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# BIOLOGICAL PROFILE OF LOCALLY GROWN BANANA CULTIVARS AND THE CAPABILITY OF THEIR PSEUDOSTEM SAP AS AN ALTERNATIVE ELECTROLYTE FOR WET CELL

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**Abstrct**
This study used the qualitative and quantitative experimental research design to establish the biological profile of the banana cultivars and the capability of their pseudostem sap as an alternative electrolyte for wet cell. Data were gathered by collecting banana sap and placing it in a 12-volt wet cell battery and observed at different time intervals. Mean, ANOVA, Duncan's Multiple Range Test, LSD and pairwise comparison were used to determine significant differences between potential voltage and time interval. Bungulan, Lakatan, and Morado are derived from Musa Acuminata, while the Bulkan, Dippig, and Tordan are from the species of Musa Acuminata x Musa balbisiana. However, each cultivar is a member of a separate group, including the AABB, Cavendish subgroup of the AAA, AA, AAA, ABB, and AAB Group. The pH of the substrate is neutral, while the pH of newly harvested pseudostem sap turns acidic after 4 weeks of storage. The effects of the treatments, time interval, and their interactions produced a highly significant difference. The positive and negative control, and the six cultivars are statistically and significantly different from one another while Bungulan, Morado and Tordan cultivars are statistically the same. Week 1 had the highest voltage recorded and statistically the same mean voltages as in Weeks 2 and 4 with the lowest voltage seen in Week 3.The interaction of the sulfuric acid, distilled water, cultivars, and time interval yielded different voltage and are not statistically comparable. The pseudostem sap of the different banana cultivars contained in a 12-volt wet cell battery can lit the 5, 10 and 15-watts LED bulbs until the fourth week of storage.Using the pairwise comparisons, the treatments are statistically the same with one another. Hence, the banana pseudostem sap can be used as an alternative electrolyte for wet cell.

**Keywords:** Banana sap, electricity generation, potential energy, renewable energy, wet cell battery.

## 1. INTRODUCTION

Banana plant is said to be one of the most important fruit crops in the world. It is a large herb that grows from an underground stem to form a false trunk or pseudostem of about 3–6 meters or 10–20 feet high. Bananas come in hundreds of different kinds with most cultivated banana types either interspecific hybrid of Musa acuminata and hybrids of the Musa balbisianasubspecies [1].

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After the banana plant has fruited, it is cut down to the ground, because each trunk produces only one bunch of fruit [2]. As such, the pseudostem is considered then as banana waste; however, it has potential to be used in the creation of useful products. For example, in the advent of time, as people continue to look for a renewable [3] [4], environmentally beneficial alternative source of electricity derived from natural resources [5] , one of these is the banana pseudostem sap which has the potential to be exploited as a source of energy. While electricity has become one of the basic needs in life, it is undeniable that most of the appliances and gadgets now are all electricity-dependent, meaning they need electricity to function.

Quirino Province as part of the Cagayan Valley region is endowed with abundant natural resources and is regarded as one of the country's banana-producing provinces. According to accounts, 5,000 acres of banana plantations have been identified in Quirino. The municipality of Maddela, Nagtipunan, Cabarroguis, Diffun, and Aglipay have the most common types of banana cultivars such as *Saba*, *Latundan*, *Lakatan*, and *Cavendish* [6]. The pseudostem contains a large volume of sap that is naturally described as colorless, minerals and other elements such as sodium, potassium, iron, manganese, calcium, magnesium, phosphorus, zinc, and chromium [3]. However, after harvesting, the pseudostems are either thrown away or chopped and used as mulch in the ground, without consideration of other benefits such as its potential for power generation due to the pH and bio-chemical compositions found in its sap [7].

Hence, this study explored the use of banana sap [8] as an electrolyte for wet cell battery in producing electricity which be an alternative or substitute [9 [10][11] for the sulfuric acid or battery solution that is commonly placed inside a wet-cell battery [12]. In essence, a battery containing an electrolyte [13] or any chemicals generates electrons through electrochemical reactions [14]. Employing agricultural waste [15] obtained from banana sap of the different cultivars namely *Bulkan (Musa acuminata x Musa balbisiana)*, *Bungulan (Musa acuminata)*, *Lakatan (Musa acuminata)*, *Morado (Musa acuminata)*, *Saba (Musa acuminata x Musa balbisiana)* and *Tordan(Musa acuminata x Musa balbisiana)* [16] [17] [18] could provide an advantage particularly in the field of research and innovation, as well as assist the industry in becoming more sustainable in terms of practices and new technologies in the production of energy. Furthermore, establishing biological profiles such as taxonomic classifications of locally grown banana cultivars in a local context could make a significant contribution to the world of agricultural education, particularly in botany and related subjects, and look into the potentials of its sap in producing an alternative and eco-friendly source of energy [19].

Studies in using alternative and potential natural sources of electricity exist. This study on identifying the voltage of the different cultivars of banana pseudostem sap for electricity generation maximized the potentials of the 3 cultivars namely *Saba*, *Lakatan*

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and *Mindanao*. In a related investigation, banana cultivars were utilized as samples to determine the potential energy in voltage of banana sap that can function as an electrolyte for electricity generation; voltage was identified, and its capability tested using a transistor radio [4]. Likewise, the urine of the different domesticated animals, including the cow, pig, and carabao were also used and placed in a wet cell battery, where the potential energy specifically the voltage was recorded [5].

Considering all these concordances, the electricity delivered by electric cooperatives or electric plants is not always continuous and the community can still face power outbreaks, brownouts, and even blackouts, particularly during typhoons.

In this context, this study intended to provide an alternative answer and address issues relative to energy sources by utilizing a natural and readily available source from the environment that is inexpensive, efficient, and environmentally friendly. To address the issue, the researcher used the banana pseudostem sap from the different cultivars of banana as an electrolyte for wet cell battery [20] [21].

At the same time, this research also established the biological profiles of locallygrown banana cultivars [15] [26] in the province, offering facts and in-depth information on the many banana species found in the province of Quirino. As a result of this research, an alternative electrolyte for wet cell can be developed [16]. Finally, this research demonstrates substantial advances in the use of banana pseudostem [22] that can pave the way for new options to support a sustainable product, particularly in the generation of energy. Furthermore, this study generally aimed to determine the biological profile of the locally grown banana cultivars and the capability of their pseudostem sap as an alternative electrolyte for wet cell battery. Specifically, it aimed to establish the biological profile of the banana cultivars in terms of Taxonomic classification and characterization;pH of the substrate; andpH of the sap, determine and compare the potential energy (Voltage) for electricity generation of the different banana cultivars sap preparation methods (Fresh, stored for 1 week, stored for 2 weeks, stored for 3 weeks, and stored for 4 weeks) and lastly determine whether the banana sap contained in wet cell batteries can lit different wattage of LED bulb.

## 2. METHODOLOGY

This study used a combination of qualitative and quantitative experimental research design. In the context of the qualitative research design, this research provided the information on the naturalistic observation and description specifically on the biological profile of the banana cultivars which includes the taxonomic classifications such as the local name, species, group, cultivar, origin and description, and characterization of the different parts including the entire plant, pseudostem and the fruits, geo mapping and other descriptions of the locally grown banana cultivars.

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Likewise, it was also applied in determining whether the set-up has the capability to lit the different wattage of LED bulbs (5 Watts, 10 Watts, and 15 Watts). On the other hand, the experimental research design of the study provided data on the pH of the substrate where the banana is planted, pH of the banana sap of the different banana cultivars, potential energy (Voltage) produced from the banana pseuodostem sap as electrolyte for wet cell batteries as affected by the different time interval of storage (Week 0, Week 1, Week 2, Week 3 and Week 4).

The locally grown banana cultivars such as the *Bulkan*, *Bungulan*, *Lakatan*, *Morado*, *Saba*, and *Tordan* were identified and collected at Purok 7, San Manuel, Aglipay, Quirino. The six cultivars used as study samples were certified by the knowledge bearer and director of Banana Resource Research and Development Center of Quirino State University as all valid and reliable based on the different characterization made including the scientific name, local name, cultivar, origin, morphological feature, geo mapping and descriptions.

Meanwhile the mean was used to determine the average pH of the substrate, the pH of the banana pseudostem sap, and potential energy (voltage) generated from the banana pseudostem sap when contained into the 12 Volts wet cell battery. TheAnalysis of Variance (ANOVA) was used to determine the significant differences between the control variable and the treatments for the generation of electricity. In the comparison of means of Factor A (Treatment), Duncan's Multiple Range Test (DMRT) was used since the number of treatment/levels/cultivars under Factor A (Treatment) was more than 6. On the other hand, in the comparison of means of the treatment and time interval, the DMRT was also used since the number of treatment combinations/levels/cultivars was more than 6. In this case the total factor combinations were 40 (8 x 5) [6]. In comparing the means of Factor B (Time Interval), the Least Significant Differences (LSD) was employed due to the number of levels being considered in Factor B (5-time interval). LSD was used when the levels was less than 6 [6].

Hence, the study was based on the previous studies of the proponent during his undergraduate studies. The author confirms being sole contributor of this work which has been approved for publication. It is important to consider that the banana plants to be cut down should be those that are ready to harvest to adhere to the protocols and research standards so that young banana plants will not be sacrificed. Likewise, the researcher respected the dignity of the result of the study and ensured that the research data was kept with confidentiality specially on the data obtained during the data gathering.

*Disposal of the Waste*

The wet cell batteries containing the sulfuric acid, distilled water and the six cultivars of banana sap were drained in a plastic bottle container and collected by the Ecological Solid Waste Management team of the Municipal Local Government of Cabarroguis. For body protection while disposing of the waste products, a laboratory gown, a mask, and goggles were worn.

## 3. RESULTS AND DISCUSSION

**Section 1.** Biological Profile of the Banana Cultivars

*Taxonomic Classification and Characteristics of the Banana Cultivars*

*Figure 2*
*Bulkan Plant*

*Figure 3*
*Bungulan Plant*

*Figure 4*
*Lakatan Plant*

*Figure 5*
*Morado Plant*

*Figure 6*
*Saba Plant*

*Figure 7*
*Tordan Plant*

*Figure 8*
*Pseudostem of Bulkan Cultivar*

*Figure 9*
*Pseudostem of Bungulan Cultivar*

*Figure 10*
*Pseudostem of Lakatan Cultivar*

*Figure 11*
*Pseudostem of Morado Cultivar*

*Figure 12*
*Pseudostem of Saba Cultivar*

*Figure 13*
*Pseudostem of Tordan Cultivar*

*Figure 14*
*Fruit of Bulkan Cultivar*

*Figure 15*
*Fruit of Bungulan Cultivar*

*Figure 16*
*Fruit of Lakatan Cultivar*

*Figure 17*
*Fruit of Morado Cultivar*

*Figure 18*
*Fruit of Saba Cultivar*

*Figure 19*
*Fruit of Tordan Cultivar*

Generally, the banana plant is a large perennial herb with pseudostems that resemble trunks made of the leaf sheaths. The plant has 8–12 leaves that can reach a length of 9 feet and a width of 2 feet. In certain instances, root development in loose soil can extend up to 30 feet laterally. The description of other plants varies depending on their variation. At least seven to twelve months after planting, the real underground

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stem (corm) starts to grow flowers. The pseudostem's middle is penetrated by the inflorescence, or flower stalk. Flowers grow in groups and spiral around their central axis. Most cultivars feature a few "hands" of neuter flowers that have ovulated and lost their stamens that follow the female flowers. Usually, 60 to 90 days after the first appearance of the blossoms, the fruits are ready. The number of "hands" along the central stem of each cluster of fruits varies. The fruit "fingers" that make up each "hand" are two transverse rows. Size (finger length and thickness), evenness of ripening, lack of blemishes and flaws, and cluster layout all affect the fruit's flavor.

The findings of this section of the study can be a valuable tool for cultivar identification and selection for planting by interested banana growers and future research by scientists for any references. As a result, each banana cultivar has its own distinctive characteristics and morphology, such as the size of the leaves, the diameter of the pseudostem, and the reproductive stage the banana goes through before bearing fruit.

Furthermore, the geographical distribution of the cultivars has demonstrated that they can still thrive at various altitudes. The descriptions have also made it possible to learn more about the information, including where it came from, where does it belongs to, and other relevant details that provides biological information.

### *pH Measurement of the Substrate*

**Table 1**
*pH of the Substrate of the Banana Cultivars*

| No. | Banana Cultivars | pH of the Substrate |
|---|---|---|
| 1 | *Bulkan* | 7.10 |
| 2 | *Bungulan* | 7.50 |
| 3 | *Lakatan* | 7.80 |
| 4 | *Morado* | 7.20 |
| 5 | *Saba* | 7.50 |
| 6 | *Tordan* | 7.30 |
| | **MEAN** | **7.40** |

*Legends: pH- Power of Hydrogen Acidic: O-6, Neutral: 7, Basic: 8-14*

The pH of the substrate is 7.40 pH on average, with *Lakatan* having the highest pH (7.80 pH) and *Bulkan* having the lowest (7.10 pH), indicating that the pH of the substrate between 7.10 pH and 7.80 pH is regarded as neutral. According to studies, fruit juices can be sources of electrolytes for generating energy, and banana sap or stem juice, which has a pH of 7, has the potential to be employed in the manufacturing of beneficial products [8]. Hence, it can be said that the pH of the substrate where the banana cultivars were plant is generally basic which is a suitable pH condition in growing the plants.

### *pH Measurement of the Sap*

**Table 2**
*Initial pH of the Banana Pseudostem Sap*

| No. | Banana Cultivars | Initial pH of the Banana Pseudostem sap |
|---|---|---|
| 1 | *Bulkan* | 8.50 |
| 2 | *Bungulan* | 7.58 |
| 3 | *Lakatan* | 8.46 |
| 4 | *Morado* | 9.35 |
| 5 | *Saba* | 8.54 |
| 6 | *Tordan* | 7.40 |
| | **MEAN** | **8.31** |

*Legends: pH- Power of Hydrogen Acidic- O-6, Neutral-7, Basic 8-14*

The computed mean on the initial pH of the banana pseudo stem sap is 8.31 pH, which indicates that it is basic. On the other hand, along with the initial pH of the banana pseudostem sap, *Morado* has the highest pH with 9.35 pH and *Tordan* has the lowest pH with 7.40 pH.

According to studies, fruit juices can serve as supplies of electrolytes for producing energy, and banana sap or stem juice, which has a pH of 7, may be used to make useful products [23] [24].

Thus, the pH measurement of the sap of the different banana cultivars particularly on the initial pH of the pseudostem sap upon extraction is generally basic.

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**Section 2.** Potential energy (Voltage) for Electricity Generation

**Table 3**
*Voltage from Positive Control, Negative Control and the Six Banana Cultivars Measured at Five Time Intervals*

| Factor A (Treatments) | Time Interval (Weeks) | | | Treatment Total |
|---|---|---|---|---|
| | **Rep. 1** | **Rep. 2** | **Rep. 3** | |
| | **B1 (Week 0)** | | | |
| Positive Control (Sulfuric Acid) | 26.70 | 26.70 | 26.80 | 80.20 |
| Negative Control (Distilled Water) | 21.60 | 22.50 | 21.90 | 66.00 |
| *Bulkan* | 18.80 | 20.60 | 20.40 | 59.80 |
| *Bungulan* | 19.00 | 20.00 | 20.30 | 59.30 |
| *Lakatan* | 19.90 | 18.90 | 18.50 | 57.30 |
| *Morado* | 18.20 | 19.80 | 20.30 | 58.30 |
| *Saba* | 18.80 | 17.60 | 19.30 | 55.70 |
| *Tordan* | 20.50 | 20.80 | 19.90 | 61.20 |
| | **B2 (Week 1)** | | | |
| Positive Control (Sulfuric Acid) | 24.00 | 26.80 | 26.40 | 77.20 |
| Negative Control (Distilled Water) | 18.90 | 23.60 | 24.40 | 66.90 |
| *Bulkan* | 24.90 | 24.80 | 25.90 | 75.60 |
| *Bungulan* | 19.40 | 19.60 | 19.80 | 58.80 |
| *Lakatan* | 24.80 | 24.50 | 24.80 | 74.10 |
| *Morado* | 19.20 | 18.90 | 21.10 | 59.20 |
| *Saba* | 20.20 | 20.30 | 20.30 | 60.80 |
| *Tordan* | 19.10 | 19.10 | 21.80 | 60.00 |
| | **B3 (Week 2)** | | | |
| Positive Control (Sulfuric Acid) | 25.60 | 22.70 | 25.90 | 74.20 |
| Negative Control (Distilled Water) | 12.50 | 16.60 | 13.30 | 42.40 |
| *Bulkan* | 23.10 | 21.70 | 20.60 | 65.40 |
| *Bungulan* | 19.70 | 17.40 | 20.60 | 57.70 |
| *Lakatan* | 19.90 | 19.60 | 20.20 | 59.70 |
| *Morado* | 16.30 | 19.30 | 19.20 | 54.80 |
| *Saba* | 22.10 | 24.10 | 20.80 | 67.00 |
| *Tordan* | 17.90 | 20.70 | 17.40 | 56.00 |
| | **B4 (Week 3)** | | | |
| Positive Control (Sulfuric Acid) | 23.20 | 25.90 | 25.80 | 74.90 |
| Negative Control (Distilled Water) | 12.60 | 16.10 | 13.20 | 41.90 |
| *Bulkan* | 23.20 | 21.70 | 20.20 | 65.10 |
| *Bungulan* | 19.80 | 17.30 | 21.00 | 58.10 |
| *Lakatan* | 19.80 | 19.90 | 20.40 | 60.10 |
| *Morado* | 16.20 | 19.50 | 19.30 | 55.00 |
| *Saba* | 22.20 | 19.50 | 19.30 | 61.00 |
| *Tordan* | 19.50 | 20.60 | 17.30 | 57.40 |
| | **B5 (Week 4)** | | | |
| Positive Control (Sulfuric Acid) | 21.70 | 23.20 | 25.20 | 70.10 |
| Negative Control (Distilled Water) | 14.60 | 16.40 | 13.30 | 44.30 |
| *Bulkan* | 23.20 | 22.80 | 21.30 | 67.30 |
| *Bungulan* | 20.60 | 17.70 | 21.10 | 59.40 |
| *Lakatan* | 20.80 | 20.90 | 20.70 | 62.40 |
| *Morado* | 18.50 | 19.70 | 19.60 | 57.80 |
| *Saba* | 22.80 | 24.20 | 21.20 | 68.20 |
| *Tordan* | 19.60 | 20.70 | 17.50 | 57.80 |
| **Rep. Total (R)** | **809.40** | **832.70** | **826.30** | |
| **Grand Total (G)** | | | | **2,468.40** |

At various times, the voltage produced by the various banana cultivars was measured, noted, and tabulated. It can be noted that the grand total of the voltage

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generated among all the treatments is 2, 468.40 V. Since it was found out that it has potential energy (voltage) at different time intervals, the banana pseudostem sap (BPS) can be used to create value-added products which is also supported by the findings and claims of Subagyo and Chafidz (2018) that it has potential chemical properties and compositions [25]. Hence, the general findings of the potential energy (voltage) from positive control, negative control and the six banana cultivars measured at five-time interval has resulted into different amount of energy present in each of the set-up. Combining all the wet cell battery could generally give a higher potential energy.

**Table 4**

*ANOVA on the Voltage from Positive Control, Negative Control and the Six Banana Cultivars Measured at Five Time Intervals*

| Source of Variation | Degrees of Freedom | Sum of Squares | Mean Square | F-computed | Tabular F | |
|---|---|---|---|---|---|---|
| | | | | | 5% | 1% |
| Factor A (Treatment) | 7 | 569.21 | 81.3156 | 42.41** | 2.12 | 2.87 |
| Factor B (Time Interval) | 4 | 93.8 | 23.4507 | 12.23** | 2.48 | 3.55 |
| Treatment x Interval | 28 | 297.28 | 10.6171 | 5.54** | 1.617 | 1.97 |
| Error | 80 | 153.38 | 1.9173 | | | |
| Total | 119 | 1113.67 | | | | |
| | | | | | | |
| **Grand Mean** | **20.57** | | | | | |
| **cv (%)** | **6.73** | | | | | |

*** - highly significant (significant at 1% level)*

The data was analyzed using completely randomized design for two-factorial experiment or study. It can be seen on the Analysis of Variance that the treatments (positive control (sulfuric acid), negative control (distilled water), *Bulkan, Bungulan, Lakatan, Morado, Saba and Tordan*in factor A, time interval (Week 0, Week 1, Week 2, Week 3, and Week 4) in factor B and the interaction of treatments and time interval yielded a highly significant difference with each other as proven by the higher F-computed value compared to the tabular F values for 5% and 1% level of significance. The coefficient of variation was shown to be 6.73% implying a very reliable data. Considering treatments as a single factor, it was shown in the ANOVA that the F-computed value of 42.41 was higher than the tabular F values of 2.12 and 2.87 for 5% and for 1% level of significance, respectively.This result depicts that the positive control (sulfuric acid), negative control (distilled water) and the six banana cultivars namely the *Bulkan, Bungulan, Lakatan, Morado, Saba and Tordan* being studied under treatments are statistically and significantly different with each other and that they are not comparable with each other.

**Table 5**
*Comparison of Mean of Factor A (Treatments)*

| Factor A (Treatments) | Means | Alphabet Notation |
|---|---|---|
| Positive Control (Sulfuric Acid) | 25.107 | a |
| Negative Control (Distilled Water) | 17.433 | d |
| *Bulkan* | 22.213 | b |
| *Bungulan* | 19.553 | cd |
| *Lakatan* | 20.907 | bc |
| *Morado* | 19.007 | cd |
| *Saba* | 20.847 | bc |
| *Tordan* | 19.493 | cd |

*Note: Means having the same letter denotes not significant with each other*

Further analysis for Factor A (treatments) was done by comparing its means using Duncan's Multiple Range Test (DMRT) to test if which among the positive control (sulfuric acid), negative control (distilled water) and the six banana cultivars namely the *Bulkan, Bungulan, Lakatan, Morado, Saba and Tordan* has a significant difference when compared with each other. Comparison of means for Factor A (treatments) revealed that positive control (sulfuric acid) has the highest voltage produced measuring a mean voltage of 25.107 V and the lowest voltage produced was observed in negative control (distilled water) with a mean of 17.433 V. However, it was observed that it is statistically the same with *Lakatan* and *Saba* with 20.907 V and 20.847 V respectively. Moreover, the result implies further that it is statistically the same with the*Bungulan, Morado* and *Tordan* cultivars with a mean of 19.553 V, 19.007 V, and 19.493 V respectively.

**Table 6**
*Comparison of Mean for Factor B (Time Interval)*

| Factor B | Means | Alphabet Notation |
|---|---|---|
| Week 0 | 20.742 | b |
| Week 1 | 22.192 | a |
| Week 2 | 19.883 | c |
| Week 3 | 19.729 | c |
| Week 4 | 20.304 | bc |

*Note: Means having the same letter denotes not significant with each other LSD (.05)= .7955*

When the effect of Factor B (time interval) from Week 0 to Week 4 was considered as a single factor, it was revealed that the potential energy (voltage) measured from five (5) different time intervals was statistically different and significantly different from each other at 1% level of significance. This was supported by the higher F-computed value of 12.23 compared with the tabular F values for 5% and 1% with 2.48 and 3.55, respectively. With a mean of 22.192, Week 1 generated the highest voltage, while Weeks 2 and 3 had the lowest means, respectively. As a result, it can be shown that the voltage measured at various time intervals varied statistically and significantly.

**Table 7**

*Comparison of Means of the Interaction of Factor A (Treatments) and Factor B (Time Interval) Using Duncan's Multiple Range Test (DMRT)*

| Treatment | Factor A | Factor B | Means | Alphabet Notation |
|---|---|---|---|---|
| 1 | Sulfuric Acid | Week 0 | 26.733 | a |
| 2 | Distilled Water | Week 0 | 22 | fghij |
| 3 | *Bulkan* | Week 0 | 19.933 | hijkl |
| 4 | *Bungulan* | Week 0 | 19.767 | hijkl |
| 5 | *Lakatan* | Week 0 | 19.1 | kl |
| 6 | *Morado* | Week 0 | 19.433 | jkl |
| 7 | *Saba* | Week 0 | 18.567 | l |
| 8 | *Tordan* | Week 0 | 20.4 | ghijklm |
| 9 | Sulfuric Acid | Week 1 | 25.733 | ab |
| 10 | Distilled Water | Week 1 | 22.3 | efghi |
| 11 | *Bulkan* | Week 1 | 25.2 | abc |
| 12 | *Bungulan* | Week 1 | 19.6 | ijkl |
| 13 | *Lakatan* | Week 1 | 24.7 | abcde |
| 14 | *Morado* | Week 1 | 19.733 | hijkl |
| 15 | *Saba* | Week 1 | 20.267 | ghijklm |
| 16 | *Tordan* | Week 1 | 20 | hijkl |
| 17 | Sulfuric Acid | Week 2 | 24.733 | abcde |
| 18 | Distilled Water | Week 2 | 14.133 | m |
| 19 | *Bulkan* | Week 2 | 21.8 | fghijk |
| 20 | *Bungulan* | Week 2 | 19.233 | jkl |
| 21 | *Lakatan* | Week 2 | 19.9 | ijk |
| 22 | *Morado* | Week 2 | 18.267 | l |
| 23 | *Saba* | Week 2 | 22.333 | efghi |
| 24 | *Tordan* | Week 2 | 18.667 | l |
| 25 | Sulfuric Acid | Week 3 | 24.967 | abcd |
| 26 | Distilled Water | Week 3 | 13.967 | m |
| 27 | *Bulkan* | Week 3 | 21.7 | ghijk |
| 28 | *Bungulan* | Week 3 | 19.367 | jkl |
| 29 | *Lakatan* | Week 3 | 20.033 | hijkl |
| 30 | *Morado* | Week 3 | 18.333 | l |
| 31 | *Saba* | Week 3 | 20.333 | hijk |
| 32 | *Tordan* | Week 3 | 19.133 | kl |
| 33 | Sulfuric Acid | Week 4 | 23.367 | bcdef |
| 34 | Distilled Water | Week 4 | 14.767 | m |
| 35 | *Bulkan* | Week 4 | 22.433 | defgh |
| 36 | *Bungulan* | Week 4 | 19.8 | ijkl |
| 37 | *Lakatan* | Week 4 | 20.8 | fghijkl |
| 38 | *Morado* | Week 4 | 19.267 | jkl |
| 39 | *Saba* | Week 4 | 22.733 | cdefg |
| 40 | *Tordan* | Week 4 | 19.267 | jkl |

The table reveals that the highest voltage measurement can be attained in the interaction of treatment 1 (Positive Control (sulfuric acid) at Week 0) with a mean of 26.733V but it was also observed that it is statistically comparable with treatment 9 (Positive Control (sulfuric acid) at Week 1), treatment 11 (*Bulkan* cultivar at Week 1), treatment 25 (Positive Control (sulfuric acid) at Week 3), treatment 17 (Positive Control (sulfuric acid) at Week 2) and treatment 13 (Positive Control (sulfuric acid) at Week 1) with a mean of 25.733 V, 25.2 V, 24.967 V, 24.733 V and 24.7 V, respectively. This means that any of the treatments will statistically (they are not the same with values, but they are treated the same in the context of statistics) give the highest voltage. Meanwhile, the lowest voltage was observed in treatment 26 (negative control (distilled water) at Week 3) with a mean of 13.967 V and was observed to be statistically the same with treatment 34 (Negative Control (distilled water) at Week 4) and treatment 18 (Negative Control (distilled water) at Week 2) with a mean of 14.767 V and 14.133 V, respectively. Hence, the findings revealed that the treatments are comparable and can be used as electrolyte for wet cell battery in the generation of electricity.

**Table 8**
*Repeated Measures ANOVA with the Treatments (Control Variables and Cultivars) as a Factor Using Mauchly's Test of Sphericity*

| Within Subjects Effect | Mauchly's W | Approx. Chi-Square | Df | Sig. | Epsilon[b] | | |
|---|---|---|---|---|---|---|---|
| | | | | | Greenhouse-Geisser | Huynh-Feldt | Lower-bound |
| Cultivars | .003 | 65.194 | 27 | .000 | .372 | .465 | .143 |

Since the Mauchly's sphericity test is significant 0.05, it can be said that that the condition of sphericity has not been attained and thus the corrected F-value is used. From the value of W (0.003), the Greenhouse-Geisser corrected F -value is used since Mauchly's W is greater than 0.75. Meaning there is a significant difference between the treatments and the cultivars used in the study. As such, the null hypothesis that the variances of the differences are not equal can be rejected. The result implies that the six cultivars of banana has a potential energy (voltage) that can be used as electrolyte for wet cell battery even when fresh and stored at different time intervals.

**Table 9**
*Tests Within-Subjects Effects of the Control Variables and the Cultivars*

| Source | | Type III Sum of Squares | df | Mean Square | F | Sig. | Partial Eta Squared | Noncent. Parameter | Observed Power[a] |
|---|---|---|---|---|---|---|---|---|---|
| Cultivar | Sphericity Assumed | 569.209 | 7 | 81.316 | 18.444 | .000 | .568 | 129.106 | 1.000 |
| | Greenhouse-Geisser | 569.209 | 2.606 | 218.434 | 18.444 | .000 | .568 | 48.062 | 1.000 |
| | Huynh-Feldt | 569.209 | 3.255 | 174.872 | 18.444 | .000 | .568 | 60.034 | 1.000 |
| | Lower-bound | 569.209 | 1.000 | 569.209 | 18.444 | .001 | .568 | 18.444 | .979 |
| Error (Cultivar) | Sphericity Assumed | 432.068 | 98 | 4.409 | | | | | |
| | Greenhouse-Geisser | 432.068 | 36.482 | 11.843 | | | | | |
| | Huynh-Feldt | 432.068 | 45.570 | 9.481 | | | | | |
| | Lower-bound | 432.068 | 14.000 | 30.862 | | | | | |

a. Computed using alpha = .05

The table indicates that for the tests of effects within-subjects for control variables and cultivars, there are significant differences among treatments as shown on the corrected F-value when using Greenhouse-Geisser Test.

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Because of this, there are significant differences between treatments with a significance value of.000 at the.05 level of significance, depending on the cultivars and control factors that are examined within-subjects.

Nonetheless, the six cultivars can be used as an alternative electrolyte for wet cell batteries despite their differences in their potential energy (voltage).

**Table 10**

*Estimates of the Voltage Produced by the Control Variables and the Cultivars of Banana Sap as Electrolyte for Wet Cell Battery*

| | | | 95 % Confidence Interval | |
|---|---|---|---|---|
| **Cultivar** | **Mean** | **Std. Error** | **Lower Bound** | **Upper Bound** |
| Positive Control (Sulfuric Acid) | 25.107 | .438 | 24.166 | 26.047 |
| Negative Control (Distilled Water) | 17.433 | 1.119 | 15.033 | 19.834 |
| Bulkan | 22.213 | .517 | 21.104 | 23.322 |
| Bungulan | 19.553 | .317 | 18.874 | 20.232 |
| Lakatan | 20.907 | .534 | 19.762 | 22.051 |
| Morado | 19.007 | .339 | 18.280 | 19.734 |
| Saba | 20.847 | .495 | 19.784 | 21.909 |
| Tordan | 19.493 | .368 | 18.705 | 20.282 |

Table 10 indicates further that the positive control (sulfuric acid) posted the highest potential energy (voltage) among all the treatments and the negative control (distilled water) has the lowest voltage generated with a mean of 17.433. Meanwhile, the *Bulkan* cultivar is the highest among experimental treatments which generated a mean of 22.213 V having an SD of .517.

The outcome also suggests that there are differences between treatments in the confidence level at the 95% confidence interval. As a result, there are differences in the estimations of the voltage produced by the control variables and banana sap cultivars as the electrolyte for wet cells.

As such, the six cultivars of banana are comparable to the sulfuric acid and the distilled water. Having discovered it has generated potential energy, the sap contained in the wet cell battery can be used as an electrolyte.

**Table 11**
*Pairwise Comparisons of the Control Variables and the Banana Cultivars*

| (I) Cultivar | (J) Cultivar | Mean Difference (I-J) | Sig.[b] |
|---|---|---|---|
| Positive Control (Sulfuric Acid) | Negative Control (Distilled Water) | 7.673* | .000 |
| | Bulkan | 2.893* | .002 |
| | Bungulan | 5.553* | .000 |
| | Lakatan | 4.200* | .000 |
| | Morado | 6.100* | .000 |
| | Saba | 4.260* | .000 |
| | Tordan | 5.613* | .000 |
| Negative Control (Distilled Water) | Bulkan | -4.780* | .001 |
| | Bungulan | -2.120 | .100 |
| | Lakatan | -3.473* | .005 |
| | Morado | -1.573 | .130 |
| | Saba | -3.413* | .032 |
| | Tordan | -2.060* | .043 |
| Bulkan | Bungulan | 2.660* | .001 |
| | Lakatan | 1.307* | .001 |
| | Morado | 3.207* | .000 |
| | Saba | 1.367* | .034 |
| | Tordan | 2.720* | .000 |
| Bungulan | Lakatan | -1.353* | .044 |
| | Morado | .547 | .267 |
| | Saba | -1.293 | .074 |
| | Tordan | .060 | .924 |
| Lakatan | Morado | 1.900* | .004 |
| | Saba | .060 | .935 |
| | Tordan | 1.413* | .040 |
| Morado | Morado | -1.840* | .016 |
| | Tordan | -.487 | .246 |
| Saba | Tordan | 1.353* | .046 |

The data violated the assumption of sphericity (W (27)=.003, p <.0005). A Greenhouse-Geisser correction determined that the mean voltages of the different cultivars differed statistically significantly (F (2.606, 36.482) = 18.444, p < 0.0005). A post-hoc analysis produced the pairwise comparisons table. Moreover, the pairwise comparisons table produced from post-hoc analysis revealed what cultivars are statistically different when compared to other cultivars. The asterisk symbol denotes a significant result when compared to a certain cultivar while absence of asterisk signifies that the cultivar in comparison is statistically the same with each other. From the results, it can be concluded that the sap of the six cultivars used as electrolyte for wet cell battery has the potential to be an alternative renewable energy source specially in the generation of electricity.

**Section 3.** Potential to Lit Different Wattage of LED Bulb

This section presents the potential of the banana pseudostem sap as an alternative electrolyte for wet cell battery to lit different wattage of LED bulbs which include the 5 watts, 10 watts and 15 watts at different time intervals.

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**Table 12**
*Capability of Each Treatment to Light 5 Watts, 10 Watts and 15 Watts LED Bulb at Different Time Intervals*

| Treatment | TREATMENT | TIME INTERVAL | 5 Watts | 10 Watts | 15 Watts |
|---|---|---|---|---|---|
| 1 | Sulfuric Acid | Week 0 | / | / | / |
| 2 | Distilled Water | Week 0 | / | / | / |
| 3 | *Bulkan* | Week 0 | / | / | / |
| 4 | *Bungulan* | Week 0 | / | / | / |
| 5 | *Lakatan* | Week 0 | / | / | / |
| 6 | *Morado* | Week 0 | / | / | / |
| 7 | *Saba* | Week 0 | / | / | / |
| 8 | *Tordan* | Week 0 | / | / | / |
| 9 | Sulfuric Acid | Week 1 | / | / | / |
| 10 | Distilled Water | Week 1 | / | / | / |
| 11 | *Bulkan* | Week 1 | / | / | / |
| 12 | *Bungulan* | Week 1 | / | / | / |
| 13 | *Lakatan* | Week 1 | / | / | / |
| 14 | *Morado* | Week 1 | / | / | / |
| 15 | *Saba* | Week 1 | / | / | / |
| 16 | *Tordan* | Week 1 | / | / | / |
| 17 | Sulfuric Acid | Week 2 | / | / | / |
| 18 | Distilled Water | Week 2 | X *Except for Treatment 2 | X | X |
| 19 | *Bulkan* | Week 2 | / | / | / |
| 20 | *Bungulan* | Week 2 | / | / | / |
| 21 | *Lakatan* | Week 2 | / | / | / |
| 22 | *Morado* | Week 2 | / | / | / |
| 23 | *Saba* | Week 2 | / | / | / |
| 24 | *Tordan* | Week 2 | / | / | / |
| 25 | Sulfuric Acid | Week 3 | / | / | / |
| 26 | Distilled Water | Week 3 | X *Except for Treatment 2 | X | X |
| 27 | *Bulkan* | Week 3 | / | / | / |
| 28 | *Bungulan* | Week 3 | / | / | / |
| 29 | *Lakatan* | Week 3 | / | / | / |
| 30 | *Morado* | Week 3 | / | / | / |
| 31 | *Saba* | Week 3 | / | / | / |
| 32 | *Tordan* | Week 3 | / | / | / |
| 33 | Sulfuric Acid | Week 4 | / | / | / |
| 34 | Distilled Water | Week 4 | X *Except for Treatment 2 | X | X |
| 35 | *Bulkan* | Week 4 | / | / | / |
| 36 | *Bungulan* | Week 4 | / | / | / |
| 37 | *Lakatan* | Week 4 | / | / | / |
| 38 | *Morado* | Week 4 | / | / | / |
| 39 | *Saba* | Week 4 | / | / | / |
| 40 | *Tordan* | Week 4 | / | / | / |

It is revealed that most of the treatments have the capability to lit the 5 Watts, 10 Watts and 15 Watts LED bulb except in Week 2, Week 3 and 4 Weeks of the negative control (distilled water). Moreover, only the 5 Watts LED bulb lit in replication 2 during Week 2, Week 3 and Week 4 while the rest of the treatments and replication along the time interval for the distilled water can no longer lit the 10 Watts and 15 Watts LED bulb. In essence, electrochemical reactions in a battery that has been filled with chemicals or any electrolytes produce electrons which are capable to lit such bulb [25]. A similar study setup was used to discover the potential of several domesticated animal urines as an electrolyte for electricity generation. The results show that these urines have the capacity to play a transistor radio due to their potential energy (voltage).

## 4. Conclusion

In the light of the findings of the study, the following conclusions were drawn: The biological profile of the six banana cultivars namely the Bulkan*, Bungulan, Lakatan, Morado, Saba* and*Tordan*was established with their taxonomic classification that include the scientific name, local name, cultivar, origin and characterization of the entire plant, pseudostems and fruits, pH of the substrate as well as pH of the sap. On the other hand, the six banana cultivars have the potential energy (Voltage) for electricity generation when fresh and stored at different time intervals such as stored for 1 week, stored for 2 weeks, stored for 3 weeks, and stored for 4 weeks. Likewise, there is significant difference on the potential energy (voltage) and the interaction between treatments as well as the time interval in the generation of electricity and lastly, the sap of the different cultivars when contained in wet cell batteries can lit the different wattage of LED bulb (5 watts, 10 watts and 15 watts) even at different time intervals. Hence, the different banana cultivars sap when can be an alternative electrolye for wet cell batteries.

## 5. Recommendations

Given the results of the study, a chemical analysis or ion composition testing should be done to identify the electrolytes or elements present in the sap to provide a more solid justification for why the banana sap can produce potential energy (voltage) for electricity generation. The capacity of banana sap as an electrolyte for electricity generation may be determined by considering additional elements, such as the power generated when connected to equipment, devices, or appliances as well as determining the duration of the generated electricity. Studies can also look into further applications for banana sap in daily life aside from LED bulb. The use of sap as a widely available, affordable, ecologically friendly, and cost-effective raw resource in the environment is suggested. Lastly, future study may investigate the consistency of the results and inclusion of other variables such as the influence of harvest time.

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