Rice Bran (Oryza Sativa)-Based Edible Cutlery: A Sustainable Alternative to Single-Use Plastics

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THE PROBLEM AND ITS BACKGROUND

The food industry increasingly resorts to using single-use plastics, since they offer benefits of convenience, affordability and availability. Disposable plastic cutlery is one of the most popular examples in the food industry, being widely used both in restaurants and take-away businesses, as well as fast food restaurants. Most plastic utensils are produced with the use of petroleum-based polymers, including polystyrene and polypropylene, which neither break down naturally in nature nor are eco-friendly (OECD, 2022). Their uncontrolled use, when not disposed of properly, causes pollution.

In many developing countries, the problem of plastic waste accumulation is becoming serious, particularly due to ineffective waste management systems. The situation has become worse due to excessive accumulation of plastic cutlery and due to inadequate recycling efforts (OECD, 2022). It is believed that disposable cutlery is disposed of after just one use and goes either to landfills, drainage systems, or oceans. The studies show that plastic cutlery, even after being discarded, contributes to the emergence of microplastics, threatening the environment through contamination of food chains (UNEP, 2023). Therefore, it is not surprising that there is an increasing need for environmentally safe substitutes.

Taking into account all of the above-mentioned issues, it is impossible not to notice that the ways of producing environmentally friendly food packaging and utensils are becoming popular today. Researchers are interested in examining edible and compostable products based on natural agricultural resources as substitutes for single-use plastics (Hwang et al., 2025). Edible cutlery offers an effective two-in-one option: it can be consumed or decomposed safely, ultimately preventing hazardous waste (Development and characterization of microfiber incorporated with industrial biopolymer composite based biodegradable cutlery: An alternative to single-use plastic, 2023). This technique promotes sustainable ways while helping reduce plastic toxicity and responsible utilization of resources (FAO, 2022).

Rice (Oryza sativa L.) is one of the most widely grown cereal crops in the world. It is a common foodstuff for over half of the global population. One of the by-products of the rice manufacturing process, rice bran, is obtained from polishing rice grains. Even though it is rich in carbohydrates, dietary fibers, proteins, lipids, and bioactive substances, rice bran is among the least utilized plant materials (Navajas-Preciado et al., 2025). With the presence of numerous properties, such as water absorption, compatibility of binders, and heat-processing stability, rice bran is a good option for high-value applications.

Cassava starch is going to be selected as the primary binding agent of the ECOBITE mixture because of its gelatinizing, binding as well as molding capabilities (Collado et al., 2023). Rice bran will serve as the major component of the food. Other substances, such as xanthan gum, will reinforce the starch mass, while guar gum will make it stronger in terms of flexural strength and breakage. Vegetable glycerin will work as a plasticizer that provides flexibility, while food-grade calcium carbonate will increase the strength of the material. Salt will improve the taste of the food item, while water will help to hydrate dry materials and promote the starch gelatinization process.

The utilization of rice bran as the primary structural element has not been properly researched. The research study will focus on environmental pollutants caused by non-degradable plastic wastes as well as insufficient usage of rice bran in high-value-added food markets. In this study, we developed and evaluated ECOBITE as a rice bran-based edible spoon prototype. We examined its formulation, observable function, sensory acceptability, equipment hygiene, and perceived environmental contribution. Its nutritional benefits, long-term product safety, and environmental impact were not measured; therefore, we do not claim that ECOBITE is healthier or demonstrably more sustainable than existing alternatives.

Background of the Study

Rice bran, an important by-product of rice milling in the Philippines, is still underused although it is known for its nutritional and functional properties. In this case, most of the rice bran produced is either used for animal feed or thrown away, which means that the rice bran is wasted and not put into use in the food processing sector. (Philippine Statistics Authority [PSA], 2024).

At the same time, the prevalence of single-use plastic cutlery has increased the problem of environmental pollution, as these materials are non-degradable and accumulate in landfills and our surroundings. (United Nations Environment Programme [UNEP], 2023).

Current studies show how agricultural by-products like rice bran can be potentially used in the industry through the proper stabilization and processing of rice bran. One of the reasons is its high content of carbohydrates, fiber, and lipids, which makes it favorable for development into innovative food products other than rice bran's conventional use (Gul et al., 2022). The results of the study conducted locally also reveal that rice bran can be used in food innovations, which will be accepted by consumers and will have promising market viability (Dalinas et al. 2023).

To respond to these concerns, we developed ECOBITE as a rice bran-based edible spoon prototype. We did not seek to eliminate conventional plastic cutlery. Our purpose was to investigate whether an agricultural by-product could be formulated into a usable utensil and to gather initial evidence about its performance and acceptability. This research, through the use of food engineering principles, product testing, and sustainable application of an underutilized agricultural by-product, aims to promote waste valorization, circular economy practices, and educated consumer choices (UNEP, 2023).

Conceptual Framework

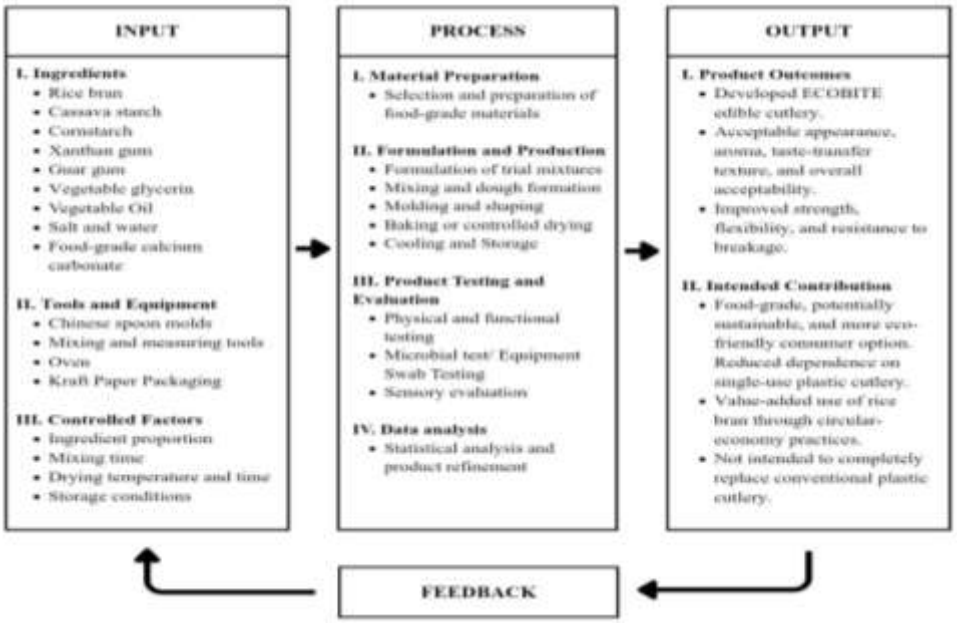

Figure 1. The Conceptual Framework

The Input phase includes raw materials such as food-grade rice bran, cassava starch, xanthan gum, guar gum, vegetable glycerin, food-grade calcium carbonate, salt, and water, along with tools, equipment, and formulation conditions. The Process phase includes ingredient preparation and formulation mixing, baking, cooling, storage, physical testing, and sensory evaluation. The Output phase produces ECOBITE edible utensils that will minimize the use of disposable ones.

Statement of the Problem

The researchers' goal is to evaluate ECOBITE's viability, usability, and acceptance as a spoon produced from food-grade rice bran. The focus will be on the physical and functional attributes of ECOBITE, user acceptance relating to sensory evaluation, and how ECOBITE serves to protect the environment compared to disposable plastic items. ECOBITE is not intended to fully replace conventional plastic cutlery, but to provide a more eco-friendly, food-grade option for consumers. Specifically, this study seeks to answer the following questions:

1. How can rice bran be used as a primary ingredient in producing edible cutlery in terms of;
   1.1. Formulation
   1.2. Preparation and Process
   1.3. Production Method
2. What are the physical and functional characteristics of the developed ECOBITE edible cutlery in terms of:
   2.1. Strength
   2.2. Structural Stability
   2.3. Moisture Resistance
   2.4. Heat Resistance
   2.5. Usability
3. Is the developed ECOBITE edible cutlery acceptable in terms of;
   3.1. Appearance
   3.2. Odor
   3.3. Texture
   3.4. Taste-transfer
   3.5. Overall Acceptability
4. What is the microbial load on the equipment used in producing the ECOBITE based on swab testing in terms of;
   4.1. Total Coliform Count
   4.2. Escherichia coli
   4.3. Salmonella Detection
5. How may ECOBITE contribute to reducing the use of single-use plastic spoons in terms of;
   5.1. Providing an additional food-grade cutlery option
   5.2. Reducing dependence on single-use plastic spoons

5.3. Encouraging the use of more environmentally responsible food-service materials

6. Is there a significant difference among the mean ratings across the evaluation dimensions in terms of consumer sensory evaluation, expert functional evaluation, and expert sensory evaluation of ECOBITE edible cutlery?
7. What improvements may be recommended to enhance the quality, functionality, sensory acceptability, and overall use of ECOBITE?

Cause and Effect Model

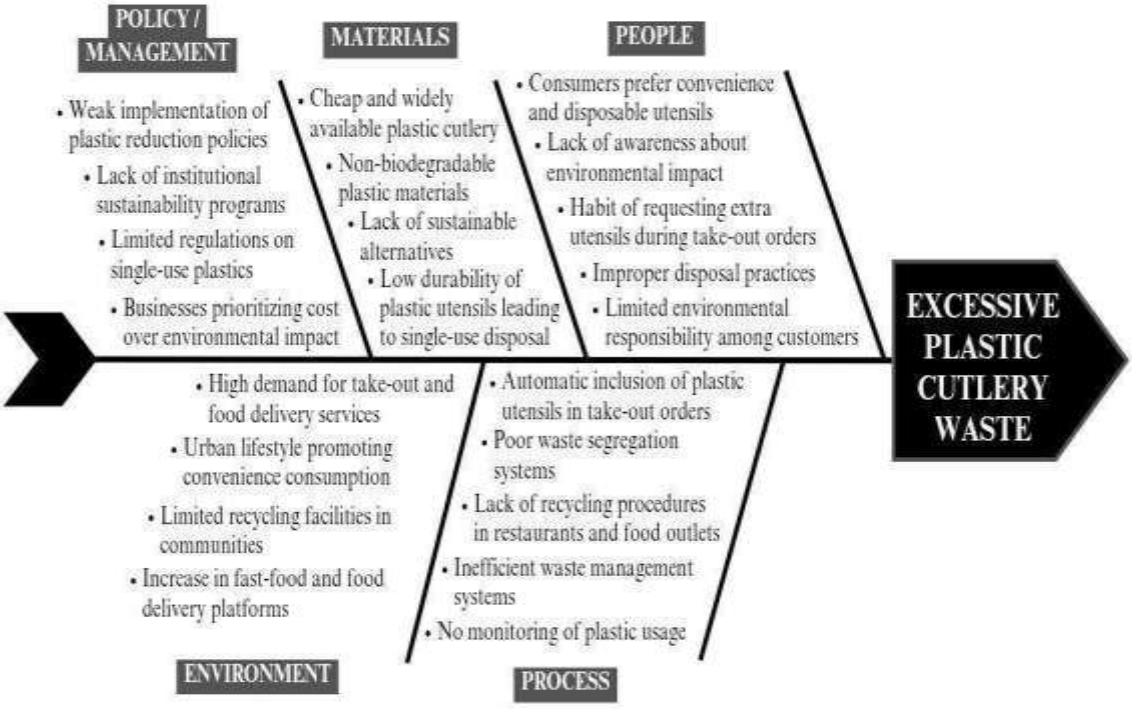

Figure 2: Cause and Effect Diagram

The fishbone diagram shows the various reasons behind the large amounts of plastic cutlery waste produced every year. The main reasons under the policy and management category include weak enforcement of policies to limit plastic use, a lack of laws on single-use plastics, a lack of sustainability programs in institutions, and price-based behavior by some companies.

In the case of the materials involved, plastic cutlery continues to be used as it is cheap and available in many places, while the inadequate number of alternatives will lead people to continue to use plastics that cannot disintegrate. Human factors also play an important role, with consumers' preference for convenience, little knowledge about the effects of plastic cutlery on nature, demand for cutlery when ordering food, and poor disposal methods being among the reasons behind the large waste. In the environmental aspect, plastic cutlery continues to be used because of the rising demand for food delivery services, convenience-oriented behaviors, limited facilities for recycling, and an increase in restaurants and food businesses.

In conclusion, the fishbone analysis reveals that the reasons behind large amounts of plastic cutlery waste produced are linked together in terms of policies, the materials used, behavior of people, environmental factors, as well as waste management methods. This leads to the possibility of bringing up the idea of developing ECOBITE rice bran cutlery as an alternative to plastic cutlery.

Objectives of the Study

General Objective

To develop and evaluate ECOBITE, a food-grade rice bran-based edible cutlery that may provide consumers

with a potentially healthier, more eco-friendly option for reducing their use of single-use plastic cutlery.

Specific Objectives

1. To develop ECOBITE through successive formulation and processing trials using rice bran as the principal ingredient.

2. To determine the prototype's functional characteristics in terms of strength, structural stability, moisture resistance, heat resistance, and usability

3. To assess the sensory acceptability of edible cutlery

4. To evaluate expert perceptions of ECOBITE's potential environmental contribution as an additional food-grade cutlery option.

5. To identify product and process improvements based on the findings.

Hypothesis

We used a 0.05 significance level to report comparisons among the five dimensions within each of the three evaluation sets. The null hypotheses concern differences among dimensions within consumer sensory ratings, expert functional ratings, and expert sensory ratings. They do not directly compare the consumer and expert groups.

$H0_1$: There is no significant difference among the mean consumer ratings for appearance, odor, texture, taste-transfer, and overall acceptability of ECOBITE.

$H0_2$: There is no significant difference in the mean expert functional ratings across strength, structural stability, moisture resistance, heat resistance, and usability of ECOBITE cutlery.

$H0_3$: There is no significant difference among the mean expert sensory ratings for appearance, odor, texture, taste-transfer, and overall acceptability of ECOBITE.

The corresponding alternative hypotheses state that at least one evaluation dimension has a mean rating significantly different from the others.

Because each participant rated five dimensions, the researchers repeated-measures analysis of variance (ANOVA) to examine differences among the dimension means within each evaluation set. We analyzed consumer sensory, expert functional, and expert sensory ratings separately. The analysis did not directly compare consumers with experts.

Scope and Limitations of the Study

The study focused on the development and evaluation of ECOBITE using food-grade rice bran, cassava starch, cornstarch, xanthan gum, guar gum, vegetable glycerin, food-grade calcium carbonate, salt, vegetable oil, and water. The production process involved ingredient preparation, formulation, mixing, molding, baking or controlled drying, cooling, and storage. The evaluation covered the physical and functional ratings, sensory properties, equipment-swab results, and perceived environmental contribution of the prototype.

We gathered responses from 100 respondents, consisting of 90 student-consumers from Hospitality and Management and Food Processing Technology programs and 10 food industry experts in the City of San Jose Del Monte, Bulacan. The food industry experts assessed the functional and sensory characteristics of ECOBITE and provided comparative and environmental-perception ratings, while the student-consumers assessed the product's sensory acceptability. The microbiological results reported in the study were obtained from swab samples from the finished spoon.

The study is limited to a prototype developed and evaluated under the conditions and with the participants represented in the research records. The results should not be generalized to all consumers or food-service settings. We did not establish quantified load capacity, water absorption, performance across controlled hot-food temperatures and immersion times, finished-product microbiological safety, shelf life, packaging stability, composting or biodegradation rates, life-cycle impact, production cost, or commercial feasibility.

Significance of the Study

Sustainable alternatives to plastic consumer products in the food processing industry are becoming vital as environmental awareness and resource consciousness grow. Through innovative applications of waste utilization and circular economy concepts, we can reduce resource waste and create products with greater added value (United Nations, 2023). Therefore, ECOBITE advances the concept of transforming stabilized rice bran into edible cutlery, offering a sustainable and environmentally conscious alternative to conventional single-use plastic cutlery. However, the experiment does not aim to completely eliminate plastic cutlery but rather to introduce ECOBITE as an alternative that encourages consumers to make more environmentally responsible choices.

More particularly, the results of this study are very important in relation to the following stakeholders:

Food Processing Industry – The research shows how the food processing industry has the capacity to change rice bran waste into a profitable product line, comply with sustainability rules, and obtain a competitive advantage in the market place.

Environmental advocates - The findings contribute to the arguments put forward by environmental advocates for the development of truly sustainable alternatives against the greenwashing phenomenon while showcasing the upcycling of rice bran waste in alignment with principles of circular economy.

Consumers - The study may provide consumers with yet another option for an edible and food-grade utensil that will create a step towards reducing their reliance on single-use plastics. It does not advocate for complete elimination or even full replacement of plastic cutlery; it simply provides an exploration into a potentially healthier and more environmentally friendly alternative available to consumers interested in sustainable consumption initiatives.

Researchers and academic establishments - The proposed methodology provides opportunities to stabilize rice bran from rancidity, thus ensuring the availability of stable raw materials for the production of multiple applications within various industries.

Farmers and Rice Millers - Farmers and rice millers benefit from converting low-value rice bran into a premium raw material, thereby opening new revenue streams and reducing waste-management costs.

Operational Definition of Terms

The following terms are operationally defined for use in this study.

Acceptability of ECOBITE Edible Cutlery. Indicates the level of acceptance of ECOBITE edible cutlery based on its sensory attributes, as perceived by respondents.

Biodegradability. Defined as the process by which ECOBITE decomposes naturally in the environment without emitting harmful products, compared with conventional plastic cutlery.

Edible cutlery. Refers to spoons, forks, and similar utensils that are food-grade and safe for eating, or that degrade over time without posing health hazards.

Environmental Sustainability. Refers to its ability to minimize plastic waste, use resources effectively, and have minimal environmental impact by using biodegradable, edible materials.

Edible Cutlery. A food-grade utensil developed from edible ingredients and intended for use with food.

Functional Characteristics. The properties considered in the study's functional evaluation: strength, structural stability, moisture resistance, heat resistance, and usability.

Oryza sativa L. bran (Rice Bran). The outer layer of the rice grain obtained during the milling process.

Rice Bran Stabilization. The treatment applied to rice bran to reduce deterioration associated with enzymatic activity.

Sensory Evaluation. Indicating the process used by the consumer to evaluate ECOBITE.

REVIEW OF RELATED LITERATURE AND STUDIES

This chapter refers to relevant literature and studies that are relatable to the current study. It includes published works and studies that have played an important role in bringing about the development of ECOBITE and addresses the areas of rice bran, edible cutlery, reduction of plastic waste, sensory evaluation studies, and sustainability of products.

Related Literature

Foreign Literature

The Organization for Economic Co-operation and Development (OECD, 2022) projected that plastic use and waste will continue to increase if current production and consumption patterns remain unchanged. Its report emphasizes that addressing plastic pollution requires more than recycling, including waste prevention, product redesign, reuse, and improved waste management. Disposable utensils matter because they are used briefly but can persist in the environment for much longer. This provides a basis for investigating alternatives such as ECOBITE; however, an edible spoon should be viewed as one possible source-reduction approach rather than a complete solution to plastic pollution.

The United Nations Environment Programme (UNEP, 2023) similarly explained that reducing unnecessary plastic use and shifting toward circular and safer alternatives are important in addressing plastic pollution. For edible utensils, replacing plastic is meaningful only if the alternative performs its intended function. A spoon must remain usable during food contact and be prepared and handled appropriately as a food product.

Accordingly, the present study evaluates functionality, sensory characteristics, and safehandling rather than relying solely on the environmental origin of the materials.

Rice bran is an important material in the present study. Eng and Mohd Rozalli (2022) described it as the outer fraction removed during rice milling and reported that it contains protein, dietary fiber, oil, vitamins, minerals, and bioactive compounds. They also discussed its potential incorporation into food products. These characteristics support its use as a value-added food ingredient rather than solely as a low-value milling by-product. In ECOBITE, rice bran is a major solid component; therefore, its particle characteristics and interactions with starch may influence texture, color, molding behavior, moisture absorption, and overall acceptability.

Manzoor et al. (2023) further reported that rice bran contains dietary fiber, protein, essential fatty acids, vitamins, minerals, sterols, and antioxidant compounds. Processing methods may improve its suitability for food applications. Nevertheless, do not attribute the nutritional characteristics of raw rice bran to the finished ECOBITE spoon without laboratory analysis of the final product. In the present study, the literature supports rice bran as a potentially useful food material and agricultural by-product for value-added product development.

A major limitation of rice bran is its susceptibility to rancidity. Yılmaz Tuncel (2023) explained that lipase activity after milling can produce free fatty acids, leading to undesirable flavor and odor. Stabilization methods such as dry heating, steaming, microwave treatment, and extrusion may reduce enzyme activity and improve storage stability. This is relevant to ECOBITE because undesirable odor or flavor could affect sensory

evaluation. Using stabilized, food-grade rice bran and appropriate storage before formulation may support more consistent product development and evaluation. The binder and other ingredients play an important role in forming the spoon's structure. Tan et al. (2022) found that starch-based materials are renewable and biodegradable; however, unmodified starch-based materials become brittle and moisture-sensitive. There can be altered characteristics owing to the introduction of plasticizers, fillers, fibers, and blends in the formulation of ECOBITE. Thus, the formulation of ECOBITE requires a careful balancing of these components to achieve the desired rigid properties without affecting any other aspect of its characteristics.

Tan et al. (2022) explained that starch-based materials may be renewable and biodegradable but are commonly brittle and moisture-sensitive when unmodified. Plasticizers, fillers, fibers, and blends can alter strength, flexibility, thermal behavior, and barrier properties. This is relevant to ECOBITE's use of starch, vegetable glycerin, gums, rice bran, and reinforcing ingredients. The formulation must balance these components because changes intended to improve rigidity or flexibility may also affect moisture response, texture, or eating quality.

In their review of edible-packaging developments, Kumar et al. (2023) identified mechanical integrity, moisture management, food safety, palatability, and consumer acceptability as important design considerations. These principles may also apply to edible cutlery. A spoon may be molded successfully but remain unsuitable if it breaks easily, softens too quickly, becomes excessively hard or gritty, or produces an unpleasant taste or odor. Accordingly, the present study considers both ECOBITE's physical function and users' sensory experience.

Local Literature

In the Philippines, the Extended Producer Responsibility Act of 2022 or Republic Act no. 11898 provides the policy framework to reduce plastic waste. The Environmental Management Bureau (2022) states that companies under the purview of the law must devise mechanisms to recover and manage plastic packaging waste responsibly, including specific plastic cutlery. Although this law does not mandate edible cutlery, it further justifies the need for research on other materials and source reduction strategies. This implies that ECOBITE can be considered a viable alternative in the wider plastic waste management efforts.

According to the Philippine Statistics Authority (2025), national palay production reached around 19.09 million metric tons in 2024. While rice milling produces fractions such as bran, the report does not specify how much rice bran is produced. This shows that there is still a local source of rice milling materials that can be considered for value addition. However, in the case of an edible product, the fact of availability is not enough, and the rice bran must undergo required preparations to ensure stabilization, storage, and food grade handling.

The Department of Science and Technology (2024) indicates that there are several Philippine initiatives in the area of packaging materials from agricultural and aquaculture raw materials such as plant fibers, chitosan, and fruit products. These initiatives suggest the local interest in using biological materials and by-products into food contact materials. They highlight the need for proper performance and safety evaluation of environmental claims to be used in ECOBITE since local availability of ingredients calls for controlled preparation and product testing.

The Philippine Rice Research Institute (2025) developed a yogurt product with stabilized pigmented rice bran, serving as an example of the local application of rice bran in food processing. While yogurt is not moldable edible cutlery, it shows that stabilized rice bran can be used in food processing applications provided that account for processing, taste, and safety issues. This furthers the broader aim of valorization of rice milling waste and the need to utilize stabilized rice bran safely in ECOBITE.

Tecson-Mendoza and Cuevas (2025) evaluated biodegradable plastic alternatives made from terrestrial resources in the Philippines and outlined ongoing challenges in terms of testing, funding, equipment standardization, production, and scaling issues. Their analysis attempts to place ECOBITE within the larger context of Filipino initiatives aimed at producing alternatives to petroleum-based plastics. However, a successful laboratory prototype does not imply commercial readiness, and further research is needed to study such areas as shelf life, manufacturing costs, regulatory compliance, and packaging.

Related Studies

Foreign Studies

The non-wheat edible spoon developed by Habla et al. (2023), using local materials like cassava and saba banana, showed that after formulation and molding trials, its functionality in hot, cold, and ambient serving conditions lasted for 30 minutes and had good sensory evaluation results.

Rice bran protein concentrate was used to enhance beta carotene encapsulates by Magnaye et al. (2022), as rice bran was able to show physicochemical and release properties in a structurally-modified food system.

Dalin-as et al. (2023) conducted research on the perception of consumers towards fermented rice bran beverages in Eastern Visayas and found that there was a low prior awareness of these beverages among the respondents but consumer knowledge about the ingredients and health benefits did influence their willingness to buy.

Fronteras et al. (2024) established a good amount of insoluble fiber and other bound phenolic compounds present in the bran extracted from the five varieties of Philippine pigmented rice and provided insights on variations between the varieties studied.

The study conducted by Caña et al. (2025) through the survey of respondents aimed to analyze the likelihood of consumers purchasing buffalo milk yogurt augmented with stabilized-colored rice bran in Negros Occidental.

Picar et al. (2025) stated that the types of ingredients as well as their ratios in the bioplastic film influenced its features, such as tensile strength and elongation.

Molina et al.(2025) further characterized their findings regarding cassava-peel-starch-based bioplastic films in terms of their water absorption capacity and enhanced understanding of moisture sensitivity in such substances.

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Research Gap

The topic of edible biodegradable cutlery as a replacement for single-use plastics has gathered much interest,

with many previous studies looking at plant-based materials such as rice flour, wheat flour, sorghum flour, millet flour, starches, and other agricultural matter. In 2022, Roy and Morya stated that rice bran flour could serve as a unique option in making edible cutlery due to its nutritional and functional characteristics.

The need for further research regarding edible cutlery from rice bran flour has been established through Iqbal et al. (2022), who showed that edible cutlery made with rice flour, sorghum flour, and wheat flour had good quality and could degrade in soil after five to seven days.

Another source adds to this continuing need for research on rice bran flour. The study by Roy et al. (2025) contained information on plant-flour-based edible tableware of which rice bran is one of the many options available for producing edible cutlery. Some major concerns in edible tableware, such as strength, water absorption, shelf life, food safety, and general consumer acceptability, have also been highlighted in this study.

Edible cutlery research has shown that production of sustainable cutlery involves more than merely the choice of material. Disposable tableware should be examined for issues related to quality, food safety, and actual performance during use. Although plant-based and agricultural materials possess promising characteristics in the area of biodegradable cutlery, continued research is needed to improve their overall strength, durability, ease of production, and shelf life. This review shows that limited research exists on using rice bran flour for edible cutlery product development. Thus, more thorough investigation is warranted concerning definitions of different formulations involving rice bran, rice bran composition, and its effects on functional characteristics such as strength when in the shape of a spoon.

Swot Analysis

Table 1: SWOT Matrix for Rice Bran-Based Spoon Cutlery

STRENGTHS	**WEAKNESSES**	**OPPORTUNITIES**	**THREATS**
ECOBITE cutlery is biodegradable, offering a sustainable alternative to single-use plastics. It utilizes abundant rice bran, a by-product of rice milling, promoting circular economy practices while aligning with global sustainability goals. Its eco-friendly nature also provides potential market differentiation (Kong, 2023; Cashmore & Cashmore, 2024).	The product has limited durability and is sensitive to moisture, which may affect its usability. It has a shorter shelf life compared to conventional plastic cutlery and requires appropriate packaging and storage to maintain its quality. Additionally, scaling up production may be challenging during the early stages (Kong, 2023; Cashmore & Cashmore, 2024).	Rising consumer awareness and demand for sustainable alternatives to create significant market potential. ECOBITE can establish partnerships with eco-conscious restaurants, cafés, food delivery services, and event organizers. There are also opportunities to expand into other biodegradable food-service products. Government incentives and policies supporting environmentally friendly innovations may further drive market growth.	The product faces competition from other biodegradable and reusable cutlery options. Market acceptance may be slow because consumers prefer traditional plastic utensils. Production costs may remain higher than conventional plasti cutlery, while environmental conditions such as humidity and temperature during storage may affect product quality and performance.

Strengths

- Rice bran is a readily available and affordable by-product of rice milling, especially in rice-producing countries such as the Philippines.
- Converts an agricultural by-product into a useful and valuable product, supporting waste reduction and sustainable production.

- Provides a biodegradable alternative to plastic spoons, helping reduce dependence on single-use plastics and lessen environmental waste.
- Promotes sustainable practices by advocating for responsible resource utilization and waste minimization, as well as environmentally friendly products.
- Makes use of sustainable and renewable natural materials, allowing it to be more eco-friendly and safer than plastic cutlery.
- Provides an alternative based on technology developed in food processing and sustainable development.

Weaknesses

- May not have the same degree of strength and durability as plastic utensils, particularly when subjected to heat and prolonged exposure to hot foods.
- May need special storage and handling requirements as moisture and humidity can affect quality and shelf-life.
- Further development and testing may make it costly to initially produce, as the manufacture of the product is still in its refinement stages.
- Consumer acceptance may pose challenges in that most people may not be familiar with utensils made from rice bran and may have concerns about its durability.

Opportunities

- Increased knowledge concerning plastic waste leads to greater demand for more green biodegradable materials.
- Regulatory efforts made by governments to reduce the amount of single-use plastic will promote the reception of eco-friendly utensils.
- The product can be presented to more customers through collaboration with restaurants, catering businesses, and eco-friendly organizations.
- The product can be modified and developed by creating different types, sizes, tastes, and better formulations with high resistance to moisture and strength.
- Allows for further value addition from rice by-products and supports local farmers.

Threats

- Must compete with various other biodegradable tableware, including those derived from bamboo, cornstarch, sugarcane bagasse, and wood.
- Still needs to compete against conventional plastic cutlery that consumers prefer because of reasonable costs, easy availability, and large-scale production.
- Some individuals may still be reluctant when switching from known plastic utensils to biodegradable.
- Current supply levels or pricing changes of other ingredients could influence production and pricing of rice bran products.

An analysis of the strengths, weaknesses, opportunities, and threats of rice bran-based cutlery (Oryza sativa L.) provides a clearer understanding of its potential as a sustainable food utensil and the challenges ahead. One primary benefit is the accessibility of rice bran as a by-product of rice milling, especially in rice-producing

countries like the Philippines. Instead of treating it as agricultural waste, rice bran can be converted into a durable, value-added product. This not only helps reduce waste but also supports sustainable rice bran management by encouraging the use of renewable resources to produce cutlery, offering an eco-friendly alternative to single-use plastic cutlery. In addition, producing rice bran cutlery is an active part of responsible consumption and production practices (United Nations, 2023) and is being improved through ongoing research, development, and promotion.

METHODOLOGY

This chapter explains how we developed and evaluated the ECOBITE spoon prototype. It covers the research design and locale, participants, formulation, preparation, molding and heating procedures, evaluation instruments, equipment-swab testing, and statistical treatment. The procedures allowed us to document the outcomes of a small-scale product-development study. The use of these methods generates information proving the acceptability and functional use of ECOBITE as another food-safe alternative for consumers who would like not to use disposable plastic cutlery.

Research Design

This study utilized an experimental research design to develop and evaluate ECOBITE, a biodegradable edible spoon made primarily from stabilized rice bran. The study focused on developing a suitable formulation through a series of experimental trials, with the goal of producing a spoon prototype that would demonstrate acceptable physical characteristics, functionality, and consumer acceptability.

During the product-development process, several trials were conducted to improve the formulation and achieve the desired consistency and structure. The resulting prototypes were observed and evaluated based on their shape, cohesion, surface condition, and ability to maintain their form during use. These observations served as a basis for refining the formulation and establishing the final version of ECOBITE.

After the development process, the finished product was presented to consumer respondents and food industry experts for evaluation. Consumers assessed its appearance, odor, texture, taste transfer, and overall acceptability, while food industry experts evaluated its perceived strength, structural stability, moisture resistance, heat resistance, and usability.

The study also included a comparative evaluation in which food industry experts assessed ECOBITE alongside conventional plastic spoons to determine their perceived differences in physical and functional characteristics. The results from the experimental trials, consumer evaluations, and expert assessments were then analyzed to determine the product's overall acceptability and potential as an alternative to conventional single-use plastic cutlery.

It should be noted that the evaluations of strength, moisture resistance, heat resistance, and other functional characteristics were based on observations and respondent assessments rather than instrument-based laboratory testing. Thus, the findings were limited to the actual procedures and evaluation methods conducted throughout the study.

Research Locale

The research was conducted in San Jose del Monte, Bulacan. The evaluation involved 100 respondents, comprising 90 student-consumers from Hospitality and Management and Food Processing programs and 10 food industry experts.

The 10 expert respondents were drawn from the food industry and were included to provide assessments informed by relevant technical or professional experience. The student-consumers assessed the sensory acceptability of ECOBITE. The food industry experts assessed its functional performance, sensory characteristics, comparative performance, and perceived environmental contribution. Their responses were treated separately because the two groups completed different evaluation instruments.

This combination of academic and professional evaluators will enable the researchers to gather more reliable information about the aroma, texture, durability, and functioning of the product. The evaluation results will determine if ECOBITE is suitable and effectively used as an alternative for environmentally friendly disposable plastic cutlery.

Materials and Ingredients

All ingredients used in ECOBITE were selected as food-grade inputs. Before production, the ingredients were inspected for appearance, physical condition, and odor. Particular attention was given to rice bran because moisture and storage conditions may influence its quality. The dry ingredients were kept in clean containers, while liquid ingredients were prepared for addition during mixing. Ingredient quantities were measured and recorded for each production run to support batch consistency. The tools and food-contact surfaces used during preparation, mixing, molding, heating, cooling, and inspection were cleaned and sanitized before production to reduce the risk of contamination and handling-related variation. The major ingredients included rice bran as the principal food ingredient; cassava starch as the primary binder; and cornstarch as a supporting starch ingredient. Xanthan gum and guar gum were included to support the cohesion and consistency of the mixture during molding. Vegetable glycerin was used as a plasticizer, vegetable oil supported handling, calcium carbonate was included as a structural additive, salt contributed seasoning, and water hydrated the dry ingredients. The quantities used in the final formulation are presented in the ingredient table.

Function of Major Ingredients. Rice bran provides the principal food base and body of the cutlery. Cassava starch serves as the main binder, while corn starch supports cohesion and firmness. Xanthan gum and guar gum help strengthen the mixture and improve its ability to hold together during molding and handling.

Table 2: Raw Ingredients of ECOBITE Cutlery

Name of Ingredient	**Image**	**Quantity**
Rice Bran		50g
Cassava Starch		35g
Cornstarch		10g
Xanthan Gum		1g
Guar Gum		1g

Vegetable Glycerin		3g
Calcium Carbonate		1g
Salt		1g
Vegetable Oil		10g
Water		45g

Table 3: Tools for Preparation and Processing

Name of Tools	**Image**	**Function/Use**
Mixing Bowl		Used to combine and mix ingredients during the preparation of ECOBITE cutlery.
Spoon Molder		Used for shaping the mixture into the desired spoon form.
Weighing Scale		Used to measure the exact amount of ingredients needed for the formulation.

Measuring Cups and Spoons		Used to measure liquid and dry ingredients during preparation.
Baking Sheet		Hold the molded cutlery during baking or drying.
Silicon spatula		Used to mix, transfer, and handle the dough mixture.
Measuring cup		Used for measuring the required amount of liquid ingredients.
Knife		Used to trim excess edges from the molded spoon to refine its shape and appearance.
Rolling pin		Used to flatten and evenly spread the dough mixture before molding it into the spoon shape.

Table 4: Equipment and its Function

Name of Equipment	**Figure**	**Function/Use**
Commercial stainless steel gas deck oven		This oven is a heating equipment designed for baking and drying food products using controlled dry heat. It works by distributing heat evenly inside the chamber, allowing the product to achieve proper texture, firmness, and moisture reduction. This process helps improve the structure, quality, and stability of the ECOBITE cutlery during the drying or baking stage.

Product Development Procedure

1. **Preparation of Ingredients –** Stabilize the rice bran in the pre-heated oven for 10 mins at 180°C, then let it cool down for a while, cassava starch, cornstarch, xanthan gum, guar gum, vegetable glycerin, food-grade calcium carbonate, salt, and water were weighed and prepared as per the requirement to begin the production process properly. All these ingredients were food grade and in appropriate quantities, quality, cleanliness, and specifications.

2. **Mixing Process –** First, combine the dry ingredients and gradually add the measured liquid ingredients. Then mixed the materials until the dough was reasonably uniform and moldable. Make sure that your dough won't dry

3. **Molding and Shaping –** The blended mixture was put into a spoon mold and pressed in order to form the desired shape of the spoon. We trimmed excess material along the edges before heating. Earlier trials also explored fork shapes, but the final assessment reported in this thesis focused on the spoon prototype.

4. **Baking –** The molded ECOBITE cutlery was subjected to a baking process by means of a commercial stainless steel gas deck oven at 150°C (300°F) for an hour until you see the desired dryness and hardness.

5. **Cooling and Storage –** The ECOBITE was allowed to cool in order to keep its design intact and keep its structure stable. Then, the product was packaged in appropriate biodegradable packaging and kept it dry and in good quality until it was evaluated.

Respondents of the Study

The study involved 100 respondents, consisting of 90 student-consumers from Hospitality and Management and Food Processing programs and 10 food industry experts. The 90 student-consumers evaluated the sensory acceptability of the developed ECOBITE product, while the 10 food industry experts assessed its functional and sensory characteristics and provided comparative and perceived environmental ratings. The responses of the two groups were tabulated separately because they completed different evaluation instruments.

Data Gathering Procedure

The researchers plan to take the following steps:

1. Development of the ECOBITE Prototype – The ingredients were weighed according to the selected formulation, mixed, molded into spoon shapes, and dried or baked according to the production procedure used by the researchers.

2. Evaluation of Functionality and Hygiene – The finished prototype was subjected to expert functional evaluation. Samples were submitted for microbiological analysis.

3. Packaging of ECOBITE Cutlery – After cooling, the spoon was handled and packaged using the packaging materials applied during the study to protect it before evaluation.

4. Distribution to Respondents – The ECOBITE spoon and the corresponding evaluation instructions were provided to the 10 food industry experts and 90 student-consumers from Hospitality and Management and Food Processing programs according to the evaluation assigned to each group.

5. Gathering of Feedback – The completed expert and consumer tally sheets were collected and checked for completeness. Expert and consumer responses were encoded separately for tabulation.

The consumer questionnaire covered appearance, aroma, texture, taste-transfer, and overall acceptability. The expert instrument covered functional characteristics and the specified expert sensory, comparative, and environmental-perception items.

The collected frequency counts, laboratory report, technical observations, and respondent evaluations were used to describe the prototype's performance and identify areas requiring further product improvement. The findings are limited to the measurements and responses documented in the study.

Research Instrument

The study utilized structured tally sheets as the primary research instruments for gathering data on the acceptability and perceived functionality of ECOBITE, a biodegradable edible spoon made primarily from stabilized rice bran. These instruments were designed to collect evaluations from consumer respondents and food industry experts regarding the product's sensory characteristics, functional performance, and environmental perception.

For consumer evaluation, a five-point hedonic scale was used to assess the product's sensory attributes, including appearance, odor, texture, taste transfer, and overall acceptability. The scale consisted of the following ratings: 5 – Like Very Much, 4 – Like, 3 – Neither Like nor Dislike, 2 – Dislike, and 1 – Dislike Very Much. This allowed the researchers to determine the level of consumer acceptance of the developed ECOBITE spoon.

For the food industry experts, structured tally sheets were used to evaluate the product's sensory and functional characteristics, particularly its strength, structural stability, moisture resistance, heat resistance, and usability. A five-point functional rating scale was applied, with the following interpretations: 5 – Excellent, 4 – Very Good, 3 – Good, 2 – Fair, and 1 – Poor. The experts also provided assessments comparing ECOBITE with conventional plastic spoons to determine their perceived differences in functionality and usability.

After data collection, all responses were organized, tallied, and subjected to appropriate statistical treatment to systematically interpret the results. The statistical analysis served as the basis for determining the product's consumer acceptability, expert evaluation, and environmental perception. The gathered data were also used to identify the product's strengths and areas that may require further improvement.

Table 5: Evaluator Scale for Assessing ECOBITE Cutlery

Point	Description	Characteristics
5	Excellent	Extremely satisfied; would definitely use again.
4	Very good	Highly satisfied; would likely use again.
3	Good	Satisfied; might use again.
2	Fair	Slightly satisfied; improvements needed.
1	Poor	Not satisfied; would not use.

Statistical Treatment of Data

The research will examine the information collected via frequency, percentage, weighted mean, descriptive summaries of technical measurements, as well as the use of Analysis of Variance (ANOVA). The frequency and percentage will summarize the profiles and responses of the subjects in the study.

ANOVA will determine whether statistically significant differences exist among the mean ratings across the specified consumer and expert evaluation dimensions at the 0.05 level of significance.

Frequency and Percentage. Frequency and percentage to describe the sex and age distribution of the 100 participants and the categorical rating counts where available.

Weighted Mean. Weighted mean will be used to summarize consumer sensory ratings and expert evaluation ratings. The weighted mean is computed as **WM = Σfx / N**, where f is the frequency of each rating, x is the rating

score, and N is the total number of respondents or evaluators.

Mean and Range. The mean and range were used to summarize the results of the researchers' experimental trials and respondent evaluations. These statistical measures helped determine the average ratings, variations, and overall results of ECOBITE's development, consumer acceptability, and expert assessments.

Descriptive Comparison. ECOBITE and traditional plastic cutlery will be compared based on experts' scores for strength, structural stability, moisture resistance, heat resistance, and usability. Because this dataset does not allow statistically valid comparisons, we will present only descriptive results.

Consumer sensory ratings are given on a five-point hedonic scale that consists of the following ratings: 5- Like very much, 4- Like, 3- Neither like nor dislike, 2- Dislike, and 1- Dislike very much. Expert functional ratings are rated on an excellent-to-poor scale, while environmental ratings are given on a strongly agree to strongly disagree scale.

Table 6: 5-Point Likert Scale

Scale	Weighted Mean	Verbal Interpretation
5	4.21 – 5.00	Strongly Agree
4	3.41 – 4.20	Agree
3	2.61 – 3.40	Neutral
2	1.81 – 2.60	Disagree
1	1.00 – 1.80	Strongly Disagree

Schematic Design

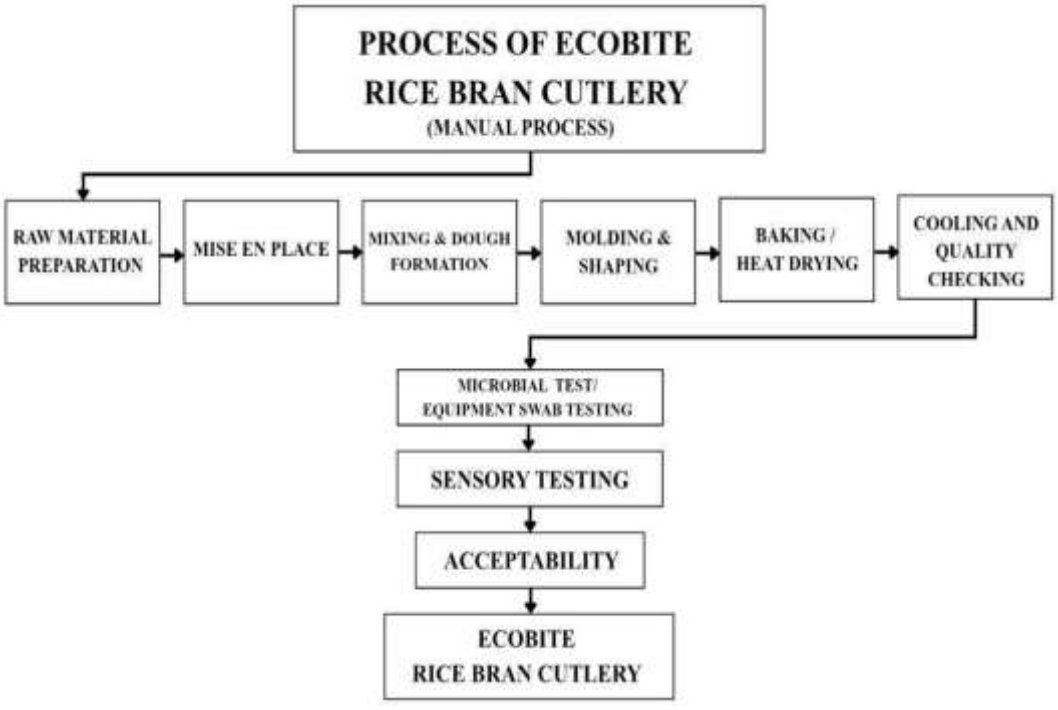

Figure 3: Manual Process of Making ECOBITE Cutlery

The flow diagram illustrates the step-by-step manual production of ECOBITE rice bran cutlery. The process begins with raw material preparation, where the rice bran is stabilized before production. This is followed by

mise en place, in which all ingredients are prepared, measured, and weighed according to the required formulation. Once everything is ready, the ingredients are mixed to form dough.

The dough is then manually molded and shaped into cutlery, ensuring that each piece has the proper form and structure. The shaped cutlery undergoes baking or heat-drying to reduce moisture and improve its strength. After baking, the products are allowed to cool before undergoing quality checking to assess their shape, texture, appearance, and overall condition.

After quality checking, equipment swab testing is conducted to assess the cleanliness of the production equipment. The cutlery then proceeds to sensory testing, where consumers and food industry experts evaluate its characteristics and overall quality. Finally, the evaluation results are used to determine the acceptability of ECOBITE as a rice bran-based biodegradable edible cutlery.

Presentation, Analysis, And Interpretation Of Data

In this chapter, we present the formulation trials, observations of the ECOBITE spoon prototype, functional and sensory rating results, equipment-swab findings, expert perceptions of potential environmental contribution, and reported ANOVA comparisons. We used descriptive summaries for the 90 student-consumers and 10 food industry experts and interpreted the results according to the instruments completed by each group.

Formulation, Preparation and Production Method

1. Development of the ECOBITE Prototype Through Formulation Trials

Table 7: 1ST–4TH Trial

Statement	Weighted Mean	Interpretation
Maintained its shape	1.50	Poor
Structural stability	1.25	Poor
Resistance to softening	1.25	Poor
Overall Weighted Mean	1.33	Poor

Legend

Functional Scale	Verbal Interpretation
1.00–1.80	Poor (P**)**
1.81–2.60	Fair **(F)**
2.61–3.40	Good **(G)**
3.41–4.20	Very Good **(VG)**
4.21–5.00	Excellent (**E)**

The first four trials were conducted to determine whether the rice bran and cassava mixture could produce spoon and fork prototypes and to evaluate their characteristics after molding and drying. The initial formulation consisted of 50 g rice bran, 35 g cassava starch, 1 g xanthan gum, 3 g vegetable glycerin, 1 g calcium carbonate, 1 g salt, 1 g lecithin, 5 g chia seeds, and 45 g water. This formulation was used consistently in all four exploratory trials. Lecithin and chia seeds were excluded from the final formulation.

For preparation, all dry ingredients were mixed thoroughly before gradually adding water and glycerin until a moldable consistency was achieved. The mixture was transferred into spoon and fork molds, shaped, dried, and cured before visual inspection. This process was repeated across the four trials to assess the formulation's consistency and moldability.

The mixture successfully formed spoon and fork prototypes; however, the results were inconsistent, with uneven thickness, poorly defined edges, and rough surfaces. The narrow fork tines were particularly difficult to shape without weak points or breakage. These findings showed that although the mixture was cohesive enough for molding, improvements in the formulation and processing method were necessary to achieve better structural strength, smoothness, and uniformity in the succeeding trials.



Figure 4:First Trials of ECOBITE

Table 8 5TH–8TH Trial

Statement	Weighted Mean	Interpretation
Maintained its shape	3.00	Good
Structural stability	2.50	Fair
Resistance to softening	2.75	Good
Overall Weighted Mean	2.75	Good

Legend

Functional Scale	Verbal Interpretation
1.00–1.80	Poor (P**)**
1.81–2.60	Fair **(F)**
2.61–3.40	Good **(G)**
3.41–4.20	Very Good **(VG)**
4.21–5.00	Excellent (**E**)

The fifth to eighth trials aimed to improve the shape, structural definition, and surface quality of ECOBITE spoons and forks, particularly their handles, spoon heads, and fork tines, which showed inconsistencies in earlier trials.

The ingredients were prepared and mixed until a moldable consistency was achieved. The mixture was then transferred into the spoon and fork molds, ensuring that thinner sections were properly filled, before drying and removal from the molds. Compared with earlier prototypes, these trials produced more recognizable shapes and better-formed handles. However, rough surfaces, uneven thickness, inconsistent edges, and irregular fork tines remained. These findings showed that although the molding process had improved, further adjustments to the formulation, materials, and equipment were needed to achieve more uniform and consistent prototypes.

Table 9: 9TH–12TH Trial

Statement	Weighted Mean	Interpretation
Maintained its shape	4.00	Very Good
Structural stability	3.50	Very Good
Resistance to softening	3.00	Good
Overall Weighted Mean	3.50	Very Good

Legend

Functional Scale	Verbal Interpretation
1.00–1.80	Poor (P**)**
1.81–2.60	Fair **(F)**
2.61–3.40	Good **(G)**
3.41–4.20	Very Good **(VG)**
4.21–5.00	Excellent (**E**)

The ninth to twelfth trials aimed to improve the cohesiveness, quality, moldability, and appearance of ECOBITE cutlery. Based on previous results, cornstarch, guar gum, and vegetable oil were added to the formulation, consisting of 50 g rice bran, 35 g cassava starch, 10 g cornstarch, 1 g xanthan gum, 1 g guar gum, 3 g vegetable glycerin, 1 g calcium carbonate, 1 g salt, 10 g vegetable oil, and 45 g water. All dry ingredients were mixed thoroughly before adding the liquid ingredients. The mixture was blended until moldable, transferred into spoon and fork molds, and dried until hardened before removal. The results showed improved cohesiveness, spoon shape, and surface smoothness compared with earlier trials. However, slight variations in thickness, texture, and finish remained, indicating the need for further adjustments in molding. Although the modified formulation produced better-shaped utensils, the previous formulation was selected for further prototyping before adjusting its water content.

Table 10: Final Trial and Formulation

Statement	Weighted Mean	Interpretation
Maintained its shape	5.00	Excellent

Structural stability	5.00	Excellent
Resistance to softening	4.75	Excellent
Overall Weighted Mean	4.92	Excellent

Legend

Functional Scale	Verbal Interpretation
1.00–1.80	Poor (P**)**
1.81–2.60	Fair **(F)**
2.61–3.40	Good **(G)**
3.41–4.20	Very Good **(VG)**
4.21–5.00	Excellent (**E**)

The ninth to twelfth trials focused on optimizing the formulation and molding process of ECOBITE cutlery to improve its cohesiveness, moldability, structural integrity, and surface characteristics. Based on the observed limitations of previous trials, cornstarch, guar gum, and vegetable oil were incorporated to enhance the binding properties, consistency, and formability of the mixture. In addition, the utensil molds were improved to achieve better shape definition, material distribution, and uniformity, particularly in the spoon heads, handles, and fork tines. The modified formulation consisted of 50 g rice bran, 35 g cassava starch, 10 g cornstarch, 1 g xanthan gum, 1 g guar gum, 3 g vegetable glycerin, 1 g calcium carbonate, 1 g salt, 10 g vegetable oil, and 45 g water.

During preparation, all dry ingredients were thoroughly homogenized before the gradual incorporation of the liquid components. The mixture was blended until a uniform, cohesive, and moldable dough was obtained. It was then transferred into the improved spoon and fork molds and evenly distributed to achieve the desired dimensions and structural profile. The molded samples were subsequently dried until sufficiently hardened for demolding.

The results demonstrated improvements in dimensional definition, structural compactness, and surface finish compared with previous trials. The incorporation of cornstarch and guar gum contributed to improved cohesion and moldability, while vegetable oil helped improve the consistency and workability of the mixture. The improved molds also facilitated better formation and more consistent shapes of the cutlery. Although minor variations in thickness, texture, and surface finish remained, the ninth-to-twelfth trial formulation was established as the final formulation of ECOBITE and used in producing the final spoon and fork prototypes.



Figure 5: Final Formulation with Packaging

Table 11: Laboratory Sensory (Organoleptic) Evaluation Result

Sensory Property	Evaluation Method	Result
Odor	Organoleptic Evaluation	Pumpkin seed or sesame oil-like aroma, with nutty, toasted, and slightly earthy notes.
Appearance	Organoleptic Evaluation	Brown, grainy, and spoonable with a thick consistency.
Texture	Organoleptic Evaluation	Rough surface on the bottom and side portions, while the top surface is smooth.

In the laboratory evaluation, ECOBITE was found to have a nutty, slightly toasted, and earthy smell, brown color with grains. This is an observation from the laboratory and is separate from consumer and expert ratings on the acceptability of ECOBITE.

Table 12: Formulation of ECOBITE Cutlery

Ingredient	Function	Role in ECOBITE
Food-grade rice bran	Main ingredient	Provides the primary food base, fiber, and body of the cutlery.
Cassava starch	Primary binder	Binds the mixture and supports gelatinization, molding, and structural formation.
Xanthan gum	Hydrocolloid	Strengthens cohesion and the starch network.
Guar gum	Hydrocolloid	Improves flexibility and helps reduce breakage.
Vegetable glycerin	Food-grade plasticizer	Reduces brittleness and supports flexibility.
Food-grade Calcium carbonate	Structural additive	Supports rigidity and structural strength.
Salt	Seasoning	Supports palatability.
Water	Hydration and mixing medium	Hydrates ingredients and supports starch gelatinization.

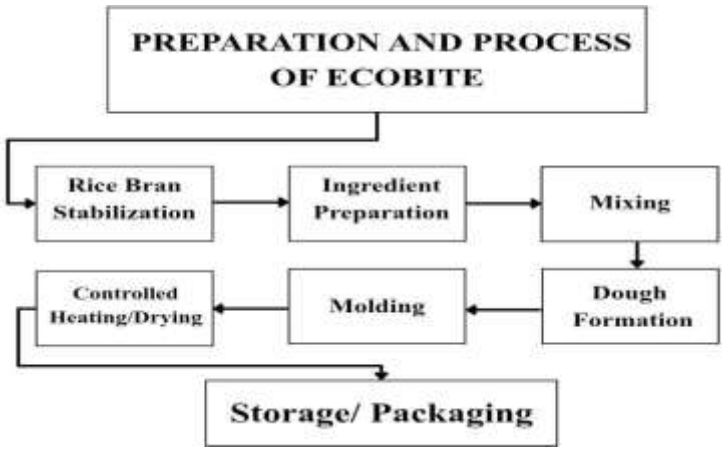

Figure 6: Final Process of ECOBITE

To prepare Ecobite, we begin by stabilizing the raw rice bran to prevent lipid oxidation and preserve matrix

integrity. The stabilized bran is then combined with prepared ingredients and thoroughly blended during the mixing stage to yield a homogeneous formulation. Next, the mixture undergoes dough formation and precise molding into the intended structural form. The molded pieces are then subjected to controlled heating and drying to optimize moisture loss and achieve structural rigidity. Finally, the finished products are routed to storage and packaging to protect against moisture regain and contamination.

2. The Physical and Functional Characteristics

Table 13: Technical Observation Tally

Observation	5 LVM	4 L	Weighted Mean	Interpretation
Maintained its shape during use	2	2	4.50	Like Very Much
Was structurally stable	3	1	4.75	Like Very Much
Resisted softening during use	1	3	4.25	Like Very Much
Remained usable during the test	2	2	4.50	Like Very Much
Overall			4.50	Like Very Much

Legend

Hedonic Scale	Verbal Interpretation
1.00–1.80	Dislike Very Much (**DVM)**
1.81–2.60	Dislike **(D)**
2.61–3.40	Neither like nor Dislike **(NLD)**
3.41–4.20	Like **(L)**
4.21–5.00	Like Very Much **(LVM)**

The researchers' technical observation checklist obtained an overall mean of **4.50**, interpreted as Excellent based on the functional-performance scale. Structural stability received the highest mean of **4.75**, showing that the cutlery maintained its structure during the observed use conditions. On the other hand, resistance to softening received the lowest mean of **4.25**, but still fell within the Excellent range. These ratings were based on four recorded observations per criterion and reflect the researchers' assessment of the product's performance during use. They represent actual observations rather than measurements from standardized mechanical strength or moisture-resistance tests

Table 14: Expert Functional Evaluation

Functional Characteristic	Weighted Mean	Standard Deviation	Interpretation
Strength	4.87	0.17	Excellent
Structural stability	4.77	0.35	Excellent
Moisture resistance	4.57	0.27	Excellent
Heat resistance	4.70	0.33	Excellent

Usability	4.77	0.27	Excellent
Overall functional mean	4.73	0.10	Excellent

Legend

Functional Scale	Verbal Interpretation
1.00–1.80	Poor (P**)**
1.81–2.60	Fair **(F)**
2.61–3.40	Good **(G)**
3.41–4.20	Very Good **(VG)**
4.21–5.00	Excellent **(E)**

The ten food industry experts gave ECOBITE an overall functional performance mean of 4.73 (SD = 0.10), interpreted as Excellent. Among the five evaluated criteria, strength received the highest mean of 4.87 (SD = 0.17), while moisture resistance obtained the lowest at 4.57 (SD = 0.27). Structural stability and usability both received a mean of 4.77, while heat resistance obtained 4.70. All five criteria were rated within the Excellent range, indicating a positive expert assessment of the product's functionality under the study conditions. However, these results reflect the experts' evaluations and should not be interpreted as direct measurements of mechanical force, moisture absorption, or thermal endurance.

Table 15: Comparison of ECOBITE and Plastic Spoon

Criterion	ECOBITE	Plastic Spoon
Strength	4.80	5.00
Structural stability	4.80	5.00
Moisture resistance	4.70	5.00
Heat resistance	4.60	4.90
Usability	4.90	4.80
Overall descriptive mean	4.76	4.94

Legend

Functional Scale	Verbal Interpretation
1.00–1.80	Poor **(P)**
1.81–2.60	Fair **(F)**
2.61–3.40	Good **(G)**

3.41–4.20	Very Good **(VG)**
4.21–5.00	Excellent **(E)**

The ten food industry experts gave the conventional plastic spoon a higher overall rating of **4.94** compared with ECOBITE's **4.76**. Plastic cutlery received higher ratings in strength, structural stability, moisture resistance, and heat resistance. However, ECOBITE scored slightly higher in usability, with a mean of **4.90** compared with **4.80** for plastic. These results provide a descriptive comparison of the experts' evaluations. However, since the tally sheet contains aggregated frequencies rather than respondent-matched ratings for both utensils, the findings cannot establish a statistically significant difference or confirm that ECOBITE is already equivalent to or a complete substitute for conventional plastic cutlery.

3. The Acceptability of Developed ECOBITE

Table 16: Texture Evaluation

Texture statement	5 LVM	4 L	3 NLD	Weighted Mean
Pleasant texture during use	85	2	3	4.91
Food flavor remains unchanged after repeated scoops	86	2	2	4.93
Surface and feel in the mouth are comfortable	84	5	1	4.92
Category mean				4.92

Legend

Hedonic Scale	Verbal Interpretation
1.00–1.80	Dislike Very Much (**DVM)**
1.81–2.60	Dislike **(D)**
2.61–3.40	Neither like nor Dislike **(NLD)**
3.41–4.20	Like **(L)**
4.21–5.00	Like Very Much **(LVM)**

The 90 consumer ratings for texture produced a category mean of **4.92 (SD = 0.20)**, interpreted as **Like Very Much**. The three item means were **4.91** for pleasant texture during use, **4.93** for the food's original texture remaining unchanged after repeated scoops, and **4.92** for surface and mouth comfort. These results indicate favorable consumer perception of ECOBITE's texture under the evaluation conditions.

Sensory Acceptability

Table 17: Sensory Acceptability of ECOBITE

Acceptability dimension	Mean	Standard Deviation	Verbal Interpretation
Appearance	4.91	(0.20)	Like Very Much

Odor	4.97	(0.10)	Like Very Much
Taste-transfer	4.92	(0.20)	Like Very Much
Overall acceptability	4.97	(0.10)	Like Very Much
Overall mean	4.97	(0.10)	Like Very Much

Legend

Hedonic Scale	Verbal Interpretation
1.00–1.80	Dislike Very Much (**DVM)**
1.81–2.60	Dislike **(D)**
2.61–3.40	Neither like nor Dislike **(NLD)**
3.41–4.20	Like **(L)**
4.21–5.00	Like Very Much **(LVM)**

The 90 consumers gave ECOBITE an overall sensory evaluation mean of **4.95 (SD = 0.07)**, interpreted as **Like Very Much**. Among the five sensory dimensions, aroma, taste-transfer, and overall acceptability received the highest means of **4.97** each. Texture followed with **4.92**, while appearance received **4.91**. All five dimensions received highly favorable ratings, indicating that consumers generally responded positively to ECOBITE's sensory characteristics and overall quality under the conditions of the evaluation.

Table 18: Appearance

Statement	5 LVM	4 L	3 NLD	Weighted Mean
Surface finish and color are pleasant	83	5	2	4.90
Shape and form are uniform	83	4	3	4.89
Overall visual appearance is acceptable	86	4	0	4.96
Category mean				4.91

Legend

Hedonic Scale	Verbal Interpretation
1.00–1.80	Dislike Very Much (**DVM)**
1.81–2.60	Dislike **(D)**
2.61–3.40	Neither like nor Dislike **(NLD)**
3.41–4.20	Like **(L)**
4.21–5.00	Like Very Much **(LVM)**

The appearance dimension received a mean of **4.91 (SD = 0.20)**, interpreted as **Like Very Much**. This indicates

that consumers found ECOBITE's visual qualities highly acceptable, particularly its surface finish, color, shape, and overall presentation.

Table 19: Odor

Statement	5 LVM	4 L	3 NLD	Mean
The odor before use is pleasant	88	2	0	4.98
Odor is pleasant when in contact with food	87	3	0	4.97
Overall odor quality is acceptable	87	3	0	4.97
Category mean				4.97

Legend

Hedonic Scale	Verbal Interpretation
1.00–1.80	Dislike Very Much (**DVM)**
1.81–2.60	Dislike **(D)**
2.61–3.40	Neither like nor Dislike **(NLD)**
3.41–4.20	Like **(L)**
4.21–5.00	Like Very Much **(LVM)**

The odor dimension received a mean of **4.97 (SD = 0.10)**, interpreted as **Like Very Much**. This indicates that consumers highly appreciated ECOBITE's aroma before and during use. The favorable rating suggests that the rice bran-based material did not produce an unpleasant odor that could negatively affect the consumers' experience. Overall, the results show that the product's odor contributed positively to its sensory acceptability and did not present a significant concern during the evaluation.

Table 20: Taste-Transfer

Statement	5 LVM	4 L	3 NLD	Weighted Mean
Food retains its usual flavor	86	4	0	4.96
Flavor remains unchanged after repeated scoops	87	3	0	4.97
No unpleasant flavor is added	88	2	0	4.98
Category mean				4.97

Legend

Hedonic Scale	Verbal Interpretation
1.00–1.80	Dislike Very Much (**DVM)**

1.81–2.60	Dislike **(D)**
2.61–3.40	Neither like nor Dislike **(NLD)**
3.41–4.20	Like **(L)**
4.21–5.00	Like Very Much **(LVM)**

The taste-transfer dimension received a mean of **4.97 (SD = 0.10)**, interpreted as **Like Very Much**. The three indicators obtained mean scores of **4.96, 4.97,** and **4.98**, showing consistently favorable consumer ratings. These results suggest that ECOBITE did not introduce an unpleasant taste or noticeably alter the original flavor of the food during the evaluation. Overall, the findings indicate that taste transfer was well accepted by consumers and contributed positively to the product's sensory acceptability.

Table 21: Overall Acceptability

Statement	5 LVM	4 L	3 NLD	Weighted Mean
Acceptable as an edible utensil	88	2	0	4.98
Willing to use as an alternative to conventional disposable spoons	89	1	0	4.99
Suitable for use again under similar condition	85	5	0	4.94
Category mean				4.97

Legend

Hedonic Scale	Verbal Interpretation
1.00–1.80	Dislike Very Much (**DVM)**
1.81–2.60	Dislike **(D)**
2.61–3.40	Neither like nor Dislike **(NLD)**
3.41–4.20	Like **(L)**
4.21–5.00	Like Very Much **(LVM)**

The overall acceptability dimension obtained a mean of 4.97 (SD = 0.10), interpreted as Like Very Much. Item means were 4.98 for acceptability as an edible utensil, 4.99 for willingness to use it as an alternative, and 4.94 for suitability for repeated use. These results indicate favorable acceptance among the evaluated consumers.

Table 22: Expert Sensory Evaluation

Dimension	Weighted Mean	Standard Deviation	Interpretation
Appearance	4.67	(0.33)	Like Very Much
Aroma	4.78	(0.14)	Like Very Much
Texture	4.56	(0.38)	Like Very Much

Taste-transfer	4.67	(0.23)	Like Very Much
Overall acceptability	4.56	(0.17)	Like Very Much
Overall Mean	4.64	(0.17)	Like Very Much

Legend

Hedonic Scale	Verbal Interpretation
1.00–1.80	Dislike Very Much (**DVM)**
1.81–2.60	Dislike **(D)**
2.61–3.40	Neither like nor Dislike **(NLD)**
3.41–4.20	Like **(L)**
4.21–5.00	Like Very Much **(LVM)**

The expert sensory evaluation assessed the sample across key quality attributes using a 5-point Hedonic scale, yielding consistently favorable results. Aroma achieved the highest score among individual sensory parameters with a weighted mean of 4.78 (SD 0.14), closely followed by appearance and taste-transfer at 4.67 each (SD 0.33 and 0.23, respectively).

Texture and overall acceptability both recorded mean scores of 4.56 (SD 0.38 and 0.17). Consequently, all evaluated dimensions received a verbal interpretation of "Like Very Much," culminating in an overall mean score of 4.64 (SD 0.17) that highlights high sensory preference and structural consistency.

4. Microbial Load on the Equipment Swab

Microbial Properties

Table 23: Equipment Swab Test / Microbiological Analysis Result

Type of Test	Actual Value	FDA Standard Value	Interpretation
Total Coliform Count	Less than 1 cfu/swab	Less than 10 cfu/swab	Passed
Escherichia coli	<2.2 MPN/swab	Less than 3 MPN/swab	Passed
Salmonella Detection	Not detected	Absent / not detected	Passed

To verify sanitary compliance, equipment surface swab testing was conducted to evaluate key microbiological properties against FDA standards. The total coliform count registered at less than 1 cfu/swab, well below the permissible limit of less than 10 cfu/swab. Similarly, *Escherichia coli* levels were recorded at <2.2 MPN/swab compared to the maximum allowed threshold of less than 3 MPN/swab. Lastly, *Salmonella* detection yielded negative results ("Not detected"), fully satisfying the standard requiring complete absence. Across all evaluated parameters, the equipment successfully passed the microbiological requirements, demonstrating effective sanitation and safety compliance.

5. The Contribution of ECOBITE in Reducing the Use of Single-Use Plastic Spoons

Table 24: Supplementary Environmental Evaluation

Statement	Weighted Mean	Interpretation
Rice bran can be transformed into edible cutlery and given useful value as an agricultural by-product	4.80	Strongly Agree
ECOBITE has potential to reduce reliance on single-use plastic spoons in appropriate settings	4.90	Strongly Agree
ECOBITE may serve as a sustainable alternative to single-use plastic spoons in appropriate settings	5.00	Strongly Agree
Overall	4.90	Strongly Agree

Legend

Likert Scale	Verbal Interpretation
1.00–1.80	Strongly Disagree (**SD)**
1.81–2.60	Disagree **(D)**
2.61–3.40	Neutral **(N)**
3.41–4.20	Agree **(A)**
4.21–5.00	Strongly Agree **(SA)**

The experts strongly agreed with the potential environmental contribution of ECOBITE, producing an overall mean of **4.90 (Strongly Agree).** The conversion of rice bran into a value-added product received **4.80**, the potential to reduce reliance on single-use plastic spoons received **4.90**, and the potential to serve as a sustainable alternative received **5.00**. These results represent expert perceptions of potential contribution, not measured environmental impact, because the study did not conduct a life-cycle assessment, biodegradation test, or quantified plastic-waste reduction study.

6. The Significant Difference Among the Mean Ratings

Analysis of Variance (ANOVA) Results

The ANOVA results were based on rating observations reconstructed from the recorded frequency counts and grouped according to their respective evaluation dimensions. These findings provide supplementary statistical evidence of variations among the dimensions assessed. However, the descriptive weighted means remain the primary basis for interpreting the evaluation results and addressing the specific objectives of the study (SOPs).

Table 25: Summary of ANOVA Results

Evaluation Dimensions	F-value	p-value	Decision (α=.05)	Interpretation
Consumer sensory dimensions	3.364	0.0224	Reject $H0_1$	Significant difference among mean ratings.
Expert functional dimensions	1.338	0.2830	Fail to reject $H0_2$	No significant difference among

				mean ratings.
Expert sensory dimensions	1.627	0.2127	Fail to reject $H0_3$	No significant difference among mean ratings.

The ANOVA results for the 90 consumers' sensory evaluation showed an F-value of 3.364 and a p-value of 0.0224 at the 0.05 level of significance. Since the p-value was below 0.05, the null hypothesis was rejected, indicating a significant difference among the mean ratings for appearance, aroma, texture, taste-transfer, and overall acceptability.

For the 10 food industry experts' functional evaluation, the analysis yielded an F-value of 1.338 and a p-value of 0.2830. Since the p-value exceeded 0.05, the null hypothesis was not rejected. This indicates that there was no statistically significant difference among the mean ratings for strength, structural stability, moisture resistance, heat resistance, and usability.

Similarly, the 10 food industry experts' sensory evaluation recorded an F-value of 1.627 and a p-value of 0.2127. As the p-value was also greater than 0.05, the null hypothesis was not rejected, indicating no statistically significant difference among the mean ratings across the sensory criteria. Overall, the findings show that significant differences were observed only in the consumer sensory evaluation, while the experts' functional and sensory ratings remained statistically comparable across their respective evaluation dimensions.

Demographic Profile of Consumers and Experts

Table 26: Sex Demographic

Sex	Frequency	Percentage
Female	46	46%
Male	43	43%
Prefer not to say	11	11%
TOTAL	100	100%

The table shows the sex distribution of the 100 respondents, consisting of 46 females (46%), 43 males (43%), and 11 (11%) who preferred not to disclose their sex. The results indicate a slightly higher number of female respondents, although the distribution between female and male participants was relatively balanced.

Table 27: Age Demographic

Age	Frequency	Percentage
18-24	75	75%
25-34	15	15%
35-44	7	7%
45-54	3	3%
TOTAL	100	100%

The table presents the age distribution of the 100 respondents. Most participants, 75 (75%), were aged 18–24, followed by 15 (15%) aged 25–34, 7 (7%) aged 35–44, and 3 (3%) aged 45–54. The results show that the

respondents were predominantly within the 18–24 age group, with fewer participants represented in the older age categories.

7. Recommended Improvements

The formulation trials demonstrated that rice bran could be successfully incorporated as the principal ingredient in developing ECOBITE edible spoon prototypes. Improvements in shape, cohesiveness, and overall product quality were observed throughout the trials. These results showed the potential of rice bran as a material for developing edible cutlery.

The final evaluation also yielded favorable results, with 90 consumers giving an overall sensory mean of 4.95 (SD = 0.07). Meanwhile, the ten food industry experts rated the product's sensory performance at 4.78 (SD = 0.14) and functional performance at 4.73 (SD = 0.10). These findings indicate positive consumer acceptance and expert assessments under the study conditions.

Despite these encouraging results, further testing is needed to evaluate the product's strength, moisture resistance, heat tolerance, and molding consistency under controlled conditions. Additional assessments of food safety, shelf life, packaging, biodegradability, and production costs are also necessary before considering wider food-service applications. Therefore, ECOBITE represents a promising small-scale prototype that requires further development and validation before it can be considered a commercially viable alternative to conventional cutlery.

SUMMARY OF FINDINGS, CONCLUSIONS, AND RECOMMENDATIONS

We developed and evaluated ECOBITE, a rice bran-based edible spoon prototype, through formulation trials, observations, participant ratings, and equipment-swab laboratory testing. We organized the following findings and conclusions according to the seven questions in the Statement of the Problem: formulation and production; physical and functional characteristics; sensory acceptability; equipment-swab findings; perceived environmental contribution; reported statistical differences; and recommended improvements.

Summary Of Findings

1. Formulation, Preparation, and Production of ECOBITE

The ECOBITE was developed using food-grade rice bran as the principal ingredient and cassava starch as the primary binder. The final formulation consisted of 50 g rice bran, 35 g cassava starch, 10 g cornstarch, 1 g xanthan gum, 1 g guar gum, 3 g vegetable glycerin, 1 g calcium carbonate, 1 g salt, 10 g vegetable oil, and 45 g water. The rice bran was stabilized at 180°C for 10 minutes before mixing and molding. The formed cutlery was then baked at **150°C for approximately one hour**, followed by cooling and evaluation. The later trials produced more cohesive and well-defined spoons, although variations in surface finish and thickness remained. Further documentation of storage conditions is also needed.

2. Physical and Functional Characteristics of ECOBITE

The researchers' technical observation checklist yielded an overall functional mean of 4.50, interpreted as Excellent. Structural stability received the highest mean of 4.75, followed by shape maintenance and remaining usability, both at 4.50, while resistance to softening received the lowest mean of 4.25. Similarly, the ten food industry experts gave ECOBITE an overall functional rating of 4.73 (SD = 0.10), also interpreted as Excellent. Among the evaluated criteria, strength received the highest mean of 4.87, followed by structural stability and usability at 4.77, heat resistance at 4.70, and moisture resistance at 4.57. In the descriptive comparison with conventional plastic spoons, plastic received a higher overall mean of 4.94 compared with ECOBITE's 4.76, although ECOBITE obtained a slightly higher usability rating. Overall, the findings show favorable assessments of ECOBITE's functional performance, with moisture resistance identified as its lowest-rated expert criterion. However, these results reflect observational and expert-based evaluations rather than measurements obtained through standardized physical testing.

3. Sensory Acceptability of ECOBITE

The 90 student-consumers gave ECOBITE favorable sensory ratings, with an overall mean of 4.95 (SD = 0.07), interpreted as Like Very Much. Among the five sensory dimensions, odor, taste-transfer, and overall acceptability received the highest means of 4.97 each, followed by texture at 4.92 and appearance at 4.91. Similarly, the ten food industry experts gave an overall sensory mean of 4.78 (SD = 0.14), also interpreted as Like Very Much. Their highest rating was for odor (4.93), followed by taste-transfer and overall acceptability (4.80 each), appearance (4.70), and texture (4.67). These findings indicate that both consumers and experts responded positively to ECOBITE's sensory characteristics. However, since the evaluations involved selected groups of participants, the results may not fully represent the perceptions of the wider population.

4. Microbiological Results of Equipment Swab Testing

The microbiological swab test conducted on the ECOBITE spoon showed total coliform counts of <1 CFU/swab, within the FDA-referenced limit of <10 CFU/swab, and Escherichia coli levels of <2.2 MPN/swab, meeting the specified limit of <3 MPN/swab. Salmonella was not detected. All three microbiological results were marked Passed by the laboratory, indicating that the tested spoon complied with the applicable FDA-referenced microbiological limits at the time of testing. However, these findings apply only to the swabbed spoon and do not establish the product's overall food safety or shelf-life stability, which require additional testing.

5. Potential Contribution to Reducing Single-use Plastic Spoons

The ten food industry experts gave ECOBITE an overall environmental-perception mean of 4.90, interpreted as Strongly Agree, indicating a highly favorable assessment of its potential environmental benefits. Specifically, ECOBITE's potential as an alternative to conventional plastic spoons received a mean of 5.00 (Strongly Agree). Its potential to reduce reliance on single-use plastic spoons in appropriate settings obtained 4.90 (Strongly Agree), while its contribution to adding value to rice bran as an agricultural by-product received 4.80 (Strongly Agree). These results show that the experts recognized ECOBITE's potential to support sustainability through the utilization of agricultural by-products and the development of alternatives to single-use plastics. However, these ratings reflect expert perceptions rather than actual measured environmental outcomes, as plastic displacement, biodegradation, composting rates, and comparative life-cycle impacts were not assessed.

6. The Significant Difference Among the Mean Ratings

The ANOVA results revealed a statistically significant difference among the five consumer sensory dimensions, with an F-value of 3.364 and a p-value of 0.0101. Since the p-value was below the 0.05 level of significance, the null hypothesis was rejected. This indicates that consumer ratings varied significantly across the sensory criteria evaluated. In contrast, the ten food industry experts' functional evaluation showed no significant difference among the five dimensions ($F = 1.338$, $p = 0.2748$). Similarly, their sensory evaluation showed no significant difference ($F = 1.627$, $p = 0.1886$). Since both p-values exceeded 0.05, the respective null hypotheses were not rejected. These findings show that significant variations occurred only in the consumer sensory ratings, while the experts' functional and sensory ratings remained statistically comparable across their respective evaluation dimensions.

7. Recommended Improvements to Enhance ECOBITE

Although all five expert-rated functional dimensions received Excellent ratings, moisture resistance (4.57) and heat resistance (4.70) were identified as the primary areas for further improvement. The first priority is to enhance moisture resistance by examining the rice bran-to-starch ratio and the formulation's binding properties to help minimize softening during food contact. The second priority is to improve heat resistance by evaluating the baking conditions and the cutlery's ability to maintain its structure when exposed to different food temperatures.

Further improvements should also focus on maintaining uniform spoon thickness and depth, strengthening the handle-to-bowl connection, and improving mold design and consistency during production. These adjustments

may help produce more uniform and structurally stable cutlery. All modifications should undergo further functional and sensory evaluations to determine whether they improve product performance without affecting consumer acceptability.

Conclusions

1. The formulation trials demonstrated that food-grade rice bran could be incorporated as the principal ingredient in producing ECOBITE spoons, with cassava starch serving as the primary binder. The successive modifications, including the addition of cornstarch, xanthan gum, guar gum, vegetable glycerin, calcium carbonate, salt, and vegetable oil, improved the mixture's cohesiveness, moldability, and shape definition. The final formulation produced more defined spoon prototypes, although some variations in thickness and surface finish remained

2. The functional evaluation showed an overall mean of 4.73 (SD = 0.10) from the ten food industry experts, interpreted as Excellent. Strength received the highest mean of 4.87, followed by structural stability and usability at 4.77, heat resistance at 4.70, and moisture resistance at 4.57. In the descriptive comparison, conventional plastic spoons obtained an overall mean of 4.94, while ECOBITE received 4.76. ECOBITE obtained a slightly higher usability rating, but plastic received higher ratings in the other functional dimensions.

3. The sensory evaluation showed favorable ratings from both groups. The 90 student-consumers gave ECOBITE an overall mean of 4.95 (SD = 0.07), interpreted as Like Very Much, while the ten food industry experts gave an overall mean of 4.78 (SD = 0.14), also interpreted as Like Very Much. The results indicate positive assessments of the spoon's appearance, odor, texture, taste-transfer, and overall acceptability among the participants.

4. The microbiological swab test conducted on the ECOBITE spoon met the laboratory's specified acceptance limits. Total coliforms were recorded at <1 CFU/swab, Escherichia coli at <2.2 MPN/swab, and Salmonella was not detected. All three results were marked Passed in the laboratory report. These findings apply to the tested spoon sample at the time of examination and do not establish the product's long-term microbiological safety or shelf-life stability.

5. The environmental-perception evaluation obtained an overall mean of 4.90 (Strongly Agree) from the ten food industry experts. Specifically, the potential of ECOBITE as an alternative to conventional plastic spoons received a mean of 5.00, its potential to reduce reliance on single-use plastic spoons received 4.90, and its contribution to adding value to rice bran received 4.80. These ratings reflect the experts' perceptions of the product's potential environmental contributions; actual plastic displacement, biodegradation, composting performance, and life-cycle impacts were not measured.

6. The ANOVA results revealed a statistically significant difference among the five consumer sensory dimensions, with $F(4, 356) = 3.364$ and $p = 0.0101$ at the 0.05 level of significance. In contrast, no statistically significant differences were found among the expert functional dimensions, $F(4, 36) = 1.338$, $p = 0.2748$, or the expert sensory dimensions, $F(4, 36) = 1.627$, $p = 0.1886$. These findings represent comparisons among evaluation dimensions within each group and do not establish direct statistical differences between consumer and expert ratings.

7. The evaluation findings identified moisture resistance and heat resistance as the main areas requiring further technical assessment, despite both receiving Excellent ratings. Variations in spoon thickness, surface finish, and molding consistency were also observed during product development. Further testing of mechanical strength, moisture absorption, thermal performance, food safety, and shelf-life stability is necessary to establish the product's performance under controlled conditions..

Recommendations

Based on the findings and conclusions of the study, the researchers recommend the following:

1. **Formulation and Process Improvement.** Future researchers and food processors should replicate the final formulation using 50 g of rice bran and 35 g of cassava starch, together with the specified supporting ingredients. The preparation process should be consistently documented, particularly the rice bran stabilization at 180°C for 10 minutes and baking at 150°C for approximately one hour. Further controlled trials should examine ingredient proportions, spoon thickness, molding consistency, and drying conditions to improve structural strength, moisture resistance, and heat tolerance before considering larger-scale production.

2. **Environmental Performance Assessment.** Future environmental researchers should investigate the actual biodegradation and composting behavior of ECOBITE under controlled and documented conditions. Studies should also quantify its potential to replace single-use plastic utensils and assess its environmental impact in comparison with conventional alternatives. These assessments are necessary to establish whether ECOBITE provides measurable environmental benefits beyond its potential as a rice bran-based edible utensil.

3. **Expanded Sensory and Functional Evaluation.** Future studies should involve a larger and more diverse consumer population to obtain a broader assessment of ECOBITE's sensory acceptability. Independent expert evaluations should also be conducted to further assess its functional performance. Testing should consider different food types, contact temperatures, and exposure durations, while maintaining individual respondent ratings to support more reliable comparisons of sensory and functional characteristics.

4. **Food Safety and Statistical Validation.** Further research should include microbiological testing of the finished product, controlled shelf-life assessments, packaging-barrier evaluations, and storage-stability studies. Researchers should also maintain complete respondent-level data, clearly document the computation of evaluation scores, and verify the assumptions of repeated-measures ANOVA before interpreting statistical significance. These measures will strengthen the reliability of the findings and provide additional evidence of the product's safety and stability.

5. **Production Feasibility and Commercial Assessment.** Rice millers, food processors, and prospective producers are encouraged to explore rice bran as a value-added raw material for edible cutlery development. Before considering commercial production, a feasibility and cost-benefit analysis should be conducted, taking into account ingredient costs, labor, energy consumption, equipment, packaging, and distribution expenses. This assessment will help determine the economic viability and potential for wider application of ECOBITE.

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