JPPIPA 9(Special Issue) (2023)

Jurnal Penelitian Pendidikan IPA

Journal of Research in Science Education

http://jppipa.unram.ac.id/index.php/jppipa/index

The Electrical Characteristics of Fruit Peel Waste as a Biobattery in Terms of Fermentation Time and Coconut (*Cocos nucifera* L.) Pulp Concentration

Siti Fatimah[1,2*], Putut Marwoto[3], Sunyoto Eko Nugroho[3]

[1] Program Doktoral Pendidikan IPA, Universitas Negeri Semarang, Indonesia.
[2] Institut Agama Islam Nahdlatul Ulama Kebumen, Indonesia.
[3] Fakultas Matematika dan Ilmu Pengetahuan Alam, Universitas Negeri Semarang, Indonesia.

Received: October 31, 2023
Revised: November 27, 2023
Accepted: December 25, 2023
Published: December 31, 2023

Corresponding Author:
Siti Fatimah
sitifatimah2023@students.unnes.ac.id

DOI: 10.29303/jppipa.v9iSpecialIssue.6477

Abstract: Bioenergy is an alternative energy that utilizes various types of organic waste that can generate electricity. The purpose of this study was to determine the effect of fermentation time and coconut pulp concentration on the electrical characteristics of durian fruit skin, banana fruit skin, and cassava skin waste as an alternative energy source. The electrical characteristics observed were the voltage generated by fruit peel waste based on fermentation time and coconut pulp concentration. This research is a laboratory-based experimental research. The results of the study showed that: 1) the length of fermentation time affects the voltage generated by durian skin, banana skin, and cassava skin; 2) the fermentation time to produce the best voltage is the fourth day (96 hours); 3) the longer the fermentation time, the lower the voltage generated; 4) coconut pulp concentration affects the voltage generated by durian skin, banana skin, and cassava skin; 5) the ratio of 25% coconut pulp concentration and 75% raw material concentration becomes the ratio that produces the best voltage; 6) durian fruit peel waste has the highest voltage compared to banana fruit peel and cassava peel waste, both in terms of fermentation time or coconut pulp concentration. 7) cassava peel waste has a higher potential difference resistance than other skin waste.

Keywords: Alternative energy; Biobattery; Coconut pulp; Fermentation; Fruit peel waste

Introduction

Electricity is a very important need for life. Based on data from the Central Bureau of Statistics in 2020, it shows that there has been an increase in the electrification ratio in Indonesia. In 2019, there was a 98.89% increase in the electrification ratio. With this increase, the Indonesian government has provided a budget for the addition of national electricity generation capacity. In 2019, national electricity generation capacity was installed at 69,6 GW and this figure will increase to 20.62 GW in 2024. Electricity is synonymous with energy from gas, coal, oil, geothermal, and water. However, with various problems such as the decreasing amount of electricity currently used, especially electricity from non-renewable natural resources, it is necessary to innovate to meet the needs of environmentally friendly electricity such as using alternative electricity (Arizona & Kurniadi, 2021; Kamilah et al., 2020a).

Alternative electricity resources that are abundant in Indonesia can come from fruit waste, vegetable waste, and other waste. Waste that can be used as an alternative energy source such as durian peel waste, banana peel, and cassava peel. It is known that Indonesia is a major producer of fruits and food, so it will also produce a lot of waste. Based on data from the Central Bureau of Statistics in 2022, Indonesia produced 1.582.172 tons of durian and 9.245.427 tons of banana. Cassava is a very

How to Cite:
Fatimah, S., Marwoto, P., & Nugroho, S.E. (2023). The Electrical Characteristics of Fruit Peel Waste as a Biobattery in Terms of Fermentation Time and Coconut (Cocos nucifera L.) Pulp Concentration. *Jurnal Penelitian Pendidikan IPA*, *9*(SpecialIssue), 1008–1016. https://doi.org/10.29303/jppipa.v9iSpecialIssue.6477

abundant commodity in Indonesia, even becoming the commodity that produces the fourth most productivity in the world. This data makes it a great opportunity to utilize durian peel waste, banana peel, and cassava peel as an alternative source of electricity.

Fruit and vegetable/food waste can be used as a source of electricity because it has a high acidity level, which can produce electricity. Durian peel has a high content of potassium, sodium, manganese, and folic acid, so it can conduct positive and negative ions. The content of durian peel is what can produce an electric current. It is known that durian peel can generate a voltage of 1,25 volts. This voltage is enough to revive the flow of electricity in a battery that run out of the power (Muhlisin, M., Soedjarwanto, N., Komarudin, 2015). Irhami et al. found that the pH of durian peel was 4,5 after fermentation (Irhamni et al., 2017).

Banana peel contains nutrients and compounds such as protein 78,2 – 85,4 g/kg dry matter, calcium 5,70-6,30 g/kg dry matter, phenol 57,6-64,9 g/kg dry weight, and tannin 53,2-58,5 g/kg dry weight (Kamilah et al., 2020b). Banana peel can be antiseptic because banana peel contains compounds such as phenol, alkaloid, flavonoid, and terpenoids (Asih et al., 2018). Banana peel contains carbohydrates and is rich in minerals such as potassium, magnesium, phosphorus, chloride, calcium, and iron. Carbohydrates contain glucose, which, when mixed with water and allowed to sit for a few days, will undergo fermentation to produce ethanol, which is then oxidized into acetic acid. Acetic acid is a type of electrolyte. It is known that the pH of banana peel is around 4-5 after fermentation (Muhlisin, M., Soedjarwanto, N., Komarudin, 2015). In addition, the potassium and chloride salts will react to form potassium chloride. Potassium chloride in water will conduct electricity because it can be ionized.

Cassava peel can be used as an alternative source of electricity because it contains a lot of cyanide acid. Cyanide acid is one of the electrolytes that can generate current (Irsan et al., 2017). Hermanto & Fitriani found that the pH of cassava peel before fermentation was 6,16, and after fermentation, the acidity increased by 3,74 (Hermanto & Fitriani, 2018).

Fermentation is the decomposition of organic compounds by microorganisms that produce products such as organic acids, alcohols, and gases. Carbohydrates contain glucose, which, when mixed with water and allowed to sit for a few days, will undergo fermentation to produce ethanol, which is then oxidized into acetic acid. Acetic acid is one type of electrolyte (Muhlisin, M., Soedjarwanto, N., Komarudin, 2015). esearch results show that the longer the fermentation, the higher the acidity will be, which will also produce more electricity (Sigalingging et al., 2022).

In addition to fermentation, coconut pulp can be used as a material to increase the potential difference. Coconut pulp becomes a material that can make the electrolyte solid and able to increase the density of the electrolyte, thus increasing the voltage/potential difference (Abidin et al., 2020; Komariyah & Rohmawati, 2021). Coconut pulp still contains oil around 12.2-15.9%, even up to 24% (Maulana & Setyoningrum, 2019), so it can be used as a raw material for the manufacture of biodiesel, one of the alternative energy sources (Khaidir, 2016; Suryawan et al., 2022).

Based on the explanation above, the purpose of this study is to analyze the effect of fermentation time and the addition of coconut pulp on the electrical characteristics of durian peel waste, banana peel waste, and cassava peel waste.

Method

This research is an experimental laboratory-based research. This study uses several variables as follows: (1) Independent variable: Fermentation time and coconut pulp concentration; (2) Dependent variable: Potential difference; (3) Control variable: Mass of tape yeast (0.5 gr), mass of durian peel waste, banana peel, and cassava peel; (4) The following are the tools and materials used; (5) Crocodile clip cables; (6) Used batteries; (7) LED lights; (8) Multimeter; m(9) pH meter; m(10) Cutter; (11) Scale; (12) Blender; (13) Tape yeast; (14) Durian peel waste, banana peel, and cassava peel; (15) Coconut pulp.

The experiment uses steps by adopting the steps of the bibattery experiment that has been patented with the number S00201904048.

Figure 1. fruit peel waste

Figure 2. Process of softening fruit peel waste with a blender

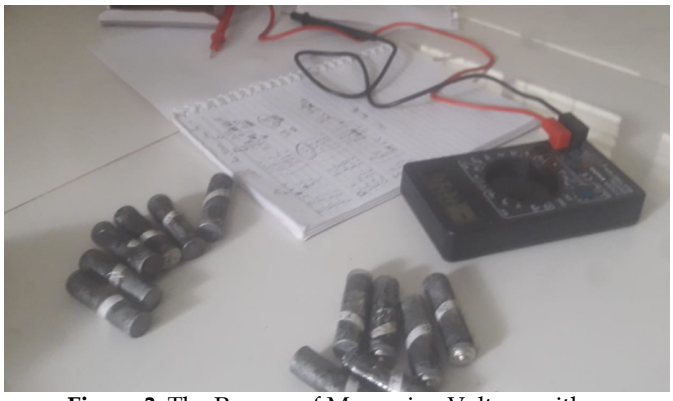


Figure 3. The Process of Measuring Voltage with a Multimeter

Result and Discussion

This experimental study aimed to determine the effect of durian, banana, and cassava fruit peel waste on voltage generation. In addition to fruit peel waste, coconut pulp and fermentation time were also independent variables or variables that affected the strength of the voltage generated by fruit peel waste. The potential difference measurement was repeated three times. The following table shows the results of the experiment on fruit peel waste as an alternative energy source.

Table 1. The Effect of Fermentation Time and Coconut Pulp on Voltage Generated by Durian Fruit Peel

Coconut pulp concentration	Raw material concentration	Fermentation time (days)	Voltage (volt)	pH	Lamp
0%	100%	1	1.46	6.8	turn on
		2	1.47	6.8	turn on
		3	1.48	6.0	turn on
		4	1.52	5.5	turn on
		5	1.51	5.5	turn on
		6	1.50	5.8	turn on
		7	1.46	5.8	turn off
		8	1.39	5.8	turn off
		9	1.24	6.5	turn off
		10	1.03	7.0	turn off
25%	75%	1	1.56	6.5	turn on
		2	1.57	6.5	turn on
		3	1.57	6.0	turn on
		4	1.58	5.5	turn on
		5	1.54	5.5	turn on
		6	1.46	5.5	turn on
		7	1.38	5.8	turn off
		8	1.27	5.8	turn off
		9	1.13	6.0	turn off
		10	1.08	6.5	turn off
50%	50%	1	1.55	6.6	turn on
		2	1.56	6.6	turn on
		3	1.56	6.0	turn on
		4	1.57	5.8	turn on
		5	1.56	5.5	turn on
		6	1.54	5.5	turn on
		7	1.43	5.8	turn off
		8	1.35	5.8	turn off
		9	1.24	5.8	turn off
		10	1.16	6.0	turn off
75%	25%	1	1.52	6.8	turn on
		2	1.53	6.5	turn on
		3	1.54	6.0	turn on
		4	1.56	5.8	turn on
		5	1.54	5.8	turn on
		6	1.51	5.5	turn on
		7	1.47	5.8	turn off
		8	1.37	5.8	turn off
		9	1.31	6.0	turn off
		10	1.22	6.0	turn off

Table 1 shows that durian peel waste can be used to generate electricity. Based on the experimental results, it was found that with the fermentation process, durian peel waste can produce a voltage that is close to ideal (1,5

Volts). It is known that the fourth day is the best fermentation time to produce a voltage/potential difference of 1,58 Volts. Considering the length of the fermentation process, it shows that the first to fifth days show an increase in voltage/potential difference. In addition to the fermentation factor, the addition of coconut pulp is one of the variables that affects the increase in voltage produced by durian peel waste. It is known that the concentration of coconut pulp with a ratio of 25%:75% is the best concentration ratio to produce a voltage/potential difference. However, after the seventh day, the voltage decreases until the tenth day. This decrease in voltage also results to turn off the lamp used as a trial indicator.

Table 2. The Effect of Fermentation Time and Coconut Pulp on Voltage Generated by Banana Fruit Peel

Coconut pulp concentration	Raw material concentration	Fermentation time (days)	Voltage (volt)	pH	Lamp
0%	100%	1	1.45	6.5	turn on
		2	1.46	6.5	turn on
		3	1.47	6.0	turn on
		4	1.50	5.5	turn on
		5	1.50	5.8	turn on
		6	1.49	5.8	turn on
		7	1.45	5.8	turn on
		8	1.35	5.8	turn off
		9	1.21	6.5	turn off
		10	1.02	6.8	turn off
25%	75%	1	1.56	6.8	turn on
		2	1.56	6.5	turn on
		3	1.56	6.5	turn on
		4	1.57	5.5	turn on
		5	1.54	5.5	turn on
		6	1.46	5.8	turn on
		7	1.39	5.8	turn off
		8	1.28	5.8	turn off
		9	1.13	6.0	turn off
		10	1.07	6.8	turn off
50%	50%	1	1.53	6.8	turn on
		2	1.54	6.8	turn on
		3	1.55	6.0	turn on
		4	1.57	5.8	turn on
		5	1.57	5.8	turn on
		6	1.55	5.8	turn on
		7	1.44	5.8	turn off
		8	1.35	5.8	turn off
		9	1.24	5.8	turn off
		10	1.19	6.0	turn off
75%	25%	1	1.51	6.8	turn on
		2	1.53	6.8	turn on
		3	1.54	6.5	turn on
		4	1.56	6.0	turn on
		5	1.55	5.8	turn on
		6	1.54	5.8	turn on
		7	1.49	5.8	turn on
		8	1.38	5.8	turn off
		9	1.32	6.5	turn off
		10	1.21	6.8	turn off

Table 2 explains that banana peel waste can be used to generate electricity. Based on the experimental results, it was found that with the fermentation process, banana peel waste can produce a voltage that is close to ideal (1,5 Volts). It is known that the fourth day is the best fermentation time to produce a voltage/potential difference of 1,57 Volts. Considering the length of the fermentation process, it shows that the first to fifth days show an increase in voltage/potential difference. In addition to the fermentation factor, the addition of coconut pulp is one of the variables that affects the increase in voltage produced by banana peel waste. It is known that the concentration of coconut pulp with a ratio of 25%:75% is the best concentration ratio to produce a voltage/potential difference. However, after the seventh day, the voltage decreases until the tenth

day. This decrease in voltage also results in the death of the lamp used as a trial indicator. It is known that on the eighth day, all lamp indicators have shown to be turn off.

Table 3. The Effect of Fermentation Time and Coconut Pulp on Voltage Generated by Cassava Fruit Peel

Coconut pulp concentration	Raw material concentration	Fermentation time (days)	Voltage (volt)	pH	Lamp
0%	100%	1	1.43	6.8	turn on
		2	1.45	6.8	turn on
		3	1.49	6.0	turn on
		4	1.51	5.5	turn on
		5	1.50	5.8	turn on
		6	1.50	5.8	turn on
		7	1.48	5.8	turn on
		8	1.46	6.0	turn on
		9	1.35	6.5	turn off
		10	1.24	6.8	turn off
25%	75%	1	1.49	6.8	turn on
		2	1.51	6.8	turn on
		3	1.52	6.5	turn on
		4	1.55	5.5	turn on
		5	1.55	5.5	turn on
		6	1.51	5.8	turn on
		7	1.50	5.8	turn on
		8	1.47	6.0	turn on
		9	1.36	6.8	turn off
		10	1.27	6.8	turn off
50%	50%	1	1.45	6.8	turn on
		2	1.46	6.6	turn on
		3	1.50	6.0	turn on
		4	1.54	5.6	turn on
		5	1.53	5.8	turn on
		6	1.53	5.8	turn on
		7	1.51	6.0	turn on
		8	1.45	6.8	turn on
		9	1.35	6.8	turn off
		10	1.23	6.8	turn off
75%	25%	1	1.46	6.5	turn on
		2	1.47	6.0	turn on
		3	1.49	6.0	turn on
		4	1.53	5.8	turn on
		5	1.53	5.8	turn on
		6	1.51	6.0	turn on
		7	1.47	6.0	turn on
		8	1.37	6.5	turn off
		9	1.28	6.8	turn off
		10	1.20	6.8	turn off

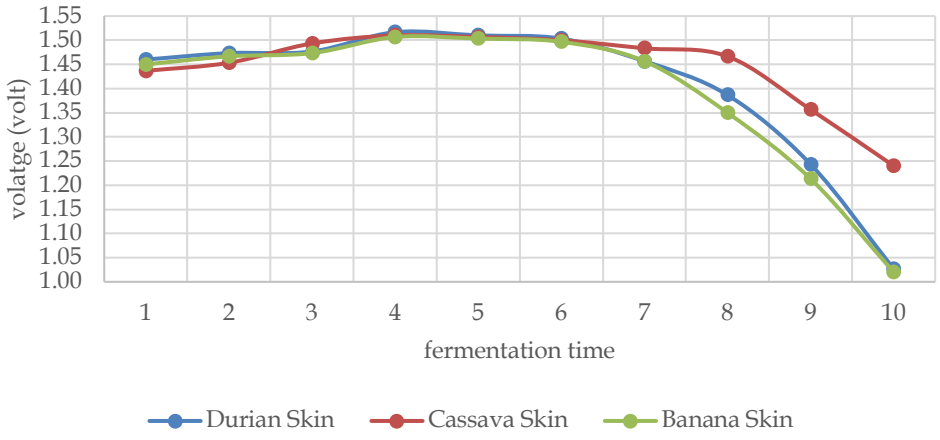
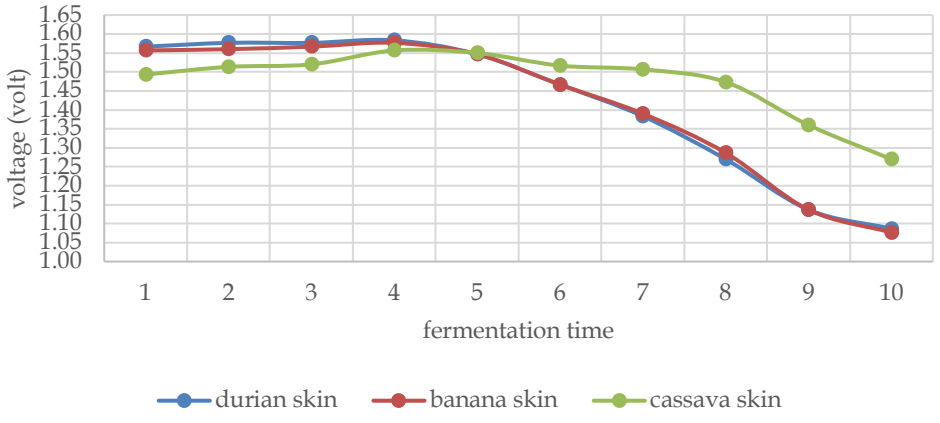
Table 3 explains that banana peel waste can be used to generate electricity. Based on the experimental results, it was found that with the fermentation process, banana peel waste can produce a voltage that is close to ideal (1,5 Volts). It is known that the fourth day is the best fermentation time to produce a voltage/potential difference of 1,55 Volts. Considering the length of the fermentation process, it shows that the first to fifth days show an increase in voltage/potential difference. In addition to the fermentation factor, the addition of coconut husk is one of the variables that affects the increase in voltage produced by banana peel waste. It is known that the concentration of coconut husk with a ratio of 25%:75% is the best concentration ratio to produce a voltage/potential difference. However, after the seventh day, the voltage decreases until the tenth day. This decrease in voltage also results in the death of the lamp used as a trial indicator. It is known that on the ninth day, all lamp indicators have shown to be turn off.

Based on the results of the three fruit peel wastes, it can be concluded that the waste has been proven to generate electricity. The decrease and increase in voltage are influenced by the length of the fermentation process. Based on the experimental results, the longer the

fermentation process, the lower the voltage will be. Specifically, starting on the fifth day, the voltage will already start to decrease and will continue to decrease until the tenth day. The fermentation process will affect the pH value of the fruit peel waste. The acidity at the beginning of the fermentation process converts organic matter into organic acids. In addition, the decomposition that occurs during the fermentation process will produce nitrogen and ammonia, which will cause the pH value to increase, which will result in a decrease in the voltage generated by the fruit peel waste (Marianti et al., 2021).

The decrease in pH indicates the growth of microorganisms, namely lactic acid bacteria such as Lactobacillus and Lactococcus, which experience very rapid growth, as evidenced by the presence of a distinctive aroma. This is because there are sufficient nutrients, temperature, and acidity levels to support the growth of the bacteria, so that it can lower the pH value. The decrease in pH means that the material is becoming more acidic. The more acidic a substance is, the better it will be at generating electricity (Marianti et al., 2021). It is also explained that long fermentation time (in this experiment is until the sixth day) causes electrical conductivity to increase, this is due to the increasingly acidic nature of the substance. Oktaviana et al. mention that tape yeast from rice flour has microorganisms that can convert carbohydrates (starch) into simple sugars (glucose). Fermented carbohydrates produce a certain amount of lactic acid which will lower the pH, resulting in a more acidic taste (Oktaviana et al., 2015).

Based on the analysis of potential difference characteristics (see Figure 4), at the initial measurement, durian peel waste always has a higher potential difference value than banana peel waste and cassava peel waste even though there are differences in coconut husk concentration. Durian peel waste has high potassium, sodium, manganese, and folic acid content that can be used as positive and negative flows (Muhlisin, M., Soedjarwanto, N., Komarudin, 2015). Durian peel waste produces a better potential difference value than other waste because durian peel waste contains 10 times more phosphorus and iron than banana peel. In addition, durian peel contains high cellulose (50%-60%), lignin (5%), and starch (5%). It also contains other minerals such as calcium (Ca), phosphorus (F), folic acid, magnesium (Mg), potassium/potassium (K), iron (Fe), zinc, manganese (Mn), copper (Cu) (Khairiah & Destini, 2017).

Comparison of the concentration of coconut pulp and fruit peel waste	Chart
0% : 100%	
25% - 75%	

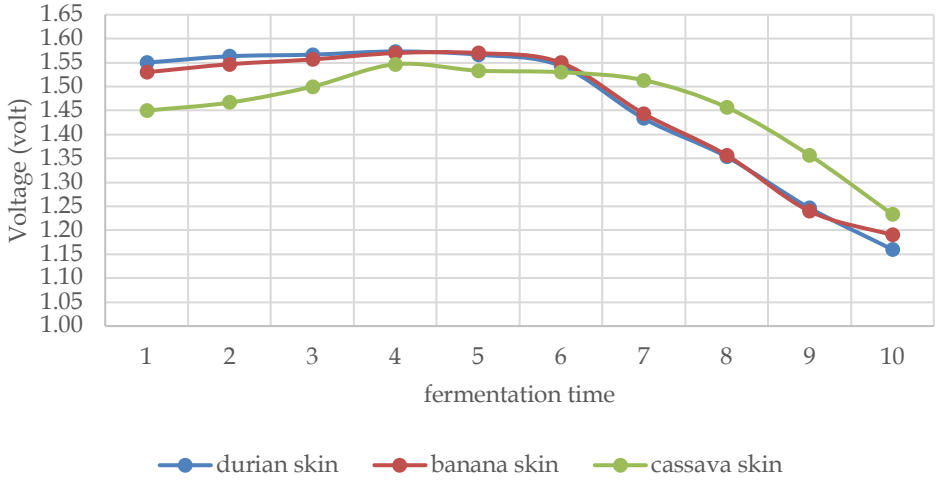
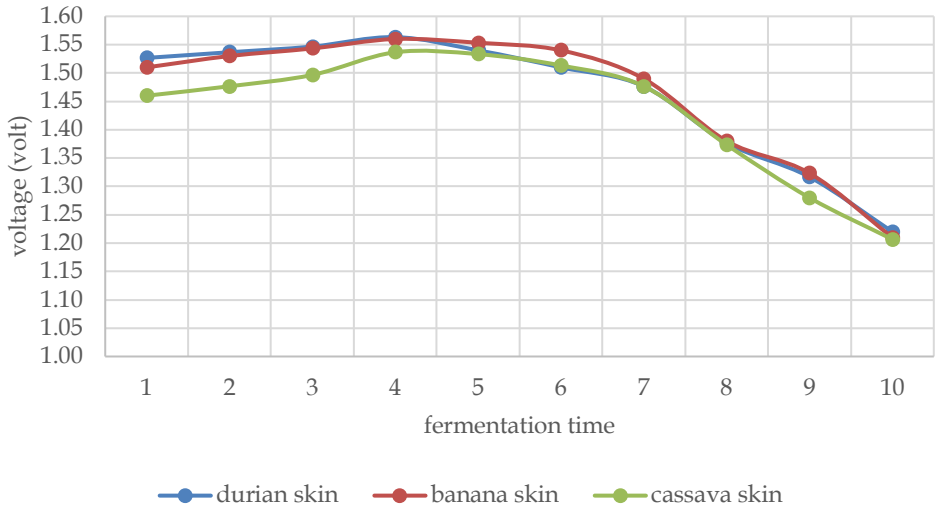
Comparison of the concentration of coconut pulp and fruit peel waste	Chart
50% - 50%	
75% - 25%	

Figure 4. Voltage value in terms of fermentation time

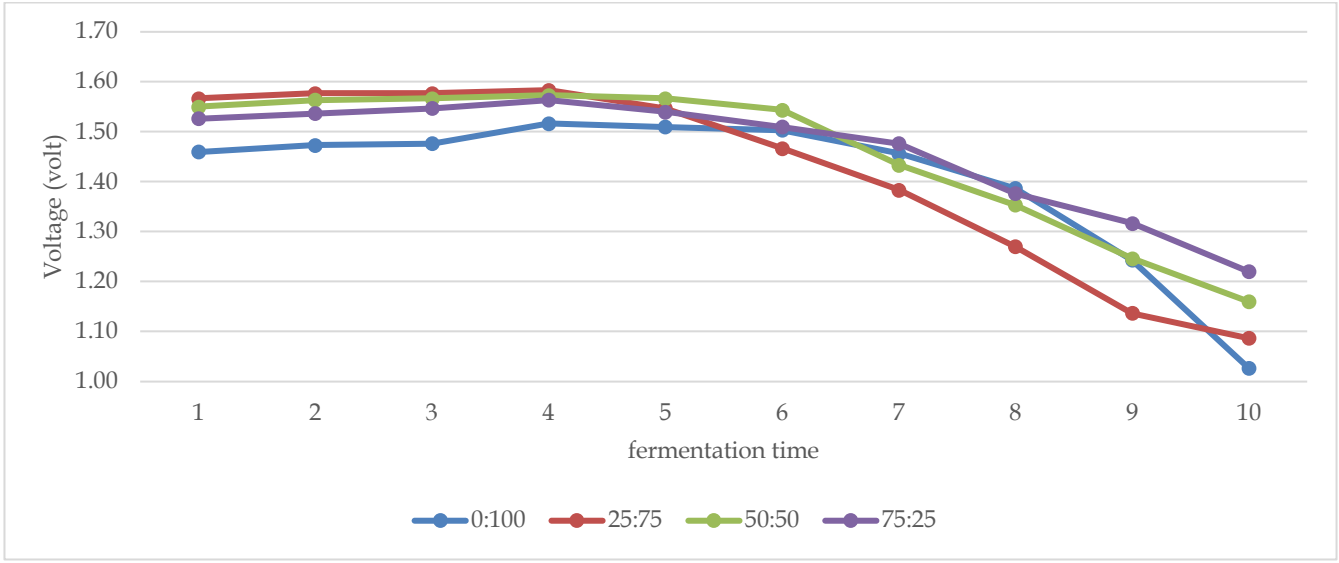


Figure 5a. The voltage value is based on the concentration of coconut pulp and durian skin waste

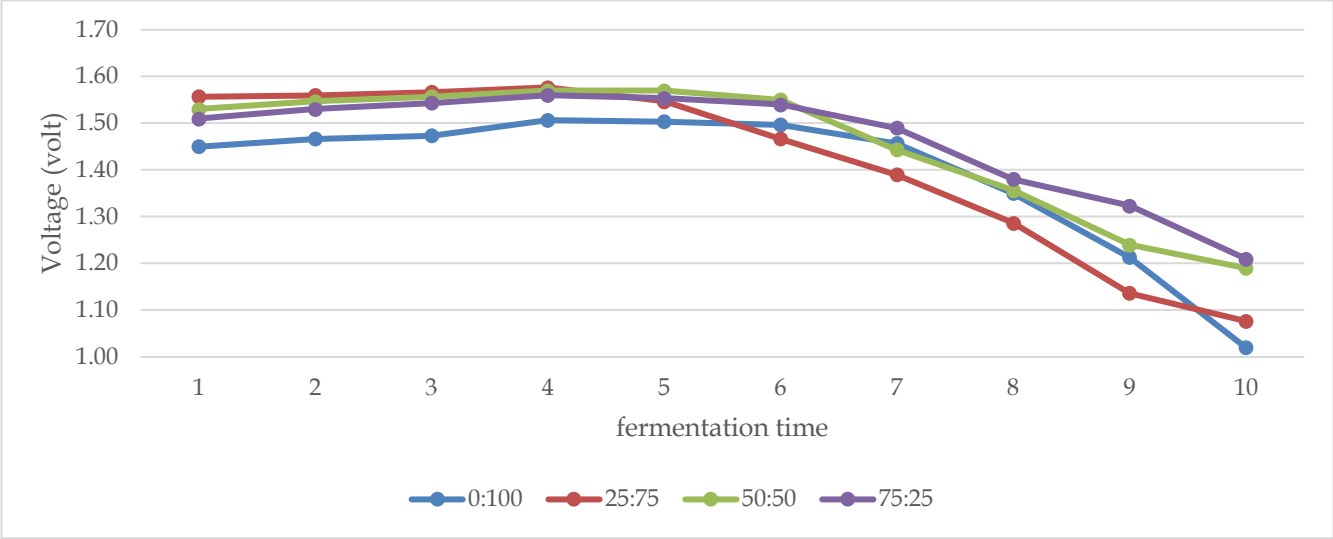


Figure 5b. The voltage value is based on the concentration of coconut pulp and banana skin waste

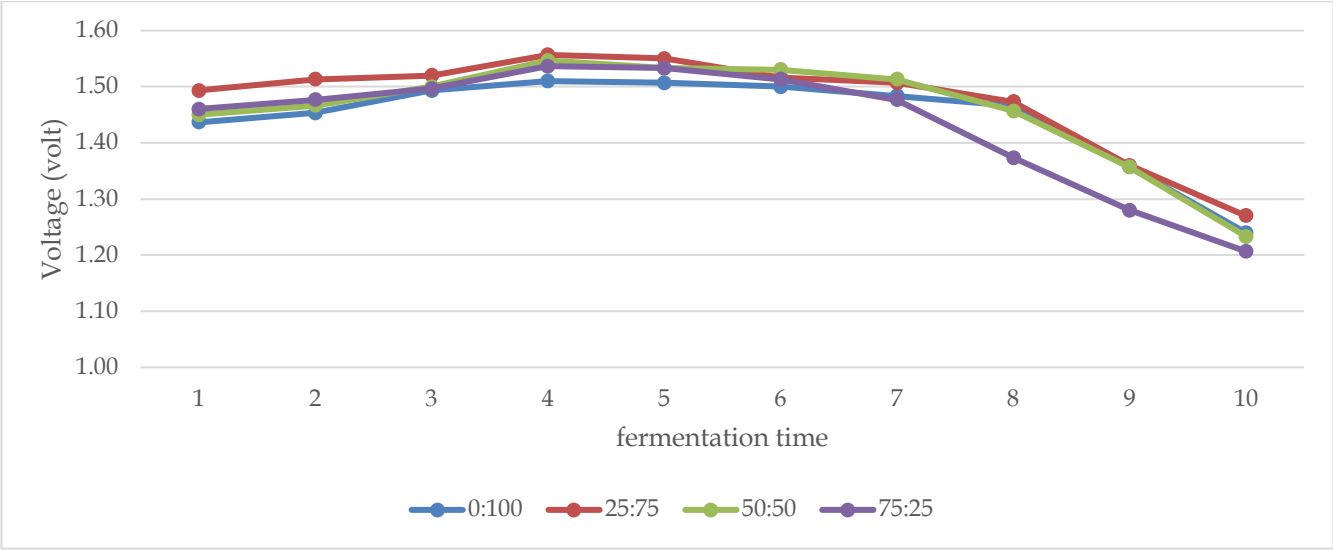


Figure 5c. The voltage value is based on the concentration of coconut pulp and cassava skin waste

The potential difference value always shows a significant increase until the fourth day for all fruit peel waste. The fourth day (96 hours) is the best time to produce a potential difference for durian peel, banana peel, and cassava peel. The increase in the potential difference occurs due to the fermentation process, which results in a decrease in the pH of the fruit peel paste. The addition of coconut husk also affects the potential difference value. The concentration ratio of 25%:75% (see Figure 5a,5b,5c) is the best ratio to produce a potential difference. The addition of too much coconut husk will result in a decrease in the potential difference of the waste skin (Komariyah & Rohmawati, 2021). With the addition of the right concentration of coconut husk, the fruit peel paste becomes a more solid electrolyte and is able to increase the density of the electrolyte, thus increasing the voltage/potential difference (Abidin et al., 2020; Komariyah & Rohmawati, 2021).

Conclusion

Based on the results of the experimental analysis, the following results were obtained: 1) the length of fermentation time affects the voltage generated by durian skin, banana skin, and cassava skin; 2) the fermentation time to produce the best voltage is the fourth day (96 hours); 3) the longer the fermentation time, the lower the voltage generated; 4) coconut pulp concentration affects the voltage generated by durian skin, banana skin, and cassava skin; 5) the ratio of 25% coconut pulp concentration and 75% raw material concentration becomes the ratio that produces the best voltage; 6) durian fruit peel waste has the highest voltage

compared to banana fruit peel and cassava peel waste, both in terms of fermentation time or coconut pulp concentration. 7) cassava peel waste has a higher potential difference resistance than other skin waste.

Acknowledgments
We thank to all staff who support this study.

Author Contributions
Conceptualization, Siti Fatimah; methodology, Siti Fatimah.; validation, Putut Marwoto and Sunyoto Eko Nugroho; analysis, Siti Fatimah; writing—original draft preparation, Siti Fatimah.; writing—review and editing, Siti Fatimah; supervision, Putut Marwoto and Sunyoto Eko Nugroho. All authors have read and agreed to the published version of the manuscript.

Funding
This research received no external funding

Conflicts of Interest
The authors declare no conflict of interest.

References

Abidin, M., Hafidz, A. F., Widyaningsih, M., Yusuf, M., & Murniati, A. (2020). Pembuatan Biobaterai Berbasis Ampas Kelapa Dan Tomat BUSUK. *Al-Kimiya*, *7*(1), 28–34.

Arizona, R., & Kurniadi, S. (2021). Pengaruh Lama Fermentasi Terhadap Karateristik Kelistrikan Yang Dihasilkan Oleh Ekstrak Buah Belimbing Wuluh (Averrhoa Bilimbi) Sebagai Solusi Energi Alternatif Ramah Lingkungan. *Jurnal Teknik Mesin*, *10*(1), 22.

Asih, I. A. R. A., Rita, W. S., Ananta, I. G. B. T., & Sri Wahyuni, N. K. D. M. (2018). Aktivitas Antibakteri Ekstrak Kulit Pisang (Musa sp.) Terhadap Escherichiacoli dan Staphylococcus aureus Serta Identifikasi Golongan Senyawa Aktifny. *Cakra Kimia*, *6*(1), 56–63.

Hermanto, H., & Fitriani, F. (2018). Pengaruh Lama Proses Fermentasi terhadap Kadar Asam Sianida (HCN) dan Kadar Protein Pada Kulit dan Daun Singkong. *Jurnal Riset Teknologi Industri*, *12*(2), 169–180. https://doi.org/10.26578/jrti.v12i2.4239

Irhamni, Mulyati, D., Diana, & Saudah. (2017). Bioetanol Limbah Kulit Durian Dengan Metode Sakarifikasi dan Liquifikasi. *Serambi Engineering*, *2*(3), 114–117.

Irsan, Supriyanto, A., & Surtono, A. (2017). Analisis Karakteristik Elektrik Limbah Kulit Singkong (Manihot esculenta Crantz) sebagai Sumber Energi Listrik Alternatif Terbarukan untuk Mengisi Baterai Telepon Genggam. *Jurnal Teori Dan Aplikasi Fisika*, *5*(1), 9–18.

Kamilah, H., Wardoyo, T. D., & Maftukhah, S. (2020a). Pemanfaatan Buah Kedondong Dan Kulit Pisang Ambon SebagaiSumber Energi Listrik Alternatif. *Jurnal Ilmiah Fakultas Teknik)*, *1*(2), 142.

Kamilah, H., Wardoyo, T., & Maftukhah, S. (2020b). Pemanfaatan Buah Kedondong Dan Kulit Pisang Ambon Sebagai Sumber Energi Listrik Alternatif. *JIMTEK : Jurnal Ilmiah Fakultas Teknik*, *1*(2).

Khaidir, K. (2016). Pengolahan Limbah Pertanian Sebagai Bahan Bakar Alternatif. *Jurnal Agrium*, *13*(2), 63–68.

Khairiah, K., & Destini, R. (2017). Analisis Pengaruh Penambahan Massa Ragi Dan Lama Waktu Proses Fermentasi Terhadap Nilai Tegangan Listrik Pasta Limbah Kulit Durian (Durio Zibethinus). *FISITEK: Jurnal Ilmu Fisika Dan Teknologi*, *1*(2), 16–22.

Komariyah, A. Y., & Rohmawati, L. (2021). Pemanfaatan Limbah Tomat Busuk dan Ampas Kelapa sebagai Baterai Alami yang Ramah Lingkungan. *Seminar Nasional Fisika (SNF)*, 161–165.

Marianti, M., Yanto, S., & Sukainah, A. (2021). Perbedaan Lama Fermentasi Kulit Jeruk Nipis, Kulit Pisang Kepok, Dan Kulit Alpukat untuk Menghasilkan Energi Listrik Pada Aki. *Jurnal Pendidikan Teknologi Pertanian*, *7*(1), 1. https://doi.org/10.26858/jptp.v7i1.12625

Maulana, A. R., & Setyoningrum, T. M. (2019). Pembuatan Biodisel dari Ampas Kelapa dengan Metode Transesterifikasi In-Situ dan Katalis Kalsium Oksida. *Eksergi*, *16*(1), 13. https://doi.org/10.31315/e.v16i1.2526

Muhlisin, M., Soedjarwanto, N., Komarudin, M. (2015). Pemanfaatan Sampah Kulit Pisang dan Kulit Durian Sebagai Bahan Alternatif Pengganti Pasta Batu Baterai. *Rekayasa Dan Teknologi Elektro*, *9*(3), 137–147.

Oktaviana, A. Y., Suherman, D., & Sulistyowati, E. (2015). Pengaruh Ragi Tape terhadap pH, Bakteri Asam Laktat dan Laktosa Yogurt. *Jurnal Sain Peternakan Indonesia*, *10*(1), 22–31.

Sigalingging, R., Panjaitan, V. C. S., & Sigalingging, C. (2022). The effect of fermentation time on fruits as a producer electrical energy. *IOP Conference Series: Earth and Environmental Science*, *1115*(1). https://doi.org/10.1088/1755-1315/1115/1/012088

Suryawan, I. W. K., Nastiti, A. D., Putri, N. H., Marwan, A. A., Khairan, A. N., & Sarwono, A. (2022). Potensi Pemanfaatan Ampas Kelapa Sebagai Biodiesel di Indonesia. *Media Ilmiah Teknik Lingkungan*, *7*(1), 9–17. https://doi.org/10.33084/mitl.v7i1.2718