INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH & DEVELOPMENT

ISSN 2278 – 0211 (Online)

Suitable Electrodes and Conditions for Optimum Production of Electricity from Food and Fruit Samples

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Abstract:
Electricity from different food and fruit samples and their ability to power LED bulb or charge smaller devices have been studied. Combination of electrodes capable of producing reasonable voltage across food and fruits has also been determined. It is found that for potato, tomato and lime; copper and zinc are best electrode combination that can produce high voltages and currents while zinc and lead were found to be the best for lemon. With separate series connections of the six different food and fruit samples, voltages greater than 4.00 V are obtainable. There is an exponential growth in current when potatoes are heated. Tomatoes were found to be more stable in generating current than the others. The voltages produced from series connection of each of samples types can light and charge phones for rural homes.

1. Introduction

Electricity is needed to lighten homes and to power devices, but when a nation's supply of it from grid system is inadequate and cost wise overwhelming, only financially privilege individuals residing in urban centers can afford it. Other alternatives like stand alone solar photovoltaic systems follow suit as initial cost of installation has gone beyond the reach of common man. For the rural dwellers, it has always been difficult to even charge their phones or lanterns. They have to pay via portable electric generators running on petrol to charge their devices.

However, with the discovery of electricity from food and fruits samples, their basic needs of lighting and charging may be taken care of using their farm produce. According to Hebrew University Researchers, electricity from series and parallel connections of potatoes can light homes for weeks. Other demonstrations of drawing electricity from fruits [1] such as lemon, vinegar, etc; it's almost a school children's toy.

To set up one of such electrical outlets, certain pre-requisite knowledge may be necessary. The knowledge of rightful combinations of electrodes and conditions of food and fruit samples for optimum performance may be highly desirable. In this work, detail knowledge of these requirements and the procedures needed has been studied and highlighted.

2. Materials and Methods

2.1. Sample Collection

Four different combinations of food and fruit samples were used in this study: potatoes, tomatoes, lemon and lime. Different stages/conditions (ripe, over ripe, unripe and spoiled) of the samples were also used. Six different electrode (positive-negative) combinations (Cu-Zn, Cu-Pb, Al-Pb, Al-Cu, Zn-Al, Zn-Pb) were tried. These were done in order to determine which of the fruit stages and the electrode combinations can deliver reasonable current and voltage.

2.2. Experimental Procedures and Data Collection

Two separate sizeable cuts of 1.5 cm apart were made on the samples to accommodate each of the electrodes which were 1 cm wide and 4 cm high. The 4 cm heights of the electrodes is to allow for at least 1 cm of their heights left exposed for terminal connections across them. To measure the performance of the samples in terms of current and voltage outputs, six different electrode combinations were tried on each of the sample types and the results recorded. The best electrode combination for each of the samples was noted and was used to study voltage-current characteristics across a 6 Ω LED load.

For the voltage-current characteristics, each set of the six samples were connected in series in order to produce reasonable supply across the LED load. Measurements of the E. M. F. of the samples, potential difference across the LED load and series current flowing through them were recorded after every hour for each of the samples. For potatoes, additional variations of the voltage and current with respect to changes in temperature of the potatoes were also measured and recorded. These procedures were repeated thrice for each of the samples used and average of which were reported graphically in this work. Other researchers [2] have used the heating process to determine changes in voltage and current in fruit samples.

Figure 1: Pictures of apparatus and samples used

3. Results and Discussion

Table 1 gives the measure of the current derivable from each of the different samples via six different combinations of electrodes across them. The results have shown that Cu-Zn electrode combination produced the much power outputs from potato, tomato and lime though there were indications of higher voltages from ripe tomato and lime, but the low current output from them have reduced their overall power outputs. On the other hand, Zn-Pb had produced more power from lemon than other electrode combinations. Generally, productions of electricity using these electrodes were visibly seen to be based on corrosion of the Zn electrodes. The zinc electrodes over time were found to be corroded and depleting.

Electrode combinations		**Potato**		**Tomato**				**Lemon**		**Lime**	
				Ripe		Over-ripe					
		V (V)	I (mA)	V (V)	I (mA)	V (V)	I (mA)	V (V)	I (mA)	V (V)	I (mA)
Cu	Zn	0.830	0.60	0.946	0.78	0.958	1.58	0.977	0.31	0.943	1.46
Cu	Pb	0.145	0.03	0.183	0.03	0.170	0.06	0.230	0.06	0.164	0.92
Al	Pb	0.664	0.19	0.553	0.39	0.462	0.89	0.638	0.11	0.386	0.60
Al	Cu	0.501	0.25	0.663	0.13	0.602	0.05	0.721	0.13	0.206	0.52
Zn	Al	0.421	0.03	0.403	0.06	0.464	0.05	0.421	0.03	0.608	0.28
Zn	Pb	0.069	0.34	1.032	0.42	0.702	0.21	1.135	0.87	1.136	0.40

Table 1: Sample electrical production under different electrode combinations

Having identified the most suitable electrode combinations for each of the samples, voltages and currents using the suitable electrodes were then measured across series connections of two of each of the unripe, ripe, over-ripe and spoiled fruit samples. The current and voltages across these series connections are presented in Table 2.

2-Unripe		**2-Ripe**		**2-Over-ripe**		**2-Spoiled**	
V (V)	I (mA)	V (V)	I (mA)	V (V)	I (mA)	V(V)	I(mA)
Lemon							
2.865	1.360	4.710	2.250	4.760	0.980	3.810	0.950
Lime							
4.810	2.370	4.760	1.140	4.792	3.190	4.832	3.250
Tomatoes							
-	-	0.938	1.820	0.958	3.840	-	-

Table 2: Electricity production from different fruit conditions

It is obvious from Table 2 that ripe state lemon produces more power (=VI) than other states of the fruit, while for lime it is the spoiled state that produced much power than the other states. In tomatoes, the over-ripe state offered more power than the ripe state. The two other states have not been tried for tomatoes. These simply implied that when current is to be drawn from fruits at the right state, more current can be obtained. In lemon the potential difference across it seem to be dependent on the state of the sample while lime and tomato seem to be relatively independent of their state/condition maintaining almost constant output voltages.

Figure 2 shows the dependence of power output from potato on temperature. As heating progresses, a gradual increase in current results starting from temperatures greater than 60°C which may be that the heating process go into reducing the internal resistance of the potato and providing the increase in current that is witnessed.

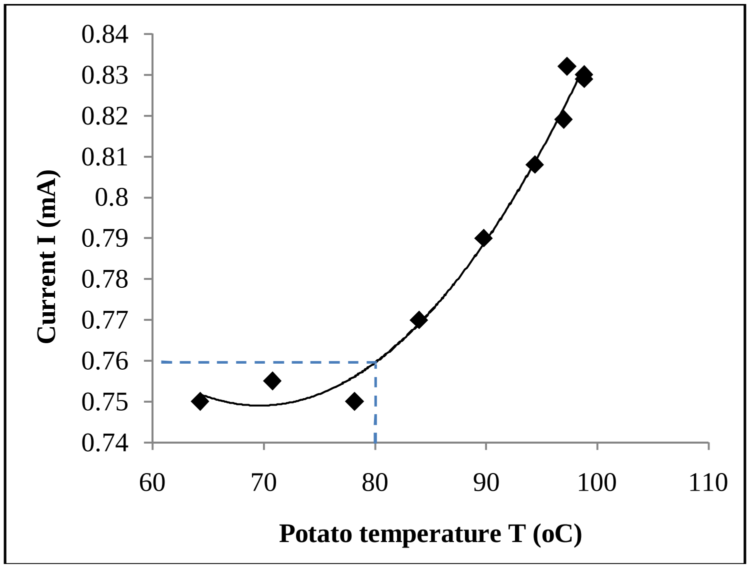

Figure 2: dependence on current on temperature of potato

These variations can comfortable be represented mathematically as:

$$\frac{dI}{dT} \propto I_o + I \tag{1}$$

where I_o is the current flowing through the potato at temperature less or equal to thecritical temperature and I the additional current as a result of increase in temperature of potato above critical.
Therefore:

$$\frac{dI}{(I_o + I)} = kdT \tag{2}$$

where k is the proportionality constant.
Solution is:

$$\ln(I_o + I) = kT + constant, C$$

At critical temperature T_o , $I = 0$, therefore, $C = lnI_o - kT_o$. Hence:

$$ln\frac{I_o + I}{I_o} = k(T - T_o)$$

$$I(T) = I_o\left(e^{k(T-T_o)} - 1\right) \tag{3}$$

For this particular potato, $T_o \cong 70^o$ is the critical temperature and corresponds to an initial current of about $I_o = 0.749$, therefore:

$$I(T) = 0.749e^{k(T-70^o)} - 0.749$$

From graph, at $T \cong 80^o, I_o \cong 0.760$. Hence:

$$k \cong 0.07005$$

Therefore,

$$I(T) = 0.749(e^{0.07005(T-70^o)} - 1) \tag{4}$$

Equation (4) can be used to determine the current at any temperature within the boiling range.

Table 3 shows the E. M. F. of the series connections of six of each of the samples before the LED load connection. This shows that tomato has the highest voltage followed by lemon, lime and potato.

Sample	Potato	Tomato	Lemon	Lime
E. M. F. (V)	4.29	5.52	5.48	4.52

Table 3: E.M.F. of series connection of six of each of the samples

Figure 3 shows plots of the potential difference across the LED bulb against current flowing through it when separately connected across the different samples and lighting it up over time.

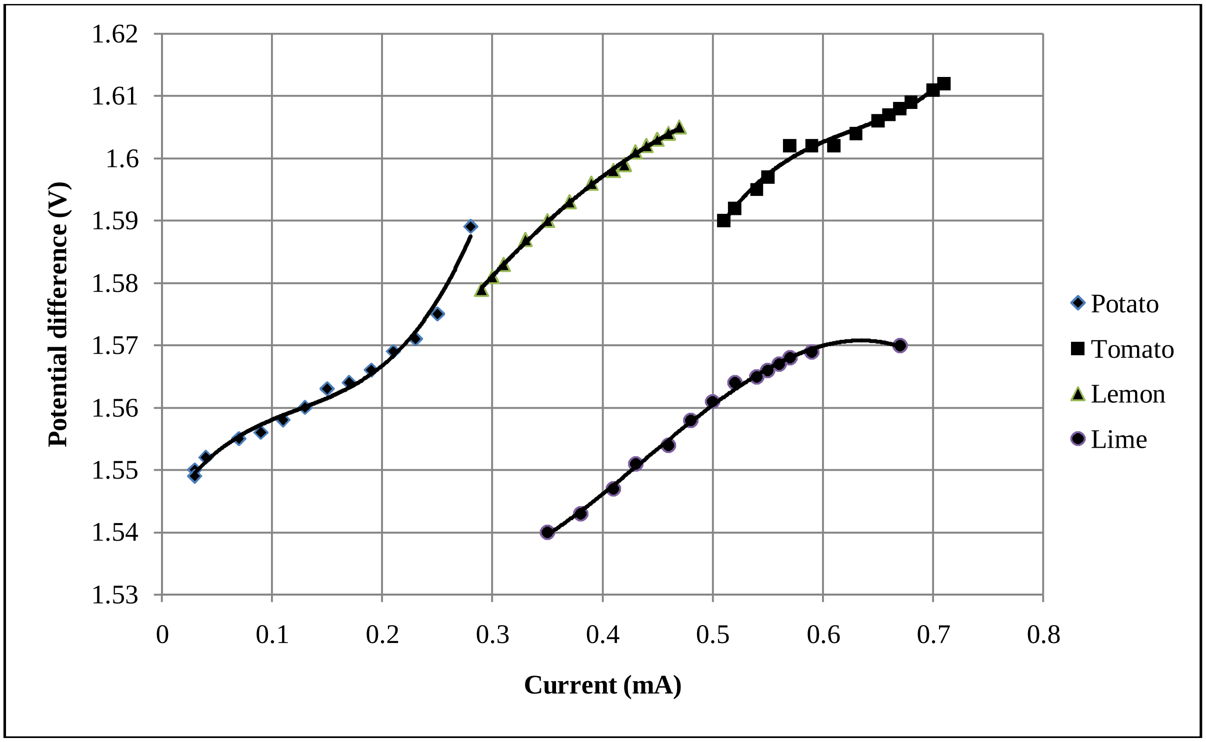

Figure 3: Plots of LED potential difference against current flowing for different samples

These are the samples behaviour as they supply power across the LED recorded every hour to determine their stability. The plots revealed the non ohmic nature of the LED lighting device. It also reveals that tomato is more stable and capable of offering more series current flowing through the load with lesser variation than the other samples over time. This probably suggests that tomato may have the lowest internal resistance with the least variation than the others.

There is no doubt that these samples can be used as power supply source in rural schools to run some simple physics experiment in the absence electricity from other sources. It can also be used for lighting and charging if jump connections of six more of the samples are added.

4. Conclusion

Cu-Zn is a more favourable electrode combination capable of drawing out more current from the food and fruit samples. Boiling potato can add more currents to its output provided its temperature is above 70^oC. In terms of using the food and fruit samples for lighting and other uses tomato may be found more stable as a power source. With jump connections of more of these samples more stable power supply capable of running some simple physics experiment, lighting or charging can be obtained.

5. References

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