Aeration-aided Pisang Awak (Musa Paradisiaca) Banana Vinegar

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ABSTRACT

The main objective of the study was to produce Aeration-aided Pisang Awak (*Musa Paradisiaca*) Banana Vinegar. Food loss was the main reason why the researcher chose to recycle the perishable banana fruit of Pisang Awak into vinegar. Adopting the developmental-experimental method of research, the sugar content of banana fruit at overripe stage was determined. Fermentation depends on the amount of sugar available in the banana for conversion into ethyl alcohol and consequently, into acetic acid for vinegar production. By using the °Brix and % Polarization as parameters, the values obtained were 23.32.and 19.64, respectively. The study further employed aeration technology to provide oxygen to the wort for 8 hours before fermentation. Sample-yeast ratio of 1:10 was established at 5.0liters/hour supply of oxygen, noted to speed up fermentation to 8 hours from 12 hours of no aeration. Evaluation of acceptability for consumer preference was done when the quality of vinegar complied with FDA standards. Physical-chemical laboratory analyses were performed, and the results were evaluated. The mean, standard deviation, and Mann-Whitney U-test were used as statistical tools for this study. The 9-point hedonic scale of likes and dislikes by Peryam and Pilgrim (1957) for acceptability test was utilized for the two aerated vinegar samples of 2.5 liters/ hour oxygen and 5.0 liters/hour oxygen. Twenty experts/respondents composing five (5) chefs, five (5) bakers, five (5) cooks, and five (5) housewives answered the standardized survey questionnaire. Based on the result of acceptability test for said two samples, a ‘very much acceptable,’ rating indicated that the vinegar was at ‘like very much’ category by the respondents. Further research should be conducted to enhance product quality of aeration-aided banana vinegar specifically the consistency in color and the increase in acidity at a shorter period.

Keywords: aeration-aided; Pisang Awak (*Musa Paradisiaca*) Banana; vinegar; sample-yeast ratio; Philippines

INTRODUCTION

Background of the Study

Vinegar is a sour liquid that is produced through the anaerobic fermentation of sugar into ethanol (or ethyl alcohol), followed by the aerobic oxidation of microorganisms that converts ethanol into acetic acid (Santos et al., 2019). Vinegar has been used extensively as a culinary spice or condiment, as a natural remedy for various illnesses, and as a household cleaner. Due to its diversity, vinegar is believed to improve digestion, skin quality, and aid in weight loss. This has led to the development of vinegar diets, which is the main reason for its increased production. In the Philippines, vinegar production is regulated by the Department of Health, Food and Drug Administration (FDA), under Administrative Order 134 series of 1970.

The distinct sweet taste of Pisang Awak, its perishable nature, and the popularity of fruit vinegar is the main reasons why the researcher chose to recycle the banana fruit into edible vinegar. Despite the researcher offering the fruit for free, some neighbors are hesitant to accept it. As a result, a portion of the fruit is either fed to livestock or thrown away, resulting in food loss. The researcher decided to experiment on the sweetness of the Pisang

Awak banana growing abundantly in the backyard. Starting from natural spontaneous fermentation, the first production of banana vinegar was around one month. By implementing technology to introduce aeration and utilizing yeast, the researcher had successfully shortened the production time to a maximum of 15 days for the final vinegar to be produced. The preliminary consumers, who are neighbors of the researcher, were fond of the unique flavor of the mild vinegar, using it in sauces, vegetable salad dressings, as well as in sweet and sour recipes.

The banana (Musa paradisiaca) is an elongated fruit of the Musaceae family, known for being an affordable and healthy fruit with valuable nutritional benefits, including calories, vitamins, minerals, and dietary fiber (Ruwaliet al., 2022). Musa species are grouped based on "ploidy" or chromosomal count, proportionate to the genes from Musa balbisiana and Musa acuminata in the DNA, with seedless cultivated types and hybrids (diploid, triploid, tetraploid, experimental hybrids) (Ghosh et al., 2013). Pisang Awak is a triploid ABB variety with occasional seeds in the fruit. It is versatile and can be consumed raw, dried, cooked, or baked. It is considered both a dessert and a cooking banana.

In this study, the overripe fruit was recycled into vinegar. This cultivated variety or cultivar is found chiefly in the researcher's lot area. When harvested, the fruit ripens after 2-3 days, quickly overripe, developing black marks on the skin. The researcher tried selling the fruit, but because the fruit physically degrades and easily rots, Pisang Awak cannot compete in the local or export market with cavendish cultivars in terms of luxury, fruit appeal, and shelf life.

There have been numerous studies conducted on banana vinegar and its application for food use. However, no research has been found on the utilization of the Pisang Awak cultivar as the main raw material. The study was conducted to produce aeration-aided Pisang Awak *(*Musa Paradisiaca) Banana Vinegar for use in sweet and sour recipes, salads, preservative, flavoring, and pickling.

Objectives of the Study

The main objective of the study was to produce Aeration-aided Pisang Awak *(Musa Paradisiaca)* Banana Vinegar.

Specifically, this study aimed to:

1. Determine the sugar content of Pisang Awak (Musa Paradisiaca) banana fruit.
2. Determine the amount of oxygen that speeds up fermentation.
3. Determine the rate of alcoholic fermentation using different sample-yeast ratio.
4. Compare the quality of aeration-aided Pisang Awak (Musa Paradisiaca) banana vinegar based on FDA standards.
5. Evaluate the acceptability of the Aeration-aided Pisang Awak (Musa Paradisiaca) Banana Vinegar based on the hedonic scale.
6. Formulation of product brochure.

Framework of the Study

The framework of the study was the overall structure that shaped this research. The INPUT-PROCESS-OUTPUT-OUTCOME or IPOO was used. Three stages of a system was represented by the IPO model: input, process, and output. Inputs include efforts and consumables added to a system at the start of its lifecycle and the conversion of inputs into outputs was the model for process (MacCuspie et al., 2014). The end result of the IPO model was the Outcome.

The Input-Process-Output-Outcome of Aeration-aided Pisang Awak (Musa Paradisiaca) Banana Vinegar is presented on

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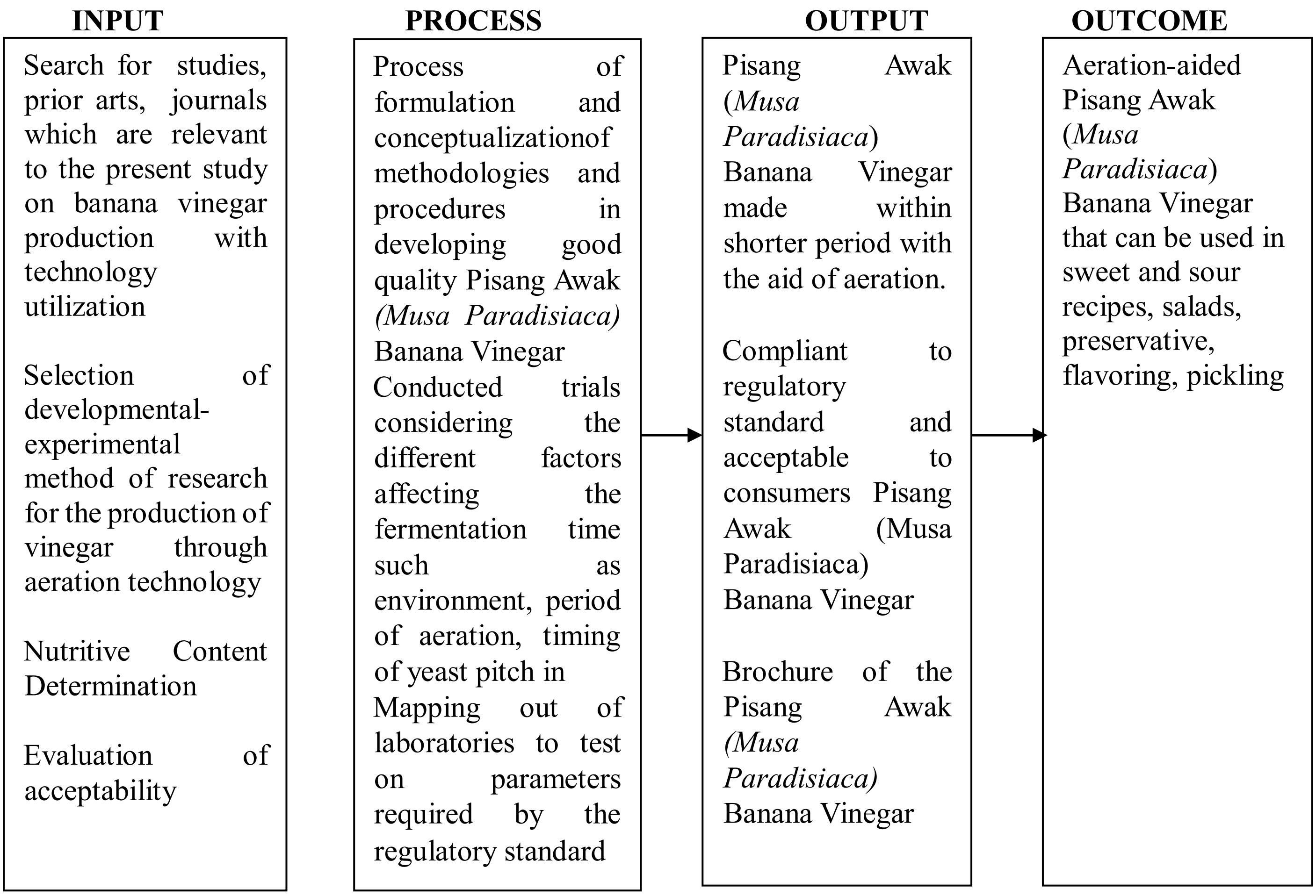
Figure 1, next page. Figure 1. Schematic Diagram Illustrating the Framework of the Study



The input phase started with the exploration of researches, studies, relevant articles to the present study, including journals on fruit vinegar production with the utilization of different technologies. There were around seventy-six research papers, journals, literature explored. Prior arts (patents, periodical articles, articles, brochures, actual goods) were checked in order to know the information regarding banana vinegar production. The characteristic of the banana cultivar and the kind of aeration technology were studied to provide a distinct characteristic and relative advantage of the product. Selection of research design was at this phase. Nutritional value such as calories, total fat, sodium, total carbohydrates, dietary fiber, sugar, and total protein was analyzed. To evaluate consumer acceptability of the banana vinegar, the 9-point hedonic scale of likes and dislikes was utilized.

During the process phase, formulation and conceptualization of methods and procedures for producing the banana vinegar were assessed. Experimentation involved trials on different factors at distinct overripe stages of the fruit, environment humidity, temperature, illumination, fermentation process with enzyme timing of pitch in, and the use of aeration technology with a specific amount of oxygen introduced and sample-yeast ratio. Testing laboratories and evaluation of results of analyses were done on parameters such as pH, acidity of vinegar, sugar content of the banana fruit, % alcohol content and °Brix attenuation (conversion of sugar into alcohol) of the fermented medium, total solids of the vinegar, ash, heavy metals such as lead, copper, arsenic.

The output was banana vinegar with shorter fermentation period, and compliant with FDA-Philippines standard for vinegar (Republic of the Philippines, 1970). The brochure of the banana vinegar was created.

The outcome of the study was Aeration-aided Pisang Awak (*Musa Paradisiaca*) Banana Vinegar, produced in filtered and unfiltered variants. Both variants were pasteurized to enhance its shelf-life. When filtered with granular activated carbon, the vinegar exhibited improved physical color, but its % Ash was lower than that of its unfiltered version, subsequently failing to meet the specifications for % Ash. The AOAC Official Method 942.05 for oxidation at 550°C for ash in vinegar measures total inorganic residue. A reduction in soluble minerals (ions) or filtered colloidal matter will quantitatively lower the ash result. Activated carbons may adsorb a wide array of metal ions from solutions, attributing this to interactions with surface functional groups (Mohan & Pittman Jr., 2006). This idea holds true for the mineral ions present in vinegar. For the yield, the Aeration-aided Pisang Awak (*Musa Paradisiaca*) Banana Vinegar harvested an average of 3 liters of vinegar from 6 kilograms of banana pulp.

Scope and Limitation of the Study

This research focused on producing vinegar from Pisang Awak or *Musa x paradisiaca* triploid genome ABB banana variety. It covered the comparative analysis of the quality of Aeration-aided Pisang Awak (*Musa Paradisiaca*) Banana Vinegar based on FDA standard Administrative Order 134 series of 1970.

The limitations of this research were the use of aerators to aid in the fermentation of the Pisang Awak cultivar, as well as the characterization of this banana fruit in terms of its sugar content. It was also limited to the amount of oxygen used to speed up fermentation, the rate of alcoholic fermentation when using different sample-yeast ratios, the evaluation of Aeration-aided Pisang Awak (*Musa Paradisiaca*) Banana Vinegar using the 9-point hedonic scale to measure consumer preference, and the formulation of the product brochure. Beyond these scope and limitations, other areas are no longer relevant.

Significance of the Study

This research study was significant to the following stakeholders:

Agriculturists. This study is significant to the Agriculturists in the continued yield development of Pisang Awak cultivar. Previously limited to kitchen gardens and homestead lands, this research could potentially increase the demand for larger plantations to provide the necessary raw materials for vinegar production.

Chefs. This study could serve as a baseline for identifying the specific aroma and flavor achieved from the raw material to the final product, banana vinegar, which is sought after by chefs. The final product can be used to enhance salad recipes as well improve the taste of sauces for sweet and sour menus.

Consumers. This study is significant to consumers who will have an option for natural remedies. Many consumers view vinegar as a remedy for common ailments, while others appreciate the product's flavor profile and the potential health benefits of banana vinegar, such as antidiabetic effects and lowering cholesterol levels.

Economists. The significant value of this study to the Economists is in supply and demand. When bananas are abundant, fermentation becomes an option to convert the excess fruit into vinegar. The fruit vinegar production industry is likely to thrive, as banana vinegar serves as a rich source of bioactive components and can be used as an ingredient in a wide variety of food products. This study is important for the local economy, as banana vinegar provides a healthy option for individuals seeking fruit-derived vinegars. Furthermore, this could mark the beginning of exploring the exportation of banana vinegar, thereby generating revenue for the national economy, as banana vinegar is generally low in cost due to its inexpensive ingredients.

Environmentalists. The value of this study lies in the reduction of losses of rejected agricultural substandard banana fruits through repurposing, which will aid environmentalists in managing environmental impact. Additionally, food waste is minimized by converting overripe bananas into a valuable product, namely vinegar. Both loss and waste being strategized will contribute to lesser garbage and provide sustainable by products (peel, mash – for composting). When peels and mashed pulp are not treated properly, natural decomposition produces greenhouse gases at the early stage of decomposition. However, the soil benefits from the conversion into humus, enriching the soil and enhancing plant growth.

Farmers. This study could help the farmers whose expertise is planting the banana, in the subsistence to a large scale of Pisang Awak plant. This could provide a livelihood to the expanding population. Furthermore, the mashed pulp by-product, when allowed to decompose as agricultural waste, can serve as a beneficial soil conditioner, offering farmers the opportunity to decrease their expenses on fertilizers.

Future Researchers. This study has the potential to generate innovative products solely from banana vinegar. Future researchers can also explore the possibility of recycling rejected bananas into other food products to prevent wastage. The surplus bananas could be utilized to create new products, such as vinegar from banana peels and banana sap, with enhanced nutritional value.

Researchers. This study could be utilized to implement technologies for reducing fermentation time and acetification, such as the use of aeration systems, different fermentation techniques, and acetification, as well as the use of new strains of yeast and acetobacter microorganisms to optimize process efficiency. These advancements are crucial for current researchers in the field.

Definition of Terms

The following terms were defined conceptually and operationally for a clearer understanding of this study. Aeration. Conceptually, the term refers to the addition of oxygen into the fermented medium by techniques such as use of aerator or of sparger (Moenne et al., 2013).

In this study, aeration to the medium is done using external aerators.

Aeration-aided. Conceptually, the term refers to the process of introducing air to provide the yeast with needed oxygen in fermentation (Permyakova et al., 2021). In this study, it denotes the use of external force to introduce air into the fermenting vat/jar to facilitate the fermentation process.

Banana. Conceptually, the term refers to herbaceous perennial monocots of the Musaceae family (genus Musa), which are grown worldwide, but especially in tropical and subtropical areas (Simmons & Shepherd, 1955). In this study, it refers to the main ingredient, which is the Pisang Awak cultivar.

Alcoholic Fermentation. Conceptually, the term refers to the conversion of sugar into ethyl alcohol and carbon dioxide by the aid of yeast acting as an enzyme (Stanzer et al., 2023). In this study, the term means the conversion of sugar present in banana fruit into ethyl alcohol and carbon dioxide with the aid of yeast and aeration, upon which the rate of conversion is measured utilizing °Brix and % Alcohol.

Banana Vinegar. Conceptually, the term refers to the vinegar produced from banana fruit concentrate via two-stage fermentation (Boonsupaa et al., 2019). In this study, the term refers to the vinegar produced from Pisang Awak (Musa Paradisiaca) banana fruit using aeration-aided technology.

Brix. Conceptually, this is the mass percentage of soluble solids (the main component is sugar) in the sugar solutions as determined by refractive index, or conductivity, microwave method using an open coaxial resonator (Liu et al., 2022). In this study, the °Brix or Brix means the percent by weight of sugar content present from the extracted banana fruit solution (or wort) up to beer (fermented wort) as measured by a refractometer.

Cultivar. Conceptually, the term means a cultivated variety, which is a group of plants selected for desirable characteristics that have been maintained during propagation. It is the most basic classification category of cultivated plants in the International Code of Nomenclature for Cultivated Plants (ICNCP) (Double & Fall, 2020). In this study, the term means Musa Paradisiaca Triploid ABB, the Musa x paradisiaca triploid genome ABB, Pisang Awak in international name (Valmayor et al., n.d.).

FDA. Conceptually, the term is an abbreviation of Food and Drug Administration of the Philippines (fda.gov.ph), a regulatory agency under the Department of Health, created under Republic Act No. 3720, series of 1963. In this study, it refers to the agency that regulates vinegar production in the Philippines.

FDA Standard. Conceptually, the term means the criteria set by the FDA-Philippines, which are a set of specifications to be complied with by the manufacturers. In this study, the term means the vinegar quality specifications set by FDA-Philippines in the Administrative Order 134 series of 1970 (Republic of the Philippines, 1970).

Fermentation. Conceptually, the term means the chemical transformation of organic substances into simpler compounds by the action of enzymes and complex organic catalysts, which are produced by microorganisms such as yeasts, bacteria, or molds (Sourvinos, 2022). In this study, it is the chemical process undergone by the banana liquid, or wort, with the aid of yeast to produce the beer ready for vinegar production.

Hedonic Scale. Conceptually, the term means a scale of likes and dislikes: "like extremely," "like very much," "like moderately," "like slightly," "neither like nor dislike," "dislike slightly," "dislike moderately," "dislike very much," "dislike extremely," which is referred to as the 9-point hedonic scale (Peryam & Haynes, 1957) and was used to test the acceptability of food in military men as consumers. In this study, it refers to the scale used by the respondents in the acceptability test to grade their preference on samples 1 and 2 of Aeration-aided Pisang Awak (Musa Paradisiaca) Banana Vinegar.

Musa Paradisiaca. Conceptually, the term is the scientific name of Pisang Awak Banana (Valmayor et al., n.d.). In this study, the term refers to Pisang Awak Banana fruit.

Oxygen. Conceptually, the term means an element with atomic symbol O, atomic number 8, and atomic weight [15.99903; 15.99977], an abundant element on earth and essential for respiration (PubChem, NIH). In this study, it means the air or oxygen injected into the cooled wort by using an external aerator or air pump with a capacity of 5.0 liters per hour.

Pisang Awak. Conceptually, the term refers to the international name variety of banana fruit with the scientific name of Musa Paradisiaca Pisang Awak subgroup ABB (Wang et al., 2021). It is one of the most vigorous and hardy cultivars of bananas and is a triploid cultivar belonging to the ABB genomic group (Valmayor et al., 1981). In this study, it means the banana fruit material used in the experiment to produce the banana vinegar.

Produce. Conceptually, the term means to be made from basic materials and other ingredients by employing a method (Hutchinson et al., 2019). As used in this study, the term means to develop a food ingredient, which is Aeration-aided Banana Vinegar, from Pisang Awak (Musa Paradisiaca) banana fruit.

Product Brochure. Conceptually, the term means a single sheet document, often folded into thirds, that is mass-produced to provide information to the public about the features of a product (Creating A Brochure, n.d.). In this study, the term refers to the document explaining the information about Aeration-aided Pisang Awak (Musa Paradisiaca) Banana Vinegar.

Quality. Conceptually, the term means an objective evaluation, the quantitative attribute of goods or products (Lone & Bhat, 2022). In this study, it means the conformance of the Aeration-aided Pisang Awak (Musa Paradisiaca) banana vinegar to the specifications set in the FDA Standard.

Sample-Yeast Ratio. Operationally, as used in this study, it means the relative volume of sample (wort) and the mass of yeast contained in the solution for fermentation. It is the sample quantities used in proportion. As an example, if the wort is 1 liter, the yeast is 20 grams, a 1:10 ratio determined by the researcher through trials.

Sugar Content. Conceptually, the term means the amount of sucrose in the material (Salelign & Duraisamy, 2021). In this study, it means the sucrose or the sugar present in the pure Pisang Awak banana fruit. The value was obtained using single polarization measured using Saccharomat and °Brix measured using refractometer.

Vinegar. Conceptually, the term means a sour liquid fit for human consumption, produced from raw material of agricultural origin, containing starch, sugars, or starch and sugars, through the process of double fermentation, alcoholic and acetous, and includes a specified amount of acetic acid by Joint FAO/WHO Food Standards Program (Cavdaroglu & Ozen, 2023). In this study, it means the fermented sour liquid final product referred to as the Aeration-aided Pisang Awak (Musa Paradisiaca) Banana Vinegar.

Wort. Conceptually, the term means the liquid product resulting from the mashing of the main raw material for fermentation, wherein starches are converted into fermentable sugar and transform into beer with the aid of yeast during alcoholic fermentation (Iorizzo et al., 2021). In this study, it means the banana liquid extracted from mashing the overripe banana pulp.

Yeast. Conceptually, the term means an enzyme and microorganism known to carry a sucrose invertase that is required for the hydrolysis of sucrose to glucose and fructose, such as *Saccharomyces cerevisiae* in microbial metabolism like fermentation (Erian & Sauer, 2022). In this study, the term refers to the enzyme which is active dry baker's yeast used in the conversion of glucose and fructose from bananas into ethyl alcohol.

Yeast Ratio. Operationally, as used in this study, it means the amount of yeast contained in the wort. At a 1:10 sample-yeast ratio, the yeast is 10 grams (and the wort measures one liter) or the yeast constitutes 1% weight by volume in the solution.

REVIEW OF RELATED LITERATURE

This chapter presents a review of related literature and prior art relevant to the present study.

Origin of Pisang Awak (Musa Paradisiaca) Banana

Bananas are one of the oldest and most popular tropical fruits in existence. Produced for over 130 nations (Woolley et al., 2022), bananas are the oldest plants currently being farmed in more than 100 nations, with the majority in the Philippines, Brazil, and India, amounting to approximately 98 million tons per year (Ruwali et al., 2022). According to the study, Musa acuminata Colla and Musa balbisiana Colla are the two wild species that have given rise to nearly all the edible sweet and cooking bananas (Simmonds & Shepherd, 1955). The origins of cultivars of edible bananas that are diploid, triploid, and tetraploid hybrids came from vegetative propagation by natural cross-pollination and hybridization between wild diploid Musa acuminata (2n = 2x = 22, AA genome) and wild diploid Musa balbisiana (2n = 2x = 22, BB genome) (Šimoníková et al., 2020). The ploidy, which refers to the number of chromosome sets they contain, and the gene percentage of Musa acuminata (A) and Musa balbisiana (B) genes in the cultivar's genome, are the groupings of the edible bananas of today. Well-known edible cultivars of banana are triploid hybrids (AAA, AAB, ABB), diploids (AA, AB, BB), and tetraploids (AAAA, AAAB, AABB, ABBB). Some triploid plants exhibit seeds, while others do not. This also applies to experimental hybrid tetraploids and uncommon cultivars (Šimoníková et al., 2020).

This group of edible triploid bananas is where Pisang Awak belongs, known as plantains or starchy banana, or ABB genome, and covers nearly 40% of global banana production (Šimoníková et al., 2020). Pisang Awak, also known as Musa x paradisiaca with a triploid genome ABB, is commonly propagated by suckers. It is referred to as Katali in the Philippines, Biji in Malaysia, Pisang Awak in Indonesia, Kluai Namwa in Thailand, and Awak internationally (Valmayor et al., 1981).

Shelf life of Pisang Awak (Musa Paradisiaca) Banana Fruit

Musa x paradisiaca, also known as Pisang Awak, is a popular banana cultivar appreciated for its flavor and stress tolerance. However, it is known for its short shelf life and rapid degradation after harvest (Zhu et al., 2020). The author of this research made a keen observation on Pisang Awak. When it ripens, it tends to develop black marks externally and becomes overripe easily. Upon harvest of the mature fruit, it takes only 2 to 3 days for Pisang Awak to degrade. In order to prevent wastage of the fruit, various alternatives were explored, such as transforming it into another product that is both healthy and can extend the shelf life of Pisang Awak fruit. This aligns with the government program on recycling to reduce food wastage, with Senate Bill 423 of 2019 the legal basis: An Act Reducing Food Waste Through Food Donations and Food Waste Recycling. One possibility for utilizing the fruit of this banana cultivar is to make fruit vinegar. The researcher suggests that the subpar fruit can be utilized to produce vinegar, which could offer significant benefits to the food sector. The government's thrust is to reduce food waste/loss generated from commodities. Research has revealed that within the Philippine Food Supply Chain, bananas experience the highest percentage of food loss/waste at 20.05, surpassing rice and corn (Pastolero & Sassi, 2022). This information highlights the need for targeted interventions across various stages, from production to consumption, to reduce food waste and improve overall supply chain efficiency. This is due to the perishable nature of the banana commodity along its processing.

Benefits from Fruit Vinegars, including Banana Vinegar

Vinegar has been used extensively as a culinary spice and natural medicine to treat various illnesses. Additionally, it was regarded by laypeople as a "superfood," said to enhance digestion, skin quality, and weight loss. Hippocrates (c. 420 BC) treated wounds with vinegar (Santos et al., 2019), which meant ancient civilization used this liquid. Vinegar is believed to have numerous beneficial effects due to its rich and nutritious qualities. It is said to possess anti-inflammatory, anti-hyperlipidemic, antidiabetic, and antibacterial activities, making it a valuable addition to one's diet. Various methods have revealed the existence of various bioactive substances in vinegar. In a review, Fruits Vinegar: Quality Characteristics, Phytochemistry, and Functionality, it was concluded that the raw ingredient that goes into making vinegar was the main component providing the bioactive substances such as polyphenolic acids, organic acids, tetramethylperazine, and melanoidins, already present or are created during the brewing process (Ousaaid et al., 2021).

Fruit vinegars, with their acetic acid nature and positive health effects, have sparked numerous research studies, as they can be made from a wide variety of fruits. This has made fruit the focus of several vinegar research endeavors (Luzón-Quintana et al., 2021). In a study on the development of banana vinegar from Thailand cultivars namely Khai Pra Tabong, Nak, Hin, and Phama Heak Kuk, the results showed that the vinegar produced from Phama Heak Kuk cultivar exhibited the highest level of acetic acid (3.49%) in comparison to Khai Pra Tabong cultivar which displayed the highest antioxidant activities (80.59%) measured by means of DPPH radical assay, and vinegars produced from Nak cultivar were observed to have the highest total phenolics (243.98 mg/L) (Boonsupa & Kerdchan, 2020). In another study by the same author on the Development of Fermented Banana Vinegar: Chemical Characterization and Antioxidant Activity, vinegar produced from the cultivar "Khai Pra Tabong," banana vinegar was shown to have the greatest level of antioxidant activity of 80.59 ± 2.30% was significantly higher than that found in Makgeolli's purple sweet potato vinegar (67.63 ± 0.17%) (Boonsupaa et al., 2019). The study focused on the Pisang Awak cultivar as there was no existing literature on the use of this variety for making banana vinegar, despite the benefits derived from bananas. *The Production of Fruit Vinegars*

Sugar content is a crucial factor to consider in the creation of vinegar, as it is directly proportional to the alcohol content that can be attained during alcoholic fermentation and consequently to the final acetic production. Vinegar can be used as a food ingredient only if it contains a minimum of 4% acetic acid or 4 grams of acetic acid per 100 ml, as specified by the European Union and Codex (Cavdaroglu & Ozen, 2023). Acetic acid is the major component in vinegar that determines its quality. The production of vinegar in the Philippines is being regulated by the Food and Drug Administration under the Department of Health (Republic of the Philippines, 1970). The production of vinegar typically involves the following steps: 1) selection of raw material, 2) preparation of fermentation medium, 3) alcoholic fermentation by yeast, 4) acetification by acetic acid bacteria, and 5) bottling of the final product. The difference in the methods of fermentation and acetification are the key in the organoleptic characteristic of the final vinegar product.

Additionally, vinegar and other fermented products are made using AAB or acetic acid bacteria due to their capability to oxidize ethanol into acetic acid (Shi et al., 2022). This literature, "Insights into the microbiota and driving forces to control the quality of vinegar" (Shi et al., 2022) has pinpointed that factors such as raw materials, microbiological composition and environmental factors will help standardize the consistency of vinegar production. Literature classified two different processes used in the manufacturing of fermentation-based vinegars, specifically the immersion and conventional techniques. The conventional approach depends on fermentations of surface cultures wherein air was used to obtain oxygen and this technique uses minimal technology inputs, therefore to achieve final vinegar require a longer fermentation time of around two months, hence this is more costly (Hutchinson et al., 2019). The submerged tank method is the second technique, which involves utilizing highly developed technology systems such as using stainless steel fermentors, coolers, antifoams, and spargers and control systems that are automated. Large companies usually employ this technique for the manufacturing of commercial vinegars. The fermentation of grape vinegar in industrial settings use the submerged Frings acetator approach, which only takes 20–24 hours at most (Hutchinson et al., 2019).

Effect of Aeration on Yeast Community Structure and Volatile Composition in Uninoculated Chardonnay Wines

Oxygen is essential in the fermentation process to invigorate yeasts. The control of oxygen, which involves adding or excluding oxygen, is a crucial instrument for winemaking, where it was used to change the mouthfeel, flavor, and aroma of wine. In this line of thought, since wine making undergoes fermentation step like vinegar making, adding air has been demonstrated to increases yeast viability and raise the effectiveness of fermentation (Varela et al., 2021). In one study, the timing of aeration was observed to be most beneficial when added at the final part of yeast exponential growth (Varela et al., 2021). However, in one study, wort aeration is mandatory before to fermentation for a high reproduction rate and maximum cell growth (Permyakova et al., 2021). After cooling the wort, the researcher utilized aeration for 8 hours. It was observed to provide the optimum aeration before pitching in the inoculated yeast. The researcher had done the eight-hour aeration for sample 1 with one hose (at 2.5 liters/hour oxygen) and sample 2 with two hoses (at 5.0 liters/hour oxygen).

It is widely acknowledged that aeration is a performance indicator for vinegar production, but high aeration rates can cause excessive foam production and medium loss. Ethanol is also lost through evaporation as a result of excessive aeration, which ultimately results in lower yields, as explained in the review on Vinegar Engineering: a Bioprocess Perspective (Hutchinson et al., 2019). Several factors affect any fermentation and oxidation processes aside from the use of aeration, such as yeast strain and quantity, acetobacter bacteria strain, immobilization materials (for reproduction and surface adsorption of acetic acid bacteria), environmental conditions, hygienic practices (Hutchinson et al., 2019). Aeration-aided fermentation and aerobic oxidation can help hasten vinegar production from the usual one-month period to 15 days, as experimented by the researcher.

9-point Hedonic Scale as Criterion for the Acceptability of Food including Vinegar

When developing a product, developers employ a variety of tools. For food products and ingredients, these tools can be chemical analyses, microbiological tests, or physical/visual checks. When instruments are used independently, diverse levels of acceptability or different perceptions can be obtained. On the current innovations of fermented foods, these products before reaching the consumers, are tested for acceptability following standard quality procedures.

The 9-point Hedonic Scale is the most common method to quantify acceptability. Ever since the scale of Peryam and Pilgrim, 1957 (Lim, 2011; Peryam & Haynes, 1957) was created, it had been the frequently used scale to gauge customer preference for various culinary items. For the acceptability of Aeration-aided Pisang Awak (*Musa Paradisiaca*) Banana Vinegar, the researcher used the nine-point hedonic scale of likes and dislikes by Peryam, D. R. and Pilgrim, F. J. Hedonic scale method of measuring food preferences Food Technology, Vol 11, Suppl., 9-14. 1957. The scale was with nine equally spaced intervals labeled with the following phrases: "like extremely," "like very much," "like moderately," "like slightly," "neither like nor dislike," "dislike slightly," "dislike moderately, " "dislike very much," "dislike extremely." The scores that each respondent rated to sample 1 and sample 2 banana vinegar (on structured scales; each response was converted into the relevant value) were the outcomes of the hedonic scale. These data were used to calculate the average acceptability values for the sample product and to assess whether there were appreciable variations in the acceptability of the banana vinegar.

Prior Art

The similarities with prior art of this banana vinegar with KR101346763B1 entitled Banana Vinegar and its Manufacturing Method by Oh Maeng-sim from South Korea was the mashing of banana to open the cells in order to extract more sugar content in the fruit. Filtration was also done to obtain the liquid for fermentation. The differences from the research study Aeration-aided Pisang Awak (*Musa Paradisiaca*) Banana Vinegar were the ingredients which were too many, the longer fermentation time, and no aeration used in this prior art. The ingredients were grape, kiwi, pineapple, lemon, tomato, grapefruit and paprika, brown sugar, and brown rice vinegar, with the banana mixture aged at 5 to 15°C for 3 to 6 months, whereas the current study had only banana fruit and purified water as ingredients, with fermentation temperature and time of 35-40°C at 8 hours respectively. Aerobic oxidation of 15 days, with the aid of aeration technology was done in the current study to shorten fermentation time.

Another similarities and differences were noted in prior art entitled Vinegar Mainly Prepared from Banana Juice and Preparation Method Thereof, CN 105695290A, by Shi Zhanbiao from China. The similarity was the addition of mother vinegar after 4 days when fermentation was finished, which was also done in the current study. Acetic acid bacteria (in the form of mother vinegar) was added to start aerobic oxidation. The differences of the current study from this prior art were the many ingredients and the technology used. In here, the main raw material – banana, was prepared as a juice with no mention on the variety, no description on stage of fruit usage such as fresh ripe fruit or overripe, no mention on the origin - from fruit, peel, mixture of both. The current study takes into account that only overripe banana fruit of Pisang Awak cultivar will be utilized. The finished product: Pisang Awak banana vinegar because of its mild taste, will be used for vegetable salad dressings, condiment in sweet and sour recipes, acidulant, pickling, flavoring - intended uses not mentioned in this prior art. Aerationaided technology was not used in this prior art.

Synthesis

The first part of the research literature focused on the information on Pisang Awak *(Musa Paradisiaca)* banana cultivar which could either be seedless or with seeds. The nomenclature and classification were also highlighted to give the cultivar its identity or the genome type ABB.

Air addition and aeration timing are both critical in yeast reproduction and fermentation process. As observed, low oxygen content in the wort hindered the primary fermentation process. The related literature discusses on the use of air. Because the timing of aeration is also vital for yeast population to increase, it was primarily observed in exponential growth phase of yeast.

Fruit vinegar is considered as a high-value by-product. From the prior art, banana fruit's bioactive substances and antioxidant properties were the main compositions carried and enhanced by fermentation into the banana vinegar produced, which may enhance or aid in the treatment of several illnesses.

In the Philippines, the quality standard for commercial vinegar is Administrative Order 134 series of 1970 standard of quality (see Appendix A). Manufacturer of fruit vinegar should consider not only biotechnological processes and innovative technologies but the development of cultivated varieties that are high in total sugar as invert.

Pasteurization as discussed in prior art was done to suppress the enzymatic activity and inactivate food-borne pathogens. Temperature and exposure period impact the pathogen reduction that are accomplished during heat treatment.

The use of 9-point hedonic scale in gauging the acceptability of food including vinegar was done to achieve the results in applying product research. With statistical and scientific procedure appropriate for consumer preference before use, quality of vinegar for customer approval was enhanced.

METHODOLOGY

This chapter presents the research design, design criteria, design plan preparation, fabrication, evaluation procedure, instrumentation, data to be gathered, parameters for analysis, cost analysis and ethical considerations.

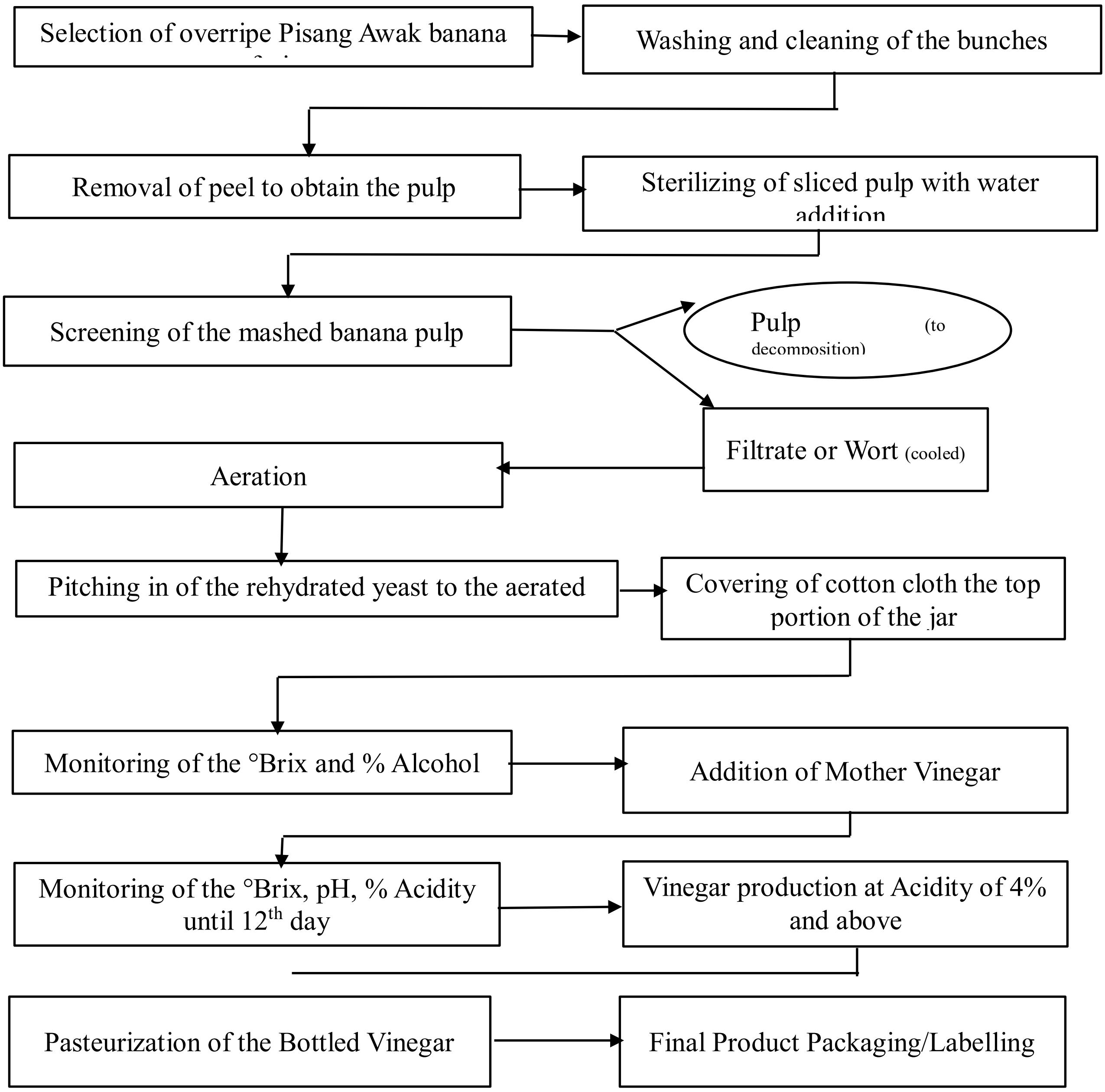
Research Design

This study adopts the developmental-experimental method of research. The development of Aeration-aided Pisang Awak (*Musa Paradisiaca*) Banana Vinegar was performed to satisfy FDA Philippine National Standard for Vinegar (Republic of the Philippines, 1970) using scientific methodology by manipulating the independent variables such as sugar content of the banana fruit, amount of oxygen from external source provided to the fermentation medium, sample-yeast ratio. Experiments were conducted using quantitative and qualitative analyses to collect data on the independent variables, the dependent variables and the control.

In objective 1, the sugar content of Pisang Awak (Musa Paradisiaca) banana fruit was determined using quantitative analysis in terms of °Brix and Polarization. Three replicate trials were done. The statistical tool that was used to get the sugar content values was descriptive statistics specifically the mean. The mean values measured for °Brix and Polarization were presented in Chapter IV.

Figure 2 on next page illustrates the Schematic Diagram of the Process of producing the Aeration-aided Pisang Awak (Musa Paradisiaca) Banana Vinegar.

Figure 2 Schematic Diagram of the Process



In objective 2, the amount of oxygen used to speed up fermentation was determined from the full capacity of the external aerator or air pump supplying oxygen to the wort.

In objective 3, the rate of alcoholic fermentation was determined by means of monitoring the beer's % alcohol reading which indicates the alcohol content per unit time. The statistical tool that was employed to get the rate of alcoholic fermentation was descriptive statistics specifically the range. The maximum range measured for the rate of alcoholic fermentation was determined, and this was presented in Chapter IV.

In objective 4, the quality of Aeration-aided Pisang Awak (Musa Paradisiaca) Banana Vinegar was analyzed by 3rd party laboratories (HPCo Lab and Negros Prawn Producers' Cooperative) and compared with the FDA Regulation Prescribing the Standard of Identity and Quality of Vinegar, A.O. 134 series of 1970 (Republic of the Philippines, 1970). The statistical tool used to obtain the results of laboratory tests was descriptive statistics specifically the mean or average of two trials. The results of the lab tests were presented in Chapter IV.

In objective 5, the evaluation on acceptability of Aeration-aided Pisang Awak (Musa Paradisiaca) Banana Vinegar was done by using a survey on acceptability utilizing the 9-point hedonic scale to twenty respondents. Purposive sampling was used to select the customers from the following categories of respondents/experts in their field: five (5) chefs, five (5) bakers, five (5) cooks, and five (5) housewives, representing varied location, age, sex, and work. The scale of likes and dislikes with phrases that represent each category written on the labels (Lim, 2011) is a standard instrument utilizing the 9-point Hedonic Scale Standard Questionnaire (Peryam, et.al, 1957) The questionnaire was used by the said respondents in evaluating sample 1 - Aeration-aided Pisang Awak (Musa Paradisiaca) Banana Vinegar at 2.5 liters/hour oxygen, and sample 2 - Aeration-aided Pisang Awak (Musa Paradisiaca) Banana Vinegar at 5.0 liters/hour oxygen. The surveyed data from these respondents were collated, tallied, tabulated, and treated using the U and p value of Mann-Whitney U-test as statistical tool.

In objective 6, the product brochure was done using an online graphic design tool used to create brochures, presentations, posters, logos, etc.

Design Criteria

In the development of banana vinegar, the ingredient used was the overripe fruit of Pisang Awak banana. Experimentation using aeration-aided technology was utilized on two samples, while the control has no aeration. A sample-yeast ratio was also established to facilitate shorter fermentation hours. This design was formulated to shorten the process of banana vinegar production from 30 days to 15 days. Oxygen was utilized to improve fermentation time. This was done with the use of external aerators with capacity of 5.0 liters per hour oxygen. Oxygen from air was introduced to the cooled wort for 8 hours. The amount of oxygen needed to facilitate faster fermentation was 5.0 liters per hour at high speed, the full capacity of the aerator. Before establishing this, the 1:10 sample-yeast ratio trials were done using high and low speeds aerator setting, at full capacity of 5.0 liters per hour oxygen. Sample 1 utilized single hose of 1-meter length, 4.0 mm internal diameter (meaning, only half of the full capacity of oxygen was introduced which was at 2.5 liters/hour). Sample 2 used a double hose of 1-meter length per hose, 4.0 mm internal diameter (the full capacity which was 5.0 liters/hour.). Time was recorded in each of the fermentation trials such as first trial with all samples (1, 2, control) without aeration, second trial was with aeration at low setting, 8 hours aeration after cooling of wort then stopped aerating after yeast was pitched in, and last trial with aeration at high setting, 8 hours aeration after cooling of wort then stopped aerating after yeast was pitched in. On sample-yeast ratio, experimented on 1:5, then on 1:10 using aerated wort at high speed, then wort aerated at low speed in the external aerator, at oxygen amount of 2.5 liters/hour and at 5.0 liters/hour. The control also followed the ratio but had no aeration. These test runs were done to establish the sample-yeast ratio of 1:10 which gave the shortest fermentation hours among the trials conducted.

Design Plan, Preparation, and Fabrication

This involved the formulation, process, production, and evaluation of Aeration-aided Pisang Awak (Musa Paradisiaca) Banana Vinegar. The formulation of Pisang Awak Banana (Musa Paradisiaca) Vinegar was the first part of the design plan. The next step was the process involved in producing the banana vinegar, followed by the production of Aeration-aided Pisang Awak (Musa Paradisiaca) Banana Vinegar, and the evaluation process of acceptability by experts. Formulation of Vinegar Samples Selection and purchase of the raw material, ingredient, tools, and equipment were the preliminary parts of the formulation. Experimental samples were established representing different amount of oxygen and sample-yeast ratio such as sample 1, sample 2 and control. Monitoring of fermentation time and completion of aerobic oxidation were done. Laboratory tests were employed to comply with the parameters and results of the FDA-Philippines (Republic of the Philippines, 1970). After the results passed the standards, the final product vinegar was evaluated for consumer acceptability. Process Involved in Producing the Banana Vinegar The first step was the selection of the overripe banana fruit. It was washed, drained, its peel removed, and then sliced to around 10-15mm thickness. For every 6 kilogram of sliced banana pulp (1 batch), purified water of 1500 milliliter was added. The proportion was established based on the °Brix of the banana juice obtained in reference to the same procedure done from the study entitled Development of Fermented Banana Vinegar: Chemical Characterization and Antioxidant Activity (Boonsupaa et al., 2019). Sterilization followed at 70-80°C for 8 hours with occasional stirring. The mixture was then cooled to room temperature. The next step was the screening of the mixture. The pulp was separated from the liquid (filtrate) by passing through a 100-mesh cloth screen. The filtrate (also called wort) was cooled to ambient temperature. The solid pulp was put to rot for use as soil conditioner. Sterilized glass jars were filled in with the cooled wort, the jars were covered, but with hole just enough for the hose to pass through. The hose was connected to an external aerator with a capacity of 5.0 liters/hour. Aeration was performed for 8 hours. The area was not direct sunlight, and was protected from rain. Samples 1 and 2 were aerated, while control was not aerated. Dry bakers' yeast was added for each jar containing samples 1, 2, and control to start the fermentation. The yeast was first rehydrated before adding to the wort. Each glass jar was gently swirled in a circular motion. Readings of pH, % alcohol, and °Brix were taken until they stabilized and reached the death phase, which signified the end of fermentation. Fermentation was visible from the activity of the yeast depicted in the formation of bubbles in the wort, now referred to as the beer. Release of carbon dioxide and disappearance of bubbles indicate end of fermentation (Sriputorn et al., 2020). The % alcohol content of the beer and the °Brix were direct indications of sugar conversion based on values of said °Brix and % Alcohol. After all the sugar had been converted into alcohol indicated from the °Brix and % Alcohol readings which became stagnant at the end of fermentation, the beer was continued to aerobic oxidation. Cotton cloth was used to cover the glass jars. Addition of mother vinegar was done four days after end of fermentation. The mother is the starter for acetic acid bacteria. The % acidity of the vinegar was checked after 15th, then 18th day. When the % acidity was above 3%, the vinegar was transferred to 375ml glass bottles. There were two variants for the vinegar produced - the unfiltered banana vinegar, and the filtered banana vinegar. Filtration through granular activated carbon (GAC) was an optional process before the pasteurization of the Aeration-aided Pisang Awak (Musa Paradisiaca) Banana Vinegar. Pasteurization was done at 60-70°C for 30 minutes. As the final step, the bottles were cooled and labeled as pasteurized unfiltered or pasteurized filtered. Production of Aeration-aided Pisang Awak (Musa Paradisiaca) Banana Vinegar In comparing the quality of vinegar based on FDA standards, tests were made according to parameters set in the said standards. The total acidity was performed using AOAC Official method 942.15 on titratable acidity of fruit products, indicator method. Phenolphthalein indicator, 1 N standardized NaOH, burette stand with clamp, measuring cylinder, pipette, Erlenmeyer flasks, and vinegar sample were used. The amount of acetic acid was computed in % (AOAC, 1990), based on this equation: $CH_3COOH(aq) + NaOH(aq) \rightarrow CH_3COONa(aq) + H_2O(l)$. The total solids monitoring was done using gravimetric method, oven drying at 103-105°C, and the % ash was analyzed by utilizing conductivity method (ICUMSA 2015, GS 1/3/4/7/8-13, 1994). For third party laboratory analysis, the % total solids was performed by Negros Prawn Producers Cooperative Analytical and Diagnostic Laboratory (NPPC) using gravimetric method. Two samples of 5.0 liters/hour Aeration-aided Pisang Awak (Musa Paradisiaca) Banana Vinegar were analyzed, the unfiltered and filtered by granular activated carbon or GAC. For the same two samples, the % Ash was analyzed by NPPC using the oxidation method at 550°C. The Heavy Metals analyses such as lead, copper and arsenic were performed by Intertek Testing Services Inc. using analytical technique, Inductively Coupled Plasma – Optical Emission Spectroscopy (OES). The nutritional value was analyzed by NPPC using the Official Methods of Analysis of the Association of Analytical Chemists and ASEAN Manual of Food Analysis Regional Center of ASEAN Network of Food Data System. The following parameters were analyzed: Calories, Calories from Fat, Total Fat, Sodium, Total Carbohydrates, Dietary Fiber, Sugar, and Total Protein.

Figure 3 shows the finished product, Aeration-aided Pisang Awak (Musa Paradisiaca) Banana Vinegar.

The tools, equipment, and reagents with their corresponding functions used in producing the vinegar are shown on Table 1.

Table 1 Tools, Equipment, and Reagent and their Functions in the Production of Aeration-aided Pisang Awak *(Musa Paradisiaca)* Banana Vinegar

Tools, Equipment, and Reagent Used	**Function**
A. Tools Weighing Scale Glass Jars Knife Chopping Board Screen (100 mesh, cloth) Strainer (fine mesh, stainless) Measuring cup Plastic Ladle Plastic Container Stainless Ladle Glass Bottles Cotton Cloth Plastic Hose Plastic Funnel **B. Equipment** Sterilizer (electrothermal) Aerator with hose Alcohol dual-function ATC wine refractometer pH Paper **C. Reagent** Active Dry Baker's Yeast Mother Vinegar (from previously produced Pisang Awak Banana Vinegar) Activated Carbon	Is used for weighing raw material and reagent Is used to contain the wort for aeration to final process Is used for slicing the banana pulp Is used as protective surface to cut the sliced pulp Is used to separate the pulp from the worth Is used to separate the sliced banana from its liquid Is used to measure the wort volume Is used to transfer the pulp from sterilizer to container Is used to hold the pulp after sterilization for screening Is used to mix the pulp being sterilized Is used to contain the final product ready for use Is used to cover the glass jar being processed Is used to transfer the air from aerator to the wort Is used to guide the liquid being transferred Is used to bring to 70-80°C the wort for 8 hours Is used to transport the oxygen from the aerator to the wort Is used to measure the °Brix of the liquid Is used to measure visually the pH value Is the reagent/enzyme used to convert sugar into alcohol and carbon dioxide by the process of fermentation Is used to start acetic acid bacteria for aerobic oxidation of alcohol into vinegar Is used as filter agent of vinegar

Table 1 presents the tools, equipment and reagents their functions in the production of Aeration-aided Pisang Awak (Musa Paradisiaca) Banana Vinegar. The tools consist of a weighing scale, glass jars, knife, chopping board, screen (100 mesh, cloth), strainer (fine mesh, stainless), measuring cup, plastic ladle, plastic container, stainless ladle, glass bottles, cotton cloth, plastic hose, and plastic funnel. For the equipment, the researcher used a sterilizer (electrothermal bucket with temperature control knob), aerator with transparent hose, hand-held refractometer, and pH paper. The chemical reagents used were the active dry yeast, mother vinegar from previous Pisang Awak banana vinegar production, and the granular activated carbon as the filter (optional). The ingredients and their uses in producing the vinegar are shown on Table 2.

Table 2 Ingredients and their Uses in the Production of Aeration-aided Pisang Awak (*Musa Paradisiaca*) Banana Vinegar

Ingredient/s	**Quantity**	**Unit**	**Uses**
Overripe Pisang Awak Banana pulp Purified Water	6 1.5	Kilograms Liters	Main Ingredient Helps macerate the pulp

Table 2 presents the ingredients and their uses in the Production of Aeration-aided Pisang Awak (*Musa Paradisiaca*) Banana Vinegar. The banana pulp was measured by weight (in Kilogram), but after sterilization using purified water, the filtrate or wort was measured by volume (in Liter or milliliter). *Evaluation Procedure*

In evaluating the acceptability of Aeration-aided Pisang Awak (*Musa Paradisiaca*) Banana Vinegar, the standardized 9-point Hedonic Scale of Likes and Dislikes by Peryam and Pilgrim (1957) was used. Evaluation of acceptability was made after the results of 3rd party laboratory analysis on Heavy Metals and on Nutritional Value (please refer to Appendices H and I) passed the FDA standard. Each respondent was provided with and explained the informed consent to participate in the survey. A standardized questionnaire was oriented to each respondent before the test. Using the said questionnaire, each respondent tasted sample 1, then sample 2 and answered the questionnaire for the acceptability test of Aeration-aided Pisang Awak (*Musa Paradisiaca*) Banana Vinegar. Table 3 shows the 9-point hedonic scale.

Table 3 9-point Hedonic Scale

Scale	Mean Score Rating	Category	Verbal Interpretation
9	8.51-9	Like Extremely	Extremely Acceptable
8	7.51-8.5 6.51-7.5 5.51-	Like Very Much	Very Much Acceptable
7	6.5 4.51-5.5 3.51-4.5	Like Moderately	Moderately Acceptable
6	2.51-3.5	Like Slightly	Slightly Acceptable
5	1.51-2.5	Neither Like nor Dislike	Neither Accepted or
4	1 – 1.5	Dislike Slightly	Unacceptable
3		Dislike Moderately	Slightly Unacceptable
2		Dislike Very Much	Moderately Unacceptable
1		Dislike Extremely	Very Much Unacceptable
			Extremely Unacceptable

Table 3 presents the 9-point hedonic scale used in the Survey Questionnaire.

Instrumentation

This study utilized a standardized questionnaire to gather feedback from the respondents. Validity and reliability were professionally established based on reference, 9-point hedonic scale of Peryam and Pilgrim

(1957). The scale ranging from likes to dislikes is centered around four positive and four negative categories, with a neutral middle on every side, with phrases that represent each category for ratings written on the labels represented by discrete data (numbers with values) (Lim, 2011). The aim was for individual respondent to utilize the simple analysis of acceptability of Aeration-aided Pisang Awak (*Musa Paradisiaca*) Banana Vinegar. This scale was used by the researcher in the survey questionnaire form.

Data to be Gathered

The data were gathered through a focus individual discussion to twenty (20) participants, experts in their categories such as chefs, bakers, cooks, and housewives. Purposive sampling was used for each category. The five selected samples were 5 (five) chefs, 5 (five) bakers, 5 (five) cooks, and 5 (five) housewives. The procedure on acceptability test and rating using the 9-point hedonic scale indicating the general level of preference or liking for the two samples was personally oriented to each respondent. Individually, the said respondents filled out the hard copy of the questionnaire, in separate events, on December 09 to 25, 2023. The answered questionnaires were collected, data were tallied, tabulated and interpreted.

Parameters for Analysis

The data gathered were tallied and tabulated for statistical analysis.

Objective 1 was done by analyzing the °Brix and Polarization for the sugar content of the Pisang Awak banana fruit three trials. The mean was used as a statistical tool to provide conclusion based on data collected. The result of the experiment done was presented in Chapter IV.

Objective 2 was obtained from the capacity of the external aerator or air pump. The amount of oxygen that speeds up fermentation was obtained from the full capacity of the aerator. The details were presented in Chapter IV. Objective 3 was measured using a sugar-alcohol dual function ATC wine refractometer. The % Alcohol and time were recorded per individual reading. The range was used as a statistical tool to provide conclusion based on data collected on % Alcohol content per unit time. The result of experiment on the rate of alcoholic fermentation was presented in Chapter IV.

Objective 4 was done by laboratory testing of Aeration-aided Pisang Awak (Musa Paradisiaca) Banana Vinegar analyzed at both 3rd party laboratory and HPCo Analytical Lab versus the FDA Standard. The physical-chemical tests such as nutritional facts, % acidity, % total solids, % ash, lead, copper, and arsenic, composing of two trials used the mean as statistical tool. The result of lab tests on the banana vinegar used to compare with FDA standard was presented in Chapter IV.

Objective 5 was done by means of a survey using the 9-point hedonic scale. Twenty gathered data of sample 1 and of sample 2 from the respondents were used for statistical treatment. Non-parametric test was used where the mean and p-value were calculated utilizing the Mann Whitney U test to evaluate the acceptability test if there is a significant difference between the two vinegar samples because the data sets were non-normal distribution (Hart 2011). The result of acceptability test of the vinegar was presented in Chapter IV.

Objective 6 was created using an online graphic design tool for brochures where all pertinent information of the vinegar product was provided. Statistical tool was not used.

Cost Analysis

The cost of the formulated Aeration-aided Pisang Awak (Musa Paradisiaca) Banana Vinegar, the ingredients and reagents, tools and equipment used, overhead expenses, and laboratory testing expenses were computed as shown on Table 4.

Table4 Cost Analysis of Aeration-aided Pisang Awak (Musa Paradisiaca) Banana Vinegar

Particulars	**Total Cost, PhP**
A. Ingredients and reagents cost	1682
B. Equipment for Aeration and Fermentation cost	7715
C. Packaging cost	528
GRAND TOTAL	**9925**

Table 4 presents the cost analysis of Aeration-aided Pisang Awak (*Musa Paradisiaca*) Banana Vinegar. From the value of the ingredients and reagents, to the cost of aeration and fermentation equipment, to packaging bottles, the grand total cost was PhP 9,925.00.

Ethical Consideration

This research study was guided by ethical considerations while conducting activities related to the community. Before the survey on acceptability was performed, the respondents were oriented on the research being undertaken by the researcher, voluntary participation in the survey, risk and benefits of participating in the survey, and confidentiality. The form was explained individually to the respondents. The respondents understood the risks of tasting the Aeration-aided Pisang Awak (*Musa Paradisiaca*) Banana Vinegar, by signing the Informed Consent to Participate in Research Survey.

Presentation, Analysis, And Interpretation of Data

This chapter includes the presentation of data, analysis of the result of evaluation, and interpretation of data gathered.

Determine the Sugar Content of Aeration-aided Pisang Awak (Musa Paradisiaca) Banana Fruit

The first objective of the study was to determine the sugar content of the banana fruit.

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The sugar content of Pisang Awak (Musa Paradisiaca) banana fruit was analyzed when the fruit was overripe. From the banana fruit pulp which watered on its own or by using a juice extractor, the juice extract collected was filtered using granular activated carbon through a 100-mesh cloth screen. Filtrate was directly read for sugar content of the banana fruit. Table 5 shows the three trials conducted for °Brix and % Polarization of banana fruit.

Table 5 Sugar Content as Determined from Brix and % Polarization of Banana Fruit Extract

Date	**°Brix**	**% Polarization**
Nov. 17, 2023	23.30	18.92
Nov. 29, 2023	24.20	20.05
Dec. 08, 2023	22.42	19.96
Mean	23.31	19.64

Table 5 presents the Sugar Content as Determined from Brix and % Polarization of Banana Fruit Extract on different dates of analysis with the calculated mean value for both parameters.

The sugar content values and physical quality of the banana fruit extract are reflected on Table 6 on the next page.

Table 6 Sugar Content Values of Pisang Awak Banana Fruit

Parameter	**Method**	**Instrument**	**Result**
°Brix % Polarization Appearance Odor Taste	Direct reading Direct reading Visual Visual Visual	Compact Refractometer at 589 nm wavelength, SCHMIDT + HAENSCH ATR BR) Saccharimeter NIR to measure sugar content in terms polarization at 587 nm wavelength, SCHMIDT + HAENSCH Saccharomat) Eyes Nose Tongue	23.31 19.64 Transparent clear liquid No off odor Sweet taste

Table 6 presents the sugar content of Pisang Awak banana fruit at °Brix of 23.31 and % Polarization of 19.64. Appearance, odor, and taste were also included to characterize the banana fruit extract.

Determine the Amount of Oxygen that Speeds up Fermentation

The second objective of the study was to establish the amount of oxygen that speeds up the fermentation.

The amount of oxygen used to speed up fermentation was 5.0 liters/hour at 1:10 sample-yeast ratio at high aerator setting. The 5.0 liters/hour oxygen setting which is the full capacity of the aerator, utilizing two hoses of 4.0 mm internal diameter at 1 meter length each hose, was determined because the oxygen input to the fermentation medium (wort) at 5.0 liters/hour resulted to fermentation time of 8 hours. This was the shortest time among

the three samples experimented - control sample with 12 fermentation hours, sample 1 with 10 fermentation hours. The corresponding findings are reflected on Table 7.

Table 7 Amount of Oxygen that Speeds up Fermentation at 1:10 sample-yeast ratio, at High vs. Low Aerator Setting

Setting	**Sample 1**	**Sample 2**	**Control**
No. of transparent length hose, 1 meter (4.0mm inside dimeter)	1	2	0
	2.5	5.0	0
Amount of oxygen introduced, liters/hour Speed setting on external aerator	High	High	None
	10	8	12
Fermentation hours Speed setting on external aerator	Low	Low	None
Fermentation hours	11	10	12

Table 7 indicates the amount of oxygen that speeds up fermentation time at 1:10 sample-yeast ratio, high vs. low aerator setting. Fastest fermentation time was recorded for sample 2 at 8 hours. The high amount of oxygen supplied to the wort had invigorated the yeast cells to reproduce more and convert the invert sugar into ethyl alcohol. This was the main factor that speed up the fermentation process of sample 2.

Determine the Rate of Alcoholic Fermentation using Different sample-yeast Ratio

The third objective of the study was to determine the rate of alcoholic

fermentation using different sample-yeast ratios. It means the alcohol content per unit time. Two trials were done on sample-yeast ratio of 1:5 and 1:10 to determine the rate of alcoholic fermentation. °Brix and % Alcohol measurements were done to check the attenuation or decrease until °Brix became stagnant. At the start of fermentation, pH was 5, then lowered to 4 during aerobic oxidation for all three samples. Table 8 reflects the corresponding data for 1:5 sample-yeast ratio.

Table 8 °Brix, % Alcohol, and Rate of Alcoholic Fermentation for Samples 1, 2, and Control at 1:5 sample-yeast Ratio

Date/ Hour	**Sample 1**			**Sample 2**			**Control**		
	°Brix	% Alc.	Rate	°Brix	% Alc.	Rate	°Brix	% Alc.	Rate
Jan. 24, 2024 /0	21.9	13.5		21.9	13.5		21.9	13.5	
Jan. 24, 2024 /2	19.4	12.4	0.55	19.0	12.0	0.75	20.5	12.4	0.55
Jan. 25, 2024 /4	17.1	9.8	**1.30**	16.5	8.9	**1.55**	17.8	10.2	1.10
Jan. 26, 2024 /36	12.5	6.4	0.11	12.0	5.0	0.12	13.0	7.0	0.10
Jan. 26, 2024 /48	7.0	5.0	0.12	5.8	2.8	0.18	7.6	6.4	0.05
Jan. 26, 2024 /50	5.8	3.0	1.00	5.8	2.8	0.00	7.3	3.7	**1.35**
Jan. 27, 2024 /71.5	5.8	3.0	0.00	5.8	2.8	0.00	7.0	3.2	0.02
Jan. 31, 2024 /167.50	5.8	3.0	0.00	5.8	2.8	0.00	7.0	3.2	0.00

Table 8 presents the °Brix, % Alcohol, and Rate of Alcoholic Fermentation for Samples 1, 2, and Control at 1:5 sample-yeast ratio. The rate of alcoholic fermentation was determined by the drop in % Alcohol produced per unit time or % alcohol content (relative to the drop in °Brix) per hour. To compare the % Alcohol content, range was used as a statistical tool. Sample 1 had its fastest rate of alcoholic fermentation recorded between hours 2 to 4 at 1.30% alcohol per hour {(12.4 9.8) /2}. Sample 2 had its fastest rat recorded between hours 2 to 4 at 1.55% alcohol per hour {(12.0 - 8.9) /2}.

Control had its fastest rate recorded between hours 48 to 50 at 1.35% alcohol per hour {(6.4 - 3.7) /2}.

Table 9 shows the corresponding data for 1:10 sample-yeast ratio.

Table 9 °Brix, % Alcohol, and Rate of Alcoholic Fermentation for Samples 1, 2, and Control at 1:10 sample-yeast Ratio

Date/ Hour	**Sample 1**			**Sample 2**			**Control**		
	°Brix	% Alc.	Rate	°Brix	% Alc.	Rate	°Brix	% Alc.	Rate
Nov. 27, 2023 / 0	17.2	9.5		17.2	9.5		17.2	9.5	
Nov. 27, 2023 / 2	12.6	6.6	**1.45**	11	6.2	**1.65**	13.5	7.1	**1.20**
Nov. 27, 2023 / 5	8.2	4.0	0.87	7.8	3.8	0.80	8.5	4.2	0.97
Nov. 27, 2023 / 7	7.0	3.7	0.15	4.8	3.0	0.40	6.0	4.0	0.10
Nov. 28, 2023 / 8	5.0	3.2	0.50	4.3	2.2	0.80	5.7	3.5	0.50
Nov. 28, 2023 / 10	4.3	2.2	0.40	4.3	2.2	0.00	5.3	2.7	0.40
Nov. 28, 2023 / 12	4.3	2.2	0.10	4.3	2.2	0.00	5.0	2.2	0.25
Dec. 05, 2023 / Day 8	4.3	2.2	0.00	4.3	2.2	0.00	5.0	2.2	0.00

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Table 9 presents the °Brix, % Alcohol, and Rate of Alcoholic Fermentation for Samples 1, 2, and Control at 1:10 sample-yeast ratio. Sample 1 had its fastest rate of alcoholic fermentation recorded between hours 0 to 2 at 1.45% alcohol per hour {(9.5 – 6.6) /2}. For sample 2, its fastest rate was also recorded between hours 0 to 2 at 1.65% alcohol per hour {(9.5 -6.2) /2}. Control had its fastest rate recorded between hours 0 to 2 at 1.20% alcohol per hour {(9.5-7.10) /2}.

The rate of alcoholic fermentation directly correlates to the amount of yeast present and to the amount of oxygen used in aeration. At exponential phase of yeast growth, the greater the oxygen supplied during yeast propagation at higher amount of yeast used, the faster the rate of conversion of sugar into ethyl alcohol (Sriputorn et al., 2020). For yeast to multiply and enable to survive during the fermentation of ethanol, oxygen is necessary. The aeration of 5.0 liters per hour oxygen with 1:10 sample-yeast ratio was successful in determining the rate of alcoholic fermentation and sample-yeast ratio to obtain the highest rate at 1.65% alcohol per hour out of the three samples.

Finally, the aeration was advantageous for the yeast growth and resulted in reduced fermentation period.

Compare the Quality of Aeration-aided Pisang Awak (Musa Paradisiaca) Banana Vinegar based on FDA Standards

The fourth objective of the study was to compare the quality of Aeration-aided Pisang Awak (*Musa Paradisiaca*) Banana Vinegar based on FDA standards.

The results from laboratory analyses were evaluated and compared with FDA-Philippines vinegar standard. Table 10 shows the Comparison of the Quality of Aeration-aided Pisang Awak (*Musa Paradisiaca*) Banana Vinegar based on FDA Standards at 1:10 sample-yeast Ratio.

Table 10 Comparison of the Quality of Aeration-aided Pisang Awak (*Musa Paradisiaca*) Banana Vinegar based on FDA Standards at 1:10 sample-yeast Ratio

A.O. 134 s. 1970 Parameter	**Pisang Awak (*Musa Paradisiaca*) Banana Vinegar**		
	Sample 1	**Sample 2**	**Control**
1. Identity Vinegar is a liquid produced by alcoholic and/or acetous fermentations of one or more of the following: malt, spirit, wine, cider, alcoholic liquors, fruits, grain, vegetables, honey, glucose, sugar (including unrefined crystals sugar and refinery syrups) or molasses.	Compliant	Compliant	Compliant
2. Optional Ingredients	There were 2 variants produced. First variant is pasteurized unfiltered banana vinegar. Second variant uses activated		
a. Caramel may be used as a coloring in any variety of the vinegar without declaration on the label b. Flavoring may be used in any variety of vinegar, provided its nature may be declared on the label.	carbon (granular) to improve color of the banana vinegar and is termed as pasteurized filtered banana vinegar.		
Acidity: 4% w/w as acetic acid (min.) except nipa sap 3% w/w/ (min.) *After 15 days* *After 18 days*	4.12 4.68	4.49 4.93	3.93 5.49

Total Solids: 1.5% w/v (min.) except nipa sap 2.2% w/v (min.) *(after 12 days)* *(after 15 days)* *(after 27 days)*	28.08% (unfiltered) 32.91% (unfiltered)	29.30% (unfiltered) 4.52% (filtered)NPPC 33.72% (unfiltered) 58.14% (unfiltered)NPPC	30.45 (unfiltered) 35.85% (unfiltered)
Ash: 0.18% (min.) except nipa sap 0.4% (min.) *(after 12 days)* *(after 15 days)* *(after 27 days)*	0.2481% (unfiltered) 0.3672% (unfiltered)	0.2445% (unfiltered) 0.12% (filtered)NPPC 0.3744% (unfiltered) 0.63% unfiltered) NPPC	0.2575% (unfiltered) 0.3601% (unfiltered)
Lead:18ppm (max.); Copper: 66ppm (max.); Arsenic: 1.5ppm max.	ND; 0.92; ND		
Others: Shall not contain synthetic acetic acid and cloudifying agent	Compliant	Compliant	Compliant

Table 10 presents the comparison of the quality of aeration-aided Pisang Awak (*Musa Paradisiaca*) Banana Vinegar based on FDA Standards at 1:10 sample-yeast Ratio.

Results were taken from third party laboratories' certificates of analysis on the physical-chemical tests on % Acidity, % Total Solids, and % Ash of sample 1, sample 2, and control.

At sample-yeast ratio of 1:10, sample 1 (at 2.5 liters/hour oxygen), sample 2 (at 5.0 liters/hour oxygen), and control (without aeration) were all compliant with the regulatory standard (Republic of the Philippines, 1970). Among the three samples, sample 2 reached the highest acidity of 4.49% after 15 days, but after 18 days, the control reached the highest acidity of 5.49% out of the three samples. The highest acidity of the control at 5.49%, analyzed after 18 days was probably the maximum acidity that can be attained by all three samples. It was just reached earlier by the control. The difference was not remarkable since the banana fruit's total sugar content which was converted to alcohol, then to acetic acid, were the same for all the three samples. Initially upon preparation of the wort, all the three samples had the same sugar content of the banana fruit. On % Ash, the filtered vinegar failed at 0.12% on its 15th day. The continued GAC filtration to obtain clear filtered vinegar affected its mineral and organic constituents and lowered the % Ash value. However, unfiltered variant of same vinegar sample passed at 0.3744% Ash. The % ash of this raw unfiltered vinegar was observed to increase with time, primarily due to the evaporative loss of water and acetic acid, which concentrates the non-volatile mineral salts. The relative percentage of ash in the remaining liquid rises, even though the absolute mass of minerals is unchanged, as an effect of concentration (Nielsen, (2017).

Based on the results, Aeration-aided Pisang Awak (*Musa Paradisiaca*) Banana Vinegar is compliant to the FDA standard in terms of identity of the vinegar, optional ingredients, % acidity, % total solids, % ash, lead, copper, arsenic, and content of synthetic acetic acid and cloudifying ingredients. It is significant that banana vinegar complies with the standard to ensure that health hazards risks are mitigated. FDA-Philippines have strict implementation on vinegar as food ingredient sold to markets because of fake ingredients. This information was from a press release on May 12, 2019, 'FDA Eyes Stricter Standards for Vinegar Brands.

Evaluate the Acceptability of Aeration-aided Pisang Awak (Musa Paradisiaca) Banana Vinegar based on the Hedonic Scale

The fifth objective of the study was to evaluate the acceptability of Aeration-aided Pisang Awak (*Musa Paradisiaca*) Banana Vinegar based on hedonic scale. A taste test approach was performed by the experts/respondents for sample 1 and sample 2.

Table 11 reflects the summary of the mean scores on the evaluation of acceptability of Aeration-aided Pisang Awak (Musa Paradisiaca) Banana Vinegar for sample 1.

Table 11 Summary of the Mean Scores for Sample 1

Respondent	Hedonic Mean Score	Standard Deviation	Verbal Interpretation
Chefs	8.6	0.5477	Extremely Acceptable
Bakers	7.6	1.3416	Very Much Acceptable
Cooks	7.6	0.8944	Very Much Acceptable
Housewives	8.0	1.225	Very Much Acceptable
As a whole	**7.95**	**1.0501**	**Very Much Acceptable**

Table 11 shows the summary of the mean scores for sample 1. As a whole, the hedonic mean score of 7.95 and standard deviation of 1.0501 were obtained from the twenty respondents who were experts in their field of food preparation. Sample 1 was interpreted as Very Much Acceptable. Chefs showed the highest mean score of 8.6, and the lowest standard deviation interpreted as Extremely Acceptable. Housewives had 8.0 mean score and 1.225 standard deviation interpreted as Very Much Acceptable. Bakers and Cooks indicated the same mean score at 7.6 but had different standard deviation at 1.3416 and 0.8944 respectively, interpreted as Very Much Acceptable. The lowest standard deviation from Chefs was an indication of the individual ratings close to each other, which possible means the five selected Chefs had Liked Very Much the sample 1.

Table 12 reflects the summary of the mean scores on the evaluation of acceptability of Aeration-aided Pisang Awak (Musa Paradisiaca) Banana Vinegar for sample 2.

Table 12 Summary of the Mean Scores for Sample 2

Respondent	Hedonic Mean Score	Standard Deviation	Verbal Interpretation
Chefs	7.8	1.095	Very Much Acceptable
Bakers	8.2	0.4472	Very Much Acceptable
Cooks	8.2	0.8367	Very Much Acceptable
Housewives	8.4	0.5477	Very Much Acceptable
As a whole	**8.15**	**0.7452**	**Very Much Acceptable**

Table 12 shows the summary of the mean scores for sample 2. As a whole, the hedonic mean score of 8.15 and standard deviation of 0.7452 were obtained from the twenty respondents who were experts in their field of food preparation. Sample 2 was interpreted as Very Much Acceptable. Housewives showed the highest mean score of 8.4 with a standard deviation of 0.5477, interpreted as Very Much Acceptable. Bakers and Cooks had the same mean score of 8.2. Bakers had the lowest standard deviation of 0.4472, while cooks had 0.8367. The results of both were interpreted as Very Much Acceptable. Chefs showed a 7.8 mean score, with the highest standard deviation of 1.095, still interpreted as Very Much Acceptable. The lowest standard deviation from Bakers was an indication of the individual ratings close to each other, which possible means the five selected Bakers had Liked Very Much the sample 2.

For purposes of comparison on the evaluation of experts, a significant difference was statistically computed for sample 1 and sample 2. The results were on Table 13.

Table 13 Mann -Whitney U Test on Significant Difference of the Two Trials (Non-parametric, non-normal distribution)

Parameter	Sample 1 (with 2.5 liter/hour oxygen)	Sample 2 (with 5.0 liter/hour oxygen)
Mean	7.95	8.15
Sample size	20	20
Standard Deviation	1.0501	0.7452
Median	8	8
Skewness	-0.497754	-0.256526

p value	0.331	0.616
U	215.5	184.5
Rank	394.5	425.5

Table 13 shows the Mann -Whitney U test on significant difference of the two trials (non-parametric, nonnormal distribution). The results indicated that there was no significant difference between sample 1 and sample 2 from the result of evaluation on acceptability when grouped according to oxygen concentration. For sample 1: U value = 215.5, $p = 0.331$. The critical value of U at $p < 0.05$ is 127. Therefore, the result is not significant at $p < 0.05$. For sample 2: U= 184.5, $p = 0.616$. The critical value of U at $p < 0.05$ is 127. Therefore, the result is not significant at $p < 0.05$. Table 13 indicated that both samples yield a Very Much Acceptable level of acceptability (M=7.95, SD=1.0501, and M=8.15, SD=0.7452 respectively for samples 1 and 2). This is different from the study of Boonsupa, et.al. (2019) wherein there is a significant difference in the consumer preference based on the 9-point hedonic scale of the vinegar drinks.

Formulation of product brochure

The sixth and last objective of the study was the formulation of product brochure of Aeration-aided Pisang Awak (*Musa Paradisiaca*) Banana Vinegar.

Figure 4 presents part of the product brochure.

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

This chapter presents the summary of findings, conclusions and recommendations of the study.

Summary of Findings

The findings of the study were:

1. The sugar content Pisang Awak Banana Fruit were 23.31°Brix and 19.64% Polarization.

2. The amount of oxygen used to speed up fermentation was 5.0 liters per hour.
3. The rate of alcoholic fermentation using different sample-yeast ratio were 1.55% alcohol per hour for 1: 5 sample-yeast ratio, and 1.65% alcohol per hour for 1:10 sample-yeast ratio.
4. The quality obtained by Aeration-aided Pisang Awak (*Musa Paradisiaca*) Banana Vinegar compared with FDA standards (A.O. 134 s. 1970) is compliant to the following:
5. Identity: passed; Optional Ingredients: No coloring, no flavoring added; Acidity: 4.93%; Total Solids: 33.72%; Ash: 0.3744%; Lead: ND; Copper: 0.92 ppm; Arsenic: ND; Others: No synthetic acetic acid, no cloudifying agent – compliant.
6. The acceptability of Aeration-aided Pisang Awak (*Musa Paradisiaca)* Banana Vinegar by the respondents was Like Very Much with verbal interpretation of Very Much Acceptable.
7. The brochure of Aeration-aided Pisang Awak (*Musa Paradisiaca*) Banana Vinegar was developed as output of study.

CONCLUSION

Based on the summary of the findings of the study, the following conclusions were drawn.

1. The Pisang Awak (*Musa Paradisiaca*) banana fruit has sufficient sugar content to convert into ethyl alcohol for vinegar production.
2. Regardless of the different initial levels of oxygen introduced in the wort, the amount of oxygen introduced helped reduce the fermentation time from 12 to 8 hours.
3. The rate of alcoholic fermentation using sample-yeast ratio of 1:10 is faster by 0.15 to 0.10 % Alcohol per hour than sample-yeast ratio of 1:5 in reference to the first 2 hours.
4. This product was within the standard minimum requirement of FDA AO 130 series of 1970.
5. The expert respondents were unanimous in their preference of Very Much Acceptable on the product.
6. The formulated brochure of Aeration-aided Pisang Awak (*Musa Paradisiaca*) Banana Vinegar is user-friendly and can be distributed throughout Negros Occidental.

RECOMMENDATIONS

Based on the conclusions, the foregoing recommendations were made.

1. The Pisang Awak banana pulp can be milled to open the cells and extract the juice for greater yield. 2. Further study may be conducted on yeast strains and aeration technology to improve on fermentation efficiency of Aeration-aided Pisang Awak (*Musa Paradisiaca*) Banana Vinegar so that it can be commercially produced in a large scale.
2. Upon ripening, the Pisang Awak banana fruit can be monitored on overripening to target the highest sucrose content it can produce which is a requirement in more vinegar yield.
3. Further research should be conducted to enhance product quality specifically consistency in color and increase in acidity at shorter period of time.
4. Broaden the category in selecting the respondents for consumer acceptability such as sex and age group to have another approach in acceptability test. For further research on the 9-point hedonic scale of banana vinegar using oxygen as the variable.
5. Provide a product demonstration to promote Aeration-aided Pisang Awak (*Musa Paradisiaca*) Banana Vinegar.

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APPENDIX

Appendix A - Philippine National Standards for Vinegar – A.O.134 series of 1970

Republic of the Philippines
Department of Health
OFFICE OF THE SECRETARY
Manila

ADMINISTRATIVE ORDER
NO. 134 s. 1970

SUBJECT: Regulation Prescribing the Standard of Identity and Quality of Vinegar (B-4.9 Condiments, Sauces, Seasonings)

B-4.9-05 Vinegar

1. Identity

a) Vinegar is the liquid produced by alcoholic and/or acetous fermentations of onw or more of the following: malt, spirit, wine, cider, alcoholic liquors, fruits, grain, vegetables, honey, glucose, sugar (including unrefined crystal sugar and refinery syrups) or mollasses.

1. Sugar vinegar is the product made by the alcoholic and subsequent acetous fermentations of sugar cane juice, sucrose, molasses or refiner's sugar.

2. Malt vinegar is the product made by the alcoholic and subsequent acetous fermentations of barley malt, or cereals whose starch has been converted to malt.

3. Coco vinegar is the product made from the alcoholic and subsequent acetous fermentations of the sap of coconut palm.

4. Pineapple vinegar is the product made by the alcoholic and subsequent acetous fermentations of pineapple jiuce.

5. Nipa-Sap vinegar (sucang puti, native vinegar) is the product made by alcoholic and subsequent acetous fermentations of the sap of nipa palm (Nipa fruticans Worm).

b) Distilled vinegar is the liquid produced by acetous fermentation of dilute distilled alcohol or by the distillation of vinegar.

2. Optional ingredients

a) Caramel may be used as a coloring in any variety of vinegar without declaration on the label.

b) Flavoring may be used in any variety of vinegar, provided its nature is declared on the label.

3. Standard of Quality

a) All vinegar shall have an acidity of not less than 4% by weight of absolute acetic acid except nipa-sap vinegar which shall have an acidity of not less than 3%.

b) All vinegar shall contain not less than 1.5% w/v of total solids and 0.18% of ash, except nipa-sap vinegar which shall contain not less than 2.2% of solids and not less than 0.4% of ash.

c) All vinegar shall contain foreign substances, drugs, sulfuric acid or other mineral acids.

d) All vinegar shallcontain not more than 18 parts per million of lead, 66 parts per million of copper and 1.5 parts per milion of arsenic.

e) Malt vinegar shall have at least 0.05% of phosphorous pentoxide (P_2O_5) and 0.04% of nitrogen.

f) Vinegar containing any artificial matter such as synthetic acetic acid, or cloudifying agent shall be deemed to be adulterared and its sale is thereby prohibited.

(SGD)

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