An In-depth Analysis of the use of Saba Banana (Musa balbisiana Colla cv. Saba) Peduncle as an Activated Carbon Electrode in Microbial Fuel Cell

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Abstract: The use of agricultural waste, particularly the consumption of banana peduncles become a significant concern, as the Philippines annually generates about 16 million tons of banana peduncles as agricultural waste. In response to this issue, researchers proposed a study aimed at utilizing saba banana peduncles as an activated carbon electrode in microbial fuel cell setups. Two identical setups were constructed, one utilizing the commercial carbon electrode, the other using banana peduncles. Diluted water from Jamboree Lake, located in Poblacion, Muntinlupa City, was collected and used as wastewater for the anodic chamber of the microbial fuel cell setup. Both chambers in each setup were housed in 1000-ml plastic containers, which were modified to accommodate wires and electrodes on both the lids and the sides to facilitate the salt bridge connection. An agar salt-bridge was constructed to connect the two chambers. The banana peduncle carbon electrode exhibited a comparable required range of voltage as the highest was averaged over the 10 hours observation. The required average and the highest current produced by the electrode were also noted. The commercial electrode recorded the highest of -76.8mV at the 10th hour while the banana peduncle level exhibited the highest of -24.5mV at the 10th hour observation period. The pH shift from pH 5 to pH 6 also serves as proof of the system's viability. Although despite the lower efficiency in activated carbon production from banana peduncles, which could be enhanced through improved drying and carbonization processes, its superior electricity generating performance compared to the commercial carbon electrode with identical setups and calibrations is evident.

Key Words: Microbial Fuel Cell; Banana Peduncles; Carbon electrodes.

1. INTRODUCTION

The Philippines is one of the genuinely great agricultural countries of the world. However, the utilization of agricultural waste, particularly in the consumption of banana peduncles is a serious problem.

The study is based on the prospect of utilizing the banana peduncles which are considered waste, as activated carbon (AC) electrodes in MFCs. Additionally, the research seeks to identify the potential of banana peduncles to reduce agricultural waste and increase electricity production (Verma & Mishra, 2023; Subran et al., 2023).

The study is aligned with the sustainable development goal 12: Responsible Consumption and Production. Instead of allowing agricultural waste to contribute to environmental pollution, Saba banana peduncles are being utilized to generate clean energy, thereby reducing waste and promoting sustainability.

2. METHODOLOGY

2.1. Pre-Treatment of the Peduncles

First, the banana peduncles underwent a cleaning process, with an initial wash in tap water, followed by a rinse in distilled water. The peduncles were cut and gently dried by patting. Following this, the peduncles experienced drying, until fully dried. The dried banana peduncle segments were pulverized to create a fine powder and sieved. It is then soaked in a phosphoric acid solution and then dried again in the oven.

2.2. Carbonization and Activation Process

The samples underwent a carbonization process to produce activated carbon through a makeshift oven. Afterwards, it was placed in an oven to dry at 100°C until completely dry, refined again by mortar and pestle for an even powder, and then sealed in a dry container.

2.3. Carbon Electrode Molding

In the process of electrode molding, activated carbon derived from the banana peduncle was combined with a polyvinyl acetate binder, forming a clay-like material. It was then cured in an oven at 100 °C for 1 hour to harden. The electrodes were then placed in a dry, sealed container.

2.4. Construction of the MFC Setup

Researchers collected diluted water and employed it as wastewater for the anodic chamber of the microbial fuel cell setup, while combining salt and water for the cathodic chamber. They then used agar and potassium chloride for the salt bridge. The container's sides and lids were adjusted and pierced to fit wires and electrodes. These wires were correctly connected to the ends of alligator clips in the multimeter for testing.

2.5. Data Collection and Analysis

The measurements were carried out over a period of 10 hours, measuring the pH level of the sludge during the experiment. Independent T-testing was used to test the null hypothesis for the significant difference between the voltage output of both setups.

3. RESULTS AND DISCUSSION

Two different setups of microbial fuel cells were used to compare the characterization and functionality of an activated carbon electrode derived from banana peduncles and a commercial activated carbon electrode.

3.1 Electrode Electricity Generation Performance

Time (hr)	**Commercial Activated Carbon Electrode Setup** (mV)	**Banana Peduncle Activated Carbon Electrode Setup** (mV)
0 (Start)	-330	-330
1	-260	-280
2	-280	-230
3	-265	-277
4	-280	-275
5	-258	-280
6	-231	-225
7	-227	-268
8	-210	-240
9	-226	-260
10	-225	-240
11 (start of opening of cathode lid and and not sinking of copper wire in the electrolyte)	-172	-160
12	-111	-127

Figure 1 Voltage Output Due to Calibration Table

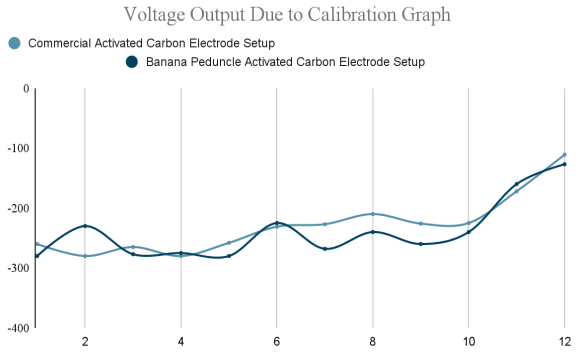

Figure 2 Line Graph showing the Voltage Output Due to Calibration

It can be observed that despite undergoing 10 hours of observation, the voltage output remained fluctuating below -200 mV without much change until configurations take place to promote the microbial fuel cell process.

Figure 3 Voltage Output Over Time Table

Time (hr)	Commercial Activated Carbon Electrode Setup (mV)	Banana Peduncle Activated Carbon Electrode Setup (mV)
0 (Start)	-130	-109
1	-132	-108
2	-137.1	-122.1
3	-105.6	-115.7
4	-118.1	-100.3
5	-106.7	-40.9
6	-106.7	-19.4
7	-99.6	-18.1
8	-89.9	-24.4
9	-81.6	-24.1
10	-76.8	-24.5

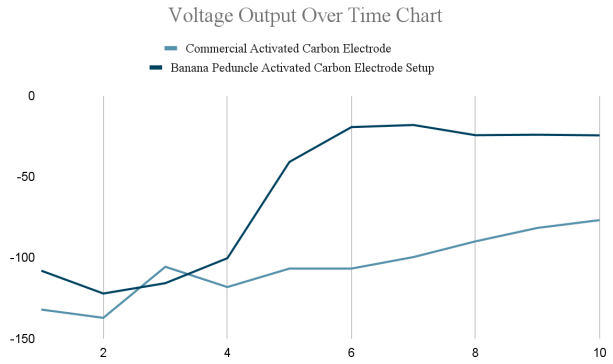

Figure 4 Line Graph showing the Voltage Output Over Time

This can be further tested using independent t-testing with different variance statistical analysis that helped compare the means of both groups, using the formula:

Eq.3 $$t = \frac{\bar{x}_b - \bar{x}_c}{\sqrt{\frac{s_b^2}{n_b} + \frac{s_c^2}{n_c}}}$$

$df = n_1 + n_2 - 2$
where:
$\bar{x_b}$ = *mean value of the banana peduncles setup*
$\bar{x_c}$ = *mean value of the commercial setup*
n_b = *size of the banana peduncles setup*
n_c = *size value of the commercial setup*
s_b = *standard deviation of the banana peduncles setup*
s_c = *standard deviation of the commercial setup*

The values from the data table in Fig 3 were used to plug in for the formula resulting into a solution and t statistic of:

t = -64.23 - (-107.65)2067.66 11 + 408.51 11
t = 2.89398271521
df = 20

Figure 5 Independent T-Testing

Groups	Sample Size	Mean	Standard Deviation
Banana Peduncle	11	-64.227	45.472
Commercial	11	-107.645	20.212

Groups	T-statistic	Degrees of Freedom	T-value/ T-critical Value	P-value
Banana Peduncle				
Commercial	2.893982715 21	20	2.894	0.009

4. CONCLUSIONS

The investigation into using banana peduncles as an activated carbon electrode in microbial fuel cells yielded intriguing results. The tendency in the results is that the banana peduncles carbon electrode has a significantly greater mean voltage output read of -64.23 mV compared to the commercial carbon electrode that posted an average mean voltage read of -107.65mV, this led to better electron transport from the anode to the cathode, thus resulting in more electricity production. Although despite the lower efficiency in activated carbon production from banana peduncles, its superior electricity generating performance compared to the commercial carbon electrode with identical setups and calibrations is evident.

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