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AVSEED BATTERY: ENVIRONMENTALLY FRIENDLY BATTERY INNOVATION AS ELECTROLYTES IN DRY BATTERIES

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ABSTRACT

Energy is a fundamental force driving transformative processes across various domains. It is perpetual and adheres to the law of energy conservation, remaining indestructible. However, the challenge lies in the finite nature of conventional energy sources, which convert energy for intended purposes and cater to diverse needs, often escalating the overall cost. Among the commonly employed energy sources, batteries play a pivotal role. This study explores the viability of avocado seeds as potential electrolytes in dry batteries. The objectives are to assess the effectiveness of avocado seeds as electrolytes and to investigate the impact of solution concentration and composition on the generated electrical energy. A dry element battery, known for converting chemical energy into electrical energy through Redox (Reduction-Oxidation) electrochemical reactions, serves as the experimental focus. Using a quantitative approach with laboratory experiments, five treatments were administered, featuring different ratios (1:1, 1:2, 1:3), a negative control with avocado seeds, and a positive control with salt. The bio-battery effectiveness assessment revealed that the P4 composition (negative control with avocado seeds) exhibited the highest initial voltage of 3.4 V and an extended runtime of 156 hours. In summary, this research underscores the potential of avocado seeds as electrolytes in dry batteries, supported by observations of voltage levels and ignition times.

Keywords*: avocado seeds, batteries, energy, environment.*

I. INTRODUCTION

ENERGY is essential for all transformative processes. According to the law of conservation of energy, it is eternal and cannot be destroyed. The problem is that conventional energy sources are limited and multifunctional, serving not only to convert energy but also to meet various needs, sometimes escalating their cost. One commonly used energy source is batteries, also known as dry elements.

A battery is a device capable of producing electrical energy and voltage by converting the chemical energy within it into electrical energy through electrochemical reactions, specifically Redox (Reduction-Oxidation) reactions. The presence of heavy metals such as mercury, lead, cadmium, and nickel in batteries contributes to environmental pollution and poses health risks if not properly managed. Batteries are classified as Hazardous and Toxic Materials (B3), which can potentially explode when exposed to water or heat, causing acute poisoning, systemic disorders, and even death [1]. In Indonesia, the use of dry batteries is approximately 500 million pieces per year, leading to the accumulation of battery waste that pollutes the environment. Therefore, there is a need to innovate new, environmentally friendly energy sources [2].

One natural resource that can be used as an energy source is avocado seeds. According to data from the Food Crops and Horticulture Office of North Sumatra Province [3], avocado production in the last three years was 8,574, 10,319, and 11,832 tons. With increased avocado production, the waste from

TABLE 1
TAXONOMY OF AVOCADO PLANTS

Classification	Name
Kingdom	*Plantae* (plants)
Subkingdom	*Tracheobionta* (Vessel-bearing plants)
Super Division	*Spermatophyta* (Produce seeds)
Division	*Magnoliophyta* (Flowering Plants)
Class	*Magnoliopsida* (Two-piece/dicotyledonous)
Sub-classes	*Magnoliidae*
Order	*Laurales*
Family	*Lauraceae*
Genus	*Persea*
Species	*Perseaamericanamill*

TABLE 2
CONTENT OF SECONDARY METABOLITES IN AVOCADO SEEDS

	Test Methods	Result
	Mayer Reagent	++
Alkaloids	Wagner reagent	+
	Dragendorff reagent	++
Triterpenoids	Liebermann-Burchard Test	+++
Tannins	FeCl3	++
Flavonoids	Ethanol	++
Saponins	Distilled water	+++

TABLE 3
THE FATTY ACID COMPOSITION OF AVOCADO SEED OIL

Fatty Acids	Total (%)
Palmiic acid (C16:1)	11.85
Palmitooleic acid (C16:1)	3.98
Stearic Acid (C18:0)	0.87
Oleic acid (C18:1)	70.54
Linoleic Acid (C18:2)	9.45
Linolenic acid (C18:3)	0.87
Arachidic acid (C20:0)	0.50
Eliosenic Acid (C20:1)	0.39
Bechenic Acid (C22:0)	0.61
Lignofiber Acid (C24:0)	0.34

avocado seeds also increases. Currently, avocado seeds are used as food coloring, antidiabetic agents, insecticides, and antimicrobials [4]. However, their use as bioenergy is not yet optimal. Therefore, this study aims to utilize avocado seeds as a source of bioenergy. According to Halimah [5], avocado seed extract contains polyphenols, flavonoids, triterpenoids, and quinones.

The objectives of this study are to determine if avocado seeds can be used as an electrolyte paste in dry batteries, to assess the effectiveness of avocado seeds as an electrolyte paste, and to evaluate the effect of solution concentration and mixture composition on the electrical energy produced. The benefits of this research include reducing reliance on fossil fuels by using environmentally friendly energy, minimizing organic waste from avocado seeds to prevent environmental pollution, and increasing public awareness of bioenergy made from avocado seeds.

Avocado is a popular fruit in Indonesia, commonly used in various food and drink preparations. With the increasing consumption of avocados, the amount of avocado waste also rises. Seeds and skins are often discarded because many people are unaware of their potential uses. Therefore, it is essential to find solutions to better utilize avocado waste to mitigate environmental waste problems. Avocado (Persea americana Mill) is a plant native to Central America with a tropical climate, now widespread in subtropical and tropical countries, including Indonesia. Avocados are available in every season. The avocado fruit consists of 65% flesh (mesocarp), 20% seed (endocarp), and 15% skin (pericarp). Table 1 provides the taxonomy of avocado plants.

Avocado seeds contain valuable compounds but have not been optimally utilized. Chemical testing of avocado seed extract shows that avocado seeds contain secondary metabolites such as alkaloids, tannins, flavonoids, triterpenoids, and saponins [6]. Table 2 presents the content of secondary metabolites in avocado seeds.

Malangngi [7] reported that avocado seed extract contains tannins. Tannins are widespread in plants, including leaves, immature fruits, stems, and bark, and are sources of acidity in fruits. Avocado seeds contain various beneficial fatty acids, each with a different percentage, as shown in Table 3.

The development of modern times is accompanied by an increasing demand for energy, particularly for dry batteries. A battery is a device that produces electrical energy and voltage by converting the chemical energy within it into electrical energy through electrochemical reactions, specifically Redox (Reduction-Oxidation) reactions. Batteries are categorized into two types: primary batteries, which are disposable, and secondary batteries, which can be recharged. Primary batteries are the most commonly found on the market, such as zinc-carbon batteries (dry batteries). The contents of a dry battery include a mixture of carbon powder, manganese dioxide, and ammonium chloride in the form of a dry paste [8].

The components of a dry cell battery are as follows: the positive pole (*cathode*) is made of carbon rods (C), the negative pole (*anode*) is made of zinc (Zn), the electrolyte solution is made of ammonium chloride (NH_4Cl), and the depolarizer is made of manganese dioxide (MnO_2) [9]. Zinc metal is used as the anode, while the cathode uses an inert electrode, such as graphite, placed in the middle of the paste, which acts as an oxidizer. Zinc undergoes oxidation according to (1). The cathode consists of a mixture of MnO_2 and NH_4Cl. The reaction at the cathode can be described by (2). Thus, the overall reaction is represented by (3).

$$Zn(s) \rightarrow Zn^{2+}(aq) + 2e^-(anode) \quad (1)$$

$$2MnO_2(s) + 2NH_4{}^+(aq)2e^- \rightarrow Mn_2O_3(s) + 2NH_3(aq) + H_2O(l) \quad (2)$$

$$Zn(s) + 2MnO_2(s) + 2NH_4{}^+(aq) \rightarrow Mn_2O_3(s) + Zn^{2+}(aq) + 2NH_3(g) + H_2O \quad (3)$$

NH_3 combines with Zn2+ to form the complex ion $[Zn(NH_3)_4]^{2+}$. These dry cells cannot be reused and have a short lifespan. Therefore, batteries are a crucial solution for managing a developing economy and must be a focus for renewable innovation in Indonesia [10]. The working principle of a battery is based on electrochemical processes utilizing reduction-oxidation reactions. In this process, the negative electrode (anode) undergoes oxidation, releasing electrons, which are then carried by electrolyte ions to the positive electrode (cathode). This electron transfer produces a voltage difference and electric current when connected to electronic components such as diodes, resistors, or capacitors [11].

The prediction of the contribution of the improvements offered covers several important aspects. First, the voltage and current generated from avocado seeds show adequate performance to compete with conventional batteries on the market. However, to achieve results comparable to market batteries, additional measures such as compacting the dry paste in batteries and combining it with other organic waste are necessary to create more environmentally friendly batteries. In the industrial sector, these improvements can contribute to the health of workers previously exposed to hazardous chemicals. By using organic waste, not only can the risk of work accidents be avoided, but further benefits such as the production of organic fertilizer from unused waste can be achieved. Finally, this solution provides additional flexibility for users, as discharged batteries can be recharged by purchasing their contents alone or by buying new batteries at a more economical price compared to conventional chemical batteries. Thus, these improvements not only offer a safer and greener alternative, but also have the potential to bring positive economic and health impacts.

Previous research addressing energy needs through bio-batteries has involved the use of banana peels and fruit and vegetable waste. Studies found that banana peels, especially from Ambon bananas, can be used as battery electrolytes because they contain electrolytes such as potassium and chloride salts. The interaction between potassium and chloride salts allows electricity to flow [12]. Meanwhile, bio-batteries using fruit and vegetable waste produce lower voltage compared to commercial batteries. For example, citrus fruit waste produces a voltage of 0.95 volts and an electric current of 0.45 mA, while commercial batteries have a voltage of 1.5 volts and a current of 2.25 mA. Despite the significant difference in voltage values, the citrus fruit waste bio-battery can power an LED light for 75 hours, with an average starting voltage of 2.9 volts and turning off at 2.31 volts [13]. Therefore, this solution utilizes

TABLE 4
COMPOSITION OF INGREDIENTS FOR MAKING A MIXTURE OF AVOCADO SEEDS WITH SALT

Material	P1	P2	P3	P4	P5
Salt	18 grams	12 grams	9 grams	0 grams	36 grams
Avocado seed powder	18 grams	24 grams	27 grams	36 grams	0 grams

natural resources and organic waste as an alternative energy source, although it still needs improved performance to compete better with conventional batteries.

II. RESEARCH METHOD

This study employed a quantitative approach with laboratory experimental methods and included five treatments: ratios of 1:1, 1:2, 1:3, a negative control with avocado seeds, and a positive control with salt. Literature methods were also used to gather information on batteries, energy, avocado seeds, and related topics [14]. The avocado seed paste was prepared by cutting the seeds into small pieces, mashing them with a blender, and filtering the mixture before weighing. The avocado seed powder and salt were then weighed and incorporated into the battery. Five types of treatments were created, with ratios of 1:1, 1:2, 1:3, a negative control, and a positive control, as outlined in Table 4.

Battery manufacturing used discarded dry batteries or battery waste. The batteries were opened, emptied, thoroughly washed with water, and dried. They were then filled with a mixture of avocado seed powder and salt [15]. The electrode rods were removed by peeling off the outer shell with a knife and pliers. After removing the outer shell, the next step was to extract the electrode rods. The battery tip was first cut to separate the cap from the electrode rod and the carbon-containing battery body. This process was done carefully to avoid damaging the electrode rods connecting the positive and negative poles. It was recommended to wear gloves to prevent contamination and reduce direct contact with battery chemicals. After removing the electrode rods, hands should be washed thoroughly with soap and running water. The carbon was removed by scraping the inner walls of the battery with a screwdriver until all the carbon was expelled. Once the battery was free of carbon, it was filled with electrolyte paste made from processed avocado seed waste.

In the battery charging process, finely processed avocado seed extract was inserted into a battery that had been cleaned of carbon. This was done evenly and slowly to ensure no free space inside the battery. Once the avocado seed extract was inserted, the next step was to seal the end of the electrode rod with an existing cover. The concept of making bio batteries involved combining avocado seed material with other organic waste materials to achieve a more efficient voltage and current, balancing the quality between bio batteries and conventional batteries on the market. At this stage, the battery was packaged by attaching a sticker labeled "AvSeed Battery" to protect it from moisture and damage. Once properly and neatly packed, the battery was ready for use.

Voltage and current measurements of all treatments were taken using a calibrated multimeter. Data collection was carried out over 168 hours, during which measurements continued until the lights went out. The voltage and current measurement data were then entered into Excel. Batteries were manufactured in varying sizes to be more functional in different uses. In smaller batteries, the avocado seed paste was compacted using a machine to achieve better voltage and current. Mashed avocado seeds and salt were placed in a measuring cup, then inserted into the battery and arranged in series with three batteries. This circuit was connected to a small LED lamp with a voltage of 2.5 Volts. The duration the lamp stayed on, the voltage, and the current flowing in the circuit were observed.

Data analysis in this research consists of qualitative data analysis [16]. This method involves collecting explanations about battery contents from various sources, which are then analyzed to obtain substitute references (treatments) for the battery contents. After determining the success of the resulting product, a voltage and electric current strength test was conducted on three batteries arranged in series and connected to a small LED lamp with a voltage of about 2.5 Volts. Measurements were taken every 12 hours until the lamp turned off.

TABLE 5
AVERAGE MEASUREMENT OF ELECTRIC VOLTAGE

MAINS VOLTAGE (V) / MEASUREMENT TIME (HOURS)	P1 (1:1)	P2 (1:2)	P3 (1:3)	P4 (CONTROL NEGATIVE)	P5 (CONTROL POSITIVE)
0	2.4	2.6	3	3.4	2.6
12	2.4	2.2	3	2.6	1.4
24	1.8	2	2.2	3.6	1.2
36	1.8	2.4	2.9	3.1	0
48	1.8	2.2	2.2	2.2	0
60	1.8	2	2	2.2	0
72	1.8	2	2	2.2	0
84	1.8	2	1.8	2.2	0
96	2	1.8	1.8	2	0
108	1.4	1.9	2	2	0
120	0.8	2.3	1.9	1.8	0
132	0	1.6	2	1.8	0
144	0	1.8	2	1.8	0
156	0	0	0	2	0
168	0	0	0	1.8	0

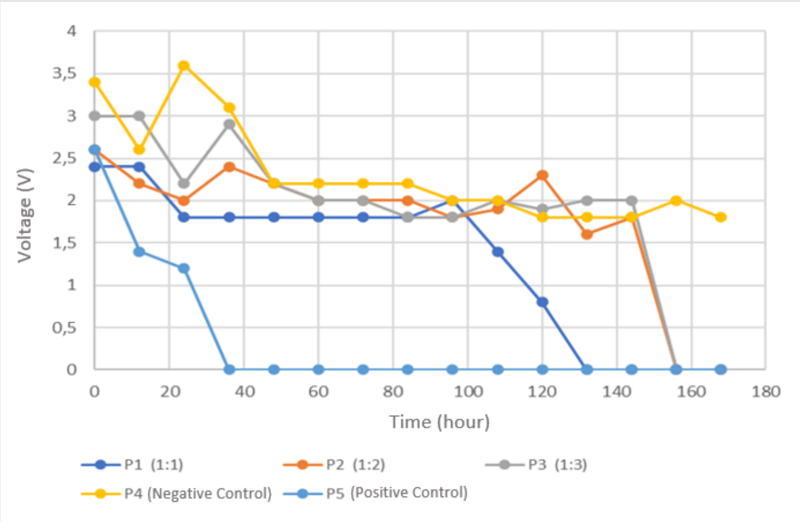

Figure 1. Comparison of Electric Voltage at P1, P2, P3, P4, and P5

III. RESULT AND DISCUSSION

A. Electrical potential of avocado seeds

The potential difference (V) is an indicator of the presence of electricity. Avocado seeds serve as an electrolyte paste, acting as a connecting medium between the anode and the cathode of the battery. The study results showed that all treatments (P1, P2, P3, P4, and P5) were able to produce an electric voltage, as presented in Table 5.

Based on the data in Table 5, the amount of electric voltage produced in each experiment varies. The largest electrical voltage is P4, followed by P3, P2, and P1, due to differences in the composition of the materials used. Avocado seeds are most abundant in P4, followed by P3, P2, and the least in P1. This shows that avocado seeds are the best electrolyte paste for conducting electric current, resulting in a greater electric voltage than in P1, P2, and P3, which contain fewer avocado seeds, and in P5 without avocado seeds.

Figure 1 represents Table 5 in the form of a line chart, allowing visualization of trends and changes in data over time or in a certain sequence. This line chart makes it easier to identify patterns, trends, and voltage fluctuations from each sample of the percentage of avocado seed composition over time. This graphic is necessary to show that the best voltage is obtained from P4, which has a composition of 36 grams of pure avocado seeds with 0 grams of salt.

TABLE 6
AVERAGE MEASUREMENT OF ELECTRIC CURRENT STRENGTH

Measurement time (hours)	Electric current (mA)				
	P1 (1:1)	P2 (1:2)	P3 (1:3)	P4 (Negative Control)	P5 (Positive Control)
0	0.5	0.30	0.70	0.80	0.070
12	0	0.15	0.50	0.40	0.025
24	0	0.20	0.30	0.40	0.015
36	0	0.20	0.50	0.30	0
48	0.1	0.15	0.40	0.20	0
60	0	0.15	0.40	0.20	0
72	0	0.10	0.20	0.15	0
84	0	0.10	0.05	0.10	0
96	0	0.10	0.05	0.10	0
108	0	0.10	0.07	0.20	0
120	0	0.20	0.10	0.30	0
132	0	0.10	0.10	0.30	0
144	0	0.05	0	0.03	0
156	0	0	0	0.05	0
168	0	0	0	0	0

TABLE 7
THE LEVEL OF EFFECTIVENESS OF AVOCADO SEEDS DURING LED LIGHT OPERATION

TREATMENT	COMPARISON	LIGHT CONDITION		
		DIM	WELL LIT	BRIGHT
P1	1:1		✓	
P2	1:2		✓	
P3	1:3			✓
P4	NEGATIVE CONTROL			✓
P5	POSITIVE CONTROL	✓		

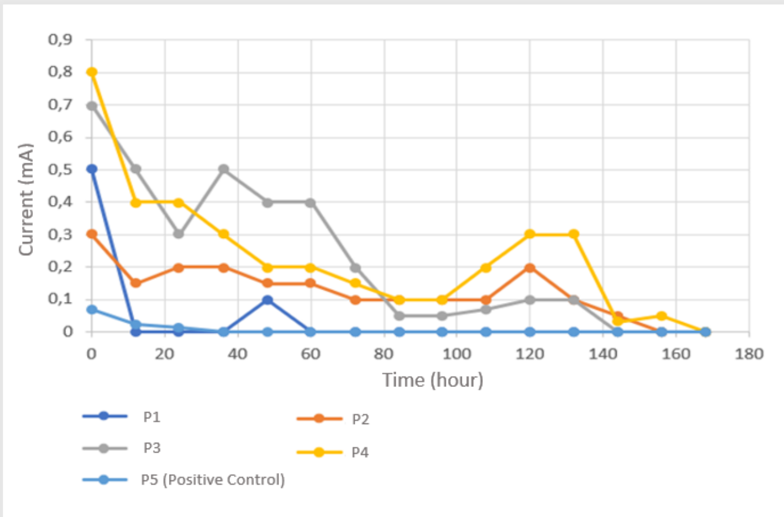

Figure 2. Comparison of Electric Current Strength at P1, P2, P3, P4, and P5

B. Strong electric current from avocado seeds

The strength of the electric current (I) is also an indicator of electricity. Electric current strength is the amount of electric charge that flows per unit of time. The study results showed that all treatments (P1, P2, P3, P4, and P5) were able to produce electric current, as presented in Table 6.

Based on the data in Table 6, the largest current strength is at P4 (negative control), ranging between 0.03-0.8 mA, while the smallest current strength is found at P5 (positive control), ranging from 0.015-0.025 mA. For P1, P2, and P3, the current strengths are 0.1-0.5 mA, 0.05-0.3 mA, and 0.05-0.7 mA, respectively. The electric voltage and current strength decrease over time because the decrease in current strength is directly proportional to the electric voltage. This decrease is due to the release of fewer H+ ions from the anode to the cathode in the battery.

The graph shows that for 12-156 hours, a strong electric current flows in the avocado seed battery. This indicates that avocado seed batteries, when assembled in series, can produce sufficient voltage and strong current to power an LED lamp with a capacity of 2.5 V, as shown in Figure 2.

TABLE 8
EXPLANATION OF LIGHT CONDITIONS DURING APPLICATION

Treatment	Comparison	Information
P1	1:1	• Application starts at 15:00 WIB. • The lamp remains on for 0.5x24 hours.
P2	1:2	• Application starts at 15:00 WIB. • The lamp remains on for 6x24 hours.
P3	1:3	• Application starts at 15:00 WIB. • The lamp remains on for 5.5x24 hours.
P4	Negative control	• Application starts at 15:00 WIB. • The lamp remains on for 6.5x24 hours.
P5	Positive Control	• Application starts at 11:00 WIB. • The lamp remains on for 1x24 hours.

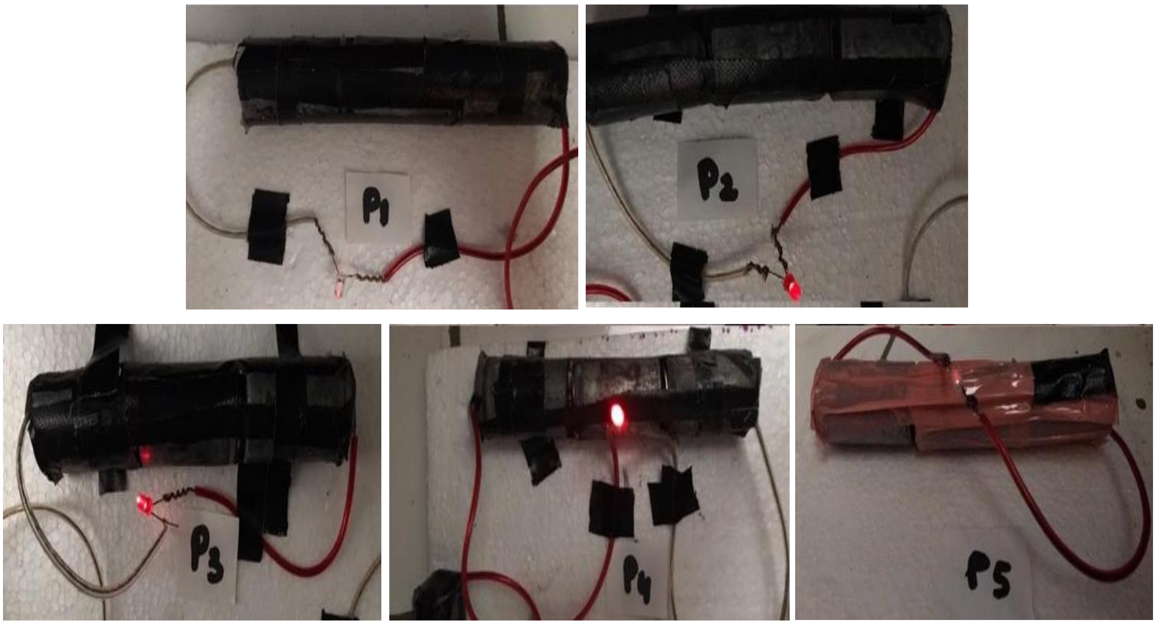

Figure 3. electrical circuits at P1, P2, P3, P4, and P5

Figure 3 illustrates a series of batteries connected to LED lights. The circuit is arranged in series, enabling the battery voltage to power LED lights ranging from 1.8 – 3.2 V. Each avocado battery produces about 1.1 – 1.2 V, so three avocado batteries are needed to power the LED lights. The brightest light is observed in the P4 series, whose battery material is purely from avocado seeds.

From the data in Table 8, it is evident that P4 is more effective at turning on lights compared to P1, P2, P3, and P5, as it can keep the lights on brightly for a relatively long time of 561,600 seconds. This is because avocado seeds contain alkaloid compounds with nitrogen atoms that have free electron pairs. The nitrogen atom in the alkaloid will be partially negatively charged, while the carbonyl carbon atom of the fatty acid (oleic acid being the dominant fatty acid in avocado seeds at 70.54%) will be partially positively charged. These partial positive and negative charges form ionic and polar bonds, producing electrical energy [9]. Although table salt is not used as a paste mixture in the battery, the lamp can still stay on for 561,600 seconds.

Batteries function electrochemically by utilizing the reduction-oxidation process. The negative electrode (anode) undergoes an oxidation reaction, causing electrons on the anode's surface to be released and carried by electrolyte ions to the positive electrode (cathode). The transfer of electrons by electrolyte ions creates a voltage difference and electric current when connected to electronic components such as diodes, resistors, or capacitors.

IV. CONCLUSION

Based on the study results, it can be concluded that avocado seeds can be used as an electrolyte paste in dry batteries. The P4 (avocado seed composition) treatment is more effective in turning on the lamp compared to P1, P2, P3, and P5, as it can keep the lamp brightly lit for a relatively long duration of

561,600 seconds. It is evident that the higher the concentration of avocado seed paste in the battery, the greater the electrical energy produced.

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