SCIENECE, TECHNOLOGY, ENGINEERING, AND MATHEMATICS (STEM)

Capstone Project Proposed Format

Research Paper Part	Content/s
1. Title Page (1 page)	- It contains the title of the study, the name of school, the name of the researcher/s, and the month and year of the study conducted.
2. Approval Sheet (1 page)	- It contains the title of the research, name of the researcher/s, name of the adviser and the panelist who examined the paper.
3. Abstract (1 page)	- It must contain no more than 250 words - It also indicates the 5 keywords. (Introduction – Method – Results – and – Discussion (IMRAD) format)
4. Table of Contents (1 page)	- It contains the list of the contents of the research paper and their corresponding pages.
5. Chapter I THE PROBLEM AND ITS SETTING (4 pages)	
1.1 Introduction and Background of the Study	- The introduction should explain what we know, and what we are uncertain about. It should explain and summarize, but it should also ask questions, clarify, compare etc. Everything you write here must relate to your research question. - It includes the concept, gap and rationale - Discussions must convince the readers that there is a necessity to conduct the study. - The discussion must start from broad to specific concept
1.2 Statement of the Problem	- Must contain questions that is parallel to the identified problem. - Parameters must be well identified.
1.3 Significance of the Study	- It provides the reader with information on what and how the study will contribute and who will be the beneficiaries. It also provides a description of the value of the research and its future significance.

1.4 Scope, Limitation and Delimitation	- It discusses the coverage of the study in terms of general purpose, population or sample, time or duration, parameters used and area or locality.
1.5 Hypothesis (if any)	- It must be parallel to the statement of the problem. - null hypothesis
6. Chapter II LITERATURE REVIEW (5-6 pages)	
2.1 Literature Review	- Combine various sources (e.g. concepts from books, journals, published research and thesis/dissertations) provided they are present a similar concept - Must be from 10 years back up to present - It is suggested to have at least 10 authors/references - The presentation of literature must be on THEMES/TOPICAL (based on the organization of your SOP) - The literature review is the summary of the findings. This is not where you state what you got from them or how they relate to problem. Here you note the **themes** of the articles and their common conclusions, NOT your conclusion. - This is not a statement about a partial solution, but a summary of information about your problem. This is a fact-based section of the paper. You aren't writing out the solution to the problem here; that comes later.
2.3 Synthesis	- It discusses the summary of the related concepts and the similarities and differences of the current study to the study cited.

7. Chapter III METHODS (2-3 pages)	- Methods is not where you tell us what you discovered. This is an analysis of the process (strengths and weakness of the process). DO NOT give the results of any of your research here. Discuss all aspects of data collection – who, what, when, where, and HOW. "How" is a big issue. Discuss why you choose one form of data collection over another. What were the strengths and weaknesses of one format over another. - Discuss any ethical issues about the collection of data, the questions themselves, any sort of ethical issues involved. You must also discuss the methods of analysis. Go into detail about how you coded interviews and how you did the statistics. - You must describe this. It is not just drawing conclusions based on interpretation of a comment, but how did you go about reaching the conclusion. - You must analyze your methods. You are NOT telling us what you discovered in method section.
3.1 Research Design	- It clearly discusses the design of the research study. - If it is experimental, show and explain the experimental design.
3.2 Respondents/Subject of the Study	- Respondent – for descriptive research - Subject – for experimental research
3.3 Data Gathering Procedures	- It discusses the procedures on how data are collected. - It should follow the standard protocol.
- Procedure	- It contains the detailed discussions of the step by step procedure of the experiment. - Must follow a standard procedure. - Avoid a recipe type discussion.
3.5 Statistical Treatment of Data	- It discusses how the different statistical tools are used in the study.

8. Chapter IV PRESENTATION, ANALYSIS AND INTERPRETATION OF DATA (4-5)	- In this section of the paper you will tell the readers the results of your research, what did the data say. Here you lay out the statistics and their interpretation. This is not the conclusion (how the research relates to your problem), but what does the research say. If needed, include a graph with your interpretation. Graphs, charts, and survey results are appendices. - Interpret the data –not just the raw numbers, but themes that come up from the numbers. Are there multiple interpretations possible? Multiple ideas/themes present? As part of the interpretation, spend time with how the method/format of research produced these results.
4.1 Presentation, Analysis and Interpretation of Data	- Must use appropriate data representation (tables, charts or graphs) - APA format
9. Chapter V SUMMARY, CONCLUSION AND RECOMMENDATIONS (2-3)	- Here is where all the conclusions are stated. Here you state the conclusions from the lit review. Here you describe the conclusions drawn from your surveys and interviews. In this section you connect the results of your research to your initial problem. Now you tell us how it all relates AND how to move forward. - Here you state recommendations for future application from your research. In other words, now what will you do with your problem. If done properly, this conclusion is driven entirely from the research you did, both lit review and other data collection. - This application points to what you are going to do/are doing now that you know WHAT to do.
5.1 Summary	- It contains the general and specific objective, the respondents/subject and the methodology of the study.
5.2 Findings	- Briefly discusses the result of the study. - Must be parallel to the statement of the problem
5.3 Conclusions	- Summary of the findings - Must answer the statement of the problem

5.4 Recommendations	- Must be anchored on the result of the study.
Bibliography	- Use APA 7th edition
Appendixes	It includes the following: 1. Communication Letters 2. Parents Permit/Consent 3. Pictures of the Procedure (no faces should be seen in the picture) 4. Statistical Data
Curriculum Vitae	- Researcher's Personal Information
Font Style - Arial	**Font Size – (text- 12pt, Subheads 13-pt, Heads – 14pt)**
Spacing – Double space	

Reference

Life Pacific University. (2019, June). *CAPSTONE PROJECT: Parts of a Capstone Project.* https://lifepacific.libguides.com/capstone

Sample Capstone Project

(by Ma Rhoda E. Panganiban and Franklin Galoyo)

CHAPTER I

THE PROBLEM AND ITS SETTING

Background of the Study

For the past decades, the world has made countless efforts in producing fuels to sustain and meet the demands of people as well as the needs of many industries worldwide. However, the increasing rate of global warming caused by relentless emission of harmful greenhouse gases from the use of fossil fuels led to a desire for an alternative fuel thus, increasing world demand for ethanol.

Ethanol, also known as ethyl alcohol has been made since ancient times by the fermentation of sugars prepared from fruits and grains (William, 2010 as cited by Adeeyo, Ayeni, & Oladimeji, 2015). It is relatively a low-cost alternative fuel that boasts less pollution and more availability.

Bioethanol can be produced using cellulosic biomass such as grasses, woods, and organic wastes through the help of advanced processing techniques. With the advancement of science and technology, the benefits from ethanol have continued to multiply. Ethanol is said to be used in nearly all industries. It can be applied as a solvent, antiseptic, fuel, and as anti-freeze in automobile radiator. It is also used as a constituent of alcoholic beverages (Otulugbu, 2012).

Studies and researches of the past have geared towards the production of ethanol from different raw materials. It has a significant potential in reducing greenhouse gas emissions. Hence, this study highlights on using lignocellulosic biomass that has no impact on food supply for bioethanol production.

Lignocellulose refers to plant biomass that is composed of cellulose, hemicellulose, and lignin. It is said to be the most abundant renewable biomass worldwide (Harmsen, Huijgen, Bermudez, & Bakker, 2010). Sawdust from woods is a major waste from furniture industries which is mainly cellulose and lignin. It is primarily fine particles of wood produced during sawing. It can be a cheap substrate in manufacturing ethanol and takes care of the environmental waste (Adeeyo, *et al.,* 2015).

Knowing that Philippines is better in using wood as their material in making houses and furniture, sawdust is abundant especially in the rural areas of Balayan, Batangas. There are large supply of sawdust from these industries but utilization is still limited. Consequently, the researchers were challenged to produce a renewable energy source that is environmental-friendly which will help increase domestic production and use of bioethanol, a renewable transportation fuel, and reduce transportation-related greenhouse gas emissions.

Statement of the Problem

Generally, this study aimed to evaluate the potentiality of lignocellulose property of sawdust for bioethanol production.

Specifically, the study expected to:

1. Determine the chemical components of sawdust that contributes to its potentiality for bioethanol production.
2. Perform the processes in producing bioethanol from sawdust
3. Evaluate the potentiality of the bioethanol produced from sawdust by determining the following properties.
    a. Physical
        i. Organoleptic;
        ii. pH;
        iii. Boiling Point; and
        iv. Volatility
    b. Chemical
        i. Miscibility; and
        ii. Combustibility

Significance of the Study

This study is beneficial for the following purposes, reasons and conditions:

1. **For the Society.** The findings of the study can benefit the society for it can contribute to a high employment in the country and be used in diverse industries leading to creation of job opportunities. Additionally, ethanol could reduce greenhouse gas emissions which could lessen the effect of global warming thus, developing an economic-friendly bioethanol can surely benefit the country men.
2. **For the Local Community.** The results of this study can help the locality of Balayan to have knowledge on how to properly utilize sawdust as a useful

bioethanol. It can provide a renewable fuel that everyone will benefit in the community.

3. **For the Fuel Companies.** The findings of this study can benefit the fuel companies for it may evolve the commercial fuel to an environmental-friendly bioethanol from sawdust. Also, it may contribute to the development of their knowledge in making fuels from cheaper raw materials. Harnessing of fuel from sawdust is an economical way to sustain any economy and prevent it from over-reliance on importation of fossil fuels like oil, and gas.
4. **For the Pharmaceutical Industries.** The results of the study can benefit the pharmaceutical industries for it could give them additional information that ethanol from sawdust can be widely used as a solvent and preservative in pharmaceutical preparations.
5. **For the Future Researchers.** This study can serve as a guide for the future studies and can be a basis for more findings and innovation. It can also provide information that can use in further studies of related topics.

Scope and Limitations

The study was focused on evaluating the potentiality of lignocellulose property of sawdust for bioethanol production. Gathering of sawdust was done only in wood furniture industries around the locality of Balayan, Batangas. The type of sawdust was limited to hardwood trees. Moreover, the obtained product underwent physical and chemical analyses and was not compared to other commercial products. This study was conducted from November 2018 to March 2019.

Hypotheses

Null Hypothesis: The Lignocellulose property of sawdust has no potential for bioethanol production.

Alternative Hypothesis: The Lignocellulose property of sawdust has a potential for bioethanol production.

CHAPTER II

LITERATURE REVIEW

This chapter presents an overview on the different concepts, literatures, and studies concerning on sawdust, bioethanol production, and properties of bioethanol. Also, this section is essential for it is a great aid in supporting the present study.

Sawdust

General Description. Sawdust is a renewable natural material and is a waste product of wood working operations such as sawing, milling, drilling and sanding of wood. It is made out of fine particles of wood. The color of sawdust depends on the wood or tree yet the type of the wood does not matter in producing of sawdust (Kiss, Alexa, & Sarosi, 2016).

Chemical Composition. The chemical composition of wood varies from species to species but it is generally 50% carbon, 42% oxygen, 6% hydrogen, 1% nitrogen, and 1% other elements such as calcium, potassium, iron, sodium, magnesium, and manganese by weight. Sawdust does not have a definite chemical composition because its component percentages vary between species of wood (Phonphuak & Chindaprasirt, 2015).

Lignocellulosic biomass like sawdust from hardwood is primarily composed of cellulose, lignin, hemicellulose, and minor amounts of extraneous materials. The percentage of these components vary depending on what it is derived from. These can differ between hardwoods, softwoods, and grasses.

Cellulose is a major structural component of cell walls and provides mechanical strength and chemical stability to plants. It is a complex carbohydrate or polysaccharide which consists of 3,000 or more glucose molecules and about 40-55% of it is present in hardwood. Moreover, lignin forms a protective layer for the plant walls and works alongside with the cellulose material to form constitutes of the wood. It is an oxygen containing organic substance and is concentrated in the cell walls of wood. About 18-25% of lignin is present in the composition of hardwood. Lastly, hemicellulose is another type of cellulose which consist of any group of complex carbohydrates that surround the cellulose fibers of plant cells and is about 24-40% of the composition in hardwoods. Apart from the three basic chemical compounds that lignocellulose consists of, minor amounts (5–10%) of water, proteins, minerals, and other components can be found in the lignocellulose composition as well (Harmsen *et al.,* 2010).

Bioethanol Production

Wood industries in the Philippines is vibrant particularly in the province of Batangas however, people nowadays are facing a big problem of disposing waste substances from wood produced from various industries. One of the solutions is to use these wastes as a component to make an economic-friendly bioethanol from sawdust by which it can get economic benefits and ecological advantage by reducing the problem. People are also working on how to make an alternative bioethanol from sawdust in replacement of commercial fuel to bring down the expenses to be spent on the materials that are needed in making fuels (Ugwuishiwu, 2013).

Ethanol from Lignocellulosic Biomass. Ethanol is a combustible liquid that has become the most promising alternative substitute for gasoline because of the

experience gained in its production, and the possibility of mixing it with gasoline in different proportions. It is a renewable biofuel since it is made from biomass. Over 90% of the global production of plant biomass is lignocellulose. Lignocelluloses offer great potential as a biomass source for ethanol production, although their use still needs in-depth analysis with an objective and holistic focus that includes present and future technologic effects. Lignocellulosic material represents a promising option as feedstock for ethanol production because of its output/input energy ratio, low cost, availability, and higher ethanol yields. Due to its chemical composition, lignocellulosic biomass varies greatly from products with high sugar or starch content. The general method used to produce ethanol from lignocellulosic biomass consists of the following steps: pre-treatment of the biomass, fermentation and distillation (Abril, and Abril, 2009).

Production Methods. Bioethanol production consists of different processes which include hydrolysis, fermentation, and distillation. The major difficulty in the hydrolysis of cellulose from wood to obtain fermentable sugars lies in separating it from lignin. Lignin functions as a glue giving the biomass fibers its structural strength that makes it difficult to destroy. Mechanical size reduction, and acid hydrolysis are some of the pretreatment methods used for the lignocellulosic contents to make it vulnerable to fermentation to produce ethanol (Adeeyo, *et al.,* 2015).

Acid Hydrolysis. It is the chemical breakdown of a compound due to reaction with acids. The complexity of lignocellulose composition makes it harder to use in fermentation. Through acid hydrolysis, the bonds between the carbohydrates, fibers, and sugar molecules can be easily broken into smaller feedstocks separating them to their smallest capacity. It is an easier way in using sugars in plant materials and is more efficient because there is

no waste. Once the structure of the biomass is disturbed, it can be converted to sugars enzymatically (Adeeyo, *et al.,* 2015).

Fermentation. It is the chemical breakdown of a substance by bacteria, yeasts, or other microorganisms. It is a metabolic process which converts sugars into cellular energy, producing ethanol and carbon dioxide as by-products. Since yeasts perform this conversion in the absence of oxygen, alcoholic fermentation is considered an anaerobic process (The Editors of Encyclopaedia Britannica, 2018).

Distillation. It is the process of purifying a liquid by a process of heating and cooling. Since the product of fermentation which is the ethanol collected is not pure and is mixed with water, ethanol can be purified up to 90-95% through distillation until it reaches its boiling point ("Distillation," 2014).

Properties of Bioethanol

Ethanol, also known as ethyl alcohol or grain alcohol, is a chemical compound which is commonly found in alcoholic beverages. In physical aspects, ethanol is a clear, colorless, and pure volatile liquid with an agreeable ethereal odor and a burning taste. It has a boiling point of 78.5° C and a low melting point of -114.5° C which allows it to be used in antifreeze products. Its density is 789 kg/m^3 which is said to be miscible in water in all proportions. A pure ethanol has a pH of 7.33 and it is easily soluble in water and a good solvent used in perfumes, paints and tinctures. In chemical aspects, ethanol has a chemical formula of C_2H_5OH which can lose a proton from the hydroxyl group and is a very weak acid, weaker than water. It is highly flammable and burns more cleanly than many other fuels. A

solution of 70-85% of ethanol is commonly used as a disinfectant and is effective against most bacteria and fungi, and many viruses. This disinfectant property of ethanol is the reason why alcoholic beverages can be stored for a long time. Moreover, its combustion products when fully combusted are only carbon dioxide and water. For this reason, it is preferred for environmentally conscious transport systems and has been used to fuel public vehicles ("Ethanol Molecule," 2016).

Sustainable Bioethanol Production from Agro-residues: A Review

Gupta and Verma in 2015 conducted a study on the production of bioethanol from agro-residues. Agro-residues are cellulosic materials that works as promising feedstocks for bio-ethanol production. Processes such as pretreatment, enzymatic hydrolysis, fermentation and distillation were used. The study claimed that proper pretreatment process may increase the concentrations of fermentable sugars and effective microorganisms may also enhance the enzymatic hydrolysis, thus improving the efficiency of the whole process.

Additionally, it has been indicated that agro-residues have the potential for sustainable bioethanol production with the use of current technologies.

Synthesis:

The study above asserted that bioethanol can be manufactured from agro-residues. The previous study strengthens the present study since both adapted the common processes in bioethanol production. Also, the raw materials used is quite alike since the agro-residues in the previous study has a cellulose content similar to the sawdust used in the present study. However, studies have differences since the previous study used

advanced technologies while the present study utilized improvised materials and approaches for the process of bioethanol production.

Yeasts in Sustainable Bioethanol Production: A Review

Based on the findings of the study conducted by Azhar, Abdulla, Jambo, Marbawi, Gansau, Faik and Rodrigues (2017), bioethanol can be produced from various types of feedstocks such as starch, sucrose, lignocellulosic and algal biomass that contain simple and complex sugars through the use of fermentation by yeasts. They asserted that yeast is the main agent used in most ethanol production because of its efficiency and tolerance in bioethanol production. However, some feedstocks have complex sugar bonds that cannot be broken down in fermentation therefore, the use of pre-treatments such as hydrolysis is used to help in converting these bonded complex sugars into fermentable sugars. Moreover, the ethanol mixture produced underwent a purification process through distillation and adsorption treatment to separate the ethanol from other materials. The study also considered several factors that affect bioethanol production such as yeast species used, temperature, pH level, fermentation time, agitation rate, and feedstock level used.

Synthesis:

It was observed that the previous research discussed about the processes on how to produce bioethanol from various types of feedstocks. It has also been concluded that yeast can be used in sustainable bioethanol production. The previous and present study is related to each other because both researches have similar processes that are to be used in producing bioethanol. Also, both studies utilized yeast in the process of fermentation. In contrast, the present study did not discussed the factors affecting bioethanol production.

Bioethanol Production from Rice and Wheat Straw: An Overview

According to the study of Swain, Singh, Sharma, and Tuli (2019) rice straw and wheat straw are lignocellulosic materials with high amounts of lignin which needs an appropriate pretreatment method for bioethanol production. It was emphasized that this serves as a challenge in the process of converting biomass to bioethanol. High amounts of cellulose and hemicellulose are also present in these substrates that can be hydrolyzed into fermentable sugars. Furthermore, accessible technologies for bioethanol production utilizing rice straw and wheat straw were used.

Synthesis:

The previous and present studies are related to each other as both are centered on bioethanol production. Both studies used lignocellulosic materials for bioethanol production but differences take place since the previous study specifically used rice and wheat straw while the present study utilized sawdust as a raw material. Moreover, technologies for the production of bioethanol were applied in the previous study while the present did not.

The previous researches have contributed a lot to the present study for it improves its credibility and relevance of the research work. It strengthened the breadth and depth of the central focus that are significant to the discussion and understanding of the study.

CHAPTER III

METHODS

This chapter provides the process of experimentation including the materials, methods, and treatment of data.

Materials

Below is the list of materials and apparatuses used and their purposes:

- **Sawdust-** It was used as the main component of the product.
- **Borosilicate glasses-** It was used as containers of the finished product.
- **Beakers-** These were used as containers for mixtures.
- **Yeast-** It was used in fermenting sawdust.
- **Candle wax-** It was used in the fermentation process to ensure an anaerobic environment.
- **Plastic containers-** These were used as containers for the mixtures in the fermentation process.
- **Plastic tube-** It was used as a flexible tubing in the fermentation process.
- **pH paper-** This was used to determine the pH of the acid mixture in the desired range.
- **Stirring rod-** It was used to stir the mixtures.

- **Graduated Cylinder-** It was used as the container of the lime solution in the fermentation process.
- **Beral Pipette-** It was used as a dropper to add the NaOH solution in each mixtures.
- **Filter paper-** This was used for separating fine substances and some other impurities from the bioethanol produced in fermentation.
- **Distillation set-up-** It was used to conduct the distillation process.
- **Physical tests set-up-** These were used for the physical analyses of the bioethanol.
- **Chemical tests set-up-** These were used for the chemical analyses of the bioethanol.

The following are the chemicals used in the study:

- **Acetic acid (CH_3O_2H) -** It was used in the acid hydrolysis of the sawdust.
- **Calcium Hydroxide ($Ca(OH)_2$)-** It was used in preparing a lime solution that was utilized in preparing an anaerobic condition for fermentation.
- **Distilled water (H_2O) -** It was used in the acid hydrolysis of the sawdust.
- **Sodium hydroxide (NaOH) -** It was used in regulating the pH of the sawdust mixture.

Methods

In performing the research, the following processes will be done:

A. Gathering of materials, and chemicals involved in the research

Sawdust will be gathered in wood furniture industries around the vicinity of Balayan, Batangas. Moreover, yeast, lime solution, and other chemicals that will be used in the study will be acquired from the local market.

B. Preparation for Bioethanol Production

- Preparation of materials, chemicals, and apparatuses
    - Preparation of 100 grams of sawdust for each treatment
    - Preparation of 8 pcs. of 500 mL beaker
    - Preparation of 4 pcs. of 50 mL beaker
    - Preparation of 100 mL of 15M Acetic acid (CH_3O_2H)
    - Preparation of 1.6 liters of Distilled water (H_2O)
    - Preparation of 8 mL of Sodium hydroxide (NaOH)
    - Preparation of 8 mL of lime solution
    - Preparation of 4 pcs. of 10 mL graduated cylinder
    - Preparation of liquid candle wax
    - Preparation of 1g/20mL, 3g/20mL, and 5g/20mL of yeast
    - Preparation of 4 pcs. of 45 cm plastic tubes
    - Preparation of filter paper
    - Preparation of Distillation set-up
    - Preparation of 4 pcs. of 25 mL Borosilicate glasses

C. Production of Bioethanol

The production of bioethanol consisted of three parts: (a) pretreatment, (b) fermentation, and (c) distillation.

a. Pretreatment

i. Acid Hydrolysis

One-hundred grams of sawdust was added to a 500 mL beaker to reach the 100 mL mark. Afterwards, 100 mL of 15M CH_3O_2H was then added to the sawdust in the beaker and

was ensured that the sawdust was fully covered by the acid. Subsequently, 400 mL of H_2O was added to a 500 mL beaker. The sawdust with acid mixture was then p7oured into it. Following this, 3 mL of NaOH solution was added to the solution by a beral pipette to make the pH in the desired range of 5.0 to 6.0 which is conducive for yeast. This procedure was repeated for four times.

b. Fermentation

After performing acid hydrolysis, 8 mL of lime solution was placed into the graduated cylinder to prepare an anaerobic condition. Afterwards, 250 mL of the mixture was poured into another bottle. A plastic tube was passed from the container of the mixture into the lime solution. Thereafter, 1g/20mL of yeast was added to the 250mL mixture in the bottle. Then, the liquid candle wax was poured above it and the bottle was closed tightly. The whole mixture was left to ferment for seven days. This procedure was repeated for 3g/20mL, and 5g/20mL of yeast. The other mixture was left with no yeast as a control.

c. Distillation

After a week, the mixtures were removed and filtered with the use of a filter paper. The filtrate contains ethanol and some other impurities. One-hundred fifty (150) mL of each of the mixtures was then distilled for 45 minutes using the prepared distillation set-up. This was repeated for the remaining mixtures.

D. Preparation of Treatments

After the production of bioethanol, four different treatments were placed in a borosilicate glass and underwent physical and chemical analyses to determine the purity of the ethanol obtained.

Table 1. Amount of yeast present in each treatment

Treatment	Amount of yeast (g/20mL)	Amount of sawdust (g)
A	1	100
B	3	100
C	5	100
D (control)	0	100

Table 1 shows varying amount of yeast present in each treatment. Four different treatments contained the same amount of sawdust (100 g) that was used in the study.

E. Evaluation of the Bioethanol Produced

1. Physical Analyses

- **Organoleptic-** This refers to the sensory test scored on the basis of the researchers' observation on the bioethanol produced which involves the use of the senses such as *sight*, *smell, taste*, and touch.

Materials:

- Researchers' senses

Procedure:

- The researchers examined the bioethanol through the use of their sense of sight, smell, and touch. The procedure was repeated for the other remaining treatments.

- **pH-** This stands for 'power of Hydrogen' and it is a measure of acidity or alkalinity of the bioethanol produced

Materials:

- pH paper test

Procedure:

- The pH paper was submerged in the bioethanol for a half second. Afterwards, strip was allowed to dry for 10 seconds. The colors of the pads were compared with the chart on the box and then read the pH of the bioethanol. The procedure was repeated for the other three treatments.

- **Boiling Point-** This refers to the temperature at which bioethanol boils and turns to vapor.

Materials:

- beaker
- wire gauze
- thermometer
- tripod
- alcohol lamp
- match

Procedure:

- The alcohol lamp was placed under the tripod and was ignited with a match. The wire gauze was placed on top of the tripod and the beaker on the top of it. Later, the ethanol was placed in the beaker and was observed until it reaches its boiling point. The temperature was then recorded using a thermometer. The procedure was repeated for the other three treatments.

- **Volatility-** This refers to the tendency of the bioethanol to evaporate at normal temperatures. The volatility of the bioethanol produced was tested through filter paper test.

  Materials:

  - filter paper
  - dropper

  Procedure:

  - Initially, 3 mL of bioethanol was placed on a dropper and was dropped on a filter paper. The time it takes to evaporate was recorded in minutes. The procedure was repeated for the other remaining treatments.

2. **Chemical Analyses**

- **Miscibility-** This refers to the property of the bioethanol to mix in all proportions.

  Materials:

  - distilled water

- beaker
- stirring rod

Procedure:

- At first, the beaker was filled with 5 mL of distilled water. Following, 5 mL of bioethanol was poured in the beaker with distilled water and the mixture was then mixed with the use of a stirring rod. The bioethanol was observed if it is miscible to water or not. The procedure was repeated for the other three treatments.

- **Combustibility-** This is a measure of how easily the bioethanol produced bursts into flame through combustion.

Materials:

- match
- petri dish

Procedure:

- Initially, 5 mL of bioethanol was placed in a petri dish and was combusted with the use of a lighted match. Combustibility property of the bioethanol was measured if the bioethanol ignited with a fire or not.

Statistical Treatment of Data

To statistically test the obtained data, the following statistical device was applied to provide objective presentation, accurate analysis and data interpretation:

1. **Chi-square Goodness of Fit Test.** This data analysis was used to test the significance of the data which were expressed nominally and in frequencies. Below is the formula that was applied for the test of difference:

$$\chi^2 = \frac{\sum(O-E)^2}{E}$$

where:

$\mathbf{X^2}$ = chi-square statistic value

0 = observed frequency

E = expected frequency