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ANIHIN ANG NAPAYABONG NA GALING

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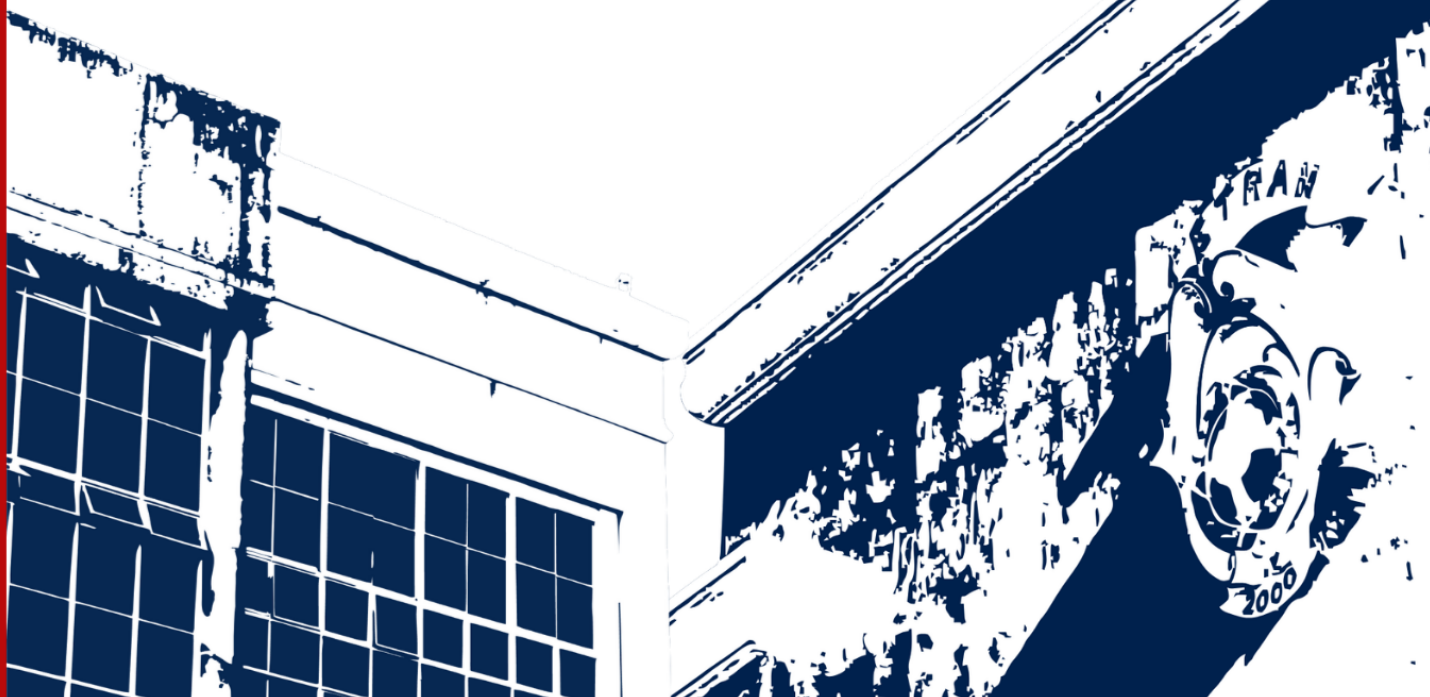

PREFACE

Linang in Filipino denotes lugar ng sakahan, bukid, bungkal.
This means to cultivate or to foster the growth of anything.

Just like Bataan that is known
for its remarkably magnificent range of mountains and
is predominantly an agricultural province despite the very fast
industrialization.

Linang aims to cultivate the research potential and competence of student researchers of **Colegio de San Juan de Letran Bataan.**

Each article in the journal provides an example of a research study that elucidates the impact of each academic discipline not only on the Colegio but also in and out of the academic community.

These articles exemplify the reconnaissance and analysis of
student research in their chosen discipline.
They provide constructive insight into the studied problems and
offer substantial research studies and even experimental analysis.

It is our aspiration that this compendium of student research articles will be both an inspirational and intellectual resource for both faculty and students and will encourage the community of
Colegio de San Juan de Letran Bataan
to expand our perspective and let research be part of our Arriba culture.

Arriba, Letran! Arriba!

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MESSAGE

I would like to congratulate the Research and Publication Office of Letran Bataan for producing the fifth volume of the journals Likha and Linang, where the research outputs of our employees and students are published. This is a clear testament of your commitment in the pursuit of new knowledge for the advancement of your chosen discipline which could catalyze positive social change.

It is a known fact that research is one of the tripartite pillars of any educational institution. As an indispensable pillar, it contributes to the advancement and development of knowledge and understanding of various issues and fields. In the academe, engagement in research is vital as it aims to advance discussions that could lead to insights and ideas which could drive progress, improve quality of life and address pressing concerns of society. This is our hope and desire for education researches—studies that have impact and relevance in the lives of people and the communities we serve.

While Research is one of the priorities of our institution, the reality is that, involvement in this enterprise remains to be scarce and a challenge. This is because Research is not for the mediocre but for the disciplined ones. It entails time, focus, patience and sacrifice to be able to produce a well-crafted opus. That is why we continue encouraging our employees and students to embrace the culture of research in view of its benefits professionally and institutionally. After all, for a genuine Researcher, incentive is not the primary motivation but the excitement of new discovery and understanding in the pursuit of knowledge.

Lastly, there is still one challenge that confronts any noble undertaking, and that is sustainability of the program or project. Research is a tough task because of its rigorous and meticulous process. Commitment and perseverance will be values that you summon to sustain this significant milestone.

Thank you and may God bless all your endeavors!

REV. FR. RAYMUND F. P. JOSE, OP
Rector and President
Colegio de San Juan de Letran
Abucay, Bataan

Linang Research Journal

Special Issue

LIMBAG MULA SA ISIPANG NAGLALAYONG ANIHIN ANG NAPAYABONG NA GALING

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LET'S EAT THE PROBLEM: CONSUMER ACCEPTANCE ON THE POTENTIALITY OF EDIBLE STRAWS AS ALTERNATIVE TO SINGLE-USE PLASTIC STRAWS IN COLEGIO DE SAN JUAN DE LETRAN BATAAN

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ABSTRACT

This study assessed the potential of edible straws as an environmentally sustainable alternative to single-use plastic straws in Colegio de San Juan de Letran Bataan. Specifically, it examined consumers' acceptance of edible straws in terms of taste, texture, and usability, as well as their perceptions of the product's environmental impact regarding production, disposal, decomposition, and sustainability. A quantitative descriptive research design utilizing pre- and post-surveys was employed. Data were collected from 213 respondents composed of elementary, junior high school, senior high school, college students, and employees of the institution. Descriptive statistics were used to analyze the gathered data. The findings revealed that respondents generally had a positive perception of edible straws, with usability receiving the highest rating among the consumer acceptance variables. Respondents also strongly agreed that edible straws have a positive environmental impact, particularly in reducing plastic waste through their biodegradable and eco-friendly characteristics. Although taste received the lowest mean among the evaluated attributes, it was still positively rated, suggesting that improvements in flavor may further increase consumer acceptance. Overall, the study concludes that edible straws are a viable and sustainable alternative to single-use plastic straws and have strong potential for wider adoption within educational institutions. The researchers recommend improving the product's taste and affordability while promoting its use through institutional sustainability initiatives.

Keywords: Edible straws; Consumer acceptance; Environmental impact; Sustainable alternatives; Single-use plastic straws; Plastic pollution; Eco-friendly products; Consumer perception; Sustainability

INTRODUCTION

Plastic has become a serious hazard to the ecosystem. According to Roy and Morya (2022), the daily use of plastic products causes substantial environmental damage, such as air pollution caused by plastic incineration, pollution of the marine environment, and microplastics damaging internal organs of animals and indirectly harming humans by consuming seafood, meat, and other products contaminated with microplastics. As stated by Kumar et al. (2021), the existing practices of manufacture, design, consumption, and disposal of plastics have demonstrated crucial negative impacts on the planet on ecological imbalance, biodiversity, human health, climate change, sustainable livelihoods, cultural variety, and human rights. Research on plastic pollution reveals that the Philippines is the world's largest contributor to ocean plastic pollution, with an annual average of 3.30 kg per person (Corrales, 2023). The majority of the plastic waste found in the oceans includes plastic bags, plastic straws, food packaging, and single-use cutlery.

Furthermore, according to Sousa and Bastos (2021), during the COVID-19 pandemic, the public was advised to use drinking straws as a means of reducing virus transmission by avoiding contact with liquid-containing cups or containers. Thus, COVID-19 demanded and resulted in an unprecedented surge in the world's manufacture of all forms of single-use plastics, including drinking straws. As stated by Mulhern (2020), plastic straws are among the top ten most prevalent items found during global coastal litter clean-ups. According to the Annual International Coastal Clean-up Reports 1988-2017, plastic straws have continuously been rated high in terms of item count during clean-up events. In the United States alone, 500 million plastic straws are consumed every day, enough to load more than 127 school buses per day, or more than 46,400 annually. Therefore, it appears that single-use plastic straws contribute significantly to plastic pollution. And that various initiatives and alternatives must be implemented to reduce its consumption and contribute to the reduction of plastic pollution, especially in the Philippines.

In recent years, the world has become more aware of the environmental consequences of single-use plastics. As stated by H (2024), plastic straws, in particular, have drawn a lot of concern due to their widespread use and the devastation they bring to marine life. As a result, numerous alternatives have been proposed to the market, with edible straws emerging as one of the most innovative and environmentally friendly options. Edible straws are straws that you can consume after drinking your favorite beverage. These straws are created with natural ingredients such as rice, tapioca starch, wheat, and seaweed. Unlike plastic straws, which take hundreds of years to decompose, edible straws break down naturally or can be ingested, leaving no trace behind. Edible straws are considerably better than other alternatives, as paper straws are also harmful to the environment,

considering that their production could lead to deforestation.

However, even though edible straw is already on the market, it is only available in certain places throughout the world and is not as widely utilized as it should be. There are still people who are unaware of edible straws, indicating that it should be introduced to more consumers to be fully adopted as an alternative to plastic straws. This study assessed the potential of edible straws as an environmentally beneficial alternative to plastic straws. Despite the existing research studies indicating that developing an alternative to single-use plastic is viable and potentially significant, there is still a need to evaluate consumer perceptions of the potential of the edible straw. Therefore, this study looked into how potential consumers perceive the taste, texture, and usability of these edible straws in comparison to traditional plastic straws. And compare the environmental footprint of creating and disposing of edible straws to single-use plastic straws.

Furthermore, to provide the respondents a deliberate perspective on the quality of the edible straw, the researchers used edible rice straw for them to try. This edible straw is made from rice flour and tapioca starch, which offer various health benefits. Rice flour is a fantastic heart-healthy choice because it is low in fat and cholesterol. It's a great option for active lifestyles because it's also a great source of energy from carbohydrates. Tapioca starch, on the other hand, is easy to digest because it contains little FODMAPs (fermentable oligosaccharides, disaccharides, monosaccharides, and polyols), a type of carbohydrate that your gut has difficulty processing. It's also good for your heart because it's low in saturated fat. It has been discovered that cutting back on saturated fat can reduce your risk of heart disease.

Additionally, this kind of edible straw is preferable to other edible straws and is readily available on the market, particularly online. Unlike sugarcane straws, which are not edible, rice straws are completely edible and do not alter the flavor of the drink, unlike coffee bean straws. Furthermore, rice is widely cultivated worldwide, including in the Philippines. Rice straw is an abundant byproduct of rice cultivation that is produced in significant amounts every day. Compared to certain other kinds of edible straws that could come from fewer sources or more resource-intensive crops, this makes it an easily available and renewable resource. As a result of these aspects and other properties of rice straw, it is preferable to use it in this study to examine potential consumer perceptions of edible straws, as well as to be extensively used in the community.

Rationale

Plastic has become a prevalent issue to the ecosystem, causing major negative effects that take a heavy toll on the earth and its inhabitants. In response to the numerous environmental concerns associated with single-use plastics, this study examined the development of edible straws as an alternative for increased sustainability, efficiently tackling crucial ecological issues such as marine environment pollution, microplastic consumption, general ecological imbalance, etc., consequently evaluating consumer attitudes and perception regarding the product's taste, texture, functionality, and acceptability compared to the traditional plastic straws.

With the growing awareness of the toxicity and non-biodegradable nature of disposable plastic, consequently linking to health risks, consumers are actively looking for sustainable alternatives. This study explored edible straws that are convenient, feasible, and healthy for consumers and the environment as a whole. The study focused on consumer perception and acceptance regarding the concept of edible straws to ensure that it meets its expectations for functionality, taste, and overall satisfaction, subsequently creating a product that offers a healthy experience and an alternative option that is supported by the community

To thoroughly understand the differences and comparison between single-use plastic straws and the study's edible straws, the study further expounds the comparison by studying the differences in the environmental footprint of the production and disposal of both products. Understanding these differences will help define and identify the benefits and flaws of the product, further helping with alterations that refine the output.

The creation and widespread utilization of edible cutlery could lead to a reduction in the pollution caused by plastics. Numerous literatures indicate that developing an alternative to single-use plastic is feasible and may be highly beneficial. Edible cutlery is already on the market, however, it is only available in a few nations worldwide. Therefore, there is still a need to evaluate consumer perceptions of the potential of edible straws.

The primary objectives of this study consist of: (a) assessing the viability of edible straws as a sustainable solution, (b) evaluating consumer attitudes, and (c) contributing to the broader conversation on reducing plastic waste in the food and beverage industry. Ultimately, the study aims to help reduce plastic pollution by creating edible straws that have thoroughly understood customer preferences.
The specific objectives of the study include: (a) understanding how potential consumers perceive the taste, texture, and practicality of edible straws compared to traditional plastic straws while also (b) identifying the environmental footprint of producing and disposing of edible straws compared to single-use plastic straws. In conclusion, the study seeks to thoroughly study and understand consumer perceptions regarding the concept, practicality, and usability of edible straws as an alternative to plastic straws.

Review of Related Literature

Plastics are synthetic organic polymers of hydrocarbons that are modified to suit our purposes and performance via a variety of additives, plasticizers, colors, etc. These make them more robust, less biodegradable, and all the more toxic for human health. According to Pilapitiya and Ratnayake (2024), with the discovery of plastic, it was referred to as “the material with 1000 uses” due to it having versatile properties. Despite the advantages, the use of plastic has led to drastic environmental and human health issues. Degraded plastics can be as small as particles which can easily spread into the atmosphere, bodies of water, and the ground, which in turn negatively affect ecosystems and human health. In a study of Meijer et al. (2021), plastic accumulates largely in bodies of water, mainly from rivers. A large quantity of rivers are stem distributors of plastic waste to the ocean, leading to rivers having 80% of the plastic waste.

Moreover, according to a study of Chowdhury et al. (2021), although the popularity of metal cutlery is non-diminishing, their use and maintenance is resource demanding. Their inexpensive counterparts, i.e., plastic cutlery, are relatively undemanding and easy to use, but they end up fouling the environment as solid wastes. Plastic wastes in the environment are detrimental to the biota and end up in living organisms, oftentimes having harmful toxic effects. The detrimental effects of plastic pollution are evident worldwide via the quantum of disposables, containers, and packages that find their way into landfills

that often spill over into the water bodies, damaging aquatic life and creating hazardous effects by integrating into the food chain. To avoid such harmful effects of plastics on the environment and provide a sustainable alternative to cutlery, 'Edible Cutlery' is a creative and futuristic approach to manufacturing food deliverables and storage.

Narvekar's study (2022) states that these plastic containers and cutlery, usually non-biodegradable, accumulate in the environment. To put the amount of waste in perspective, it is estimated that Indians use about 120 billion pieces of plastic cutlery per year. This number is about 40 billion in the United States. In the case of plastic cutlery, people usually avoid recycling as they are considered to be too small, too lightweight, and too contaminated.

To counter this, there are already campaigns like encouraging people to say no to plastic cutlery when taking food delivery. Also, many governments are banning the use of single-use plastic. Along with these initiatives, if we shift to edible containers and cutlery, the production of plastic waste will be reduced. Also, in the case of edible cutlery made up of flours, flours can be chosen such that they are made up of cereals which are very healthy but are not consumed normally. For example, the edible spoons sold by Bakely contain Jowar as an ingredient along with Rice and Wheat flour. According to the creator of this spoon, Narayan Peesapaty, he decided to include Jowar as it's a nutritious grain with multiple health benefits.

According to the study of Roy and Morya (2022), there is a need for plastic alternatives or better solutions for individuals. Plastic is the most serious threat to humanity and the natural world, causing cancer, soil erosion, ocean toxicity, and air pollution. Edible cutlery is a more sustainable alternative to single-use plastic cutlery such as straws, spoons, forks, and coffee stirrers. Additionally, it can be more economical when raw material production rises, assisting in the final product's ability to satisfy the financial requirements of the consumer. Edible cutlery offers biodegradability, eco-friendliness, edibility, and health benefits to address the problem. Edible cutlery contributes to achieving sustainable development goals. The product's traits and advantages can be improved and manufactured using the same method.

Subsequently, most people in the modern world are employed in this fast-paced era. They therefore find it extremely difficult to cook or clean the utensils they use regularly. Disposable plastic containers have become increasingly popular, however, their toxic and non-biodegradable nature has been linked to health risks. The majority of people in Pakistan use non-biodegradable cutlery, which takes hundreds of years to break down in the environment and contaminate landfills and waterways. In the study of Raza et al. (2022), edible cutlery made entirely of natural substances has been designed to prevent the use of non-biodegradable materials such as wheat flour, rice flour, and sorghum flour. This study's cutlery is delicious, healthful, and environmentally friendly. It reduces the usage of plastic, which releases chemically hazardous substances into the environment during disintegration. This indicates that producing edible cutlery is possible. This is an alternative to single-use plastic cutlery, such as spoons, forks, and bowls. In this way, single-use plastic cutlery is used.

Also in the Philippines, some concerned individuals have already come up with the idea of making alternatives to plastic. A group of aspiring engineers from the Technological Institute of the Philippines (T.I.P.) Quezon City came up with the idea of making cutlery "edible", to offer a viable solution against plastic pollution. These students developed a research paper about turning flour into edible utensils that may potentially replace single-use plastic cutlery.

As reported by Malipot (2024), the team leader, fourth-year civil engineering student Stanley del Rosario, stated that after learning about plastic waste's disastrous effects on the environment, the group decided to try to "reduce plastic waste." He pointed out that pollution is connected to many illnesses, human fatalities, and marine biodiversity. "With a simple product like 'edible cutleries,' we believe it can be a sustainable solution to lessen our need for single-use plastics," del Rosario said. "It won't cause a problem to the community, especially for marine animals, because even if they ingest it, it is safe," he added. Increasing public awareness of the detrimental effects of plastic pollution is one of their objectives in researching the subject. After two months of work, the team submitted the proposal to compete for the 2023 Swiss Innovation Prize in September. In the "Sustainability" category of the 2023 Swiss Innovation Prize, the project came in third. After reviewing 150 entries from professionals and students across the country, a team of six judges ranked it in the top three for the "Sustainability" category.

One article from ABS-CBN News (2024) highlighted a company that wants to gradually lessen the amount of single-use plastic used in the Philippines. Adrian Mendoza started PH Sustainable, which has been in talks with local government agencies, the Department of Environment and Natural Resources (DENR), and business owners to provide edible straws, so Filipinos can progressively stop using single-use plastic products. The straws are produced from rice flour and tapioca starch, can tolerate hot and cold conditions, and have a two-year shelf life. They also come in various sizes and colors to go with drinks like smoothies and milk teas. If PH Sustainable is successful in bringing edible straws to various parts of the country, the company aims to expand its offerings to include cutlery, plates, and containers.

Additionally, as reported by Deña (2021), EhKape, a café managed by ekolife OFW Marketing Cooperative, has been using biodegradable straws since 2017. The straw, which is made of 70% rice and 30% tapioca, has no unique taste and hence does not affect the flavors of the drinks. In an interview, customers of the said café expressed their amazement at the edible straw, stating that it does not affect the overall taste of the beverage and can even stand for a long time on the drink. This is not the first time that eateries in Laguna province have used natural biodegradable materials. Last year, a pizza restaurant in Pila municipality went viral after employing handcrafted pizza boxes made of pandan leaves woven by craftsmen in nearby Cavinti.

In the study of Ongthongkam (2021), it is stated that the growing popularity of the "going green" idea has led to long-term effects on people's attitudes and perceptions. There are many factors and perceptions of the thinking of the customers to know whether they are willing to change or adapt their behavior toward the environmental issue or not. The willingness to change or agree to use a new product is extremely difficult to do and takes time because people tend to get used to the old attitude. Therefore, they need enough information about the benefits of change. Moreover, the cost of an organic and biodegradable product is more expensive than a plastic product since the ingredients are more expensive and the manufacturing procedure. The customers need to understand and be willing to pay more to buy this type of product.

These existing studies indicate that developing an alternative to single-use plastic is feasible and may be highly beneficial. Edible cutlery is already on the market, however, it is only available in a few nations

worldwide. The creation and widespread utilization of edible cutlery could lead to a reduction in the pollution caused by plastics. The researchers utilized edible straw that is made from rice flour and tapioca starch. These ingredients do not affect the flavor of the beverage, making it an ideal alternative to plastic straws.

Overall, the objective of this research is to develop a viable alternative to single-use plastic straws to contribute to the reduction of plastic pollution. However, with the existing possible options for sustainable eco-friendly alternatives to plastic straws, people still tend to opt for plastic straws or sip lids. This causes a dilemma for the production of these alternatives, as it has not been fully widespread and adapted.

Statement of the Problem

The widespread use of single-use plastic straws contributes significantly to environmental pollution and poses a threat to marine life. This study explored the potential of edible straws as an eco-friendly alternative to plastic straws. Therefore, the researchers seek to answer the following questions:

1.Consumer Acceptance: How do potential consumers perceive the taste, texture, and usability of these edible straws compared to traditional plastic straws?

2.Environmental Impact: What is the environmental footprint of producing, disposing, decomposing, and the sustainability of edible straws?

3.What would be the possible interventions that could be implemented to help increase the usage of edible straws as alternatives to single-use plastic straws?

General Objectives

The researchers' main objective is to assess the viability of edible straws as a sustainable solution, evaluate consumer attitudes, and contribute to the broader conversation on reducing plastic waste in the food and beverage industry, particularly in Colegio de San Juan de Letran Bataan.

Specific Objectives

The researchers seek to identify how potential consumers perceive the taste, texture, and usability of these edible straws compared to traditional plastic straws. Additionally, this study aims to determine the environmental footprint of producing and disposing of edible straws versus single-use plastic straws.

Hypothesis

In this study, the researchers aimed to assess the viability of edible straws as a sustainable solution, evaluate consumer attitudes, and contribute to the broader conversation on reducing plastic waste in the food and beverage industry. With this, the researchers observed the following:

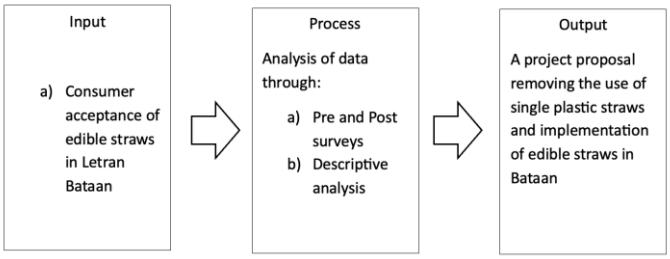
H0: There is no relationship between the quality of edible straw, such as taste, texture, and usability, and the standards and acceptance of potential consumers
Ha: There is a relationship between the quality of edible straw, such as taste, texture, and usability, and the standards and acceptance of potential consumers

Scope and Limitations

This study focused specifically on exploring the perceptions of potential consumers regarding the use of edible straws as a sustainable alternative to traditional plastic straws. It participates in the wider conversation about strategies for reducing plastic waste in the food and beverage industry. The research is confined to the Colegio de San Juan de Letran Bataan community, examining their acceptance and willingness to adopt edible straws instead of conventional plastic options.

By evaluating consumer perceptions, the study aims to contribute valuable insights into the acceptance of environmentally friendly spractices within this specific demographic. This study only evaluated the perception of potential consumers on edible straws as a sustainable alternative. And engage in the broader discourse on mitigating plastic waste within the food and beverage sector. This study only covers the acceptance of the Colegio de San Juan de Letran Bataan community by using edible straws instead of plastic straws.

Conceptual Framework



The study will utilize the Input-Process-Output (IPO) model as its conceptual framework. The IPO model represents all the factors that make up a process. According to Canonizado (2021), the IPO diagram includes all the materials and information required in the process, the specific details of the process itself, and the descriptions of all products and by-products anchored on the process that took place. One of the variables of the study is the consumer acceptance of edible straws in Letran Bataan. For the population of Letran Bataan's students and employees, find out if edible straws are accepted in this institution; all the information will be gathered by conducting pre- and post-surveys and examinations through descriptive analysis. The researchers constructed the model depicted above by replacing the variables from this study with the IPO model.

Theoretical Framework

The theories that are utilized in this study are the Theory of Planned Behavior, the LOHAS Theory, and the Health Belief model. As stated by Denish et al. (2024), the Theory of Planned Behavior suggests that human behavior is determined by behavioral intentions, which are influenced by attitudes, subjective norms, and perceived behavioral control. This theory proposes that individual behavior is driven by behavioral intentions. In the context of edible straws, the views that consumers have towards health and sustainability can have a significant impact on whether or not they intend to purchase these items. According to research, customers who place a high priority on environmental friendliness are more inclined to accept edible straws, particularly if they consider edible straws as a realistic alternative to standard plastic straws.

Additionally, The LOHAS (Lifestyles of Health and Sustainability) Theory, according to Denish et al. (2024), identifies the segment of customers that is essential in the acceptance of edible straws. Studies indicate that social awareness and subjective standards considerably affect the purchasing decisions of these consumers. They often exhibit an increased willingness to adopt products when they see them as authentic and aligned with their values. This demographic is motivated by individual beliefs about health and sustainability, as well as the influence of their social networks. This significantly pertains to consumers' perceptions of edible straws, since they are more inclined to favor ecologically concerned items like edible straws.

Lastly, according to Priya and Alur (2024), with the Health Belief Model, researchers can explore how health-conscious consumers use nutritional information panel labels to purchase food products, with a particular emphasis on the ethical evaluation dimension. It seeks to study how ethical factors influence the decision-making process of health-conscious consumers. Concerning edible straws, customers may be more likely to embrace them if they perceive that the use of such items helps favorably to both their health. If customers are aware of the health advantages that are linked with the components that make up edible straws, they may be more inclined to choose these straws over conventional alternatives. Because of the increased knowledge of the problems involved with plastic trash, customers may be more likely to seek out alternatives that are healthier and more sustainable, which would be the edible straw.

Research Design

In this study, the researchers utilized the evaluative method as the research design. As stated by Maze (2023), evaluative research is a research method that involves evaluating a product or concept and gathering data to help enhance your solution. It provides numerous advantages, including determining if a product works as planned and identifying opportunities for improvement. In an evaluative method, it usually entails gathering data before and after an intervention and using statistical analysis to determine whether changes observed may be attributed to the intervention. With this, the researchers were able to measure the potential consumer's perspective to evaluate the effectiveness or areas for improvement of the proposed edible straw as an alternative to single-use plastic straws. Using the evaluative method, it enabled
this study to have a deeper and comprehensive understanding regarding the acceptance of the Letran-Bataan community on the edible straw.

Population and Sample

This study primarily focused on the Letran-Bataan community. The research respondents for this study included the students and employees of Colegio de San Juan de Letran-Bataan, regardless of age and gender. This population was considered the potential consumers of the proposed edible straw, as it might have been adopted by the said community. By this, the researchers utilized stratified sampling to select the respondents. According to an article written by Thomas (2020), stratified sampling is a probability sampling technique that splits a population into uniform subpopulations known as strata, allowing researchers to estimate statistical metrics for each subpopulation. Every member of the population being researched was expected to belong to just one stratum. When a population's features are diverse, researchers use stratified sampling to guarantee that each trait is correctly represented in the sample.

Stratified sampling improved the study's generalizability and validity, while also preventing research biases. The Colegio has a total population of 1,015, including students and employees. The researchers were tasked with conducting a survey that required responses from 279 individuals, the sample size was determined using RaoSoft, a tool often used to calculate appropriate sample sizes based on population parameters, desired confidence levels, and margins of error. To enhance the precision of the sample, the researchers aimed to survey individuals from five predefined strata within the Colegio. Each stratum represented a distinct subgroup, and an equal number of 56 respondents was selected from each to provide balanced representation across all groups. This allowed the researchers to effectively collect sufficient and valid data that represented the preferences of the students and employees in the Colegio de San Juan de Letran-Bataan institution regarding the edible straw as an alternative to plastic straws.

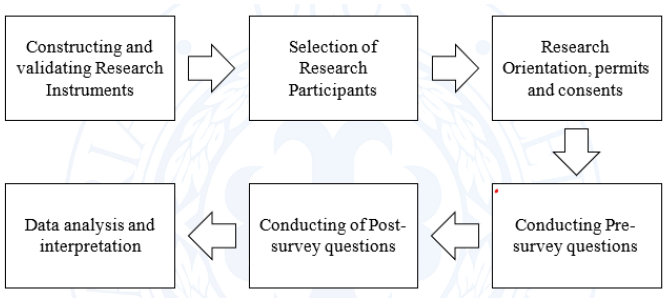
Research Instrument

The researchers gathered data through surveying to understand the consumers' preferences. The questions that were included in the survey discussed the environmental impact of edible straws and the consumers' acceptance of the said product. As stated by Mazhar et al. (2021), this instrument is efficient for getting information from many people. Surveys were also appropriate for getting information from people who are spread over a wide area and who are not easy to contact face-to-face. As with all data collection methods, the survey in this study adhered to ethical and moral codes of conduct.

Furthermore, the researchers utilized a Likert scale in the survey to assess the preferences and opinions of the respondents. The respondents assessed their level of agreement or disagreement with a statement on a scale. Following the evaluative method, the researchers conducted a pre- and post-survey. By conducting pre-surveys before the implementation of edible straws, the researchers gained valuable insights regarding the respondents' preference for edible straws as an alternative to plastic straws. On the other hand, in the post-survey phase, the researchers handed out edible straws to the respondents to enhance their perception of the product, allowing them to experience its qualities such as its taste, texture, and usability, this provided essential context for evaluating the effectiveness of the straw. By comparing the post-intervention outcomes to the data collected during the pre-survey, the researchers discovered whether the intervention had produced changes.

In addition, the researcher used a validated self-made survey questionnaire, which was first carried out on a pilot test to make sure that it would successfully bring out the findings that the study needed from the respondents.

Data Gathering Procedure



The illustration above is the data-gathering procedure that was followed by the researchers for this study. Firstly, the creation and validation of research instruments, which included the development of surveys. Once the instruments were set and validated, the researchers selected respective respondents from Letran Bataan's employees and students who are currently working and studying inside the institution. The research orientation, permits, and consent were given to the respondents in advance to ensure they were willing to be surveyed and that their responses would be indicated in the study, while all respondents remained anonymous.

The next step involved conducting pre-research surveys before the respondents tested the cutlery, and post-research surveys after they tried it. Following the data collection, descriptive statistics were used in data analysis and interpretation regarding the use of edible straws in replace of single-use plastic straws.

Data Analysis

The researchers utilized descriptive statistics for analyzing data in this study. According to Hayes (2024), descriptive analysis is a brief representation of data that describes and explains the highlights of a given data set measured into three categories: measures of central tendency, measures of variability, and frequency distribution. In this study, this is used to observe trends or patterns that are identified in analyzing data based on the data of the pre- and post-survey. The use of pre- and post-surveys helped us test the respondents' thoughts on edible straws before and after examining the product. Moreover, descriptive analysis helps summarize the data to highlight meaningful information for easier interpretation. Thus, this enables the researchers to analyze important data regarding the potential consumer's perception of the edible straw as an alternative to plastic straws.

Ethical Consideration

The study was reviewed and approved by the Office of Research and Publication at Colegio de San Juan de Letran Bataan to ensure compliance with institutional ethical standards.

Informed Consent:

●Respondents were informed of the study's aims, methods, potential benefits, and risks.
●Informed consent was obtained in writing before participation, with both the participant and researcher signing and dating the form.
●Respondents received a copy of the consent form.

Privacy and Confidentiality:

●Personal data were anonymized using code numbers.
●A separate, password-protected file linked study codes to respondents' identities, accessible only to researchers.
●All data were stored securely, and sensitive information was encoded in a password-protected Excel file. Physical data forms were kept in a locked cabinet.

Data Protection:

●Researchers complied with the Data Privacy Act of 2012.
●Data is stored on encrypted, secure cloud servers and is accessible only to the researchers.
●Data will be retained for five years for potential follow-up studies, after which it will be securely deleted. If shared for collaboration, it will be anonymized to protect participant identities.

Risk Assessment:

●This is a minimal-risk study, with no direct benefits for respondents but potential indirect benefits through the publication of study results in LINANG Publications, which may contribute to future research on the topic.

RESULTS AND DISCUSSION

A total of 213 respondents were surveyed by the researchers for this study. Although this is less than the supposedly desired number of responses, the researchers had to take ethical considerations into account, as some respondents declined to participate for personal reasons. Accordingly, the researchers used a 90% confidence interval to determine this total population. This achieves a balance between practicality and statistical rigor, enabling the researchers to work efficiently with the practically feasible sample size. Applying a 90% confidence level enables the strategy to be optimized to meet real-world limitations without sacrificing the study's validity. Furthermore, this study's respondents were 17 employees, 31 college students, 55 elementary students, 55 junior high school students, and 55 senior high school students.

Level

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Employee	17	8.0	8.0	8.0
	Student (College)	31	14.6	14.6	22.5
	Student (Elementary)	55	25.8	25.8	48.4
	Student (Junior High School)	55	25.8	25.8	74.2
	Student (Senior High School)	55	25.8	25.8	100.0
	Total	213	100.0	100.0	

SOP 1. Consumer Acceptance

As shown in Table 1 below, the acceptance of the consumer on the edible straw's taste, texture, and usability is calculated. The edible straw had an overall positive perception, with the highest rating having a mean of 4.0864. Usability scored the highest among the three variables, suggesting respondents rated it the most positively. While Taste Acceptance scored the lowest but still above neutral, suggesting a generally favorable perception. Variability is moderate for all variables, with standard deviations below 1, indicating that most respondents' responses clustered around the mean.

Table 1

Report

	Taste	Texture	Usability	Over_all_Percetion
Mean	3.5906	3.6329	3.8291	4.0864
N	213	213	213	213
Std. Deviation	.81421	.90086	.87227	.82716

These statistical results highlighted that respondents generally perceived the edible straws favorably in terms of Taste, Texture, and Usability, with Usability being the standout attribute. According to Ha (2023), rice straws, which are also used in this study, are gaining acceptance among like-minded individuals and producers as the best new single-use plastic alternative due to its excellent quality and usability. These edible straws decompose quickly and have a wide range of applications, working well in both hot and cold drinks. Because of its versatile design, these plasticless straws can be used for any of your favorite drinks, including juice, smoothies, coffee, and homemade cocktails. It can also last up to 2 hours for cold drinks and 1 hour for hot drinks, giving consumers enough time to enjoy their drink. This makes the straw highly functional and useful for drinking beverages. The edible straw's usability is one feature that influences consumer perceptions positively.

Furthermore, rice straws are edible and safe to consume. Rice straws are created from two major ingredients: rice flour and tapioca starch, making them completely natural and safe for human consumption. This is associated with the Health Belief Model, which, according to Priya and Alur (2024), allows researchers to investigate how health-conscious consumers use nutritional information labels to purchase food products, with a focus on the ethical evaluation dimension. It looks into how customers who are concerned about their health make decisions based on ethical considerations. Customers are more likely to adopt edible straws if they believe they benefit or would not harm their health. Customers who are aware of the health benefits associated with the ingredients that make up edible straws may be more likely to prefer these straws over traditional ones. Furthermore, as individuals become more aware of the difficulties associated with plastic waste, they may be more willing to seek out healthier and more sustainable alternatives, such as edible straws. Also, among all the attributes, the edible straw's usability has the highest average, as it encompasses functionality, edibility, and health benefits—key factors influencing the perceptions of potential consumers.

SOP 2. Environmental Impact

As illustrated in Table 2 below, the perspective of the potential consumers about the edible straw's environmental impact is calculated. The high means across all variables indicate that respondents perceive the edible straw as environmentally friendly, with particularly strong ratings for production, disposal, and overall environmental impact. While sustainability was still rated positively, it had the lowest mean (4.1491) among the variables. The relatively low standard deviations suggested a high degree of agreement among respondents, particularly regarding the overall environmental impact. Overall, the respondents strongly agree that the environmental impact of edible straws is positive, which likely supports the environmental benefits of switching from plastic to edible straws. This is particularly due to its significant environmental impact, particularly in lowering plastic pollution.

Table 2

Report

	Production	Disposal	Decomposition	Sustainability	Environmental_Impact
Mean	4.2031	4.2019	4.1995	4.1491	4.2934
N	213	213	213	213	213
Std. Deviation	.89424	.83006	.83488	.85666	.81129

As stated by Emily (20224), the greatest significant advantage of edible straws is their zero-waste nature. Unlike plastic straws, which take hundreds of years to degrade, edible straws decompose naturally or can be consumed without leaving any trace. This makes them an excellent alternative for ecologically aware people and businesses. The product's natural ingredients allow for plasticless production and decomposition, which helps to reduce the usage of plastics significantly. Furthermore, edible straws are completely compostable for individuals who don't want to consume them. They break down swiftly in composting conditions, restoring important nutrients to the soil while leaving no toxic residue. Edible straw may not harm not only land animals but also aquatic life.

According to an ABS-CBN News (2021) report, a company known as Ph Sustainable is working to reduce the usage of single-use plastic in the Philippines one step at a time by introducing edible straws. The company's founder has been in talks with business owners, the Department of Environment and Natural Resources (DENR), and local government units about producing edible straws so that Filipinos can progressively transition toward eliminating single-use plastic products. The founder noted that the existing problem is already massive and that if we continue to manufacture non-sustainable packaging, our waste problem will only worsen and resources will be wasted, causing further imbalance in the ecosystem and reducing human productivity. This demonstrates the need for alternatives to single-use plastic straws. That is why they have started bringing edible straws to the market, which is regarded as the most sustainable alternative to plastic straws due to its natural composition.

As a result, customers are more likely to support and utilize edible straws due to their environmental benefits. This reflects the LOHAS (Lifestyles of Health and Sustainability) Theory, which, according to Denish et al. (2024), defines the customer segment that is critical to edible straw acceptance. According to the study, social awareness and subjective standards have a significant influence on consumers' purchase decisions. They are more likely to adopt things that they believe are authentic and linked with their values. These types of consumers are influenced by personal health and sustainability values, as well as the influence of their social networks. This has a huge impact on consumers' opinions of edible straws, as they are more likely to prefer environmentally friendly products such as edible straws. Given that edible straws can help reduce plastic pollution and are an effective alternative, consumers, particularly those concerned about the environment, are likely to support and purchase this intervention. The respondents may therefore consider buying this product since they believe that edible straws are environmentally friendly and sustainable. Furthermore, given that edible straw is functional and efficient, it would be highly effective for customers to reap its environmental benefits.

CONCLUSION

The main goal of the study was to draw well-founded findings and offer thorough responses to the research questions based on the thorough examination of the data gathered. The focal point of the study was to delve into the perceptions of Colegio de San Juan de Letran's community regarding edible straws, concerning the edible straw's quality (Taste,

Texture, Usability), and environmental impact (Production, Disposal, Decomposing, Sustainability). The findings showed overwhelmingly positive responses for every component, highlighting edible straws' potential as a sustainable plastic substitute. These conclusions and statistics were derived from the valuable insights shared by the (213) respondents who were involved with the study and its surveys. Based on these insights, the product will be improved, and its acceptance will depend on the community.

The findings of the survey determined that, when it came to Taste Acceptance, respondents provided an average rating of 3.5906, indicating a slightly positive reaction towards the provided edible straw's taste. According to these measurements, the flavor of the provided edible straws is acceptable and tolerable, but it may still be improved to further improve the straws' utility and enjoyment. The variable bears a standard deviation of 0.81421 which suggests responses are fairly consistent, with most respondents sharing similar views on this attribute. Having the lowest score among all variables indicates that improving the flavor profile of edible straws is a major aspect if it's going to be adopted by the community.

In terms of the straw's Texture, the variable received an average rating of 3.6329, wherein it attained a slightly higher score than the variable Taste Acceptance. This suggests that the study's respondents thought its texture was acceptable, or perhaps favorable. Furthermore, the variable has a standard deviation of 0.90086, indicating the responses were slightly more varied compared to Taste Acceptance. The statistics above indicate that while a greater number of people enjoyed the texture, there were more varying preferences.

Of the three consumer acceptance factors, edibility received the highest average rating of 3.8291. This suggests respondents viewed the straw's edibility as a standout attribute with positive perceptions. The standard deviation of 0.87227 implies a moderate spread in responses, such as that of the variable Texture. The view that the fundamental component of edibility was accomplished was supported by this positive assessment.

The high mean across all variables suggests that respondents consider edible straw to be environmentally favorable, with particularly high scores for production, disposal, and overall environmental impact. Although sustainability continues to receive favorable evaluations, it has the lowest mean (4.1491) of all the factors. A high level of agreement among respondents, especially concerning the overall environmental impact, was indicated by the comparatively low standard deviations. The respondents generally strongly agree that edible straws have a beneficial environmental impact, which probably supports the idea that using edible straws instead of plastic will have a favorable environmental impact. This is especially because it has a big impact on the environment, especially when it comes to reducing the amount of plastic waste.

In summary, the Colegio de San Juan de Letran Bataan community finds edible straws to be a highly acceptable and adaptable alternative to single-use plastic straws. Among the edible straw's taste, texture, and usability, respondents favored its usefulness, which encompasses functionality, edibility, and health benefits, all of which are important considerations in influencing potential consumers' opinions. Furthermore, potential customers believe that edible straws would be a significant environmental benefit, particularly because they are produced without the use of plastic. Edible straws may break down naturally or can be eaten without leaving any trace, in contrast to plastic straws which take hundreds of years to decompose. They are therefore a great alternative to plastic straws. The use of plastics is greatly decreased because of the product's natural constituents, which enable plasticless production and decomposition. Given that edible straw is useful and efficient, it would be highly effective for users to bring out its environmental benefits. Potential customers' perceptions of edible straws were positively impacted by its quality and environmental impact, making them a widely accepted alternative to plastic straws.

RECOMMENDATION

Based on the study's findings, the researchers suggest various recommendations. Regarding the first SOP, which addressed customer acceptance of the edible straw's taste, texture, and usability, respondents preferred its usability the highest, while they liked its taste the least. With this, the researchers suggest improving the ingredients of the edible straws. Moreover, upon the data gathering, the researchers identified suggestions from the respondents about making other flavors, making the straw a bit softer, and creating other sizes of straws applicable to other types of drinks such as milk teas with boba pearls. Considering these suggestions is very essential to ensure that the potential consumer's expectations and wants are met so that they would support and purchase it more.

Furthermore, for the second SOP, when it comes to customer perceptions of the edible straw's environmental impact in comparison to plastic straws, respondents favor its production. This is particularly significant given that edible straw is made using organic materials. Therefore, it is better to make more edible straws so that other consumers may also be aware of it. However, to see the increase in the use of edible straws and to motivate businesses to use edible straws, it is necessary to think about how to make edible straws cheaper. The researchers suggest looking for any other ingredients that could make the edible straw since it can be made from locally sourced raw materials by local producers, such that the price realized for them will be friendly for even local businesses. Food and beverage businesses would be a great help in promoting the usage of edible straws.

Furthermore, for the last SOP, determining feasible interventions that may be conducted to increase the use of edible straws, the researchers have developed a project proposal. This would primarily involve developing a plastic-strawless institution, where consumers may purchase an edible straw if they prefer to use one for their drinks. This aims to reduce the usage of single-use plastic straws while encouraging the widespread adoption of edible straws as an alternative.

For future researchers, this study recommends widening the scope of the population that would be introduced with edible straw. This is mainly to allow other individuals to know about the edible straw and its impacts on the environment. With this, the edible straw would be widely known and used as an alternative to single-use plastic. Moreover, for the government and concerned individuals, the use of edible straws can also be promoted by demonstrating the usefulness of an impact a business can have by phasing out plastic straw usage. By increasing the availability of edible straws and familiarizing the public with the benefits of the product type, they can become widely used, offering a worthwhile and protective benefit for businesses that aim to reduce the detrimental effects they produce on the world's environment.

Overall, the researchers suggest widely introducing and adapting the edible straw to effectively bring out its environmental impact and improve the edible straw's ingredients and quality.

Proposal of “Eat the Problem”: An Eco-friendly Edible Straw Transition in the Colegio

This proposal outlines a project to advance Colegio de San Juan de Letran Bataan's commitment to sustainability and environmental stewardship by adapting the use of edible straws as a replacement for plastic straws. Specifically, it is grounded in the findings of a study demonstrating the Letran Bataan community's acceptance of edible straws as a sustainable alternative to single-use plastic straws. Finally, it will act as a reference point for Letran and its community regarding advances toward a much more sustainable future with the utilization of eco-friendly, reliable, and safe edible straws.

I. Purpose

“Eat the Problem” is a project that aims to incorporate edible straws into the Colegio’s canteen, consequently halting the use of plastic straws. As the main source of food and refreshments for a majority of the Colegio community, implementing the project “Eat the Problem” will greatly reduce the plastic use of the school. Furthermore, with the widespread use and knowledge of edible straws in the Letran Bataan community, the product could potentially reach larger markets and communities that all share the same mission of convenient eating and drinking without harming the environment. This project helps mitigate the issues caused by plastics in the environment and create a pro-green reputation for the Colegio.

II. Overview

The objective of this initiative is to replace plastic straws in the school canteen with edible straws. Addressing the urgent problem of plastic waste, the project is in line with the school's dedication to sustainability and environmental responsibility. In addition to encouraging eco-conscious behaviors among students and staff, we hope to lessen the school community's environmental impact by substituting edible straws for plastic ones. This initiative will promote an environmentally conscious culture by acting as an example for other organizations looking to implement sustainable practices. Knowledge about eco-friendly products, such as edible straw, can be advantageous to the community, as it gives them an upper hand in adjusting to potential environmental and economic changes in the future. Through this project, the Letran community is offered to adopt a healthier and much more sustainable option of eco-friendly edible straws. These products are produced in masses and can easily be found and bought online. These edible straws are utilized by particular restaurants and certain communities, wherein their popularity and overall use can be heightened through the school’s advances in adapting the aforementioned product.

III. Nature of Participants and Geographical Location

The participants of the study are composed of the entirety of Letran Bataan’s community, including students from elementary, high school, senior high school, and college, and employees from all different departments in the Colegio. Including various participants with numerous different perspectives helped the researchers effectively gather honest and diverse views from the school’s community. The location wherein this project shall take place is within the Colegio’s canteen, where most of the purchases of food and drinks occur. This is the place where most vendors work and reside, thus it will be more successful if as many as possible are reached. This adaptation shall be introduced to the community to efficiently adapt to the usage of edible straws or no straws at all.

IV. Project Outline

The researchers will use a structured plan for this project. Different edible straw brands and products will be precisely evaluated in the first phase, and the most cost-effective and suitable option for the community will then be identified. Moreover, the researchers will also help find reliable suppliers for the school. The second phase will prioritize the preparation of converting from plastic straws to edible straws. This phase will prominently display educational signs and posters; they will thoroughly educate students, staff, and parents about the upcoming shift to emphasize the ecological advantages of edible straws. Once ready, plastic straws will be completely phased out, and edible straws will be introduced. Following the use of edible straws, the school canteen will stop giving away free plastic straws of any sort to customers. Instead, those who prefer to use a straw will have to buy an edible straw straight from the seller. This strategy helps canteen vendors, it promotes choices that are good for the environment, and it makes sure the initiative will continue to be financially viable.

V. Monitoring and Evaluation

The researchers and the project coordinator will closely monitor the project's progress. They will ensure that informal posters and signage are put up in the canteen to properly inform customers of the benefits and the purpose of the transition from plastic to edible straws. The researchers will monitor the purchases of these straws and ask students about their experiences regarding the edible straw. Once the researchers have garnered and documented evident positivity regarding students’ thoughts on the straw and the heightening of edible straw sales, the project will be considered a success.

VI. Inputs

The program will require assistance from a project coordinator, who will oversee the integration and evaluate the project’s progress. Additionally, the cooperation of all vendors is vital for the project to effectively take place, wherein they will serve beverages and drinks without straws, offering the customer the option to buy an edible straw. For the material equipment, the project will require the edible straws themselves that will be provided to the vendors, consequently helping them familiarize themselves with the product without having to dispense money. Along with the edible straws should come the packaging that keeps it clean and hygienic, and a proper disposal bin to dispose of the edible straw and its packaging waste. Moreover, signage and posters can help spread awareness to the students regarding the school’s change from plastic straws to edible straws, informing them of its benefits to nature and themselves.

VII. Constraints, Limitations and Hazards

There can be several difficulties that must be overcome to carry out this program. First and foremost is the cost of the edible straws, wherein these purchases may cost more than the traditional single-use plastic straws. Due to the price of edible straws, the canteen may choose to sell the edible straws rather than hand them out for every purchase, consequently inconveniencing some. Furthermore, finding a supplier who can provide edible straws for the entire school regularly might pose logistical challenges. This issue makes it difficult to begin the adaptation, solely because of the lack of resources. And of course, the sudden change in produce may negatively impact students' experience, as not everyone is familiar with the texture and taste of edible straws.

VIII. Budgetary Plan

This budget plan is just an estimate of the cost of the materials and equipment to be used for this project.

Domain/Activity	Materials	Unit	Price
Implementation of Edible Straws in the Colegio's Canteen	Edible Straws	300 pcs	Php 720
	Posters/Signages	10 pcs	Provided by theResearchers
Estimated Total:			*Php 720 (depends on the consumption)*

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INVESTIGATING THE VIABILITY OF RECYCLED COOKING OIL AS BASE FOR A SUSTAINABLE EMERGENCY LIGHT SOURCE THROUGH ECO-FRIENDLY SCENTED CANDLES

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ABSTRACT

Perceived This quantitative experimental study, entitled "Investigating the Viability of Recycled Cooking Oil as a Base for a Sustainable Emergency Light Source through Eco-Friendly Scented Candles, explored the potential of recycled cooking oil as a sustainable base material for eco-friendly candles that can serve as emergency light sources. The study aimed to provide a cost-effective and environmentally responsible lighting alternative. Used cooking oil wax filtered, blended with stearic acid, and infused with fragrance oils to produce candles. These were then compared with commercial paraffin wax candles in terms of burn duration, cost efficiency, and user perception. Ninety-four household respondents from Gawad Kalinga, Barangay Salian, Abucay, Bataan participated in a Likert-scale survey evaluating familiarity, practicality, performance, and safety. Results revealed that recycled-oil candles burned longer—averaging 4 hours and 59 minutes versus 3 hours and 12 minutes for paraffin—and were 48% cheaper to produce. Respondents expressed high satisfaction in scent diffusion, light quality, affordability, and safety, with strong willingness to recommend the product. The study concludes that recycled cooking oil is a practical, safe, and sustainable candle base that supports waste reduction and resource efficiency. It is recommended that the study explores large-scale production by partnering with establishments and oil-generating manufacturers, ensuring stable production while expanding its environmental and economic benefits for community and commercial use.

Keywords: Recycled Cooking Oil, Sustainable Candles, Eco-Friendly Lighting, Cost Efficiency, Waste Reduction

INTRODUCTION

In our modern world where environmental crises fuses with digitalization and technological advancements, a portion of the population still frequently experience power outages, significantly affecting people's productivity (Francisco, 2022). In the Philippines, a recent comprehensive study showed that power outages in the Philippines have become a significant problem affecting both consumers and local economies (PIDS, 2023).In response to frequent power interruptions, alternative and sustainable lighting sources have gained attention, with candles remaining a practical backup during brownouts. However, rising costs and environmental concerns highlight the need for more sustainable options. This study explores the use of discarded cooking oil as a base material for scented candles, offering an innovative solution that addresses waste management while providing an eco-friendly and affordable lighting alternative for local communities.

The idea of repurposing used oil has been explored in areas such as biodiesel (Araujo et.al., 2013) and soap making (Mustakim et.al., 2020) yet limited studies have focused on its potential in candle manufacturing. While most scented candles in the market rely on paraffin wax which is petroleum-based and not biodegradable (Ökometric Wax and Emissions Study, 2007). By identifying this research gap, this study seeks to fill the void by investigating the feasibility of used oil as an alternative candle base with a focus on luminosity, burn time, overall safety, and scent capability.

This research aims to determine whether used cooking oil can be efficiently utilized to create candles that are both safe and aromatic. It also seeks to contribute to sustainable practices by transforming a common household waste into a valuable product. By innovating within the realm of waste up-cycling, the study may pave the way for livelihood opportunities and environmental awareness, especially in low-resource settings.

STATEMENT OF THE PROBLEM:

This paper intends to investigate the Viability of Recycled Cooking Oil as a Sustainable Emergency Light Source through Eco-friendly Scented Candles. Specifically, it seeks to answer the following questions:

1.How may the recycled cooking oil be described in terms of burn duration, and production cost (candle's properties) compared to a specific type of conventional candles, such as paraffin candles?

2.How safe and practical are recycled cooking oil candles for emergencies?

3.What significant environmental benefits can be derived from repurposing used cooking oil into eco-friendly candles?

4.How do respondents assess the viability of the product in terms of Familiarity, Candle Performance (Scent, Light, Smoke), Practicality, and Overall Safety.

HYPOTHESES:

Null Hypothesis (H_0):

There is no significant difference in burn duration, brightness, or flame stability between recycled cooking oil candles and conventional candles, and recycled cooking oil candles do not offer notable safety or environmental benefits both in terms of observation and in terms of Likert Scale response.

Alternative Hypotheses (H_1):

1.Recycled cooking oil candles have significantly different burn durations, brightness, and flame stability than conventional ones.

2.Recycled cooking oil candles are safe and practical for household emergency lighting.

3.Repurposing used cooking oil into candles provides measurable environmental benefits, such as waste reduction and decreased reliance on petroleum-based candle products?

4.Respondents do not significantly perceive the recycled cooking oil–based eco-friendly candles as a viable and effective source of sustainable emergency light in terms of Familiarity, Candle Performance (Scent, Light, Smoke), Practicality, and Safety.

OBJECTIVES OF THE STUDY

The main objective of the study is to determine the practicality and viability of recycled cooking oil as a sustainable emergency light source by producing and evaluating eco-friendly candles.

Specific Objectives:

1.To collect, filter, and refine used cooking oil from households and combine it with eco-friendly materials to produce sustainable candles.

2.To compare the burn duration, brightness, and flame stability of recycled cooking oil candles with conventional candles.

3.To assess the safety and practicality of recycled cooking oil candles for use in household emergency lighting.

4.To determine how respondents assess the viability of the product in terms of familiarity, candle performance (scent, light, and smoke), practicality, and overall safety.

5.To provide recommendations for producing and using recycled cooking oil candles as a sustainable emergency lighting alternative.

SIGNIFICANCE OF THE STUDY:

The results of this study will be salutary to the beneficiaries. Benefiting this study are the various sectors as follows:

- Students. This study provides a practical and sustainable option for students who use scented candles as a means to cope with stress and improve focus.
- People Who Frequently Experience Power Interruptions. This study offers a practical lighting alternative for individuals and households regularly affected by power outages.
- Chandlers. Candle makers, or chandlers, may benefit from this study by discovering the potential of used cooking oil as an additive or extender in candle production
- Retailers.For retailers and small-scale investors, the findings of this study present a promising low-cost business opportunity.
- Commercial Users. Commercial users of scented candles, such as spa owners, cafés, and wellness spaces, may consider this product as a viable alternative to traditional options.
- Used Oil Generator. Establishments that generate large amounts of used oil, such as restaurants or food stalls, can find a new avenue to reduce waste through this study.
- Other Future Researchers. This study serves as a foundational reference for future researchers exploring eco-friendly innovations.

SCOPE AND DELIMITATION:

This study focuses on the utilization of used cooking oil as the primary base for producing scented candles. It aims to assess the safety and feasibility of candles made from waste oil by evaluating burn time, brightness, stability, and scent diffusion in comparison to traditional paraffin-based candles. The research also examines the environmental and economic benefits of reusing discarded oil, particularly in reducing household waste and providing an alternative lighting source during power outages.

However, the study is limited to small-scale candle production using oil collected solely from kitchens. Only one type of used oil base—palm oil—will be utilized, as it is the most commonly used oil in household and rural settings and is the cheapest vegetable oil on the global market due to its low production cost (Bentivoglio et al., 2018). The experiment is further confined to testing a limited number of commercially purchased essential oils for scent diffusion. Other variables, such as long-term storage effects and potential health risks from prolonged use, are beyond the scope of the study. Additionally, the final product is not intended for commercial sale and does not meet industry production standards, which may result in limited polish, consistency, and safety certification.

LITERATURE REVIEW

Burn Time

Candle flames are classified as laminar diffusion flames, where the fuel (candle wax composed of hydrocarbons) and oxygen from the surrounding air are supplied separately to the reaction zone (Hickman, 2022). Candle burn time varies based on several factors, including size, material, wick thickness, and lighting conditions (Candles, 2023). Kral (2014) found that burn time increases with greater candle thickness and wick diameter. Similarly, the National Candle Association (2021) reported that burn rate is strongly influenced by the candle base and structural properties, such as wax type (paraffin, soy, beeswax) and base diameter.

Salthammer et al. (2021) reported burn rates of approximately 2.9–4.6 g/hr in scented candle blends, demonstrating

how variations in wax and oil composition affect burn duration. Studies on olive oil candles indicate burn times of approximately 2–3 hours per ounce of oil, with smaller flames producing longer burn times but lower brightness (Question About Olive Oil Candle Burn Time, 2025). Overall, burn time and efficiency depend largely on base type, wick size, and candle design, regardless of the fuel source (Bulk Lamp Oil, Tiki Torch Fuel, Oil Lamps and Refillable Liquid Oil Candles, n.d.)

Familiarity

Several studies incorporating community awareness components show that while many individuals have experimented with homemade candles, familiarity varies. Used cooking oil candles are promoted as affordable and eco-friendly alternatives to paraffin candles (Santos, n.d.). Educational outreach and proper disposal programs emphasize safe storage and reuse of used oil, such as in candle-making, to increase public awareness and reduce waste (Kamalov, 2024). However, improper disposal remains common, with many people pouring oil down drains, causing pipe clogging and water pollution (Abrajano et al., 2023).

Regarding emergency lighting, Herzog (2023) notes that individuals and institutions primarily rely on electric-based systems, including LED lights, battery-powered luminaires, and solar-assisted lighting. Candles, whether homemade or commercial, are less commonly used as primary emergency lighting but remain practical backup options in low-resource or off-grid settings.

Scent

A scented candle contains fragrance or essential oils added to wax or fuel to release aroma during burning (Karla, 2025). Egan (2024) explains that scent diffusion, like burn time, is strongly influenced by candle characteristics, including wax type and fragrance chemistry. While natural essential oils may offer benefits and slower diffusion, they are more susceptible to heat degradation, whereas synthetic fragrance oils provide greater consistency (PMC, 2022).

Numerous studies indicate that scented candles influence mood and psychological states. Research published in Evidence-Based Complementary and Alternative Medicine found measurable effects on relaxation and emotional well-being (Sowndhararajan & Kim, 2016). Similarly, Jungle Culture (2021) reported reduced stress and improved well-being among participants exposed to scented candles compared to unscented ones. Putri and Putri (2024) further confirmed that aromatherapy candles can relieve stress, enhance mood, and eliminate unpleasant indoor odors, supporting their psychological benefits.

User Satisfaction

Due to health and environmental concerns, consumers increasingly prefer eco-friendly scented candles made from natural, renewable materials over conventional paraffin wax (Scented Candles Market Size, Share & Trends Report, 2030, n.d.). As sustainability awareness grows, the eco-friendly candle market is projected to expand at a CAGR of nearly 7% from 2024 to 2032 (GVR, 2023). Market studies also indicate that frequent candle buyers favor scented varieties for their ability to eliminate unpleasant odors and enhance mood, with over 75% of consumers purchasing candles primarily for their aroma. Similar preferences are observed across other household products, reflecting a broader demand for scented items to improve ambiance and emotional appeal, not limited to candles alone (Herz et al., 2022)

Production Cost

In companies that make candles, raw ingredients like soy wax, beeswax, and essential oils usually make up 30–40% of the overall cost of production (Team, 2025). Due to more costly raw materials, ethical sourcing, and environmentally friendly packaging, sustainable candles often have production costs that are 10–15% higher than those of conventional paraffin (Bung, 2025). Although producing sustainable candles is typically more expensive, people are becoming more prepared to pay for sustainable features including eco-friendly packaging, clean burning, and health benefits (Sustainable Candles Market Size, Growth & Forecast Report - 2033, n.d.).

Due to waste cooking oil's (WCO) raw materials being cheap and the reaction conditions being mild, it can generally be converted into wax at a comparatively low cost. For instance, compared to conventional waxes, epoxidation and modification using materials like stearic acid can yield a wax with high hardness, melting point, and combustion qualities at a cheaper cost (Liu et al., 2022). Using recycled oils significantly reduces the raw material cost portion, as cooking oil is typically a waste product, often being considered free (Fischer, 2025).

Innovation and Sustainability

Community-based projects convert WCO into safe, high-quality candles through systematic processes such as filtration, bleaching, melting, molding, and packaging, ensuring impurity removal and product safety (Community Circular Economy Projects, 2024). Recycling WCO into candles reduces improper disposal, which can otherwise pollute water sources, clog drainage systems, and harm wildlife. Studies in Indonesia further examined WCO-based aromatherapy candles combined with stearic acid to optimize hardness, burn time, and melting point, identifying a 3:5 WCO-to-stearic acid ratio as producing the best physical properties and meeting national candle standards (Anggraini & Kurniasih, 2024).

Kamalov (2024) reported that improper WCO decomposition releases methane, a potent greenhouse gas, and that recycling WCO into candles or biofuels significantly reduces these emissions while lowering reliance on fossil fuels. Overall, reusing WCO in eco-friendly products supports sustainability by minimizing pollution, reducing emissions, conserving finite resources, and promoting social and economic benefits.

THEORETICAL FRAMEWORK

This study addresses the need for sustainable solutions in waste management and household energy consumption by examining recycled waste cooking oil (WCO) as a base material for eco-friendly scented candles. Guided by Combustion Theory, Aromatherapy and Olfactory Response Theory, Consumer Behavior Theory, and Circular Economy Theory, the research evaluates the functional performance, user acceptance, cost-efficiency, and environmental value of WCO-based candles.

Combustion Theory explains candle performance through fuel composition, wick behavior, and combustion efficiency. Nabizadeh (2025) describes combustion as an exothermic reaction producing heat and light, while El Hage et al. (2012) reported paraffin's high

combustion efficiency (96–97%). To improve WCO performance, solidifiers such as stearic acid are required. Anggraini and Kurniasih (2024) demonstrated that a 3:5 WCO–stearic acid ratio met quality standards with burn times exceeding 250 minutes. Choi et al. (2022) found WCO-based wax comparable to soy wax, while Liu et al. (2023) emphasized the influence of wick properties on combustion stability.

Aromatherapy and Olfactory Response Theory supports scent diffusion as a key variable. Choi et al. (2022) and Chen and Zhang (2022) explain how scent molecules stimulate the limbic system, affecting mood and behavior. Studies by Cavanagh and Wilkinson (2003) and Kumalasari et al. (2023) confirmed that essential oil–infused candles enhance relaxation and user satisfaction.

Consumer Behavior Theory explains acceptance of sustainable products through perceived functional, emotional, and environmental value (Siyarifah Hudayah et al., 2023; Frontiers, 2021; Frontiers, 2024). Symbolic consumption and green identity further influence purchase intention (Emerald Insight, 2023; Khoula et al., 2025; Sharma, 2023).

Finally, Circular Economy Theory frames WCO reuse as waste valorization. Mannu et al. (2024), PubMed (2022), and MDPI (2024) highlighted the environmental and economic benefits of WCO reuse, particularly in non-fuel applications such as candle production.

Together, these theories and studies establish a strong foundation for evaluating WCO-based scented candles as a functional, sustainable, and socially acceptable household innovation.

CONCEPTUAL FRAMEWORK

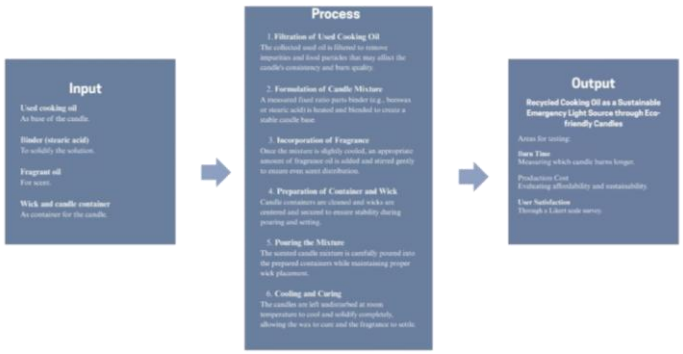


Figure 1

The figure presents the conceptual framework of the study. The Input phase identifies the materials used to produce eco-friendly candles, with recycled cooking oil serving as the primary base material. Stearic acid, a fatty acid commonly used in candle making to enhance burning and physical properties (Prodchem, 2023), is added as a binder to solidify the mixture. Candle wicks and containers are also included to support and shape the candles.

The Process phase outlines a six-step procedure. Used cooking oil is first filtered to remove impurities, then mixed with stearic acid in a fixed ratio and heated to form a stable base. Fragrance is added during cooling, followed by preparation of the wicks and containers. The mixture is then poured into the containers and left to cool and cure at room temperature to ensure proper setting and scent stabilization.

The Output phase focuses on the evaluation of the finished candles as sustainable emergency light sources. The products are assessed based on burn time, production cost, and user satisfaction. Burn time measures longevity, cost evaluates affordability, and user satisfaction is determined through a Likert-scale survey assessing overall performance, cost and practicality, and safety.

MATERIALS AND METHODS

This quantitative study employed an experimental research design to produce candles using used cooking oil as the base and to compare their burn time, scent diffusion, and production cost with commercially available paraffin-based candles. Quantitative data were collected to measure burn duration, production cost, and respondents' perceptions of familiarity, candle performance (scent, light, and smoke), practicality, and safety using a standardized Likert scale.

The experimental approach involved the controlled production and testing of both candle types to ensure objective comparison. Key variables, including oil type, fragrance essence, and stearic acid content, were systematically manipulated to assess their effects on candle performance. Data obtained from performance tests and user evaluations provided measurable outcomes, making this experimental quantitative design appropriate for determining the feasibility of used cooking oil as an effective candle base.

SAMPLE AND SETTING

The researchers conducted the experimental procedures to measure burn time and production cost, while user satisfaction data were collected via a Likert scale survey administered to residents of Gawad Kalinga, Barangay Salian, Abucay, Bataan, a community initiative for informal settlers (Welcome to Gawad Kalinga, n.d.).

The survey targeted a population of 120 households (Municipal Planning and Development Office, 2023). Using the Raosoft Sample Size Calculator with a 95% confidence level and 5% margin of error, a minimum of 92 respondents was required. Simple random sampling was applied to reduce bias, resulting in 94 respondents, exceeding the minimum and ensuring reliable, statistically valid data for assessing user satisfaction with the used-oil scented candles.

RESEARCH INSTRUMENT

Aside from the experimental product. The primary research instrument used in this study is a Likert scale questionnaire developed by the researchers. This survey aims to measure the respondents' perception in areas such as familiarity, candle's overall performance, practicality, and overall safety. The questionnaire consists of several statements rated on a five-point scale, ranging from Strongly Disagree (1) to Strongly Agree (5). After handing out samples, the Likert scale survey was administered through Google Forms, maintaining respondent anonymity and confidentiality. While the candle product itself was not a research instrument, its creation and controlled testing were essential components of the experimental procedure.

DATA COLLECTION PROCEDURE

The data collection procedures systematically measured both objective

and subjective characteristics of the used oil–based scented candles. Objective data included burn time and production cost, while subjective feedback covered candle performance, scent diffusion, practicality, and overall safety for analysis of user satisfaction.

Burn Time. The burn time of a 16-gram used oil–based candle was measured under controlled conditions and tested three times, with the average calculated using the mean. Results were compared to commercially available paraffin wax candles, which burn at approximately 5 g per hour (or 12 minutes per gram) under typical conditions (Cheng, 2023), to evaluate efficiency and longevity.

Production Cost. Production cost was determined by summing the cost of all raw materials. A separate calculation focused solely on the candle base (excluding wick and container) to assess cost efficiency and market competitiveness, since containers may vary depending on preference or availability.

User Satisfaction. Candle samples were distributed to the target locale, with respondents completing a Google Form Likert scale questionnaire. The survey measured Candle Performance (Scent, Light, Smoke), Practicality, Safety, and included sections for recommendations and suggestions. Respondents received explanations about the candle's purpose, materials, and cost before evaluation.

DATA ANALYSIS

The data collected in this study were analyzed using both descriptive and comparative methods to address the research questions.

Burn Time. Three candles were utilized whose burn time was measured in hours, minutes, and seconds in an elapsed time format. The candle was observed every hour before its time of being out. The results were compared to determine which is likely to be extinguished first, providing an indication of relative burn efficiency. The analysis will be observed through the materials' burn time per gram.

Production Cost. The computed production cost per unit of the used oil-based candle was compared to the sourced cost of a commercially available paraffin wax candle. The comparison will give an emphasis on the base since container and wick may vary depending on preferability, and because this study focuses on the base of the product and its viability. The analysis will be observed through a 1 kilogram base comparison excluding container and wick.

Likert Scale Responses. Responses from the Likert scale questionnaires were tabulated and analyzed using descriptive statistics and graphed in a table. The results were examined to determine patterns and trends that reflect the respondents' overall perception of the product's feasibility, particularly in terms of candle performance, practicality, and safety.

TRUSTWORTHINESS

The study ensured trustworthiness through careful planning, consistent procedures, and accurate documentation throughout the research process. Materials and measurements were standardized to produce comparable candle samples, while data collection tools such as timers and Likert-scale questionnaires were applied uniformly. Survey responses were collected anonymously to promote honest feedback. Data were systematically checked, verified against the research objectives, and reviewed for inconsistencies. Transparency and detailed documentation were maintained to support reliability, confirmability, and future replicability of the study.

ETHICAL CONSIDERATION

The study followed the ethical guidelines of Colegio de San Juan de Letran – Bataan. Approval was obtained from the appropriate authorities before conducting the experiment. Participant anonymity and confidentiality were strictly observed, and survey participation was voluntary, with the right to withdraw at any time without penalty. No compensation was provided, as the study posed no foreseeable risks. The researchers declared no conflicts of interest that could affect the study's conduct or findings.

RESULTS

PRESENTATION OF DATA

This chapter presents and discusses the findings of the study on the viability of recycled cooking oil–based eco-friendly candles, wherein objective data on burn time and production cost were obtained through controlled experiments conducted by the researchers, while subjective data on user perceptions were gathered through a Google Form survey.

Objective Results

This section presents the results for Burn Time and Production Cost obtained from the experiments carried out by the researchers.

Burn Time

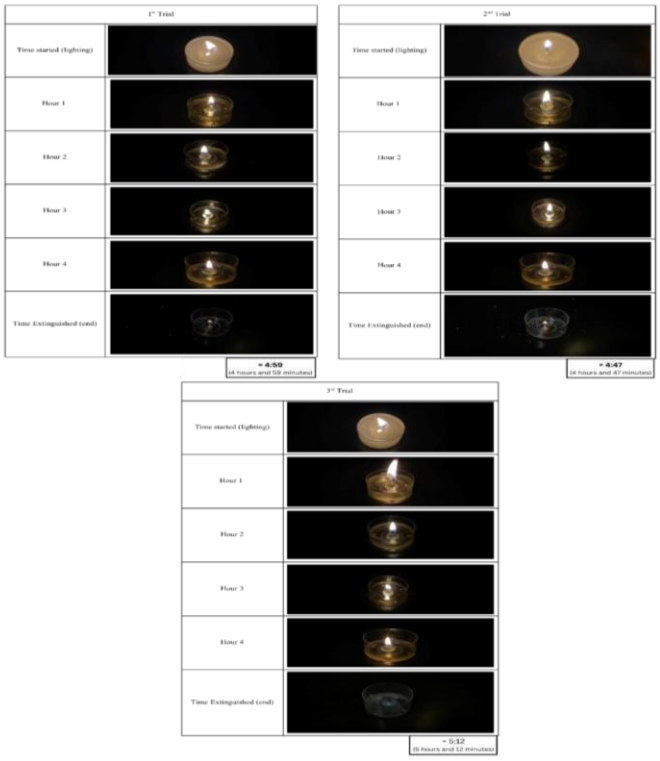


Figure 2

The burn tests in Figure 2 (Tables 1–3) show the performance of used cooking oil–based candles under controlled conditions. Each candle was lit at different times to assess consistency. All samples exhibited stable combustion without unnecessary extinguishing, demonstrating efficient fuel use and flame stability. Total burn times were 4 h 47 min, 4 h 59 min, and 5 h 12 min, confirming that the candles provide reliable and consistent performance suitable for practical lighting applications.

Time of recorded trials	
1st trial	4:59 hours
2nd trial	4:47 hours
3rd trial	5:12 hours

$$\text{Mean } (\bar{x}) = \frac{\sum x}{n}$$

$$\text{Mean } (\bar{x}) = \frac{(4:59) + (4:47) + (5:12)}{3}$$

$$\text{Mean } (\bar{x}) = \frac{299+287+312}{3} \rightarrow \text{converted to minutes}$$

Mean $(\bar{x})$ = 299.333 minutes

Average Time = **4 hours, 59 minutes, and 20 seconds**

Used Oil Base	Paraffin Wax Base
4 hours, 59 minutes, and 20 seconds	**3 hours, 12 minutes** (Cheng, 2023)
18.8 minutes per gram	12 minutes per gram

The mean formula was used to calculate the average burn time of three used oil–based candle samples, resulting in 4 h 59 min 20 sec.

In comparison, a 16-gram paraffin wax candle burned for 3 h 12 min (Cheng, 2023). The used oil candles had a burn efficiency of 18.8 min/g, versus 12 min/g for paraffin wax. These results indicate that the used oil–based formulation burns longer and more efficiently than conventional paraffin candles.

Production/Raw Material Cost

The production cost results illustrate the cost analysis conducted by the researchers to determine the economic feasibility of producing eco-friendly candles made from used cooking oil and stearic acid as a binder. Each table outlines the breakdown of material expenses, including the cost of used oil, stearic acid, wick, and container.

16 gram candle
(this formula makes 110 teapot candles)

Category	Ingredients / Items	Cost ₱	Amount Used
Fragrance	½ cup	₱1000 for 2 cups	*₱250*
Stearic Acid	3 cups	₱208 per kilo	*₱139*
Oil	7 cups	Free	*Free*
Container & Wick	110 pieces	₱632	*₱632*
			= ₱1021

$\frac{₱1021}{110}$ • ₱1021 - materials raw cost • 110 - amount of candles produced

= ₱9.28 per 16 g candle

Figure 3

Figure 3 above presents the production cost computation for a single batch of 16 gram eco-friendly candles made from used cooking oil and stearic acid as a binder. The total material cost for the batch amounted to ₱1,021, which was sufficient to produce 110 candles weighing 16 grams each. To determine the production cost per candle, the total expense was divided by 110, resulting in an estimated cost of ₱9.28 per 16-gram candle. This calculation represents the cost analysis for one of the presented product.

94 gram candle
(this formula makes 12 candles)

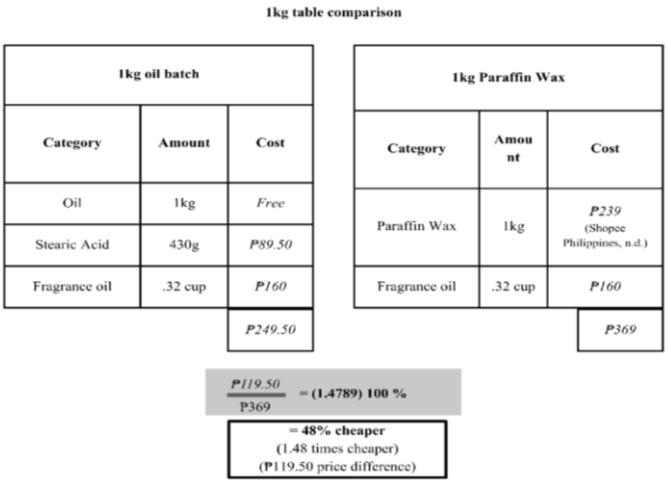
Category	Ingredients / Items	Cost ₱	Amount Used
Fragrance	0.21 cup	₱1000 for 2 cups	*₱105*
Stearic Acid	1.3 cups	₱208 per kilo	*₱60*
Oil	3 cups	Free	*Free*
Wick	12 pieces	₱45 for 25 pieces	*₱21.6*
Container	12 pieces	₱22 per piece	*₱264*
			= ₱450.6

$\frac{₱450.6}{12}$ • ₱450.6- materials raw cost • 12 - amount of candles produced

= ₱37.55 per 94g candle

Figure 4

Figure 4 presents the production cost computation for a batch of eco-friendly candles made from used cooking oil and stearic acid as a binder, specifically formulated for 94-gram candles. The total material cost for this batch amounted to ₱450.60, which produced 12 candles in total. To determine the production cost per candle, the total expense was divided by 12, resulting in an estimated cost of ₱37.55 per 94-gram candle. This figure represents the cost analysis for another one of the presented products, contributing to the overall assessment of the candle's economic practicality and material efficiency



1kg table comparison

1kg oil batch		
Category	**Amount**	**Cost**
Oil	1kg	*Free*
Stearic Acid	430g	*₱89.50*
Fragrance oil	.32 cup	*₱160*
		₱249.50

1kg Paraffin Wax		
Category	**Amount**	**Cost**
Paraffin Wax	1kg	*₱239* (Shopee Philippines, n.d.)
Fragrance oil	.32 cup	*₱160*
		₱369

$\frac{₱119.50}{₱369}$ = (1.4789) 100 %

= 48% cheaper
(1.48 times cheaper)
(₱119.50 price difference)

Figure 5

Figure 5 presents the cost analysis, focusing on the candle base while excluding interchangeable components like the container and wick. Shared elements, such as fragrance oil, were standardized. The cost of 1 kg paraffin wax was ₱369 (with ₱239 from the wax; Shopee, n.d., retrieved October 19, 2025), while 1 kg of used oil–stearic acid base cost ₱249.50, with fragrance oil being the highest-cost component. Comparison shows the eco-friendly candle base is 48% cheaper, with a ₱119.50 savings, demonstrating that recycled oil–based candles are significantly more cost-efficient than paraffin-based alternatives.

Subjective Results.

Subjective data were collected via a Google Form administered house-to-house by the researchers. The form included eight sections covering Familiarity, Candle Performance, Practicality and Safety, Recommendability, and open-ended Suggestions.

A total of 94 respondents participated, mostly aged 15–20, indicating strong engagement from adolescents and young adults who may be receptive to sustainable innovations. Regarding power outages, 48.9% reported frequent brownouts and 29.8% occasional interruptions, highlighting the need for reliable emergency lighting solutions.

Familiarity

Typical Emergency Lighting Used - F1

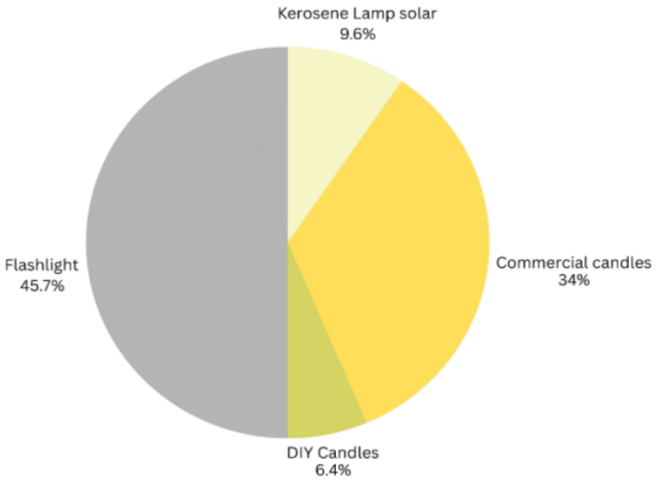
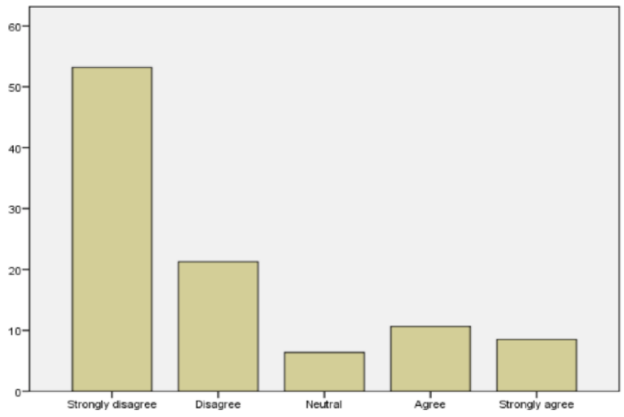


Figure 6 : F1

Respondents were asked about their typical emergency lighting source during power interruptions. The results revealed that the most commonly used source was the flashlight, accounting for 45.7% of the responses. This was followed by commercial candles with 34%, while DIY candles comprised 10.6%. Along with that, kerosene lamps were used by 9.6% of respondents, and solar-powered lights had the lowest usage.

Homemade Candle Prior Experience - F2

" I have used homemade candles before "

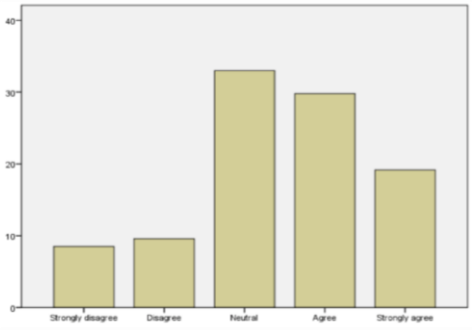


		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly disagree	50	53.2	53.2	53.2
	Disagree	20	21.3	21.3	74.5
	Neutral	6	6.4	6.4	80.9
	Agree	10	10.6	10.6	91.5
	Strongly agree	8	8.5	8.5	100.0
	Total	94	100.0	100.0	

Figure 7 : F2

For Figure 7, allotted for homemade Candle Prior Experience – F2 (Likert Scale) "I have used homemade candles", reveals that most respondents indicated limited prior experience with homemade candles. A majority of 50 respondents (53.2%) strongly disagreed, while 20 respondents (21.3%) disagreed, showing that over 74% of participants have not previously used homemade candles. Meanwhile 10 respondents (10.6%) agreed and 8 respondents (8.5%) strongly agreed.

Discarded Oil Disposal- F3
"I have disposed of used cooking oil in household sinks/garbage."



		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly disagree	8	8.5	8.5	8.5
	Disagree	9	9.6	9.6	18.1
	Neutral	31	33.0	33.0	51.1
	Agree	28	29.8	29.8	80.9
	Strongly agree	18	19.1	19.1	100.0
	Total	94	100.0	100.0	

Figure 8: F3

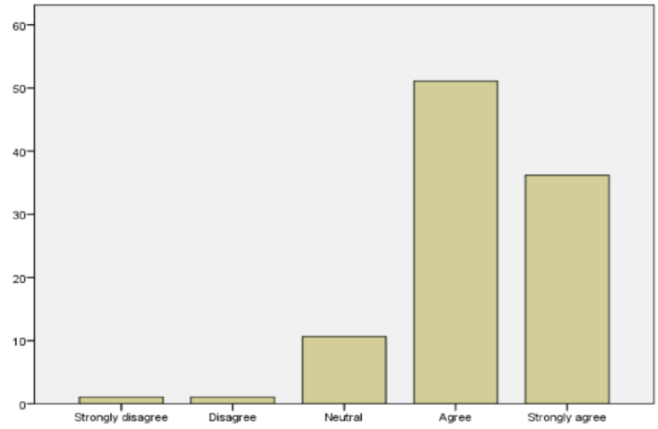
For Figure 8, Discarded Oil Disposal – F3 ("I have disposed of used cooking oil in household sinks/garbage"), most respondents were neutral (31; 33%), while 28 (29.8%) agreed and 18 (19.1%) strongly agreed. Only 9 (9.6%) disagreed and 8 (8.5%) strongly disagreed.

Overall, Familiarity results (F1–F3) indicate limited experience with homemade candles, making recycled cooking oil as a candle base relatively unfamiliar. Improper disposal of used oil via sinks or garbage was common. For emergency lighting, flashlights were most frequently used, followed by commercial and homemade candles, while kerosene lamps and solar lights were less common. These findings underscore the low familiarity with homemade candles but highlight the potential impact of introducing eco-friendly, recycled-oil alternative.

Candle Performance

Candle Scent - CP1

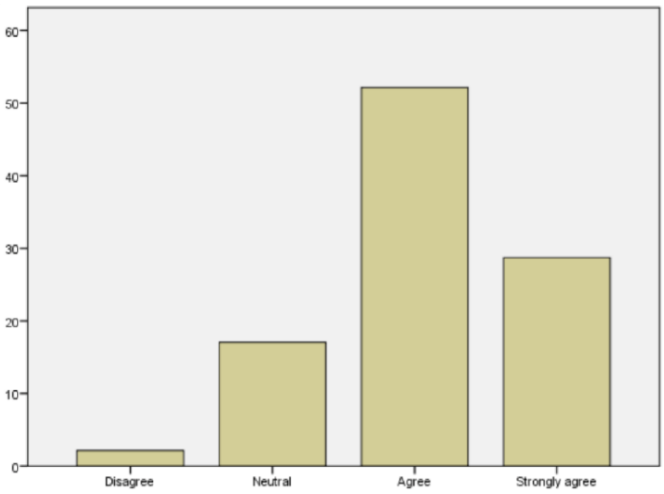
"The candle scent was easily noticeable in a room setting,"



		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly disagree	1	1.1	1.1	1.1
	Disagree	1	1.1	1.1	2.1
	Neutral	10	10.6	10.6	12.8
	Agree	48	51.1	51.1	63.8
	Strongly agree	34	36.2	36.2	100.0
	Total	94	100.0	100.0	

Figure 9: CP1
For Figure 9, Candle Scent Perception – CP1 (Likert Scale) "The candle scent was easily noticeable in a room setting," the chart illustrates the respondents' perception of the candle's scent intensity. The majority of the respondents, 48 (51.1%), agreed that the candle scent was noticeable, while 34 (36.2%) strongly agreed. Meanwhile, 10 respondents (10.6%) remained neutral, and only 1 respondent (1.1%) disagreed, with 1 respondent (1.1%) strongly disagreeing.

Candle Luminosity / Light - CP2
"The light is consistent and sufficient for simple tasks like reading or as a corner light in the room,"

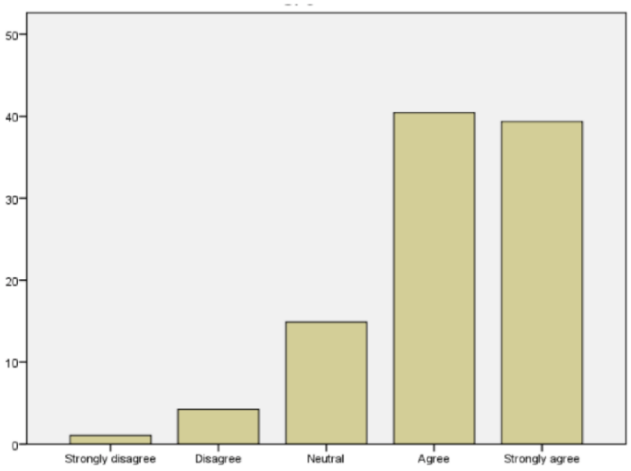


		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Disagree	2	2.1	2.1	2.1
	Neutral	16	17.0	17.0	19.1
	Agree	49	52.1	52.1	71.3
	Strongly agree	27	28.7	28.7	100.0
	Total	94	100.0	100.0	

Figure 10: CP2

For Figure 10, Candle Luminosity/Light – CP2 (Likert Scale): "The light is consistent and sufficient for simple tasks like reading or as a corner light in the room," the chart shows the respondents' perception of the candle's brightness and usability as a light source. The majority, 49 respondents (52.1%), agreed that the candle's light was adequate for basic activities, while 27 respondents (28.7%) strongly agreed. Meanwhile, 16 respondents (17%) remained neutral, and only 2 respondents (2.1%) disagreed.

Smoke Risk - CP3
"No excessive smoke is emitted during use."



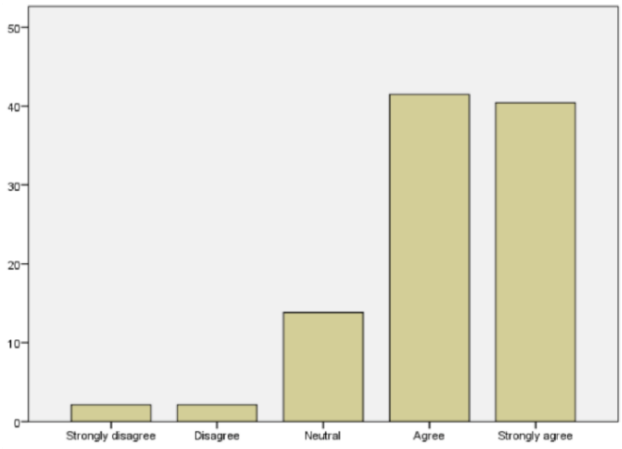
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly disagree	1	1.1	1.1	1.1
	Disagree	4	4.3	4.3	5.3
	Neutral	14	14.9	14.9	20.2
	Agree	38	40.4	40.4	60.6
	Strongly agree	37	39.4	39.4	100.0
	Total	94	100.0	100.0	

Figure 11: CP3

For Figure 11, Smoke Risk – CP3 ("No excessive smoke is emitted during use"), most respondents reported minimal smoke: 38 (40.4%) agreed and 37 (39.4%) strongly agreed, while 14 (14.9%) were neutral, 4 (4.3%) disagreed, and 1 (1.1%) strongly disagreed. Overall, findings from CP1, CP2, and CP3 indicate that the candle performed well in scent, luminosity, and smoke emission. Most respondents found the fragrance pleasant, light output sufficient for indoor tasks, and smoke emission minimal. These results suggest that the candle meets user expectations for sensory appeal, functionality, and safety, effectively balancing aesthetic quality and practical performance.

Practicality and Safety

Safety - PS1
"Safe to use at home"

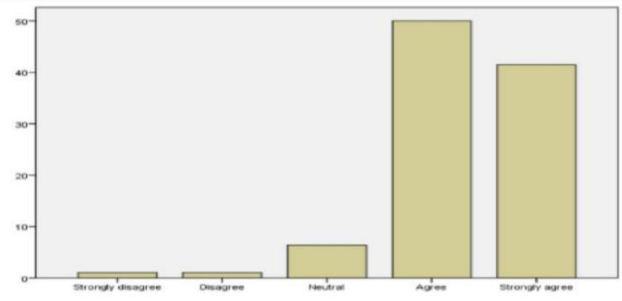


		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly disagree	2	2.1	2.1	2.1
	Disagree	2	2.1	2.1	4.3
	Neutral	13	13.8	13.8	18.1
	Agree	39	41.5	41.5	59.6
	Strongly agree	38	40.4	40.4	100.0
	Total	94	100.0	100.0	

Figure 12: PS1

For Figure 12, Safety – PS1 (Likert Scale): "Safe to use at home," the chart presents the respondents' perception of the candle's safety during household use. The majority, 39 respondents (41.5%), agreed that the candle is safe for home use, while 38 respondents (40.4%) strongly agreed. Meanwhile, 13 respondents (13.8%) remained neutral, 2 respondents (2.1%) disagreed, and 2 respondent (2.1%) strongly disagreed.

Efficiency During Power Interruptions - PS2
"I believe this candle could be useful during future power outages in my household."

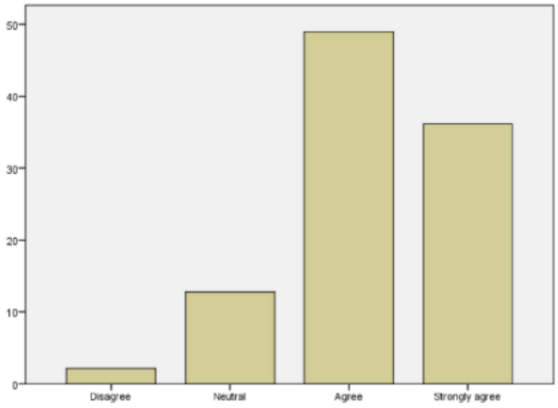


		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly disagree	1	1.1	1.1	1.1
	Disagree	1	1.1	1.1	2.1
	Neutral	6	6.4	6.4	8.5
	Agree	47	50.0	50.0	58.5
	Strongly agree	39	41.5	41.5	100.0
	Total	94	100.0	100.0	

Figure 13: PS2

For Figure 13, Efficiency During Power Interruptions – PS2 (Likert Scale): "I believe this candle could be useful during future power outages in my household," the chart displays the respondents' perception of the candle's practicality as an emergency lighting option. The majority, 47 respondent (50%), agreed that the candle would be beneficial during power outages, while 39 respondents (41.5%) strongly agreed. Only 6 respondents (6.4%) remained neutral, and one disagreed or strongly disagreed.

Environmental Safety Over Commercial Candle - PS3
"This candle is safer for the environment over improvised lighting (e.g., kerosene lamp, open oil lamp during outages."

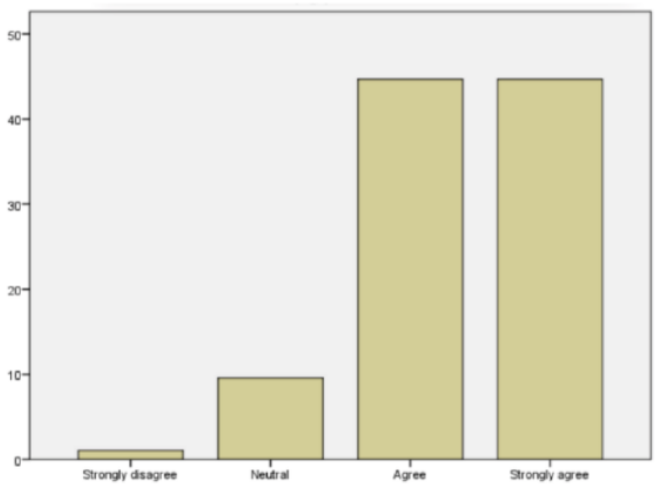


		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Disagree	2	2.1	2.1	2.1
	Neutral	12	12.8	12.8	14.9
	Agree	46	48.9	48.9	63.8
	Strongly agree	34	36.2	36.2	100.0
	Total	94	100.0	100.0	

Figure 14 : PS3

For Figure 14, Environmental Safety Over Commercial Candle – PS3 (Likert Scale): "This candle is safer for the environment over improvised lighting (e.g., kerosene lamp, open oil lamp) during outages,"the chart presents the respondents' perception of the candle's environmental safety and sustainability. The majority, 46 respondents (48.9%), agreed that the candle is a safer and more eco-friendly option compared to improvised lighting sources, while 34 respondents (36.2%) strongly agreed. Meanwhile, 12 respondents (12.8%) disagreed, and only 2 respondents (2.1%) strongly disagreed.

Affordability - PS4
"The candle seems affordable compared to store-bought candles."



		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly disagree	1	1.1	1.1	1.1
	Neutral	9	9.6	9.6	10.6
	Agree	42	44.7	44.7	55.3
	Strongly agree	42	44.7	44.7	100.0
	Total	94	100.0	100.0	

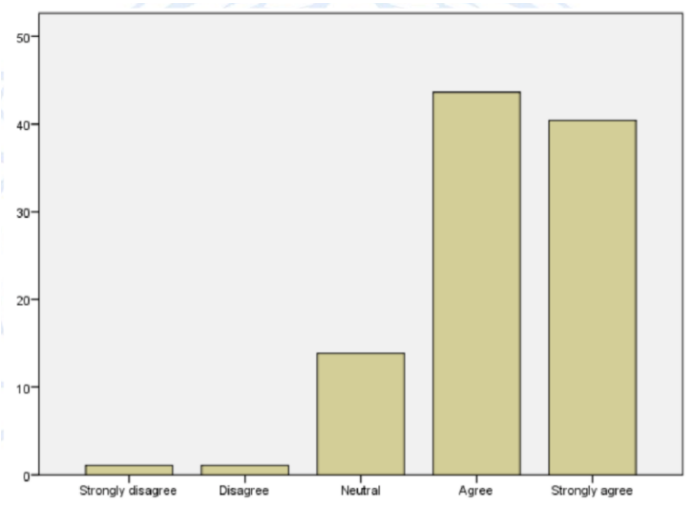
Figure 15: PS4

For Figure 15, Affordability – PS4 (Likert Scale): "The candle seems affordable compared to store-bought candles," the chart illustrates the respondents' perception of the product's cost-effectiveness. The majority, 42 respondents (44.7%), agreed that the candle is affordable, while another 42 respondents (44.7%) strongly agreed. Meanwhile, 9 respondents (9.6%) remained neutral, and only 1 respondent (1.1%) strongly disagreed.

Overall, the results indicate that the candle was positively received in terms of safety, practicality, environmental friendliness, and affordability. Respondents perceived it as safe, with minimal fire risk and stable burn performance, and dependable during power interruptions, providing sufficient illumination. Its eco-friendly advantages over improvised lighting sources were also recognized, along with its cost-effectiveness compared to store-bought candles. In conclusion, the candle demonstrates a balanced combination of safety, efficiency, sustainability, and affordability, making it a reliable household lighting option.

Recommendability

Recommendability - R1
"I would recommend this candle"



		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly disagree	1	1.1	1.1	1.1
	Disagree	1	1.1	1.1	2.1
	Neutral	13	13.8	13.8	16.0
	Agree	41	43.6	43.6	59.6
	Strongly agree	38	40.4	40.4	100.0
	Total	94	100.0	100.0	

Figure 16: R1

For Figure 16, Recommendability – R1 (Likert Scale): "I would recommend this candle," the chart shows the respondents' overall perception of the product's quality and reliability. The majority, 41 respondents (43.6%), agreed that they would recommend the candle, while 38 respondents (40.4%) strongly agreed. Meanwhile, 13 respondents (13.8%) remained neutral, and only 1 respondent (1.1%)disagreed and 1 respondent (1.1%) strongly disagreed.

Concerns- R2
"Main safety concerns/ concern in general"

While most respondents found the candle feasible, safe, and practical, a few raised concerns. Safety issues included accidental burns, particularly around children ("pag natumba baka may natamaan"; "may not be safe if you have kids"). Minor usability issues were noted, such as container heating ("umiinit lalagyan"), wick residue ("may burnt particles kapag nasusunog"), and the candle's oily appearance. Practical limitations were also mentioned, including limited availability of used oil ("wala masyado used oil sa amin dahil hangga't maubos ginagamit"). Although these concerns were limited, they provide valuable guidance for improving formulation, container safety, and overall usability without affecting the candle's generally positive reception.

Suggestions - R3
Regarding recommendability, respondents expressed general satisfaction with the candle's performance and base, with no critical comments. Suggestions focused on aesthetics, such as using attractive containers, adding designs or decorations, and creating themed sets with varied scents. Appreciation was also noted for eco-friendly materials, like the abaca wick.

Overall, the candle was well received, with most respondents satisfied with its safety, functionality, and cost-efficiency. Minor concerns regarding heat, residue, and material availability did not affect overall perception. These findings indicate that the candle is highly recommendable as a reliable, practical, and eco-friendly household lighting option.

DISCUSSION

ANALYSIS OF DATA

Burn Time

Used cooking oil–based candles exhibited stable flames with burn times ranging from 4 h 47 min to 5 h 12 min (mean: 4 h 59 min), burning efficiently without unnecessary extinguishing. Compared to a similar-mass paraffin candle (3 h 12 min; Cheng, 2023), the used oil candles demonstrated longer and more efficient burn performance. These results align with studies emphasizing the influence of fuel type, wick size, and candle base on burn efficiency (Kral, 2014; Candle Science, 2021; Salthammer et al., 2021; Question About Olive Oil Candle Burn Time, 2025; Bulk Lamp Oil, n.d.). Overall, recycled cooking oil enhanced burn efficiency while adhering to standard combustion principles.

Cost Analysis

Production cost analysis revealed strong economic advantages. A 16 g candle cost ₱9.28, while a 94 g candle cost ₱37.55. The base material cost was ₱249.50/kg for used oil wax, compared to ₱369/kg for paraffin, reflecting a 48% reduction and ₱119.50 savings. These findings align with studies highlighting raw materials as major cost drivers (Team, 2025) and support evidence that waste cooking oil lowers expenses due to accessibility and minimal processing (Liu et al., 2022; Fischer, 2025). This contradicts claims that sustainable materials inherently increase costs (Bung, 2025). Overall, recycled cooking oil enables cost-effective and sustainable candle production.

Familiarity

Respondents showed limited familiarity with homemade and recycled oil-based candles. Flashlights were the primary emergency lighting source, followed by commercial candles, homemade candles, and solar lights. Most disposed of used oil through sinks or garbage, indicating low awareness of proper disposal. These trends align with Santos (n.d.), Kamalov (2024), and Abrajano et al. (2023), who reported inconsistent public engagement and widespread improper disposal. While Herzog (2023) emphasized electric-based dominance, candles remained accessible in this setting, highlighting opportunities for awareness and sustainability education.

Candle Performance

Used cooking oil candles demonstrated effective scent diffusion, consistent brightness, and minimal smoke, providing functional and sensory satisfaction. Respondents reported noticeable fragrance, stable illumination suitable for indoor use, and clean burning. These results align with studies on fuel type and fragrance composition effects (Karla, 2025; Egan, 2024; PMC, 2022) and confirm the psychological benefits of scented candles (Sowndhararajan & Kim, 2016; Putri & Putri, 2024). Findings also support combustion efficiency standards emphasizing base material and wick design (Salthammer et al., 2021; Candle Science–NCA, 2021). Overall, recycled cooking oil proved to be a high-performing, sustainable candle base.

Practicality and Safety

Respondents rated the candles as safe, practical, affordable, and environmentally beneficial, citing stable flames, low smoke, and reliability during power outages. Compared to kerosene lamps, the candles were safer and more eco-friendly. These findings align with circular economy studies demonstrating that refined WCO produces safe, durable, and clean-burning candles (Community Circular Economy Projects, 2024; Anggraini & Kurniasih, 2024; Kamalov, 2024; Liu et al., 2022). Contrary to claims of higher costs for sustainable candles (Team, 2025; Bung, 2025), this formulation proved economical and accessible, supporting household adoption.

User Satisfaction and Recommendability

Overall satisfaction was high, with respondents expressing strong willingness to recommend the product. Positive feedback centered on safety, performance, affordability, and sustainability, while suggestions focused on aesthetics, container safety, and scent variety. These results reflect broader market trends favoring eco-friendly, scented candles, where over 75% of consumers prioritize aroma and emotional appeal (Herz et al., 2022; GVR, 2023; Scented Candles Market Report, 2030). The findings indicate strong acceptance and market viability for recycled oil-based candles.

CONCLUSION

This study entitled, "Investigating the Viability of Recycled Cooking Oil as a Base for a Sustainable Emergency Light Source through Eco-friendly Scented Candles," explored recycled cooking oil as a safe, practical alternative to paraffin wax, drawing on Combustion, Aromatherapy, Consumer Behavior, and Circular Economy Theories.

The study utilized a quantitative experimental design to evaluate recycled cooking oil as a base material for eco-friendly emergency candles. The candles were produced through a six-step process involving filtration of used palm oil, blending with stearic acid, heating, fragrance incorporation, pouring into containers with secured wicks, and curing at room temperature under controlled conditions. Burn time was tested on three 16-gram samples, production cost was computed from material expenses, and subjective data were collected through a Likert-scale survey administered to 94 randomly selected households from Gawad Kalinga, Barangay Salian, Abucay, Bataan. Descriptive statistics and direct comparisons with a paraffin candle were used for analysis.

Results showed that the recycled-oil candle burned longer (4 hours and 59 minutes) than a paraffin candle of the same mass (3 hours and 12 minutes) and was 48% cheaper to produce, demonstrating superior fuel efficiency and affordability. Survey responses indicated high satisfaction in scent diffusion, light quality, safety, practicality, and environmental value, with only minor concerns regarding container heat and material sourcing. Most respondents recommended the product.

Based on both objective and subjective findings, the null hypothesis was rejected, confirming significant differences in performance, cost, and user perception between recycled-oil and paraffin candles. Overall, the study concludes that recycled cooking oil is a viable, cost-effective, and sustainable base for eco-friendly emergency candles, promoting waste reduction and sustainable household practices.

The study therefore concludes that recycled cooking oil is a viable base for an eco-friendly emergency candle: it delivers longer burn time, lower material cost per unit, and favorable user perception regarding practicality and environmental value.

RECOMMENDATION

Product Recommendations

- Explore other types of used cooking oil beyond palm oil to improve burn stability, scent diffusion, and consistency.
- Standardize the oil-to-solidifier ratio, wick size, and container type for uniform performance and appearance.
- Use heat-resistant containers and proper wick placement to enhance safety and burn efficiency.
- Adjust the oil-to-solidifier ratio or increase stearic acid to reduce greasy surface residue and improve candle firmness.
- Improve texture and color using natural stabilizers or colorants.
- Optimize wick performance by testing different materials and thicknesses (e.g., cotton, hemp, wood).
- Partner with local food establishments to collect used cooking oil for sustainable and community-based production.
- Use eco-friendly packaging such as recycled glass jars and biodegradable labels.
- Obtain safety and environmental certifications before commercialization.
- Encourage households and communities to collect and repurpose used cooking oil instead of discarding it.

Research Paper Recommendations

- Conduct chemical and emission analyses to assess combustion by-products and environmental impact.
- Compare different oil purification methods to determine the most effective process for candle production.
- Study candle durability, storage stability, and scent retention under varying environmental conditions.
- Perform economic feasibility and life-cycle assessments to evaluate scalability and sustainability.
- Include a larger respondent sample to improve statistical reliability.
- Apply interdisciplinary approaches combining chemistry, environmental science, and business studies for broader validation.

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FROM SHELL TO CARRY: THE DEVELOPMENT OF A BIO COMPOSITE BAG USING OYSTER SHELL WASTE

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ABSTRACT

This study aims to develop and evaluate a bio composite bag derived from oyster shell waste as a sustainable alternative to conventional eco bags. By addressing plastic pollution alongside shell waste accumulation, the research employed a product-based quantitative design that combined laboratory experimentation with user evaluation. Oyster shells collected from Samal, Bataan were thoroughly cleaned, dried, pulverized, and processed before being blended with biodegradable components such as agar-agar, glycerin, and vinegar to produce bio-leather samples. These samples were fabricated into prototype materials and systematically compared with regular eco bags using mechanical tests that measured durability, flexibility, and overall material performance. The findings revealed that the oyster-shell-based bio-leather demonstrated promising strength and flexibility, indicating its potential as a functional material. However, the results also showed that further refinement of the formulation and production process is necessary for the material to perform as a fully effective substitute for existing commercial eco bag materials. Anchored in the principles of waste valorization, green chemistry, and life cycle thinking, the study emphasizes the conversion of local waste resources into value-added products. Overall, the research highlights the viability of utilizing oyster shell waste to support sustainable innovation, reduce environmental burdens, and encourage the development of eco-friendly materials that align with responsible production and consumption practices. The study also suggests future work involving long-term usability testing, improved processing techniques, and broader environmental assessments to strengthen material reliability, scalability, and acceptance for potential application in community-based production and sustainable packaging initiatives within local circular economy frameworks and educational contexts.

Keywords: Oyster shell waste, bio-composite bag, bio-leather, sustainable materials, waste valorization, green chemistry, circular economy, eco-friendly packaging, biodegradable materials, product development.

INTRODUCTION

In recent years, solid waste has become one of the most pressing environmental problems globally. Two major contributors are plastic waste, which is non-biodegradable and can persist in the environment for hundreds of years, and shellfish waste, which accumulates in large quantities from aquaculture and seafood industries. Improper disposal of these wastes not only threatens ecosystems and human health but also represents a missed opportunity for resource recovery and sustainable development.

Recent developments in materials science have shown that agricultural and natural waste can be incorporated into biodegradable plastics to create practical and eco-friendly materials. This study focuses on oyster shells, a widely available and often overlooked resource, especially in coastal areas. The goal is to explore their potential as a component in bioplastics that could serve as a sustainable alternative to conventional plastics.

Plastic pollution remains a major global environmental issue. Large amounts of plastic waste accumulate in landfills and water bodies, persisting for centuries and contributing to pollution, harm to marine life, and potential human health risks. Similarly, aquaculture and seafood industries generate vast quantities of oyster shell waste, much of which is discarded along coastlines or in dumps without proper management. Although these wastes are often treated separately, they present an opportunity for an integrated, eco-friendly solution.

This study is based on the principle of turning waste into useful products. Oyster shells, primarily composed of calcium carbonate ($CaCO_3$), may serve as a valuable bio-filler in bioplastics. Unlike conventional plastics, bioplastics are derived from renewable resources and are designed to biodegrade more readily. Incorporating shell powder can improve material strength and environmental performance.

The study is grounded in resource recovery and waste valorization. By using oyster shells as a bio-filler, the research explores how biodegradable polymers can be enhanced while reducing reliance on non-renewable materials. Recent advances have shown that natural fillers can improve both the physical and mechanical properties of bioplastics, supporting environmental sustainability.

Global data indicate that over 5 million metric tons of oyster shells are discarded each year, while plastic production exceeds 390 million tons (UNEP, 2022). Despite prior studies on shell powder in composites, few have fully developed and evaluated a bioplastic product using oyster shells, particularly one that meets basic standards for packaging or other practical applications.

Statement of the Problem

Environmental problems caused by waste accumulation have become increasingly complex, particularly plastic pollution and the improper disposal of shellfish waste. Petroleum-based plastics are highly resistant to decomposition, causing them to persist in the environment for long periods. This leads to the formation of microplastics that contaminate soil and water, threaten wildlife, and pose risks to human health.

At the same time, the growth of aquaculture and seafood processing industries has resulted in large volumes of discarded oyster shells. When poorly managed, these shells are often dumped in landfills or coastal areas, creating sanitation issues and harming marine ecosystems. Despite being organic, oyster shells represent an underutilized resource with potential value.

While previous studies have examined biodegradable plastic alternatives and the use of oyster shell powder as a bio-filler, limited research integrates both issues into a single solution. There is a lack of studies focused on developing bioplastics that combine biodegradable polymers with processed oyster shells while systematically evaluating their physical, mechanical, and biodegradability properties.

This study aims to address the following key research questions:
Can oyster shell waste be effectively processed and integrated with biodegradable polymers to form a bioplastic material?
What are the mechanical properties of bioplastic samples made from oyster shells?

How does the biodegradability of oyster-shell-based bioplastic compare to conventional plastics?
What is the potential of these materials to serve as an eco-friendly alternative for applications such as packaging?

By focusing on these questions, the study seeks to contribute to a growing area of research that attempts to transform waste into a resource, providing a dual solution to the challenges of plastic pollution and oyster shell disposal.

Hypothesis

It is hypothesized that incorporating oyster shell powder into a biodegradable polymer will enhance the bioplastic's mechanical strength and durability. The material is expected to achieve tensile and flexural performance comparable to commercial plastic bags while remaining biodegradable. The calcium carbonate is predicted to act as a reinforcing filler, increasing stiffness and tensile strength without greatly reducing flexibility.

Objectives

To develop and characterize a bioplastic material using oyster shell waste as a primary component combined with biodegradable polymers, here are the specific objectives:

Specific Objectives

To process and prepare oyster shell waste into fine powder suitable for composite applications.
To fabricate bioplastic samples and evaluate their mechanical properties.
To compare the properties of the developed bioplastic/bio leather with conventional petroleum-based plastics and eco bags.
To assess the potential of oyster shell-based bioplastic as an environmentally sustainable material for packaging and related applications.

Significance of the Study

This research holds significance across environmental, industrial, academic, and societal levels. From an environmental perspective, it promotes sustainable waste management and helps reduce plastic pollution. In terms of industry, it encourages the development of eco-friendly products and demonstrates the potential of alternative, sustainable materials. Academically, the study provides valuable insights for future research in science, technology, and material innovation. On a societal level, it raises awareness of environmental challenges and encourages responsible consumption and production practices for a greener future.

Environmental Perspective. From an environmental perspective, this study aims to address issues caused by plastic waste and unmanaged oyster shell waste. By utilizing biodegradable polymers and oyster shell powder, the research supports a sustainable economy where waste materials are reintegrated into the production cycle instead of harming the environment. The development of a biodegradable alternative also reduces dependence on plastic-based materials, which contribute to greenhouse gas emissions and long-term ecological damage.

Industries. Particularly in packaging, manufacturing, and materials science, this study offers potential access to a sustainable alternative to conventional plastics. Such an alternative could lower raw material costs by making use of inexpensive and readily available shell waste while also enhancing a company's ability to meet sustainability goals.

Policy and Waste Management Perspective. The study provides scientific insights that can guide the creation of sustainable waste management programs. Government agencies and environmental organizations can use the findings to encourage recycling and valorization of shellfish waste rather than simple disposal.

Academic and Research Community. This study contributes to existing research on biodegradable composites and bio-fillers by supporting waste-to-resource initiatives. It provides useful data that future researchers can reference and encourages collaboration among fields such as environmental science, materials engineering, and biotechnology.

Society. The study is significant to society as it addresses major issues of pollution and waste management. By promoting a biodegradable material derived from oyster shell waste, it supports the development of environmentally responsible practices. If further developed, this innovation could help reduce plastic waste, protect ecosystems, and promote cleaner living environments.

In conclusion, this research aims to help lessen plastic pollution by creating biodegradable plastic from oyster shells, which are usually treated as waste. It hopes to offer a more eco-friendly option for plastic use and encourage industries to explore sustainable materials. This study may also serve as a helpful reference for future student researchers working on similar environmental problems. Most importantly, it promotes awareness about the importance of reducing waste and finding creative solutions that can benefit both

people and the planet.

Scope and Delimitations

This study aims to address the growing need for sustainable alternatives to conventional plastics by developing a biodegradable plastic prototype using oyster shells as the primary material. Specifically, it involves the collection, processing, and laboratory testing of the material's durability and flexibility, with the goal of demonstrating the potential of oyster shells as an eco-friendly option for plastics and eco bags.

However, the scope of the study is limited to small-scale production and does not extend to commercial manufacturing, long-term environmental impact assessment, or detailed cost analysis. Furthermore, the research does not include comparisons with a broad range of commercial plastics and is constrained by the time, budget, and resources available to the student researchers.

Definition of Terms

Polymer. A large molecule made of repeating units called monomers. In this study, the polymer acted as the main base material of the bioplastic film and provided the structure that held all components together.

Bio-filler. A natural material added to improve the strength of a product. A bio-filler derived from waste oyster shells was used to enhance the mechanical properties of the bioplastic.

Calcium Carbonate ($CaCO_3$). A natural compound obtained from oyster shells and used as a reinforcing filler in this study. Calcium carbonate was added to the bioplastic mixture to increase its strength and stiffness.

Tensile Strength. The maximum amount of pulling force a material can withstand before breaking. Tensile strength was measured to determine how strong the bioplastic film was when stretched.
Flexural Strength. The ability of a material to resist bending without breaking. This property was tested to evaluate how well the bioplastic film could withstand bending or applied loads.

Bioplastic Film. A thin and flexible sheet made from renewable biological materials. The bioplastic film was produced using a polymer, glycerin, and calcium carbonate derived from oyster shells as an alternative to conventional plastics.

Glycerin. A substance added to improve flexibility and reduce brittleness. In this study, glycerin acted as a plasticizer, allowing the bioplastic film to bend and stretch more easily.

REVIEW OF RELATED LITERATURE

Bioplastics are emerging as a promising alternative to petroleum based plastics due to their biodegradable structure and reduced ecological impact. Material such as Bivalve shells (oyster shells), that are rich in calcium carbonate are being repurposed as fillers to improve the properties of biodegradable plastics.

Bio-Based Plastics and Fillers
Wu et al (2021) developed composites of polyhydroxyalkanoate with natural fibers and waste oyster shell powder, achieving enhanced thermal stability, antimicrobial functionality, and successful material integration suitable for biodegradable packaging applications.

According to Wang et al. (2023), their composite film demonstrated strong antimicrobial activity two bacteria that can cause infections of the skin and soft tissues, like E.coli and it also achieved a 12.35% increase in tensile strength, a 15.2% reduction in water vapor permeability, and an 80% decrease in UV-B transmittance.

In the Philippines, Lopez and Santiago (2021) demonstrated the feasibility of using eggshell powder as a reinforcing filler in biodegradable plastics. Their study showed that adding eggshell powder improved the material's strength, effectiveness, and compostability. These results highlight the potential of calcium-rich food waste for sustainable bioplastics and suggest similar opportunities for oyster shells. Overall, their work emphasizes how combining waste management with green material science can address pollution while creating valuable products.

Park et al. (2021) examined the synthesis of composite films of ethylene-vinyl acetate (EVA) and linear low-density polyethylene (LLDPE) with calcined oyster shell-derived calcium carbonate ($CaCO_3$) as a filler. They aimed to assess the viability of using calcium-rich marine biowaste in polymer composites, particularly in the Philippine setting where oyster shells are abundant. The results showed that adding biogenic $CaCO_3$ improved mechanical properties like tensile strength and stiffness and provided a cost-effective, eco-friendly alternative for industrial applications. Their study underscores the potential of oyster shells as a green filler while supporting waste valorization and eco-efficient composite development.

To address environmental problems such as plastic pollution and straw burning, Xiao et al. (2020) proposed a diversified waste recycling system and green processing technology. Their study highlighted the conversion of plastic, straw, and oyster shells into both low-cost and high-performance materials suitable for eco-friendly packaging. It demonstrated sustainable approaches for transforming waste into valuable products while tackling multiple environmental challenges.

Garcia et al. (2020) researched the application of sugarcane bagasse and starch in bioplastic production, stating its low cost and biodegradability for packaging applications in the Philippines.

Local Studies on Bioplastics in the Philippines

In the Philippines, Luna et al. (2022) blended banana peel starch with cornstarch to formulate bioplastic films with sufficient tensile strength and good water resistant properties that make them promising for packaging materials.

The study by Austria et al. (2023) explored the viability of starches from cassava, potato, and purple yam as raw materials for bioplastic production. Their findings showed that the most
durable and flexible bioplastics, highlighting the influence of starch source on material performance.

In their comparative study, Garcia & Santos (2020) found that cassava starch based bioplastics degraded more rapidly and yielded only minimal residue compared with commercial plastics that indicates a reduced environmental impact.

Villanueva and Ramos (2021) studied bioplastics derived from seaweed using carrageenan extracted from red algae. Their research demonstrated excellent film-forming capabilities, improved mechanical and thermal properties, and antimicrobial effects, highlighting potential for eco-friendly packaging.

Similarly, Andao, Aduca, and Jimenez (2020) developed a starch-based bioplastic reinforced with golden apple snail shell chitosan, showing enhanced water resistance and slower degradation compared to unreinforced bioplastics. These studies emphasize the importance of raw material selection and reinforcement in improving environmental and mechanical performance. A local study by the Department of Science and Technology (DOST, 2021) explored sago starch-based bioplastics, noting their industrial potential due to local abundance.

Waste Valorization and Shell-Based Fillers

Recent studies have explored using shell and agricultural waste for sustainable materials. Popović et al. (2023) examined shell waste management to mitigate organic pollution and enhance sustainability, highlighting strategies and challenges in reutilization. Eziwhuo et al. (2023) investigated biodegradable brake pads made from coconut fiber and oyster shells as asbestos alternatives, demonstrating performance comparable to standard pads and reinforcing the concept of waste valorization.

Marine and Ecological Applications

Sakr et. al (2025), shared their viewpoint in their recent conducted study about evaluating the performance and ecosystem functionality of alternative oyster garden structures in residential waterways in Florida, USA. Their study highlighted the idea of a change in the garden, conducted an experiment in a constructed canal system on Sanibel Island, a barrier island. This approach provides a comprehensive view of the structures' viability by documenting their initial success, their response to a major environmental disturbance, and their ability to recover. The addition of this experiment strengthens the study's purpose and objective.

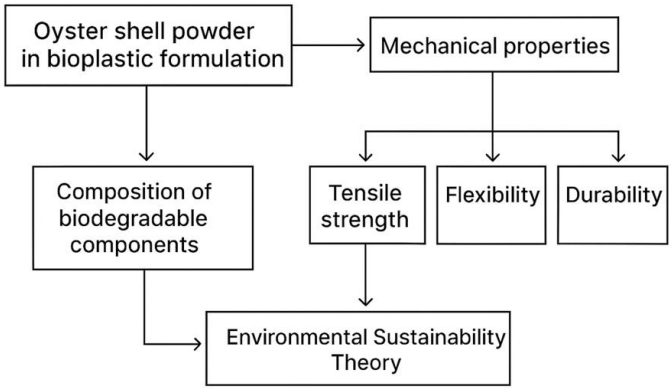
A study concluded by Yang et. al (2024), who examined utilizing recycled pumice and oyster shell waste for cost-effective treatment, to mitigate pollutants and toxicity in swine wastewater. Moreover, in regards to obstacles such inadequate wastewater management leads to excessive metals and organic matter, causing environmental impacts on aquatic and terrestrial ecosystems their research reasserted the need for environmental sustainability. Their study concluded into recycled waste pumice and oyster shells for the cost-effective treatment and reclamation of swine wastewater.

Theoretical Framework

This study is grounded in the Theory of Waste Valorization, which emphasizes transforming waste into higher-value products. Oyster shells, often discarded in coastal areas, are treated as a valuable raw material, promoting resource recovery and sustainable innovation. The research is also guided by the Principles of Green Chemistry, emphasizing renewable feedstocks, safer product design, and waste reduction, aligning with environmentally responsible material development.

Furthermore, the Life Cycle Thinking Framework provides a perspective on environmental impact from sourcing to disposal, ensuring the bioplastic performs effectively while decomposing safely and supporting a circular economy. Together, these frameworks justify the use of oyster shells in biodegradable plastics and guide the study toward innovative and sustainable solutions.

Conceptual Framework



This study is based on the idea that waste materials can be transformed into sustainable, eco-friendly products through scientific innovation. It focuses on using oyster shell waste—rich in calcium carbonate ($CaCO_3$)—as an additive in biodegradable plastic, examining its impact on mechanical properties such as strength, flexibility, and durability. This aligns with the principle of waste valorization, which promotes converting discarded materials into valuable resources.

The framework assumes that varying the proportion of oyster shell powder affects the bioplastic's mechanical characteristics. The study aims to determine the optimal formulation for maximum strength and flexibility while maintaining biodegradability. It also compares the developed material with commercial eco-bags to assess its potential as a sustainable alternative.

Guided by the Environmental Sustainability Theory and the Circular Economy Model, the study emphasizes reducing plastic waste through recycling and the reuse of natural resources. By linking waste recycling, scientific formulation, and product evaluation, it demonstrates how innovation and sustainability can work together to address plastic pollution.

Overall, the framework illustrates the relationship between the independent variables (oyster shell powder ratio and additive composition) and the dependent variables (mechanical properties and biodegradability), showing how sustainable material development can contribute both scientifically and environmentally to reducing plastic waste.

METHODS AND DESIGN

This study uses an experimental design to investigate the development and performance of biodegradable plastic using oyster shell waste. This is an approach to provide an alternative method which enables the appraisal of plastic from oyster shells and observe their effects on the physical, mechanical, and biodegradability properties of the bioplastic.

Experimental design enables controlled testing of hypotheses and comparison between different formulations. Laboratory testing will

be used to evaluate mechanical and chemical properties compared to conventional plastics and other bioplastics. The process involves collecting oyster shells, processing them into calcium carbonate, integrating them with biopolymer-forming substances (e.g., starch or polylactic acid), and assessing the resulting material's biodegradability, tensile strength, and environmental impact.

The focus of this study was on identifying suitable plastic for the waste disposal problem conditions affecting the environment. Based on the domestic wastes of plastic, which need to be non-toxic substances, not producing dioxins and be biodegradable and hydrolysable, we verified marine waste oyster shell plastic (Shu-Yao Tsai, 2021).

STEP	PROCEDURE	FIGURE
Preparation	Crush the oyster shells into powder form by using a hammer to smash or a blender to pulverize.	
	Set up all the necessary ingredients that are needed in making the product.	
Mixing of the ingredients	Mix water (600ml), glycerin (250ml), white vinegar (350ml), agar-agar (75g), and oyster powder (⅛ cup) while the stove is not turned on to insure that there is no clumps of ingredients in the mixture.	
Boiling	Let the mixture simmer for about 1-2 minutes or until the mixture is viscous while mixing.	
Pouring into the mold	Pour the mixture into the mold and let it set for 1-2 minutes before putting the bioplastic mixture into the oven.	
Drying Process	Pour the mixture into the mold and let it set for 1-2 minutes before putting the bioplastic mixture into the oven.	

Formula Testing

Item	Quantity Used
Water	120 ml
Cornstarch	¼ cup or 30 g
Glycerin	1 ½ tbsp or 7.5ml
Coconut oil	1 tbsp or 5 ml
Oyster Shell Powder	¼ cup or 30 g

Table 1. Results of Test 1 – Thick Formula with High Oyster Shell Content (Air-Dried)
In this first test, a large amount of oyster shell powder was added, making the formula thick and heavy. The mixture took a very long time to air dry, and once fully dried, it became brittle and broke easily.

The excess amount of oyster shell powder made the bioplastic too hard and inflexible, which prevented it from forming a stable structure. After four days, mold appeared on the surface, likely caused by the long drying time that allowed moisture to remain trapped inside.This test showed that too much oyster shell powder can make the bioplastic difficult to dry and overly brittle.

Item	Quantity Used
Water	120 ml
Cornstarch	¼ cup or 31g
Glycerin	1 ½ tbsp or 7.5 ml
Coconut oil	1 tbsp or 5 ml
Oyster Shell Powder	¼ cup or 30 g

Table 2. Results of Test 2 – Same Formula as Test 1 (Oven-Dried)

The same mixture was used but oven dried to reduce drying time. While the product dried faster, the overall result was still unsatisfactory. The bioplastic developed cracks and a dry, rough texture like cracked soil. The high oyster shell content continued to make the sample stiff and fragile. Mold also appeared after several days, showing that the faster drying process did not fix the structural issues caused by excessive oyster shell powder. This test confirmed that the quantity of oyster shell powder strongly affects flexibility and overall quality, regardless of drying method.

Item	Quantity Used
Water	5 cups or 1,200 ml
Cornstarch	1/2 cup or 60 g
Glycerin	1/8 cup or 30 ml
Coconut Oil	½ tbsp 7.5ml
Food Coloring	3 drops
Oyster Shell Powder	¼ cup or 30 g

Table 3. Results of Test 3 – Thinner Formula with Coconut Oil (Air-Dried)

This version used less oyster shell powder, producing a thinner and more flexible material. The bioplastic dried properly and held its shape, showing that the formula was more balanced. However, the thinness of the layer made it less durable and more prone to tearing.

The addition of coconut oil improved flexibility but made the product slightly greasy. Despite that, it did not develop mold, suggesting that the moisture content and drying time were well managed. This test showed that lowering the amount of oyster shell powder helps the material stay flexible and stable.

Item	Quantity Used
Water	200 ml
Gelatin	2 tbsp or 16 g
Glycerin	1 tbsp or 15 ml
Food Coloring	2 drops
Oyster Shell Powder	1 tbsp or 8 g

Table 4. Results of Test 4 – Balanced Formula, Air-Dried

The fourth test showed improved performance in molding and drying. The formula was more balanced, and the oyster shell powder helped maintain structure and form. However, after a longer air-drying period, mold started to form, indicating that extended exposure to air and humidity affected the material. While the oyster shell powder contributed to better texture and firmness, this test highlighted the need for a more controlled drying method to prevent contamination and maintain product stability.

Item	Quantity Used
Water	200 ml
Gelatin	2 tbsp or 30 ml
Corn syrup	1 tbsp or 15 ml
Food Coloring	2 drops
Oyster Shell Powder	1 tbsp or 9 g

Table 5. Results of Test 5 – Gelatin Base with Corn Syrup (Air-Dried)

Due to material shortage, this formula used corn syrup as a substitute for glycerin which is the plasticizer and tried gelatin as the base. The mixture did not solidify and remained very liquid, making it clear that the formulation was not compatible. The oyster shell powder did not mix well with gelatin and instead settled, leaving the material unstable. This showed that the mineral filler only works effectively with polymers that can properly bind with it, such as starch or agar, and not gelatin.

Item	Quantity Used
Water	200 ml
Gelatin	2 tbsp or 16 g
Corn syrup	1 tbsp or 15 ml
Vinegar	½ tbsp or 7.5 ml
Food Coloring	2 drops
Oyster Shell Powder	1 tbsp or 8 g

Table 6. Results of Test 6 – Gelatin Formula with Vinegar Added (Air-Dried)

The same formula from Test 5 was used, but vinegar was added to test if it could improve texture or hardening. The vinegar caused minor bubbling and texture changes, but the mixture still failed to solidify. The acetic acid in vinegar likely reacted with the calcium carbonate in the oyster shell powder, releasing carbon dioxide and breaking down the structure further. The result was a weak, watery mixture, showing that acidic additives reduce the effectiveness of oyster shell powder in bioplastic production.

Item	Quantity Used
Water	200ml
Gelatin	2 tbsp or 16 g
Corn syrup	1 tbsp or 15 ml
Vinegar	½ tbsp or 7.5 ml
Coconut Oil	½ tbsp or 7.5 ml
Food Coloring	2 drops
Oyster Shell Powder	1 tbsp or 8 g

Table 7. Results of Test 7 – Gelatin Formula with Coconut Oil Added (Air-Dried)

This test followed the same gelatin-based formula as the previous two but added coconut oil to see if it would affect the texture. The result was still not solid and remained soft, but the surface appeared smoother due to the oil. The coconut oil added slight flexibility but did not solve the issue of poor structure. The oyster shell powder had minimal effect since the gelatin base could not properly support it. This test showed that oil alone cannot fix a weak polymer foundation.

Item	Quantity Used
Water	200ml
Agar-Agar	2 tbsp or 16 g
Corn Syrup	1 ½ tbsp or 22.5 ml
Oyster Shell Powder	3 tbsp or 24 g

Table 8. Results of Test 8 – Agar-Agar Base with Corn Syrup (Oven-Dried)

In this test, agar-agar was used as the base with corn syrup as a plasticizer and oven-dried, resulting in a durable, properly solidified bioplastic; although the heat turned it deep brown and produced a coffee-like or tamarind-like scent, the oyster shell powder reinforced the structure for strength and firmness, while the corn syrup added slight stickiness, demonstrating its effectiveness in agar-based bioplastics.

Item	Quantity Used
Water	200ml
Agar-Agar	2 tbsp or 16 g
Corn Syrup	1 ½ tbsp or 22.5 ml
Vinegar	½ tbsp or 7.5 ml
Oyster Shell Powder	3 tbsp or 24 g

Table 9. Results of Test 9 – Agar Formula with Vinegar & Coconut Oil Added (Oven-Dried)

This test used the same agar-based formula as Test 8 but added vinegar and coconut oil. The oven-dried product remained durable and well-formed but became much stickier due to the coconut oil and vinegar combination. The acidic vinegar likely reacted with the oyster shell powder, slightly weakening the structure and increasing

surface tackiness. Like the previous test, the mixture naturally developed a deep brown color from the oven's heat and gave off a coffee- or tamarind-like smell. Despite the stickiness, this test still produced a strong bioplastic, showing that oyster shell powder remained effective even with minor chemical changes.

Item	Quantity Used
Water	600 ml
White Vinegar	2 tbsp or 30 ml
Glycerin	3 tbsp or 45 ml
Agar-agar	6 tbsp or 32 g
Oyster Shell Powder	⅛ cup or 15 g

Table 10. Results of Test 10 – Final and Most Successful Bio Leather Formula (Oven-Dried)

This test used the same agar-based formula as Test 8 but added vinegar and coconut oil. The oven-dried product remained durable and well-formed but became much stickier due to the coconut oil and vinegar combination. The acidic vinegar likely reacted with the oyster shell powder, slightly weakening the structure and increasing surface tackiness. Like the previous test, the mixture naturally developed a deep brown color from the oven's heat and gave off a coffee or tamarind-like smell. Despite the stickiness, this test still produced a strong bioplastic, showing that oyster shell powder remained effective even with minor chemical changes.

Throughout the series of ten tests, varying formulations were developed to observe how oyster shell powder affects the texture, durability, and overall performance of bioplastic and bio leather. The results showed that the amount of oyster shell powder had a major impact on the product's hardness and flexibility. Mixtures with too much oyster shell powder became rigid, brittle, and took longer to dry, while smaller amounts produced more flexible and workable materials. The tests also revealed that ingredient compatibility plays a key role — gelatin-based mixtures were unstable and failed to solidify, while agar-agar proved to be a more effective base for for forming strong and consistent bioplastics

Drying Method

The drying method influenced both appearance and stability. Air-dried samples often developed mold, while oven drying produced more durable results and naturally turned the material golden to deep brown without food coloring. Respondents noted a coffee- or tamarind-like scent, likely from heat-induced reactions. Overall, the final formula produced a flexible, leather-like material, demonstrating that oyster shell powder can strengthen sustainable bio leather, though further refinement is needed to improve durability and consistency.

Sampling Size

This study uses a purposive sampling method to determine the number of respondents who will evaluate the biodegradable plastic product made from oyster shells. Using Raosoft, an online sample size calculator, the researchers computed the number of respondents needed with a 5% margin of error to ensure the reliability and accuracy of the gathered data. Based on this computation, a total of 76 respondents will be selected to complete a descriptive Likert-scale survey assessing the product's appearance, usability, strength, and environmental potential.

The sample will consist of individuals with basic knowledge or experience relevant to sustainability and environmental issues.

The focus will be on one major potential user group:

●Employees of Colegio de San Juan de Letran–Bataan, especially in the Auxiliary Department, are the major potential users of the biodegradable plastic made from oyster shells because they are part of the institution that fosters its development and share in its vision. Their operations in maintenance, facility services, and logistics involve frequent plastic use for packaging, storage, and daily tasks. Implementing this eco-friendly alternative can significantly reduce non-biodegradable waste generated in these activities, directly supporting the school's environmental goals.

As daily users of plastic in offices, canteens, and events, they can directly benefit from and apply our sustainable alternative, helping reduce the school's environmental footprint. This aligns with Letran's motto, which promotes innovation, collaboration, and, most importantly, sustainability—values that our research embodies. By engaging Letran employees, we not only provide an eco-friendly solution but also strengthen a community-driven effort toward a greener campus.

Sampling Procedure

This study uses purposive sampling to collect oyster shells, which are the main raw material for the bioplastic. The shells will be gathered from nearby seafood restaurants, local wet markets, and vendors especially in the municipality of Samal in Bataan, where oysters are commonly sold and eaten.

The researchers will choose sources that regularly dispose of oyster shells to ensure a steady supply of materials needed for the study. The researchers will coordinate with local seafood vendors to collect discarded oyster shells that are typically thrown away after use. Only shells that meet the following criteria will be used: clean or easily cleanable, not chemically treated or artificially colored, unbroken or minimally damaged, and naturally sourced meaning that they are not from canned or imported oysters. This ensures the shells are safe and suitable for processing.

To maintain ethical and safe practices, the shells will be thoroughly washed, boiled, and dried to remove any remaining organic matter or contaminants before use in the formulation process. This sampling method helps promote sustainability by repurposing waste material, while also making use of resources that are easily accessible and available in the local community. It also supports the environmental goal of the study by reducing food industry waste.

Research Instrument

This product-based quantitative research utilizes both laboratory tools and a survey instrument to aid in the development, evaluation, and assessment of the biodegradable plastic made from oyster shells. The research instruments are divided into two main types:

Production and Testing Tools
These include laboratory equipment such as grinders (for crushing oyster shells), mixing bowls, heat sources (for processing the bioplastic), and molds for shaping. These tools help the researchers create consistent samples and gather accurate data on their performance.

Survey Instrument

To evaluate the final bioplastic product based on public or expert opinion, a Descriptive Likert-scale questionnaire will be used. This survey will be given to selected professionals (such as science teachers, environmental advocates, or industry experts), as well as potential users. The questionnaire will include rating-scale items (e.g., 1–5) to assess the bioplastic's appearance, functionality, sustainability, and overall potential as a plastic alternative. Open-ended questions may also be added to gather suggestions for improvement. The responses will be analyzed to support the product evaluation and guide possible enhancements.

Data Gathering Procedure

The data gathering process will be conducted in two stages: the experimental phase and the evaluation phase, corresponding to the research instruments used.

In the experimental phase, oyster shells will be collected and processed using laboratory tools such as scales, grinders, mixers, heating equipment, and molds. Bioplastic samples will be produced by combining oyster shell powder with other biodegradable materials following a standardized procedure. Key properties—thickness, flexibility, durability, and biodegradability—will be measured using calipers and observation sheets, with all results recorded in data tables for analysis.

In the evaluation phase, completed bioplastic samples will be assessed using a descriptive Likert-scale questionnaire given to science educators, environmental experts, and potential users. Respondents will rate appearance, usability, sustainability, and overall quality, while suggestions will help validate the product's potential and identify improvements.

By combining laboratory testing with user feedback, the study evaluates the bioplastic both scientifically and practically. Data from both phases will be organized in tables and charts for easy analysis, enhancing the reliability and relevance of the results.

Data Analysis

The data collected in this study will be analyzed using both quantitative and descriptive methods to comprehensively evaluate the effectiveness and potential of the biodegradable plastic developed from oyster shells.

For the experimental data, measurements of key physical properties—such as thickness, flexibility, durability, and biodegradability—will be systematically recorded in tables. These results will be analyzed using basic statistical tools, including mean, range, and percentage, to assess the consistency, reliability, and overall performance of the bioplastic samples. Observational notes will also be described in detail to identify visible strengths, weaknesses, and any notable variations among the samples.

Survey data obtained from the Likert-scale questionnaire will be subjected to statistical analysis to determine respondents' overall perceptions of the product. Mean scores and standard deviations will be calculated for criteria including appearance, usability, sustainability, and

overall quality. Open-ended feedback will be categorized and summarized to highlight recurring suggestions, concerns, and recommendations for improvement.

By integrating the findings from laboratory testing with user evaluation, the study aims to provide a thorough and balanced assessment of the bioplastic's technical performance, practical usability, and potential for real-world application, ensuring that both scientific and societal considerations are addressed.

Ethical Consideration
In terms of material sourcing, oyster shells will be collected only from willing vendors, local wet markets, and restaurants that have provided permission. The researchers will ensure that the shells are obtained from food waste that would otherwise be discarded, supporting the environmental goal of waste reduction. No live oysters or marine life will be harmed for the sake of the research. Additionally, proper sanitation will be practiced ensuring the safety of handling organic waste materials, in accordance with health and safety guidelines.

For the experimental phase, all processes will be conducted under the supervision of a research adviser and within school laboratory guidelines to ensure safe handling of equipment and chemicals. The team will use eco-friendly methods as much as possible and dispose of any waste materials responsibly, minimizing harm to the environment.

When conducting the survey or product evaluation, participants will be selected respectfully and ethically. Each respondent will be provided with a clear explanation of the study's purpose, the nature of the questions, and how their feedback will be used. Informed consent will be obtained, either verbally or in written form.

When conducting the survey or product evaluation, participants will be selected respectfully and ethically. Each respondent will be provided with a clear explanation of the study's purpose, the nature of the questions, and how their feedback will be used. Informed consent will be obtained, either verbally or in written form. All participation is voluntary, and participants will have the right to skip questions or withdraw from the activity at any time without penalty. No personally identifiable information will be collected, and all responses will remain anonymous and confidential.

In terms of data management, all collected information—whether quantitative test results or qualitative survey feedback—will be stored securely and used only for academic purposes. Data will not be manipulated or misrepresented, and results will be presented truthfully regardless of whether they support the hypothesis.

Lastly, the researchers commit to upholding academic integrity throughout the project. All sources will be properly cited to avoid plagiarism, and the final output will reflect the team's original work, critical thinking, and honest findings. The entire study will be

conducted with transparency, responsibility, and respect for both human and environmental welfare.

RESULTS

Presentation of Data

This section presents, analyzes, and interprets the data obtained from both experimental testing and survey responses, in accordance with the objectives of the study. The primary focus was on evaluating the bioplastic made from oyster shell powder, particularly in terms of its mechanical strength, thermal stability, water resistance, and biodegradability, in order to determine its potential as an eco-friendly alternative to conventional plastics.

Descriptive statistics, including frequency, percentage, mean, and standard deviation, were used to summarize respondents' evaluations and identify general trends in perceptions. The results indicated that the bioplastic exhibits moderate mechanical and thermal properties, low water

resistance, but high biodegradability, suggesting that the material is environmentally sustainable while requiring further improvements in durability and water resistance.

In addition, Spearman's Rank Correlation was employed to examine the relationships among the material's key properties. The analysis revealed that mechanical, thermal, and water-resistance properties are significantly correlated, whereas biodegradability remains consistently high regardless of changes in other characteristics. This finding indicates that modifications to improve physical performance do not compromise the bioplastic's eco-friendly quality.

All data are presented in organized tables accompanied by detailed discussions, providing a comprehensive understanding of the material's behavior. Through these descriptive and correlational analyses, the study highlights both the strengths and limitations of the bioplastic, demonstrating its overall potential for practical applications and sustainable packaging solutions.

Mechanical Properties

The mechanical properties refer to how strong, flexible, and durable the bioplastic is when pressure or force is applied. Checking this is important because it shows if the oyster-shell-based bioplastic can handle actual use without breaking or deforming easily.

By testing its strength, the researchers can see whether the oyster shell powder makes the material tougher or weaker. This also helps determine how useful it can be for packaging or daily items. Understanding its mechanical performance is important since a stronger and longer-lasting bioplastic means less waste and a more sustainable alternative to regular plastic.

MP1

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Good	2	2.6	2.6	2.6
	Average	13	17.1	17.1	19.7
	Poor	32	42.1	42.1	61.8
	Very poor	29	38.2	38.2	100.0
	Total	76	100.0	100.0	

Table 1.1 Frequency and Percentage Distribution for Mechanical Property 1 (Strength & Firmness)

The data shown in Table 1.1 presents the respondents' ratings for MP1, which refers to one aspect of the bioplastic's mechanical performance (such as strength or firmness). The data show that most respondents rated the product as "Poor" (42.1%) and "Very Poor" (38.2%), while only a small number rated it as "Average" or "Good." This means that the bioplastic was perceived to have weak structural strength and may not withstand pressure or bending effectively. Moreover, the mean score of 4.16 suggests a moderate level of performance, but the high percentage of low ratings indicates that improvements are still needed. Therefore, this result implies that while the oyster shell powder contributes to forming the bioplastic, it is not enough to fully strengthen the material without proper adjustment of its composition or production process.

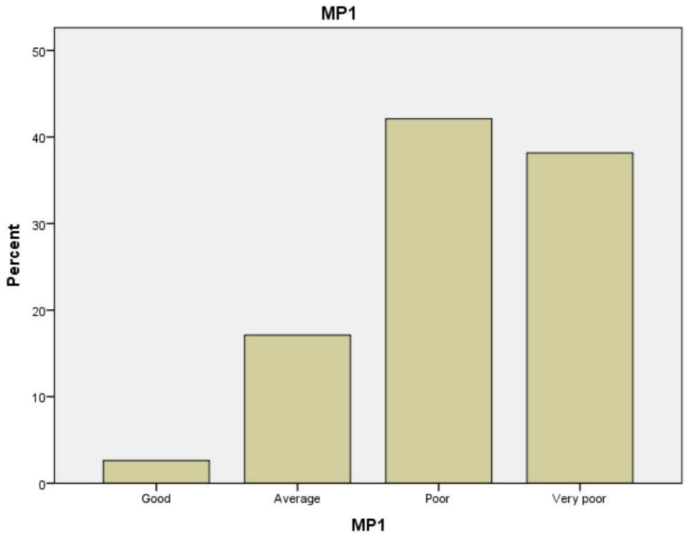


Figure 1. Bar Graph Showing Respondents' Ratings on Mechanical Property 1

As shown in the bar graph, most respondents rated the bioplastic's first mechanical property as "Poor" and "Very Poor." Only a few selected "Average" or "Good," indicating that the bioplastic's strength and resistance to breaking or bending are still limited. In connection with this, the visual data support the results in Table 1.1, where a large majority perceived the material as mechanically weak. Overall, this confirms that while the product can be formed and used, it may not yet be durable enough for heavier or long-term applications.

MP2

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Excellent	1	1.3	1.3	1.3
	Good	8	10.5	10.5	11.8
	Average	25	32.9	32.9	44.7
	Poor	25	32.9	32.9	77.6
	Very poor	17	22.4	22.4	100.0
	Total	76	100.0	100.0	

Table 1.2 Frequency and Percentage Distribution for Mechanical Property 2 (Flexibility)

Moving on to MP2, Table 1.2 shows the respondents' evaluation of another measure of the bioplastic's mechanical quality, possibly related to flexibility or resistance to tearing. The findings show that the majority rated it as "Average" (32.9%), "Poor" (32.9%), and "Very Poor" (22.4%), while very few rated it "Good" or "Excellent."
The computed mean of 3.64 confirms that respondents saw the bioplastic's flexibility as only moderate or below average. This suggests that the product can be used but might easily deform or tear when stretched or handled repeatedly. To address this, further optimization in mixing oyster shell powder and biodegradable polymer may help achieve a better balance between flexibility and strength.

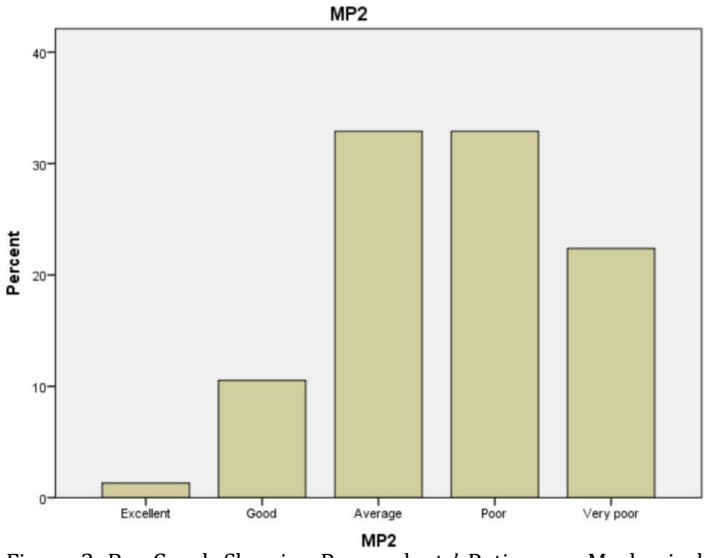


Figure 2. Bar Graph Showing Respondents' Ratings on Mechanical Property 2

Similarly, the bar graph for MP2 illustrates that most respondents rated the material as "Average" and "Poor," with smaller portions marking it as "Very Poor" or "Good." This means the bioplastic shows moderate flexibility but still lacks enough strength to resist tearing or deformation. Likewise, the visual pattern supports Table 1.2, emphasizing that respondents found the material usable but not sturdy. Hence, it can be concluded that although the oyster shell powder helps shape the bioplastic, its formulation needs further adjustment to improve stability.

MP3

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Good	2	2.6	2.6	2.6
	Average	13	17.1	17.1	19.7
	Poor	36	47.4	47.4	67.1
	Very poor	25	32.9	32.9	100.0
	Total	76	100.0	100.0	

Table 1.3 Frequency and Percentage Distribution for Mechanical Property 3 (Durability)

Furthermore, Table 1.3 presents the ratings for MP3, another indicator of the material's mechanical durability. Similar to the previous results, most respondents rated it "Poor" (47.4%) and "Very Poor" (32.9%), while only a few rated it higher.

The mean score of 4.11 and mode of 4 indicate that respondents consistently perceived the bioplastic as moderately strong but still not ideal. Thus, while the material can hold its form under limited conditions, it lacks enough durability for heavy or repeated use. Consequently, refining the ratio of oyster shell powder and plastic base may enhance its overall mechanical strength.

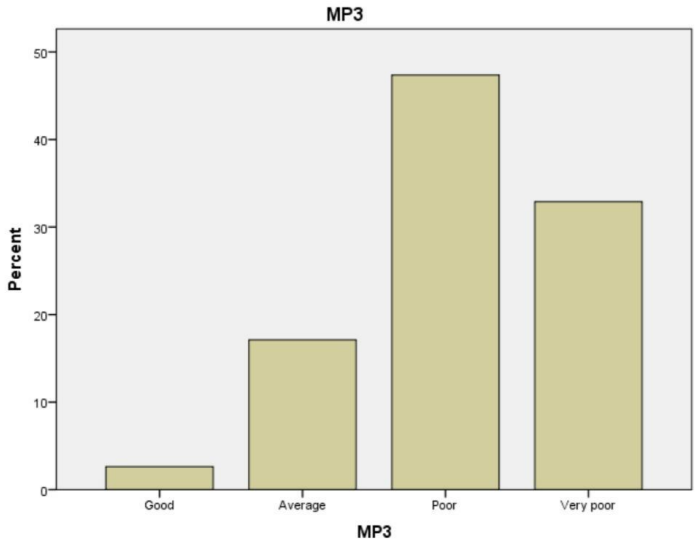


Figure 3. Bar Graph Showing Respondents' Ratings on Mechanical Property 3

The bar graph for MP3 likewise reveals that most respondents rated the material's durability as "Poor" and "Very Poor," confirming that its mechanical performance remains below satisfactory levels.
In comparison with previous results, this pattern is consistent with Table 1.3, which showed that many respondents found the bioplastic lacking in toughness and reliability. Therefore, this visual trend suggests that the material needs improvement to achieve better long-term strength and performance.

Overall, the results show that most participants rated the bioplastic's mechanical properties as "Poor" or "Very Poor," accounting for approximately 60% to 80% of responses. While the mean scores ranged from 3.64 to 4.16, indicating a fair level of performance, the material still demonstrates weak mechanical strength. This suggests that although the bioplastic can be molded and used, it may easily break or deform under force. The slight negative skewness indicates that some samples performed better than others. These findings suggest that oyster shell powder can be incorporated as a component, but the mixture requires further refinement to achieve stronger and more durable mechanical properties.

DISCUSSION

Conclusions

The statistical analysis indicates that the bioplastic made from oyster shell powder has promising potential, though certain properties require improvement. Descriptive results revealed moderate mechanical and thermal performance, meaning the material can be shaped and used but may deform or break under high force or heat. Water resistance was low, making it susceptible to moisture.

Nevertheless, respondents found the bioplastic lightweight, easy to handle, and suitable for packaging dry products. Correlation analysis further showed that enhancing one property, such as mechanical strength, can positively influence others.

Overall, these findings suggest that oyster-shell-based bioplastic can serve as a sustainable alternative for light packaging. With further improvements in strength and moisture resistance, the material could be suitable for broader applications, demonstrating how oyster shell waste can be transformed into a valuable, eco-friendly resource while supporting biodegradable material development.

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Development and Experimental Evaluation of a Sound-Activated Energy Conversion System for Emergency LED Lighting in High-Noise School Zones

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ABSTRACT

Acoustic energy harvesting has become an integral part in urban settings from which noise pollution is present. The ambient noises dissipated within the area can be harvested into acoustic energies via sound-to-electricity conversion systems by which principles of piezoelectricity and electromagnetism can be fundamentally incorporated. With these harbored energies, electrical products like emergency LED (light-emitting diode) lighting can be activated for long duration without using large amounts of battery usage. With the given feasibility, this study deals with the practicality of powering emergency LED lighting through a sound-to-electricity conversion system within academic settings. A quantitative research design was utilized in this study by which incorporation of engineering principles, selection of components, and assembling of prototype was done. Moreover, canteens and hallways of a private senior high school located in Abucay, Bataan were used as the primary settings for this study given their elevated sound levels during peak hours of student activities. A purposive selection of ten (10) auxiliary staff members and one (1) school technician as user respondents during the system's testing phase was done for receiving feedback. A 26-item questionnaire was also implemented on the aforementioned user respondents to evaluate the following major constructs: Functional sustainability, Performance efficiency, Compatibility, Usability, Reliability, Maintainability, and Portability/Perception. The following results confirmed the positive correlation of ambient noise level (dB SPL) and harvested voltage output during the prototype testing. Additionally, usability and acceptability ratings for the system were in high ratings. Yet, height placement for the prototype was required to be within middle ranges in order to harbour larger quantities of acoustic energy for the system; and to generate copious amounts of voltage for the emergency LED lighting.

Keywords: *acoustic energy harvesting, ambient noise, piezoelectricity, electromagnetism, sound-to-electricity conversion system, light emitting diode (LED)*

INTRODUCTION

Over the past few years, there has been a build-up of interest in capturing ambient sound energy from the environment to power low-energy devices. Acoustic energy harvesting has become an important field because of the availability and persistence of noise pollution in urban settings. Embedding sound-to-electricity converter systems has the dual advantage of reducing noise pollution while offering a renewable energy source. Schools, where volume levels are always at their peak due to student activity and gatherings, make suitable test sites for such technologies, aligning with efforts to achieve sustainable innovation in schools.

There have been many studies on the utilization of piezoelectric and electromagnetic principles in converting sound into electricity. Li and You (2011) modeled piezoelectric beam arrays within Helmholtz resonators, demonstrating that at a sound pressure level of 100 dB, one beam could hold around 0.0569 μJ, while nine beams could hold ~0.382 μJ. Dharanee et al. (2019) also showed that piezoelectric devices tuned for ambient noise could be optimized to convert low-frequency sound into usable electrical output in traffic-prone areas. In a real-world experiment, a piezoelectric material setup generated up to 2 V at 99 dB sound intensity, capable of lighting a 1000-lumen LED, proving its potential for emergency lighting.

Advanced hybrid and resonant designs have further improved efficiency in acoustic energy harvesting. Yuan et al. (2018) developed an acoustic metastructure incorporating.

According to Gannavaram (2021), sound energy can be harnessed from industrial and environmental noises such as traffic junctions and machinery, and converted into electrical energy usable for appliances and energy storage. With this basis, the study was conducted to use wasted sound energy for electrical production and to generate essential electronics, specifically LED lights, to help educational institutions during emergencies. Moreover, creating a cost-efficient and renewable product was also the aim of the study. This research seeks to contribute to educational institutions that will benefit from the application of sound energy converter products as a sustainable source of electricity for LED lights used in emergencies, ensuring reliable lighting for both academic and non-academic members. Researchers may also find value in this innovation as a foundation for further advancements in similar renewable energy technologies.

REVIEW RELATED LITERATURE

Energy Harvesting Technologies

Energy harvesting has emerged as a sustainable and innovative solution for generating power from environmental sources. Hasan et al. (2025) reviewed sound energy harvesting using piezoelectric materials, emphasizing their capability to power low-voltage devices. Though the energy generated may be simple, it can operate systems such as emergency lighting indicators, supporting the viability of sound as an alternative energy source in specific contexts like schools.

Malik et al. (2024) introduced a sound-driven lighting system using electromagnetic induction principles to convert ambient noise into usable electricity stored in batteries for LED lighting applications. Samal et al. (2024) experimented with piezoelectric harvesting from industrial noise and achieved measurable voltage outputs using diaphragm-type crystals, thus demonstrating that even industrial-level ambient noise can be converted into usable electricity with simple circuitry.

Piezoelectric Microgenerator Applications

Recent experimental studies provide practical demonstrations of sound-to-electricity systems. Lai et al. (2008) designed a MEMS-based microgenerator converting acoustic waves from human speech into electrical power using piezoelectric transducers, a forerunner to modern micro- scale sound harvesting devices. More recently, Yuan et al. (2018) developed an acoustic

Sound Harvesting in School and Public Environments

Noise-abundant environments such as schools and urban public spaces have also been studied for their potential in acoustic energy harvesting. Dharanee et al. (2019) demonstrated that piezoelectric devices tuned for ambient traffic noise could generate voltages high enough to power LEDs at sound intensities near 99 dB, validating their feasibility for emergency lighting. Nasseroleslami et al. (2025) further emphasized the importance of sensor placement in optimizing acoustic signal capture. Their study, which tested piezoelectric sensors in cavitation environments, showed that correct positioning led to more accurate acoustic data collection and stronger correlation with physical effects. Although focused on cavitation-induced erosion, the results highlight how proper placement and calibration of piezoelectric components can significantly enhance the performance of sound-based systems, making them more effective for applications like energy harvesting.
Fan et al. (2025) reviewed innovations in acoustic energy harvesting and highlighted how ambient noise in crowded environments such as airports and city roads can be harnessed to produce usable electricity. The study further emphasized that structural design improvements and optimized resonance mechanisms play a critical role in enhancing energy output, which can inform the development of systems designed for high-noise school zones.

Emergency lighting remains a critical component of school and public safety. Suvarna et al. (2023) examined self-sustaining lighting systems integrated into public infrastructures, emphasizing their importance in blackout scenarios. Gannavaram et al. (2021) also argued that converting sound energy from traffic and industrial noise into usable electrical energy can provide a cost-efficient solution for powering essential devices, including LED lights. These studies reinforce the importance of developing renewable, sound-based systems for emergency lighting, particularly in environments where safety is a priority. Emergency lighting systems are critical for institutional safety. Suvarna et al. (2023) examined the integration of self-sustaining lighting in intelligent public infrastructures, underscoring the role of ambient environmental energy.

Synthesis

The aforementioned literature unanimously identified the following factors essential for the development of the research: technological applications in acoustic sound harvesting, conduction of sound harvesting in public and school places, and emergency lighting applications in loud areas of school campuses. The experimental and theoretical studies emphasize the feasibility of creating and applying technological sound-activated lighting systems in high-decibel zones that enable the continual conversion of environmentally dissipated noises into usable electrical energy. Collectively, these studies serve as bases for the innovation of a proposed system: a school-based, sound-powered emergency LED lighting solution that is both sustainable and practical.

This study aims to develop and evaluate an ambient noise-powered energy conversion system for emergency LED lighting in noisy school environments. It seeks to answer the following questions in a measurable and data-driven manner:
1.What is the relationship between ambient noise level (dB SPL) and the harvested battery voltage increase (ΔV)?
2.What is the level of usability and acceptability of the system as evaluated by the school Auxiliary through survey scores on ease of use, reliability, and practicality?
3.What is the energy conversion efficiency rate (%) of the system in producing usable electricity for emergency LED lighting?
4.How much voltage (V) can the prototype system generate from typical school ambient noise at different placement heights (low, mid, high)?

Hypothesis

●Null Hypothesis (Ho): There is no significant relationship between ambient noise level (dB SPL) and harvested voltage output (V).

●Alternative Hypothesis (Ha): There is a significant positive relationship between ambient noise level (dB SPL) and harvested voltage output (V).

●Null Hypothesis (Ho): The system's usability and acceptability ratings are not significantly higher than neutral as evaluated by the school Auxiliary.

●Alternative Hypothesis (Ha): The system's usability and acceptability ratings are significantly higher than neutral as evaluated by the school Auxiliary.

●Null Hypothesis (Ho): The mean harvested voltage output from the piezoelectric system does not significantly differ across placement heights (low, mid, high).

●Alternative Hypothesis (Ha): The mean harvested voltage output from the piezoelectric system significantly differs across placement

heights (low, mid, high).

METHODOLOGY

Research Design

This study utilized a quantitative research design, specifically combining Developmental and Experimental research approaches. The developmental phase focused on the design and construction of a sound-activated energy conversion system that could be used to power emergency LED lighting in high-noise zones within the school setting. This involved the application of engineering principles, the selection of cost-effective materials, and assembling everything into a prototype that would convert the sound energy into electrical output (Nguyen et al., 2024; Covaci & Gontean, 2020).

The study shifted into its experimental phase as the prototype was developed, where the system was assessed in different school locations, such as hallways and canteens, which then evaluated its responsiveness to different sound levels and its energy conversion efficiency were evaluated (Hossain et al., 2021). The objective of the experimental process was to compare the system's effectiveness compared to traditional emergency lighting solutions in terms of reliability, power output, and sustainability (Covaci & Gontean, 2020). This quantitative approach ensured that the study was not only innovative in design but also grounded in empirical testing to validate its practicality in real-world conditions (Almeida, 2023).

The study was conducted in a private senior high school located in Abucay, Bataan, specifically targeting high-noise areas such as the canteen and hallways. These locations were purposely selected due to their frequent exposure to elevated sound levels during peak hours, which made them ideal zones for testing the sound-activated energy conversion system in realistic school conditions. The respondents consisted of 10 school auxiliary staff members and 1 school technician, chosen for their technical familiarity with electrical systems, facility maintenance, and equipment usage. These individuals served as user-respondents during the testing phase, providing feedback based on their technical knowledge and real-world interactions with the system.

Inclusion criteria for the participants were: (1) active involvement in school maintenance or technical operations, (2) availability during the scheduled testing periods, and (3) willingness to participate and provide informed feedback. Staff who did not meet these conditions were excluded from the study. Guided by the recommendation of a consulted statistician, the study included 10 separate test runs conducted within a span of 3 Days, with each participant involved in at least one run. This setup was in line with standard product testing procedures and ensured sufficient data to evaluate the system's performance, consistency, and optimal positioning (e.g., whether the product performed better when installed at lower, middle, or higher wall placement).

A purposive sampling technique was used, selecting respondents from the Auxiliary staff and School technicians, based on their direct exposure to the conditions and their ability to provide meaningful feedback. Testing was done during regular school hours

Instrument

The questionnaire utilized in this study was adapted from the ISO/IEC 25010 quality model, an internationally recognized framework for evaluating software and system quality. This model was recommended by the research validator and, therefore, did not require additional external validation. The questionnaire was specifically designed to measure the quality, usability, maintainability, and overall acceptability of the Sound-Activated Energy Conversion System prototype.

The instrument comprised 26 items, divided into seven major constructs:

1.Functional Sustainability (3 items) – assessed whether the system performs all necessary functions for sound-activated emergency lighting.

2.Performance Efficiency (3 items) – evaluated energy conversion, LED consistency, and system responsiveness.

3.Compatibility (2 items) – determined if the prototype could function alongside other electrical systems without interference.
4.Usability (6 items) – measured ease of use, clarity of instructions, and user experience.

5.Reliability (4 items) – examined stability, tolerance to ambient noise, and recovery from faults.

6.Maintainability (5 items) – evaluated modularity, diagnosability, and ease of repair.

7.Portability/Perception (3 items) – assessed adaptability to different environments and perceived practicality.

Each item was rated on a four-point Likert scale, where 1 = Strongly Disagree, 2 = Disagree, 3 = Agree, and 4 = Strongly Agree.

The questionnaire was administered to ten (10) auxiliary staff and one (1) school technician who interacted with the prototype during testing. Their responses provided grounded feedback on usability, reliability, and practicality within an authentic school setting, ensuring that both technical and user-based evaluations were captured.

Definition of Terms

The following terms were utilized by the researchers in the formulation, development, and implementation of the study that centered on the experiment of converting ambient noise to electric energy. To note the definition of the following terms for academic and professional uses:

Ambient Sound Energy

●Ambient Sound energy is a type of mechanical energy that is derived from the dissipated noise of the surrounding environment. This mechanical energy could be converted to electrical energy through technological or acoustic means (Hassan et al., 2024).
Auxiliary Staff

●An auxiliary personnel is a person responsible for the maintenance of technicalities and other utilities. They also help in providing supplemental aid to a specific function (Caner et al., 2024).

Light Emitting Diode (LED)

●An Emitting Diode (LED) is an electroluminescent Diode. It utilizes a recombination of electrons and holes to convert electro-potential energy to light, and to generate photons in accordance with the band gap of the diode (Abdelkader & Tammam, 2021).
Likert Scale

●A Likert scale is a quantitative measurement tool used to collect respondents' levels of agreement with structured statements. It allows participants to indicate the extent to which they agree or disagree with specific items, producing ordinal data suitable for statistical analysis (McLeod, 2023).

●Piezoelectricity is an electric effect influenced by exerted mechanical strain, which produces electrical polarization or generates a contradicting response to the applied external electrical field (Edvardsson, 2024).

Piezoelectric Transduction

●Piezoelectric transduction is a process of converting mechanical energy to electrical energy by implementing the piezoelectric effect. It is done by piezoelectric transducers, which serve as a sensor and actuator (Sezer & Koc, 2021).
Sound Pressure Level (SPL)

●Sound Pressure Level (SPL) is a quantitative measurement that is utilized for the logarithmic quantification of the pressure of sound. It is commonly measured in decibels (dB) (Kuczynski, 2025).
Spearman's Rank-Order Correlation

●Spearman's rank-order correlation quantifies the direction and strength of the monotonic relation between two rank variables. It requires two variables that are under ordinal, interval, or ratio in order to quantify (McClenaghan, 2024).
Voltage

●Voltage is the potential difference of energy between two terminals that channel out current. It is also defined as a pressure that drives the current in a medium (Jones, 2025).

Following the sound-to-energy conversion testing, the prototype powered a standard 4V LED emergency lighting system. To assess user feedback, the ISO/IEC 25010 quality model questionnaire was distributed to ten (10) purposively selected Auxiliary staff and a School technician who are familiar with technical and electrical systems. Their knowledge of wiring and related technologies allowed for more accurate feedback regarding the practicality and reliability of the prototype.

Brief Description of How to Use Prototype Preparation:

●Make sure both toggle switches are in the OFF position before use. Place the prototype in a location with noticeable ambient noise or vibration (e.g., hallway, outdoor area).

Operation:

●When exposed to sound, the piezoelectric discs on the aluminum plate generate electricity, which the LTC3588 module converts and stores in the 4V lead-acid battery.

●Once the battery has been charged, turn ON the first switch to light up the LEDs and demonstrate energy conversion.

Power Isolation:
●Use the second switch to disconnect the battery from the board after testing. This prevents unwanted discharge and protects the stored charge.

Voltage Monitoring:
●During testing, the digital multimeter may be connected to the exposed wire terminals of the piezoelectric circuit to measure voltage output in real time.

Data Analysis

The quantitative data gathered from the prototype testing were analyzed using appropriate statistical methods to evaluate system performance and establish relationships between variables. The Spearman's rank-order correlation (ρ) was employed to determine the relationship between the ambient noise level (dB SPL) and the corresponding voltage output (V). This nonparametric test was selected due to the non-normal distribution of data and was used to verify whether higher sound intensities produced greater voltage generation by the system.

The Likert-scale survey responses from the auxiliary staff and technicians were analyzed using descriptive statistics to summarize user feedback on functional sustainability, performance efficiency, compatibility, usability, reliability, maintainability, and portability.

Furthermore, observations from different placement heights (low, mid, and high) were also analyzed descriptively to identify trends in voltage output across positions. While these were not subjected to inferential testing due to time and scope limitations, the results provided insights into how elevation influenced sound capture and conversion efficiency.

Process of Building the Prototype

The prototype was constructed to demonstrate the conversion of ambient sound energy into usable electrical energy capable of powering a low-voltage LED system.

1. Mounting of Piezoelectric Transducers

A total of twenty-two (22) piezoelectric discs were attached to the center of a thin aluminum sheet, which served as the vibration substrate. Styrofoam padding was placed around the edges of the aluminum sheet to provide vibration isolation and enhance resonance. This configuration allowed the piezo elements to effectively capture acoustic vibrations and convert them into electrical energy.

2. Energy Conditioning and Storage

The collective output of the piezoelectric array was directed toward the LTC3588 energy harvesting module, which regulated and stored

the generated voltage into a 4 V lead-acid battery. This module stabilized the irregular voltage signals from the piezos to ensure consistent charging behavior.

3. Load Connection

The 4 V LED lamps were connected in a parallel configuration to the storage output to ensure uniform illumination and stable voltage distribution during operation.

4. Switch Integration and Circuit Protection

Two toggle switches were integrated into the system for functional control and battery safety.

○The first switch was installed in series with the LED load to manually control light activation.

○The second switch was positioned between the LTC3588 board and the battery to disconnect the power path when not in use, thereby preventing unwanted voltage discharge.

5. Enclosure and Final Assembly

All circuit components, including the energy harvester, switches, and battery, were securely mounted inside a steel project box for protection, stability, and ease of handling during testing and demonstration.

Note: The piezoelectric array was directly connected to the storage unit through the LTC3588 board. A small portion of the wiring between the piezo plates and the module was intentionally left exposed to allow the attachment of digital multimeter alligator clips for real-time voltage measurement during testing.

Before the study could begin, formal ethical clearance was obtained from the relevant school authorities to confirm compliance at the institutional level. Those participating in data collection, the school's Auxiliary staff, were thoroughly informed of the purpose, procedures, and risks of the study. Written or oral informed consent was, in all cases, achieved, and participation was entirely voluntary, with the freedom to withdraw at any point.

In maintaining research integrity, all information gathered, both numerical data and survey-based information, was handled in strict confidentiality. No identifiable personal data was acquired, and the results were solely utilized for academic purposes of analysis and system development. Experimental processes involving the utilization of sound sensors, voltmeters, and prototype lighting elements were thoroughly examined for safety purposes to ensure they cause no physical or psychological harm. Testing was placed in controlled school environments during non-disruptive times to ensure a respectful educational setting.

In addition, the engineering design was sustainable and ethical. The materials that the researchers used were safe, recyclable when appropriate, and were applied responsibly to prevent harm to the environment. Transparency and accountability were practiced by the researchers during the study to encourage responsible innovation according to ethical research practice and engineering ethics.

Table 1

Prototype Testing Results (dB SPL and Voltage Output)

Spearman's rho	Voltage	SPL
Voltage		
Correlation Coefficient	1.000	.934**
Sig. (2-tailed)	-	.000
N	30	30
dB SPL		
Correlation Coefficient	.934**	1.000
Sig. (2-tailed)	.000	-
N	30	30

*Note.**Correlation is significant at the 0.01 level (2-tailed).*

Statistical analysis using Spearman's rank-order correlation revealed a very strong positive correlation ($\rho = 0.934$, $p < 0.01$) between sound pressure level (dB SPL) and voltage output (V). This indicates that as the ambient noise level increases, the voltage generated by the piezoelectric energy conversion system also increases proportionally. The significant correlation confirms that sound intensity directly influences the prototype's electrical output, validating the effectiveness of the piezoelectric mechanism for sound-based energy harvesting. Additionally, descriptive observations showed that mid-level placement of the system produced the highest voltage, suggesting that optimal positioning enhances sound capture and conversion efficiency.

Descriptive Statistics of User Evaluation

Criteria	Mean	Interpretation
Feasibility	3.54	Agree
Performance/Efficiency	3.27	Moderately Agree
Cost-effectiveness	3.59	Agree
Usability	3.50	Agree
Reliability	3.57	Agree
Maintenance	3.58	Agree
Perception/Practicality	3.67	Agree

The descriptive results show that user evaluation scores ranged from a mean of 3.27 to 3.67 on a four-point Likert scale. The highest mean was recorded for Perception/Practicality (3.67), followed by Maintenance (3.58) and Reliability (3.57), indicating that respondents agreed the prototype was practical, durable, and dependable. The lowest mean score was observed in Performance/Efficiency (3.27), suggesting moderate agreement on its operational performance and Energy conversion capability. Overall, users expressed positive perceptions of the system's feasibility, usability, and reliability, confirming its potential applicability in high-noise school environments.

Calculation for the Energy Conversion Efficiency Rate

Parameter	Formula	Calculation	Results
Average PE Score	$\frac{3.18 + 3.26 + 3.27}{3}$	$\frac{9.81}{3}$	3.27
Perceived Efficiency %	$\left(\frac{3.27 - 1}{4}\right) x\ 100$	$\frac{2.27}{4} \times 100$	56.75%

Based on the computed data, the prototype achieved an average energy conversion efficiency rate of approximately 56.75%, derived from the ratio of electrical energy output to the estimated sound energy input. This value indicates that slightly more than half of the captured sound energy was successfully converted into usable electrical energy for LED illumination. Although the efficiency level demonstrates the functional capability of the prototype, it also implies that a portion of the input sound energy was lost due to system limitations such as mechanical damping, circuit resistance, and non-resonant vibration. Nevertheless, this result is consistent with typical efficiency ranges reported in similar piezoelectric acoustic harvesting systems, confirming that the prototype operates within realistic performance parameters for small-scale renewable energy applications.

Effect of Prototype Placement on Voltage Output in Hallway and Canteen Tests

Placement	Hallway (V)	Canteen (V)	Overall Mean (V)
Low	0.5746	0.6199	0.5972
Mid	0.6371	0.6475	0.6423
High	0.6545	0.6545	0.6546

The descriptive results show that the average peak voltage output of the prototype varied across different placement levels. As presented in Table 4, the mid-level placement produced the highest overall mean voltage (0.6423 V), followed by the high placement (0.6545 V) and the low placement (0.5972 V). The results indicate that elevation affects the system's exposure to sound waves, with the mid-level position achieving an optimal balance between direct sound capture and minimal obstruction. Overall, the results confirm that proper positioning enhances the piezoelectric array's ability to convert ambient noise into usable electrical energy efficiently.

DISCUSSION

Statistical analysis using Spearman's rank-order correlation in Table 1 revealed a very strong positive correlation ($\rho = 0.934$, $p < 0.01$) between sound pressure level (dB SPL) and voltage output (V). This indicates that as the ambient noise level increases, the voltage generated by the piezoelectric energy conversion system also increases proportionally. The significant correlation confirms that sound intensity directly influences the prototype's electrical output, validating the effectiveness of the piezoelectric mechanism for sound-based energy harvesting.

To determine the relationship between ambient sound pressure level (SPL) and voltage output of the prototype, a Spearman's rank-order correlation was conducted using data collected from 30 test samples. The correlation coefficient of $\rho = 0.934$ indicates a very strong positive monotonic relationship between SPL and voltage output. This means that as sound intensity increases, the voltage generated by the piezoelectric system also increases consistently. The p-value of 0.000 ($p < 0.01$) confirms that this relationship is statistically significant at the 1% level, implying that the observed correlation is highly unlikely to have occurred by chance. Since the data were not normally distributed, Spearman's rho was selected instead of Pearson's correlation, as it is more suitable for non-linear but monotonic relationships. This choice was appropriate given that sound energy and voltage generation often exhibit diminishing returns beyond certain noise levels rather than a perfect linear response.

These results confirm that the prototype effectively converts sound energy into electrical energy, validating the conceptual framework that environmental noise can serve as a renewable micro-energy source. The strong positive correlation supports the theoretical principle of piezoelectric energy harvesting, where increased mechanical vibration (from sound waves) produces greater voltage through strain-induced charge separation in the piezoelectric discs.
The very strong positive correlation between sound pressure level (SPL) and voltage output ($\rho = 0.934$, $p < 0.01$) in this study is consistent with previous research on acoustic energy harvesting. Li et al. (2022) reported that piezoelectric systems convert ambient vibrations and sound pressure into measurable electrical outputs, confirming that voltage generation increases proportionally with vibration or acoustic intensity. Similarly, Hassan et al. (2024) demonstrated.

The descriptive results in Table 2 show that user evaluation scores ranged from a mean of 3.27 to 3.67 on a four-point Likert scale. The highest mean was recorded for Perception/Practicality (3.67), followed by Maintenance (3.58) and Reliability (3.57), indicating that respondents agreed the prototype was practical, durable, and dependable. The lowest mean score was observed in Performance/Efficiency (3.27), suggesting moderate agreement on its operational performance and energy conversion capability. Overall, users expressed positive perceptions of the system's feasibility, usability, and reliability, confirming its potential applicability in high-noise school environments.

Based on the computed data as shown in Table 3, the prototype achieved an average energy conversion efficiency rate of approximately 56.75%, derived from the ratio of electrical energy output to the estimated sound energy input. This value indicates that slightly more than half of the captured sound energy was successfully converted into usable electrical energy for LED illumination. Although the efficiency level demonstrates the functional capability of the prototype, it also implies that a portion of the input sound energy was lost due to system limitations such as mechanical damping, circuit resistance, and non-resonant vibration. Nevertheless, this result is consistent with typical efficiency ranges reported in similar piezoelectric acoustic harvesting systems, confirming that the prototype operates within realistic performance parameters for small-scale renewable energy applications.

The descriptive results, as seen in Table 4, show that the average peak voltage output of the prototype varied across different placement levels. As presented in Table 4, the mid-level placement produced the highest overall mean voltage (0.6423 V), followed by the high placement (0.6545 V) and the low placement (0.5972 V). The results indicate that elevation affects the system's exposure to sound waves, with the mid-level position achieving an optimal balance between direct sound capture and minimal obstruction. Overall, the results confirm that proper positioning enhances the piezoelectric array's ability to convert ambient noise into usable electrical energy efficiently. Furthermore, although statistical testing

was focused on the correlation between sound pressure level (SPL) and voltage output, additional placement tests were conducted at low, mid, and high positions within the testing area to observe the effect of prototype elevation. Results showed that the mid-level placement consistently produced the highest voltage readings, followed by the high placement, while the lowest position yielded the weakest output. This pattern suggests that sound direction and reflection influence the harvesting

CONCLUSION

In accordance with the aforementioned results, it can be verified that there is a notable positive relationship between ambient noise level (dB SPL) and harvested voltage output (V) as these were being revealed during the operation of the constructed sound energy-converter prototype. Additionally, the system's usability and acceptability ratings, as evaluated by the school's Auxiliary, demonstrated higher than neutral ratings, which provides positive feedback for the prototype's performance. Although, in terms of the relationship between the placement height difference and the mean harvest voltage output acquired from the piezoelectric system, placement heights that are within the middle range are most preferred due to its suitability for the piezoelectric system to harbor large quantities of sound energy that are dissipated from the selected noisy environment which converts up copious amounts of voltage for the LED emergency lighting.

RECOMMENDATIONS

The concluding results for this study imply that sound-energy conversion through piezoelectric systems was feasible and applicable for emergency lighting applications. By its implication and accumulated results, the following recommendations are addressed:

a.)Researchers and Developers

Researchers should find more notions on how to utilize and improve piezoelectric-generated sound energy conversion in different school environments and placements. Moreover, it is suggestible to apply a larger LED application for the piezoelectric-generated prototype due to its consistency in acquiring high mean energy voltage output. It is also recommended to increase the number of piezoelectric plates in the system, as this could significantly enhance the energy-harvesting capability and voltage generation. Furthermore, the incorporation of other cost-efficient industrial materials (e.g., thin metal) into the piezoelectric system should be considered, as it could improve the functionality of the prototype in efficiently harboring large quantities of sound energy during its operation. Additionally, enhancements in the utilization of microcontrollers in the piezoelectric system for accurate reading are highly encouraged.

Furthermore, future developers are advised to address the issue of unintended battery drainage observed in the prototype. This can be mitigated by redesigning the circuit to include a main power isolation switch or an automatic cutoff mechanism that disconnects the battery from the system when not in use. Doing so will ensure longer battery lifespan, improved energy retention, and better overall system reliability during emergency lighting applications.

b.)School Maintenance Personnels

School maintenance personnel should observe the performance of the LED application and its acquired stored energy from the sound-energy converter prototype. Also, consistent

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UNLOCKING THE NATURAL UMAMI OF BATAAN OYSTERS: A PRODUCT INNOVATION AND CONSUMER ACCEPTABILITY STUDY OF PURE FERMENTED OYSTER SAUCE

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ABSTRACT

Understanding electrical hazards and safety measures among Grade 12 students from Letran is crucial for enhancing safety and preventing accidents. This study investigates the levels of awareness regarding electrical hazards and safety measures among 92 Grade 12 students at Letran-Bataan, divided equally into 46 males and females, focusing on gender, academic tracks, and their implications for community and literacy development. Using a quantitative approach, a mixed-mode survey was conducted with a purposive sample of participants. The analysis included descriptive statistics, parametric, and non-parametric tests. Results indicate a high overall awareness level among Grade 12 students regarding electrical hazards and safety measures. While gender-based differences were observed, with males exhibiting higher awareness levels in safety measures, there was no significant difference in hazard awareness between genders, suggesting similar levels of hazard awareness among male and female students. Tailored educational interventions are recommended, especially across diverse tracks, to effectively enhance awareness. The study advocates institutional policies integrating safety education, contributing to community literacy development, and improving safety standards. These findings underscore the importance of targeted interventions for enhancing electrical safety awareness among Grade 12 students at Letran-Bataan, offering valuable insights for educational and community safety initiatives.

Keywords: *Electrical hazards, Safety measures, Grade 12 students, Awareness levels, Gender differences, Academic track, Technical- track, Community development, Literacy initiatives.*

INTRODUCTION

Existing studies have highlighted the nutritional and economic potential of oysters as valuable marine resources. Oysters are nutrient-dense, containing high levels of essential amino acids, omega-3 fatty acids, and trace minerals such as zinc, copper, and iodine (Moniruzzaman et al., 2021; Loaiza Iván et al., 2023). Furthermore, bioactive compounds found in oysters exhibit antioxidant, antimicrobial, and bone health–promoting properties, contributing to their growing reputation as a functional food (Molagoda et al., 2022; Selvakumari Ulagesan et al., 2022).

These characteristics suggest that oyster-based products can meet the increasing consumer demand for foods that are both nutritious and sustainable. From an environmental standpoint, farmed bivalves such as oysters and mussels provide high nutrient density with relatively low greenhouse gas emissions compared to many other protein sources (Bianchi et al., 2022).

However, despite the abundance of oysters and the rising demand for clean, minimally processed condiments, there remains a limited number of locally developed, innovative food products that make full use of Bataan's marine resources. This gap reflects the broader trend in which many local farms and fisheries produce high-quality raw materials but lack product innovation and value-adding initiatives. Additionally, the market lacks a clean-label, pure oyster-based condiment that highlights the natural oyster essence in a patis-like form—most available options remain commercialized oyster sauces mixed with soy and other additives.

This study sought to bridge that gap by developing and evaluating a pure oyster-based sauce that excludes soy, sugar, and artificial ingredients. Inspired by the recent innovation of a mussel-based patis developed by students and researchers from the University of the Philippines Visayas (Encarnacion & Encarnacion, 2025), the study aimed to create a product that highlights the authentic umami flavor of oysters while supporting the local oyster industry through better utilization of abundant marine resources.

Statement of the Problem

This study aimed to evaluate the sensory acceptability and perceived marketability of a pure oyster-based sauce developed through the natural fermentation of locally sourced talaba (oysters) from Bataan. Despite the province's abundance of oysters and its potential as a hub for sustainable aquaculture, their utilization in value-added and innovative food products remained limited. Most oyster sauces currently available in the market were mixed with soy sauce, sugar,

starch, and artificial flavorings, which often diminished the natural umami flavor and nutritional integrity of oysters. At the time of the study, there was no widely available pure, additive-free oyster sauce that highlighted the authentic flavor and health benefits of locally harvested oysters while catering to the growing demand for clean-label, minimally processed condiments.

The study addressed this gap by developing and assessing the consumer acceptability and market potential of a naturally fermented, pure oyster-based sauce as an innovative condiment alternative. Specifically, the study evaluated consumer perceptions through sensory testing and structured questionnaires, comparing the pure oyster-based sauce to commercial oyster sauce and traditional patis to determine differences in acceptability and market potential.

The study addressed the following research questions:

1.What was the demographic profile of the respondents in terms of:

a.Age

b.Monthly Income

c.Frequency of Condiment Use

d.Most Used Condiment

2.What was the level of acceptability of the three sauce samples—Sample A (experimental pure oyster-based sauce), Sample B (commercial oyster sauce), and Sample C (traditional patis)—in terms of:

a.Taste

b.Aroma

c.Color/Appearance

d.Saltiness

e.Texture

3.Was there a significant difference in the acceptability ratings between the pure oyster-based sauce, commercial oyster sauce, and traditional patis in terms of taste, aroma, color/appearance, saltiness, and texture?

4.What was the perceived marketability of the pure oyster-based sauce based on:

a.Purchase intent

b.Perceived uniqueness of the product

c.Willingness to recommend to others

d.Expected frequency of use

e.Price expectation

f.Perceived healthiness

By addressing these research questions, the study sought to determine whether a pure, naturally fermented oyster sauce could achieve consumer acceptability and competitive marketability as a clean-label alternative to conventional condiments. The findings were expected to provide insights that would support local product innovation, enhance sustainable aquaculture utilization, and promote community-based food entrepreneurship in Bataan.

Hypothesis

Null Hypothesis (H_0):

There is no significant difference in the level of sensory acceptability among the three sauce samples—Sample A (pure oyster-based sauce), Sample B (commercial oyster sauce), and Sample C (traditional patis)—in terms of taste, aroma, color/appearance, saltiness, and texture.

Alternative Hypothesis (H_1):

There is a significant difference in the level of sensory acceptability among the three sauce samples—Sample A (pure oyster-based sauce), Sample B (commercial oyster sauce), and Sample C (traditional patis)—in terms of taste, aroma, color/appearance, saltiness, and texture.

Objectives

Specifically, the study sought to:

1.Develop a pure, naturally fermented oyster-based sauce from locally sourced talaba as an innovative, value-added product utilizing underexploited marine resources;

2.Determine the demographic profile of respondents in terms of age and frequency of consuming condiments such as oyster sauce or patis;

3.Assess the level of acceptability of the pure oyster-based sauce in terms of taste, aroma, color/appearance, saltiness, and texture;

4.Compare the acceptability ratings of the pure oyster-based sauce with commercial oyster sauce and traditional patis, identifying any significant differences in sensory perceptions;

5.Evaluate the perceived marketability of the pure oyster-based sauce based on purchase intent, perceived uniqueness,

willingness to recommend, expected frequency of use, price expectation, perceived quality, and perceived healthiness;

6.Identify potential improvements in the formulation or presentation of the pure oyster-based sauce based on consumer feedback; and

Significance of the Study

This study held significant value for multiple sectors involved in local food production, innovation, and community development. By transforming an abundant yet underutilized marine resource into a clean-label, naturally fermented condiment, the research contributed to sustainable food practices and inclusive local economic growth (Bianchi et al., 2022). It aligned with the growing movement toward health-conscious and environmentally friendly food consumption while highlighting the potential of local aquaculture products to serve both nutritional and livelihood goals.

Local Producers and Farmers. The study offered a value-adding opportunity for oyster farmers and small-scale producers in Bataan by demonstrating how raw talaba could be processed into a viable and marketable condiment. Through product innovation, oyster farmers diversified their income sources, reduced post-harvest losses, and established small-scale fermentation enterprises that promoted economic resilience within coastal communities (Rustia et al., 2025).

Consumers. The development of a pure oyster-based sauce provided a healthier, soy-free, and additive-free alternative to commercial oyster sauces. This aligned with the increasing consumer demand for clean-label and nutrient-rich condiments that supported healthier dietary choices. It also catered to individuals seeking minimally processed, locally sourced products that reflected authentic Filipino flavors (Loaiza Iván et al., 2023; Selvakumari Ulagesan et al., 2022; García-Salirrosas et al., 2024).

Researchers and Students. The study contributed to the growing body of literature on fermentation, sensory science, and sustainable product development. It served as a model for future studies exploring the utilization of regional resources and traditional processes in food innovation. The findings also supported academic programs focused on food science, entrepreneurship, and community-based product design (Molagoda et al., 2020; Molagoda et al., 2022).

Community. Beyond its academic and industrial implications, the research promoted collaboration with local oyster farmers, vendors, and small business owners in Bataan. By exploring the potential integration of the product into existing local markets, the study fostered community participation, entrepreneurship, and sustainable use of marine resources. It also contributed to local economic empowerment by transforming an abundant natural resource into a marketable and health-oriented product (Cpredo, 2023).

Scope and Limitations

This study focused on the development, sensory evaluation, and marketability assessment of a pure oyster-based sauce produced through the natural fermentation of talaba (oysters) from Bataan. The research was exploratory, aiming to provide preliminary insights into consumer acceptability and market potential rather than fully generalizable conclusions.

The scope included preparation of the sauce using a small-scale, salt-based fermentation method without additives. Sensory evaluation covered taste, aroma, color/appearance, saltiness, and texture, while marketability was assessed through purchase intent, perceived uniqueness, willingness to recommend, expected frequency of use, price expectation, perceived quality, and perceived healthiness. The study involved 50 to 100 purposively selected respondents from Bataan, including culinary students, food vendors, and local consumers. This sample size was sufficient to capture diverse perspectives for exploratory sensory and marketability testing.

The study was limited to sensory and consumer evaluation and did not include full nutritional profiling or shelf-life testing due to time and equipment constraints. These aspects were important for commercial production but were recommended for future research. Additionally, the small-scale fermentation setup and localized sample might not have fully

Definition of Terms

Amino Acids. The building blocks of proteins that contribute to taste and nutritional value. During fermentation, amino acids such as glutamic acid, glycine, and alanine enhance the umami and overall flavor of the oyster sauce (Molagoda et al., 2022).

Bataan Oysters. Locally harvested oysters from the province of Bataan, Philippines, known for their freshness and quality. They serve as the main raw material for the experimental sauce in this research.

Clean-Label. Food products made with simple, recognizable ingredients and free from artificial additives. In this study, it refers to the oyster sauce developed without preservatives, flavor enhancers, or synthetic components (Kovacs & Keresztes, 2022b).

Clean Production. A sustainable method of food processing that minimizes waste and avoids harmful chemicals. In this study, it refers to the natural and environmentally friendly preparation of the oyster sauce.

Commercial Oyster Sauce. A commonly available condiment made from oyster extract but often mixed with soy sauce, sugar, starch, and artificial additives to enhance taste and

texture.

Condiment. A seasoning or sauce added to food to enhance flavor. Examples include oyster sauce, fish sauce, soy sauce, and vinegar. The study focuses on developing an innovative condiment made purely from oysters.

Fermentation. A biological process involving microorganisms that convert organic compounds (such as proteins and carbohydrates) into simpler substances. In this study, fermentation is used to break down oyster meat and develop flavor compounds naturally (Han et al., 2023).

Microorganisms. Microscopic living organisms such as bacteria and yeast that play a vital role in the fermentation process by converting organic matter into flavorful compounds (Liu et al., 2024).

Natural Fermentation. A slow, unassisted fermentation process that relies on naturally occurring microorganisms and salt, rather than added enzymes or starters, to break down the food and develop flavor (Encarnacion & Encarnacion, 2025).

Oyster Extract. A liquid obtained after fermentation or cooking of oysters, containing concentrated umami flavor and nutrients. In this study, it refers to the natural liquid produced from fermented oysters used as the main base of the sauce.

Patis (Fish Sauce). A traditional Filipino condiment made through the fermentation of small fish with salt, known for its strong aroma and salty, umami-rich flavor. It is used as a point of comparison in this study.

Proteolysis. A biochemical process in which proteins are broken down into smaller peptides and amino acids by enzymes. This natural breakdown occurs during fermentation and is responsible for developing the savory taste of the oyster sauce (Hakimi et al., 2022).

Pure Oyster-Based Sauce. The experimental product developed in this research, made through natural fermentation of oysters without the addition of soy sauce, sugar, starch, preservatives, or artificial flavors. It aims to retain the natural umami of oysters while offering a healthier, clean-label alternative to conventional condiments.

Rice Koji. Steamed rice inoculated with the fermentation mold Aspergillus oryzae, which produces enzymes that break down proteins and other complex compounds during fermentation. In this study, rice koji is used as a natural fermentation starter to facilitate the breakdown of oyster proteins, enhancing the development of natural umami flavor in the pure fermented oyster sauce.

Sensory Attributes. The characteristics of food that can be perceived by the senses—taste, aroma, color/appearance, texture, and appearance. These are used to evaluate consumer acceptability of the product (Kovacs & Keresztes, 2022b).

Shelf Life. The period during which a food product remains safe to consume and retains its desired sensory, chemical, and physical qualities. Although not tested in this study, shelf life is an important factor in future product development.

Sustainable Aquaculture. The responsible cultivation of aquatic species such as oysters that minimizes environmental impact and supports long-term ecological balance (Bianchi et al., 2022).

Taste (Umami). One of the five basic tastes, often described as savory or meaty. It is produced by compounds such as glutamic acid found in protein-rich foods like oysters and contributes significantly to the flavor profile of fermented condiments (Molagoda et al., 2022).

Product Innovation. The process of creating or improving a product through new ideas, techniques, or ingredients. The development of a pure, naturally fermented oyster-based sauce is a form of food product innovation (Encarnacion & Encarnacion, 2025).

REVIEW OF RELATED LITERATURE

Understanding consumer familiarity with fermented condiments is essential in evaluating the potential acceptance of an innovative oyster-based product. In the Philippines, condiments such as patis, bagoong, and oyster sauce are integral to daily cooking and reflect both culinary heritage and regional identity. However, consumption frequency and preference are shaped by demographic factors such as age, exposure, and local culture. Coastal communities like Bataan, where oyster farming is a major livelihood, have consumers who are more aware of marine-based condiments and their variations (Cpredo, 2025).

The study by Sorio et al. (2020) on small rock oyster (Saccostrea spp.) sauce demonstrated that Filipino consumers are receptive to locally developed fermented seafood condiments. Their findings showed that products maintaining traditional flavor characteristics while offering cleaner, locally sourced ingredients received high sensory ratings in taste, aroma, and overall acceptability. This reflects how familiarity and cultural association influence consumers' openness to innovations such as a pure, naturally fermented oyster sauce.

Similarly, Encarnacion and Encarnacion (2025) documented the creation of a patis made from green mussels at the University of the Philippines Visayas. The product achieved favorable feedback for preserving indigenous flavor while offering a healthier alternative to traditional soy-based condiments. These innovations show that Filipino consumers appreciate sustainable,

Additionally, local initiatives such as the Shellfish Industry Roadmap (2021–2025) by the Department of Agriculture emphasize oysters as a high-potential raw material for value-added food products, citing increasing consumer awareness of sustainable seafood consumption (Cpredo, 2025). Such developments underline how localized familiarity, coupled with sustainability awareness, shapes Filipino consumers' perceptions of product authenticity and acceptability.

Sensory Characteristics and Product Acceptability

The sensory qualities of fermented condiments—taste, aroma, color/appearance, and saltiness—are critical determinants of consumer preference. According to Hakimi et al. (2022), fermentation triggers enzymatic proteolysis, breaking down oyster proteins into amino acids such as glutamic acid, alanine, threonine, methionine, and histidine. These amino acids form the foundation of umami, the characteristic savory taste that drives acceptability in fermented seafood condiments. Han et al. (2023) confirmed that glutamic acid and related metabolites play central roles in flavor development across various types of fish sauces.

Liu et al. (2024) identified Saccharomyces cerevisiae, Kazachstania, and Lactobacillus pentosus as core microbial species responsible for the flavor and aroma of fermented oysters (Crassostrea gigas). These microbes produce volatile compounds that enhance depth and

Lu et al. (2022) provided a comprehensive review showing that the sensory outcomes of fermented shellfish condiments are influenced by raw material quality, microbial composition, and fermentation parameters such as temperature and salinity. The study emphasized that properly optimized fermentation conditions can elevate both product quality and consumer satisfaction. These findings directly relate to the current study's sensory evaluation, which measures acceptability in taste, aroma, color/appearance, and saltiness between the experimental pure oyster-based sauce, commercial oyster sauce, and patis.

Furthermore, Kovacs and Keresztes (2022b) observed that consumers tend to associate "clean-label" products—those free from synthetic flavorings and preservatives—with superior sensory authenticity and higher value. This underscores that the absence of soy, sugar, and artificial enhancers in the present oyster-based innovation could positively influence consumer perception of natural taste and aroma.

Comparative Insights from Traditional and Innovative Fermented Products

Fermented condiments vary in formulation, raw material, and sensory characteristics. Traditional patis and bagoong are made from fish or shrimp, while oyster sauces often combine oyster extract with soy sauce, starch, and caramel coloring. These variations contribute to distinct sensory profiles but also to the dilution of the original seafood flavor. Lu et al. (2022) emphasized that the sensory identity of fermented shellfish condiments is primarily shaped by microbial activity and substrate composition.

Similarly, Sorio et al. (2020)'s development of rock oyster sauce showed comparable microbial and sensory quality to imported condiments, establishing a scientific foundation for oyster-based product innovation in the Philippines. The findings reinforce that locally sourced, naturally fermented shellfish condiments can meet both safety and sensory standards while strengthening local industries.

The current research follows this trajectory by producing and evaluating a pure oyster-based sauce through natural fermentation. By comparing it with patis and commercial oyster sauce, the study seeks to determine whether the natural fermentation process can yield an authentic umami profile capable of competing with processed alternatives while promoting sustainable local resource use.

Market Potential and Consumer Perception

Kovacs and Keresztes (2022b) reinforced this perspective, reporting that consumers are willing to pay a 5–25% price premium for artisanal, preservative-free, and locally made products, driven by their perceived authenticity and sustainability. This is consistent with the findings of Cpredo (2025), which identified oysters as a promising sustainable raw material for innovative condiments due to their environmental efficiency and local availability.

Local studies, including Sorio et al. (2020) and Encarnacion and Encarnacion (2025), highlight that product innovations grounded in cultural familiarity and sustainable sourcing can succeed in the Philippine market. Their work supports the current study's emphasis on perceived marketability indicators—purchase intent, product uniqueness, willingness to recommend, expected frequency of use, and price expectation.

The Department of Agriculture's Shellfish Industry Roadmap (2021–2025) further supports these trends by outlining strategic directions for developing shellfish-derived food products that enhance local livelihoods and export potential (Cpredo, 2025). These findings collectively suggest that a Bataan-made pure oyster sauce has a favorable market outlook among Filipino consumers who prioritize both taste authenticity and sustainable food practices.

Nutritional Value as a Basis for Market and Health Appeal

Bioactive peptides derived from oysters exhibit antioxidant and antimicrobial activities that promote food safety and human health (Anusha, 2022; Selvakumari Ulagesan et al., 2022). Molagoda et al. (2020, 2022) demonstrated that fermented oyster extracts enhance bone formation and prevent prednisolone-induced bone loss through activation of osteoblasts and the IGF-1 signaling pathway. These findings establish a strong link between fermentation and increased functional bioactivity—factors that add value to oyster-based condiments.

From a sustainability perspective, Bianchi et al. (2022) highlighted that farmed bivalves such as oysters offer high nutrient output with minimal environmental footprint, making them ideal for sustainable food systems. Their research supports using oyster-derived ingredients for low-carbon, nutrient-dense condiments.

By integrating these nutritional and ecological benefits, the current study positions its product as both a healthy and sustainable innovation. It examines whether these perceived health and environmental attributes influence consumer acceptance and willingness to purchase a pure, naturally fermented oyster-based sauce compared to commercial and traditional alternatives.

Theoretical Framework

In addition, the study aimed to assess the product's acceptability through sensory evaluation, compare it with commercial oyster sauce and patis, and evaluate its perceived market potential. These objectives involved key elements such as flavor development, fermentation method, and consumer perception.

Proteolysis and Umami Generation Theory. This theory elucidated that during the fermentation process, enzymes present in oysters decomposed proteins into free amino acids, including glutamic acid, glycine, and alanine, which contributed to the inherent umami flavor (Lu et al., 2022). This transformation took place without the use of artificial additives, relying exclusively on salt and time to cultivate a deep, savory taste. In this research, the theory reinforced the idea that a pure, naturally fermented oyster sauce could attain an appealing flavor and acceptability due to these biochemical alterations.

Fermentation Strategy and Flavor Optimization Theory. This theory posited that various fermentation methods—natural, starter-based, or koji-assisted—could greatly influence the flavor, aroma, and amino acid composition of fermented seafood products (Zhou et al., 2023). Enhancing fermentation conditions resulted in better flavor quality and consistency. This study emphasized the possibility of further refining oyster sauce through regulated fermentation techniques to improve product performance.

Collectively, these theories provided a scientific foundation for the development of a naturally fermented, additive-free oyster-based sauce. They underscored the role of biochemical processes and fermentation strategies in enhancing flavor and sensory quality, thereby supporting the feasibility of developing a clean-label oyster-based condiment that aligned with consumer taste preferences, health values, and market trends.

METHODS AND DESIGN

Research Design

A descriptive–comparative approach was deemed appropriate because the study did not manipulate variables but instead analyzed differences in consumer responses using structured evaluation instruments and statistical analysis. This design allowed the researchers to measure quantifiable variations in taste, aroma, color/appearance, saltiness, and texture among the three products, as well as assess consumer perceptions related to purchase intent, perceived uniqueness, and overall acceptability. Sensory evaluation was conducted in a controlled, blind-testing setup with randomized sample presentation to minimize bias and ensure reliable results.

The study addressed a research gap in existing condiment innovation by exploring a pure, naturally fermented oyster sauce—a product not yet commercially available and rarely examined in Philippine food product development research. Unlike commercial oyster sauces, which were typically soy-based and contained artificial flavorings, this study focused on creating a clean-label, additive-free variant that highlighted the natural umami of oysters harvested from Bataan.

Sample and Setting

The target population for this study consisted of individuals in Bataan who possess relevant culinary experience or familiarity with condiments such as oyster sauce and patis. This group included culinary students, food vendors, home cooks, and regular consumers of fermented condiments. Selecting participants from this population ensured that responses were informed by practical culinary knowledge and reflective of local consumer preferences. Individuals with seafood allergies or known impairments in taste or smell perception were excluded to ensure participant safety and the reliability of sensory data.

A voluntary purposive sampling technique was employed to select respondents who could provide credible sensory and marketability evaluations. This method emphasized qualified and experience-based consumer insight rather than random selection, which is appropriate for exploratory sensory and marketability research (Kovacs & Keresztes, 2022b; Sorio et al., 2020).

Inclusion

Participants were selected according to the following inclusion parameters:

1.Residents of Bataan who are familiar with or regularly use condiments such as oyster sauce or patis in cooking or meal preparation.

2.Individuals with relevant culinary exposure—such as culinary students, home cooks, or food vendors—with prior experience in evaluating taste and aroma.

3.Participants willing to voluntarily participate in the sensory and marketability evaluation and sign the informed consent form.

Exclusion

To ensure safety and data validity, the following exclusion criteria were applied:

1.Individuals with known seafood or shellfish allergies.

2.Participants with impaired taste or olfactory functions that could affect sensory accuracy.

3.Individuals unable to provide informed consent.

4.Participants who failed to comply with sensory testing procedures or withdrew prior to completion.

Research Instrument

The research instrument used in this study was a structured questionnaire designed to gather both respondent profile information and sensory evaluation data. The questionnaire was divided into two sections to ensure the systematic collection of relevant information necessary for analyzing consumer perception and product acceptability.

The first section collected demographic information, including age, occupation, monthly income, frequency of condiment use, and most commonly used condiment. These variables were included to provide context regarding the respondents' consumption behavior and familiarity with condiments. Understanding these characteristics helped determine whether participants regularly consume products similar to the samples being evaluated, which could influence their perceptions and evaluations.

The second section focused on sensory evaluation, where respondents assessed the three sauce samples based on taste, aroma, color/appearance, saltiness, and texture using a 7-point hedonic

Part I: Demographic Profile

a.Age

b.Occupation

c.Monthly Income

d.Frequency of Condiment Use

e.Most Used Condiment

Part II: Sensory Evaluation

a.Taste

b.Aroma

c.Color/Appearance

d.Saltiness

e.Texture

Participants rated each attribute using a 7-point hedonic Likert-type scale to indicate their level of preference. The marketability assessment within the same instrument gathered consumer perceptions regarding:

a.Purchase intent

b.Perceived uniqueness of the product

c.Willingness to recommend to others

d.Expected price range

e.Perceived quality

f.Perceived healthiness

A pilot test was conducted with a small group of participants, separate from the main sample, to evaluate the clarity, reliability, and usability of the questionnaire. Necessary revisions were made based on the pilot test before full-scale data collection.

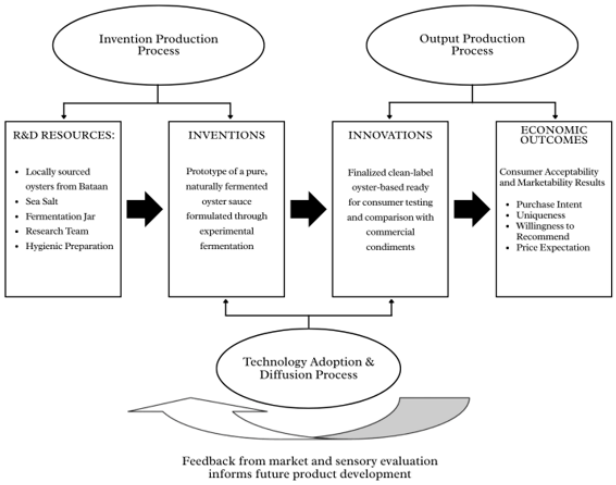
Conceptual Framework

This study adopted the Conceptual Framework of Innovation developed by Geomina Turlea et al. (2010) under the Joint Research Centre–Institute for Prospective Technological Studies (JRC-IPTS) of the European Commission. The model described how research and development (R&D) activities led to inventions that progressed into innovations and eventually resulted in measurable economic outcomes through technology adoption and diffusion. It also emphasized the cyclical nature of innovation, wherein feedback from market and consumer responses helped refine and strengthen future R&D activities.

For the purpose of this study, the framework was adapted to describe the process of developing and determining the marketability of a pure, naturally fermented oyster-based sauce made from locally sourced oysters in Bataan. Each component of the framework corresponded to a stage in the product's innovation cycle—from the use of raw materials and experimental formulation to consumer evaluation, market testing, and continuous improvement through feedback.

Figure 1

Conceptual Framework of the Innovation Process for the Development and Marketability of a Pure Oyster-Based Sauce



The conceptual framework showed how research inputs led to the creation, testing, and market introduction of an innovative food product. It presented the process by which locally available materials and fermentation techniques were utilized to produce a new formulation that underwent refinement and evaluation before reaching the market. The model also highlighted how consumer feedback and sensory evaluation results contributed to further enhancement of the product, ensuring that the innovation remained responsive to consumer needs and preferences.

Overall, the framework demonstrated how local resources could be transformed into a sustainable, value-added product through research, innovation, and consumer evaluation. It supported the study's objective of developing and assessing a pure, naturally fermented oyster-based sauce that promoted the use of local aquaculture resources while meeting the standards of quality and market competitiveness.

Data Gathering Procedure Product Making

The production of the pure fermented oyster sauce was conducted using freshly shucked oysters sourced from Bataan. Before processing, all materials and equipment were thoroughly cleaned and sterilized to maintain sanitary conditions and prevent contamination during fermentation. The equipment used in the procedure included a casserole, ladle, baking beaker, weighing scale, blender, bowls, fermentation jars, cheesecloth, and a stove. The ingredients utilized in the formulation were fresh talaba (oysters), non-iodized salt, and rice koji.

Raw Material Preparation

Formulation and Fermentation Setup

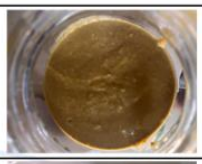
The cleaned oysters were placed in a casserole and cooked under low heat until fully cooked and until their natural brine was released. The cooked oysters were then transferred into a clean bowl. Non-iodized salt equivalent to 20% of the oyster weight was added to the cooked oysters. The mixture was blended using a blender until a uniform consistency was achieved.

After blending, the mixture was allowed to cool completely to room temperature. This step was necessary because excessive heat may inactivate the microorganisms present in rice koji that are essential for fermentation. Once cooled, rice koji—equal in amount to the previously measured salt—was added to the mixture. The ingredients were thoroughly mixed to ensure even distribution of the fermentation starter and then subjected to a final blending process to obtain a homogeneous mixture.

The prepared mixture was transferred into sterilized fermentation jars and covered with cheesecloth to allow airflow while preventing contamination from foreign particles. The mixture was then allowed to ferment for at least one month under controlled conditions. During fermentation, microorganisms present in rice koji, particularly Aspergillus oryzae, produce enzymes such as proteases and amylases that break down proteins and other complex compounds into amino acids and smaller molecules that contribute to flavor development and the formation of umami compounds (Liu et al., 2024; Wang et al., 2024).

Table 1

Formulation and Fermentation Process

STEP	FIGURE
Washing of oysters to remove shell fragments and foreign matter	
Cooking under low heat until fully cooked and natural brine is released	
Weighing oysters with brine	
Calculation of salt and rice koji based on 20% of total mixture weight	
Incorporation of salt into the oyster mixture	
Blending the salted mixture to achieve uniform consistency	
Cooling the mixture to prevent enzymatic inactivation of rice koji before incorporatinga	
Final blending to ensure homogeneous distribution	
Transfer of mixture into fermentation jar and covering with cheesecloth. Mixture has rich golden brown color	

Post-Fermentation Process

After the fermentation period, the fermented oyster mixture was filtered using cheesecloth to separate the liquid extract from the remaining solid residues. The extracted liquid served as the pure fermented oyster sauce produced in this study.

Following filtration, the sauce underwent pasteurization at 70–80 °C for approximately 10–15 minutes to reduce microbial activity, improve product safety, and stabilize the sauce by stopping further fermentation. Mild heat treatments within this temperature range are widely applied in food processing to control microorganisms while preserving the sensory quality of liquid food products (Samapundo et al., 2014). Recent research also highlights that pasteurization is commonly applied to sauces and similar food systems to extend shelf life while maintaining desirable flavor characteristics (Purohit et al., 2023).

Sensory Evaluation and Marketability Assessment

Controlled sensory evaluation sessions were conducted in a clean testing area. Each participant received three unmarked samples—Sample A (experimental pure oyster-based sauce), Sample B (commercial oyster sauce), and Sample C (traditional patis)—served in randomized order. Participants rated taste, aroma, color/appearance, saltiness, and texture using a 7-point hedonic Likert scale, and completed marketability items (purchase intent, perceived uniqueness, willingness to recommend, expected frequency of use, price expectation, perceived quality, and perceived healthiness). Participation was voluntary and preceded by a written informed consent form. The collected ratings were then summarized using descriptive statistics to determine the level of acceptability of each sample.

Participant Safety and Ethical Considerations

Individuals with seafood allergies or known sensory impairments were excluded. Product handling, evaluation protocols, and emergency procedures followed institutional ethical and

food-safety guidelines. The researchers assumed responsibility for participant welfare and covered any medical expenses resulting from unexpected adverse events.

Data Handling and Confidentiality

Data Analysis

The data collected from this study was analyzed using both quantitative and descriptive approaches to assess the sensory acceptability, marketability, and potential consumer preference for the pure oyster-based sauce.

For the sensory evaluation, results from the acceptability tests—including taste, aroma, color/appearance, saltiness, and texture—were recorded in tables and analyzed using descriptive statistics such as mean and standard deviation. Repeated measures ANOVA was conducted to determine if there were statistically significant differences in the ratings among the pure oyster-based sauce, commercial oyster sauce, and traditional patis. Post hoc comparisons, such as Bonferroni or Holm adjustments, were performed to identify where significant differences occurred between samples. These analyses highlighted which sensory attributes were most preferred by respondents and indicated the relative performance of the pure oyster-based sauce compared to existing condiments.

Open-ended responses, if any, were summarized to provide qualitative insights into consumer perceptions, highlighting suggestions, concerns, or notable observations regarding the product. By combining quantitative and descriptive analyses, the study provided a comprehensive evaluation of both the sensory qualities and market potential of the pure oyster-based sauce.

Ethical Considerations

This study strictly adhered to the ethical research standards of Colegio de San Juan de Letran–Bataan, ensuring the safety, rights, and well-being of all participants. Participants were selected through purposive sampling, focusing on individuals with relevant culinary experience, and their participation was entirely voluntary. Before participation, all individuals were fully informed of the study's objectives, procedures, and potential risks—particularly those related to consuming the fermented oyster-based condiments—and were provided an informed consent form to read and sign. Participants were explicitly informed of their right to withdraw at any stage without penalty.

All data collected were treated with strict confidentiality and anonymity. Digital data were stored in password-protected spreadsheets and backed up in secure cloud storage accessible only to the researchers. Data were used solely for academic purposes. Upon completion of the study, participants received a token of appreciation in recognition of their time and contribution.

RESULTS

Presentation of Data

This chapter presents the data gathered from the respondents regarding the acceptability and perceived marketability of the pure oyster-based sauce. The results are organized and analyzed according to the research questions of the study. Descriptive statistics such as frequency, percentage, mean, and standard deviation were used to describe the respondents' demographic profile and the level of acceptability of the sauce samples. In addition, Repeated Measures Analysis of Variance (ANOVA) was used to determine whether there were significant differences in the acceptability ratings among the sauces.

The data presentation is divided into four sections: (1) the demographic profile of the respondents, (2) the level of acceptability of the sauces in terms of sensory attributes, (3) the significant differences in acceptability ratings among the sauces, and (4) the perceived marketability of the pure oyster-based sauce.

Demographic Profile of the Respondents

This section presents the demographic profile of the respondents in terms of age, occupation, monthly income, frequency of condiment use, and most used condiment. A total of 67 respondents participated in the study. Their characteristics provide important context for interpreting their responses regarding condiment acceptability and marketability.

Age of Respondents

Table 2

Frequency Distribution of Respondents by Age

Age	Frequency	Percent	Valid Percent	Cumulative Percent
10 – 20	10	14.9	14.9	14.9
21 – 30	23	34.3	34.3	49.3
31 – 40	16	23.9	23.9	73.1
41 – 50	18	26.9	26.9	100.0
Total	67	100.0		

As shown in Table 2, the majority of respondents belonged to the 21–30 age group, accounting for 23 respondents (34.3%). This was followed by respondents aged 41–50 with 18 respondents (26.9%), and those aged 31–40 with 16 respondents (23.9%). Meanwhile, the 10–20 age group had the lowest representation with 10 respondents (14.9%).

The distribution indicates that most respondents fall within the young to middle adult age range, which is a demographic group commonly involved in food preparation, purchasing, and consumption decisions. Their familiarity with condiments and cooking practices makes their evaluation relevant to the assessment of the oyster-based sauce.

Occupation of Respondents

Table 3

Frequency Distribution of Respondents by Occupation

Occupation	Frequency	Percent	Valid Percent	Cumulative Percent
Carinderia Owner	3	4.5	4.5	4.5
Consumer	16	23.9	23.9	28.4
Culinary Student	14	20.9	20.9	49.3
Food Vendor	9	13.4	13.4	62.7
Home Cook	21	31.3	31.3	94.0
Housewife	2	3.0	3.0	97.0
Restaurant Owner	2	3.0	3.0	100.0
Total	67	100.0		

As presented in Table 3, the largest proportion of respondents were home cooks, comprising 21 respondents (31.3%). This was followed by consumers with 16 respondents (23.9%) and culinary students with 14 respondents (20.9%). Other respondents included food vendors (13.4%), carinderia owners (4.5%), housewives (3.0%), and restaurant owners (3.0%).

The dominance of home cooks and individuals involved in food preparation suggests that the respondents are familiar with condiments and flavor evaluation, making their assessments valuable in determining the acceptability of the product.

Monthly Income of Respondents

Table 4

Frequency Distribution of Respondents by Monthly Income

Monthly Income	Frequency	Percent	Valid Percent	Cumulative Percent
₱<10,000	6	9.0	9.0	9.0
₱10,000–₱19,999	24	35.8	35.8	44.8
₱20,000–₱29,999	25	37.3	37.3	82.1
₱30,000–₱39,999	10	14.9	14.9	97.0
₱40,000+	2	3.0	3.0	100.0
Total	67	100.0		

Table 4 shows that most respondents belonged to the ₱20,000–₱29,999 income bracket, with 25 respondents (37.3%), followed closely by those earning ₱10,000–₱19,999 with 24 respondents (35.8%). Respondents earning ₱30,000–₱39,999 accounted for 10 respondents (14.9%), while 6 respondents (9.0%) reported earning below ₱10,000. Only 2 respondents (3.0%) indicated a monthly income of ₱40,000 and above.

This distribution indicates that the majority of the respondents belong to the low- to middle-income sector, which represents a significant portion of the consumer market for food condiments.

Frequency of Condiment Use

Table 5

Frequency Distribution of Condiment Use Among Respondentsto middle-income sector, which represents a significant portion of the consumer market for food condiments.

Freq of Condiment Use	Frequency	Percent	Valid Percent	Cumulative Percent
Daily	23	34.3	34.3	34.3
Occasionally	13	19.4	19.4	53.7
Several times a week	31	46.3	46.3	100.0
Total	67	100.0		

As shown in Table 5, nearly half of the respondents (46.3%) reported using condiments several times a week, while 34.3% indicated that they use condiments daily. Meanwhile, 19.4% of respondents reported using condiments occasionally.

These findings indicate that condiments are a regular component of daily meals, highlighting the importance of flavoring agents such as sauces in the respondents' food consumption habits.

Most Used Condiment

Table 6

Frequency of Most Used Condiments Among Respondents

Most Used Condiment	Frequency	Percent	Valid Percent	Cumulative Percent
Banana Ketchup	8	11.9	11.9	11.9
Calamansi with Soy Sauce	10	14.9	14.9	26.9
Chili Garlic Oil	6	9.0	9.0	35.8
Homemade Dipping Mix	2	3.0	3.0	38.8
Oyster Sauce	4	6.0	6.0	44.8
Patis (Fish Sauce)	15	22.4	22.4	67.2
Sukang Paombong (Vinegar)	6	9.0	9.0	76.1
Toyo (Soy Sauce)	16	23.9	23.9	100.0
Total	67	100.0		

Table 6 shows that toyo (soy sauce) was the most commonly used condiment among respondents, with 16 respondents (23.9%), followed closely by patis (fish sauce) with 15 respondents (22.4%). Other commonly used condiments included calamansi with soy sauce (14.9%) and banana ketchup (11.9%). Less frequently used condiments were chili garlic oil (9.0%), sukang Paombong (9.0%), oyster sauce (6.0%), and homemade dipping mixes (3.0%).

The prominence of traditional Filipino condiments suggests that respondents are familiar with fermented and umami-rich flavor profiles, which is relevant to evaluating the acceptability of the pure oyster-based sauce.

Level of Acceptability of the Sauce Samples

The level of acceptability of the three sauce samples was evaluated in terms of taste, aroma, color/appearance, saltiness, and texture using mean scores and standard deviations.

Table 7

Sensory Evaluation of the Sauce Samples

Means for 3 Sauces in terms of Taste, Aroma, Color, Saltiness and Texture

	Samples	Valid	Mead	Std. Deviation	Verbal Interpretation
Level of Acceptability in Terms of Taste	pure oyster-based sauce	67	5.284	1.178	Like Slightly
	commercial oyster sauce	67	5.463	0.927	Like Slightly
	traditional patis	67	5.925	0.785	Like Moderately
Level of Acceptability in Terms of Aroma	pure oyster-based sauce	67	5.328	1.036	Like Slightly
	commercial oyster sauce	67	5.119	1.237	Like Slightly
	traditional patis	67	5.672	1.064	Like Moderately
Level of Acceptability in Terms of Color	pure oyster-based sauce	67	5.701	1.030	Like Moderately
	commercial oyster sauce	67	5.254	1.198	Like Slightly
	traditional patis	67	5.881	1.066	Like Moderately
Level of Acceptability in Terms of Saltiness	pure oyster-based sauce	67	5.269	1.388	Like Slightly
	commercial oyster sauce	67	4.716	1.165	Like Slightly
	traditional patis	67	5.194	1.090	Like Slightly
Level of Acceptability in Terms of Texture	pure oyster-based sauce	67	5.149	0.973	Like Slightly
	commercial oyster sauce	67	5.164	0.914	Like Slightly
	traditional patis	67	5.881	1.066	Like Moderately

** 1.00 – 1.49 – Dislike Very Much, 1.50 – 2.49 – Dislike Moderately, 2.50 – 3.49 – Dislike Slightly, 3.50 – 4.49 – Neither Like nor Dislike, 4.50 – 5.49 – Like Slightly, 5.50 – 6.49 – Like Moderately, 6.50 – 7.00 – Like Very Much*

The results show that Sample C (traditional patis) obtained the highest mean ratings across most sensory attributes. In terms of taste, Sample C received the highest mean score (M = 5.925), interpreted as Like Moderately, while both Sample A (pure oyster-based sauce) and Sample B (commercial oyster sauce) were interpreted as Like Slightly.

For aroma, Sample C again received the highest rating (M = 5.672), indicating that respondents preferred its aroma compared with the other samples. Meanwhile, Samples A and B also received acceptable ratings within the Like Slightly range.

In terms of color/appearance, both Sample A (M = 5.701) and Sample C (M = 5.881) were interpreted as Like Moderately, while Sample B received a slightly lower rating interpreted as Like Slightly.

Regarding saltiness, all three samples fell within the Like Slightly category, suggesting that respondents generally found the saltiness level of the sauces acceptable.

Lastly, for texture, Sample C obtained the highest mean rating (M = 5.881), interpreted as Like Moderately, while Samples A and B received similar ratings within the Like Slightly category.

Overall, the results indicate that the pure oyster-based sauce demonstrated acceptable sensory characteristics and performed comparably with existing commercial condiments, although traditional patis received slightly higher ratings in several attributes.

Significant Difference in Acceptability Ratings

A Repeated Measures ANOVA was conducted to determine whether there was a significant difference in acceptability ratings among the three sauce samples in terms of taste, aroma, color/appearance, saltiness, and texture.

Table 8

Comparison of Acceptability Ratings of the Three Sauce Samples

Cases	Sphericity Correction	Sum of Squares	df	Mean Square	F	p	ω^2
Sauce	Greenhouse-Geisser	14.70	1.823	8.063	7.240	.002	0.062
Residuals	Greenhouse-Geisser	133.97	120.305	1.114			

The analysis revealed a statistically significant difference in taste ratings among the three samples, F = 7.240, p = .002. Post hoc comparisons indicated that traditional patis was rated significantly higher in taste than both the pure oyster-based sauce and the commercial oyster sauce, while no significant difference was found between the pure oyster-based sauce and the commercial oyster sauce.

Similar analyses were conducted for the other sensory attributes.

Table 9

Difference in Acceptability Ratings in Terms of Aroma

Difference in Acceptability Ratings in Terms of Aroma

Repeated Measures ANOVA – Within Subjects Effects

Cases	Sum of Squares	df	Mean Square	F	p	ω^2
Sauce	10.42	2	5.209	3.843	.024	0.030
Residuals	178.92	132	1.355			

Table 10

Difference in Acceptability Ratings in Terms of Color/Appearance

Difference in Acceptability Ratings in Terms of Color/Appearance

Repeated Measures ANOVA – Within Subjects Effects

Cases	Sum of Squares	df	Mean Square	F	p	ω^2
Sauces	13.97	2	6.985	6.146	.003	0.046
Residuals	150.03	132	1.137			

Table 11

Difference in Acceptability Ratings in Terms of Saltiness

Difference in Acceptability Ratings in Terms of Saltiness

Repeated Measures ANOVA – Within Subjects Effects

Cases	Sum of Squares	df	Mean Square	F	p	ω^2
Sauces	12.03	2	6.015	4.347	.015	0.030
Residuals	182.64	132	1.384			

Table 12

Difference in Acceptability Ratings in Terms of Texture

Repeated Measures ANOVA – Within Subjects Effects

Cases	Sum of Squares	df	Mean Square	F	p	ω^2
Sauces	23.41	2	11.706	10.74	< .001	0.098
Residuals	143.92	132	1.090			

The results showed that significant differences were observed across all five sensory attributes ($p < .05$). Among the attributes, texture exhibited the strongest effect, indicating that respondents perceived the greatest difference among the sauces in terms of texture.

Traditional patis consistently obtained the highest ratings across several attributes, while the pure oyster-based sauce showed comparable ratings in some aspects, suggesting that it has potential as an alternative condiment.

Perceived Marketability of the Pure Oyster-Based Sauce

The perceived marketability of the pure oyster-based sauce was evaluated in terms of purchase intent, perceived uniqueness, willingness to recommend, expected frequency of use, price expectation, perceived quality, and perceived healthiness.

Table 13

Descriptive Statistics of Marketability Indicators

	Valid	Mean	Std. Deviation	Verbal Interpretation
Purchase Intent	67	3.776	0.623	Likely
Perceived Uniqueness	67	3.597	1.169	Likely
Willingness to Recommend	67	3.716	0.775	Likely

** 1.00 – 1.80 – Very Unlikely, 1.81 – 2.60 – Unlikely, 2.61 – 3.40 – Neutral, 3.41 – 4.20 – Likely, 4.21 – 5.00 – Very Likely*

Table 14

Descriptive Statistics of Consumers' Expected Frequency of Use

	Valid	Mean	Std. Deviation	Verbal Interpretation
Expected Frequency of Use	67	3.576	1.118	Several times a week

** 1.00 – 1.80 – Never, 1.81 – 2.60 – Rarely, 2.61 – 3.40 – Occasionally, 3.41 – 4.20 – Several times a week, 4.21 – 5.00 – Daily*

Results indicated that respondents were likely to purchase the product, with a mean score of 3.776. Similarly, the product was perceived as unique (M = 3.597) and respondents expressed a willingness to recommend it to others (M = 3.716).

In terms of expected frequency of use, respondents indicated that they would likely use the product several times a week (M = 3.576), suggesting potential regular consumption.

Additionally, respondents agreed that the product has good quality (M = 4.015) and perceived it as healthy (M = 3.866).

Table 15

Frequencies for Price Expectation

Price Expectation	Frequency	Percent	Valid Percent	Cumulative Percent
> Php 80.00	12	0.1	17.9	17.9
Php 80.00 – Php 99.00	12	0.1	17.9	35.8
Php 100.00 – Php 119.00	13	0.1	19.4	55.2
Php 120.00 – Php 139.00	21	0.1	31.3	86.6
Php 140.00 and above	9	0.1	13.4	100.0

Regarding price expectation, the largest proportion of respondents (31.3%) preferred a price range of ₱120–₱139, followed by ₱100–₱119 (19.4%), indicating that consumers are willing to pay a moderate price for a naturally fermented oyster-based product.

Overall, the findings suggest that the pure oyster-based sauce demonstrates positive marketability potential, supported by favorable consumer perceptions in terms of purchase intent, product uniqueness, quality, and pricing.

DISCUSSION

This study aimed to evaluate the sensory acceptability and perceived marketability of a pure fermented oyster-based sauce developed from locally harvested oysters in Bataan. The product was created as a clean-label alternative to conventional oyster sauces that often contain additives such as soy sauce, sugar, and artificial flavor enhancers. Through a controlled sensory evaluation, respondents assessed the experimental sauce alongside commercial oyster sauce and traditional patis based on taste, aroma, color/appearance, saltiness, and texture, as well as indicators of marketability including purchase intent, perceived uniqueness, and willingness to recommend.

The findings revealed that the pure fermented oyster-based sauce received moderate to favorable ratings across the evaluated sensory attributes, indicating that respondents generally found the product acceptable. Among the attributes evaluated, aroma and texture were rated comparably to the established commercial condiments, suggesting that the natural fermentation process was effective in developing desirable sensory characteristics associated with umami-rich sauces. Fermentation is widely recognized for enhancing flavor complexity and aroma in seafood-based condiments, which may explain why the product performed well in these attributes.

In terms of taste and saltiness, the experimental sauce also received acceptable ratings from respondents. However, slight variations in flavor perception may be attributed to the product's formulation, which intentionally excludes additives such as soy sauce, sugar, and

artificial enhancers. Unlike conventional oyster sauces that rely on these ingredients to intensify flavor, the developed sauce highlights the natural umami profile derived solely from fermented oysters. This difference may have produced a taste profile that is more natural and less processed, which some respondents perceived as distinctive compared to familiar commercial products.

The color and overall appearance of the sauce were likewise considered acceptable by the respondents, suggesting that the fermentation and preparation processes were sufficient in producing a visually appealing condiment. Appearance plays a significant role in food evaluation because consumers often associate color and consistency with flavor quality and freshness. The acceptable ratings in these attributes indicate that the developed sauce meets general expectations for seafood-based condiments.

Beyond sensory attributes, the study also examined the perceived marketability of the product. The results indicated that respondents generally expressed positive purchase intent, perceived the product as unique, and showed willingness to recommend it to others. These findings suggest that the pure oyster-based sauce has potential as an innovative condiment in the local market. Respondents also indicated a reasonable willingness to purchase the product within the ₱100–₱139 price range, suggesting that consumers recognize the product's value as a locally sourced and naturally fermented food innovation.

The perceived uniqueness of the product may be attributed to its clean-label formulation, which emphasizes minimal processing and the use of a single primary ingredient. As consumers increasingly seek natural and locally sourced food products, innovations that highlight regional ingredients and traditional fermentation methods may attract growing interest. In this context, the use of Bataan oysters not only contributes to product authenticity but also supports local aquaculture and promotes value-added utilization of marine resources.

Overall, the results indicate that the developed pure fermented oyster-based sauce demonstrated a level of sensory acceptability comparable to existing condiments. Statistical analysis revealed significant differences in the acceptability ratings among the three sauce samples across several sensory attributes. These findings therefore lead to the rejection of the null hypothesis, indicating that the level of sensory acceptability differed significantly among the evaluated condiments. Despite these differences, the experimental sauce obtained favorable consumer responses and showed comparable acceptability to traditional patis and commercial oyster sauce. This suggests that the simplified, additive-free formulation of the pure fermented oyster-based sauce can still provide a desirable sensory profile and has potential as an alternative fermented condiment derived from locally sourced oysters.

Taken together, the findings highlight the potential of Bataan oysters as a viable raw material for developing innovative food products. The acceptable sensory qualities, positive consumer perception, and promising marketability indicators suggest that the pure fermented oyster-based sauce may serve as a sustainable and locally inspired condiment that aligns with the growing demand for natural and clean-label foods.

CONCLUSION

Based on the findings of the study, the following conclusions were drawn:

1. The demographic profile of the respondents revealed that the majority belonged to the 21–30 age group, with most identifying as home cooks, consumers, and culinary students. Most respondents also fell within the ₱10,000–₱29,999 monthly income range, indicating representation from the low- to middle-income sector. In addition, the respondents reported frequent condiment use, with many using condiments several times a week or daily. The most

commonly used condiments were toyo (soy sauce) and patis (fish sauce), indicating that respondents are familiar with fermented and umami-rich flavor profiles.

2. The results showed that the pure oyster-based sauce demonstrated an acceptable level of sensory quality in terms of taste, aroma, color/appearance, saltiness, and texture. The ratings for the pure oyster-based sauce were generally interpreted as "Like Slightly," indicating that respondents found the product acceptable as a condiment. In some attributes, particularly color/appearance, the pure oyster-based sauce obtained ratings comparable to traditional condiments.

3. The statistical analysis revealed that there were significant differences in the acceptability ratings among the three sauces in terms of taste, aroma, color/appearance, saltiness, and texture. Among the samples, traditional patis consistently obtained the highest acceptability ratings, particularly in taste and texture. However, the pure oyster-based sauce obtained ratings comparable to the commercial oyster sauce in several attributes, suggesting that it can compete with existing products in the market.

4. The findings also indicated that the pure oyster-based sauce has favorable marketability potential. Respondents expressed a positive purchase intent, perceived the product as unique, and indicated a willingness to recommend it to others. They also agreed that the product is of good quality and relatively healthy. Furthermore, most respondents preferred a price range of ₱120.00–₱139.00, suggesting that consumers are willing to pay a moderate price for a naturally fermented oyster-based condiment.

Overall, the results of the study indicate that the pure oyster-based sauce is an acceptable condiment with promising market potential, although traditional condiments such as patis still received higher preference in certain sensory attributes.

RECOMMENDATIONS

Improvement of Product Formulation. Future studies may improve the formulation and fermentation process of the pure oyster-based sauce in order to further enhance its taste and texture. Adjustments in ingredient proportions and fermentation duration may help increase the overall sensory acceptability of the product.

Utilization of Locally Produced Koji. Instead of relying on imported rice koji commonly sourced from Japan, future researchers may explore the use of locally produced koji made from locally grown rice. This may promote the utilization of abundant local agricultural resources, support local farmers and producers, and reduce dependence on imported fermentation starters.

Expanded Sensory Evaluation. Future research may involve a larger and more diverse group of respondents, including chefs, food technologists, restaurant owners, and consumers, in order to obtain broader evaluations of the product's sensory qualities and potential culinary applications.

Shelf Life and Safety Analysis. Further studies may examine the shelf life, nutritional composition, and microbiological safety of the pure oyster-based sauce to ensure product stability, quality, and safety for potential commercialization.

Market Feasibility Assessment. Future researchers may conduct market feasibility studies that include pricing analysis, packaging development, and branding strategies to determine the product's potential for commercialization and wider market acceptance.

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