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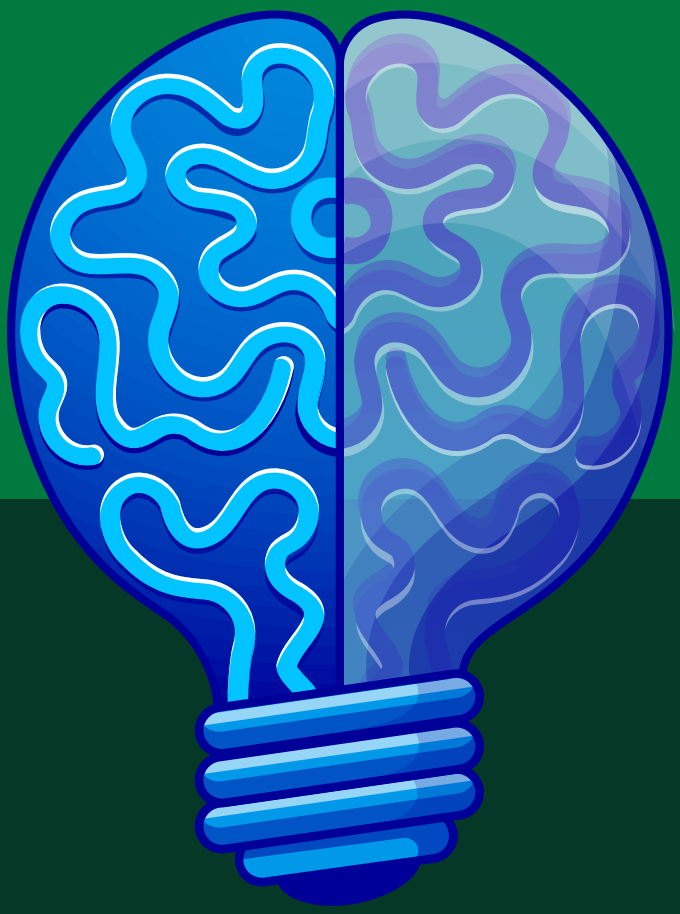
UNIVERSITI TEKNOLOGI MARA
PERAK BRANCH

SCIENTIFIC PROJECT COLLOQUIUM 2025



BIOLOGY ~ CHEMISTRY ~ PHYSICS

Final Year Project Colloquium 2025
Faculty of Applied Sciences,
Universiti Teknologi MARA,
Perak Branch Tapah Campus,
35400 Tapah Road, Perak, Malaysia.

Colloquium date 12th July 2025
Publication date 31st October 2025

Proceedings of Extended Abstracts

EDITORS
Pn. Rosliza Ali
Pn. Nunshaimah Salleh
Pn. Norsakina Zurina Zulkifli
Pn. Adibatul Husna Fadzil
Pn. Yanti Yaacob
Pn. Lili Widarti Zainuddin

e-1.S.B.N: 978-629-97630-6-2

Published by Faculty of Applied Sciences, Universiti Teknologi MARA, Perak Branch Tapah Campus

Faculty of Applied Sciences,
Universiti Teknologi MARA,
Perak Branch Tapah Campus,
35400 Tapah Road,
Perak, Malaysia.

Preface

The Scientific Project Colloquium offers a platform for publishing Diploma Science final year projects (FYP). The objective is to effectively distribute research findings throughout all scientific disciplines. The primary objective of including final year projects into the course curriculum is to encourage students to put their theoretical knowledge into practical applications.

We would like to express our gratitude to our primary establishment, the Faculty of Applied Sciences and Universiti Teknologi MARA, Perak Branch, for their invaluable assistance.

Lastly, we would like to express our gratitude to all of the authors for the tremendous help in preparing the articles, without which this undertaking would not have been completed.

Editors

Rosliza Ali
Nunshaimah Salleh
Norsakina Zurina Zulkifli
Adibatul Husna Fadzil
Yanti Yaacob
Lili Widarti Zainuddin

Universiti Teknologi MARA
Perak Branch Tapah Campus
October 2025

THE ELECTROCHEMICAL POTENTIAL OF A NATURAL GREEN BATTERY FROM FRUITS

Adibah Mohd Noor[1*], Northaqifah Hasna Mohamed Khir[2], Sıtı Aısyah Kamal Arıfin[1], Nur Alya Farıza Md Yasın[1], Nurul Adılah Mohd Dın[1], Zetty Nabılah Adam[1]

[1]Faculty of Applied Sciences, Universiti Teknologi MARA, Perak Branch, Tapah Campus, 35400 Tapah Road, Perak, Malaysia
[2]Faculty of Applied Sciences, Universiti Teknologi MARA, Terengganu Branch, Bukit Besi Campus, 23200 Dungun, Terengganu, Malaysia

[*]E-mail: adibah_mnoor@uitm.edu.my

Abstract: A battery is an electric cell, a device that produces electricity from a chemical reaction used for many purposes. Commercial batteries often contain toxic materials that can contaminate water sources and cause harm to the environment due to improper disposal. As the pollution alarms, this study investigates the potential of fruits as a green alternative to commercial batteries. The objectives of this study are to compare the pH and voltages of variations of fruits, to determine the difference in voltage between fresh fruit, non-fresh fruit and blended fruit and to study the potential of fruits as an alternative to the battery for a decoration product created. The methodology begins with the pH identification of four variations of fruits; lemon, orange, green apple and pineapple. Then, the voltage of the fruits was measured using copper and zinc as electrode. A product decoration in flower form is created with the fruit juice as a green battery. The resulted pH of lemon was measured is 3 and pH 4 is for orange, green apple and pineapple. Fresh fruit juice produced higher voltages than non-fresh and blended samples, with lemon, orange, green apple and pineapple yielding 2.08 V, 1.48 V, 1.76V and 1.22 V, accordingly. Meanwhile, the light-emitting diode (LED) lighted up the brightest when using lemon fruit compared to other fruits. These findings demonstrate that fresh lemon juice is the most effective fruit-based electrolyte for biobattery applications, offering higher voltage output and better performance for powering small decorative devices compared to orange, green apple and pineapple.

Keywords: *Battery, Green battery, Fruit, electricity, Voltage, Energy*

INTRODUCTION

Batteries are essential energy sources which contains two plates made of dissimilar metals as electrodes that are immersed in a conducting solution called as electrolytes. According to Hill et al. (2005), chemical reactions occur when an electron flows from cathode to anode through an electrolyte. This is called as an oxidation-reduction reaction or known as a redox reaction transform chemical energy into electrical energy (Chang et al., 2013). Commercial battery production increased by day and improper disposal leads to the polluted environment. The materials in alkaline commercial batteries are corrosive acids like cadmium, lead and mercury that will risk the ecosystem and contamination of soil and water sources. Hence, an eco-friendly and biodegradable power supply has become an important focus by encouraging the society to use green batteries derived from natural materials. Fruit based electrochemical cell will help to reduce the chemical waste contain in an alkaline battery that cannot be recycled. The effect of pollution and greenhouse will reduce and safe to the environments (Garcia et al., 2003).

The introduction of fruits is naturally acidic, being a source of battery that can generate electricity. In recent years, green batteries derived from natural resources and used food from fruits or vegetables. The natural organic acids in the fruit's juices provide electrolytes that facilitate ion transfer between electrodes thus triggering a chemical reaction (Sagar et al., 2010). Usually, the acidic fruits are used because of high acidity. Therefore, acid is the producer of electrons in producing electricity (Garcia et al., 2003). There are several factors that affect the conduction of electric in fruits which are pH and the condition of the fruits or vegetable. The pH affects the voltage obtained from the chemical reaction between the electrodes and the electrolytes. Meanwhile, the condition of the fruit was determined based on its physical state and its stage of decomposition (Klotz et al., 2003).

This study investigated the electrochemical potential of the different types of fruits as alternative energy sources. The difference in pH and voltage output under different conditions which are fresh, non-fresh and blended between types of fruits were measured. The potential application as a green battery in powering decorative product was studied. Fresh lemon produced the highest voltage of 2.08V and LED lighted up brightly in decorative product compared to the other fruits.

METHODOLOGY

The methodology consisted of three main parts; pH and voltage determination, and application of fruits as a green battery. Four different fruits were focused involving lemon, orange, green apple and pineapple. First, the pH value of each fruit was determined using pH paper. Each fruit was cut and squeezed to extract the juice and a pH paper was dipped. The pH paper was observed and compared against the standard pH scale to obtain the pH value. Next, the voltage of each fruit was measured. Lemon was cut using a knife, where the slits matched for the plate to be inserted. A copper plate and a zinc plate were inserted halfway into each of the slits, opposite of each other. Both copper and zinc plate were connected together with a set of wire and alligator clips, where the other ends were connected to a multimeter (Sagar et al., 2010). The voltage reading was recorded and the same steps were repeated for other fruits. The steps were repeated for fruit juice aged for a day and blended juice. The final procedure involved the application of the fruit as a green battery for the decoration product created. The electrolytes from fruit need to power up the LED on a decoration. The decoration was initially constructed by cutting a piece of coloured paper into several pieces, with the shape of a flower petal. The copper wire and galvanised wire were then cut into several pieces, each about 5 cm in length. A piece of the copper wire was slipped alternately into the holes of a petal and galvanised wire at the opposite side. The copper wire on the petal was twisted with the galvanised wire on another petal and continued until five petals for a flower were comprised. The copper wire of the fifth petal was twisted to an LED instead and the same goes for the galvanised wire of the first petals. The petals of the flower were drenched with juice. In order to make the light of the LED observable, the decoration flower was placed inside a cardboard box wrapped with black coloured paper.

FINDINGS

The experimental results were obtained from measuring the pH and voltage output of four different fruits under fresh, non-fresh, and blended conditions. As shown in Table 1, lemon exhibit the lowest pH value which was 3 and pH 4 for orange, green apple and pineapple. Lower pH value of lemon indicated that lemon has high concentration of acidity from organic acid. According to Karadeniz (2004) the highest acid content was found in lemon juices compared to other fruits, with 58.94 g/L corresponding to citric acid. Based on the sample fruit tested, lemon and orange were categorized as citrus fruits that had high amount of citric acid. However, pH orange is 4 due to less concentration of citric acid than lemon. Nevertheless, green apple and pineapple are not classified as citrus fruits and contain organic acid primarily malic acid more than citric acid. However, both fruits are still acidic.

Table 1 The pH and voltage of variation condition of fruits

Types of fruit	pH	Voltage, V		
		Fresh juice	Non fresh juice	Blended juice
Lemon	3	2.08	1.96	1.43
Orange	4	1.48	1.42	1.04
Green apple	4	1.76	1.69	1.21
Pineapple	4	1.22	1.12	0.86

Reference: Mohd Noor, 2016

For the voltage output, lemon produced the highest voltage compared to others. Higher acidity in lemon produced more voltage. Citric acid acts as electrolytes in the battery, increasing the strength of the electric current and thereby the voltage produced (Akbar et al., 2018). This shows a correlation that the lower pH of the fruit directly contributes to the higher voltage produced (Sultana et al., 2018). The more citric acid present in acidic fruit, the more hydrogen ions being produced to react with the electrons on both electrodes, generating higher current flow (Sangaranarayanan et al., 2011).

Table 1 also revealed that the fresh fruits consistently produced the highest voltage for each type of fruits compared to non-fresh fruit and blended fruit. Fresh lemon exhibited the highest voltage of 2.08V, followed by green apple, orange and pineapple with 1.48V, 1.76V and 1.22V accordingly. Citric acid in lemon enhances conductivity and resulted in greater voltage generation, which is supported by a previous study where acid is a good conductor of electrons. This created an electric current that can be used as bio battery (Sasongko et al., 2025). While the orange produced more voltage than the pineapple but less than green apple, the pH remained similar to that of the apple despite its higher citric acid content. This may be attributed by the variations in acid concentration, fruit size and surface area. By comparing fresh and non-fresh juice, a decrease in voltage was observed with ageing as shown in Table 1. Lemon fresh juice produced higher voltage 2.08V compared to 1.96V for non-fresh fruit. Similar trends were observed for orange, green apple and pineapple. The lowest voltage was pineapple in non-fresh juice condition. Research by Sasongko et al. (2025) emphasized that the freshness of the fruits depends on its storage or preservation time which is known as aging time. The fresh and aged fruits can

indicate their biochemical and electrochemical state. These values are influenced by factors such as the chemical composition, ripeness, water content, and the degradation of organic compounds during ageing. In addition, voltage values obtained from all the fruits juice electrolyte reduce with time. This is probably due to the oxidation process on the electrolyte. Lemon and orange juice electrolyte decreases with time, possibly due to oxidation (Osahenvemwen et al. 2020). The biochemical degradation process affects the decrease in voltage. In comparison with all conditions, blended juice produced the lowest voltage among the three conditions, with pineapple being the lowest at 0.86 V. The decreased voltage may be due to the disruption of the natural fruit structure during blending, which limits efficient electron transfer between the electrodes. Thus, fresh juices produced higher voltages than aged samples.

Additionally, the application of fruit juices in powering a decorative LED flower and the electrochemical performance as a green battery electrolyte was discussed. For the application, Table 2 summarizes the qualitative performance of lemon, orange, and pineapple juices showing the brightness level of the LED as an indicator of each fruit's effectiveness as a natural green battery.

Table 2 The condition of LED on the application of natural green battery

Types of Fruit	Condition of LED
Lemon	The LED light up brightly
Orange	The LED light up
Green apple	The LED light up
Pineapple	The LED light up

Reference: Mohd Noor, 2016

Table 2 revealed the result of the different types of fruit that act as a natural green battery in flower decoration product that has been made. Among the four fruits tested, lemon produced the brightest light, indicating that its higher voltage output translated into more effective current flow through the LED circuit as shown in Figure 1. Meanwhile, orange, green apple and pineapple were able to light up the LED, but with visibly lower brightness, reflecting their lower voltage values.

Figure 1 The condition of the LED when the petals is implemented with fresh lemon juice

Based on the finding, this confirms that the lemon is the most potential fruit electrolyte due to its higher acidity and citric acid concentration, which enhance conductivity and electron transfer between electrodes. The performance difference also highlights that voltage strength is directly correlated with LED brightness, making lemon juice the best candidate for the green battery applications among the fruits studied. Overall, lemon provides the highest voltage among all the electrolytes used and the most effective material for being as bio green battery.

CONCLUSIONS

From the study, the pH of a fruits does affect the value of the voltage obtained. Comparing all the types of fruit, fruits with higher acidity produced higher voltage outputs, with lemon as pH 3 generating the greatest voltage among the fruits tested with 2.08V, followed by orange, green apple and pineapple. The acidity affects the higher voltage obtained. Fresh lemon juice was identified as the most potential electrolyte, producing a higher voltage compared to non-fresh and blended juices. Fresh juices produced higher voltages than aged sample because electron transfer was more efficient, whereas blending disrupted the internal structure and reduced conductivity. For the application as a green battery, a decorated flower utilizing fresh lemon juice produced a brighter LED illumination compared to orange juice, green apple and pineapple juice. Nevertheless, further research is needed to optimize this alternative battery system for practical use as a replacement for conventional alkaline batteries. Future work should explore different electrode materials, acid concentrations and methods to preserve juice

freshness over time. Additionally, improvements to the green battery prototype are necessary to enhance its efficiency and stability.

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