 110ºC for 60 minutes.[12]

The Bio-Battery Testing on Wall Clocks

The battery type selected is single-use or *single-use* medium size. The battery shell is peeled off using nail clippers to separate the outer shell from the inner battery shell. Then the electrode rod is removed, by cutting the end of the battery so that the cap connected to the electrode rod can be separated from the battery body which contains carbon. Next, the carbon inside the battery is removed using a screwdriver so that all the carbon can be removed. Then activated charcoal mixed with the juice that has been made is put into the battery to replace the carbon in the battery and then closed again and tested on a wall clock. The test was carried out by inserting 10 grams of activated charcoal into a 1.5 Volt ABC battery with the addition of 20 mL of cassava peel juice.

RESULTS AND DISCUSSION

Measurement of pH

Measurement of the degree of acidity or pH of cassava peel juice using a digital pH meter. Cassava peel juice has a pH=5 which is a weak acid that functions as an electrolyte solution, so it contains ions that can conduct good current. The electrodes used are Cu and Zn electrodes. In the cassava peel juice cell, the reduction is not Cu^{2+} ions but H^+, because, in the electrolyte solution, there are no Cu^{2+}. The H^+ comes from organic acids contained in cassava peel juice which is weakly acidic, so it is very possible as a bio-battery material. Therefore, it is necessary to measure the electrical voltage against the electrode distance in cassava peel juice.

Cathode: $2H^+ + 2e \leftrightarrow H^2$ E^0=0.00

Anode: $Zn \leftrightarrow Zn^{2+}$ E^0=0.76

Cell Reaction: $2H^+ + Zn \leftrightarrow Zn^{2+} + H_2$ E^0=0.76

Measurement of Electrical Voltage on Electrode Distance in Cassava Peel Juice

Testing the voltage on the bio-battery is done by connecting the multimeter directly to the bio-battery (cassava peel juice) in series. The electric voltage generated in this study can be explained by the working principle of a galvanic cell. When two different electrodes are put into an electrolyte solution, it will produce electrical energy as a result of a chemical reaction. The reaction that occurs in the bio-battery (cassava peel juice) is a redox reaction (oxidation-reduction). At the anode (Zn) an oxidation reaction occurs while at the cathode (Cu) a reduction reaction occurs. Electrons continue to move from the anode to the cathode, this reaction is repeated until it produces electrical energy.[13] This research was conducted by measuring the electrical voltage at the copper (Cu) and zinc (Zn) electrodes which were spaced from 0.5 cm to 4 cm. The cassava peel extract can be used as an electrolyte solution in a galvanic battery system using zinc (negative electrode) and copper (positive electrode). Negative ions from the zinc plate flow to the copper plate through the cassava peel juice to obtain electrical energy.[5] The results of measuring the voltage on the electrode distance from cassava peel juice can be seen in Fig.-4, which shows that there is an effect of electrode distance on the electricity of cassava peel electrolyte juice. The electrode distance of 0.5 cm indicates the largest voltage value. After that, the electrode distances were (1, 1.5, 2, 2.5, 3, 3.5, and 4) cm respectively. The distance that has the lowest stress value is a distance of 4 cm. The voltage generated from cassava peel juice is at a distance of 0.5 cm at 0.563 V. Based on the measurement of the electrode distance, it can be explained that the closer the distance between the electrodes, the greater the voltage and the farther the distance between the electrodes, the higher the voltage. low. This is because of the transfer of active materials such as H^+ ions and Zn^{2+} ions, so the length of time it takes will reduce the current so that the electric voltage produced is getting smaller.[13-15]

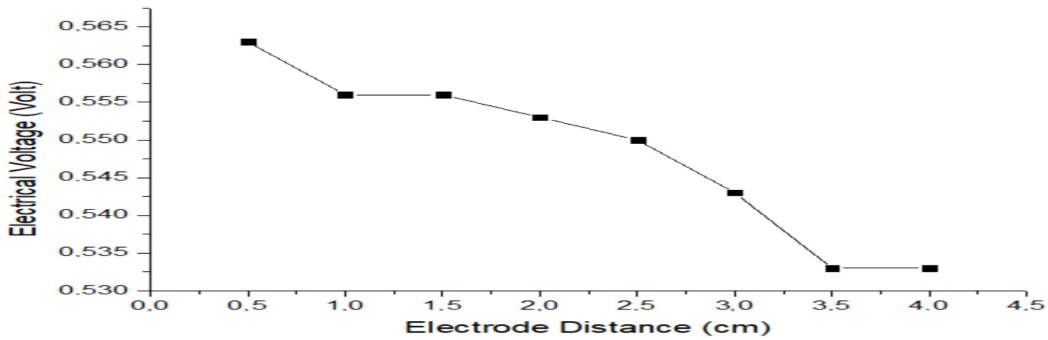

Fig.-4: Graph of Electrical Voltage of Cassava Peel Juice against Electrode Distance

Measurement of Current Density Against Electrode Surface Area

This measurement was carried out to determine the amount of electric current produced from cassava peel electrolyte juice with an electrode distance of 1.5 cm and an electrode depth of 0.5 cm to 4 cm. A series of pairs of negative electrodes and positive electrodes were placed on cassava peel juice which is connected to an alligator clip. A digital multimeter was used to obtain current value data in cassava peel juice with 100 ohms. Measurement of current density against the surface area of cassava peel juice is shown in Fig.-5.

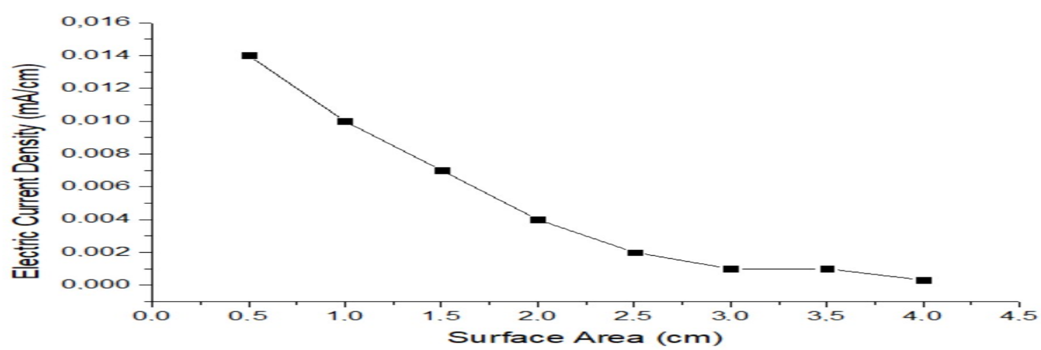

Fig.-5: Graph of Electric Current Density of Cassava Peel Juice against Surface Area

The measurement data above with the difference in the surface area of the electrodes also shows a tendency for the current density to get smaller. This is because the current density at the electrode surface is a process of transferring electrons in a very thin interfacial area on the electrode surface, and involves the relationship between the electrode and ions or electrically active matter.[16] So, in measuring the current density in cassava peel juice with the addition of the electrode surface area dipped in the electrolyte (cassava peel juice). The speed of the reaction that occurs on the surface of the electrode determines the amount of current produced.[13,14,17]

Making Activated Charcoal as a Media

This research is one of the steps/methods taken to reduce environmental pollution, especially solid waste sourced from households, namely by utilizing waste cassava bark which is no longer used by the local community by turning it into activated charcoal to replace batteries. In the process of making activated charcoal, starting with cleaning the cassava bark with running water, then the cassava peel must go through a dehydration stage, namely to remove the water content in the peeled cassava. The dehydration process in the sun for two days until the cassava skin becomes dry.[11] The dried cassava peel at 400 ˚C for 1 hour until it becomes charcoal. This process is known as pyrolysis which will only leave carbon as the end product. This event is known as carbonization. The carbon produced is the result of burning cellulose from the cassava bark then sieved on 100 mesh. They are filtering functions to reduce the shape.[18] Cassava peel charcoal is then activated through chemical activation which aims to replace battery carbon in commercial batteries. Activated charcoal is used or chosen because charcoal has a carbon element with type C which can be used as a corrosion inhibitor on metals due to the acidic nature of the electrolyte solution. In addition, charcoal also has pores on its surface that can easily absorb other materials because element C has an atomic mass of 6, so it has 4 free bonds that can bind to other elements.[19-20] The process of mixing this material is carried out to make a battery content become a solid, not a liquid. This solid form of battery charge is used to avoid rapid corrosion of the electrode surface. In addition, the liquid form of the battery is not effective enough to be applied as a single electrolyte (cassava peel juice) because it can cause a precipitate if left for a long time so it cannot keep the voltage stable. Therefore, mixing electrolyte materials using cassava bark charcoal is used, which is a type of carbon. This charcoal aims to prevent corrosion on electrode plates made of metal, and as a reservoir of water that can be absorbed has twice as much volume as using only orange juice as the electrolyte.[19-20]

Bio-Battery Testing on the Wall Clock

The test was carried out by inserting 10 grams of activated charcoal into a 1.5 Volt ABC battery with the addition of 20 ml of cassava peel juice. The result obtained is that the bio-battery can be lit on the wall clock for 8 hours. This is because the bio-battery used has a voltage below 1.5 Volts so that the bio-battery does not last too long.

CONCLUSION

The optimum electrode distance is at a distance of 0.5 cm which produces a voltage of 0.563 V and a current of 0.014 mA. The electrode distance affects the voltage and current produced, the closer the electrode distance, the greater the distance between the voltages and the resulting strong current. In addition, the large pH value also greatly affects the voltage and current strength, the smaller the pH value (strong acid), the greater the voltage and current produced, and vice versa, the greater the pH value, the smaller the voltage and electric current value of the solution.

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CONFLICT OF INTERESTS

The authors declare that there is no conflict of interest.

AUTHOR CONTRIBUTIONS

All the authors contributed significantly to this manuscript, participated in reviewing/editing and approved the final draft for publication. The research profile of the authors can be verified from their ORCID ids, given below:

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