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"Investigating Labog (Hibiscus sabdariffa L.) as a Novel Biomass for Electricity Generation"

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Abstract: This research assessed Hibiscus Sabdariffa L. "LABOG" as an electricity source, testing three mixtures. Conducted from November 2022 to November 2023, the study used a trial method in a true experiment. Researchers analyzed average voltage and current for three mixtures and connections (series, parallel, series-parallel) over five tests. Despite unstable readings, the boiled mixture had the highest average voltage (3.89V, 0.22mA), and the squeezed mixture had the highest for series connection (4.27V, 0.43mA). Overall, the series connection produced the highest voltage and current, and the squeezed mixture had the highest values under the same conditions.

***IndexTerms* – hibiscus sabdariffa, biomass, alternative source, voltage generation**

INTRODUCTION

Electricity is crucial for various aspects of modern life, powering homes, healthcare facilities, communication networks, and industries. It plays a vital role in enhancing comfort, connecting people globally, supporting healthcare and education, and driving economic growth. In the 21st century, the global imperative for sustainable and eco-friendly energy sources has become apparent due to climate change, increasing energy demands, and limited fossil fuel reserves. In this context, exploring the potential of Hibiscus sabdariffa L., known as "Labog," as an alternative electricity source is a promising avenue of research. The plant, known for its red calyxes, exhibits unique structural and material properties that suggest it may harness electrical energy through the piezoelectric effect—a natural phenomenon where materials generate an electric charge in response to mechanical stress or deformation. The study investigated boiled Hibiscus sabdariffa, the plant's juice, and chopped Hibiscus sabdariffa to explore its viability as an alternative electricity source.

NEED OF THE STUDY.

The study investigating Hibiscus sabdariffa or "Labog" as a renewable energy source serves a multifaceted purpose in addressing crucial needs within sustainable energy development. Firstly, it contributes to the diversification of renewable energy options, offering an innovative alternative beyond conventional sources such as solar and wind power. Secondly, by tapping into the potentially abundant local resource of Labog, the research aligns with the principles of sustainable development, promoting the utilization of regionally available materials and reducing dependence on centralized energy infrastructure.

The study also highlights the potential for low environmental impact associated with harnessing energy from Hibiscus sabdariffa, in line with broader goals of minimizing the carbon footprint linked to energy production. Additionally, the exploration of Labog's piezoelectric properties contributes to the innovation and development of renewable energy technologies, inspiring novel approaches for sustainable energy generation. The potential benefits of Labog for community and rural electrification address the need for accessible and decentralized energy solutions, particularly in areas where traditional infrastructure is challenging. Furthermore, the study enhances scientific understanding by delving into how plants, specifically Hibiscus sabdariffa, can generate electricity, thereby advancing knowledge in plant physiology and bioelectric phenomena.

Lastly, the research provides valuable educational opportunities, raising awareness about sustainable energy options and fostering scientific curiosity among students and communities, ultimately promoting a sense of environmental responsibility. In summary, the study on Labog as a new renewable energy source comprehensively addresses critical needs in the realms of diversification, local resource utilization, environmental impact reduction, innovation, community electrification, scientific understanding, and educational outreach within the broader context of sustainable energy development.

RESEARCH METHODOLOGY

The methodology section outlines the plan and method that how the study is conducted. This includes Universe of the study, sample of the study, Data and Sources of Data, study's variables and analytical framework. The details are as follows;

3.1 Population and Sample

Three formulations were prepared: Profile 1 consisted of boiled labog with 2L tap water, Profile 2 involved blended labog with 2L tap water, and Profile 3 utilized squeezed labog with 2L tap water. Each profile comprised 9 cells, each containing 8 oz of the respective mixture. The testing spanned 9 hours, with measurements taken every 3 hours.

3.2 Data and Sources of Data

The study found that Hibiscus sabdariffa, or "Labog," can generate electricity using various mixtures and connections. The squeezed Labog exhibited the highest voltage among the tested mixtures. However, parallel and series-parallel connections with three mixtures yielded voltages below 1 volt, resulting in 0.00 milliamperes, insufficient for a 2-volt LED. In a series connection, the voltage reached 4 volts, illuminating the LED, with the squeezed mixture producing 0.15 milliamperes during trial 1. Yet, parallel and series-parallel connections generated inadequate voltage for LED illumination, confirming the initial conclusion.

3.3 Statistical tools and econometric models

This section elaborates the proper statistical/econometric/financial models which are being used to forward the study from data towards inferences. The detail of methodology is given as follows.

3.3.1 Descriptive Statistics

Mean was used as a statistical tool and was computed manually using the formula:

$x=(\sum x)/n$

IV. RESULTS AND DISCUSSION

4.1 Results of Descriptive Statics of Study Variables PROFILE 1 –

Boiling 1 kilo of labog and 2 liters of tap water.

VOLTAGE OUTPUT OF EACH CELL AT NO-LOAD CONDITION

Table 1 shows voltage production at 2-hour intervals under average room temperature using nine cups of 8-ounce hibiscus sabdariffa (labog) solution in a series connection. In three trials, the voltage varied: 4.41 volts in trial 1, 3.753 volts in trial 2, and 3.5 volts in trial 3, indicating instability. Despite the fluctuating readings, the mean voltage was 3.89 volts. The corresponding current production, measured in microamperes, exhibited inconsistency as well. Trial 1 yielded 0.15 microamperes, trial 2 produced 0.5 microamperes, and trial 3 showed 0.00 microamperes. This indicates unstable and notably low current generation by hibiscus sabdariffa (labog), insufficient for practical electricity use. The mean current was 0.22 microamperes. In light of these findings, the researchers opted to conduct parallel connection tests with the same sample.

Table 1: Voltage and Current output of the battery when connected in series.

Trial (2-Hour interval)	Amount of water	Voltage produced	Current
1	1 liter	4.41 volts	0.15 mA
2	1 liter	3.753 volts	0.5 mA
3	1 liter	3.5 volts	0.00 mA
		$\sum x$ = 11.663	$\sum x$ = 0.65 mA
		Mean: 3.89	0.22 mA

Table 2 shows the results of the voltage produced a in 2-hour interval under average room temperature with nine cups of 8-ounce solution in a parallel connection, where 0.487 volts was made in trial 1; 0.48 volts in trial 2; and 0.475 volts in trial 3. This shows that the voltage produced by hibiscus sabdariffa (labog) was unstable. It reveals different readings but is relatively close to each other; the mean is 0.48 volts. The table also shows the current produced in three (3) trials in 2-hour intervals under average room temperature in which 0.00 milliamperes is made in trial 1; 0.00 milliamperes is produced in trial 2; and 0.00 milliamperes is produced in trial 3. Findings show that the voltage and current produced in parallel connection were low, so the researchers decided to try the series-parallel connection using the same sample.

Table 2: Voltage and Current output of the battery when connected in parallel.

Trial (2-hour interval)	**Amount of water**	**Voltage generated**	**Current**
1	1 liter	0.487 volt	0.00 mA
2	1 liter	0.48 volt	0.00 mA
3	1 liter	0.475 volt	0.00 mA
		∑x=1.44	∑x=0.00 mA
		M=0.48	M=0.00 mA

Table 3 shows the voltage produced in three (3) trials under normal temperature in a series-parallel connection of Labog boiled in 1 liter of water where 0.624 volts was produced in trial 1; 1.73 volts in trial 2; and 1.41 volts in trial 3. This shows that the voltage produced by hibiscus sabdariffa (labog) was unstable. It reveals different readings that are relatively close to each other. The mean is 1.254 volts. The table also shows that 0.00 milliamperes were the current produced in three (3) trials.

This shows that the current generated by boiled Labog in a series-parallel connection is unstable and very low. It reveals that the current generated cannot sufficiently supply electricity because of the small amount of current produced with a mean of 0.00 milliamperes. The researcher decided to squeeze the Labog to test.

Table 3: Voltage and current output of the battery when connected in series-parallel

Trial (2-hour interval)	**Amount of water**	**Voltage**	**Current**
1	1 liter	0.624 volts	0.00 mA
2	1 liter	1.73 volts	0.00 mA
3	1 liter	1.41 volts	0.0 mA
		∑x=3.764	∑x=0.00 mA
		M=1.254	M=0.00 mA

PROFILE 2 – Blended mixture using 1 kilo of labog and 2 liters of tap water.

VOLTAGE OUTPUT OF EACH CELL AT NO-LOAD CONDITION

Table 4 shows the voltage generated in three (3) trials under average temperature by the squeezed labog connected in series in which 4.18 volts was produced in the first trial, 4.23 volts was produced in the second trial, and 4.41 volts was produced in the third trial. The mean was 4.27 volts. The table also shows the current generated in three (3) trials with squeeze labog in a series connection under average temperature in which 0.10 milliamperes was produced in the first trial, 0.7 milliamperes was produced in the second trial, and 0.5 milliamperes was produced in the third trial.

This table shows that the current generated by boiled labog in a series connection is unstable and very low. It reveals that the current generated cannot sufficiently supply electricity because of the small amount produced with a mean of 0.43 milliamperes. The researcher decided to test the squeeze labog in parallel.

Table 4: Voltage and current output of the battery when connected in series.

Trial (1hour interval)	**Voltage**	**Current**
1	4.18 volts	0.10 mA
2	4.23 volts	0.7 mA
3	4.41 volts	0.5 mA
	∑x=12.82	∑x=1.3 mA
	M=4.27	M=0.43 mA

Table 5 shows the voltage generated in three (3) trials under average temperature by the squeezed labog connected in parallel, in which 0.41 volt was produced in trial 1; 0.40 volts was produced in trial 2; and trial 3 produced 0.23 volts. With a voltage mean of 0.411. The table also shows the current generated in three (3) trials with squeezed labog in a parallel connection under average temperature in which 0.00 milliamperes were produced in all three (3) trials.

This shows that the voltage and current generated by squeezed Labog in parallel connection are unstable and very low. It reveals that the current generated cannot sufficiently supply electricity because of the small amount of voltage produced, with a mean of 0.00 milliamperes. The researchers decided to test the squeeze Labog in a series-parallel connection.

Table 5: Voltage and current output of the battery when connected in parallel.

Trial	**Voltage**	**Current**
1	0.41	0.00 mA
2	0.40	0.00 mA
3	0.423	0.00 mA
	∑x=1.233	∑x=0.00 mA
	M=0.411	M=0.00 mA

Table 6 shows the voltage generated in three (3) trials under average temperature by the squeezed labog in which 0.643 volt was produced in trial 1; 0.54 volts was produced in trial 2; and trial 3 produced 0.478 volts. With a voltage mean of 0.411. The table also shows the current generated in three (3) trials with squeezed labog in a parallel connection under average temperature in which 0.00 milliamperes were produced in all three (3) trials.

Table 6: Voltage and Current output of the battery when connected in series-parallel

Trial	**Voltage**	**Current**
1	0.643 volts	0.00 mA
2	0.54 volts	0.00 mA
3	0.478 volts	0.00 mA
	∑x=5	∑x=0.00 mA
	M=1	M=0.00 mA

PROFILE 3 – Squeezed mixture of 1 kilo of labog and 2 liters of tap water.

VOLTAGE OUTPUT OF EACH CELL AT NO-LOAD CONDITION

shows the voltage generated in three (3) trials under average temperature by the blended labog connected in parallel in which 4 volts was produced in the first trial, 3.8 volts was produced in the second trial, and 3.825 volts was produced in the third trial. The mean is 3.875 volts.

The table also shows the current generated in three (3) trials with blended labog in a series connection under average temperature in which 0.15 milliamperes were produced in the first trial, 0.10 milliamperes were produced in the second trial, and 0.076 milliamperes were produced in the third trial. The researchers decided to try the parallel connection using the same sample.

Table 8: Voltage and Current output of the battery when connected in series.

Trial	Voltage	Current
1	4 volts	0.15 mA
2	3.8 volts	0.10 mA
3	3.825 volts	0.076 mA
	∑x= 11.625	∑x= mA
	M= 3.875	M= mA

Table 8 shows the voltage generated in three (3) trials under average temperature by the blended labog in which 0.54 volt was produced in first trial; 0.40 volts was produced in second trial; and 0.35 volts was produced in the third (3) trial. With an average mean of 0.43 volts. The table also shows the current generated in three (3) trials with squeeze labog in a parallel connection under average temperature in which 0.00 milliamperes were produced in three (3) trials conducted with a 2-hour interval per trial.

Table 8: Voltage and Current output of the battery when connected in parallel.

Trial (2 hours interval)	Voltage	Current	
1	0.54 volt	0.00 mA	
2	0.40 volt	0.00 mA	
3	0.35 volt	0.00 mA	
	∑x= 1.29	∑x=0.00 mA	
	M= 0.43	M=0.00 mA	

Table 9 shows the voltage generated in three (3) trials under average temperature by the blended labog in which 0.82 volt was produced in the first trial; 0.76 volt was produced in 2 trials; and 0.63 volts was produced in the 3 trials. The average mean of the voltage being produced in a series-parallel connection is 0.74 volts. The table also shows the current generated in three (3) trials with blended labog in a series-parallel connection under average temperature in which 0.00 milliamperes was produced in all the trials.

Table 9: Voltage and current output of the battery when connected in series-parallel

Trial	Voltage	Current
1	0.82 volts	0.00 mA
2	0.76 volts	0.00 mA
3	0.63 volts	0.00 mA
	∑x=2.21	∑x= 0.00 mA
	M= 0.74	M= 0.00 mA

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