Conversion of Fruit to Battery

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Abstract

Batteries are device that store chemical energy and convert it to electrical energy, so using fruit as battery acts like a wet cell that consists of a negative and positive electrode with an electrolyte which conducts ions, also, copper and zinc metals acts as electrodes while citric acid of the fruit is the electrolyte. Fruits battery comprises of the combination of different materials which are the copper penny (coin), galvanized nail, multimeter, alligator clips, connecting wires and light emitting diode (LED) bulb, by which all connected together make up the fruit battery used to light up a LED bulb. The fruit battery has different application which are; lightening a bulb and charging a battery in which the combinations are all connected in such a way that the penny and the galvanized nail are inserted into the fruits with alligator clips attached to end of the two electrodes and connected to others in series, the two ends of the connecting wire is then connected to the LED bulb depending on the capacity of the fruit battery. In a nutshell, apple generated the highest voltage out of all the fruits tested, the higher the acidity and size of the fruit, the higher the voltage, also, the far apart the electrodes inserted into the fruits, the higher the voltage using copper and zinc as the best electrode over copper and steel or steel and zinc electrode.

Keywords; Light Emitting Diode, Electrode, Electrolyte, Voltage

1. Introduction

Electric current is the flow of electrons of an electrical charge and is measured using an ammeter. Voltage is the force that pushes the electrons through a circuit and is measured in volts. When two dissimilar metals are placed in a common conducting solution, electricity will be produced. This is the basis of the electrochemical or wet cell. (Hulme,1970).

In 1791, Luigi Galvani discovered electrical activity in the nerves of the frogs that he was dissecting. He thought that electricity was of animal origin and could be found only in living tissues. A few years later, in 1800 Alesssandro Volta discovered that electricity could be produced through organic means. In fact, by using small sheet of copper, zinc and cloth spacers soaked in an acid solution, he built the first apparatus capable of producing electricity. (Gollner and Adam, 2010). There are numerous sets of instructions for making fruit batteries and for obtaining components such as Light Emitting Diode (LED),

electrical wires (multimeter), zinc coated (galvanized) nails and screws. After the cell is assembled, a multimeter can be used to measure the voltage or the electrical current from the voltaic cell. (Heiser,2003).

Zinc and copper electrode are reasonably safe and easy to obtain. Other metals such as lead, iron, magnesium can be studied as well; they yield different voltages than the copper or zinc pair. But a magnesium electrode for the zinc electrode makes a cell with a large voltage (1.5 – 1.6v), and single magnesium or copper cell will power some devices (Naidu and Kamakshiah, 1995).

In the research, fruit provides both the electrolyte and a simple way to support the electrodes. The acid involved in citrus fruits (lemon, orange, grape fruits, e.t.c.) is citric acid. The acidity which is measured by the pH varies substantially (Watson and Preedy, 2010).

In this research, Light Emitting Diode (LED) is used to indicate if the fruit cell is generating an electric current. A LED is a semiconductor device which converts electricity into light. An electric current can flow only in one direction through LEDs which means that they have a positive and a negative terminal (also referred as the anode and cathode). The cathode should be connected to the negative zinc metal strip and the anode to the positive copper strip (Feldkamp and Susan, 2002).

2. Chemical reaction of the fruit battery

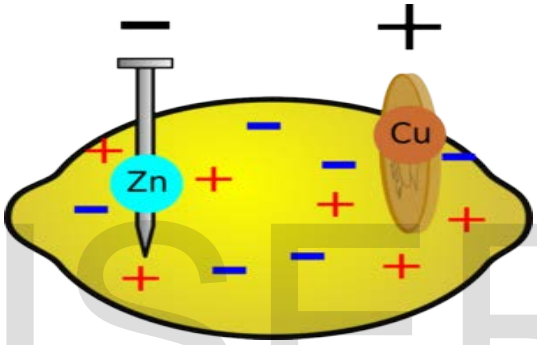
Copper and zinc metals are used as the electrodes while the citric acid found in fruit is the electrolyte. The zinc is more reactive than copper but copper atoms attract electrons more than the zinc atoms, as the attracted electrons concentrate on the copper: the electrons repel each other. The electrons on the zinc strips flows to the copper strip through an external circuit, the hydrogen ions in the fruit accept these electrons to form hydrogen gas which explains why bubbling of gas is produced at the copper strip when two metals are connected by a wire. Zinc metals enter the electrolyte as ions missing two electrons (Zn^{++}). Two negatively charged electrons from the dissolved protons (H^{+}) in the acidic electrolyte combine with the two electrons from the zinc to form molecular hydrogen (H_2), which bubbles off the copper electrode. The electrodes lost to the copper are made up by moving two electrons from the zinc through the external wire. When the cell is providing an electrical current through an external circuit, the metallic zinc at the surface of the zinc electrode is dissolving into the solution, zinc atoms dissolve into the liquid electrolyte as electrically charged ions (Zn^{2+}), leaving two negatively charged electrons (e-) behind in the metal (Sorey, *et al*., 2012).

$$Zn \longrightarrow Zn^{2+} + 2e^{-}$$

This is called an oxidation reaction as zinc is entering the electrolyte; two positively charged hydrogen ions (H^+) from the electrolyte combine with two electrons at the copper electrodes surface and form an uncharged hydrogen molecule (H_2).

$$2H^+ + 2e^- \longrightarrow H_2$$

This is called a reduction reaction. The electrons used from the copper to form the molecules of hydrogen are transferred by an external wire connected to the zinc. The hydrogen molecules formed at the surface of the copper by the reduction reaction ultimately bubble away as hydrogen gas. The apple battery works well because the apple has an acid content. The electrodes undergo chemical reaction that block the flow of electricity.



3. Troubles Shooting

- A typical problem is that the electrodes or the bare metal parts of the lead wires are touching each other accidentally. The zinc and the copper electrode must not touch each other inside the fruit. The alligator clips must not touch each other when you connect them to the LED.
- The LED must be connected correctly. Trying switching the connections to the two wires that come out from the LED case.
- The connection of the three cells must be right. Each fruit should have zinc and one copper electrode. The wires that run from one fruit to another must run from a zinc electrode to a copper electrode.
- Citrus fruits should be juicy inside, to break up the internal membranes of an unripe fruit, roll it while pushing down.
- Four apple fruit is the minimum needed to light a LED bulb of 3volts. (Heiser, 2003).

4. Materials

The materials used are:

Fruits and vegetables like: lime, water melon, apple, orange, potato, cucumber and pineapple, zinc galvanized nail (2 inches in length), copper penny (coin), connecting wire, paper tape, blade or knife, multimeter, alligator clips, LED bulbs (3v, 6v, 9v).

5. Experimental Procedure

- All the fruit to be used were rolled with the palm on a tabletop in order to loosen the juice inside the fruit.
- A slit is made at one end of the fruit and the galvanized nail was deeply inserted into the fruit carefully, the galvanized nail was made to get to the center of the fruit but a little bit of it remain outside the fruit so that the connecting wire or alligator clip can be attached to it.
- A slit was made opposite the galvanized nail of the same fruit and the copper penny was inserted into the fruit leaving a little part outside the fruit. The electrodes are placed opposite each other because the farer the electrode the higher the voltage it will produce. The two charged electrodes will now permit the flow of electrons through them.
- The voltage produced between the electrodes was measured by hooking two alligator clip to the two electrodes and connecting one of the multimeter terminals to the copper and the other terminal to the galvanized nail to measure the volt present, when connected in series the two end of the alligator clip was connected to the terminals of the multimeter.
- All fruit was connected together with an alligator clip. An end of alligator clip was connected to the penny of a fruit, and the other end to the galvanized nail of another fruit, an alligator clip was also being connected from the penny of the second fruit to the galvanized nail of the third fruit then the connection goes on like that to the last fruit. The two remaining end of the experiment will be connected to the LED. After this series of connection, the LED light up. The different cells make up this battery.

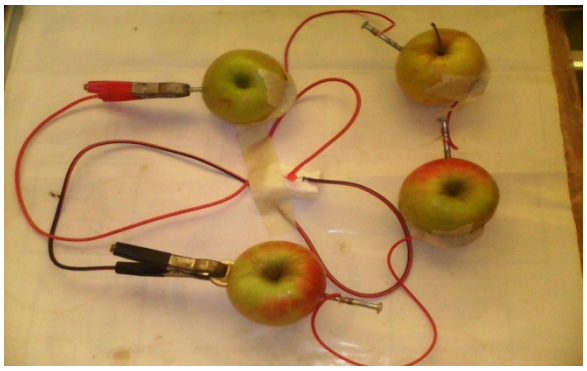


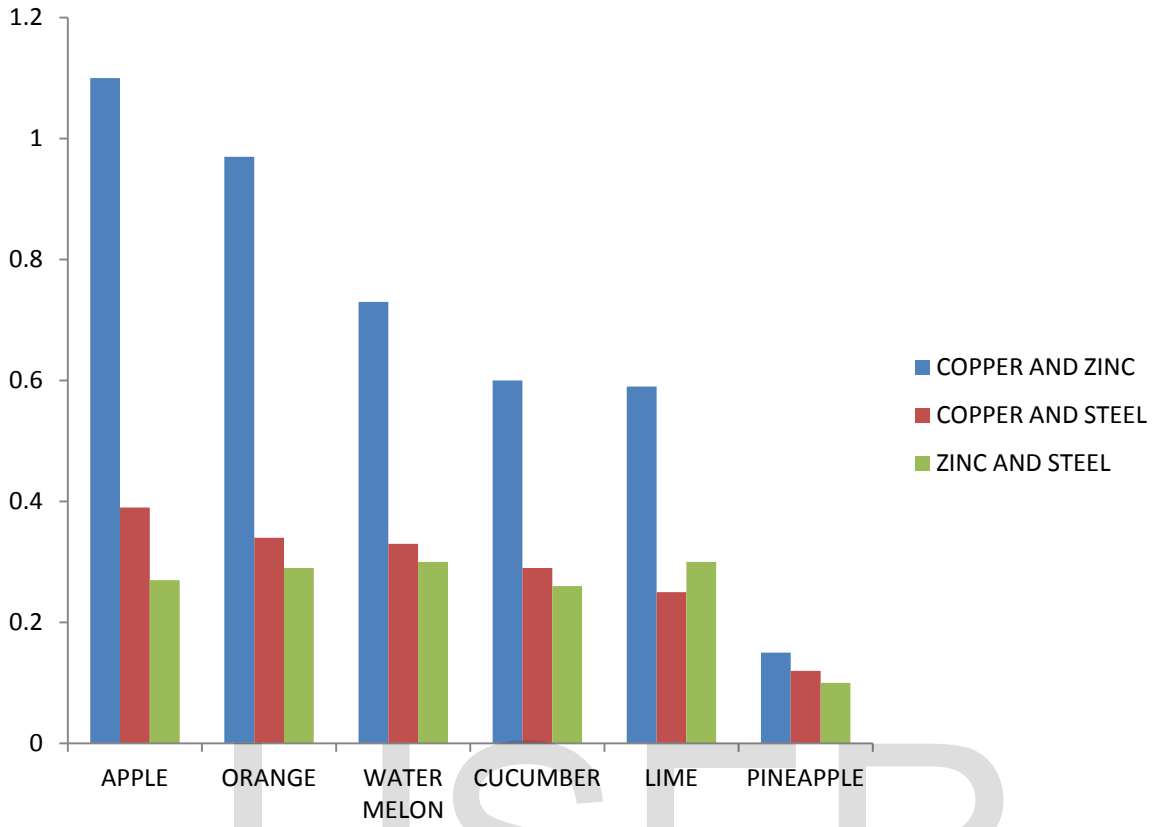
Figure 1: Experimental Set Up

6. Results

Table 1: Volts Measured from Fruits and Vegetable using different electrodes.

Fruits	Electrodes		
	Copper and Zinc (volts)	Copper and Steel (volts)	Zinc and Steel(volts)
Apple	1.10	0.39	0.27
Orange	0.97	0.34	0.29
Potato	0.83	0.31	0.23
Water Melon	0.73	0.33	0.30
Cucumber	0.60	0.29	0.26
Lime	0.59	0.25	0.30
Pineapple	0.15	0.12	0.10

Table 1 shows the voltage that was measured from different fruit such as; apple, orange, potato, water melon, cucumber and lime using the multimeter. Different electrodes such as zinc, copper and steel was used to know which can generate high voltage and it was discovered that the copper and zinc electrode generated a high voltage than others. Also from table 1 apple has the highest voltage.

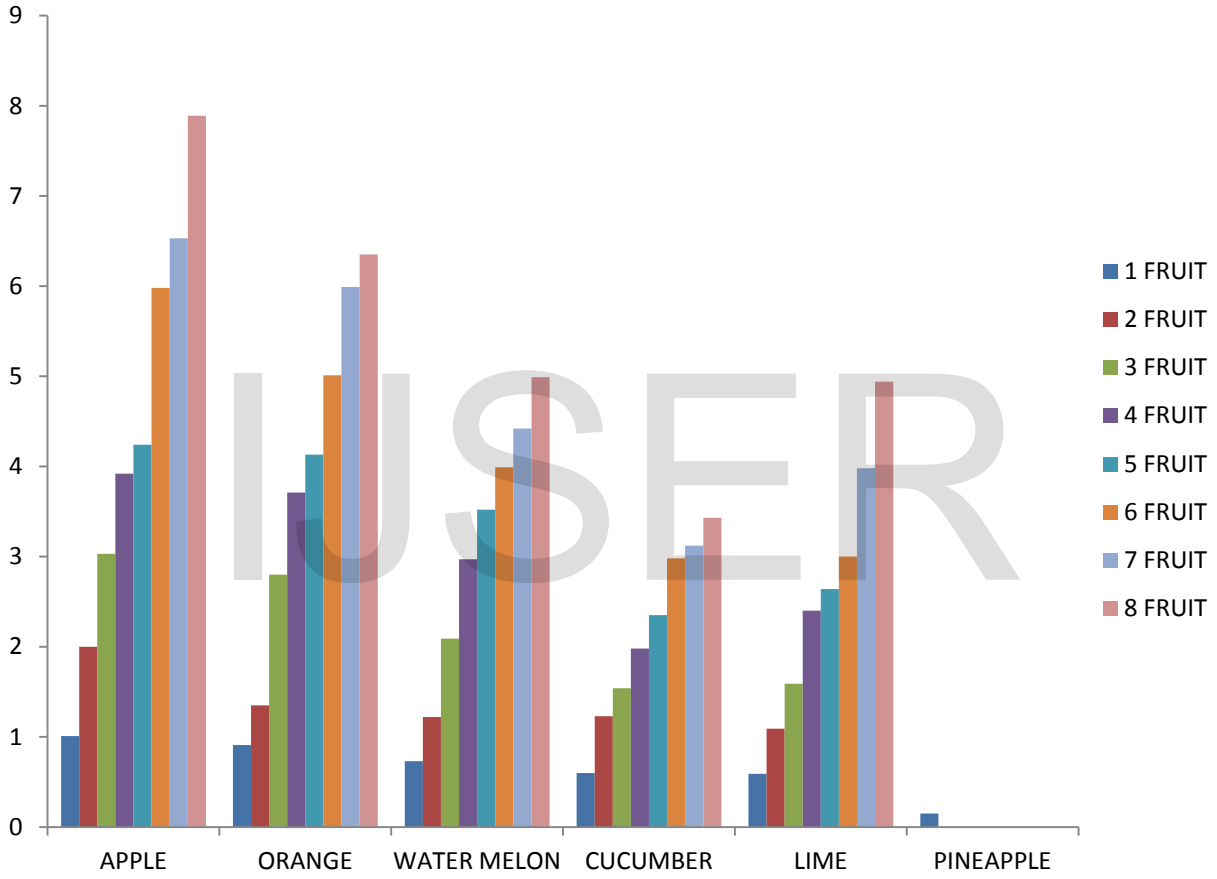


GRAPH 1: THE GRAPH OF VOLTS MEASURED USING DIFFERENT ELECTRODE

Table 2: Volts measured from fruits and vegetable of different quantity using the copper and zinc electrode only.

Fruits	Electrode (Copper and Zinc)							
	1 Fruit	2 Fruits	3 Fruits	4 Fruits	5 Fruits	6 Fruits	7 Fruits	8 Fruits
Apple	1.01	2.00	3.03	3.92	4.24	5.98	6.53	7.89
Orange	0.91	1.35	2.80	3.71	4.13	5.01	5.99	6.35
Potato	0.83	1.22	2.09	2.97	3.52	3.99	4.56	5.86
Cucumber	0.60	1.23	1.54	1.98	2.35	2.98	3.12	3.43
Lime	0.59	1.09	1.59	2.40	2.64	3.00	3.98	4.94
Pineapple	0.15	-	-	-	-	-	-	-

Table 2 shows the voltage found in different fruits and vegetable of different quantity using only copper and zinc electrode. It can be derived from the table that as the quantity of the fruit increases so the voltage increases depending on the fruit used. it can also be denoted that the voltage of one apple is higher than the voltage of the other fruit, and the voltage of 8 apples is still the highest. While pineapple have the lowest voltage.

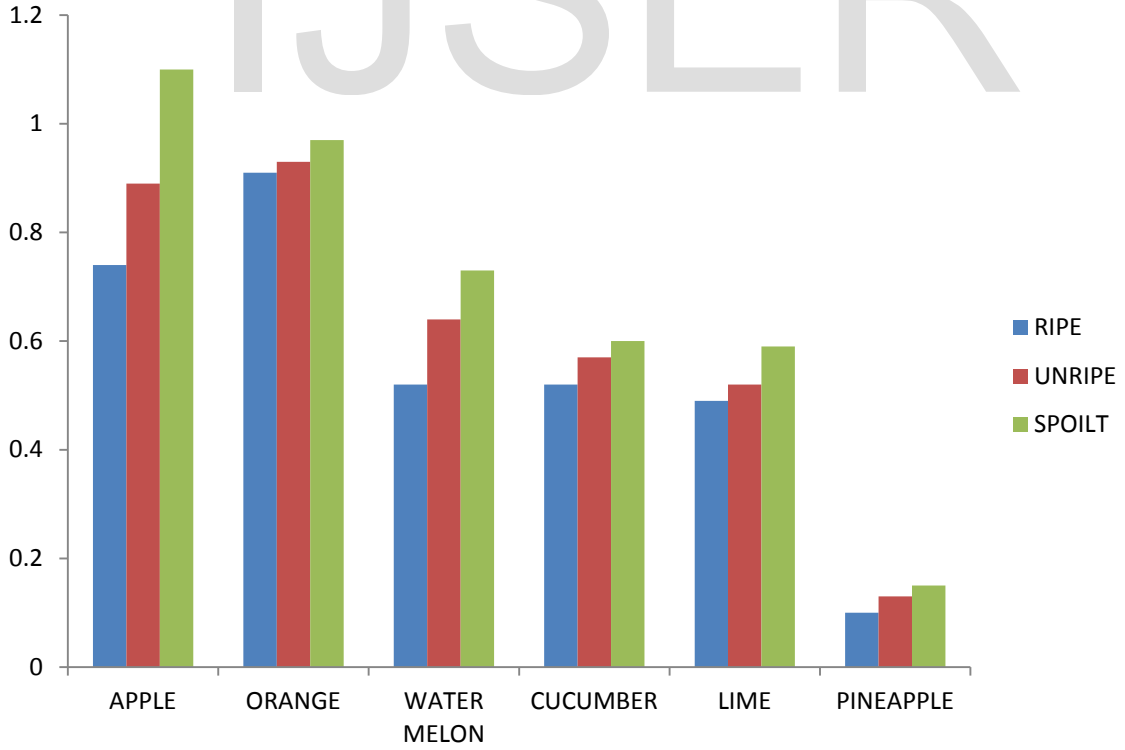


GRAPH 2: GRAPHICAL REPRESENTATION OF VOLTS MEASURED AGAINST FRUITS OF DIFFERENT QUANTITY

Table 3: Voltage measured from ripe, unripe, and spoilt fruits and vegetable using the copper and zinc electrodes only

Fruits and Vegetable	Electrode (Copper and Zinc)		
	Ripe	Unripe	Spoilt
Apple	0.74	0.89	1.10
Orange	0.91	0.93	0.97
Potato	0.69	0.72	0.83
Water Melon	0.52	0.64	0.73
Cucumber	0.52	0.57	0.60
Lime	0.49	0.52	0.59
Pineapple	0.10	0.13	0.15

Table three shows the volts of different fruits for ripe, unripe, and spoilt fruit using the copper and zinc electrodes and it can be derived that apple has the highest voltage among all fruits used. The voltage of ripe fruit for all the fruit is lower than the unripe fruit and the unripe fruit is also lower than the spoilt fruit which means that the spoilt fruit can generate a higher voltage with a high acidity. It can also be denoted from table three that apple also generated a high voltage for spoilt fruit. (Waste to Wealth).



GRAPH 3 THE GRAPH OF VOLTS AGAINST RIPE, UNRIPE AND SPOILT FRUIT

7. Conclusion

The electrode reacts with the juice in the fruit and vegetable to generate electricity and it was discovered that spoilt fruit produced highest voltage out of all tested fruits. The further apart the electrode and the higher the acidity of the fruit, determine the high value voltage. Copper and zinc electrode is the best for this experiment. Also, the highest voltage recorded in apple may be as a result of its surface area and acidity.

Instead of disposing all waste fruit or spoilt fruit they can be converted to batteries to generate high voltages good enough to light / charge our appliances of little volt at home. Such as our phones, touch light and batteries.

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