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PRODUCTION AND ACCEPTABILITY OF PINEAPPLE *(Ananas comosus)* AND BANANA *(Musa acuminata)* EXTRACT IN MAKING VINEGAR

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ABSTRACT

This study explores the production and acceptability of vinegar made from pineapple *(Ananas comosus)* and banana *(Musa acuminata)* extracts. Using overripe bananas and pineapples, three types of vinegar were prepared: banana vinegar, pineapple vinegar, and a combination called "Two Seasons Vinegar." The fermentation process involved combining fruit extracts with sugar and yeast, followed by a two-week fermentation period. The final products underwent sensory evaluation by 120 respondents, including residents, school staff, students, and food experts. Evaluations focused on sourness, aroma, color, appearance, and overall acceptability. Results indicated that Two Seasons Vinegar was the most preferred due to its superior taste and highest acetic acid content. This study concludes that pineapple and banana are promising raw materials for vinegar production. Recommendations include scaling up the production of Two Seasons Vinegar, expanding future research to include a larger respondent base, and investigating its nutritional benefits and market potential.

Keywords: *Banana, Fermentation, Pineapple, Sensory Evaluation, Vinegar*

INTRODUCTION

Vinegar, a versatile and ancient condiment, is produced through the fermentation of ethanol, resulting in its key ingredient, acetic acid (ethanoic acid). The concentration of acetic acid in vinegar typically ranges from 4% to 8% by volume for table vinegar and can reach up to 18% for pickling (Johnston & Gaas, 2006). Beyond acetic acid, natural

vinegars contain small amounts of other acids, such as tartaric and citric acids, which contribute to their complex flavor profiles (Budak et al., 2014). The term "vinegar" derives from the Old French "vin agre," meaning "sour wine," reflecting its historical use and production from fermented grape juice (Mazza & Murooka, 2009). Vinegar has been a staple in culinary traditions worldwide for thousands of years, prized for its acidity and flavor-enhancing properties (Tesfaye et al., 2002).

Vinegars are unique among condiments due to their acidic nature and can be broadly categorized into grain and fruit vinegars based on their raw material sources (Gullo et al., 2018). Both grain and fruit vinegars, when fermented using traditional methods, exhibit a range of physiological functions, including antibacterial, anti-infection, antioxidant, blood glucose control, lipid metabolism regulation, weight loss, and anticancer activities (Budak et al., 2014; Solieri & Giudici, 2009). These health benefits are primarily attributed to the acetic acid and various bioactive compounds present in vinegars (Tesfaye et al., 2002; Xia et al., 2018).

Vinegar is renowned for its healing properties, including treating yeast infections, lowering blood sugar levels, aiding digestion, and soothing insect bites (Johnston et al., 2004). It is also widely used as a natural cleaning agent due to its antibacterial properties (Johnston & Gaas, 2006). However, while vinegar can offer numerous health benefits when produced and used properly, it can also pose risks if consumed inappropriately (Budak et al., 2014). For instance, "artificial" or "commercial" vinegars, made through chemical processes, contain synthetic acetic acid, which can damage tooth enamel if consumed undiluted and may lead to other health issues such as potassium imbalance, allergic reactions, and gastrointestinal irritation (Shimoji et al., 2002; Solieri & Giudici, 2009).

The production of vinegar for mass consumption poses significant challenges, especially concerning the use of synthetic acetic acid. According to a study by the Philippine Nuclear Research Institute (PNRI), 15 out of 17 brands of vinegar sold in major supermarkets in the Philippines were found to contain synthetic acetic acid, a by-product of petroleum, which could potentially cause diseases, including cancer (Sucgang et al., 2019). Synthetic acetic acid is not suitable for food consumption due to the presence of impurities that may pose health risks, including degenerative diseases like Parkinson's (Sucgang et al., 2019). Instead, these synthetic compounds are intended for industrial uses, such as producing vinyl acetate for waterproofing wood products (GMA News Online, 2019).

Given the alarming side effects of synthetic vinegar, there is a pressing need to develop alternative, healthier vinegar options for safe consumption. This underscores the importance of producing vinegar from natural ingredients such as fruits and vegetables (Solieri & Giudici, 2009). Consequently, this study aims to explore the production of organic vinegar from fruit extracts, specifically from banana (Musa acuminata) and pineapple (Ananas comosus), which are widely available in the Philippines.

Organic vinegar, made through a biological process utilizing Acetobacter aceti bacteria, is a superior alternative to synthetic vinegar. It retains essential amino acids from its fruit sources and is reported to possess medicinal properties, aiding in digestion and alleviating gastric troubles (Johnston et al., 2004; Tesfaye et al., 2002). Organic vinegar offers numerous health benefits, including improved digestion, reduced inflammation, strengthened immune function, and enhanced nutrient absorption (Budak et al., 2014; Xia et al., 2018).

Bananas and pineapples are abundant in the Philippines, with significant production in regions like Davao del Sur, North Cotabato, South Cotabato, and Bukidnon (Philippine Statistics Authority, 2014). In Isabela and Quirino, bananas are extensively grown in municipalities such as San Pablo, Benito Soliven, San Mariano, San Guillermo, Jones, and San Agustin. Pineapples are cultivated in areas including Isabela, Nueva Vizcaya, and Quirino (Philippine Statistics Authority, 2014). Despite their availability, the potential of these fruits in vinegar production remains underexplored, largely due to consumer preference for cheaper alternatives and the lengthy fermentation process required for natural vinegars (Gullo et al., 2018).

This study seeks to address these challenges by investigating the feasibility of combining banana and pineapple extracts to produce vinegar. This approach not only promotes the use of locally sourced fruits but also presents an opportunity to create a value-added product that could serve as a promising business venture in the Philippines.

Research Questions

The study was conceptualized to determine the feasibility of utilizing banana *(Musa acuminata)* and pineapple *(Ananas comosus)* fruits as raw materials in the production of two seasons of vinegar and test its acceptability through sensorial evaluation.

To achieve the specific objectives set within the main purpose of this study, sought to find answers to the following key research questions:

1. What are the processes for preparing banana and pineapple extract in making vinegar?
2. What is the potential advantage of the produced vinegar in terms of nutritive value?
3. What is the degree of consumer's acceptability via sensorial evaluation of the produced vinegar in terms of:
   a. sourness or acidity;
   b. smell;
   c. color; and
   d. appearances?
4. Is there a significant difference in the acceptability of banana vinegar, pineapple vinegar, and the two seasons of vinegar (a combination of banana and pineapple)?

METHODOLOGY

Developmental Procedure

This study used banana (*lakatan*) and pineapple fruit extract, a Philippine variety. The production procedure began with selecting over-ripe banana and pineapple fruits which were extracted. After the extraction of the fruits, the preparation for vinegar making comes next. The process is shown in Figure 1.

Preparation of Banana and Pineapple Fruit for Extraction

The preparation of banana and pineapple fruit extraction starts with sorting/selecting, washing, storing the banana for two weeks, slicing the pineapple into chunks, extracting the pineapple with a blender, and sifting the extract with a clean cloth. After two weeks, the banana is squeezed with a cloth for extraction.

Preparation of Fruit Extracts in Making Vinegar

Measure ingredients- banana extract, pineapple extract, yeast, and sugar. For the individual vinegar, combine 5 cups of banana with ½ cup sugar and ½ tsp yeast so as with the pineapple extract. For the combination of banana and pineapple, (Two Seasons Vinegar) combine 2 ½ cup of banana extract, 2 ½ cup pineapple extract, ½ cup sugar, and 1 tsp. yeast. Stir with a wooden spoon. Cover and ferment for two weeks. After the fermentation period, strain it with a clean cloth. Bring into heat. Do not boil. Let it cool and transfer it to sterilized bottles. Pasteurized the bottles. Label them and store them.

Materials

Table1. Tools and Utensils Used in the Conduct of the Study

Preparatory tools	Cutting tools	Measuring tools	Storing tools	Sensory evaluation tools
Glass container	Sterilized knife	Weighing scale	Bottles	Plastic spoons
Chopping board	Blender	Measuring cups	Jars	
Cheesecloth		Measuring spoon		
Rubber band				

Ingredients

Table 2. The Proportion of Ingredients in the Preparation of Banana and Pineapple Vinegar

Banana Vinegar	Pineapple Vinegar	Banana/Pineapple or 2 Seasons Vinegar
5 cups banana extract	5 cups pineapple extract	2 ½ cups banana extract
½ tsp. yeast	½ tsp. yeast	2 ½ cups pineapple extract

½ cup sugar	½ cup sugar	½ tsp. yeast
		½ cup sugar

Legend: c- cup tsp- teaspoon

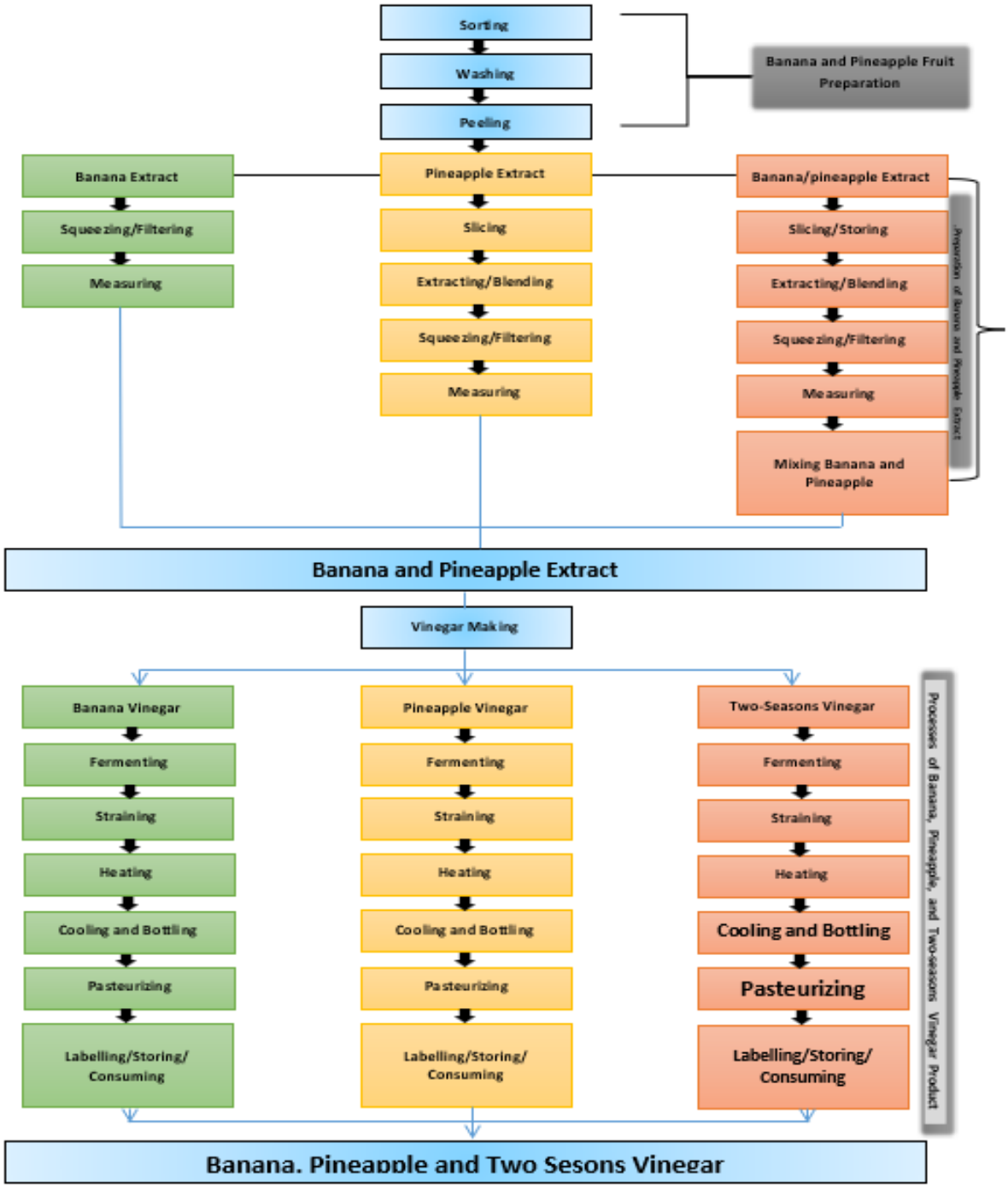

Figure 1. The Flow Diagram of the Study

Sensory Evaluation

The completed products were subjected to sensory evaluation. One hundred twenty (120) respondents were selected and classified into three groups: The households of Villanueva, San Manuel Isabela, faculty, staff, and students of Callang National High School, and a group of food experts. The respondents were appropriately oriented on what and how to evaluate the products using the given sensory evaluation sheet. The samples were arranged and evaluated.

The respondents were asked to taste and smell the sample from each container of the given vinegar samples. Data on the sourness/acidity, smell, color, appearance, and general acceptability of each sample were collected and tabulated for statistical analysis.

The tool for data collecting was a score sheet using a qualitative analysis method to determine the acceptability of the vinegar products. The responses to the level of the vinegar sample in terms of sourness/acidity, smell, color, and appearance were collected using the five-point Likert scale and given weight as shown in the table.

Table 3. The Range Numerical Rating and its Equivalent Descriptive Rating

Numerical Rating	Descriptive Rating
4.21 – 5.00	Like very much
3.41 – 4.20	Like moderately
2.61 – 3.40	Neither like or dislike
1.81 – 2.60	Dislike moderately
1.00 – 1.80	Dislike very much

RESULTS

Product Evaluation

Table 4. Total Acetic Acid of the Vinegar Samples

Sample Description	Result (g/100g)
Banana Vinegar	2.08
Pineapple Vinegar	0.67
Banana/Pineapple Vinegar	2.13

Table 4 shows the acid content (acetic) of the three vinegar samples. The results were obtained through the Titrimetric method which determined the amount of acetic acid present in the three (3) vinegar samples. Banana vinegar contained 2.08g of acetic acid in 100g of the given sample, pineapple vinegar contained 0.67g of acetic acid in 100g of the given sample, and the two-seasons vinegar (Banana and pineapple) contained 2.13g of acetic acid in 100g of the given sample. Based on the results of the acetic test on the

three samples, it can be said that the two-season vinegar is the most potential vinegar product as it contains the highest value of acetic acid.

Table 5. Nutritive value of Two-seasons vinegar (Banana and Pineapple) Sample

Analysis Name	Result
Ash	0.78 %
Crude Fat	<0.10 %
Crude Protein	0.71 %
Moisture	74.91 %
Sodium (Na)	13.71 mg/100g
Calories from Carbohydrates	94.40 kcal/100g
Calories from Fat	<0.90 kcal/100g
Calories from Protein	2.84 kcal/100 g
Total Calories	97.24 kcal/100g
Total Carbohydrates	23.60 %

As to the nutritive value of the two-season vinegar, Table 5 shows that *Ash content* was at 0.78%, *Crude fat* content was at less than 0.10% which is the minimum detection limit, *Crude protein* was at 0.71 %, moisture content was at 74.91 % and the sodium content was 13.71 mg of the given 100g of the sample.

For calorie content, calories from carbohydrates was 94.40 kcal/100g, calories from fat was less than 0.90 kcal/100g, and calories for protein was 2.84 kcal/100g. All in all, the total calories of the vinegar sample were 97.24 kcal/100g and the total carbohydrate content was 23.60 %.

Table 6. Nutritive Content of Produced Banana and Pineapple Vinegar Compared with Available Vinegar in the Market

Vinegar	Ash	Crude Fat	Crude Protein	Moisture	Sodium	Calories from Carbohydrates	Calories from Fat	Calories from Protein	Total Calories	Total Carbohydrates
Banana Pineapple Vinegar	0.78 %	<10 %	<0.71%	74.91 %	13.71 mg/ 100 mg	94.40 kcal/ 100 mg	<0.90 kcal/ 100 mg	2.84 kcal/ 100 mg	97.24 kcal/ 100 mg	23.60%
Vinegar A				2%	2 mg					
Vinegar B					380 mg					1%

The table shows the report of analysis of the Department of Science and Technology (DOST) on Banana and Pineapple vinegar regarding its nutritive value. The data revealed that the protein content of Banana and Pineapple vinegar has a high protein value of 0.71%from crude and 2.84 kcal compared to the vinegar A and B available in the market with 1g of protein.

Consumers' Acceptability of the Produced Vinegar

Table 7. Acceptability of Banana Vinegar (Sample A) based on Evaluation of the Household of Villanueva San Manuel, Isabela

Characteristics	Mean	Interpretation
Sourness/acidity	4.53	Like very much
Smell	4.33	Like very much
Color	4.55	Like very much
Appearance	4.63	Like very much
Grand Mean	*4.51*	*Like very much*

Table 7 reveals the means of Sample A – Banana Vinegar as to characteristics as perceived by the household of Villanueva, San Manuel, Isabela. First was appearance with a mean of 4.63 and interpreted as *"like very much"*, the second was color with a mean of 4.55, third was sourness/acidity with a mean of 4.53 and lastly, smell with a mean of 4.33 with all interpreted as *"like very much".* The grand mean of 4.51 was interpreted as *"like very much."* This implies that the households of barangay Villanueva San Manuel, Isabela enjoyed much the product.

Table 8. Acceptability of Pineapple Vinegar (Sample B) based on Evaluation of the Household of Villanueva San Manuel, Isabela

Characteristics	Mean	Interpretation
Sourness/acidity	3.68	Like moderately
Smell		Like moderately
3.78		
Color	4.40	Like very much
Appearance	4.48	Like very much
Grand Mean	*4.09*	*Like moderately*

The table shows the evaluation of the Pineapple Vinegar (Sample B) by the household of Villanueva, San Manuel, Isabela. The product's appearance and color obtained means a qualitative description of *"like very much"*. Meanwhile, sourness/acidity and smell had means interpreted as *"like moderately."* In sum, the means of all the four

characteristics yielded a description of *"like moderately"* which suggests households of barangay Villanueva, San Manuel, Isabela moderately enjoyed the product.

Table 9. Acceptability of Banana/Pineapple Vinegar -Two Seasons (Sample C) based on Evaluation of the Household of Villanueva San Manuel, Isabela

Characteristics	Mean	Interpretation
Sourness/acidity	4.70	Like very much
Smell	4.60	Like very much
Color	4.68	Like very much
Appearance	4.73	Like very much
Grand Mean	*4.68*	*Like very much*

In the above table, all four characteristics/criteria for Banana/Pineapple Vinegar (two seasons) had obtained means with a common description of *"like very much."* This connotes that the households of barangay Villanueva, San Manuel, Isabela greatly favored the product.

Table 10. Acceptability of Banana Vinegar (Sample A) based on Evaluation of CNHS Faculty & Students

	Mean	Interpretation
Sourness/acidity	4.08	Like moderately
Smell	4.40	Like very much
Color	3.83	Like moderately
Appearance	4.48	Like very much
Grand Mean	*4.20*	*Like moderately*

As shown in Table 10 the appearance and smell of Sample A – Banana Vinegar were *"liked very much"* by the CNHS Faculty and Students. On the other hand, the product's sourness/acidity and color were *"liked moderately"* by the evaluators. With the grand mean of 4.20 or "like moderately", the product was moderately acceptable.

Table 11. Acceptability of Pineapple Vinegar (Sample B) based on Evaluation of CNHS Faculty & Students

Characteristics	Mean	Interpretation
Sourness/acidity	3.88	Like moderately
Smell	4.08	Like moderately
Color	4.35	Like very much
Appearance	4.55	Like very much
Grand Mean	*4.22*	*Like very much*

Table 11 shows that the appearance and color of Pineapple Vinegar (Sample B) were *"liked very much"* by the CNHS Faculty and students whereas they *"liked moderately"* the two other criteria of sourness/acidity and smell. With a grand mean of 4.22 interpreted as *"like very much"*, it is implied that the product was very acceptable to the evaluators.

Table 12. Acceptability of Banana/Pineapple Vinegar –Two Seasons (Sample C) based on Evaluation of CNHS Faculty & Students

Characteristics	Mean	Interpretation
Sourness/acidity	4.60	Like very much
Smell	4.53	Like very much
Color	4.68	Like very much
Appearance	4.75	Like very much
Grand Mean	*4.64*	*Like very much*

The table above presents the acceptability of Banana/Pineapple Vinegar (Sample C) or two seasons as to the four criteria of sourness/acidity, smell, color, and appearance. Data would show that the product (two seasons) is most acceptable to the evaluators since it obtained a grand mean of 4.64 which is interpreted as *"like very much".*

Table 13. Acceptability of Banana Vinegar (Sample A) as Evaluated by Experts

Characteristics	Mean	Interpretation
Sourness/acidity	4.18	Like moderately
Smell	4.45	Like very much
Color	4.33	Like very much
Appearance	4.38	Like very much
Grand Mean	*4.34*	*Like very much*

The table above shows the evaluation of Banana Vinegar by experts. Of the four criteria for assessment, the smell, color, and appearance of the product appeared to be *"liked very much"* by the evaluators while they only *"liked moderately"* its sourness/acidity. It implies that the sourness/acidity of the product did not completely get the nod of tasters. On the whole, Banana Vinegar was very acceptable to experts.

Table 14. Acceptability of Pineapple Vinegar (Sample B) based on Evaluation Experts

Characteristics	Mean	Interpretation
Sourness/acidity	3.65	Like moderately
Smell	4.15	Like moderately
Color	4.35	Like very much
Appearance	4.28	Like very much

Grand Mean	4.11	Like moderately

In the above table, experts *"liked very much"* the color and appearance of the product while they *"liked moderately"* its smell and sourness/acidity. The grand mean of 4.11 which is interpreted as *"like moderately"* indicates that the product Pineapple Vinegar was moderately agreeable to the group of experts.

Table 15. Acceptability of Banana/Pineapple Vinegar Two Seasons (Sample C) as Evaluated by Experts

Characteristics	Mean	Interpretation
Sourness/acidity	4.80	Like very much
Smell	4.78	Like very much
Color	4.85	Like very much
Appearance	4.83	Like very much
Grand Mean	4.82	Like very much

As indicated by the above data, all four (4) criteria for Banana/Pineapple Vinegar (Sample C) obtained means with an interpretation of "like very much" which indicates that the two seasons of vinegar were very acceptable to experts.

Table 16. Summary of Evaluation of characteristics of the produced vinegars using Anova Test

Sources of Variation	Sum of Square	Degrees of Freedom	Mean of Square	F	f Tabular	Degrees
In-Between	1.50	2	3			
Group	0.08	6	0.48	6.25	5.14	Reject HO
Within-Group						
TOTAL	1.58	8				

The study hypothesized that there was no significant difference in the acceptability of banana vinegar, pineapple vinegar, and the two seasons of vinegar (a combination of banana and pineapple) in terms of sourness or acidity, smell, *color*, and appearance. Since the computed value of 6.25 is greater than the f tabular value of 5.14 at a 0.01 level of significance, the null hypothesis is rejected. This means that there is a significant difference in the acceptability of the three products particularly in between groups. This can be attributed to the fact that the three groups of evaluators had differing perceptions or evaluations of the products. The expert group, for instance, had a rating that was different from the two other groups.

Table 17. Level of General Acceptability of Banana, Pineapple, and Two Seasons Vinegar Across the Three Groups

Category	Banana Vinegar	Pineapple Vinegar	Two Seasons Vinegar
Households	4.51	4.09	4.68
CNHS Faculty & Students	4.20	4.22	4.64
Experts	4.34	4.11	4.82
Total	13.05	12.42	14.14
GRAND MEAN	4.35	4.14	4.71

Table 17 shows that the *two seasons* of *vinegar* had the highest acceptability rating among the three groups of respondents based on its grand mean of 4.71.

Conclusions

Based on the research findings, the study concludes that extracts from pineapple *(Ananas comosus)* and banana *(Musa acuminata)* can be made into vinegar products for household and commercial purposes following strict processes. Of the three samples tested, the two seasons (a mixture of banana and pineapple extracts) are the most favored. Moreover, the two seasons vinegar has the highest acetic content, making it the most acceptable product. With high nutritive value, it is also fit for consumption by households. As a whole, pineapple and banana are two readily available products that have high potential use for vinegar production.

Recommendations

In the light of conclusions made, the researcher forwards the following recommendations:

1. Two seasons (combination of banana and pineapple) vinegar is highly recommended.
2. Vinegar manufacturers may produce a combination of banana and pineapple vinegar as two seasons vinegar for commercial products.
3. For future studies involving two seasons of vinegar, researchers may use a larger number of respondents for validation and more variety of vinegar extract for comparison to determine the best vinegar extract.
4. There should be a separate and more comprehensive study on the nutritive value of the two season's vinegar. Future studies may delve into the comparison in nutritive value between the two season's vinegar and banana and pineapple vinegar separately.
5. Similar studies may be done to test its potential marketability and profitability to improve the findings of the study.

Compliance with Ethical Standards

This research followed ethical standards and adhered to principles of integrity, respect, and responsibility towards the participants. Before conducting the study, the researcher obtained informed consent from the participants. She ensured that they understood the purpose of the study, its procedures, and potential risks. Confidentiality and anonymity were well kept up throughout data collection, analysis, and dissemination, safeguarding participants' privacy. Additionally, the researcher made sure that there was no conflict of interest in conducting the study, avoided plagiarism issues, and no bias was made in the interpretation of the results of the study. Finally, she ensured that the findings were used only for the research.

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