

Generation of Bio-Electricity from Fruits and Vegetable Waste

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Abstract

The increasing generation of fruit and vegetable waste has created significant challenges in waste management and environmental protection, while the demand for sustainable energy sources continues to increase. This paper presents a small-scale bio-electricity generation system that utilizes fruit and vegetable waste as an energy source. The proposed system converts organic waste into a liquid substrate and uses an electrochemical arrangement consisting of anode and cathode electrodes to generate electrical energy. The generated electrical energy is measured, conditioned, stored in a battery, and proposed for low-power applications such as mobile-phone charging. The system incorporates a mixer-grinder for waste preparation, a waste collection arrangement, electrodes, capacitor, diode, battery, PCB, and USB charging port. Experimental testing of the developed prototype produced a measured output voltage of 2.06 V, demonstrating the feasibility of obtaining measurable electrical potential from fruit and vegetable waste. Although the generated power is relatively low, the system provides a promising approach for combining organic-waste management with decentralized renewable energy generation.

Keywords— Bio-electricity, fruit waste, vegetable waste, microbial fuel cell, waste-to-energy, renewable energy, electrochemical cell, battery charging.

INTRODUCTION

The increasing demand for electrical energy and the environmental problems associated with conventional energy generation have encouraged the development of alternative and renewable energy technologies. At the same time, large quantities of fruit and vegetable waste are generated by households, markets, restaurants, agricultural activities, and food-processing industries. Much of this organic waste is disposed of through landfilling or other conventional methods, which can contribute to environmental pollution and greenhouse-gas emissions. Therefore, converting organic waste into useful electrical energy provides an opportunity to address both waste-management and energy-generation challenges.

Fruit and vegetable waste contains organic compounds such as sugars, starches, and other biodegradable materials that can participate in electrochemical and microbial processes. Bio-electricity generation can be achieved using microbial fuel cells (MFCs), in which microorganisms decompose organic matter and release electrons and protons. The electrons can be collected through an external circuit to produce electrical energy. The project investigates the practical use of fruit and vegetable waste for electricity generation and the subsequent storage of the generated energy in a battery for low-power applications.

The proposed system is particularly relevant to decentralized and low-power applications. Generated electricity can be stored and used for applications such as LED illumination and mobile-phone charging. The concept can also support waste management in locations where access to conventional electrical infrastructure is limited. Thus, the proposed approach provides a combined waste-to-energy solution with potential environmental and social benefits.

LITERATURE SURVEY

Kavya Venugopal *et al.* investigated the generation of electricity from food waste using electrochemical reactions between electrodes and organic waste, demonstrating the potential of food waste as an alternative energy source while addressing waste-disposal problems [1]. Rojas-Flores *et al.* studied sustainable electricity production using avocado waste and reported a maximum voltage of 0.861 ± 0.241 V and current of 3.781 ± 0.667 mA under optimized conditions, highlighting the influence of pH and conductivity on bio-electricity generation [2]. Rocky and Saha examined the resource recovery potential of kitchen waste and identified fruits, vegetables, food residues, and other biodegradable materials as significant recoverable resources [3]. Latuihamallo *et al.* investigated vegetable waste for bio-electricity production using a microbial fuel cell and reported a maximum voltage of 288 mV after seven days of incubation, demonstrating the influence of operating conditions on electrical output [4].

Rojas-Flores *et al.* further investigated bio-electricity generation from fruit and vegetable waste using microbial and biotechnological approaches. Their work highlighted the simultaneous benefits of renewable-energy generation and reduction of organic waste, while identifying low power output and scalability as major challenges [5]. Kramer *et al.* proposed a modular waste/renewable-energy system for producing electricity, heat, and potable water in remote locations, demonstrating the potential of decentralized waste-to-energy systems [10]. Based on these studies, it is observed that fruit and vegetable waste can be utilized as a potential source of bio-electricity, but the generated output depends on waste composition, electrode materials, microbial activity, and operating conditions. Therefore, the present work focuses on developing a simple fruit and vegetable waste-based electricity-generation system with battery storage and a USB output for low-power applications.

Problem Statement

Large quantities of fruit and vegetable waste are generated every day and are commonly discarded through land filling or other disposal methods. This creates environmental problems while valuable organic material remains unused. Although bio-electricity generation from organic waste has been demonstrated at laboratory scale, achieving useful electrical output and scaling the technology remain challenging.

Objectives

The main objectives of the proposed system are:

1. To generate measurable electrical energy from fruit and vegetable waste using an electrochemical/bio-electricity generation arrangement.
2. To store the generated electrical energy in a battery and investigate its application for low-power loads such as mobile-phone charging.

PROPOSED SYSTEM

The proposed system consists of a waste-preparation unit, liquid-waste collection arrangement, electrode-based electricity generation section, energy-conditioning circuit, battery-storage unit, and mobile-charging output. The fruit and vegetable waste is first processed using a mixer-grinder to obtain a suitable liquid or slurry. The prepared waste is then transferred to the electrochemical container containing the electrode arrangement. The generated electrical energy is collected through the electrical circuit and subsequently supplied to the storage and load sections.

The overall system includes vegetable waste, a juice mixer-grinder, liquid-waste pipeline, electrochemical process, power-supply line, solar-power-house arrangement, battery, and USB charging port. The battery is used to store the generated energy, while the USB port provides an interface for low-power charging applications.

BLOCK DIAGRAM

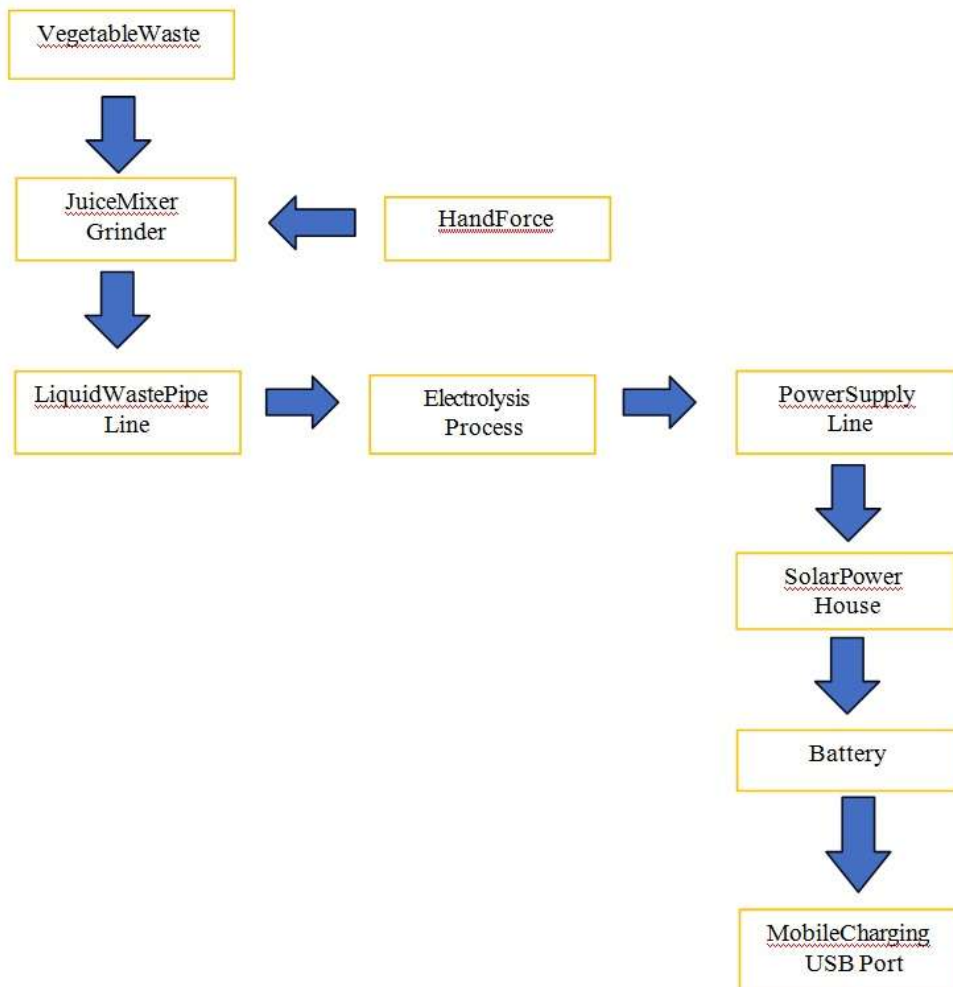
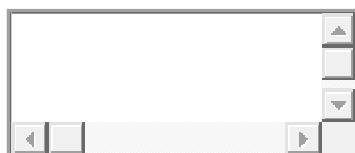


Fig 1 block diagram of generation of electricity from fruits and vegetable waste.

The Fig. 1 shows the block diagram of the vegetable-waste-based power generation system, where vegetable waste is processed using a manually operated grinder and supplied to the electrolysis process through a liquid waste pipeline. The generated electrical energy is managed through the power supply and solar power unit, stored in a battery, and utilized for mobile charging through a USB port.



CONNECTION DIAGRAM

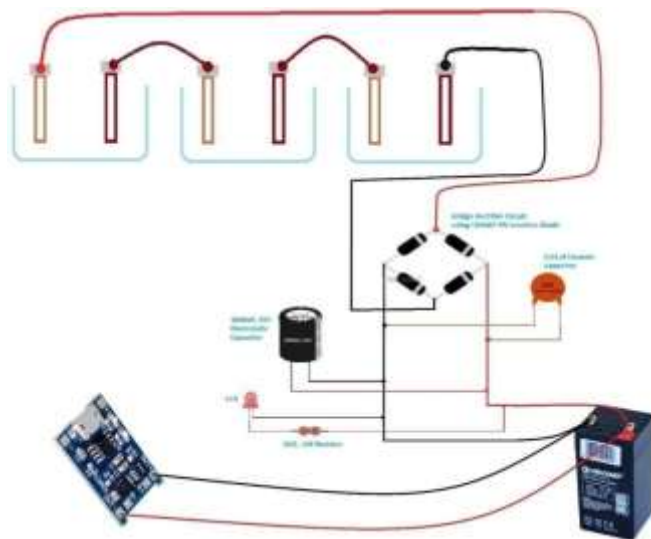


Fig 2 Connection diagram of generation of electricity from fruits and vegetable waste.

The **Fig. 2** shows the circuit diagram of the waste-based electrical energy generation and battery-charging system, consisting of electrode cells, a bridge rectifier, capacitors, LED indicator, and battery. The generated electrical output is rectified and filtered before being supplied to the battery for charging and energy storage.

METHODOLOGY

The methodology begins with the collection and preparation of fruit and vegetable waste. Waste materials such as peels, pulp, and leftover scraps are collected from suitable sources and cleaned to remove unwanted contaminants. The waste is then cut into smaller pieces and homogenized using a mixer-grinder to increase the availability of organic material for the electrochemical or microbial process. The prepared waste slurry serves as the substrate for electricity generation.

The electricity-generation section consists of anode and cathode electrodes separated through the electrochemical arrangement. In a microbial fuel cell configuration, microorganisms decompose the organic matter at the anode and release electrons and protons. The electrons travel through the external circuit toward the cathode, producing an electrical current. Voltage and current can be monitored using a multimeter or ammeter. The electrical output depends on parameters such as waste composition, microbial population, electrolyte concentration, and electrode material.

The prototype described in the project also uses copper and zinc plates in the liquid-waste container. The electrochemical reaction between the electrode materials and the fruit/vegetable liquid produces electron flow through the external circuit.

The generated electrical energy is subsequently directed toward the storage and load sections. A capacitor is included for energy storage/filtering, while a diode is used for rectification and controlled current flow.

The major hardware components include anode and cathode plates, a 25 V/1000 μ F capacitor, LED bulb, resistor, DC motor, plastic box, battery, PCB, juicer mixer-grinder, mobile-charging USB port, 1N4007 diode, and connecting wires.

RESULTS AND DISCUSSION

As shown in **Fig. 3**, the developed hardware prototype was experimentally tested to evaluate the feasibility of generating electrical energy from fruit and vegetable waste. The electrical output produced by the prototype was measured using appropriate measuring equipment, and an output voltage of approximately **2.06 V** was obtained. The experimental result demonstrates that the proposed fruit and vegetable waste-based system is capable of producing a measurable electrical potential.

The obtained voltage is relatively small and therefore the present prototype is more appropriate for low-power applications and experimental demonstrations rather than high-power electrical loads. The project identifies several parameters that influence the generated output, including the type and composition of organic waste, electrode materials, microbial activity, and electrolyte conditions. Optimization of these parameters can potentially improve the electrical performance of the system.

Parameter	Observed Value
Waste source	Fruits and vegetable waste
Generation method	Electrochemical/bio-electricity process
Output voltage	2.06 V
Measurement	Multimeter
Intended storage	Battery
Proposed application	Low-power/mobile charging



fig 3 hardware experimental setup

CONCLUSION

This paper presented a fruit and vegetable waste-based bio-electricity generation system for converting organic waste into useful electrical energy. The proposed prototype combines waste preparation, an electrochemical generation arrangement, energy storage, and a USB output for low-power applications. Experimental testing produced a measured output voltage of **2.06 V**, demonstrating the feasibility of obtaining measurable electrical potential from fruit and vegetable waste.

The proposed approach provides a dual benefit by addressing organic-waste management while exploring renewable energy generation. However, the low power output, slow generation process, dependence on waste availability, maintenance requirements, and scalability limitations must be addressed. The project recommends further optimization of microbial fuel cell configuration, electrode materials, waste pre-treatment, microbial conditions, and system integration. With continued development, fruit and vegetable waste-based bio-electricity generation could contribute to small-scale, decentralized, and sustainable energy applications.

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