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The Influence of Cinnamon Powder from *Cinnamomum burmannii* bark on quality and storage period of liquid sugar palm (*Arenga longipes* Mogeia)

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Abstract. Liquid palm sugar is produced from *Arenga longipes*. Liquid palm sugar is easily oxidized than contaminated by fungi and bacteria. This study aims to measure the effectiveness of powdered cinnamon in inhibiting bacterial growth and its potential as a preservative for liquid palm sugar. Making liquid area sugar is done by boiling 5 liters of tapping sap for 4 hours at 100 °C until liquid palm sugar thickens. During the boiling of the sap, cinnamon powder was added with various concentrations, namely 0%, 2%, 4%, 6%, 8%, and 10% (w/w). The results showed that the addition of cinnamon powder had no significant effect on water content, pH value and ash content. However, the addition of cinnamon powder had a very significant effect on the parameters of the water insoluble solid, and the antibacterial activity of *Escherichia coli* and *Staphylococcus aureus*. The most effective and economical results on the parameters of the anti-bacterial activity test were the addition of 2% cinnamon powder. Based on the results of this study it can be concluded that the addition of cinnamon powder can inhibit the growth of bacterial and has a longer storage period than without cinnamon powder treatment.

1. Introduction

Palm sugar is considered a natural sweetener based on the natural food classification [1]. Sugar can be produced from plants that produce glucose and sucrose. Sugar is an additive in food manufacturing. Sugar is also not a staple food for humans. Some sugar-producing plants include sugar cane, corn, and aren palm. Palm sap sugar is a sweetener which is made from the sap or nectar collected from different varieties/species of palm trees [2]. Aren palm sugar has a lower glycemic index and fewer calories compared to cane sugar, while also being more nutritious, making it an ideal choice for those seeking a healthier sweetener [3]. Aren palm is one of the nira-



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producing plants that can be used as a raw material for sugar. Aren palm sap is a plant that has the potential to replace sugar cane as the main raw material for making sugar. Aren palm is also commonly known as a plant that has many benefits, such as producing black fiber (palm fiber), sugar, starch and lightweight construction wood [4].

Arenga longipes is a palm plant that is cultivated by some people on the island of Sumatra, Indonesia [5]. It's one of the arenas that produces a variety of raw materials for industrial needs, especially food. There are three products that can be harvested from aren palm plants, namely nira, fruit, and starch contained in the stems. Nira is very popular as a raw material for traditional fermented tuak drinks and also as a raw material for making palm sugar [6]. As a raw material for making palm sugar, nira can produce palm sugar in several forms, such as solid palm sugar (large and small), powdered palm sugar, and liquid palm sugar [7]. Solid and powdered palm sugar have a long shelf life, while liquid palm sugar has a low level of durability. Liquid palm sugar still contains a high water content, so it is still very easily contaminated by fungi and bacteria, which causes the taste of the sugar to become sour and not suitable for consumption. Whereas liquid palm sugar in application for consumption is very beneficial because it does not need stirring in mixing with food ingredients. Palm sugar not only adds sweetness but it also impacts the colour, texture and flavour of the food product [8], it's has rich nutritional profile consisting of amino acids, antioxidants, dietary fibres and vitamins [9].

Cinnamon is a spice commodity that has been traded in regional and international markets. The West Sumatra and Jambi regions have made cinnamon a superior commodity. This is evidenced by the increase in income from cinnamon processors by 26.93% of the results of their farming business, or 16.03% of the total income of farmers [7]. The content of essential oil compounds contained in cinnamon includes sinamaldehyde, eugenol, methyl ketene, furtural, benzaldehyde, nonyl aldehyde, hydrocinnamaldehyde, cuminaldehyde, and coumarin [10]. The content of essential oils contained in cinnamon is very effective as an inhibitor of the process of bacterial growth, including *S. aureus* and *E. coli*. The cause is the active sinamaldehyde compound contained therein and sinamic acid [11]. The content that functions as an antibacterial in *C. burmannii* is essential oil around 0.5-2 % (such as eugenol, safrole, cinnamaldehyde, and linalool), polysaccharides around 10 % (such as diterpenes and coumarins), phenol components 4-10 % (such as tannins), and flavonoids [12].

Previous studies have focused on the characteristics of palm sugar, such as physicochemical properties, antioxidant activities, and volatile compounds [3], chemical characteristics [13], color changes during processing [14], phenolic analysis [15] and macro elements (sucrose, glucose and fructose) and micro elements (metal minerals) [16]. The addition of sweet bark powder to liquid palm sugar products will be a solution to extend the expiration period by inhibiting the growth of fungi and bacteria in liquid palm sugar. This study aims to increase the durability and expiration period of liquid palm sugar and evaluate the effect of the addition of sweet bark powder on the quality of liquid palm sugar.

2. Materials and methods

2.1 Materials

The tools used in this palm sugar processing include measuring cups, sample bottles, stoves, palm nira containers, and woks. In testing are a pH meter and scales, an Erlenmeyer, beaker glass, scales, hot plate, stirrer, pipette, burette, pH meter, Brix hand refractometer, thermometer, analytical balance, bottle, and autoclave. The materials used were nira water and cinnamon powder (*C. burmannii*) produced by CV. Gaharu Wana Insani, Medan Johor, Medan.

2.2. Methods

Nira tapping was carried out in the community palm plantation of Sei Limbat Village, Selesai District, Langkat Regency. After the tapping process, 1000 mL of nira water was cooked at ± 100 °C for 90 minutes. The mixing process of cinnamon powder was carried out at a cooking time of 70 minutes. The concentration of cinnamon powder as a different treatment is 0%, 2%, 4%, 6%, 8%, and 10% while still cooked until it releases foam and reaches the desired consistency.



Figure 1. Process of making liquid palm sugar.

2.2.1. Determination of moisture content. Moisture content is defined as the weight loss on heating to 105 °C. The procedure for determining moisture content is to weigh 2 g (W).

$$\text{Moisture Content} = \frac{W}{W_1} \times 100\% \quad (1)$$

Where W is the weight of the sample before drying (g) and W1 is the weight of the sample after drying (g).

2.2.2. Application of ash content. Ash content is defined as the process by which organic substances are broken down into water and CO₂, but organic matter is not. The procedure for determining ash content is by weighing a sample of liquid palm sugar weighing 2-3g (W) into a porcelain cup that has been weighed.

$$\text{Ash Content} = \frac{W_1 - W_2}{W} \times 100\% \quad (2)$$

Where w is the weight of the sample before ashing, w1 is the weight of the sample and cup after ashing, and w2 is the weight of the empty cup.

2.2.3. Determination of water insoluble materials. Water insoluble solids are defined as gross substances such as sand, pieces of leaves, insects, and others.

$$\text{Water Insoluble Materials} = \frac{W_1 - W_2}{W} \times 100\% \quad (3)$$

Where w is the weight of the sample, w1 is the weight of the weighing sample and filter paper containing the water insoluble part, and w2 the weight of the weighing bottle and empty filter paper.

2.2.4. Determination of sucrose content. The determination of sucrose content is hydrolyzed into reducing sugar. The amount of reducing sugar is determined in the same way as in the determination of reducing sugar content.

$$\% \text{ sugar after inversion} = \frac{v_2 \times fp}{w} \times 100\% \quad (4)$$

Where v_2 is the glucose produced from the list, fp is the dilution factor and w is the sample weight, with criteria:

% total sugar: $0.95\% \times \% \text{ sugar after inversion (as sucrose)}$

% total sugar: $0.95\% \times \text{sugar (after and before inversion)}$

2.2.5. Determination of reducing sugar content. Reducing sugars such as glucose, fructose, maltose, and laccose will reduce the luff solution determined by titrating the luff solution with Cu_2O . The amount of sugar solution that reduces luff solution is determined by titrating it with sodium thiosulfate solution.

$$\% \text{ sugar before inversion} = \frac{w_1 \times fp}{w} \times 100\% \quad (5)$$

Where:

w_1 : glucose

fp : dilution factor

w : sample weight.

2.2.6. Antibacterial activity test. First, prepare a Petri dish with each bottom divided into six parts. Then each cup is given 25 mL of agar media. Then inoculate 0.5 mL of bacteria in the media and stir until evenly distributed. After that, wait until the media solidifies. Then, on the media that has solidified and been inoculated with bacteria, six wells are made with a size of 5 mm and a depth of 4 mm with a sterile borer. Put in the media that has been punched as much as 5 μL of various concentrations of extracts. Put in an incubator at 37°C for 24 hours. Observe and measure the inhibition zone.

Table 1. Table of bacterial inhibition categories according to Davis and Stout [17].

Bacterial inhibition	Category
> 20 mm	very strong
10-20 mm	strong
5-10 mm	medium
< 5 mm	weak

2.2.7. Statistical analysis. The experimental design used in this study was a non-factorial, completely randomized design (CRD). Data analysis was carried out using R Studio software version 4.2.1 with the Analysis of Variance (ANOVA) statistical test, which aims to see treatment differences. If significant or significantly different results were obtained, it was continued with Duncan's Multiple Range Test (DMRT).

3. Result and discussion

3.1. Characteristics of nira water content and nira ph of tapping results

The highest water content value is found in sample P2, and the lowest in sample P1. The high water content is due to the influence of the season. Taking nira in the rainy season causes high

water content and low sugar content. The highest water content value was found in samples P1, P2 and the lowest in sample P3. This proves that the pH of the nira is in the normal range (6.5-7.5). Too low a pH will cause the nira to become acidic due to fermentation, thus affecting the process of making sugar and affecting shelf life. The problem found in sugar products on the market is their low pH content. The low pH in the nira content is also caused by the presence of microorganisms that live in the palm sap itself [18]. On the other hand, rains positively affect yield and greater yield is seen in monsoon season [19].

Table 2. Calculation of water content and pH levels.

Sample	Testing	
	Water content	pH
P1	58.52	7
P2	67.29	7
P3	67.07	6.6

3.2. Moisture content, ash content, and water insoluble solids of liquid palm sugar

Table. 3 shows the measurement results of moisture content obtained, respectively, in the control sample: 13.14; 2%: 19.02; 4%: 18.36; 6%: 17.23; 8%: 15.58; 10%: 15.18. The highest water content was obtained in the sample with the 2% treatment, and the lowest was obtained in the control treatment, which was 13.14932%. The moisture content meets the standards according to SNI 01-2978-1992 regarding the quality requirements of glucose syrup, which are for a moisture content of 20%. Cooking is done using the principle of evaporation, where water is evaporated from fresh nira water samples until it thickens and increases total solids so as to reduce water activity and change color. The cooking process is in line with changes in water content, the longer the cooking, the lower the water content [20]. Table 3 shows that the average water content of nira before becoming sugar is 64%, and after inversion through the cooking process, it is an average of 16%. Table. 3 obtains data on the amount of ash content of liquid palm sugar with a mixture of cinnamon powder, respectively, as follows: control: 0.45; 2%: 2.37; 4%: 2.27; 6%: 2.94; 8%: 3.55; 10%: 4.28. The lowest data is 0.45% and the highest is 5.28%. Therefore, only the control sample, which was 0.45%, met the ash content standard (<1%).

Table 3. Calculation of moisture content, ash content, and water insoluble solids of liquid palm sugar.

Treatment	Testing		
	Water content (%)	Ash content (%)	Water insoluble solids (%)
T1 (control)	13.14	0.45	0.79 c
T2 (2%)	19.02	2.37	3.83 b
T3 (4%)	18.36	2.2	2.27 b
T4 (6%)	17.23	2.9	2.94 b
T5 (8%)	15.58	3.5	3.55 b
T6 (10%)	15.18	4.28	4.28 a

Notes: The same letter behind the number indicates the treatment is not significantly different.

The high ash content is caused by the high mineral content of cinnamon. During the cooking process, the remaining cinnamon did not dissolve in the sugar, so it still left a considerable amount of powder texture. When the process is carried out in the furnace at a temperature of 505 °C, the remaining insoluble minerals become ash. This is also in line with the results obtained in Table 3

about water insoluble solids, which have a fairly high value [21]. The average data obtained ranged from 0.7% to 4.2%, which in this case only met the standard (<1%) in the control treatment, which amounted to 0.79%, and treatments 2, 4, 6, 8, and 10% did not meet the standard. This was due to the high yield of the remaining cooking sugar derived from cinnamon.

3.3. Characteristics of reducing sugar and sucrose content in liquid aren sugar

The levels of reducing sugar and sucrose sugar in palm sugar affect qualitative and quantitative aspects, including aroma and taste [22]. Reducing sugar was in the range of 3.04%-3.55%. These results are in accordance with the standards set by SNI, namely that the content of reducing sugar in palm sugar is a maximum of 6%. The lowest value was obtained by the control treatment and the highest by the 10% treatment. The addition of cinnamon can make the liquid sugar more durable and can affect the sugar crystallization process. This is due to the fact that higher content of reducing sugar in a sugar material will inhibit the process of sugar crystallization [23]. Table. 4 shows that the sucrose sugar content of sugar with various treatments varies between 37.3-67.4%, with the lowest content in the 10% treatment with a value of 37.3% and the highest in the control treatment with a value of 67.4%. Sugar content and aroma profile create distinct, unique characteristics, when added to food, its positive health effects make it a ready alternative to cane sugar [25]. The results obtained are inversely proportional, where the greater the concentration of cinnamon powder, the smaller the results obtained. This is thought to be when mixing cinnamon powder into the sap during the cooking process. Cinnamon is hygroscopic, or absorbs water so that it affects the water content. Changes in cinnamon moisture content will affect the dimensions and properties of sugar, such as texture, color and aroma [24].

Table 4. Calculation of reducing sugar and sucrose sugar content.

Treatment	Reduced Sugar (%)	Sucrose Sugar (%)
T1 (control)	3.04	67.4
T2 (2%)	3.27	54.2
T3 (4%)	3.31	53.9
T4 (6%)	3.37	46.5
T5 (8%)	3.51	43.9
T6 (10%)	3.55	37.3

3.4. Bacterial inhibition of liquid aren sugar with cinnamon powder added

The lowest concentration that has inhibition is at a concentration of 2% with an average of 15.2 mm, and the highest at a concentration of 17.2 mm. From the test results, it can be categorized as strong, according to the clear zone standard by Davis-Stout presented in Table 5. The 2% concentration with an average clear zone of 15.2 mm is classified in the strong category (10-20 mm), 4% concentration with an average clear zone of 15.4 mm is classified in the strong category (10-20 mm), 6% concentration with an average clear zone of 16.3 mm is classified in the strong category, the 8% concentration with an average clear zone of 16.9 mm is classified in the category (10-20 mm), and the 10% concentration with an average of 17.2 mm is classified in the strong category (10-20 mm). Table 5 shows the results of the anti-bacterial activity test of liquid palm sugar with a mixture of cinnamon powder (*C. burmanni*) by measuring the diameter of the clear zone formed. The increase in the diameter of the bacterial inhibition zone is directly proportional to the increase in the concentration of cinnamon powder tested. The content of essential oil in cinnamon functions as an antibacterial against *E. coli* and *S. aureus*. The inhibition of bacteria against *E. coli* and *S. aureus* is classified as strong this is due to several factors. Cinnamon has

hygroscopic properties and will turn into a gel when heated with water, so the active compounds in it affect growth inhibition of bacterial growth.

Table 5. Diameter of clear zone of inhibition of *Staphylococcus aureus* and *Escherichia coli* bacteria.

Bacteria	Treatment	Average
<i>Staphylococcus aureus</i>	T1	0 b
	T2	15.3 a
	T3	16.1 a
	T4	16.7 a
	T5	17.1 a
	T6	17.5 a
<i>Escherichia Coli</i>	T1	0 b
	T2	15.2 a
	T3	15.4 a
	T4	16.3 a
	T5	16.9 a
	T6	17.2 a

Notes: The same letter behind the number indicates the treatment is not significantly different.

Based on the analysis of variance (ANOVA) statistical test for the diameter of the inhibition zone of *Staphylococcus aureus* bacteria, the results were significantly different between the T1 control and all treatments (T2, T3, T4, T5, and T6). The same results were also obtained in the inhibition test for *E. coli* bacteria, with significantly different results between the T1 control and all treatments (T2, T3, T4, T5, and T6). 2% concentration with an average clear zone diameter of 15.3 mm is classified in the strong category (10-20 mm), 4% concentration with an average clear zone of 16.1 mm is classified in the strong category (10-20 mm), 6% concentration with an average clear zone of 16.7 mm is classified in the strong category, 8% concentration with an average clear zone of 17.1 mm is classified in the strong category (10-20 mm), and 10% concentration with an average of 17.5 mm is classified in the strong category (10-20 mm).

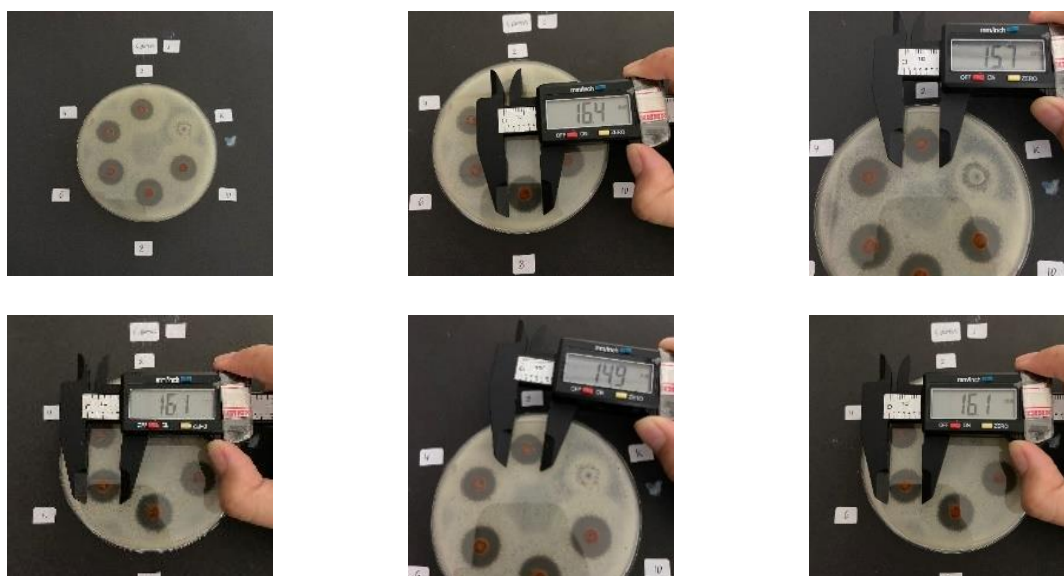


Figure 2. *S. aureus* antibacterial activity assay.

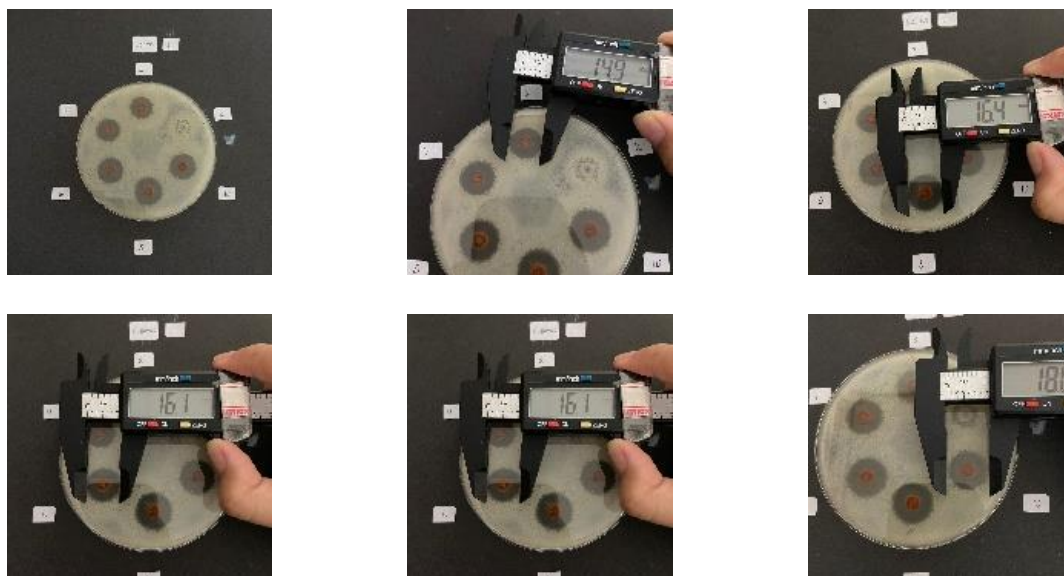


Figure 3. *E. coli* antibacterial activity assay.

4. Conclusion

The results showed that the addition of cinnamon powder did not have a significant effect on water content, pH value, and ash content. However, the addition of cinnamon powder has a significant effect on the parameters of the water insoluble solids test, and the antibacterial activity against *E. coli* and *S. aureus*. Liquid palm sugar craftsmen should give cinnamon powder with the treatment level T2 (2%) because it is more effective and economical in processing liquid palm sugar and inhibits antibacterial activity.

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