Conversion of Waste Fluted Pumpkin (Telfairia Occidentalis Hook. F) Leave in to Bio Electricity Using Microbial Fuel Cells (MFCS) Application

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Abstract **- A double chamber microbial fuel cells technology has been applied on defective leave of fluted pumpkin (Telfairia occidentialis Hook.F) through the conversion of its waste leave into Bioelectricity. Adopting method of research fabrication described by Karmau etal (2017) the result of the voltage of 4.5V against 0.3V from the 2.5kg sample, current density (j) of 113A/m^2 and power (p) of 2.0W in 120hours. The result present linearity in increase in voltage, power density, current density and power. It is likely that a slight increase in the system temperature enhanced a corresponding decrease in internal resistance of the electrolyte leading to ionic mobility and conductance as concentration increase with leave decomposition. Therefore, processing of waste or defective fluted pumpkin (Telfairia occidentialis Hook.F) leave via Microbial fuel cell application can be a good source of green electricity generation and a good step on its waste management.**

I. INTRODUCTION

Microbial fuel cells (MFCs) technology has gained tremendous attention of researchers in recent times. It is emphasized when conversion of organic waste to clean and green energy in the form of electricity is prioritized (Kamanu etal, 2017). The technology is a means of waste management and a transition path to low carbon community (Nastro etal, 2017). As a bio-electrochemical system (BES), MFCs produce green electricity from organic waste by trapping microbial power (patit etal 2018, Keith etal 2018, Yifeng etal, 2009).

Microbial fuel cells (MFCs) can generate chemical energy from several classes of organic waste with the potential to effectively convert it to electrical energy (Nastro etal, 2017). This means that microbial fuel cells (MFCs) is a good alternative for management of organic waste through direct conversion into electricity. Organic waste can contaminate and pollute the environment if left unchecked or poorly managed. As organic wastes that can contaminate environment Fluted Pumpkin (Felfairia Occidentalis Hook. F) is a creeping vegetable shrub that spread slowly across the ground with broad lobes leaves and long twisting tendrils rich in antioxidants and dietary fibre (Harsfall and Spiff, 2005, Kayode etal, 2011). Telfairia Occidentalis (Fluted Pumpkin) is the highest consumed vegetable in the West African sub-region and Nigeria in particular as it is reported to have good nutritional and medicinal values (Akang etal 2019, Fabuyi 2008 and Ganiyu 2005). The seed is reported to contain about 28.88% of protein with crude fat content of 58.41% and good number of essential amino acids (Akpabio etal, 2007), making the vegetable a regular and common part of meals in Nigeria. However, the rate of its production quite surpasses its consumption. It therefore creates one of the major agro-waste problem in Nigeria as preliminary investigation showed that several tons of the Telfairia Occidentalis waste are produced daily in market places around the country but scarcely consumed compare to production, constituting environmental nuisance (Ekpete etal 2011). However, studies have shown that bioelectricity is possible through microbial fuel cells technology using single or double chamber using a given organic waste as a substrate. Kamau etal 2017, showed that microbial fuels cells technology can be used to generate electricity from cow dung. In another work, Kamau etal 2018, experimented with rumen fluid in production of bio-energy and observed that maximum voltages of 0.584V was obtained from tomatoes wastes when 500ml rumen fluid was used. Agany etal (2016) carried out study on bio electricity production from cassava mill effluent using microbial fuel cells technology. The study reported that the effluent from the cassava mill generated voltage and current to the maximum of 27mV and 275mV respectively. Others include works of Akuma etal (2014), Nyoyoko etal (2015), Fogg etal (2016), Mbugua etal (2018), Logan etal (2012) and Emad (2013). Therefore, in this current research, electricity generation was bio-electrochemically undertaken using waste Fluted Pumpkin (Telfairia Occidentalis) leaf and tendrils obtained from Ahia Nwantu Umuechem and Ahia ordu Igwuruta markets through the application double chamber microbial fuel cells. The voltage, current, power, power density and current density including linearity of the voltage was ascertained.

II. MATERIAL AND METHODS

The Fluted Pumpkin (Telfairia Occidentalis) leaf and tendrils that were damaged and decomposing used in this work were obtained from Ahia Nwantu market in Umuechem in Etche Local Government and Ahia Ordu market in Igwuruta in Ikwere Local Government area, all in Rivers State, Nigeria. The defective leaves were shredded using kitchen knife, weigh and loaded into the anodic chamber containing a double chamber of microbial fuel cells containing water. Other materials used were PVC pipes, Lamp wick, Graphite rod electrodes from used batteries with determined surface area of $0.00399m^2$, 100hms resistor, adhesive glue, driller, scissor, masking tape, pipe joiner, copper wire, digital multi-meter, 3% agar 1M Nacl, weighing balance, 10 ltr transparent container.

The study adopted the method of microbial fuel cells fabrication described by Kamau etal (2017). The same design fabricated from locally sourced materials was used for 2.5kg and 5kg weights of defective fluted Pumpkin leaf and tendrils respectively.

III. VOLTAGE GENERATION

In both experimental setups, voltage was monitored and recorded 24 hourly for 120 hours using the multi-meter while the power, power density and current density were determined by use of formula.

Where;

Power (P) = VI [1]

$$\text{Current density(j)} = \frac{I}{A_{area}} \quad [2] \quad \text{and}$$

$$\text{Power density} = \frac{Power}{A_{area}} = \frac{P}{A_{area}} = \frac{VI}{A_{area}} \quad [3]$$

$A_{area} = 0.00399m^2$ – the surface area of the graphite rod used as the electrode.

Analytically, the physio-chemical parameters in the waste Telfairia Occidentalis were evaluated using method in line with APHA (1998)

The power, power density and current density were determined by the used of the formula;

$$P = VI \quad [4]$$

Where P is power, V is the voltage, and I is the Current.

Current density (j) $j = {}^{I}/_{A}$ [5]

Where I is the current and A the cross-sectional area of the electrode in $M^{2.}$ Finally, the power density was determined thus; $power\ density = \frac{P}{A}$ [6]

With a known external resistor of 100hms. The current was calculated via the equation

$$I = {}^{V}/_{R} \quad [7]$$

Where V is the voltage and R the resistor.

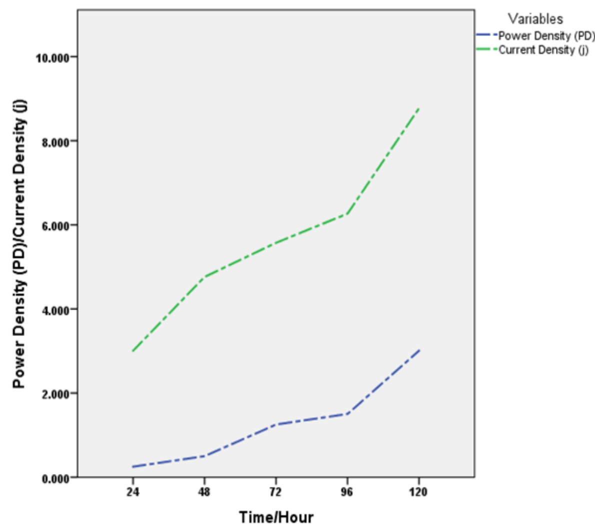
IV. RESULTS AND DISCUSSION

Table 1: 2.5kg of waste fluted pumpkin leaf and tendril

For 2.5kg of Pumpkin material					
Time/Hour	Voltage (V)	Current (I)	Power (P)	Power Density (PD)	Current Density (j)
24	0.115	0.012	0.001	0.251	3.007
48	0.118	0.019	0.002	0.501	4.762
72	0.221	0.022	0.005	1.253	5.574
96	0.246	0.025	0.006	1.504	6.266
120	0.357	0.035	0.012	3.007	8.772

Table 2: 5kg of Pumpkin material

For 5kg of Pumpkin material					
Time/Hour	Voltage (V)	Current (I)	Power (P)	Power Density (PD)	Current Density (JI)
24	3.176	0.318	1.01	253.132	79.699
48	3.725	0.373	1.4	350.877	93.488
72	3.944	0.394	1.554	389.494	98.747
96	4.236	0.424	1.8	451.128	106.266
120	4.518	0.452	2.042	511.78	113.283



From the tables and figures presented above and below, for every twenty four (24) hours, a record of the voltage and corresponding current determined and was recorded for five (5) days, given 120 hours for the 2.5kg and 5kg by weight of the Fluted Pumpkin (Telfairia Occidentalis Hook F) waste materials respectively. The voltage showed a linear increase. This indicate that voltage and current produced by the waste pumpkin leave, increased with increase in time.

The highest voltage and current were obtained from the 5kg set-up. The possible explanation is that as degradation of the Pumpkin materials continue and increase with time is the concentration and mobility of the ions. Kamau etal (2018) had noted that the electrons generated from the microbial degradation of waste are able to secure absorption site on the electrode surface as the current density indicate the number of electrons produced per unit surface area of electrode.

The current that enters the electrolyte through the anode is discharge via the cathode. Faraday's law holds it that the mass (m) of a substance liberated during electrolysis is proportional to the quantity of electricity passed through the electrolyte and this mass increase as the product of current and time increase.

$$M = Q \qquad [8]$$

But $$Q = It \qquad [9]$$

$$\therefore M = It \qquad [10]$$

Introducing a proportionality constant called electrochemical equivalent z

$$M = ZIt \qquad [11]$$

But $$I = \frac{V}{R} \qquad [12]$$

$$\therefore M = \frac{Zvt}{R} \qquad [13]$$

From table 2 the highest voltage was recorded on the 120 hours in the degradation of the 5kg Pumpkin material (table 2), with the highest current density and hence the greater number of electrons. This observation is further supported by the reaction rate law which stated that the rate of a chemical reaction is directly proportional to the concentration of the reactants raised to a power (Atkin etal).

$$V = K[A][B] \qquad [14]$$

Again,

$$V = IR = {}^{1}/_{\lambda} \qquad [15]$$

Where V is the electrical potential difference in volts across a conductor of resistance R ohms (Ω) which produces a current flow, I amperes.

The conductance $\lambda\, ohms^{-1} = I/R\ ohms$ (Fenbom 1966). It was noted that as the leaves and stem of the Pumpkin decomposes per time, the temperature slightly increases. In appreciating the observed increase linearly in voltage in both 2.5kg and 5kg system, consider that increase in temperature results in decrease of the resistance of an electrolyte solution. It is so since the conductance of an ion depends on its rate of movement through the solvent and its mobility will be related to the fluidity of solvent (fenbom 1966, Lee 2008). Furthermore, if conductance is a function of rate process, taking place at a rate which is increasing with temperature as conductance of ion depends on its rate of movement, the it can be presented as

$$\lambda = Ae^{-E/RT} \qquad [16]$$

Where E is the activation energy for common ions in H_2O, R is the gas law constant, T is the degree in Kelvin and A is a constant.

Where;

$$In\lambda = InA = E/RT \qquad [17]$$

$$E = In\lambda RT \qquad [18]$$

Considering the kinetics of the reaction and in pursuance to Hammond postulate, the reaction transition state is likely late (product like) endothermic. The activation energy of an endothermic reaction is likely as large as ΔH^0 establishing a minimum energy for endothermic reaction which cannot be done for thermoneutral and exothermic reactions.

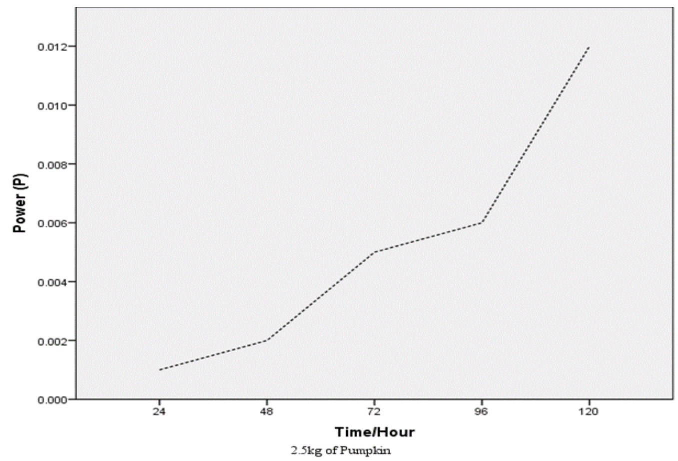


Figure 1: Power Density(PD) and Current Density(j) against Time(T) for 2.5kg Pumpkin material

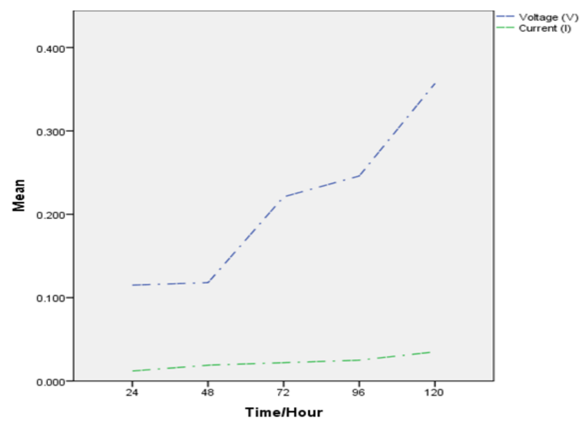


Figure 2: Power Density(PD) against Time(T) for 2.5kg Pumpkin material

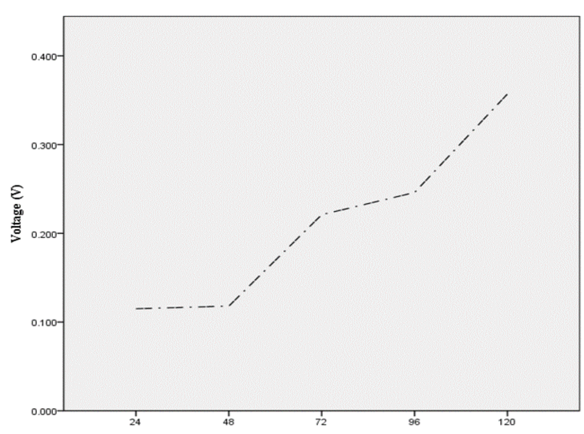


Figure 3: Voltage(V) against Time(T) for 2.5Kg Pumpkin material.

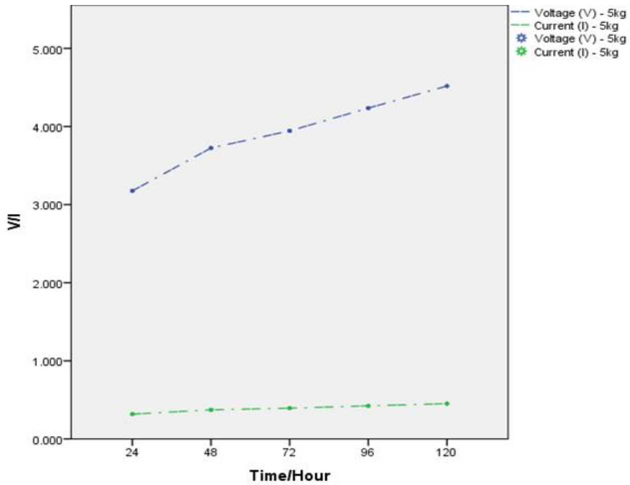


Figure 4: Voltage(V), Current (I) against Time(T) for 2.5Kg Pumpkin material

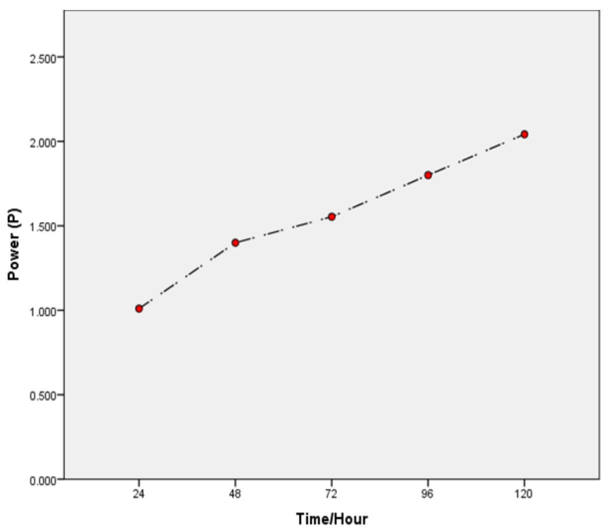


Figure 5: Power Density(PD) and Current Density(j) against Time(T) for 5kg Pumpkin material.

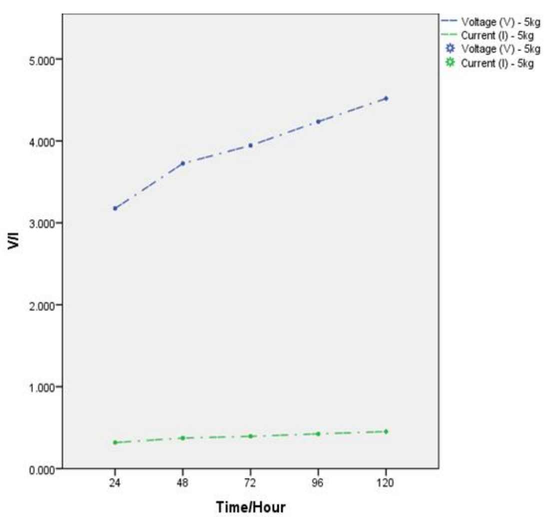


Figure 6: Power Density(PD) against Time(T) for 5kg Pumpkin material

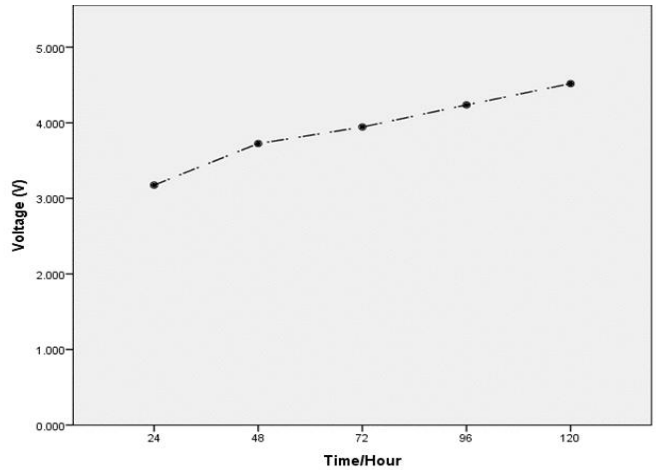


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Figure 7: Voltage(V) against Time(T) for 5Kg Pumpkin material

IV. CONLUSION

In the present study involving the conversion of water of Fluted Pumpkin (Telfairia Occidentalis Hook F), relationship between weight (kg), Time (t), Voltage (v) and current (i) was established.

From tables 1 and 2 and figures 3,4 and 7, 2.5kg and 5kg of the Fluted Pumpkin leave showed a linear relationship. As decomposition of the leave increase with time, the value of voltage and its corresponding current increases too. Also as the weight of the leave materials increase from 2.5kg to 5kg the voltage and current out put increases from 0.357V and 0.035I to 4.578V and 0.452I respectively, suggested that on a large scale, considered leave of Fluted Pumpkin can be converted into electricity for household use in rural areas.

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