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HARNESSING PLANT-BASED ELECTROLYTES: THE ELECTROCHEMICAL POTENTIAL OF GARLIC *(Allium Sativum)* AND ONION *(Allium Cepa)*

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HARNESSING PLANT-BASED ELECTROLYTES: THE ELECTROCHEMICAL POTENTIAL OF GARLIC *(Allium Sativum)* AND ONION *(Allium Cepa)*

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By

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TABLE OF CONTENTS

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ABSTRACT

With an emphasis on their capacity to produce voltage and current through plant-based bio-batteries, this study investigates the potential of onions (Allium cepa) and garlic (Allium sativum) as sustainable electrical energy sources. Motivated by the growing need for renewable alternatives to fossil fuels, the research examines the chemical composition of garlic and onion and evaluates their effectiveness in producing electrical power. The experiment followed five phases: material preparation, extraction of plant puree, assembly of the electrical setup, data collection, and proper disposal. Garlic, due to its high sulfur content and beneficial ionic activity, produced a greater voltage output, whereas onions produced a stronger current flow, suggesting lower internal resistance and improved conductivity. With a balanced synergy of voltage and current generation, the most effective configuration, Setup C, which combined garlic and onion, produced the highest electrical output. According to these findings, garlic and onions are readily available and safe materials for producing electricity on a small scale. They may also be used in low-power gadgets and green energy technologies.

Keywords: Garlic, Onion, Bio-battery, Voltage, Current, Renewable energy, Electrical conductivity.

Background of the Study

Ever-growing energy needs and depleting fossil-fuel resources demand sustainable energy alternatives, including renewable energy sources and sustainable storage technologies. A few existing technologies address these issues, but in each case, fundamental and technological hurdles remain to be overcome (Larcher & Tarascon, 2015). However, they are often limited by environmental conditions and their inability to store excess power efficiently during peak demand times. As a result, there is a growing demand for energy storage devices such as batteries. Various issues arise concerning material production and consumption (De Selliers & Spataru, 2021).

Electric power energy is characterized by current or the flow of electric charge and voltage or the potential of charge to deliver energy (Thomson et al., 2025). Moreover, voltage is the difference in electric potential between two points; it is the cause of the current, current is the effect of the voltage that cannot flow without voltage, and current is the rate at which electric charge flows in a circuit at a particular point (BYJU'S, 2021). A Bio battery is an electrical energy storage device used in several applications. Bio batteries generate electricity from renewable fuels, providing a sustained, on-demand portable power source of bio batteries using renewable and biodegradable materials, reducing, and decreasing environmental impact. As biofuel is supplied, bio batteries can continuously generate power (Bhaska & Sreelekha, 2022).

Garlic and Onion are rich in sulfur-containing compounds, which may enhance their ability to conduct electricity. Garlic contains approximately 33 sulfur compounds, including allicin, diallyl disulfide, and diallyl trisulfide, all of which are known to support electron transfer in biological systems (Ayuluna et al., 2024; Amagase, 2006). Garlic contains approximately 33 sulfur compounds, including allicin, diallyl disulfide, and diallyl trisulfide, all of which are known to support electron transfer in biological systems (Ayuluna et al., 2024; Amagase, 2006). Onion, similarly, contains S-propenyl-L-cysteine sulfoxide (PeCSO) and other organosulfur compounds, which are believed to have conductive properties beneficial in energy applications (Nature India, 2017; Goyal, 2021).

Research in battery chemistry has shown that sulfur is valuable in lithium-sulfur (Li-S) batteries due to its high capacity, cost-effectiveness, and sustainability. While this study does not directly apply lithium or industrial-grade sulfur, it takes inspiration from this technology by exploring the natural sulfur content in plant materials to generate electricity (Manthiram et al., 2014). The sulfur in garlic and onion may facilitate redox reactions, essential in generating a flow of electrons in battery systems.

Previous studies have also demonstrated that fruits and vegetables with high acidic or ionic content—such as potatoes, lemons, and tomatoes—can generate low voltage levels when used with metal electrodes. This project extends that idea by determining whether sulfur-rich vegetables like garlic and onion can serve a similar or improved function in a bio-battery context (Vijayakumar et al., 2020). Therefore, this study aims to investigate garlic and onion's voltage and current output when used as natural electrochemical cells. By evaluating their electrical potential, this research could contribute to the ongoing pursuit of simple, affordable, and sustainable energy solutions—especially for educational and rural applications where traditional batteries may not be easily accessible.

Statement of the Problem

This study aims to assess garlic and onion's electrical power potential by identifying the voltage and current they can generate in a simple bio-battery setup. Specifically, it seeks to answer the following questions:

1. How effective is garlic in generating electrical energy in terms of:
    1.1. Voltage output
    1.2. Current output
2. How effective is onion in generating electrical energy in terms of:
    1.1. Voltage output
    1.2. Current output
3. How effective is the combination of garlic and onion in generating electrical energy in terms of:
    1.1. Voltage output
    1.2. Current output
4. How does the electrical energy generated by the combination of garlic and onion compared to the energy generated by garlic and onion when used separately in the terms of:
    1.1. Voltage output
    1.2. Current output

HYPOTHESIS

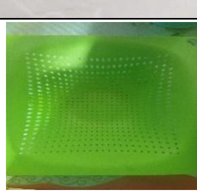
If garlic (*Allium sativum* L.) and onion (*Allium cepa*) contain sulfur compounds capable of supporting the flow of electric charge, then they can generate measurable electrical energy—specifically voltage and current—when used in a simple bio-battery setup and if the combination of garlic and onion generate higher electrical energy compared to using each one separately, due to the possible synergistic interaction of their sulfur compounds then they can enhance conductivity and energy output.

METHODS AND MATERIALS

Using a quantitative experimental method, this work investigated the electrical energy potential of garlic (Allium sativum) and onions (Allium cepa) in a simple bio-battery system. When paired with other electrodes, the study sought to ascertain the potential voltage and current that these plant materials may produce. The kind and composition of the plant extract are among the independent variables in this study, while the observed voltage and current outputs are the dependent variables. The experiment consisted of five phases: preparation of materials, extraction of onion and garlic samples, assembly of the bio-battery, data gathering, and disposal of materials used.

Phase I - Preparation of Materials

The researchers prepared the following materials: garlic and onion, which are bought at the Calinan Supermarket; galvanized nail as an alternative for zinc electrode; copper wire; multimeter/voltmeter, container, measuring cup, distilled water, blender, and strainer.

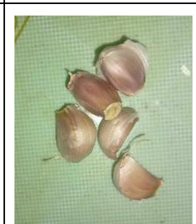
				
				

Phase II - Extraction of Onion and Garlic Samples

In the extraction phase, will contain 3 steps. First. the garlic and onion were peeled and sliced. Second, is blending the garlic and onion separately and another batch for combining the garlic and onion with distilled water to obtain their natural juices. Third, is straining the liquid removing the large debris from the garlic and onion.

Three different setups were created, each with three trials. Setup A used garlic only, with Trial 1 consisting of ½ cup distilled water and three cloves of garlic; Trial 2, ½ cup distilled water and five cloves of garlic; and Trial 3, ½ cup distilled water, five cloves of garlic, and ½ tablespoon of salt. Setup B used onion only, with Trial 1 containing ½ cup distilled water and ½ tablespoon of onion; Trial 2, ½ cup distilled water and one tablespoon of onion; and Trial 3, ½ cup distilled water, one tablespoon of onion, and ½ tablespoon of salt. Setup C combined both garlic and onion, with Trial 1 containing ½ cup distilled water, three cloves of garlic, and ½ tablespoon of onion; Trial 2, ½ cup distilled water, five cloves of garlic, and one tablespoon of onion; and Trial 3, ½ cup distilled water, five cloves of garlic, one tablespoon of onion, and ½ tablespoon of salt. The researchers blend and strain the mixtures before putting them into their containers for testing and observation.

Table 1: Setups for each trial

	Trial 1	Trial 2	Trial 3
Setup A			 

Setup B			 
Setup C	 	 	  

Phase III: Assembly of the Bio-Battery

A copper wire and a galvanized nail were positioned a few centimeters apart inside each plant extract container to ensure optimal electrical flow. The current and voltage were measured with a digital multimeter. The red (positive) probe was attached to the copper wire, while the black (negative) probe was attached to the galvanized nail. Each trial was reviewed separately, and measurements were recorded.

Phase IV – Data Collection

In this face Second steps were created. First, measuring the electrical energy specifically the V(volts) for the voltage and mA (milliamps) for the current using a digital produced during each trial were measured and was noted. Second, subsequently analyzing and determine which mixture configuration produced the highest electrical output using the measurements that was gathered.

Phase V – Disposal of Materials Used

After the experiment and data collection, the researchers cleaned and washed the used materials. The onion and garlic extraction were properly disposed on a sink that the sink is also being cleaned after the onion and garlic extraction being poured. The researchers then thoroughly cleaned their hands.

RESULTS AND DISCUSSION

Research Question 1: How effective is garlic in generating electrical energy in terms of voltage output and current output?

Table 2: Measurement of voltage and current

	Trial 1	Trial 2	Average
Voltage	0.09 – 0.23V	0.13 – 0.34V	19.75%
Current	0.09mA	0.13mA	11%

Garlic showed an average ability in terms of producing electrical energy. The average voltage output was 19.75%, suggesting that it can produce a measurable amount of electrical power. The current output was significantly low, only at 11%, which suggests that it has a limited flow of electrical charge. Overall, garlic can be effective in producing voltage but less efficient in generating currents.

The study results indicate that garlic (Allium sativum) and onions (Allium cepa) have much potential as building blocks for biobatteries that generate electrical energy. Garlic has generated a higher voltage than onions, indicating a large current output. The high concentration of sulfur-rich compound in garlic, gives it powerful biological and electrical properties. It has been discovered that the sulfur compounds in garlic enhance its voltage output and ion transportation. Allicin has been demonstrated to change cells' electrical potential, affecting their electrochemical functions (Gruhlke et al., 2010).

Furthermore, research by Ayuluna et al. (2024) that emphasized the sulfur-rich components in garlic's potential as an energy source is in line with the increased voltage output of garlic. Applications that require voltage buildup in a series circuit, including LEDs, voltage-sensitive devices, or small energy-harvesting systems, are best suited for this higher voltage (Ayuluna et al., 2024).

Research Question 2: How effective is onion in generating electrical energy in terms of voltage output and current output?

Table 3: Measurement of voltage and current

	Trial 1	Trial 2	Average
Voltage	0.2 – 0.5V	0.11 - 0.23V	26%
Current	0.2mA	0.5mA	35%

The onion showed consistent capabilities in producing electrical energy. The average voltage output of the onion was 26%, showing its capacity to produce a measurable amount of electrical energy. Its current output average was 35%, suggesting that it can produce a strong flow of electrical charge.

Onions produced more current, though, indicating that they are appropriate for circuits that need much current. This is explained by onions reduced internal resistance and increased conductivity, which promote electron mobility. The main components of onions that improve their conductivity are their organosulfur compounds, flavonoids, ascorbic acids, and carbohydrate prebiotics (Sagar et al., 2022). These results are consistent with earlier studies that found onions' distinct biochemical makeup enables them to function better in the current generation, making them a perfect material for parallel circuits where current capacity is essential for powering sensors, energy storage systems, or small loads (Sharma et al., 2019).

Manthiram et al. (2014), who explored the potential of sulfur-based batteries, and Goyal (2021), who looked at the role of sulfur in battery technology, both complement the conclusions of this study. The significance of sulfur in raising energy density and conductivity—two factors critical to bio-battery efficiency—is emphasized in both sources. Studies on the electrochemical characteristics of several fruits and vegetables indicate that plant-based materials, such as garlic and onions, could produce renewable and sustainable electrical energy (Sharma et al., 2019; Vijayakumar et al., 2020).

Research Question 3: How effective is the combination garlic and onion in generating electrical energy in terms of voltage output and current output?

Table 3: Measurement of voltage and current

	Trial 1	Trial 2	Average
Voltage	0.6V	0.9V	75%
Current	0.08mA	0.2mA	14%

The combination of garlic and onion exhibits high effectiveness in generating electrical energy, specifically in voltage output, with its average being 75%. This suggests that the mixture of garlic and onion has strong potential in producing adequate electrical energy. Overall, the combination shows good potential for generating electrical energy.

Garlic and onion showed complementary strengths in the combined configuration (Set-up C), with garlic delivering higher voltage and the onion delivering higher current. This balanced synergy is essential for bio-battery applications, where voltage and current are required to satisfy specific devices. These two plant-based materials can be combined to maximize energy storage and use, resulting in more effective biobatteries. Combining plant-based materials to improve battery performance has been investigated in earlier research (Vijayakumar et al., 2020; Sharma et al., 2019).

Manthiram et al. (2014), who explored the potential of sulfur-based batteries, and Goyal (2021), who looked at the role of sulfur in battery technology, both complement the conclusions of this study. The significance of sulfur in raising energy density and conductivity—two factors critical to bio-battery efficiency—is emphasized in both sources.

Studies on the electrochemical characteristics of several fruits and vegetables indicate that plant-based materials, such as garlic and onions, could produce renewable and sustainable electrical energy (Sharma et al., 2019; Vijayakumar et al., 2020).

Research Question 4: How does the electrical energy generated by the combination of garlic and onion compared to the energy generated by garlic and onion when used separately in the terms of voltage output and current output?

Table 4: Measurement of voltage and current

	Voltage	Current
Combination	75%	14%
Onion	26%	35%
Garlic	19.75%	35%

The combination of garlic and onion generated the highest voltage output at 75%, which is significantly higher than other setups. However, in terms of current output, the two individual setups produced 35% of the current, which is higher than the combination. This shows that while the combination has better voltage production, it decreases the current output.

Garlic and onion demonstrated complementary properties in the combined configuration (Set-up C), where garlic generated a higher voltage, and onion produced a stronger current. This synergy suggests that combining these two plant-based materials can enhance energy storage and utilization, thereby improving the effectiveness of biobatteries. Previous studies have also explored the potential of combining plant-derived substances to optimize battery performance (Vijayakumar et al., 2020; Sharma et al., 2019). While onions were more effective in generating current—making them suitable for high-current circuits—this is attributed to their lower internal resistance and better conductivity, which facilitate electron flow. The enhanced conductivity of onions is primarily due to the presence of organosulfur compounds, flavonoids, ascorbic acids, and carbohydrate prebiotics (Sagar et al., 2022). Meanwhile, garlic's high sulfur content contributes to its notable electrical and biological characteristics. Sulfur compounds in garlic have been shown to improve voltage output and ion transport, with allicin influencing cellular electrical potentials and their electrochemical activity (Gruhlke et al., 2010).

CONCLUSION AND RECOMMENDATIONS

Conclusion

The findings indicate that onions are better at producing current, whereas garlic is better at producing voltage. In the combination setup, Setup C's garlic and onion mixture yielded the most outstanding results in terms of both voltage and current. As a result, the combination of both plants demonstrated the most promising outcomes for electrical energy generation. Moreover, the experimental findings indicate that both onions (Allium cepa) and garlic (Allium sativum) have great promise as bio-battery materials capable of producing electrical energy. Onion contributes a larger current output than garlic, while garlic provides a higher voltage output. Together, these two plants form a balanced bio-electrolyte, directly emphasizing limitations that onion enhancing current, and garlic boosting voltage. Nevertheless, garlic and onions possess characteristics that are suitable for low-power, sustainable energy solutions, despite their limitations in larger-scale use. Therefore, this is appropriate for a low-power devices like LEDs, sensors, and energy-harvesting systems that have minimal energy needs.

In conclusion, Setup C proved to be the most effective experimental configuration for bio-battery performance, as it delivered the highest electrical output from the combination of salt, garlic, and onion.

Recommendations

Future research should focus on a few enhancements and additional studies. Initially, using copper and zinc electrodes may result in more precise voltage and current measurements, improving the overall effectiveness and dependability of the findings. Future research should also examine different extraction techniques and consider including additional natural materials that might improve the bio-electrolyte performance of onions and garlic. Experimenting with various pH values and concentrations and adding conductive materials could enhance the electrical output. Furthermore, in real-world applications where low-power energy requirements are required, it is recommended to test garlic and onions. These bio-batteries could be incorporated into tiny gadgets like wearables, sensors, or miniature energy-harvesting systems by providing a sustainable and environmentally friendly substitute for traditional power sources. Better understanding and maximizing the potential of onions and garlic as renewable bioenergy sources, especially for small-scale energy applications, will be made possible by expanding research in these areas.

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