

Characterization of the Chemical and Microbiological Composition of a Fermented Beverage from Pineapple Peel (*Ananas comosus* (L) Merr.)

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Abstract. The issue of agro-industrial waste, particularly from tropical fruits such as pineapple (*Ananas comosus* L.), has become an important topic in the context of food sustainability and environmental impact. Pineapple peels can be utilized for fermentation, reducing organic waste while producing an economically valuable and health-promoting beverage such as *tepache*. *Tepache* is a traditional fermented beverage originating from Mexico, made from pineapple peels (*Ananas comosus* L.), sugar, and spices such as cinnamon and cloves. During the fermentation process, both chemical and microbiological changes occur. Therefore, it is crucial to detect the chemical content of fermented products as an indicator of quality and stability. This study aims to identify the chemical and microbiological contents of *tepache*. The research methodology employed is experimental, as it aims to determine the chemical characteristics, including pH, total sugar, and total acidity, as well as the microbiological characteristics using the TPC (Total Plate Count) method. The study consists of two stages: product preparation and product analysis. The analysis results showed the chemical content of the product as follows: pH 3.1, total acidity 0.927%, total sugar 20 Brix, and total plate count of 7.3×10^7 .

Keywords: *Tepache*, fermentation, pineapple peel, chemical content, microbiology

1 Introduction

The issue of agro-industrial waste, particularly from tropical fruits such as pineapple (*Ananas comosus* L.), has become a significant concern in the context of food sustainability and environmental impact. Pineapple peel, which has long been considered waste, actually holds great potential as an alternative raw material for functional food products. This part of the fruit contains bioactive compounds such as bromelain, vitamin C, flavonoids, and sufficient carbohydrates and fiber to support the growth of microorganisms during the fermentation process [9]. Utilizing pineapple peel in fermentation products not only reduces organic waste but also produces beverages with economic and health value, such as *tepache*.

Tepache is a traditional fermented beverage originating from Mexico, made from pineapple peel (*Ananas comosus* L.), sugar, and spices such as cinnamon and cloves. This beverage has a sweet, sour, and slightly carbonated taste, which is produced through natural fermentation by microorganisms, such as lactic acid bacteria (*Lactobacillus*) and yeast (*Saccharomyces*

cerevisiae). *Tepache* is one of the popular non-alcoholic fermented beverages found in various regions, especially in Mexico and other Latin American countries [8] The fermentation of *tepache* utilizes the sugars in the pineapple peel that are dissolved during the cooking and soaking process, which are then converted into acids by microorganisms, creating a balance between sweet and sour flavors.

Fermentation is a biotechnological process that relies on the activity of microorganisms, such as lactic acid bacteria (LAB) and yeast, to transform substrates into compounds that contribute to the flavor, aroma, and health benefits of the final product. During this process, chemical changes such as pH reduction, increased total acidity, and decreased sugar content occur, indicating successful fermentation and microbial metabolic activity (Widyastuti et al, 2021). Therefore, it is important to detect the chemical content of the fermented product as an indicator of its quality and stability.

In addition to chemical parameters, the microbiological aspect is also a crucial component in evaluating the quality of fermented beverages. Microorganisms such as *Lactobacillus* sp. and *Saccharomyces* sp. play a vital role in the fermentation process. Microbiological detection is necessary to assess the viability of LAB as a functional indicator of the product. To date, scientific studies on pineapple peel fermentation remain limited, particularly those linking chemical changes and microbiological dynamics during fermentation. Therefore, this study is important to provide scientific data that can be used as a basis for developing safe, stable, and consumer-accepted fermented beverage products based on pineapple peel. This research aims to detect and analyze the chemical and microbiological content of fermented beverage products made from pineapple peel (*Ananas comosus* L.). The chemical parameters analyzed include pH, total acidity, and sugar content, while the microbiological parameters include total microbial count using the Total Plate Count (TPC) method.

2 Method

This study was conducted from November 2024 to January 2025 at the Nutritional Analysis Laboratory of the Nutrition Study Program, Universitas Negeri Medan, and the Laboratory of the Industrial Standardization and Services Center in Medan. This research employs an experimental approach, as it aims to determine the chemical characteristics, including pH, total sugar, and total acidity, as well as the microbiological characteristics. The product formulation can be seen in Table 1. The study consists of two stages: product preparation and product analysis.

Table 1. Formulation of Product

No	Ingredients	units	Formulation
1	Pineapple peel	gr	500
2	Palm sugar	gr	500
3	Fermentation time	jam	36
4	Water	mL	1,5
5	Cinnamon stick	cm	10

2.1 Product Preparation Procedure

1. Boil water until it reaches a rolling boil, then add the brown sugar according to the treatment. Wait until the brown sugar is completely dissolved.

2. Allow the boiled water to cool until it reaches room temperature.
3. Pour the sugar water into a clear 2-liter jar.
4. Add the cleaned pineapple peel along with the cinnamon sticks into the sugar water, then cover the jar with a cloth.
5. Ferment according to the specific treatment.
6. After fermentation is complete, strain the beverage and discard the peel and spices.
7. Analysis on each selected sample.

2.2 Acidity/pH Test [6]

The measurement of pH is fundamentally based on the electrochemical potential that occurs between the solution inside the glass electrode, whose solution is known, and the solution outside the glass electrode, whose solution is unknown. The pH value of probiotic food and beverage products can be measured using a pH meter.

2.3 Sugar Content (SNI 2891-1992)

The sugar content of the sample is measured using a refractometer. A drop of the liquid is placed on the refractometer, utilizing the principle of the refractive index. The higher the sugar content in the liquid, the higher the refractive index, and thus, the refractometer will indicate a higher scale. The unit used is % Brix.

2.4 Total Acidity (Amanda et al., 2013)

A 10 mL sample is added with 2-3 drops of phenolphthalein indicator, then titrated with 0.1 N NaOH solution until it turns pink and remains stable, corresponding to the standard solution. The volume of the titration result is then inserted into the formula for calculation.

2.5 Microbiological Analysis with Total Plate Count (TPC) (ISO 4833-1:2015)

To analyze microorganisms, a Total Plate Count (TPC) method is used for microbial analysis. The result is measured in CFU/mL, with a ratio scale. The procedure for the Total Plate Count (TPC) analysis is as follows:

1. Take 1 mL of the sample from each dilution and place it in a sterile petri dish.
2. Pour 15-20 mL of liquid PCA medium into the petri dish.
3. Gently swirl the petri dish in a horizontal or figure-eight motion to ensure that the sample is evenly mixed with the medium.

3 Result and Discussions

3.1 Production of Fermented Pineapple Peel Beverage

The process of making *tepache* begins with washing and cutting the pineapple peel, followed by soaking it in a mixture of brown sugar water and spices such as cinnamon. This mixture is left at room temperature for 36 hours to allow fermentation by natural microorganisms, such as lactic acid bacteria (*Lactobacillus* spp.) and yeast (*Saccharomyces* spp.). During fermentation, the sugars are converted into lactic acid and a small amount of alcohol, providing a sweet-sour

taste with a slight carbonation in the *tepache*. The product preparation process can be seen in Figure 1.

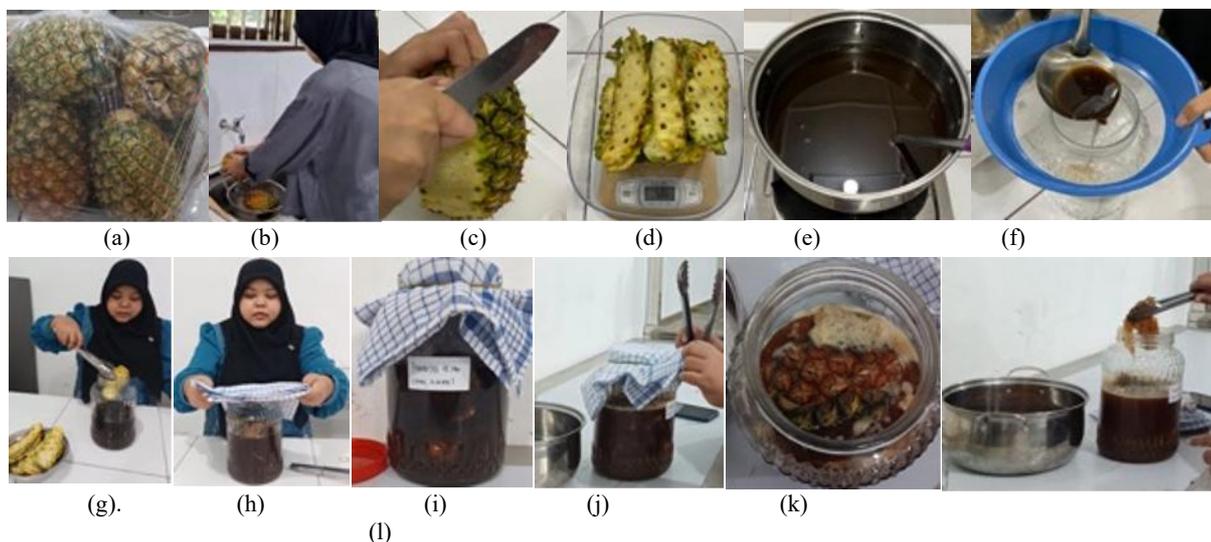


Figure 1. (a) Fresh pineapple fruit; (b) Washing the whole pineapple; (c) Separation of the pineapple peel; (d) Dissolution of brown sugar in water; (e) Filtration and simultaneous filling of brown sugar water into the fermentation container; (f) Adding the pineapple peel to the brown sugar solution; (g) Closing the fermentation container with a clean cloth; (h) Fermentation process for 36 hours; (i) After fermentation; (j) Fermented product; (k) Separation of pineapple peel and spices from the product.

The fermentation process of pineapple peel beverage (*tepache*) is currently ongoing, with natural microorganisms from the environment, such as lactic acid bacteria and yeast, beginning to proliferate and convert sugars into acids and a small amount of alcohol. This process results in a decrease in pH, a reduction in sugar content, and the formation of natural carbonation that imparts a refreshing sensation to the final product [3] Pineapple peel is also utilized for fermentation due to its remaining nutrient content, which supports the growth of microorganisms, including its sugar content, moisture level, acidity, and bromelain content. Bromelain found in pineapple aids in protein breakdown and can enhance the effectiveness of fermentation [4]

3.2 Chemical and Microbiological Analysis Results (TPC)

The results of the pH, total acidity, total sugar, and microbiological analyses on *tepache* indicate that the fermentation process is progressing well, with key microorganisms such as lactic acid bacteria and yeast playing a role in the reduction of pH and sugar consumption. The total acidity and reduction in sugar are closely related to the fermentation temperature, with higher temperatures accelerating these chemical changes. Microbiological monitoring is also crucial to ensure that the fermented product is free from pathogenic microbial contamination and safe for

consumption. The results of the pH, total sugar, total acidity, and total plate count analyses of the samples are presented in Table 2.

Table 2. Results of chemical and microbiological analysis of *tepache* beverages

Parameters	Result	Analysis Method
pH	3,1	pH Meter
Total acidity (%)	0,927	Amanda et al, 2013
Sugar content (Brix)	20	SNI 2891-1992
Total plate count (colony/mL)	$7,3 \times 10^7$	[5]

The pH testing method using a pH meter is an accurate way to measure the acidity level. The pH test results for *tepache* showed a value of 3.1, indicating a relatively low level of acidity. This decrease in pH is a result of the fermentation process, where microorganisms such as lactic acid bacteria and yeast consume sugars and produce acids, primarily lactic acid and acetic acid. The fermentation process generally causes a decrease in pH over time, which imparts a sour taste to the fermented beverage. A pH value of 3.1 indicates that this fermented product falls within the safe pH range for consumption and is consistent with other fermented beverages, which typically have a pH between 3.0 and 4.5 [7]. The significant decrease in pH also indicates that the fermentation process is progressing well, and the microorganisms involved are functioning optimally. The increase in acidity can also improve the shelf life of the product by inhibiting the growth of pathogenic microbes.

The total acidity test results showed a value of 0.927%, which represents the total acid produced during fermentation. This total acidity may include lactic acid, acetic acid, and other acids produced by microorganisms during their metabolism. The decrease in pH recorded in the previous test is consistent with this total acidity result, indicating that more acid is being produced by the lactic acid bacteria during fermentation. The measured acid content is important because it can affect the taste, shelf life, and microbiological stability of the product. The higher the acidity, the more sour the taste, which is a key characteristic of fermented products. This result aligns with previous research [1], which revealed that the total acidity level in fermented beverages can vary depending on the fermentation duration and the types of microorganisms involved.

The total sugar test was conducted using a refractometer. The total sugar test results showed a value of 20 Brix, indicating that the sugar content in this fermented beverage is 20%. The sugar is primarily derived from palm sugar, with a small amount from the pineapple peel used as the raw material. During fermentation, the sugar is consumed by microorganisms, which convert it into acids and gases. The high sugar content on the first day of fermentation is normal, as fermentation gradually reduces the sugar content over time. In general, fermented beverages have a lower sugar content after several days of fermentation, depending on the temperature and duration of the process. This result also indicates that the fermentation of *tepache* at the time of testing had not yet reached its final stage, as there was still a significant amount of sugar present. The Total Plate Count (TPC) test result showed a value of 7.3×10^7 colonies/mL, which represents the total number of microorganisms present in the *tepache* sample. Referring to the SNI 7552:2009 standard for fermented dairy beverages, which requires a minimum of 10^6 – 10^8

CFU/mL of lactic acid bacteria [2] the tepache product with its formulation meets the criteria for a probiotic beverage. The high number of microorganisms, especially lactic acid bacteria and yeast, indicates that the fermentation process is actively taking place. This total plate count is in accordance with the standard outlined in ISO 483, which is the standard method for counting microbial colonies in liquids. The presence of lactic acid bacteria and yeast is crucial for providing the characteristic sour taste of tepache and ensuring that the product has probiotic characteristics beneficial for digestive health.

4 Conclusions

Based on the results of the pH, total acidity, total sugar, and microbiological tests, it can be concluded that the fermentation process of *tepache* is progressing well, as evidenced by the significant decrease in pH, increase in total acidity, and reduction in sugar content. The high microbial count indicates that active fermentation is taking place, with the dominance of lactic acid bacteria and yeast, which play a role in imparting the sour taste and carbonation to the product. These results suggest that the tested *tepache* has the potential to be further developed as a healthy and safe fermented beverage, taking into consideration factors such as temperature and fermentation duration.

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