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The Effect of Steaming Time on the Chemical and Organoleptic Characteristics of Kepok Banana Tape (*Musa paradisiaca* Linn)

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Abstract: Steaming is a very important factor in the processing of food ingredients, especially kepok bananas before being fermented into tape. This study was to determine the effect of steaming time on the quality of kepok banana tape seen from the chemical characteristics including pH value determined using a pH meter, sugar content with the phenol sulfate method, alcohol content with the acid-base titration method, and organoleptic testing by 15 panelists. The bananas used were half-ripe kepok bananas from Dolo District, Sigi Regency, with variations in steaming time of 25, 30 and 35 minutes. The results showed that kepok banana tape with a steaming time of 25 minutes had a pH of 4.88; sugar content 12.62%; alcohol content 1.47%; color preference 3.4; aroma 2.8; texture 3.6 and taste 2.8. Tape with a steaming time of 30 minutes had a pH of 4.85; sugar content 16.37%; alcohol content 1.52%; color preference 3.5; aroma 2.6; texture 3.2; and taste 3.1. And tape with a steaming time of 35 minutes has a pH of 4.85; sugar content 10.57%; alcohol content 1.61%; color preference 3.4; aroma 3; texture 3.4; and taste 3.4. Based on the results of chemical and organoleptic characteristic tests, the best quality of banana kepok tape is tape with a steaming time of 35 minutes. This study provides educational relevance by illustrating the application of chemistry concepts such as acid-base reactions, fermentation, and analytical techniques in real-world food processing, making it a potential contextual learning material in science education.

Keywords: Chemical characteristics; Kepok banana; Organoleptic; Steaming; Time

Introduction

Kepok banana is one of the bananas that is delicious to eat after being processed first. Kepok banana has a slightly flat fruit and thick skin. When ripe, the skin of the fruit will turn yellow, the flesh is reddish yellow and the texture is rather hard. The color of the fruit matches the name of the type of banana, namely white and yellow. It tastes sweet, but the aroma is not fragrant (Fauziah et al., 2020).

The highest banana plant production in Central Sulawesi Province is in Sigi Regency with a range of 8,089.00 tons with a land area of 48.33 Ha, while the lowest production is in North Morowali Regency at 457.70 tons with a land area of 6.07 Ha. The amount of banana plant production in Sigi Regency is higher because the land for banana plants in Sigi Regency is wider (Mahuku, 2022). One type of banana plant that is quite abundant is the kepok banana. Just like bananas in general, kepok bananas also have several nutritional contents in them (Azizah et al., 2024; Lubis et al., 2023; Luthfiyah et al., 2024; Wulandari et al., 2023).

The nutritional content in 100 grams of kepok bananas has an average water content of 65.94%, ash 0.72%, fat 0.1%, protein 1.76% and carbohydrates of 31.48%. Kepok bananas have the advantage of high starch and fiber content. The starch content in kepok bananas is 22-25% and contains fructooligosaccharide

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compounds of around 0.3% which are a source of prebiotics (Utami, 2017). With a dominant sweet taste and rich content in the flesh of kepok bananas, it is the reason why many people are interested and like to consume the flesh of the fruit both directly and indirectly (Handayani et al., 2017).

Kepok bananas produced by farmers in Sigi Regency are not only consumed directly, but also processed into foods such as fried bananas, banana chips and banana sale. However, it is undeniable that the lack of public knowledge in processing and consuming kepok bananas in other processed forms causes many bananas to go unconsumed. Seeing that kepok bananas have a fairly high starch content, one alternative for processing starchy materials is to process them into tape. According to Fauziah et al. (2020), tape is a food produced through a fermentation process, and is also a processed form that is widely favored by various groups of people ranging from children, teenagers, to adults. The level of public interest in consuming tape is also determined by the quality of the tape when consumed.

The quality of tape is generally determined by taste. Tape has a sweet, slightly sour and alcoholic flavor. In addition to taste, the quality of tape can also be determined from the chemical characteristics of tape. The chemical characteristics of tape that can be measured are the amount of sugar, the amount of alcohol and pH (degree of acidity) (Utami, 2017). Research Adijaya (1998) explains that steaming bananas will affect the color of the resulting tape and the fermentation process. The longer the banana is steamed, the less likely it is to brown because bananas contain phenolic compounds and phenolase enzymes that can cause enzymatic browning reactions. Likewise, the softer the texture of the steamed banana, the easier it will be broken down by the microorganisms involved in the fermentation process.

Based on the statement, it is necessary to conduct research on the effect of steaming time on the quality of kepok banana tape. The quality of kepok banana tape produced from variations in steaming time is tested through its chemical characteristics (pH, amount of sugar, amount of alcohol) and validated with organoleptic tests (color, aroma, texture and taste) to see the level of people's preference in consuming kepok banana tape.

Method

This research was conducted in the Chemistry Laboratory, Faculty of Teacher Training and Education, Tadulako University, Palu. The equipment used were: digital scales, analytical scales, mortar and pestle, pH meter, beaker, measuring cup, measuring flask, titration tool, measuring pipette, filler, watch glass, stirring rod, spatula, funnel, test tube and tube rack, spray bottle, erlenmeyer and UV-Vis spectrophotometer. The materials used were: half-ripe kepok banana, tape yeast, distilled water, glucose solids, 5% phenol, 55% H_2SO_4, 0.5 N HCl, 0.1 N NaOH, phenolphthalein indicator, filter paper and aluminum foil.

Sample Preparation

Sample preparation was carried out by washing the kepok bananas thoroughly, then steaming them with varying steaming times (25, 30 and 35 minutes) and cooling them to near room temperature. After cooling, peel the skin and weigh 150 grams then sprinkle 1.5% yeast evenly over the entire surface of the banana and wrap it tightly using banana leaves. After that, ferment for 60 hours at room temperature between 25-30°C.

Determination of pH (Degree of Acidity)

Determination of pH refers to that carried out by (Sugawara et al., 2014), namely: Smoothing the tape with a steaming time of 25 minutes as much as 10 grams. Turning on the pH meter until stable (letting it stand for ± 15-30 minutes). Placing the electrode into the sample until a stable reading is obtained. Repeating three times (triple). Doing the same thing on the tape with a steaming time of 30 and 35 minutes. Calculating the pH of the sample with the following average (mean) equation:

$$Average = \frac{x_1 + x_2 + x_3}{n} \quad (1)$$

Determination of Sugar Content

Determination of sugar content using the phenol sulfate method (Qalsum et al., 2017), namely: First prepare the sample by adding 10 mL of distilled water to 1 gram of tape with a steaming time of 25 minutes then smooth it. Put it in a 250 mL beaker and add 5 mL of 0.5 M HCl. Add 100 mL of distilled water and homogenize it. After that, filter the mixture into a 250 mL measuring flask and dilute it by adding distilled water to the limit mark. The dilution results obtained are used as samples to measure sugar content. Repeat the treatment for tape with a steaming time of 30 and 35 minutes.

Measurement of sugar levels refers to what has been done by Qalsum et al. (2017), namely: Making standard glucose solutions with concentrations of 30, 60, 90, 120 and 150 ppm. Take 1 mL of each solution and put it in a test tube then add 1 mL of 5% phenol solution and shake it. Add 5 mL of 55% H_2SO_4 solution and shake again, then let stand for 5 minutes. Measure the absorbance at a wavelength of 490 nm. Make a standard curve. Carry out the same treatment on the three samples by replacing the standard solution using a solution from diluting kepok banana tape with a steaming time of 25, 30 and 35 minutes. Sugar content is

expressed in% of total sugar using the following equation:

$$\%\ sugar\ content = \frac{FP \times Concentration\ (x) \times 100\% \times V}{Sample\ Weight\ (mg)} \quad (2)$$

Determination of Alcohol Content

Determination of alcohol content using the acid-base titration method (Berlian et al., 2016), namely: Adding 50 mL of distilled water to 10 grams of tape with a steaming time of 25 minutes and smoothing it, filtering the mixture into an Erlenmeyer flask. Adding 3 drops of phenolphthalein indicator to the filtrate and homogenizing it. Next, titrate the filtrate with 0.1 N NaOH solution until it changes color to pink. Record the volume of NaOH used. Repeat the treatment three times (triple). Perform the same treatment on tape with a steaming time of 30 and 35 minutes. Calculate the alcohol content using the following equation:

$$Alcohol\ Content\ (\%) = \frac{a \times M \times Mr\, C_2H_5OH \times Dilution}{Sample\ Weight \times 100} \quad (3)$$

The NaOH used has gone through a standardization process with oxalic acid first, the procedure is to titrate the NaOH solution (which has been dripped with phenolphthalein indicator) using oxalic acid solution until the pink color disappears. Then record the volume of titrant used and calculate the NaOH concentration.

Organoleptic Test

Organoleptic tests were carried out by referring to what was done by Aryana (2014), namely: Organoleptic testing of kepok banana tape with variations in steaming time was carried out by 15 panelists from various ages, education and occupations. Sensory tests carried out include color, aroma, texture and taste. The test uses a hedonic scale test consisting of 5 scales (1-5) with 5 statements (very dislike - very like). The panelist's organoleptic results are calculated using the following average equation (mean):

$$Average = \frac{x_1 + x_2 + x_3 + \cdots + x_{15}}{n} \quad (4)$$

Result and Discussion

Chemical Characteristics of Kepok Banana Tape

pH

Based on the test results, the average pH value of Kepok banana tape is at 4.88 and decreases with increasing steaming time, as can be seen in Figure 1. This decrease in pH is related to the performance of microorganisms during the fermentation process. Bekti (2006) explained that during steaming, bananas undergo a starch gelatinization process which causes the fruit texture to become soft and the availability of sugar increases. This facilitates microorganisms to work more easily in breaking down sugar into various organic acids during the fermentation process. Desroiser in Utami (2017) explained that bacteria will produce volatile acids, including lactic acid, acetic acid, formic acid, butyric acid and propionic acid. Thus, the longer the steaming time, the softer the texture of the banana and the greater the availability of sugar. The softer the texture of the banana, the easier it will be for bacteria to break down sugar into acid. The more acid that is formed, the higher the acidity level in the tape, causing the pH value to decrease.

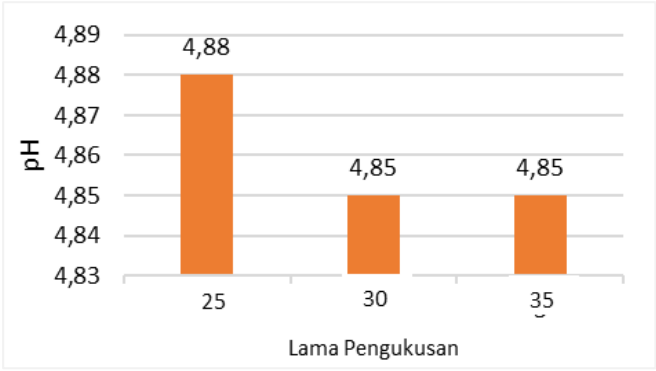

Figure 1. Effect of steaming time on the pH of Kepok banana tape

Based on Figure 1, the average pH value shows no significant difference. According to Aditya et al. (2012), variations in steaming time do not have a significant effect on the pH value of tape because the steaming process mainly functions to mature the ingredients and does not directly affect the activity of microorganisms that play a role in fermentation.

Sugar Content

Based on the results of the test, the average sugar content has a range of 10.75-16.37% shown in Figure 3, the highest sugar content consecutively occurs in tape with steaming for 30 minutes, 25 minutes, then 35 minutes. Based on the theory Musita (2009) high heating temperatures can damage starch granules, causing the release of amylose and amylopectin chains from starch granules or called starch hydrolysis. So that the longer the steaming, the more the amount of simpler sugar increases. Simply put, the process of hydrolyzing starch into simple sugars using an acid catalyst can be see in figure 2.

Fauziyah (2019) explained that the zymase enzyme produced by the yeast Saccharomyces cerevisiae as a microorganism found in yeast will convert simple sugars into alcohol and carbon dioxide. So it can be seen that the longer the steaming will produce tape with less sugar content, because the sugar contained in bananas is

converted by yeast into alcohol and carbon dioxide so that its content is reduced.

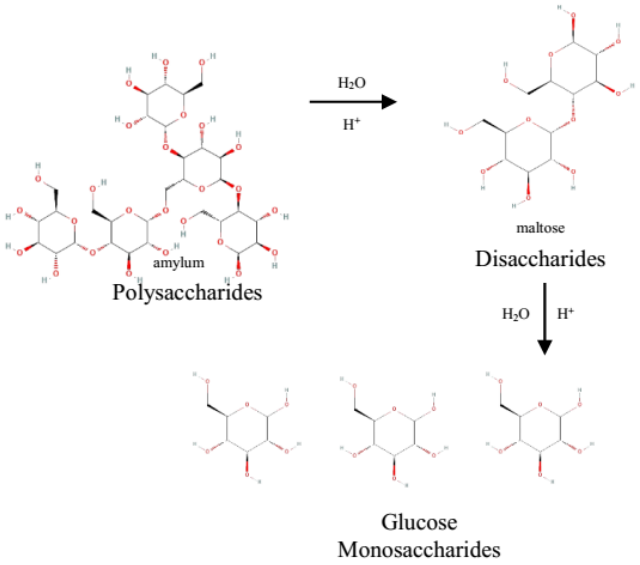

Figure 2. Hydrolysis reaction of starch with acid

Based on Figure 3, it can be seen that the sugar content obtained is not in order according to the theory above. This is because: first, the amylase and amyloglucosidase enzymes from mold in yeast that convert starch into sugar can work optimally in substrate conditions that are steamed for 30 minutes (Aditya et al., 2012). Second, this study used acid hydrolysis (HCl) which caused the starch to be hydrolyzed imperfectly and produced irregular sugar levels. Third, in the treatment of starch hydrolysis using HCl, it was not stirred using a magnetic stirrer but a stirring rod which again caused the hydrolysis process to occur imperfectly.

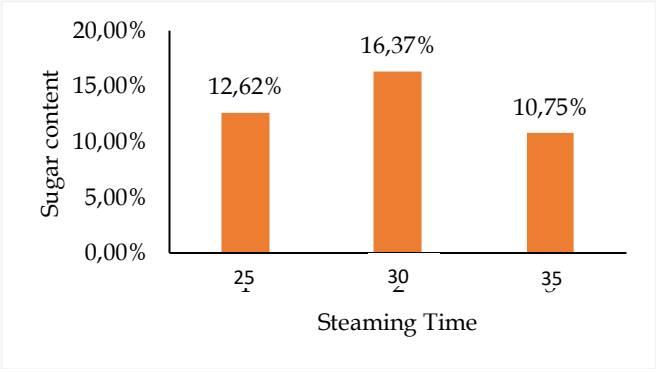

Figure 3. Effect of steaming time on sugar content of Kepok banana tape

Alcohol Content

Based on the test results, there was an increase in alcohol content along with the increase in steaming time, as can be seen in Figure 4. In general, the quality of tape produced from a good fermentation process is seen from the fragrant, delicious, legit and non-pungent aroma due to the high alcohol content, so determining the alcohol content is important to know (Gusnita et al., 2022).

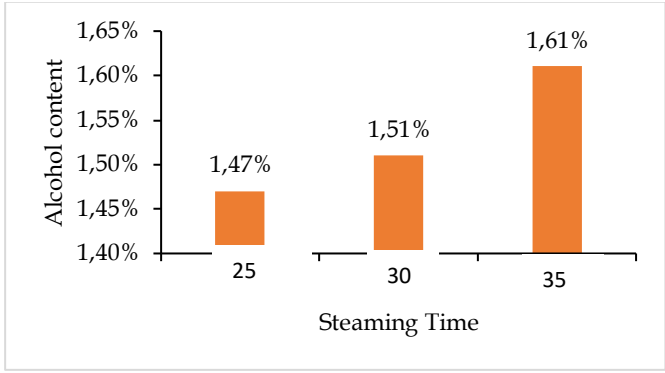

Figure 4. Effect of steaming time on the alcohol content of Kepok banana tape

This increase in alcohol content occurs because the duration of steaming can affect the texture and starch content in bananas. During steaming, there is a partial hydrolysis process of starch with three stages, namely the gelatinization stage which produces a softer texture of kepok bananas, then the liquefaction and saccharification stages will produce more simple sugar content (Musita, 2009). The sugar produced will be utilized by the zymase enzyme from the yeast Saccharomyces cerevisiae to be converted into alcohol (ethanol) and carbon dioxide (Fauziyah, 2019). Saccharomyces cerevisiae produced both zymase and invertase enzymes to break down the glucose into fructose and glucose into bioethanol (Laili et al., 2022). In this case, it can be seen that the longer the steaming, the softer the texture and increase the simple sugar content in bananas. A soft texture will make it easier for microorganisms to break down simple sugars into alcohol. The more simple sugars, the more alcohol is produced. In simple terms, the process of hydrolysis of glucose into ethanol can be explained by the Gay Lussac equation, namely:

$$\underset{\text{(Glucose)}}{C_6H_{12}O_6} \rightarrow 2\underset{\text{(Ethanol)}}{C_2H_5OH} + 2\underset{\text{(Carbon Dioxide)}}{CO_2}$$

Based on te regulation of the Food and Drug Supervisory Agency (BPOM) Number 5 of 2021 concerning the Safety and Quality Standards of Alcoholic Beverages, the maximum limit for methanol content in alcoholic beverages is no more than 0.01% b/v. Meanwhile, the results of the agreement of the Indonesian Ulema Council (MUI, 2018), food and beverages that contain alcohol must not exceed 1%, so that food and beverages with an alcohol content of more than 1% are included in the category of haram for consumption. However, it should be noted that these

regulations focus more on alcoholic beverages. For foods that naturally contain alcohol due to the fermentation process such as bread or certain fruits, BPOM does not specifically set an alcohol content limit. However, MUI through fatwa Number 10 of 2018 provides tolerance for ethanol levels in final food products without certain limits, as long as they are not medically harmful to consumers/drunk.

Organoleptic of Kepok Banana Tape

Organoleptic test was conducted to determine the level of consumer acceptance of tape made from kepok banana with different steaming times. The results of the organoleptic test are shown in Table 1.

Table 1. Organoleptic Test Results of Kepok Banana Tape

Steaming time (minutes)	Score			
	Color	Aroma	Texture	Flavor
25	3.4	2.8	3.6	2.8
30	3.5	2.6	3.2	3.1
35	3.4	3	3.4	3.4

Panelists' preferences for color, aroma, texture, and taste parameters ranged from 3.4 to 3.5; 2.6 to 3; 3.2 to 3.6; 2.8 to 3.4 (2 = dislike, 3 = rather like).

The highest color parameter test results were produced on tape with 30-minute steaming, which only differed by 0.1 from the other two tapes. The color produced by tape with 30-minute steaming was yellowish white. The panelists' preference for this color was due to its color which was neither pale nor too yellow. This means that panelists generally prefer tape with a yellowish or fresh yellow color. Steaming can affect the color of the resulting tape (Hustiany et al., 2023) explained that browning in bananas can be minimized starting from steaming for 25 minutes because at this time it can inactivate the polyphenoloxidase and peroxidase enzymes which cause enzymatic browning in banana flesh.

The highest aroma parameter test results were produced in tape with 35 minutes of steaming which had an alcoholic aroma. In general, the aroma produced from Kepok banana tape does have an alcoholic aroma as a characteristic of the aroma of tape in general. This is because the types of microorganisms found in the tape yeast Mucorchlamidosporus and Endomycopsis fibuliger break down the starch in bananas into dextrin and simple sugar compounds. By Saccharomyses cerevisiae, glucose and fructose are hydrolyzed into alcohol, this alcohol will be oxidized into organic acids and form esters which are components that form the typical aroma of tape (Salsabila et al., 2021).

Table 1 shows the results of the highest texture parameter test produced in tape with 25 minutes of steaming with a soft texture and not mushy/soft. During the steaming process, starch hydrolysis occurs. Starch hydrolysis begins from the gelatinization stage which causes granular starch to absorb water, swell, and finally give a soft texture to the banana. Heat can also break down protein and fiber bonds in banana tissue, making the banana softer. In the fermentation process, biochemical and physical changes occur that change the appearance of food ingredients, shape and flavor. The difference in the length of steaming of kepok bananas has a significant effect on the texture of the fermented product. The softer the texture of the banana, the tape will be produced with a softer and more watery texture due to the anaerobic fermentation process which produces water (Sugawara et al., 2014).

Based on Table 1 the highest level of panelist preference for taste was produced in tape with 35 minutes of steaming, namely a sweet and sour taste and the lowest in tape with 25 minutes of steaming with a slightly sour sweet taste that has not shown the typical taste of tape. In general, tape has a typical sweet taste that tends to be sour. This is because the alcohol produced from the decomposition of glucose by yeast will be broken down into acetic acid under rganol conditions. Esterification between acetic acid and alcohol (ethanol) forms ethyl acetate. This ethyl acetate is one of the components that forms the taste of tape (Sugawara et al., 2014).

Conclusion

Steaming time affects the pH value, sugar content, alcohol content and organoleptic of kepok banana tape. The best criteria for kepok banana tape were produced at 35 minutes steaming time with a pH value of 4.85; sugar content of 10.75% and alcohol content of 1.61%. The organoleptic value of kepok banana tape with 35 minutes steaming time for color, aroma, texture and taste were 3.4; 3, 3.4 and 3.4 respectively. Based on the results of the chemical and organoleptic characteristic tests, kepok banana tape with 35 minutes steaming time was suitable for consumption, and potential as a contextual learning medium in science education.

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Author Contributions

All authors contributed equally to the writing of this.

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Conflicts of Interest
All authors declare that they have no conflict of interest.

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