Pili (*Canarium Ovatum*) Pulp Extract

Bio-Battery Operated Power Bank

A Research Proposal presented to the faculty of Vinzons Pilot High School

In partial fulfillment of the Requirements in Practical Research II

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A. BACKGROUND OF THE STUDY

The use and cost of energy affect each of us in our everyday lives. Numerous issues emerge as a result of energy use: greenhouse gas emissions, acid rain, climate change, and dependency on limited fossil fuel resources — especially in economically unstable areas around the world. Primary energy demand is expected to triple by 2050, according to the World Energy Council, as the global population rises to 8-9 billion people and developed countries improve their living standards.

A battery is a type of electrical device that alter chemical energy into electrical energy. Batteries are categorized into various categories depending on their intended use, and these are used in different electrical and electronic devices. An electrical battery contains chemicals such as mercury compounds and lead that is highly hazardous in nature and is not environmentally friendly. Apart from that, there is a risk of chemical leakage as well as battery explosion in some situations.

To address this problem, researchers have developed bio-battery, which reduces the effect of these chemicals on the environment while also providing a significant benefit to humans.

A bio-battery is defined as a device in which organic or inorganic substrate content is converted into electric energy. Using different biological or biochemical agents, such as enzymes or micro-organisms, this conversion takes place. The substrate is broken down to release protons and electrons in the presence of these agents. Electricity is produced by the continued circulation of these protons and electrons inside the bio-battery.

The Philippines has been vulnerable to recurring power outages since the early 1990s. During the summer, when electric power plants run low on renewable resources due to increased electricity demand, power outages are frequent. In the province of Camarines Norte that is consists of 12 municipalities, there are some remote areas and islands that do not have access to electricity. The researchers come up with the idea of developing research entitled, "Pili (*Canarium Ovatum*) Pulp Extract Bio-Battery Operated Power Bank", to create a device that is powered up by organic compounds that can produce energy.

Power banks can be described as portable batteries using circuitry to monitor any power in and out. When power is available, they can be charged using a USB charger, and then used to charge battery-powered products such as cell phones and a host of other devices that would typically use a USB charger.

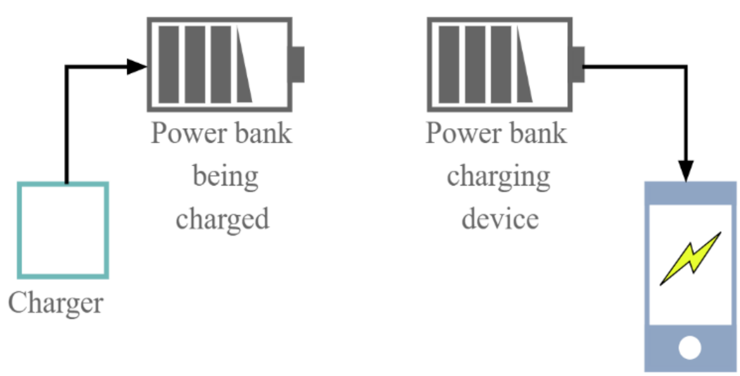

Figure 1. Power Bank

There are a few different types of power bank:

- *Universal or standard power bank*

These power banks are typically charged from a regular USB adapter, and the power bank has some hint as to its charge status. This may be a series of small LED lamps or a simple alphanumeric indicator showing the level of the charge as a percentage of the overall charge. A micro USB connector is usually used as the connecting force.

- *Solar power bank*

As the name indicates, to fuel up, these solar power banks will use sunlight. They have photovoltaic panels to do this. When put in sunlight, these can really only trickle-charge the internal battery since the solar cells are relatively thin, but this can still be a very useful feature, but really only in very sunny or bright conditions.

- *Wireless power bank*

With many devices such as tablets, ear-pods and the like now having the ability to be charged wirelessly, the power bank industry has embraced this idea. Power banks that are themselves charged from a regular USB source can be obtained, but they can wirelessly charge phones and other wirelessly charged compatible electronic devices.

The source of electricity of the portable power bank is an organic bio-battery. A bio-battery is defined as a device in which organic or inorganic substrate content is converted into electric energy. Using different biological or biochemical agents, such as enzymes or micro-organisms, this conversion takes place. The substrate is broken down to release protons and electrons in the presence of these agents. Electricity is produced by the continued circulation of these protons and electrons inside the bio-battery.

A bio battery is a device that stores energy using organic compounds that are able to continuously keep themselves charged without an external power supply. Many studies about bio-batteries are mainly focused on the components of organic materials to produce electricity. The researchers want to propose a power bank that is operated by a bio-battery from pili (*Canarium Ovatum*) pulp extract in order to utilize the capability of the pulp extract as the power source of the device.

Aside from usually being thrown part of the pili, the pulp will be turning into useful raw material, it is also safe and much better than batteries that contain certain chemicals which are highly toxic in nature and prone to explosions.

The pili pulp is similar in composition to avocado. It contains 28–36% oil, carbohydrates, and protein. Its color varies from yellow green to dark green, depending on the type of extraction.

A research article entitled “Philippine *Pili (Canarium ovatum,* Engl.) varieties as source of essential minerals and trace elements in human nutrition” stated that potassium and calcium are the major macro minerals in pulp and *Pili* nut contains sodium, iron, aluminum, zinc, manganese, copper, nickel and chromium. Bioavailability minerals of the pulp and the kernel in the small intestine is high for Mg (pulp: 75.8–90.3%, kernel: 54.4–61.2%) and Ca (pulp: 15.8–40.9%, kernel: 13.7–22.5%). In terms of Tannic acid, it is said that it is higher in pulp.

B. STATEMENT OF THE PROBLEM

The study aims to determine Pili (*Canarium Ovatum*) Pulp extract bio battery as power bank operated. Specifically, this study aims to answer the following questions:

1. Is Pili (*Canarium Ovatum*) Pulp Extract capable of generating electricity as main component of bio-battery?
2. Can the Pili (*Canarium Ovatum*) Pulp Extract bio battery be the source of power as a powerbank?
3. What are the characteristics of Pili (*Canarium Ovatum*) Pulp Extract Bio battery in terms of:
    i. Usability
    ii. Efficiency

C. SIGNIFICANCE OF THE STUDY

This innovative study can help people who experience scarcity or shortage of electricity in their area particularly during calamities. During those times, the power bank using bio battery can be used as temporary source of current. This will provide people a portable power made from a bio-battery to charge battery powered items such as essential equipment like mobile phones, flashlights, and radio. This this will lead to an evident utilization of pili pulp as a potential source of electrical power.

This study is significant to the following:

People. This project will give them a temporary source of energy, especially for those people who live in remote areas that experience scarcity or shortage of electricity. It will also help those people who cannot afford to buy universal, solar or wireless power banks for essential purposes due to its high cost.

Community. This study will help to save resources and reduce the potential problem of waste disposal.

Researchers. This project will help them to broaden their knowledge about the use and importance of bio-waste materials.

Future Researcher. This research will serve as a reference material if they would conduct a similar study.

D. STATEMENT OF THE HYPOTHESIS

This study will foresee the possibility of Pili (*Canarium Ovatum*) Pulp Extract as a potential electric source for bio battery power bank. Furthermore, the maximum potential 7difference and terminal voltage on electricity produced by Pili (*Canarium Ovatum*) Pulp Extract Bio Battery Power bank will be evaluated to test the device acceptability and effectivity.

If the amount of electricity produced by the extract is sustained for a long period of time, then Pili (*Canarium Ovatum*) Pulp Extract can be a potential electric source for bio battery power bank.

E. OBJECTIVES OF THE STUDY

Particularly, this study has the following objectives:

1. To assess the capability of Pili (*Canarium ovatum*) Pulp Extract as the main source of electricity in a bio Battery.
2. To create a Power Bank operated by Pili (*Canarium ovatum*) Pulp Extract Bio Battery.
3. To evaluate the general acceptability of Pili (*Canarium ovatum*) Pulp Extract Bio-battery as a Power Bank in terms of:
    a. Design;
    b. Usability; and
    c. Efficiency

F. SCOPE AND DELIMITATION

The study of Pili (*Canarium ovatum*) Pulp Extract Bio-battery as a Power Bank focuses on the capability of the bio-battery that is made from the pili pulp extract to provide enough number of electrolytes to be able to serve as a temporary source of energy. The Pili (*Canarium ovatum*) will be collected from Barangay Gabon, Talisay, Camarines Norte.

The study will mostly focus on the capability of Pili pulp bio battery to serve as a power bank in terms of; efficiency, maximum potential difference, terminal voltage, design, general acceptability, safety and handy.

In this case, the limitations would be the inability to control the environment during the carbonization process and the lack of related literature and studies leading to the bio battery capacity of Pili (*Canarium ovatum*) Pulp.

G. DEFINITION OF TERMS

- **Biological augmentation** – the addition of archaea or bacterial cultures required to speed up the rate of degradation of a contaminant.
- **Biocatalyst** – a substance, such as an enzyme or hormone that initiates or increases the rate of a chemical reaction.
- **Biochemical** – relating to the chemical processes and substances which occur within living organisms.
- **Biomolecule** – a chemical compound found in living organisms. These include chemicals that are composed of mainly carbon, hydrogen, oxygen, nitrogen, sulfur and phosphorus.
- **Potential Difference Maximum** – the difference in potential between two points that represents the work involved or the energy released in the transfer of a unit quantity of electricity from one point to the other.
- **Mediator** – is a person who helps negotiate between two feuding parties.

- **Microbial Consortium or Consortium** – a two or more bacterial or microbial groups living symbiotically. Consortiums can be endosymbiotic or ectosymbiotic, or occasionally may be both.
- **Microbial Fuel Cell (MFC)** – a bio-electrochemical system that drives an electric current by using bacteria and a high-energy oxidant such as O2, mimicking bacterial interactions found in nature. MFCs can be grouped into two general categories: mediated and unmediated.
- **Rhodopseudomonas Palustris** – a rod-shaped gram-negative purple non-sulfur bacterium, notable for its ability to switch between four different modes of metabolism.
- **Saccharification rate** – usually rate-limiting step in biofuel production using lignocellulosic materials or microalgal biomass that contain a cellulose source.
- **Terminal Voltage** – the voltage at the terminals of an electrical device (as a battery or a generator).

II. REVIEW OF RELATED LITERATURE AND STUDY

A. THEORETICAL FRAMEWORK

a) Bio-battery

A bio-battery is an energy storing device that is powered by organic compounds. Bio-Battery generates electricity from renewable fuels (glucose, sucrose, fructose, etc.) providing a sustained, on-demand portable power source. When enzymes in our bodies break down glucose, several electrons and protons are released. Therefore, by using enzymes to break down glucose, bio batteries directly receive energy from glucose. These batteries then store this energy for later use. This concept is almost identical to how both plants and many animals obtain energy. Bio battery use biocatalyst, either biomolecules such as enzymes or even whole living organism to catalyze oxidation of bio mass-based materials for generating electrical energy.

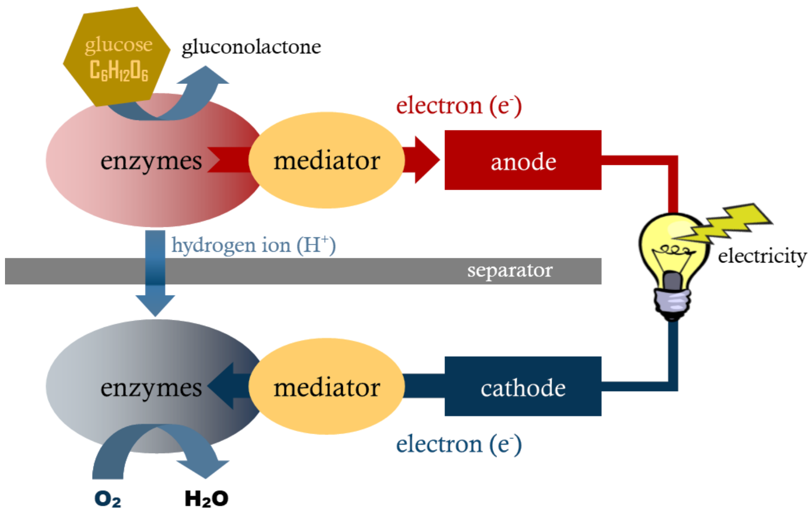

Figure 2. Mechanism of Bio-battery

The Bio Battery is a type of battery which uses energy sources such as carbohydrates, amino acids and enzymes from a variety of sources, based on the work of Professor Kenji Kano (Kyoto University). The anode consists of enzymes that digest sugar and the mediator, and the cathode consists of enzymes that reduce oxygen and the mediator. Vitamin K3 for the anode and potassium ferric cyanide for the cathode are the mediators in this situation. The anode grabs the electrons and hydrogen ions as sugar is added to the mixture. As power is produced by the battery, the protons pass through the electrolyte to the cathode to react with oxygen to create water. The miniaturized bio-fuel cell could, in theory, be produced as a membrane-less fuel cell because the biocatalysts (enzymes) are very catalytically selective.

a) Power Bank

Power banks with higher capacity are also in high demand for charging cell phones, ranging from 2000 mAh to 20000 mAh or beyond. There are three components of the power bank, for example Battery with lithium-ion, circuit and external safety Box. The battery is the central power bank, among other items and security of hardware regulates current, tension, and as well as the temperature. (Narayan et al., 2018)

Narayan et al. (2018) stated that as easy and compact as they are, these power banks commonly used to charge all portable electronic devices. For the operational period of cellphones, high energy batteries are needed.

The power bank consists of three components such as lithium-ion battery, hardware protection circuit, and outer case. Among all, the battery is the heart of the power bank and hardware protection controls the current, voltage and temperature as well. (Narayan et al., 2018)

Narayan et al. (2018) also stated that the power bank input and output are designed to compatible with universal series bus (USB) and this protects the system from any electrical surges while plug-in. The USB connectors are user friendly to connect with any portable electronic devices such as smartphones, cameras, tabs, etc.

According to the study of Narayan et al. (2018), the amount of energy charge in a battery is the capacity and is expressed in ampere-hour (Ah). The power is the electrical energy of the battery and it is the product of the capacity and nominal voltage and is expressed in watt-hour. The charging process is carried out at ambient temperature through USB. During the process, there is a change in the voltages which consume energy. The consumption of energy is obtained and estimated the actual usable capacity of the power bank.

b. EMPIRICAL RELATED STUDIES

The world is changing, people's demands are increasing, and the more we progress in technologies the more we need to keep all energy options open to satisfy the growing demand. In fact, “the percentage of people with access to electricity globally has been steadily increasing over the last few decades. In 1990, around 71% of the world’s population had access; this has increased to 87% in 2016” (Ritchie, and Roser, 2019). In the same study, the authors stated that 40% of people in the world do not have access to clean fuels for cooking, in 2016, only 60% of the world population had access to clean fuels for cooking. This means 4-in-10 people globally did not have access. The industrial and consumer flow of energy and its effects on the environment is higher. They influence the economic, political, regulatory, and social factors of a country. So that the economy of the country is directly relying on the transformation and utilization of resources. Sustainable energy sources are the key, which is pollution-free and environmentally friendly. According to U.S Energy Information Administration (EIA, 2020), biomass is renewable organic material that comes from plants and animals. Biomass contains stored chemical energy from the sun. Plants produce biomass through photosynthesis. Biomass can be burned directly for heat or converted to renewable liquid and gaseous fuels through various processes. The following studies show the potential of plants as a source of electricity.

a) Corn Stover (2009)

Corn stover is usually treated by an energy-intensive or expensive process to extract sugars for bioenergy production. However, it is possible to directly generate electricity from corn stover in microbial fuel cells (MFCs) through the addition of microbial consortia specifically acclimated for biomass breakdown. A mixed culture that was developed to have a high saccharification rate with corn stover was added to single-chamber, air-cathode MFCs acclimated for power production using glucose. The MFC produced a maximum power of 331 mW/m2 with the bio augmented mixed culture and corn stover, compared to 510 mW/m2 using glucose. Denaturing gradient gel electrophoresis (DGGE) showed the communities continued to evolve on both the anode and corn stover biomass over 60 days, with several bacteria identified including Rhodopseudomonas palustris. The use of residual solids from the steam-exploded corn stover produced 8% more power (406 mW/m2) than the raw corn stover. These results show that it is possible to directly generate electricity from waste corn stover in MFCs through bioaugmentation using naturally occurring bacteria (Wang et. al, 2009).

b) Onions (2010)

The (U.S Department of Energy, 2010) stated that the onion waste powers two 300 kW fuel cells, which produce enough electricity to meet up to 100 percent of the processing plant's baseline energy needs. The onion-waste-to-energy system uses two parts: a biomass system that turns onion waste into hydrogen gas, and fuel cells that turn that hydrogen into electricity. The onion tops, tails, and trimmings are juiced, and the sulfur (the substance in onions that makes people cry) is removed from the juice. The juice is then mixed with water and fed through an anaerobic digester containing a series of bacteria that consume the sugars in the onion juices. One eventual result is methane, which is stripped of its hydrogen. That hydrogen is then fed into the two 300 kW fuel cells, producing electricity.

c) Algae Biomass (2010 & 2013)

In this study, we have exploited the potential of sustainable energy production from wastes. Activated sludge and algae biomass are used as substrates in a microbial fuel cell (MFC) to produce electricity. Activated sludge is used at the anode as an inoculum and nutrient source. Various concentrations (1–5 g/L) of dry algae biomass are tested. Among tested concentrations, 5 g/L (5000 mg COD/L) produced the highest voltage of 0.89 V and power density of 1.78 W/m2 under 1000 Ω electric resistance. Pre-treated algae biomass and activated sludge are also used at the anode. They give low power output than without pre-treatment. Spent algae biomass is tested to replace whole (before oil extraction) algae biomass as a substrate, but it gives low power output. This work has proved the concept of using algae biomass in MFC for high energy output. (Rashid, Cui, Rehman, & Han, 2013, p. 91-94).

However, the study of Hannon, Gimpel, Tran, Rasala, Mayfield, (2011) argue that algae biofuels may provide a viable alternative to fossil fuels; nevertheless, this technology must overcome several hurdles before it can compete in the fuel market and be broadly deployed. These challenges include strain identification and improvement, both in terms of oil productivity and crop protection, nutrient and resource allocation and use, and the production of co-products to improve the economics of the entire system. Although there is much excitement about the potential of algae biofuels, much work is still required in the field (pp. 763-784).

d) Rice Husk (2013 & 2016)

The rice husk is the external covering of a rice bit and shields the inward fixings from outer assault by bugs and microscopic organisms. To play out this capacity while ventilating air and dampness, rice plants have created one-of-a-kind nanoporous silica layers in their husks through long periods of characteristic development. Regardless of the monstrous measure of yearly creation almost 108 tons around the world. With an end goal to reuse rice husks for high-esteem applications, we convert the silica to silicon and use it for high-limit lithium battery anodes. Exploiting the interconnected nanoporous structure normally existing in rice husks, the changed over silicon displays astounding electrochemical execution as a lithium battery anode, recommending that rice husks can be an enormous asset for use in high-limit lithium battery negative cathodes (Jung, Ryou, Sung, Park, & Choi, 2013).

Also, Mohiuddin et. al (2016) examines the electricity production potential and social benefits of rice husk in Pakistan. It is estimated in this study that if 70% of rice husk residues are utilized, there will be annual electricity production of 1,328 GWh, and the cost of per unit electricity by rice husk is found at 47.36 cents/kWh as compared to 55.22 cents/kWh of electricity generated by coal. Importantly, the study will increase the awareness of the benefits of utilizing agricultural waste for useful products such as silica, with several social and environmental benefits such as a reduction of 36,042 tCO2e/yr of methane, reducing carbon dioxide emissions, and improving the air quality.

e) Banana and Orange Peel (2016 & 2018)

Microbial Fuel Cell (MFC) is one of the green technologies widely developed for future renewable energy sources. The MFC is a bio-electrochemical system that uses bacterial growth to transform organic substrates, via oxidation-reduction reactions, from chemical energy into electricity. Two different organic substrates include banana peel waste (BPW) and orange-peel waste (OPW) are investigated for their potency as a feedstock for MFCs. In this study, single-chamber MFC was used in all experiments, without chemical pre-treatment or the addition of extra mediators. Both electricity current and potential values were measured for 10 days. The characterization study indicated that OPW contains higher organics materials than that of BPW, as indicated by the VS values of 87.06% total solids/TS (OPW) and 75.32% TS (BPW). Furthermore, the results also showed that both wastes produced electricity with a slightly different amount. On average, BPW has a voltage rating of 0.492 V and an electric current rating of 0.101 mA. While, OPW has average values of 0.563 V and 0.017 mA, respectively. The study confirmed that the organic content of substrates and the microbial activity influenced the electricity produced from the MFCs. (Elviliana, Toding, Virginia, & Suhartini, 2018).

Another study used a different process to turn banana feels into electricity. In this work, Cu2O-Cu composite catalyst has been fabricated by a facile laser-irradiation method. The addition of Cu2O-Cu composite in activated carbon air-cathode greatly improves the performance of the cathode. Our results indicate the enhanced performance is likely attributed to the synergistic effect of the high conductivity of Cu and the catalytic activity of Cu2O towards the oxygen reduction reaction.

Furthermore, an alkaline fuel cell equipped with the composite air-cathode has been built to turn banana peels into electricity. The peak power density of 16.12Wm-2 is obtained under the condition of 3M KOH and 22.04gL-1 reducing sugar, which is higher than other reported low-temperature direct biomass alkaline fuel cells. HPLC results indicate the main oxidation products in the alkaline fuel cell were small organic acids (P. X. Lui, Dong, Q. Lin, Tong, Y. li, & Zhang, 2018).

f) Aloe Vera (2018 & 2019)

Aloe vera contains acid, which has the potential to generate an electric current. The objective of this research is to study the potency of aloe vera extract as an electrolyte for an accumulator. Experimental results showed that aloe vera extract has no stable value of voltage and currency. The voltage and currency of aloe vera extract were reduced by more than 50% for 60 minutes. Then, aloe vera extract was mixed with accu zuur to produce an electrolyte solution. The mixture composition of aloe vera extract to accu zuur of 50:50 (v/v) generated stable voltage and currency. The experimental results showed the potential use of aloe vera extract to reduce the chemicals used in a conventional electrolyte solution. (Azmi, Sispriatna, Ikhsan, Masrura, Azzahra, Mahidin and Supardan, 2018).

Another study was conducted to analyze the characteristic of Aloe Barbadensis Miller (Aloe Vera) leaves in terms of electrical energy generation under specific experimental setups. (Chong, Singh, Kok, 2019) identify that 1111.55uW electrical power can be harvested from the Aloe Vera with 24 pairs of electrodes and this energy is capable to be stored in a capacitor. This energy has a high potential to be used to power up a low power consumption device.

g) Lime, Orange, and Tangerine Waste (2020)

According to the studies of Rojas et. al (2020) revealed that the tangerine microbial fuel cell evidenced a maximum voltage peak of 1.1 V on day 13 while displaying abrupt voltage losses on the following days and throughout the remaining period of substrate monitoring. On the other hand, orange-based fuel denotes lower current generation during these 28 days with values close to 1.6 mA and 0.25 mA on the first and last day, respectively. Still, orange generated 3.5 mA on the first day with values sharply declining in the following days until reaching 0.91 mA on the last day.

In general, substrate volumes in the microbial fuel cells diminished over time, which is consistent with the voltage and current values reported. In addition, pH values increased from day 1 for all substrates, reaching acidic pH values on the last day of measurement due to the consumption of carbon sources. Tangerine reported the highest current density (CD) at 72 mW/cm2 and a maximum voltage of 1.06 volts, while orange generated a CD of 62.5 mW/cm2 and 0.94 volts.

h) Rotten Tomato (2021)

This study focused on the bioelectricity produced by the rotten tomato. According to the experiment of Habbis et. al (2021) conducted for the production of protein, biofuel, and bioelectricity from the culture system of Spirulina platensis (Gomont) in supernatant of three different amount of digested rotten tomato (Solanum lycopersicum), and Kosaric Medium (KM) as control.

Three different concentrations such as 25, 50 and 75% rotten tomato were allowed to digest under aeration. After 17 days, the colorless supernatant was screened and taken in 1.0 L conical flask with three replications. Then, Spirulina platensis was inoculated to grow in these three media (treatments) with the addition of 9.0 g/L $NaHCO3$ and micronutrients, and also in KM as control for a period of 14 days. The cell weight, optical density, chlorophyll, and total biomass of spirulina was attained to the maximum values when grew in KM on the 10th day of culture followed by supernatant of 50% digested rotten tomato (DRT) than in 25 and 75% DRT culture. The chemical properties of the culture media such as pH, salinity, dissolved bio-oxygen, electric conductivity and bioelectricity were increased from first day up to 12th day of experiment. Total biomass of spirulina grown in these media had highly significant ($P < 0.01$) correlation with cell weight ($r = 0.825$) and chlorophyll a ($r = 0.866$) of spirulina. The results showed that the growth performances of S. platensis grown in supernatant of 50% DRT was significantly ($P < 0.01$) higher than that of spirulina grown in supernatant of 25 and 75% DRT. Bioelectricity (300 ±10.20 mV) produced in culture of spirulina in supernatant of 50% DRT was higher than that recorded in KM (240 ±10.20 mV) followed by 75% DRT and other media.

Bioelectricity had directly and strongly significant ($p < 0.001$) correlation with pH ($r = 0.812$), dissolved bio-oxygen ($r = 0.832$), salinity ($r = 0.788$) and electric conductivity ($r = 0.856$). Therefore, this procedure will produce huge amount of electricity in the world and will make a revolution in this field of bio-electricity production. Whole world will be benefited from the output (results) of this experiment.

C. CONCEPTUAL FRAMEWORK

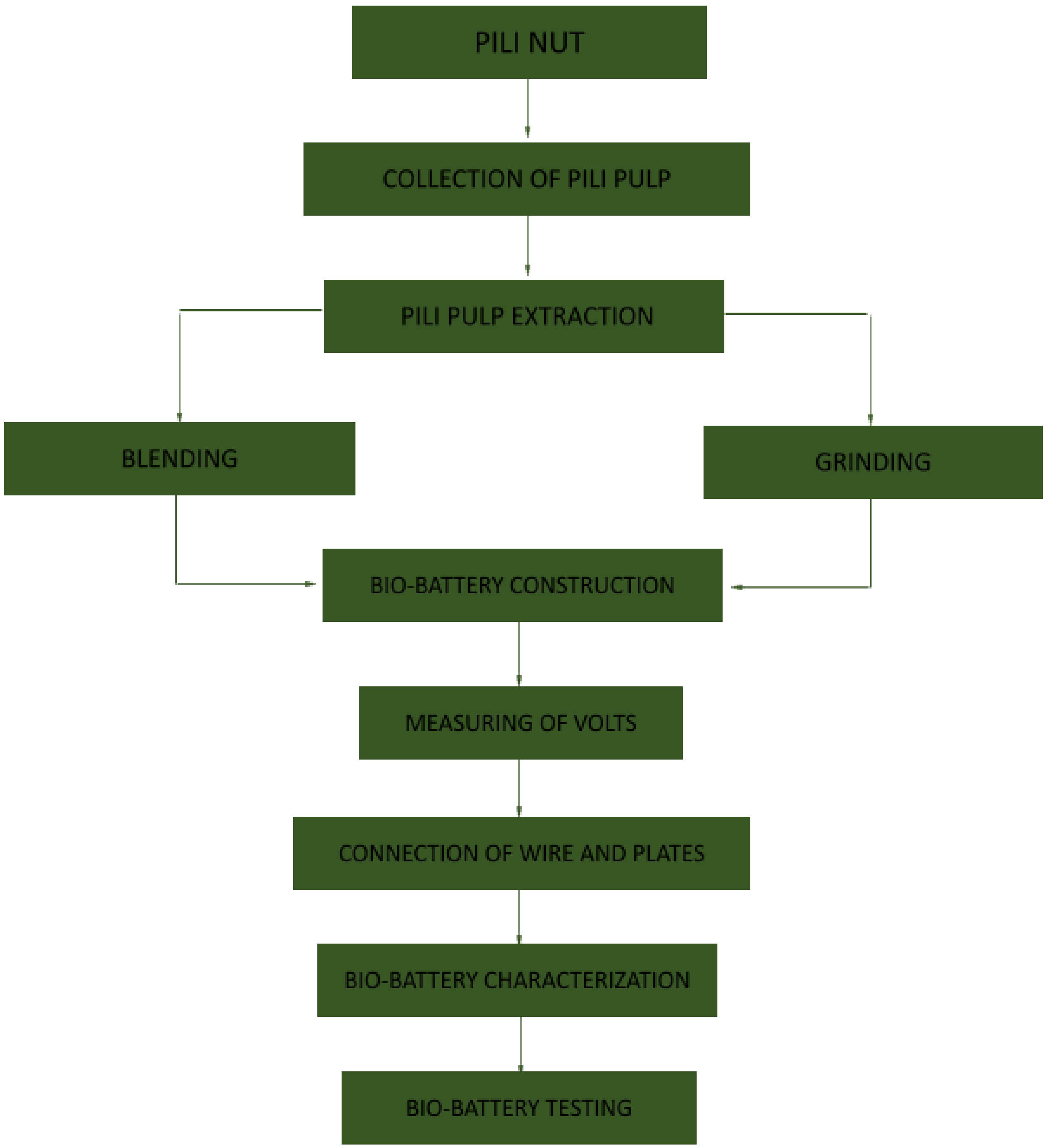

Figure 3: Conceptual Framework

This study determined the capability of a Pili (*Canarium Ovatum*) pulp as a potential source of power that serve as renewable source of energy.

In this research, Pili (*Canarium Ovatum*) Pulp extract will be used as a main component in making this bio- battery device. The researchers will blend the pulps using a blender and a sterile water with a ratio of 1 to 1 to get the extract.

This will be constructed using an indirect galvanic cell. Copper wire will be used in connecting each electrode in one end and the other end will be connected with crocodile clip. Current production will be measured while the device is connected to a 100 W resistor for every 4 hours in 7 days.

This device will provide a temporary source of electricity especially in times of calamities. This will be a good source of electricity to charge a battery-powered device such as mobile phones, flashlights and radios.

III. METHODOLOGY

A. EXPERIMENTAL DESIGN

In this research, the approach will use the designing approach. Procedures that have been developed by experts were used in the development of this research. This research will take four (4) steps that will help develop the device. These are the steps that were used to develop the device: 1) examining the needs of the system, 2) constructing the system 3) constructing electronics circuits, and 4) preparing and testing.

B. PROCEDURES

a) Plant Extraction

The materials that will be used in this research are Pili Pulp, sterile water, copper electrodes, zinc electrodes, copper electrical wire, alligator clips, and beakers. The instruments that will be used in this research included an electronic blender to get the Pili Pulp Extract.

b) Bio-battery construction

A bio-battery device will be constructed using an indirect galvanic cell. In this experiment, the Pili (*Canarium Ovatum*) Pulp Extract will be made by grinding then blending with sterile water with a ratio of 1 to 1 using a household blender. The extract will then be transfer to a plastic container. One electrode of each metal (zinc and copper). A copper wire was connected to each electrode on one end and the other end was connected to crocodile clips. Two identical devices will be made for both current production and electrochemical characteristics.

c) Bio-battery characterization

The open circuit voltage will be measured by connecting the positive terminal to the zinc electrode and the negative terminal to the copper electrode. Current production characterization will be measured while the device is connected to a 100 W resistor for every 4 hours up to 7 days of measurement. The electrochemical characterization will be revealed from the polarization and power curve. This can be done by measuring the voltage obtained from varying the resistance (10000, 8000, 5000, 3000, 1000, 800, 500, 300, and 100 Ω) between anodes and cathodes of the cells. The current and the power at each resistance will be calculated from the measured voltage.

APPENDIX

A. DESIGN OF THE DEVICE

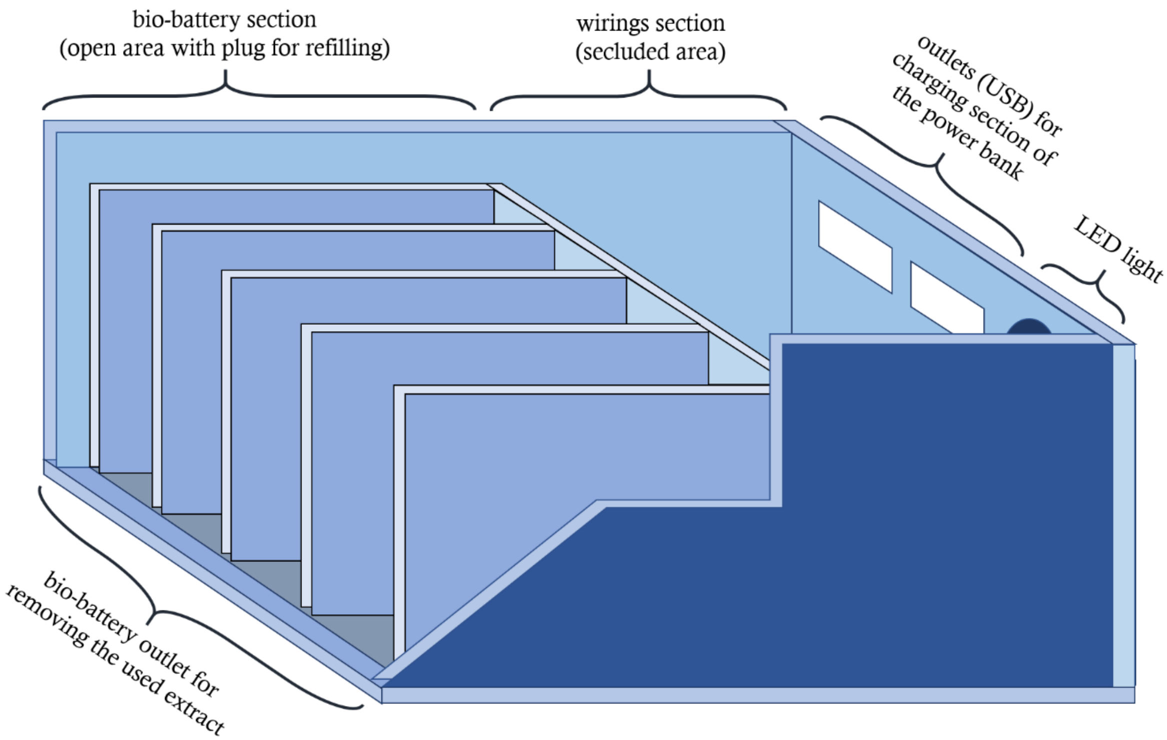

Figure 4. Inner Part of the Power Bank

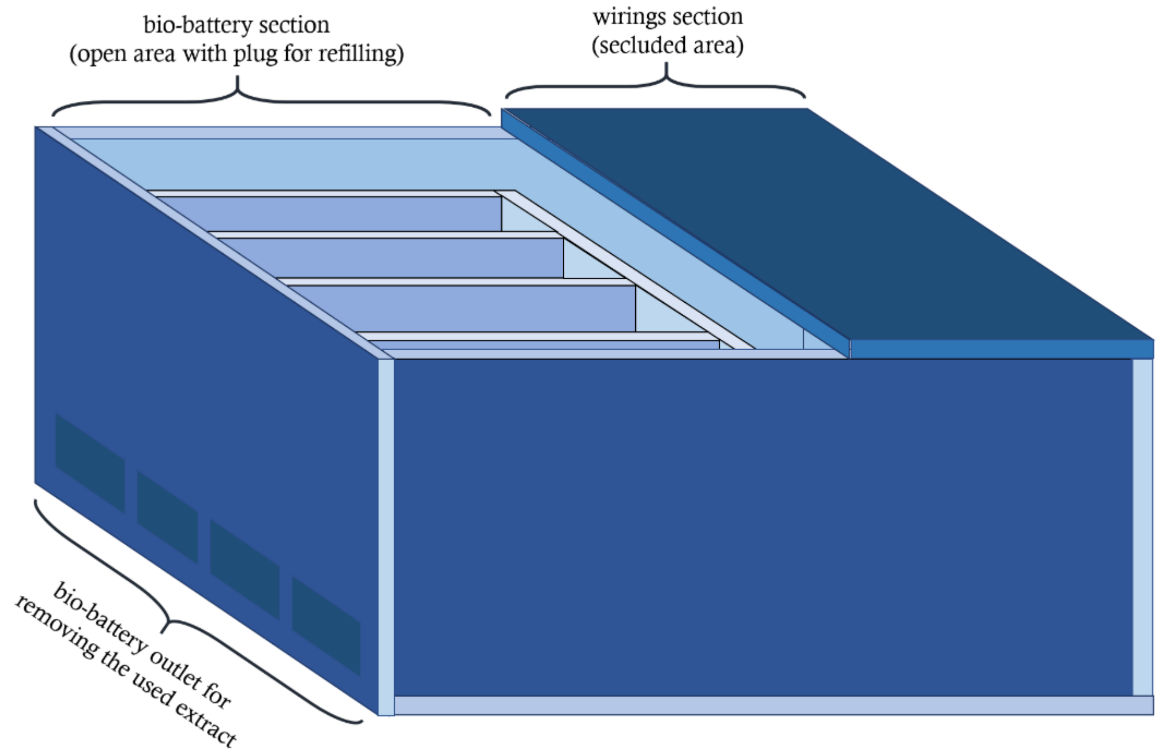

Figure 5. Outer Part of the Power Bank

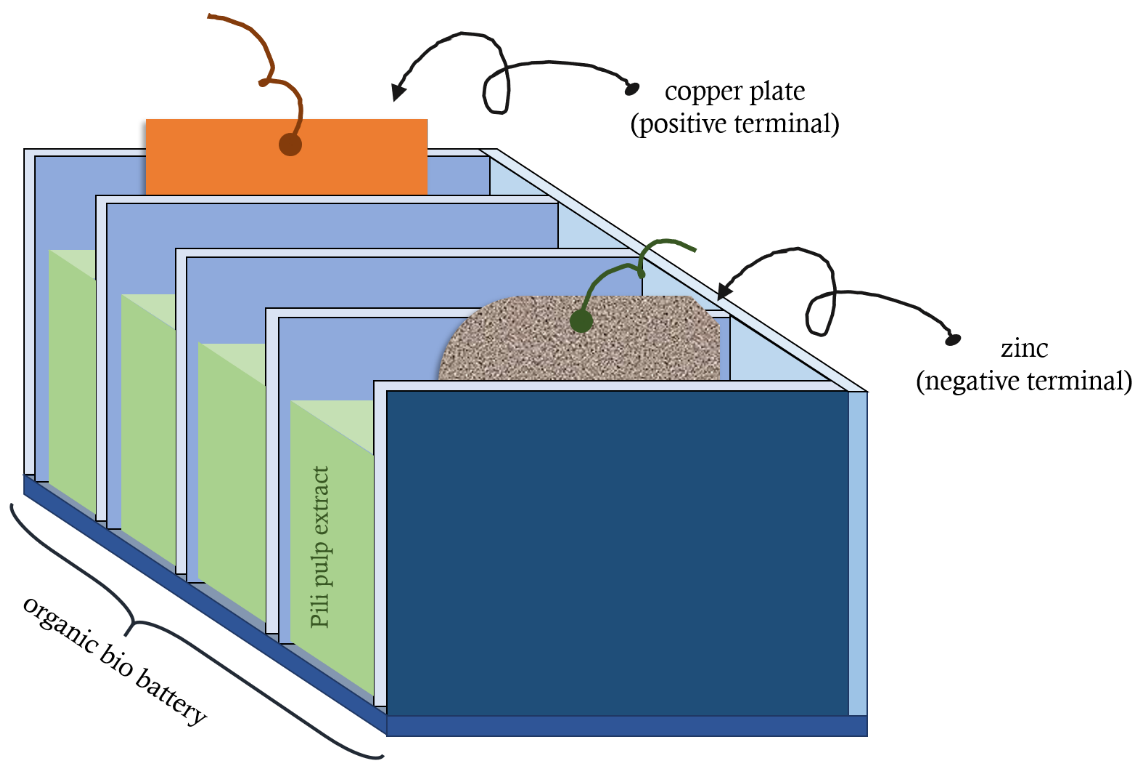

Figure 6. The Power House or the Bio-Battery

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