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Examining Activator and Carbonization Pineapple Crown Leaf Resistor: Wuluh Star Fruit and Calamansi Variant

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Abstract. Learning in the environmental physics course is directed at sharpening students' sensitivity to overcoming problems and utilizing the potential that exists in the environment. Waste management is the main focus in environmental physics learning, which in this research is pineapple crown leaf waste which has the potential as activated carbon to be processed into resistors. The purpose of this study was to test the activator and carbonization tool for pineapple crown leaves with the highest inhibition value. This activator is in the form of Wuluh star fruit and Calamansi. The carbonization tools are an infrared stove and a blue flame twister furnace. This research method is in the form of an experiment. This activity research is integrated with the STEAM-2C components. The data analysis technique is in the form of comparing the average resistance values of the pineapple leaf resistor variations. It was found that R_{AI} = 0.067 MΩ; R_{A2} = 0.16 MΩ; R_{BI} = 0.12 MΩ; R_{B2} = 0.14 MΩ. It was concluded that the activator and carbonization tool for pineapple crown leaf with the highest inhibition values were the Calamansi activator and Infrared stove carbonization tool. This research is expected to add insight into producing innovations that are tested experimentally as the implementation of environmental physics learning.

Key words: activator; carbonization; pineapple crown; resistor; steam.

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INTRODUCTION

Environmental physics learning requires students to be sensitive to natural phenomena that occur and environmental impacts on activities caused by humans and those that occur naturally. These various things ultimately lead to solutions to overcome problems and take advantage of the potential of the existing environment. This research explains how nature (environment) can be used to produce new findings in the form of resistor products.

Charcoal resistors or carbon resistors are resistors made with the main material of charcoal or carbon rods (Basri & Dedi, 2018). Resistors in this study are made from natural materials obtained from the environment, namely pineapple leaves which are processed into carbon powder. The nature of the active carbon of pineapple leaves or in Latin *Ananas comosus* (L.) Merr. It has been widely researched (Setiawan et al., 2017; Firman et al., 2019).). However, there has never been research on pineapple crown leaves that can be used as a resistor, so this research presents an innovative product in the form of a pineapple crown leaf-based resistor. Pineapple leaves contain 25.33% cellulose (Mayangsari et al., 2019), and pineapple crown leaves have a high cellulose content (Keon et al., 2018; Sriandriani et al., 2020). In order for this pineapple crown leaf to become carbon, then need to be carbonized at a high heating temperature.

Carbonization is a conversion process from an organic substance into carbon or carbon-containing residues in the process of making carbonaceous charcoal (Ridhuan & Joko, 2016). Charcoal or activated carbon can be synthesized from biomass (Kristianto, 2017), like a plant stem (Emmy et al., 2017). In this study, carbonization was carried out by burning pineapple crown leaves so that the water content and other materials in the crown leaves were lost pineapple that is not needed by charcoal such as (Ridhuan & Joko, 2016) hydrogen and oxygen or volatile materials. The rapid carbonization process ranging from 50-300℃ is called primary pyolysis which produces charcoal (Pari, 2004). The temperature has an effect on pyrolysis in the carbonization process in terms of the quality of the activated carbon produced (Melki, 2018). Pyrolysis is the process of decomposition of a material at high temperatures in the absence of air or with limited air (Ridhuan & Joko, 2016). Physical changes result from the carbonization process, including, color, sound, flame, hardness, and fragility (Fauziah, 2009). The color changes to jet black produce a " Kress.. kress" sound, can light up (fire out) when the temperature is high even though it is not in direct contact with the fire, has a hard or crisp texture, and is very brittle or breaks easily if hit or pressed even with great force low. This shows that the physical properties of carbonization which in this study are in the form of pineapple crown leaves are easier to make into carbon powder.

Carbon powder comes from the carbonization of a substance followed by certain processing, such as pounding or grinding using a mortar. Carbon powder forms a separate unit structure from one another, so it is necessary to activate it to convert the carbon powder material into an adsorbent. Carbon can be activated (Rahmadani & Puji, 2017; Esthi et al., 2017). Activation is a treatment for enlarging the pores of charcoal by breaking hydrocarbon bonds or oxidizing surface molecules so that the charcoal undergoes changes in physical and chemical properties, namely the surface area increases and affects the adsorption power (Sembiring & Sinaga, 2003), called an activator. The activators in this study were the juice of Wuluh star fruit and Calamansi.

Wuluh star fruit whose Latin language is *Averrhoa Bilimbi* is a fruit that has pH 2 and contains high levels of acid (Aminonatalina, 2016) one of which is citric acid, $C_6H_8O_7$ (Aminonatalina, 2016; Wiradimadja, 2015). There have been many studies on Wuluh star fruit, some of which are used as a source of electricity (Suryaningsih, 2016; Sulaiman & Romadhoni, 2020; Wibowo, 2020). This shows that Wuluh star fruit can be used as one of the activators in this study. Likewise, the selection of calamansi as an activator because can also be a source of electricity (Nabila et al., 2017). Calamansi whose Latin is *Citrofortunella microcarpa* has a low acid content which also contains citric acid with pH 2,53 (Budiyanto et al., 2019). These two activators are considered suitable as independent variables in this study because they can be used as a source of electricity, contain citric acid, and are acidic but both have different pH levels, calamansi is higher than Wuluh star fruit. In addition to the variety of activators, heating devices used in the carbonization process are also varied. This carbonize uses an infrared furnace and a blue flame twister furnace. This variation is intended to be able to investigate whether there are differences in carbonization results from different ignition sources in terms of the resistance value of the pineapple crown leaf resistor produced.

Research activity on pineapple crown leaf resistor in this study was integrated with the STEAM-2C. The various stages carried out lead to Science, Technology, Engineering, Art, Mathematics, Culture, and Communications. STEAM is a modification of STEM, it’s a study of an object with a cross-field review (Anjarsari, 2019; Ramli, 2017). STEAM-2C is considered to be able to optimize students' ability to generate innovation so that the research direction becomes clear and structured. In this study, STEAM-2C methods have started from the preparation, and process, to the resulting output. This study aims to test the activator and carbonization tool for pineapple crown leaves with the highest inhibition value. The benefit of this research is to add insight that everything in the environment (nature) can be utilized and tested through simple experiments so as to produce new innovations. This is in line with the objectives in the environmental physics course, where this research is the implementation of environmental physics learning.

METHODS

This research method is the form of quantitative research with experimental design. The independent variables in this study were the type of activator (Wuluh star fruit and Calamansi), and the type of carbonization heating device (infra-red and blue flame twister furnace). The dependent variable is the result of measuring the resistance value of the pineapple crown leaf resistor with a variation of the independent variable. The control variables were the initial mass of the pineapple crown leaf used, the volume of the given activator solution, the same process in making and measuring, resistor measuring, and the same place (indoor laboratory).

The experimental steps in this study are as follows. (1) Pineapple crown leaves are cut into small pieces and weigh 2 x 30 gr; (2) The pieces of the pineapple crown are heated to a maximum (constant) temperature with an infrared stove, and repeat on a blue stove; (3) the carbonization process ends and the stove is turned off when the pineapple crown leaves turn dry, has a hard and brittle texture, is black in color (perfect), does not emit gas/smoke, and ignites (sparks out); (4) pineapple leaf carbon is immediately crushed with a mortar and pestle into carbon powder; (5) the mass of carbon powder was weighed 3 times and it was recorded; (6) carbon powder is added with Wuluh star fruit activator then mix thoroughly, repeat for Calamansi; (7) reweigh the dissolved mass, recorded; (8) compress activated carbon powder in a thick plastic tube with a stainless compress stick; (9) each side of the end is planted with wire; (10) each side is glued and dried with a hair dryer; (11) the resistance value is measured with a digital multi meter, and recorded.

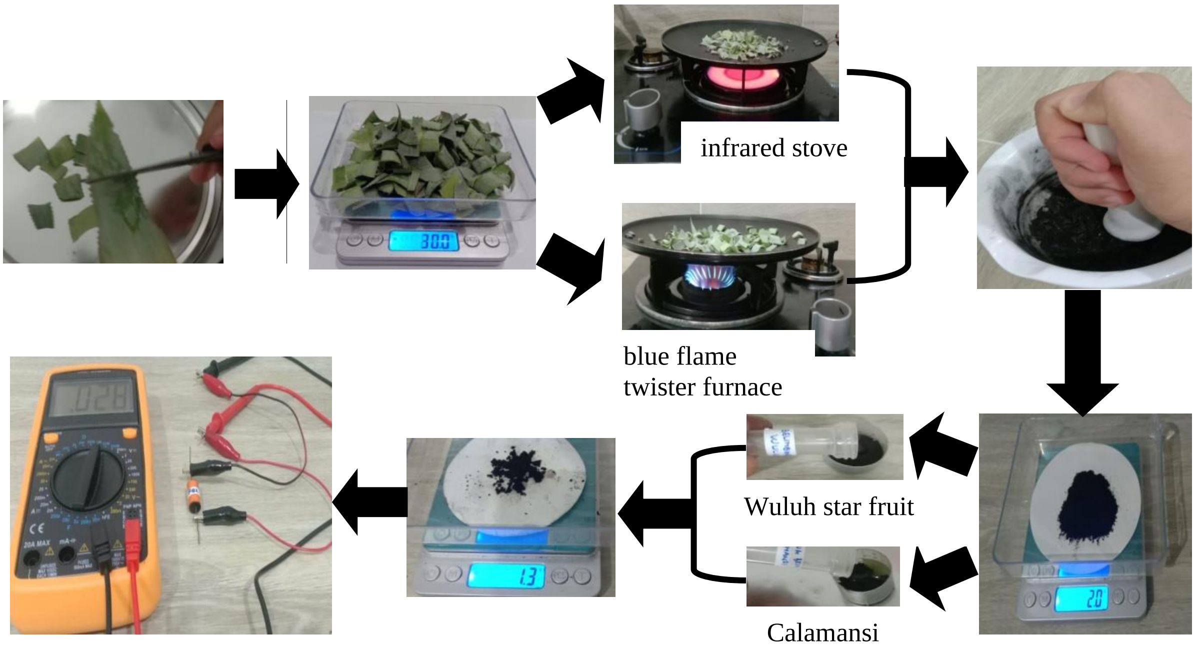


Figure 1. Procedure Pineapple Crown Leaf Measuring

Besides being able to be seen from changes in color, sound, flame, hardness, and brittleness, the carbonization results of carbon powder can also be determined by changes in the density of the substance (Fauziah, 2009), which in this study was determined by comparing the density of carbon in pineapple crown leaves in terms of the type of activator and the carbonization tool used as a variable, and calculated using equation (1).

$$density\ (\rho) = \frac{mass\ (m)}{volume\ (V)} \qquad (1)$$

This research was conducted in a laboratory to maintain the stability of external factors affecting the results. To simplify the measurement process, the variable resistor variations in this study are symbolically described as follows.

Table 1. Variables of Pineapple Crown Leaf Measuring

Carbonation Tool	Activator	
	Wuluh star fruit (1)	Calamansi (2)
Infra-red Furnace (A)	R_{A1}	R_{A2}
Blue Fire Twister Furnace (B)	R_{B1}	R_{B2}

Based on Table 1, there are two classifications of groups of independent variables with a total of four variations of variables, namely two activator variables (Wuluh star fruit and calamansi), and two variables for carbonization tools (infra-red furnace and blue flame twister furnace). The measurement of resistance value of each pineapple crown leaf resistor is measured with 5 repetitions, and the average value is taken to minimize measurement errors. A comparison of resistance values from the measurement results of each pineapple leaf resistor is intended to determine the type of pineapple crown leaf resistor that has the highest resistance value from each variable classification.

This activity research is integrated with the STEAM-2C components, which are described as follows. Science (S): knowledge of activated carbon contained in pineapple leaves, Wuluh star fruit can conduct electricity (potentially as an activator), and the carbonization process can be carried out by heating using a stove. Technology (T): there are tools to support the resistor manufacturing process with a variety of activator and carbonization tools with the help of technology; Engineering (E): the process of making pineapple crown leaf resistors with variable manipulation; Art (A): there is variable manipulation in the form of variations of activators and carbonization tools; Mathematics (M): the process of calculating and measuring data on changes in the mass of objects before and after the carbonization process, the length of time complete carbonization occurs, measuring the resistance of resistors with different activators. Culture (C): the inference process whose results are linked back to the environment or nature, the basic materials used are derived from natural potential in the surrounding environment that has the potential as waste, namely pineapple leaves; Communications (C): communicated with the team in determining the appropriate culture/nature potential to be explored, the right activator to be used, and the comparison of the appropriate carbonization tool to be used (infra-red stove and a blue flame twister furnace).

RESULTS AND DISCUSSION

It was found that there was a difference in mass before and after the carbonization process (initial mass of fresh pineapple crown leaf and final mass (pineapple crown leaf carbon powder), different time intervals in the complete carbonization process in the infra-red furnace carbonization apparatus (Sample A) and blue flame twister furnace (Sample B).

Table 2. Mass and Time Data

Sample	Time-lapse (t) (minute)	Initial mass, m_1 (g)	Final mass, m_2 (g)	Mass loss ($\Delta m = m_2 - m_1$) (g)
A	19	30	1.9	28.1
B	25	30	2.0	28

Based on Table 2, there are large changes in the mass of pineapple crown leaves before and after the carbonation process. The mass of fresh pineapple crown leaves of 30g can produce ± 2 g. So, one's resistors with a length of 1.5 cm with a diameter of 0.8 cm require 15 g of fresh pineapple leaves, so 4 resistors mean 4 x 15 g = 60 g of fresh pineapple leaves. There is a difference in mass change (Δm) of ± 28 g. This is because, during the carbonization process, pineapple crown leaves cause the burning of substances there in contained (Fauziah, 2009). Resulting in the formation of activated carbon (Setiawan et al., 2017; Firman et al., 2019; Mayangsari et al., 2019). In addition, the carbonization time interval between the infra-red stoves was faster than the blue flame twister furnaces, but the difference in shrinkage or mass loss due to the evaporation of substances contained in the pineapple crown leaf was found to be very small, only ± 0.1 g with 3 times repeat the mass measurement. The carbonization process is faster on the infra-red stove because the furnace with an infrared stove has a larger surface area of 150mm with an even temperature at each point; gas and air mix perfectly so that the gas burns completely, and no gas is wasted before burning; The red flame covered in the infrared frame keeps the fire trapped in the frame, thus achieving a high stability of heating resistance because the infrared fire is not easily extinguished by wind or spilled water. In addition, there is a possible energy difference between heating (carbonization) of pineapple crown leaf carbon powder using an infra-red furnace and a blue flame twister furnace, which is considered necessary to be investigated in further research.

Pineapple crown leaf carbon powder was given as much as 1.5 ml of activator for each treatment, so that the density can be measured and calculated by equation (1).

Table 3. Density of carbon powder of pineapple crown leaf for each variable

Sample		Carbon powder mass (g)		Mass of dissolved carbon powder (g)		Density $(\boldsymbol{\rho}) = \frac{\boldsymbol{m_t}}{\boldsymbol{V}}$, (g/ml)
A	1	0.9	1	1.2	1	0.8
	2	0.9	2	1.2	2	0.8
B	1	1	1	1.3	1	0.87

2	1	2	1.3	2	0.87

Based on Table 3, the smallest density is carbon powder from pineapple crown leaf in an infrared stove with both activators. This is because the dissolved mass of carbon powder of pineapple crown leaves is smaller in carbonization with an infrared furnace. The results of carbonization of pineapple crown left in this study have physical characteristics similar to the previous explanation (Fauziah, 2009), that is a change in color from green to perfect black, dry, easy to grind, ignite, or emits sparks even without direct contact, does not emit gas or smoke, causing black traces/spots, physical shrinkage, and changes in mass and density.

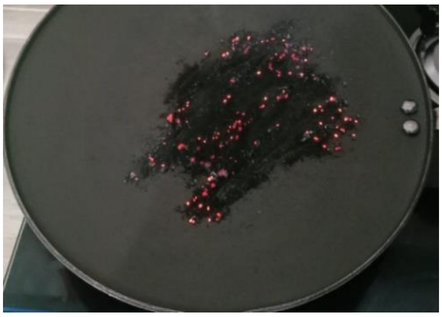


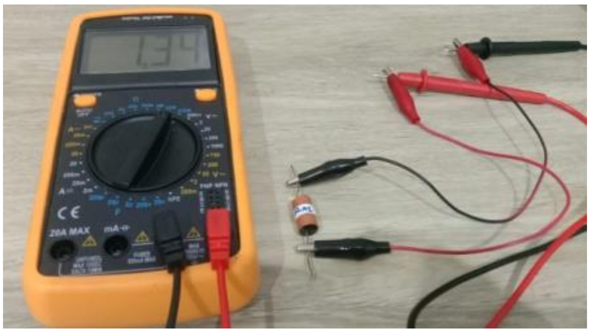
Figure 2. Pineapple crown leaf carbonization

This pineapple leaf resistor is measured for its resistance value using a digital multi meter as many as 4 resistors with different variations of variables. Measurements were repeated 5 times.

Table 4. Data on the measurement results of resistor values

Resistor Code	Repeat of Resistor Values					Average
	1 (MΩ)	2 (MΩ)	3 (MΩ)	4 (MΩ)	5 (MΩ)	
R_{A1}	0.067	0.067	0.067	0.067	0.068	0.067
R_{B1}	0.12	0.12	0.12	0.12	0.12	0.12
R_{A2}	0.16	0.16	0.16	0.16	0.16	0.16
R_{B2}	0.14	0.14	0.14	0.14	0.14	0.14

Data Table 4 is the result of data recapitulation from the numbers listed on the digital multi-meter screen multiplied by the direction of the player switch, 20 MΩ, one of which is exemplified below.



$R_{layer} = 1.34/20$ MΩ
$R_{layer} = 0.067$ MΩ

Figure 3. Measurement of Resistor Methods

The pineapple crown leaf resistor produced in this study is physically shown in *Figure 4* as follows.

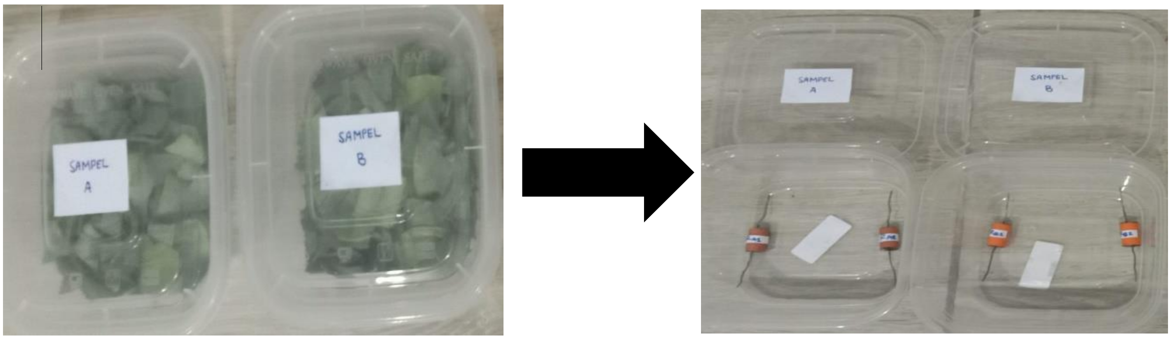


Figure 4. Pineapple crown leaves resistor

The resistor that has the highest resistance value in terms of the type of carbonization device and its activator is R_{A2}. R_{A2} shows that the type of carbonation tool in the form of infra-red and the type of activator in the form of calamansi have the highest resistance value. It is buried in a stove with an infra-red furnace which produces a density of smaller yields compared to the density in a blue flame twister furnace. Density value affects the quality of carbonization (Fauziah, 2009). Calamansi activator has a pH level higher than Wuluh star fruit (Aminonatalina et al., 2016; Budiyanto et al., 2019) the higher the final pH the less the binding capacity decreases (Zulfahmi, 2010), so the resulting resistance value is higher. However, the resulting resistance value is very high, namely Mega Ohm or 10^6 units so the resistor from the pineapple crown leaf cannot replace the manufacturer's resistor which has a small resistance value. This is because the material obtained is purely natural, so the high resistivity in its inertness has the possibility of being a natural antidote to these plants against lightning and various other environmental consequences.

The results of this study can be sure that the environment (nature) can be used as research material, where the sensitivity of students to environmental phenomena both from existing problems and looking for solutions and looking at the potential that exists in the environment becomes a benchmark in getting ideas. The product of innovation and additional knowledge insights as the results obtained in this research are expected to be a vehicle for students to be more open to learning that leads to nature and across fields through STEAM-2C.

CONCLUSION

The conclusion in this study is the activator and carbonization tool for pineapple crown leaf with the highest inhibition values are Calamansi activator and Infrared stove carbonization tool.

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