Antihyperglycemic Effect of Combined Pomelo *(Citrus maxima)* and Banana *(Musa × paradisiaca L.)* Peel Extract Against Induced Diabetic Sprague Dawley Rats

San Beda University – Rizal
Integrated Basic Education Department
Junior High School Unit

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APPROVAL SHEET

This research paper with the title "**Antihyperglycemic Effect of Combined Pomelo *(Citrus maxima)* and Banana *(Musa × paradisiaca L.)* Peel Extract Against Induced Diabetic Sprague Dawley Rats**", prepared and submitted by **William N. Amores III, Sean Matthew L. Aniano, Ramon Jacob L. Caluag, Anne Gei Mikaela B. Gervacio, Aimee Patricia Monique T. Juco, Neil Albert A. Oabel,** and **Isabella Mishka M. Santos** of **10-13 St. Odo of Cluny, Pre-STEM Health Allied Class**, in partial fulfillment for the requirements of Grade 10, is hereby accepted and approved.

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DEDICATION

The researchers dedicate this paper to the present and future San Beda University Grade 10 students for the development of the skills and knowledge used in creating this paper. May this study serve as a reminder that with perseverance and dedication, everything is possible.

They would also like to devote this paper to people with diabetes. May this research study serve as a contributing factor in the making of a new drug for hyperglycemia.

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ABSTRACT

Buildup of blood sugar leads to a condition known as hyperglycemia which is attributed to diabetes mellitus that leads to numerous conditions such as blurry vision, heart problems, and in severe cases, death. In 2022, the mortality rate due to diabetes was 6.6% making it the fourth leading cause of death in the Philippines. Plants bearing fruits have flavonoids, an active compound that exhibits antidiabetic and antihyperglycemic activity. Thus, this study aims to determine the antihyperglycemic effect of combined Pomelo *(Citrus maxima)* and Banana *(Musa x paradisiaca L.)* peel extract against induced diabetic Sprague Dawley Rats. In this study, the researchers utilized 3 groups with 2 rats each, an experimental group treated with 50% PPE: 50% BPE, a positive control group treated with commercially available antihyperglycemic drug Metformin, and a negative control group. After the treatment period, the results have shown that both fruit extracts and the commercially available drug was effective in lowering the blood glucose levels of the rats with an average percent decrease of 64.94% and 83.49% respectively however the untreated rats also present an average percent decrease of 64.81%. Afterwards, the data was statistically analyzed using ANOVA with an alpha value of 0.01. However, the result shows a p-value 0.489306 which is higher than the desired alpha value. In general, combined Pomelo *(Citrus maxima)* and Banana *(Musa* x *paradisiaca L.)* peel extract was effective in lowering the blood glucose level of the rats but not as effective as commercially available antihyperglycemic drug.

Keywords: antihyperglycemic, pomelo, banana, diabetes mellitus, sprague dawley rats, citrus maxima, musa x paradisiaca l.

CHAPTER I
THE PROBLEM AND ITS BACKGROUND

INTRODUCTION

Diabetes Mellitus or commonly known as Diabetes is a health disorder affecting more than 422 million people worldwide according to the World Health Organization (WHO). It is a chronic condition brought by insufficient insulin production by the pancreas. Diabetes can lead to numerous problems such as blurry vision, heart conditions, and in severe cases, death. In the Philippines, passing due to diabetes was recorded as 2,882 cases or 6.6% making it the fourth leading cause of mortality in the country. (Philippine Statistics Authority, 2022). According to the Center of Disease Control and Prevention (CDC), Diabetes can lead to the buildup of sugar or glucose in the bloodstream due to two issues: the pancreas cannot produce enough insulin to regulate the movement of glucose into the cells. Cells respond poorly to insulin due to insulin resistance, thus resulting in more glucose in the bloodstream, thus leading to Hyperglycemia or high blood sugar which can lead to various health issues and is often attributed to diabetes (Dhatariya et al., 2020). Combating hyperglycemia can be done by taking compounds with antihyperglycemic effects or those that lower glucose levels. Pomelo (*Citrus maxima*) and Banana *(Musa x paradisiaca L.)* has compounds that can be used to lower blood glucose.

Pomelo (*Citrus maxima*) is a fruit commonly found and is abundant in the Philippines. 26.93 thousand metric tons of Pomelo were produced in 2021 (Statista, 2022). The peel of Pomelo which is 30% of the mass of the fruit (Zarina & Tan, 2013), is often unused and commonly becomes waste despite having potential health benefits (Van Hung et al., 2020). Pomelo peel exhibits antihyperglycemic (Tran et al., 2021) and antidiabetic effects (Mohammed et al., 2021).

On the other hand, Banana (Musa × paradisiaca L.) is a combination of M. acuminata and M. balbisiana. Banana peels have been proven to contain active compounds that exhibit antihyperglycemic and antidiabetic (Vijay et al., 2019) activity. Despite this, the peel of the banana often becomes a by-product as it is not consumed and instead is thrown away as waste.

It has been proven in previous research that Pomelo *(Citrus maxima)* and Banana *(Musa × paradisiaca L.)* peel extracts are both effective on their own as antidiabetic and antihyperglycemic agents. Furthermore, the peels of both fruits contain Flavonoids (Nguyen et al., 2021) and other active compounds that have antidiabetic and antihyperglycemic effects. Pomelo *(Citrus maxima)* peel contains hesperidin, a substance proven to prevent hyperglycemia and have antidiabetic effects (Peng et al., 2020). On the other hand, Banana *(Musa × paradisiaca L.)* peel has higher antioxidant activity (Okolie et al., 2016). Therefore, given this information, this study aims to evaluate the antihyperglycemic effect of combined Pomelo (*Citrus maxima*) and Banana *(Musa × paradisiaca L.)* peel extract on induced diabetic Sprague Dawley rats

SETTING OF THE STUDY

This study including its experimentation was conducted in San Beda University – Rizal Campus, located in Taytay, Rizal. The rats were housed in bin cages in the Subiaco Hall while the extracts were prepared at the Chemistry Laboratory. The induction of Alloxan Monohydrate and the measurement of the rats' fasting blood glucose levels were carried out in the Physics Laboratory.

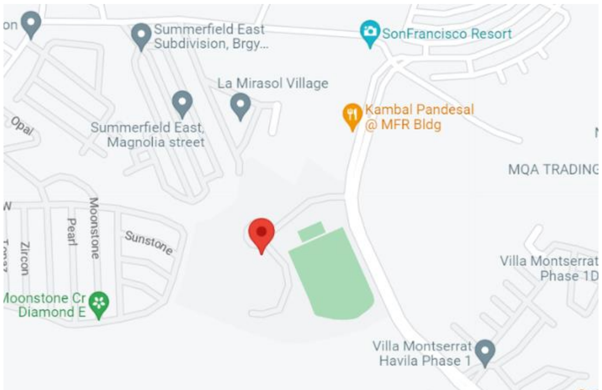

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Figure 1.1. *Location of San Beda University – Rizal*

Figure 1.2. *Animal Housing*

Figure 1.3. *Chemistry Laboratory*

Figure 1.4 *Physics Laboratory*

CONCEPTUAL FRAMEWORK

Input **Process** **Output**

Figure 2. *Conceptual Framework*

STATEMENT OF THE PROBLEM

This study aims to test the antihyperglycemic effect of combined Pomelo *(Citrus maxima)* and Banana *(Musa × paradisiaca L.)* peel extract on induced Diabetic Sprague Dawley rats.

1. Will the ratio of 50% Pomelo (Citrus maxima) and 50% Banana (*Musa × paradisiaca L.*) peel extract be effective in lowering the blood glucose level of induced diabetic Sprague Dawley rats?

2. Is there a significant difference between the blood glucose level of induced diabetic Sprague Dawley rats after being treated with Pomelo *(Citrus maxima)* and Banana *(Musa × paradisiaca L.)* peel extract and Metformin?

HYPOTHESIS

Ho1. The ratio of 50% Pomelo *(Citrus maxima)* and 50% Banana *(Musa × paradisiaca L.)* peel extract will not be effective in lowering the blood glucose level of induced diabetic Sprague Dawley Rats.

Ha1. The ratio of 50% Pomelo *(Citrus maxima)* and 50% Banana *(Musa × paradisiaca L.)* peel extract is effective in lowering the blood glucose level of induced diabetic Sprague Dawley Rats.

Ho2. There is no significant difference between the glucose level of induced diabetic Sprague Dawley rats after being treated with 50% Pomelo *(Citrus maxima)* and 50% Banana *(Musa × paradisiaca L.)* peel extract and Metformin.

Ha2. There is a significant difference between the glucose level of induced diabetic Sprague Dawley rats after being treated with 50% Pomelo *(Citrus Maxima)* and 50% Banana *(Musa × paradisiaca L.)* peel extract and Metformin.

OBJECTIVES OF THE STUDY

The study aims to determine the effectiveness of combined Pomelo (*Citrus maxima*) and Banana *(Musa × paradisiaca L.)* as an antihyperglycemic agent against induced diabetic Sprague Dawley rats.

Specifically, this research study aims to:

1. Determine the effectiveness of combined 50% Pomelo (*Citrus maxima*) and 50% Banana (*Musa × paradisiaca L.)* peel extract as an antihyperglycemic agent against induced diabetic Sprague Dawley rats.

2. Determine the significant difference between the fasting blood glucose of the induced diabetic Sprague Dawley Rats between the groups treated with 50% Pomelo (*Citrus maxima*) and 50% Banana *(Musa × paradisiaca L.)*, Metformin, and the negative control group.

SIGNIFICANCE OF THE STUDY

Aiming to investigate and determine the antihyperglycemic effect of combined pomelo and banana peels extract, this research would be beneficial and impactful in line with the Sustainable Development Goals of the United Nations and the Benedictine Hallmarks. Specifically, this study would be of significance to the following:

Pharmaceutical Industry. In line with the Sustainable Development Goals, #3 Good Health and Wellbeing, #4 Quality Education, #12 Responsible Consumption and Production, #17 Partnerships for the Goals, and the Benedictine Hallmarks of Community, and Stewardship, the findings of this study can be used as a basis and reference to develop and manufacture Pomelo (*Citrus maxima)* and Banana *(Musa x paradisiaca L.)* peel-based antihyperglycemic medication.

Local Farmers. In line with Sustainable Development Goals, #11 Sustainable Cities and Communities, #12 Responsible Consumption and Production, and the Benedictine Hallmarks of Community, and Stewardship, this study utilizes organic-based materials sourced from local farmers. Thus, this study could potentially create a greater demand for the cultivation of Pomelo (*Citrus maxima*) and Banana *(Musa x paradisiaca L.).*

Future Researchers. In line with the Sustainable Development Goals, #3 Good Health and Wellbeing, #4 Quality Education, #11 Sustainable Cities and Communities, and #12 Responsible Consumption and Production, and the Benedictine Hallmarks of Community, and Stewardship, this study can serve as a reference for future studies discussing the antihyperglycemic properties of Pomelo *(Citrus maxima)* and Banana *(Musa x paradisiaca L.).* This study would also be advancing and improving previous related studies. Given the findings of this study, the Department of Health can utilize this research to further investigate the antihyperglycemic effects of Pomelo *(Citrus maxima)* and Banana *(Musa x paradisiaca L.)* to develop and test the use of the peels extract as a treatment for hyperglycemia.

SCOPE AND DELIMITATION

This study aims to investigate only the antihyperglycemic effect of combined Pomelo (*Citrus maxima*) and Banana *(Musa × paradisiaca L.)* peel extract against induced diabetic Sprague Dawley rats over a one (1) week period with a dose given to each rat daily. There have been previous studies proving Pomelo peel extract and Banana peel extract to be individually effective as antihyperglycemic agents, however, this study aims to investigate the combined effect of the two peel extracts as an antihyperglycemic agent.

Any physical changes or observations to the rats unrelated to the experiment were not considered during the experimentation, as well as any observed adverse effects on the rats by the different treatments.

For ethical reasons, this study utilized an animal model of hyperglycemia and diabetes over conducting testing on humans, thus, this study does not investigate the antihyperglycemic effect of the peels extract on humans.

Due to budgetary and resource constraints, this study utilized a commercially available glucometer over more accurate biochemical assays. A single blood extraction was done on the rats due to the lack of training and skills of the researchers; thus, further testing may result in dangerous or potentially fatal blood loss in the rats. In addition, the glucometer used in this study has a testing limit only being able to detect blood glucose levels below 599.4 mg/dL, therefore, any blood glucose levels that surpass this limit will be recorded as 599.4 mg/dL.

Due to the lack of an Institutional Animal Care and Use Committee (IACUC), the request to procure certified male Albino Mice from the Research Institute of Tropical Medicine (RITM) was denied. Thus, the male Sprague Dawley rats were instead procured from Marlyn's Petshop at Cartimar, Pasay. Furthermore, due to budgetary and time constraints, the researchers faced a lack of rats as only six (6) rats were able to survive until the end of experimentation.

CHAPTER II
REVIEW OF RELATED LITERATURE AND STUDIES

This chapter provides a concise overview of the variables and concepts that support the study, such as Diabetes and Hyperglycemia, Pomelo *(Citrus maxima)*, Banana *(Musa × paradisiaca L.),* and Sprague Dawley Rats. Parameters and procedures used to obtain the necessary data for this research were also discussed in this chapter, such as the glucometer. Associated topics and related information from other journals are also included in this chapter to further strengthen and establish the information used in this research study.

Diabetes and Hyperglycemia

Diabetes mellitus, commonly known as Diabetes, is a group chronic, metabolic disease and health disorder that leads to the buildup of blood sugar or glucose in the bloodstream which causes high blood sugar. Glucose is the main type of sugar in the blood, it is an essential source of energy for the cells that make up the body's muscles and tissues, and it is also the main source of fuel for the brain (Mayo Clinic, 2023). Hyperglycemia is the technical term for high blood glucose, this occurs when the body has inadequate insulin secretion, or the body is unable to adequately utilize insulin. An excessive amount of glucose in the blood can lead to diabetes. Diabetes develops when the pancreas is unable to produce enough insulin to regulate the movement of glucose into the cells, or when the cells respond poorly to insulin due to insulin resistance, thus resulting in more glucose in the bloodstream. Insulin is a hormone that is created by the pancreas that moves and controls the amount of glucose from the blood into the cells, which lowers the amount of glucose or sugar in the bloodstream. It also stores glucose in the liver, fat, and muscles. Essentially, it regulates the body's metabolism of carbohydrates, fats, and proteins (Cdces & Jaffe, 2022).

Diabetes, when left untreated, could cause health complications such as heart disease, stroke, chronic kidney disease, nerve damage, and other problems with feet, oral health, vision, hearing, mental health, and in extreme cases, death (*Prevent Diabetes Complications*, 2022). The most common symptoms of diabetes are polydipsia, frequent urination, fatigue, blurred vision, and unexplained weight loss. However, the symptoms vary according to the types of diabetes, namely, Type 1, Prediabetes, and Type 2. Type 1 diabetes, formerly known as juvenile diabetes or insulin-dependent diabetes, is an autoimmune disease that attacks and destroys the insulin-producing β-cells in the pancreas. Type 1 diabetes often stems from genetics however, it may also develop from an immunological response (Watson, 2022). On the other hand, pre-diabetes occurs when the blood glucose is higher than normal but not high enough to be diagnosed as Type 2 diabetes. Pre-diabetes may develop int Type 2 diabetes if the capacity of the pancreatic β-cells to secrete insulin is unable to combat insulin resistance (Sissons, 2021). It is the most common type of diabetes and mainly affects adults. It stems from a combination of genetics and lifestyle factors (Cleveland Clinic, n.d.). Diagnosis and treatment of diabetes is often done using a glucometer, a small portable machine to measure the amount of glucose in the blood. (Mayo Clinic, 2022)

Monitoring of blood glucose through a glucometer, a small portable machine to measure the amount of glucose in the blood (Mayo Clinic, 2022) is essential to determine if the treatment plan is working and provides information on how to manage diabetes daily (Cleveland Clinic, n.d.). Oral diabetes medication or oral antihyperglycemic agents are the usual treatments for Type 2 diabetes as these aid in lowering of blood glucose levels while still producing insulin (Farinde, 2021). Metformin is the first prescribed medicine as it is an antihyperglycemic agent and it primarily works by lowering glucose production in the liver and improving insulin sensitivity, thus allowing the body to use insulin more effectively (Mayo Clinic, 2023). In addition, active compounds such as flavonoids exhibit antihyperglycemic effects through improvement of pancreatic β-cell proliferation, promoting insulin secretion, reducing apoptosis, and regulation of glucose metabolism. (Al-Ishaq et al., 2019) Flavonoids are commonly found in vegetables, roots, stems, flowers, and fruits such as Banana (*Musa x paradisiaca L.*) and Pomelo (*Citrus maxima*) (Panche et al., 2016)

Pomelo *(Citrus maxima)*

Pomelo, commonly and scientifically known as shaddock and *Citrus maxima*, is the largest citrus fruit from the Rutaceae family (Infopedia, 2017). It has numerous nutrients and benefits such as vitamin C, a powerful antioxidant, and an immune system booster. It's also rich in copper, fiber, and potassium, among other vitamins, minerals, and nutrients (WebMD, 2020). Pomelo is a popular citrus fruit in the Philippines as its production reached 26.93 thousand metric tons in 2021 and is usually harvested from November to January (Statista, 2022).

Numerous researchers have used Pomelo to test its antidiabetic and antihyperglycemic effects against induced diabetic rats. Its peel is a well-known agricultural residual waste that makes up about 30% of the total fruit weight and contains phytochemicals including aroma-active volatiles, pectin, flavonoids, phenolic acids, carotenoids, coumarins, and polysaccharides. The recovery of these phytochemicals provides an opportunity for value-added utilization such as the development of nutraceuticals (Tocmo et al., 2020). Citrus fruits exhibit several biological activities, such as antioxidant, anticancer, anti-inflammatory, hypolipidemic, antihypertensive, antiatherosclerotic, antithrombotic, antiulcer, anti-allergy, and antimicrobial activities (Mohammed et al., 2021). Overall, the pomelo industry provides a great opportunity to recover or make valuable products from the large amounts of residual waste that pomelo generates.

Banana *(Musa × paradisiaca L.)*

Banana, scientifically known as *(Musa × paradisiaca L.)* fruit of the genus Musa, of the family Musaceae, one of the world's most important fruit crops and the most consumed nutritious fruit available worldwide with different shapes, sizes, and colors (Vijay et al., 2019). Bananas are high in fiber, potassium, vitamin B6, vitamin C, and a variety of antioxidants, phenolic compounds, and phytonutrients (Arnarson, 2023).

Research studies indicate that antioxidants present in the banana peel can reduce inflammation and protect against chronic conditions, such as heart disease, cancer, and diabetes (Ajmera, 2019).

Numerous researchers have used bananas to test its antidiabetic and antihyperglycemic effects against induced diabetic rats. The peel of a banana makes up about 35% of the ripe fruit and is often discarded rather than consumed. The fruit peel contains various antioxidant compounds such as gallocatechin and dopamine. Current advances focus on the isolation, characterization, and utilization of natural antioxidants, with a particular emphasis on polyphenols as possible disease-preventing agents (Bashmil et al., 2021).

Sprague Dawley Rats

Sprague Dawley Rats are a cross between an Albino Wistar female rat and a hooded male hybrid of unknown origin. It is a versatile albino outbred strain that has an elongated head and a tail longer than its body. (McNay, n.d.) Sprague Dawley rats are widely used for animal models of human conditions including diabetes, obesity, and cardiovascular disease, due to their ease of handling. (Brower et al., 2015)

Sprague Dawley rat models of Type 2 Diabetes use different methods to induce diabetes. Typically, diabetogenic agents such as streptozotocin, alloxan monohydrate, and glucocorticoids are used to induce diabetes in the rats. Alternatively, high fat diets are also used to induce diabetes (Gheibi et al., 2017). Development of diabetes in rodent models works similarly to humans. From an insulin-resistant or pre-diabetic state wherein its blood sugar is higher than normal but not diabetic, the rats become diabetic once the pancreatic β-cells cannot secrete enough insulin to counteract the high blood sugar and insulin resistance (Shpilberg et al., 2011). Once a rat has a fasting blood glucose of 101 mg/dL and higher it is considered as diabetic.

Glucometer

Glucometers, also called glucose meters, are compact, portable, simple-to-use device that is used to check and monitor blood glucose levels. This device analyzes a small amount of blood, usually a drop coming from a fingertip and provides accurate results within a matter of seconds. Normally, a human with diabetes has a blood glucose level of 126 mg/dl or higher. On the other hand, in rats a blood glucose level of 101 mg/dl and higher is considered diabetic. Each glucometer has its own settings and limitations.

Glucose oxidase, glucose dehydrogenase, and hexokinase are three principle enzymatic reactions utilized by current glucometers. Although other enzymes can be used, the most important and commonly used enzyme is glucose oxidase. This is due to its low cost, high sensitivity to glucose concentration, and its tolerance to pH levels and temperatures. When the blood is added to the test strips, glucose oxidase reacts producing gluconic acid from the glucose in the blood which oxidizes the present glucose molecules. The electrons that are lost during the oxidation process are subsequently transported to the devices electrodes which causes a current. The concentration of the oxidized glucose and the current are related linearly. The glucometer then uses the relationship between the output of the current and the concentration of blood glucose to determine the glucose level of the blood sample in either mg/dl or mmol/l. This whole process only takes 30 seconds which makes the glucometer deliver accurate results in a matter of seconds. (Schwenk, 2019)

CHAPTER III
DEFINITION OF TERMS

This chapter contains numerous terminologies and vocabularies relevant to the study, as well as descriptions of how these terms were utilized, including their conceptual and operational definitions.

Alloxan Monohydrate is a cyclic-urea derivative. It is a highly effective diabetogenic agent used widely as a tool to induce experimental diabetes (Furman, 2016).

Antihyperglycemic means lowering or reducing blood glucose level (Pharm, n.d.)

BPE is an acronym used to shorten Banana Peel Extract.

B.W. is an acronym used for Body Weight.

Diabetogenic Agent is an agent that consistently raises blood glucose levels to levels within those recommended by the International Expert Committee on the Diagnosis and Classification of Diabetes Mellitus (Furman, 2007).

EXG is an acronym used to shorten Experimental Group.

Extract is a solution of essential constituents of a complex material (Merriam-Webster, 2023).

Glucose is also called sugar, which is one of the body’s primary fuel sources and which is also key to keeping your body in top working order (BSN, 2022).

Metformin is a non-sulfonylureas drug and is a medicine used together with diet to lower high blood sugar in patients with Type II Diabetes (WebMD, 2023).

NCG is an acronym used to shorten Negative Control Group.

PPE is an acronym used to shorten Pomelo Peel Extract.

PCG is an acronym used to shorten Positive Control Group.

CHAPTER IV
METHODOLOGY

This chapter discusses and provides an in-depth explanation of the procedures for completing the experiment and the materials, statistical treatment, and other measures needed for experimenting.

A. RESEARCH DESIGN AND APPROACH

This study utilized a quantitative method and was conducted as experimental research. This study used an experimental group treated with a 1:1 ratio of Pomelo *(Citrus maxima)* peel extract combined with Banana *(Musa × paradisiaca L.)* peel extract. The control groups in this study consist of a positive control group that was treated with Metformin and a negative control group. A commercially available glucometer was used to measure the fasting blood glucose of the Sprague Dawley rats prior to and after the oral administration of the different treatments. The data and results obtained from the experiment were interpreted using Singe Factor Analysis of Variance (ANOVA) as the statistical treatment. The procedures used in the experiment and listed in this chapter were adapted from previous studies relating to antihyperglycemic and antidiabetic effects and agents.

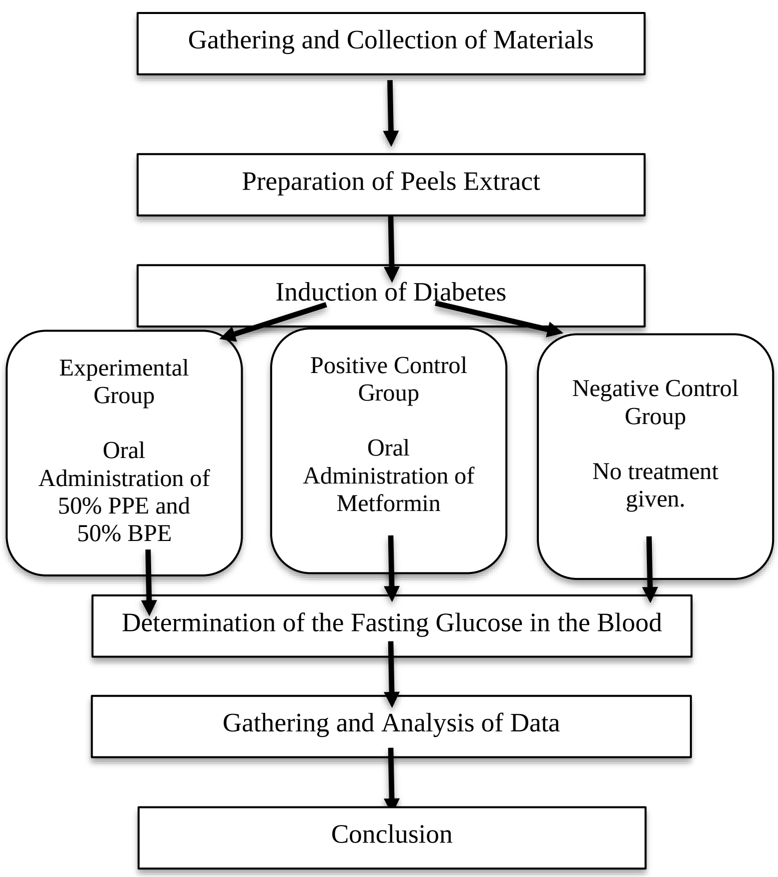

Figure 3. *Methodology Flowchart*

I. Experimental Design

The experimental group was treated with 0.005 ml/g b.w. of 50% PPE and 50% BPE. The positive control group was treated with 0.0015 mL/g b.w. 1% Metformin, a commercially available and proven antidiabetic and antihyperglycemic drug, and the negative control group was given no treatment. The fasting blood glucose of the rats was measured on three (3) occasions (Pre-Treatment, Post-Induction of Diabetes, and Post-Treatment) using the ACCU-CHEK Instant Blood Glucose Meter.

B. RESEARCH PROCEDURE

I. Collection of Materials

The Pomelo *(Citrus maxima)* was picked from Brgy. Kalayaan, Angono, Rizal and Banana *(Musa x paradisiaca L.)* were bought at a store located in Taytay, Rizal. Alloxan monohydrate was purchased from Tokyo Chemical Industries Co., Ltd., located in Tokyo, Japan, and imported to the Philippines through the Theo-Pam Trading Corporation, located in Pasay City.

II. Preparation of Pomelo *(Citrus maxima)* and Banana *(Musa × paradisiaca L.)* Peels Extract

The peels of Pomelo *(Citrus maxima)* and Banana *(Musa × paradisiaca L.)* were cut into small pieces and dried in an oven for four (4) hours at 100 °C. The dried peels were then pulverized and soaked in 70% ethanol for three (3) days. The extraction process was sped up using the Reflux Method. The extract was filtered using cheesecloth, filter paper, and a centrifuge to obtain the liquid extract of the peels. The Pomelo *(Citrus maxima)* peel extract and Banana *(Musa x paradisiaca L.)* peel extract were then mixed in a 1:1 ratio.

III. Animal Handling

There were two (2) rats in each group housed in bin cages with tightly enclosed bars at an outside temperature under a 12-hour light/dark cycle. Each group was given commercially available food pellets daily equal to 15% of total body weight once a day and was given sufficient water ad libitum. After the induction of Alloxan Monohydrate, the rats were fed twice a day. Thirty-five white male Sprague Dawley Rats were supplied from Marlyn's Petshop at Cartimar, Pasay. The rats weighed 30 – 40 grams at purchase with an average weight of 36.7 grams. In preparation for the specimen, the rats were nursed and observed for one (1) week to ensure that they were properly acclimatized to their new surroundings (Aloba et al., 2019). For maintenance and sanitary purposes, the bin cages of the rats were cleaned once a day. This was done daily to ensure that during the span of the experiment, the test subjects were not exposed to any bacterial diseases that might put the health of the rats in danger. The rats were approached in a calm and confident manner, avoiding sudden and exaggerated movements (Animal Handling | National Agricultural Library, n.d.).

IV. Evaluative Observation of the Sprague Dawley Rats

The physical appearance and attributions of the rats were observed throughout the experiment, including the rats' body weight, fur color, fur health, size, and behavior, to determine any changes in behavior or variations between the rats during the induction of diabetes due to possible genetic differences.

V. Induction of Diabetes using Alloxan Monohydrate

Prior to the induction of diabetes, the glucose levels of the rats were initially measured as a baseline. Alloxan monohydrate was intravenously induced in twenty-nine (29) Sprague Dawley rats at a dose of 0.15 mg/g b.w. The solution of Alloxan monohydrate was prepared by dissolving the drug in saline solution with a volume of 1.5 mL for injection. The fasting blood glucose levels of the rats were then measured two (2) days later. Rats with a fasting blood glucose greater than 100 mg/dL were considered diabetic (Fontaine, 2019).

VI. Administration of Plant Extract and Control Drug

Six (6) surviving diabetic rats were selected for the experiment. The experimental group was treated with Pomelo *(Citrus maxima)* and Banana *(Musa x paradisiaca L.)* peel extract in a 1:1 ratio at a dose of 0.005 ml/g b.w. (Muhtadi et al., 2015). The positive control group received 1% Metformin dissolved in a saline solution at a dose of 0.0015 ml/g b.w. (Sabahi et al., 2016). The negative control group did not receive any treatment. The treatments were administered orally to the rats using oral gavage.

VII. Determination of the Fasting Glucose in the Blood

Prior to the extraction of blood glucose, the rats were fasted overnight. ACCU-CHECK Instant Blood Glucose Meter was used to determine the fasting blood glucose of the rats. Blood was obtained from the lateral tail vein of the Sprague Dawley rats prior to the treatment, after the induction of diabetes, and after the treatment period.

C. STATISTICAL TREATMENT

The data gathered was subjected to Single Factor Analysis of Variance (ANOVA) to calculate the significant difference found between the different groups. The alpha value used was 0.01 to reduce the percentage of error as the research study is considered as a medical study (Principles of Biostatics for Medicine, n.d.).

CHAPTER V
ANALYSIS, PRESENTATION, AND INTERPRETATION OF DATA

This study aims to test the antihyperglycemic effect of combined Pomelo *(Citrus maxima)* and Banana *(Musa × paradisiaca L.)* peel extract on induced Diabetic Sprague Dawley rats. This chapter presents the fasting blood glucose level prior to the treatment, after the induction of Alloxan Monohydrate, post treatment, and the difference of the Sprague Dawley Rats. The collected data was statistically analyzed using Single Factor Analysis of Variance (ANOVA).

Table 1.1 *Fasting Blood Glucose Level and % Decrease of Rat 1 Per Group*

Groups	Pre-Treatment	Induced	Post Treatment	% Decrease
EXG	118.8 mg/dl	147.6 mg/dl	70.2 mg/dl	52.44 mg/dl
PCG	93.6 mg/dl	599.4 mg/dl	75.6 mg/dl	87.39 mg/dl
NCG	86.4 mg/dl	207 mg/dl	102.6 mg/dl	50.43 mg/dl

Table 1.1 shows the fasting blood glucose of the rats Pre-Treatment, after the induction of Alloxan Monohydrate, Post Treatment, and the % Decrease. The data shows that the fasting blood glucose of Rat 1 during Pre-Treatment is at a normal level. When Alloxan Monohydrate was induced, the fasting blood glucose of Rat 1 increased and were considered diabetic, PCG Rat 1 reached the limit of the glucometer which is 599.4 mg/dL. The fasting blood glucose lowered after the treatment and compared to the fasting blood glucose during the pre-treatment, all groups of Rat 1 lowered except for the negative control group. Comparing all the groups, Positive Control Group has the highest decrease with 87.39%. The formula used to calculate for the percent decrease of the data was $\boldsymbol{Percent\ Decrease = \frac{Old\ Value - New\ Value}{Old\ Value} \times 100}$.

Table 1.2. *Fasting Blood Glucose Level and % Decrease of Rat 2 Per Group*

Groups	Pre-Treatment	Induced	Post Treatment	% Decrease
EXG	151.2 mg/dl	295.2 mg/dl	66.6 mg/dl	77.44 mg/dl
PCG	95.4 mg/dl	599.4 mg/dl	122.4 mg/dl	79.58 mg/dl
NCG	84.6 mg/dl	354.6 mg/dl	73.8 mg/dl	79.19 mg/dl

Table 1.2 shows the fasting blood glucose of the rats Pre-Treatment, after the induction of Alloxan Monohydrate, Post Treatment, and the % Decrease. The data shows that the fasting blood glucose of Rat 2 during Pre-Treatment is at a normal level. When Alloxan Monohydrate was induced, the fasting blood glucose of Rat 2 increased and were

considered diabetic, PCG Rat 2 reached the limit of the glucometer which is 599.4 mg/dL. Post Treatment data shows that the fasting blood glucose lowered compared to the Pre-Treatment and Induced Alloxan Monohydrate except for the Pre-Treatment fasting blood glucose of the Positive Control Group. Comparing all the groups, the Positive Control Group has the highest % decrease, but has a minimal decimal difference to the Negative Control Group. The formula used to calculate for the percent decrease of the data was $\boldsymbol{Percent\ Decrease = \frac{Old\ Value - New\ Value}{Old\ Value} \times 100}$.

Table 2. *ANOVA: Single Factor Analysis of % Decrease of Blood Glucose in the Blood Glucose Level Pre and Post Treated Rats*

SUMMARY

Groups	***Count***	***Sum***	***Average***	***Variance***
EXG1	**2**	**129.88**	**64.94**	**312.5**
PCG	**2**	**166.97**	**83.485**	**30.49805**
NCG	**2**	**129.63**	**64.815**	**413.2813**

ANOVA

Source of Variation	***SS***	***df***	***MS***	***F***	***P-value***	***F crit***
Between Groups	**461.6677**	**2**	**230.8339**	**0.915669**	**0.489306**	**9.552094**
Within Groups	**756.2793**	**3**	**252.0931**			
Total	**1217.947**	**5**				

Table 2 shows the Analysis of Variance (ANOVA) Single Factor to statistically analyze the % decrease of the blood glucose of the treated rats. The alpha value of the study is 0.01 (Principles of Biostatics for Medicine, n.d.) The table shows that the P-value is 0.489306 which is higher compared to the desired alpha value 0.01. The alpha value was decided to be 0.01 to reduce the percentage of error as the research study is considered as a medical study. The P-value on Table 2 shows that the difference in the % decrease of the blood glucose of the rats is statistically not significant. Thus, the researchers fail to reject the null hypothesis that there is no significant difference between the % decrease of the blood glucose level of the treated rats.

CHAPTER VI

SUMMARY OF FINDINGS, CONCLUSIONS, AND RECOMMENDATIONS

This chapter interprets the gathered data on the blood glucose levels of the rats before and after being treated with Pomelo (*Citrus maxima*) and Banana (*Musa x paradisiaca L.*) as well as providing conclusions, and recommendations for future researchers.

SUMMARY OF FINDINGS

This study determined the antihyperglycemic effect of Pomelo (*Citrus maxima*) and Banana (*Musa x paradisiaca L.*) against induced diabetic Sprague Dawley rats. After experimentation and data gathering, this study found that the experimental group treated with the peel extract exhibited an average percent decrease blood glucose post-treatment of 64.94%. The positive control group treated with Metformin exhibited an average percent decrease of 83.48%. While the negative control group given no treatment exhibited an average percent decrease of 64.81%. After the data was subjected to Single Factor Analysis of Variance (ANOVA), the p-value was found to be 0.489306, higher than the alpha value of 0.01 indicating no significant difference between the groups.

In addition, irregularities and differences were observed between the two rats contained within the same group specifically the Experimental and Negative control groups. In the experimental group, Rat 1 and 2 presented a percent decrease in blood glucose level of 52.44% and 77.4% respectively. This discrepancy within the result of two rats given the same treatment is likely attributed to the behavior and diet of the rats. Rat 2 had a constant increase in weight due to increased food consumption while the weight of Rat 1 stayed relatively the same. Furthermore, in the negative control group, Rat 1 and Rat 2 showed a decrease in blood glucose level by 50.43% and 79.19% respectively due to similar circumstances as the experimental group.

The result of the study supports the findings of Wu et al. (2015) and Tran et al. (2021) which concluded that the Pomelo (*Citrus maxima*) and Banana (*Musa x paradisiaca L.*) peel extract were effective in decreasing the blood glucose levels of the rats. However, unlike the aforementioned studies, this study did not show any significant difference between the group treated with the peel extract and the control groups, likely due to the lack of trials used in this study.

The result of the study implies that the combined extract of Pomelo (*Citrus maxima*) and Banana (*Musa x paradisiaca L.*) potentially has an antihyperglycemic effect as the group treated with the peel extract experienced a decrease in their blood glucose post-treatment, however, due to irregularities and the limitations of the study further research need to be conducted before the extract is used as a treatment for hyperglycemia.

CONCLUSIONS

Based on the data gathered, the experimental group treated with the 50% PPE: 50% BPE exhibited a lower blood glucose post-treatment with an average percent decrease of 64.94%. However, decreases in blood glucose were also observed in the positive and negative control groups exhibiting an 83.48% and 64.81% average percent decrease respectively. Thus, the decrease of blood glucose levels in the experimental group may be attributed to environmental changes or the living conditions of the rats rather than the peel extract. In addition, after being analyzed using statistical treatment the data showed no significant difference likely attributed to the lack of trials used in this study.

RECOMMENDATIONS

Based on the experiences of the researchers in conducting this study, the researchers recommend the following for future studies on the topic with similar variables or methodology.

Numerous rats died in the process of induction of diabetes due to the high dosage of Alloxan monohydrate. This study utilized a conversion of 1 mg = 1 ml for the calculation of the dosage given to the rats. However, future studies should utilize a conversion unit of 1 mg = 0.001 ml to avoid the death of rats. The lack of surviving diabetic rats results in less accurate data and conclusions due to the limited number of trials in the experiment. Future studies should utilize 10 rats as used in Wu et al. (2015)

Furthermore, the Sprague Dawley rats were procured from a pet shop rather than a laboratory supplier which may affect the reliability of this study as the species of the rats were not properly verified. Thus, future studies should acquire rats from a laboratory supplier or obtain proper certification on the species of the rats.

In addition, future studies and experimentation on Sprague Dawley rats conducted by researchers lacking experience in animal handling should be conducted under the supervision and assistance of a veterinarian.

The use of commercially available glucometers may result in less precise results. To ensure precise data either multiple tests must be conducted, or biochemical assays must be used over glucometers.

The researchers also recommend the use of Rotary Evaporator as this creates a more concentrated extract thus potentially exhibiting a greater antihyperglycemic effect. In addition, the effectiveness of different ratios of the peel extract should be determined in future studies. Lastly, the researchers recommend conducting a phytochemical analysis on the organic-based materials to identify and authenticate the compounds and characteristics of the material.

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