e-ISSN: 2355-620X
DOI: 10.12928/jrkpf.v9i1.20

The electrical productivity of Arabica coffee grounds battery based on electrode distance and dryness level

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Abstrak. Bio-battery is an alternative natural energy source that utilizes organic compounds to generate electricity. This research uses coffee grounds as an environmentally friendly electrolyte paste. This study aims to identify and analyze the current and voltage produced by the bio batteries with the durability of bio batteries made from Arabica coffee grounds based on electrode distance and dryness level. The method used is a direct measurement of coffee grounds using copper (Cu) and zinc (Zn) as electrodes, further testing of the output current and voltage is carried out every 24 hours. The results showed that Arabica coffee grounds produce a maximum voltage of 1.01 V, a current of 0.49 mA and a power of 0.42 W. Based on these results, Arabica coffee grounds have the potential to be used as bio batteries.

Keywords: Alternative Energy, Bio battery, Electrolyte Paste, Arabica Coffee.

I. Introduction

Electrical energy is one of the many energies that play an important role in life. Humans make electrical power a basic need after food, clothing, and shelter. That's because the part of electricity is very important in supporting all aspects of life. Data from the Ministry of Energy and Mineral Resources shows that electrical energy consumption in 2015 was only 910 kWh per capita and then increased to 1,084 kWh / capita in 2019. This increase is in line with the electrification ratio, which also increased from 84.35% in 2014 to 98.89% in 2019.

The use of electrical energy in the world from year to year is increasing. Meanwhile, the electrical energy supply sourced from oil, natural gas, and coal has limitations. This is because these materials are non-renewable. In this global era, scientists are conducting research to save energy from natural resources from within the earth. One of them can be seen in the use of batteries as a source of electricity which continues to increase along with technological advances. A battery is a device that can generate an electric current through a chemical process [1]. The battery is made of zinc as an anode, carbon as a cathode, and the electrolyte used in a mixture of manganese oxide (MnO_2) paste, carbon powder, and ammonium chloride (NH_4Cl). The commercially available batteries in use today contain heavy metals such as mercury, lead, cadmium, and nickel. These battery components can pollute the environment because the battery includes hazardous and toxic waste (B3), which is difficult to decompose by microbes and is dangerous [2].

Coffee is one of the most well-known caffeinated beverages, and the commercial level is constantly growing. According to the International Coffee Organization report for 2020/2021, global coffee consumption is 167 million bags. The coffee consumed will leave a residue, and about 90% of the coffee produced ends up

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in coffee grounds or Spent Coffee Grounds (SCG) [3]. Coffee grounds contain 13% cellulose, 42% hemicellulose, 25% lignin, 2% fat and 18% protein [4]. In addition, coffee grounds also contain nitrogen, phosphorus, and potassium [5], [6].

The study of the utilization of coffee grounds has been carried out in the following examinations with applications such as energy storage [7], [8], and alloys for batteries [2], [9], [10]. The focus of this research is to identify the potential of coffee grounds as a bio-battery electrolyte paste material and analyze several factors that influence coffee grounds to produce current and voltage stability. The factors involved in this study were the electrode distance and the dryness of the coffee.

II. Materials and Methods

The method used in this research is the experimental method. Several stages include preparing raw materials, data collection, and data analysis. Preparation of raw materials consists of collecting coffee grounds and then drying with different types of wet, 12 hour, and 24 hour drying. The dried coffee grounds are then mashed, weighed, and put into the prepared container. Electrical characteristics were tested using a multimeter Sanwa CD800a. Current and voltage stability tests were carried out every 24 hours for seven days on various variations of coffee grounds with different electrode distances. The stages of collecting, preparing, and characterizing the electrical properties of coffee grounds are shown in Figure 1.

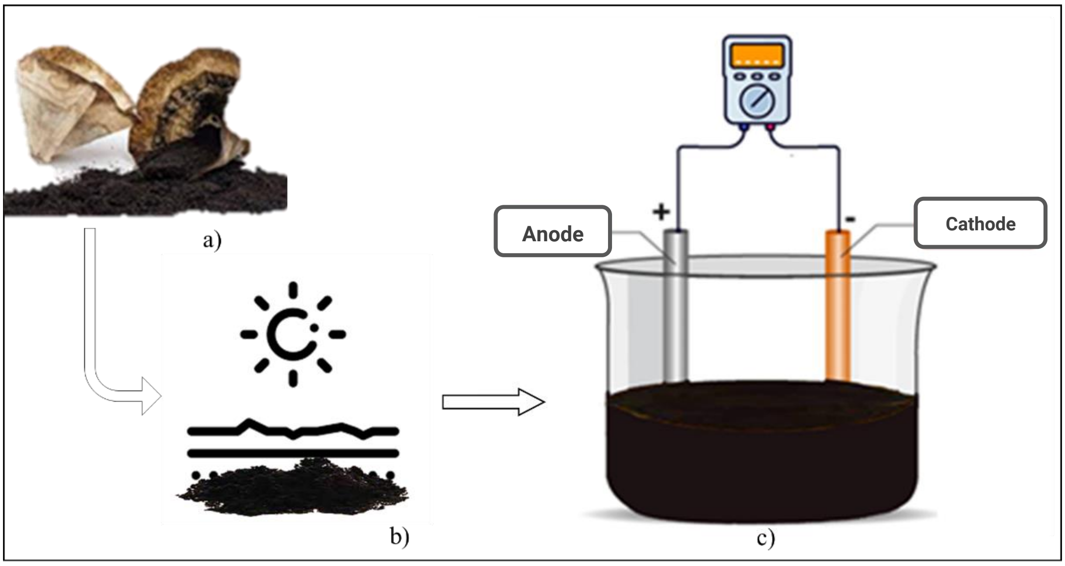


Figure 1. Stages a) Preparation, b) Variation of treatment, and c) Characterization of electrical properties of Arabica coffee grounds

III. Results and Discussion

The study began with the collection of Arabica coffee grounds. The collected coffee grounds were treated with different drying times, including wet, 12 hours, and 24 hours. The dried coffee grounds are ground, weighed, and put into a container. Several electrode spacings of 2 cm, 4 cm, and 6 cm were applied to each sample. The characteristic electrical test and bio-battery stability test made from coffee grounds are shown in Figure 2.

Testing of current and voltage electrical characteristics was carried out using a Sanwa CD800a multimeter. Stability testing of the electrolyte paste was carried out every 24 hours for seven days which had previously been connected to a 100 ohm resistor. Measurement results of voltage (*V*), current (*I*), and power (*P*) on Arabica coffee grounds as bio-battery are presented in the following tables and graphs.

Figure 2. Electrical characteristic and stability test of coffee grounds biobattery

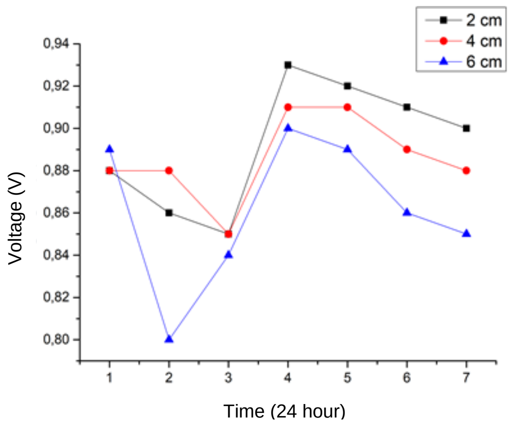
Arabica coffee grounds wet

Arabica coffee grounds are now referred to as Arabica coffee grounds wet. The electrical characteristics obtained at the electrode distances of 2 cm, 4 cm, and 6 cm are shown in table 1.

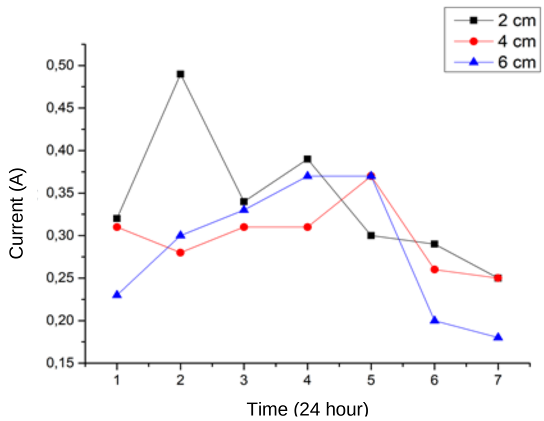
Table 1. Arabica coffee grounds 24 hours with an electrode distance of 2 cm, 4 cm, and 6 cm

Day	2 cm			4 cm			6 cm		
	V (V)	*I* (A)	*P* (W)	*V* (V)	*I* (A)	*P* (W)	*V* (V)	*I* (A)	*P* (W)
1	0.88	0.32	0.28	0.88	0.31	0.27	0.89	0.23	0.20
2	0.86	0.49	0.42	0.88	0.28	0.24	0.80	0.30	0.24
3	0.85	0.34	0.29	0.85	0.31	0.26	0.84	0.33	0.27
4	0.93	0.39	0.36	0.91	0.31	0.28	0.90	0.37	0.33
5	0.92	0.30	0.27	0.91	0.37	0.33	0.89	0.37	0.33
6	0.91	0.29	0.26	0.89	0.26	0.23	0.76	0	0
7	0.90	0.25	0.22	0.88	0.25	0.22	0.73	0	0
Min.	**0.85**	**0.25**	**0.22**	**0.85**	**0.25**	**0.22**	**0.73**	**0**	**0**
Max.	**0.93**	**0.49**	**0.42**	**0.91**	**0.37**	**0.33**	**0.9**	**0.37**	**0.33**
Average	**0.89**	**0.34**	**0.30**	**0.89**	**0.30**	**0.26**	**0.83**	**0.23**	**0.20**

Table results showed that current. voltage. and power values varied. The graph of the relationship between voltage and time is shown in Figure 3a. The existing connection to the time graph is established in Figure 3b.



(a)



(b)

Figure 3. Graph of the relationship a) voltage (V) and b) current (A) against time (24 hours) Arabica coffee grounds wet

Figure 3a) shows that wet Arabica coffee grounds voltage and electric current values fluctuate at an electrode distance of 2 cm. 4 cm. and 6 cm. On the first day. the electrode distances of 2 cm. 4 cm. and 6 cm. respectively. had 0.88 V. 0.88 V. and 0.89 V. The electrode distances of 2 cm and 4 cm from the second day until the third day. experienced a trend of decreasing voltage up to 0.85 V simultaneously. Then on the fourth day. the voltage increased to 0.93 V and 0.91 V. From the fifth to the seventh day. the voltage decreased to 0.90 V and 0.88 V. Meanwhile. The electrode distance of 6 cm on the second day reduced the voltage to 0.80 V and showed a different trend on the third to fourth day. which increased to 0.90 V. then on the fifth to the seventh day it decreased to 0.85 V.

Figure 3b) showed an increase and decrease in current in Arabica coffee grounds wet with electrode distances of 2 cm. 4 cm. and 6 cm for 24 hours. At a distance of 2 cm. the electrode had a current of 0.32 A on the first day. and on the second day. the current increased to 0.49 A. then on the third day. the current decreased to 0.34 A. On the fourth day. the current increased to 0.39 A. and from the fifth day to the seventh day. the current dropped to 0.25 A. Arabica coffee grounds wet with a distance of 4 cm. on the first day had a current of 0.31 A. and on the second day. the current decreased to 0. 28 A. The current increased to 0.31 A on the third day and was stable until the fourth day. Then on the fifth day. the current increased to 0.37 A. From the sixth day to the seventh day. the current decreased to 0.25 A. At an electrode distance of 6 cm on the first day. it has a current of 0.23 A. and from the second day to the fourth day. the current increases until it reaches 0.37 A and are stable until the fifth day. then on the sixth to seventh day the current decreases to 0.18 A.

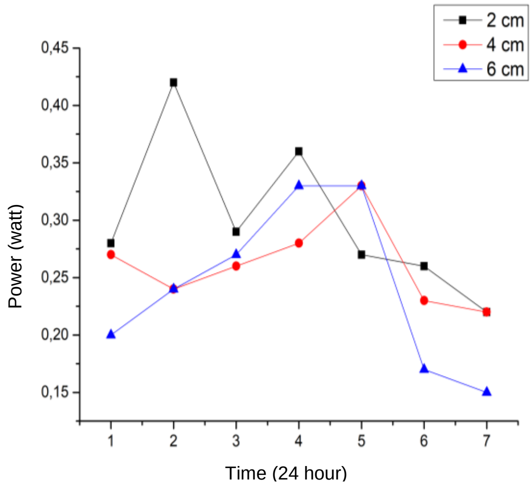


Figure 4. Graph of the relationship between power (Watts) against time (24 hours) Arabica coffee grounds wet

Figure 4 shows a graph of the power produced by Arabica coffee grounds wet with electrode distances of 2 cm. 4 cm. and 6 cm for 24 hours. At a distance of 2 cm. electrodes on the first day have a power of 0.28 Watt. and on the second day. the power increases to 0.42 Watt. then on the third day. the energy decreases to 0.29 Watt. On the fourth day. the power increased to 0.364 Watt. and from the fifth day until the seventh day. the power fell to 0.22 Watt. Coffee Arabica with a distance of 4 cm. on the first day. has a power of 0.27 Watt and on the second day has decreased power to 0.24 Watt. From the third day to the fifth day. the power increased to 0.33 Watt. From the sixth day to the seventh day. the power decreased to 0.22 Watt. At a distance of 6 cm. electrodes on the first day have a power of 0.20 Watt. and on the second day to the fourth day. the power increases to 0.33 Watt and is quite stable until the fifth day. then on the sixth to seventh day the power decreases to 0. 15 Watts.

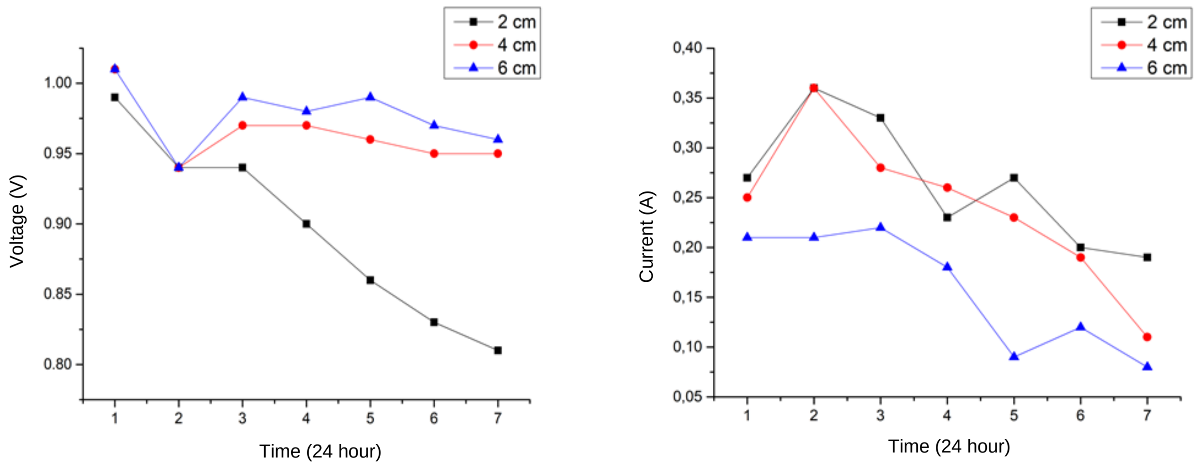
Arabica coffee grounds 12 hours drying

From the research. several results were obtained according to the electrode distances of 2 cm. 4 cm. and 6 cm. which are shown in the following table and table 2.

Table 2. Arabica coffee grounds 12 hours drying with an electrode distance of 2 cm. 4 cm. and 6 cm

Day	2 cm			4 cm			6 cm		
	V **(V)**	***I*** **(A)**	***P*** **(W)**	***V*** **(V)**	***I*** **(A)**	***P*** **(W)**	***V*** **(V)**	***I*** **(A)**	***P*** **(W)**
1	0.99	0.27	0.27	1.01	0.25	0.25	1.01	0.21	0.21
2	0.94	0.36	0.33	0.94	0.36	0.33	0.94	0.21	0.19
3	0.94	0.33	0.31	0.97	0.28	0.27	0.99	0.22	0.21
4	0.90	0.23	0.20	0.97	0.26	0.25	0.98	0.18	0.17
5	0.86	0.27	0.23	0.96	0.23	0.22	0.99	0.09	0.08
6	0.83	0.2	0.16	0.95	0.19	0.18	0.97	0.12	0.11
7	0.81	0.19	0.15	0.95	0.11	0.10	0.96	0.08	0.07
Min.	**0.85**	**0.25**	**0.22**	**0.85**	**0.25**	**0.22**	**0.73**	**0**	**0**
Max.	**0.93**	**0.49**	**0.42**	**0.91**	**0.37**	**0.33**	**0.9**	**0.37**	**0.33**
Average	**0.89**	**0.34**	**0.30**	**0.89**	**0.30**	**0.26**	**0.83**	**0.23**	**0.20**

From the table 2. the calculation results of deviations (deviations or errors in data collection) are different. ranging from 0.02 to 0.07. A graph of the relationship between voltage and time is shown in figure 3(a). A diagram of the current connection to time is shown in figure 3(b). and a graph of the power relationship to time is shown in figure 5.



(a) (b)

Figure 5. (a) Graph of the relationship between voltage (*V*) against time (24 hours) on Arabica. (b) current (*I*) against time (24 hours) on Arabica coffee grounds 12 hours drying

Figure 5a) above: There was a decrease and increase in stress on the Arabica coffee grounds 12 hours drying at a distance of 2 cm. 4 cm. and 6 cm for different 24 hours. On the first day. the voltage was 0.99 V. 1.01 V. and 1.01 V and decreased on the second day by 0.94 V. 0.94 V. and 0.94 V. From the second day until the seventh day of Arabica with a distance of 2 cm experienced a decrease in voltage to reach 0.81 V. Arabica coffee grounds with a length of 4 cm increased by 0.97 V and on the fourth day to the seventh day decreased to 0.95 V. Coffee grounds arabica with a distance of 6 cm fluctuated on the first day to the fifth day and the sixth day to the seventh day decreased to 0.96 V.

Figure 5b) above shows a decrease and increase in current in the Arabica coffee grounds 12 hour at different distances of 2 cm. 4 cm. and 6 cm every 24 hours. Arabica coffee grounds 12 hours drying at each electrode distance were 0.27 A. 0.25 A. and 0.21 A. At a distance of 2 cm. the electrode fluctuated. On the second day. the current increased by 0.36 A and experienced a decreased on the third day to the fourth day of 0.23 A and increased on the fifth day to 0.27 A. From the sixth day to the seventh day. the current decreased by 0.19 A. At a distance of 4 cm. the electrode increased by 0.36 A on the second day. and from the third day to the seventh day. the current decreased by 0.11 A. Meanwhile. at a distance of 6 cm. the first day to the third day had a fairly stable current. On the fourth and fifth days. the current decreased by 0.09 A. then on the sixth day. the current increased to 0.12 A. and on the seventh day. the current reduced to 0.08 A.

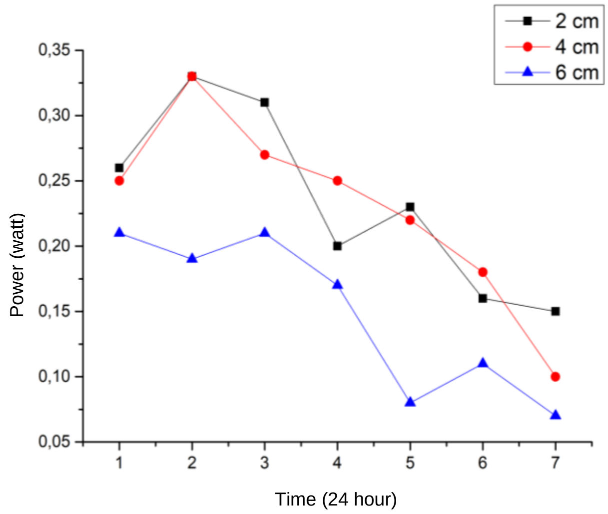


Figure 6. Graph of the relationship between power (Watts) and time (24 hours) on Arabica coffee grounds 12 hours drying

The decrease and increase in power (Watt) on Arabica coffee grounds 12 hours drying can be seen in Figure 6 with a distance of 2 cm. 4 cm. and 6 cm. The energy at the electrode distance of 2 cm fluctuated. On the first day. the power was 0.27 Watt. On the second day. the power increased to 0.33 Watt. and from the third to the fourth day. the power decreased to 0.20 Watt. On the fifth day. the power in Arabica increased by 0.23 Watt. and on the sixth to seventh day fell by 0.15 A. On the first day. Arabica. with a distance of 4 cm. had 0.25 Watt power and increased by 0.339 Watt on the second. From the third day to the seventh day. the power decreased to 0.105 Watt. While at a distance of 6 cm. it fluctuates. On the first. second. and third days. it has a power of 0.21 Watt. 0.19 Watt. and 0.21 Watt. On the fourth to fifth day. the power decreased to 0.08 Watt. On the sixth day. the power increased by 0.11 Watt. and this voltage decreased due to the reduction process at the copper (Cu) electrode. and the oxidation event at the zinc (Zn) electrode used [1].

Arabica coffee grounds 24 hours drying

From the research that has been done. some results were obtained according to the electrode distances of 2 cm. 4 cm. and 6 cm Arabica coffee grounds 24 hours drying with an electrode spacing of 2 cm. 4 cm. and 6 cm are shown in table 3.

Table 3. Arabica coffee grounds 24 hours drying with an electrode spacing of 2 cm. 4 cm. and 6 cm

Day	2 cm			4 cm			6 cm		
	V (V)	*I* (A)	*P* (W)	*V* (V)	*I* (A)	*P* (W)	*V* (V)	*I* (A)	*P* (W)
1	0.93	0.03	0.02	0.74	0	0	0.76	0	0
2	0.81	0	0	0.61	0	0	0.57	0	0
3	0.80	0	0	0.64	0	0	0.55	0.01	0
4	0.79	0	0	0.61	0	0	0.54	0	0
5	0.79	0	0	0.63	0	0	0.48	0	0
6	0.80	0	0	0.67	0	0	0.49	0	0
7	0.78	0	0	0.72	0	0	0.44	0	0
Min.	**0.78**	**0**	**0**	**0.61**	**0**	**0**	**0.44**	**0**	**0**
Max.	**0.93**	**0.03**	**0.02**	**0.74**	**0**	**0**	**0.76**	**0.01**	**0**
Average	**0.05**	**0.01**	**0.01**	**0.05**	**0**	**0**	**0.1**	**0**	**0**

The table 3 results show different deviations (deviations or errors in data collection) from 0 to 0.10. In the table of research results above. it can be seen that the current generated is very small. so the power generated is also small. Therefore. only a graph of the relationship between voltage and time is presented in Figure 7.

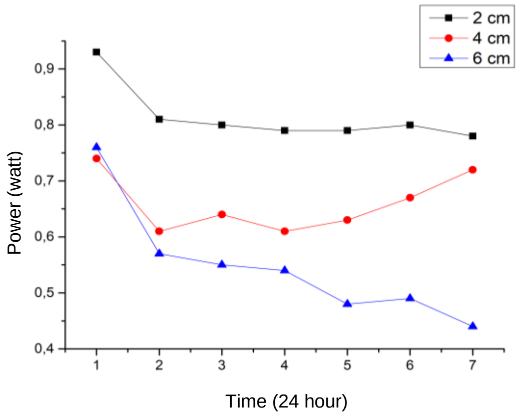


Figure 7. Graph of the relationship between voltage (V) against time (24 hours) on Arabica coffee grounds 24 hours drying

From figure 7 above. it can be seen that there is a decrease and increase in stress in the Arabica coffee grounds 24 hours drying at a distance of 2 cm. 4 cm. and 6 cm for different 24 hours. It has a voltage of 0.93 V. 0.74 V. and 0.76 on the first day. On the second day. the voltage decreased to 0.81 V. 0.61 V. and 0.57 V. At a distance of 2 cm. electrodes on the third day to the sixth day had a fairly stable voltage. On the seventh day. the voltage decreased by 0.78 V. Arabica coffee grounds 24 hours drying. 12 hours apart at a distance of 4 cm. on the third day. experienced a voltage increase of up to 0.64 V. and on the fourth day decreased by 0.61 V. From the fifth day to the seventh day the voltage increased to 0.72 V. From a distance of 6 cm electrodes on the third day to the fifth day. the voltage decreased to 0.48 V. On the sixth day. the voltage increased to 0.49 V. On the seventh day. the voltage dropped to 0.44 V.

The results showed that there were several highest values of different voltage (*V*). current (*I*). and power (*P*) for each coffee ground with the same treatment. Arabica coffee grounds wet with different electrode distance have the highest voltage. current and power respectively 0.93 V. 0.49 A. and 0.42 Watt. Arabica coffee grounds treated for 12 hours with electrode distances of 2 cm. 4 cm. and 6 cm had the highest voltage. current and power. respectively 1.01 V. 0.36 A. dan 0.33 Watt. In Arabica coffee grounds 24-hour drying with electrode distances of 2 cm. 4 cm. and 6 cm. the highest voltage. current and power were 0.93 V. current 0.03 A. and power 0.02 W.

The research results on bio-batteries made from coffee grounds produce current. voltage. and power. The resulting current is closely related to the activity/presence of glucose in coffee grounds [11]. The glucose content in the electrolyte paste affects the current generated. The electrons that flow from the zinc (Cu) electrode to the copper (Zn) will cause the copper electrode to be covered by a layer of oxidation. It contributes to a decrease in the voltage value due to the reduction process at the copper (Cu) electrode and oxidation events at the zinc (Zn) electrode [1]. Furthermore. the level of dryness of coffee grounds affects the electrical production of Arabica. Bio-battery from coffee grounds has the potential for producing voltage and electrical power.

IV. Conclusions

Based on the results obtained. it can be concluded that the bio-electrolyte paste made from Arabica coffee grounds produces an electric current and voltage. which is influenced by the degree of dryness and the distance of the electrodes. Arabica coffee grounds can produce voltage. current. and power with a maximum value of 1.01 V. 0.49 mA current. and 0.42 W power.

Acknowledgments

The authors thank the Community of Women of Toraja Inspiration for Culture (KPTIB) Arrang Dibatu. who has facilitated and motivated the process of writing this article and publication.

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