Journal of NAMP 67 (2024) 65-70

The Nigerian Association of Mathematical Physics

Journal homepage: https://nampjournals.org.ng

EFFECT OF pH ON THE AMOUNT OF ELECTRIC CURRENT PRODUCED BY FIVE TROPICAL FRUITS

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https://doi.org/10.60787/jnamp-v67i1-345

ARTICLE INFO

Article history:
Received xxxxx
Revised xxxxx
Accepted xxxxx
Available online xxxxx

Keywords:
pH,
Electrolyte,
Oxidation,
Reduction,
Electric Current.

ABSTRACT

Fruits contain mineral salts which are in the forms of ions such as Ca+2, K+, Mg+3, etc. These ions as electrolytes, can be made to produce electric current when a potential difference is set up with metal electrodes of different potentials. In this research, the amount of electric current produced by five different tropical fruits; Lime, Orange, Pineapple, Mango and pawpaw (0.93mA, 0.66mA, 0.6ImA, 0.43mA and 0.32mA respectively) were compared to their pH (2.30, 3.20, 3.50, 4.10 and 5.50 respectively) with a view of finding a relationship between current produced and pH. The results indicated that the lower the pH of the fruit, the higher the current produced and the higher the pH of the fruit towards neutral, the lower the current produced. The results also indicated that acid fruits generate better electric current than low acid fruits.

1.0 Introduction

Mineral salts are found in fruits. The mineral salts in fruits are present as ions such as Ca^{+2}, K^{+}, Mg^{+3}, etc. As a result of these ions present in fruits, fruits can generate electricity when a potential difference is set up [1, 2]. It therefore means that fruits can function as electrochemical cells [3]. According to Gibbs [4], an electrochemical cell is a device that uses energy generated during a spontaneous redox reaction to produce an electric current. When fruits produce electricity, they act as electrochemical cells. The fruit here is connected with two conductive electrodes (the anode and the cathode).

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Any material that is sufficiently conductive, such as graphite, metals, and semiconductors, can be used as electrodes. The fruit juice, made up of freely moving ions becomes the electrolyte [5, 6].

There are two distinct chemical reactions occuring at the metal electrodes used in the fruit cell. Oxidation occurs at the anode while at the cathode, reduction occurs. To enable the flow of electrons from the metal of the anode to the ions at the cathode's surface, the two electrodes must be electrically connected to one another. The electron flow therefore generates an electric current that can be utilised to power a lightbulb or turn on a motor, among other things [7].

The reactions occurring at both electrodes are given in the equation;

Zinc electrode (anode): $Zn_{(s)} \rightarrow Zn^{2+}{}_{(aq)} + 2e$

Copper electrode (cathode): $2H^{+}_{(aq)} + 2\ e \rightarrow H_{2(g)}$

Once the two electrodes are linked by an external connection, The metal atoms of the zinc electrode dissolve into the fruit solution (electrolyte). The zinc atoms dissolve into the liquid electrolyte in the form of charged ions (Zn^{2+}). Two negatively charged electrons are released in the process:

$Zn—Zn^{2+} + 2e^{-}$

This is an oxidation reaction.

The electrons released passes through the external circuit to the surface of the copper electrode where hydrogen ions (H^{+}) from the Fruit juice take up the electrons to form hydrogen molecule (H_2):

$2H^{+} + 2e^{-} \rightarrow H_2$

This is a reduction reaction.

The hydrogen molecules formed on the copper's surface as a result of the reduction reaction eventually bubble away as hydrogen gas [5].

Electrolytes are found in the body as vital minerals required for various body metabolisms [8, 9]. Deficiency in these minerals leads to electrolyte imbalance. The most common cause of electrolyte imbalances in the body is extreme dehydration brought upon by vomiting, diarrhea, or heavy perspiration. The body's natural processes may be hampered by severe imbalances. In the process, a person loses water and electrolytes, especially sodium. Fruits, vegetables, dairy products, nuts and seeds are just a few of the foods that contain electrolytes. Ascorbic acid (Vitamin C), antioxidants and electrolytes are also abundant in many tropical fruits; oranges, pawpaw, lime, pineapples, and mangoes [10].

Depending on their pH level, fruits can be distinguished into two categories: acid fruits and low acid fruits. Majority of fruits contain organic acids of different types for examples; ascorbic acid, citric acid, and maleic acid, among others. These fruits' pH is determined by the concentration and strength of these acids. [11]. Fruits classified as acidic fruits are those whose pH is 4.6 or less due to their high acid content. They consist of fruits like limes, tangerines, sour peaches, lemons, grapefruits, oranges, pineapples, sour apples, sour plums, etc. Fruits classified as low-acid have pH levels between 4.6 and

6.9. They consist of fruits like fresh figs, olives, delicious apples, cherries, sweet peaches, sweet plums, pawpaw, and other fruits like apricots, strawberries, tangerines, raspberries, black-berries, mangos. Etc. [11].

The type of ions and the concentrations of ions present in fruits vary from fruit to fruit, so it should be expected that different fruits should generate different amount of electric current. Since pH is connected to the concentration of ions present, the pH will equally vary from fruit to fruit. The objective of this research is therefore to compare the pH of selected fruits to the amount of electric current generated by these fruits.

2.0 Experimental Procedures

2.1 Determination of Electric Current Produced by Fruits.

A zinc nail (anode) was carefully inserted into one end of the sample fruit. A copper wire (cathode) was inserted at another end of the fruit 3cm apart. The leads on the digital multi-meter (XL830L Portable digital multi-meter) was connected to both ends of the copper and zinc electrodes and the amount of current produced was recorded. The procedure was repeated for each fruit sample but with fresh copper and zinc electrodes each time. The procedure was also used for deionized water as control.

2.2 Determination of pH in Fruits

The pH of the fruits was determined electronically using a pH meter (Fisher Scientific). The pH was first standardized with standard buffer solutions (pH 4, pH 7 and pH 10) before readings were taken.

The juice of the fruit was first squeezed out and filtered using filter paper. The dried electrode of the pH meter was carefully placed into the beaker three quarter filled with the fruit juice. The beaker was swirled gently. The pH meter was switched on and readings were taken. The procedure was repeated for all fruits with the electrode rinsed with deionised water and dried before each use. The pH of deionized water was also taken as control.

3.0 Results

3.1 pH of Fruits Analysed

The pH of the various fruits analysed are given in table 1;

FRUIT	pH
Lime	2.30
Orange	3.20
Pineapple	3.50
Mango	4.10
Pawpaw	5.50

Table 1-Results pH of Fruits Analysed

3.2 Electric Current Produced by Fruits

The amount of electric current produced by each fruit analysed is given in table 2;

FRUIT	ELECTRIC CURRENT (mA)
Lime	0.93
Orange	0.66
Pineapple	0.61
Mango	0.43
Pawpaw	0.32

Table 2-Results of Electric Current Produced By Fruits

3.3 Relationship Between pH and Current

The relationship between pH and electric current generated is given in table 3.

FRUIT	pH	ELECTRIC CURRENT(mA)
Lime	2.30	0.93
Orange	3.20	0.66
Pineapple	3.50	0.61
Mango	4.10	0.43
Pawpaw	5.50	0.32

Table 3- Relationship Between pH and Current

4.0. Discussion

Deionized water was used for the control experiment, and it recorded a pH of 7 which indicates neutral. Pure water is neither acidic nor alkaline.

Table 1 shows the pH of the five fruits used in this research. The lime fruit recorded the lowest pH of 2.30 (high acidity) and the pawpaw fruit recorded a high pH of 5.50 (low acidity). The result goes to indicate that lime, orange and pineapple fall into the category of acid fruits, while, mango and pawpaw falls into low-acid fruits [10]. Table 2 shows the quantity of electric current produced by each fruit analysed. The result shows that the lime fruit produced the most current with 0.93mA. Pawpaw recorded the lowest current with 0.32mA

The deionized water used in the control experiment did not produce any electric current when used as an electrolyte. This is an indication that pure water with a neutral pH of 7 cannot produce electric current.

Table 3 shows the relationship between the pH recorded for each fruit and the corresponding current produced. This table clearly shows that the lower the pH of the fruit, the higher the current generated

and the higher the pH of the fruit towards neutral, the lower the current produced. This also indicates that acid fruits will generate better electric current than low acid fruits.

Research in electrolysis have indicated that when two different metals of moderate reactivity are in contact with an electrolyte, a potential difference is created [5,12]. The potential difference created between the two metals is as a result of the ions moving in the electrolyte. The positive ions are drawn towards the metal cathode while the negative ions are drawn towards the metal anode.

This sudden movement of the ions generate electric current which can be measured using a digital multi-meter. The pH of the electrolyte is an indication of how much ions are present [4]

Conclusion

Acidic fruits can serve as good electrolytes and can be used in making simple electric cells which can generate electric current. The electric properties of fruits depend on the pH of the fruits. The lower the pH is from neutral, the more electric current it can generate.

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