

The Impact of Acidity (pH) and Temperature on the Crystallization Process of Coconut Palm Sugar

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ABSTRACT. This experiment concerns the optimization of coconut sugar production by using innovative processing methods. The raw material, coconut sap, is systematically collected by tapping coconut flowers to ensure consistency. Focusing on the process of coconut sap into coconut sugar in a convenient powdered form emphasizes a systematic approach. The research utilizes a controlled heating method with a crystallizer, introducing variations in pH and temperature. This research was to determine the best temperature and pH to produce coconut palm sugar products that comply with several SNI 3743: 2021 standards. To solve the problems associated with traditional palm sugar production emphasizes the need for innovative and efficient approaches. The results show the quality of palm sugar: sucrose content of 86.93%, moisture content of 1.03%, ash content of 1.65% and Pb content according to Indonesian Nasional Standard of palm sugar SNI 3743:2021. This systematic and innovative approach aligns coconut sugar with the quality standards specified in SNI 3743:2021, offering a high-quality and marketable form.

1. INTRODUCTION

Coconut sap is one of the many products resulting from coconut plants that have not been optimally utilized, coconut sap is a clear liquid contained in coconut flowers obtained by tapping [1]. Palm sugar is one of the products derived from coconut sap. With the development of new technology and innovation, coconut sugar can be in more practical powder form, has a distinctive aroma and is more durable. The advantages of palm sugar are that it dissolves more easily in water because the water content in the sugar is small, has a distinctive flavour and is more durable.

SNI 3743:2021 states that the characteristics of palm sugar include 80% - 93% sucrose content, 3.0% moisture content, 2.5% ash content and negative Pb. Demand for palm sugar continues to increase, but the productivity rate of palm sugar production is still insufficient to meet the desired rate [2]. The production process of palm sugar is still done manually using human power, so it takes quite a long time. This can result in considerable production costs and limited output.

In previous research, "The Effectiveness of Making Palm Sugar Using Conventional and Modern Methods" the production process of making palm sugar takes quite a long time, which is approximately 5 hours, with the process of cooking sap, crystallization, sieving and drying carried out using conventional methods or human labour [3].

In this experiment, producing palm sugar from coconut sap using the conventional method with a crystallizer machine only takes 3 hours to produce. This research also obtained the optimum cooking temperature and pH for product results that are in accordance with SNI 3743: 2021.

Kapur sirih has alkaline properties that can maintain a stable nira pH and can increase the purity of nira because whitening can precipitate impurities in the nira[4]. Kapur sirih is also an inhibitor of coconut sap damage [5].

The process of making palm sugar consists of several stages, namely sap filtration, sap cooking, crystallization, sieving and drying. All of this is done to find the optimum conditions for making palm sugar from coconut sap and the efficiency of applied technology in making palm sugar from coconut sap with a crystallizer machine.

2. MATERIALS AND METHODS

2.1 Research Materials

The main ingredient in making palm sugar is coconut sap, and an additional element is $\text{Ca}(\text{OH})_2$ (0,25 gram, Merck) to increase the pH of coconut sap.

2.1 Research Tools

The crystallizer machine is the main tool used in making palm sugar from coconut sap.

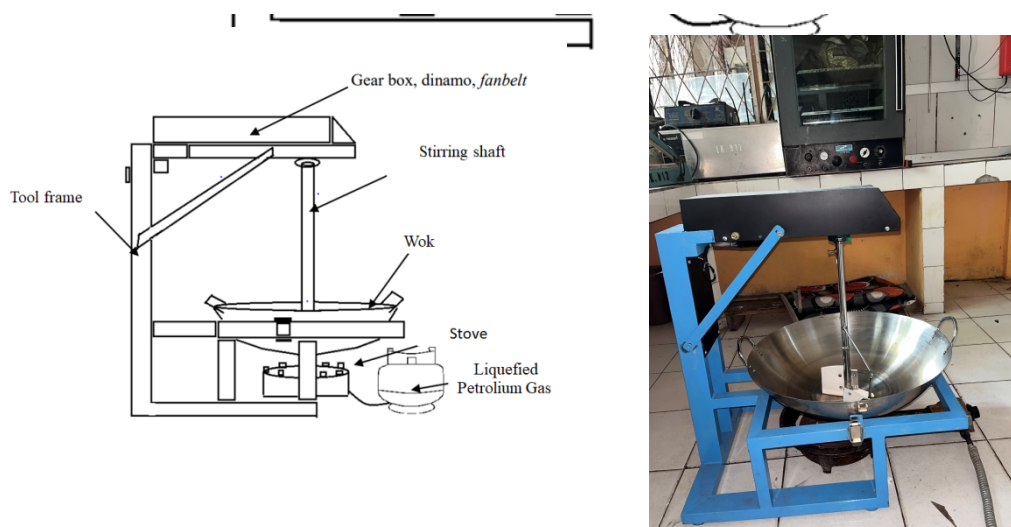


Table 1. Crystallizer Specification

Part Name	Specifications	Function
1. Tool Framework	- 70 cm high - 50 cm wide	As engine support
2. Mixer Blade	- Anchor Shape, - Food Grade Standard, - Teflon-based. - Mixer Speed 4-18 RPM	Stirring sap in the crystallization process
3. Stirring Shaft/Bar	- 45 cm high - Mixer Width 25.5 cm	Channeling energy from the gear box to the stirring blade
4. Dynamo (stirring motor)	- 12 V - Power Supply Total power: 80 Watts Voltage In: 220 V Voltage Out: 12 V	Drive shaft and stirring blade
5. Gear box	Ratio 10:2	Channeling and regulating the speed generated by the engine to the stirrer
6. Fan Belt		Channeling dynamo rotation to the gear box
7. Heating Chamber		Where to put the heater in the form of an LPG stove
8. Wok	- Stainless - 5-10 L capacity - Diameter \pm 55 cm - Height \pm 16 cm	Nira collection and cooking area
9. Stove/Burner	1 Eye	As a heater, to cook sap
10. LPG Gas Cylinder	3 kg gas cylinder	Stove fuel

The experimental procedure for making ant sugar from coconut sap is as follows:

- Standard Operating Procedure for Crystallizer:

1. Preparing the crystallizer.
2. Putting the pan in position and lock it with the lock on the pan to prevent it from shifting.
3. Lower the stirrer on the machine, then lock it so it does not sway.
4. Then, once installed, put the raw materials into the wok.
5. Plugging the cable on the tool into the socket, then turn on the tool by pressing the ON button located on the back of the tool.
6. Turning the stirring speed on the back of the tool as needed.
7. Turning off the appliance by pressing the OFF button and unplugging the cable from the socket.

2.3 Research Steps

In this research on making palm sugar, the main ingredient used is coconut sap, an additional ingredient in the form of lime whiting, which is useful for increasing the pH of coconut sap. The process of making palm sugar from coconut sap uses a crystallizer machine with several processes, namely sap filtration, sap cooking, crystallization, sieving and drying.

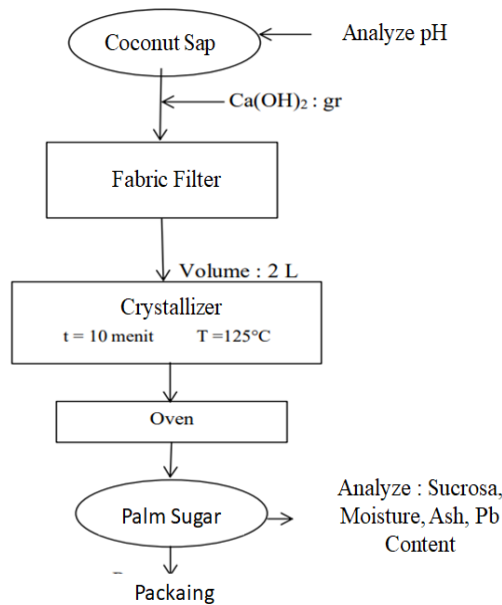


Figure 1. Flowchart of Palm Sugar Production from Coconut Sap.

- Preparation of raw materials

1. Taking coconut sap by tapping it, then check the pH and filter it using a sieve.
2. Adding $\text{Ca}(\text{OH})_2$ until the desired pH has been reached, which is 6–8.

- Stages of coconut ant sugar-making process

1. Preparing the crystallizer.
2. 2 Coconut juice that has been in accordance with the desired pH is then cooked in a crystallizer using a gas stove until the juice thickens.
3. After the nira thickens, it is cooled while flattened in the cauldron until it hardens slightly, then stirred using a stirrer on a crystallizer and assisted with a spatula to change the texture of the nira into powder form.
4. Sugar in powder form is sifted manually using a sieve to homogenize the size.
5. After sieving, the drying process was carried out using sunlight for 30 minutes to reduce the water content in the sugar.
6. Then, the ant sugar is ready to be packaged.

2.4 Research Analysis Method

The method of analyzing characteristics according to SNI 3743: 2021 [6] nawa is in the form of sucrose content, water content, ash content, and Pb metal content.

1. Water Content

Determine the water content using the oven drying method. Analysis of water content is carried out to reduce the growth of microorganisms in palm sugar from coconut sap. Water Content Analysis Procedure (SNI 3743-2021) is as follows:

- Heating the porcelain cup in the oven for 1 hour at 105 °C and then cooling it in a desiccator to room temperature, then weighing the porcelain cup using an analytical balance. (W_0)
- Putting 1 gram of sugar sample into the porcelain cup, and then weighing the cup containing the sample. (W_1)
- Heating the cup containing the sample in the oven for 2 hours at 115°C until the value is constant.
- Moving the porcelain cup into a desiccator to room temperature and weighing the weight of the cup and the final sample. (W_2)

Calculate the % moisture content:

$$\% \text{ Moisture Content} = \frac{w_1 - w_2}{w_1 - w_0} \times 100\%$$

2. Ash Content

The determination of ash content aims to determine the best or not in the palm sugar processing process.

Ash Content % Analysis Procedure (SNI 3743-2021) as follows:

- Heating the crucible in the oven for 1 hour at 105 °C, and then cooling it in a desiccator to room temperature, then weighing the crucible using an analytical balance. (W0)
- Putting 1 gram of sugar sample into the crucible, then weighing the crucible containing the sample. (W1)
- Heating the crucible containing the sample into the furnace for 4 hours at 550°C.
- Move the crucible into a desiccator to room temperature and weigh the weight of the crucible and the sample. (W2)

Calculate the % ash content:

$$\% \text{ Ash Content} = \frac{w_2 - w_0}{w_1 - w_0} \times 100\%$$

3. Sucrose Content

Determining the sucrose content of palm sugar from coconut sap. Sucrose content was analyzed using a Digital Pocket Refractometer 3840 Atago Pal-3.

Sucrose Analysis Procedure (SNI 3140:3:2010): (Pocket Digital Refractometer Manual Book) as follows:

- Prepare tools and samples of palm sugar, approximately 1 gram.
- Cleaning the digital refractometer using 0.3 ml of distilled water, pressing START then pressing the ZERO button so that the reading starts from number 0 (blank solution).
- Preparing the sample and dissolving it until homogeneous with distilled water.
- Measuring a sample of 0.3 ml is inserted in the prism of the tool. Then the tool will read the measurement.
- Record the sucrose content that has been read by the tool.
- Clean and tidy up the tools and materials that have been used.

4. Lead Content (Pb)

Lead content was analyzed to determine the lead content in palm sugar from coconut sap. Lead content (Pb) was analyzed using the GBC AAS 932 Plus tool. The lead (Pb) Analysis procedure using the AAS 932 Plus apparatus is as follows:

- Prepare tools and samples to be used.
- Pressing START then waiting until it reads instrument ready.
- Pressing ZERO then waiting again until it reads instrument ready.
- Enter the blank solution in the form of aquadest then click OK.
- Entering the standard solution then click OK.
- Enter the sample to be tested in sequence.

Table 2. SNI 3743: 2021 Components of palm sugar

Component	Content
Reduced Sugar	Max 3,0%
Sucrose(%)	80% - 93%
Moisture (%)	Max 3,0%
Ash (%)	Max 2,5%
Water insoluble part (%)	Max 1%
Colour Substance	Allowable
Lead (Pb)	Negative
Starch	Negative
Shape	Powder

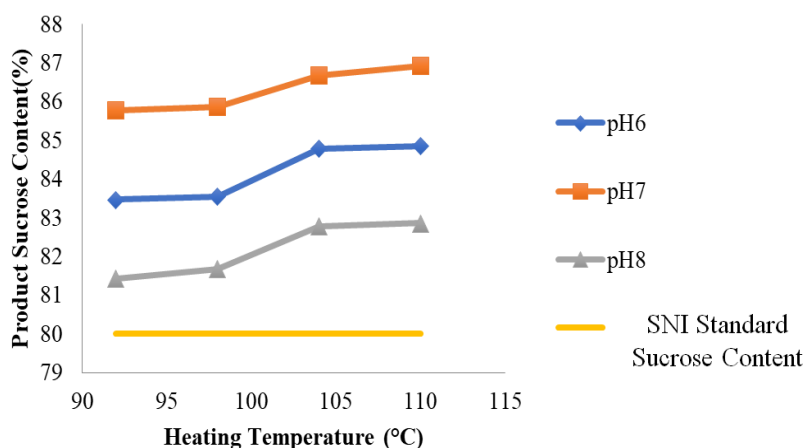
3. RESULTS AND DISCUSSION

After this experiment, we made palm sugar from coconut sap using a crystallizer machine. With the addition of whitening to increase the pH of coconut sap. In previous research, good-quality nira was found to be at pH 6 - 7 [7]. The temperature variations used are 92 °C, 98 °C, 104 °C and 110 °C. The optimum temperature affects the duration of the heating process. The higher the heating temperature, the greater the evaporation of water. The results of palm sugar analysis can be seen in Table 3.

Table 3. Sugar analysis data of coconut sap

Sample	T(°C)	pH	The Characterization of SNI 3743:2021			
			80%-93%	Maks 3,0%	Maks 2,0%	Maks 0,25
			Sucrose (Brix)	Water Content (%)	Ash Content (%)	Lead (Pb)
A ₁	92	6	83,47%	2,42	1,42	0,00
A ₂	98		83,54%	2,01	1,33	0,00
A ₃	104		84,78%	1,42	1,20	0,00
A ₄	110		84,83%	0,96	1,31	0,00
B ₁	92	7	85,77%	2,33	1,26	0,00
B ₂	98		85,86%	1,8	1,43	0,00
B ₃	104		86,67%	1,46	1,39	0,00
B ₄	110		86,93%	1,03	1,65	0,00
C ₁	92	8	81,43%	3,26	1,96	0,00
C ₂	98		81,68%	2,65	2,26	0,00
C ₃	104		82,78%	1,9	2,28	0,00
C ₄	110		82,86%	1,32	2,34	0,00

The Effect of Heating Temperature, pH on Sucrose Content

**Figure 2.** Chart of Heating Temperature and pH on Sucrose Content of Palm Sugar from Coconut Sap

The chart below shows that pH 8 has the lowest sucrose content compared to pH 6 and 7 because pH 8 starts to be alkaline, so the sucrose content decreases. Sucrose content is one of the important parameters to determine the quality of palm sugar products. According to the applicable SNI, the sucrose content of palm sugar is at a minimum limit of 80%. The chart shows that the higher the cooking temperature, the higher the sugar-sucrose content.

Temperature Effect on the Moisture Content of Palm Sugar Products from Coconut Sap

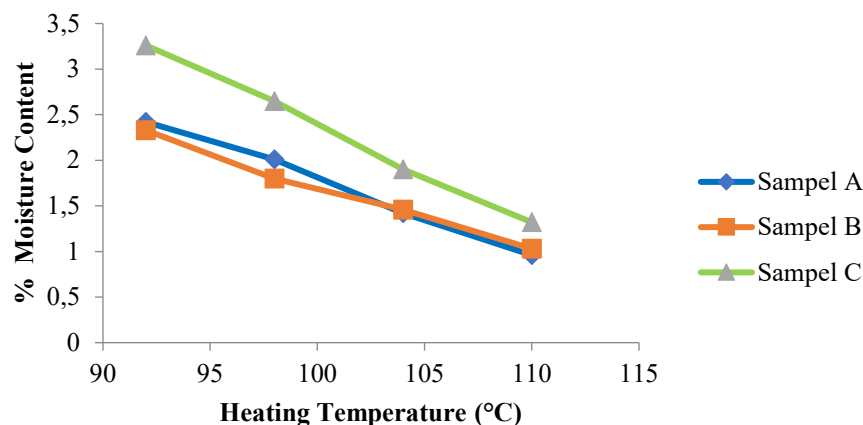


Figure 3. Chart of the Effect of Cooking Temperature on the Moisture Content of Palm Sugar from Coconut Sap

The chart above states that the higher the temperature, the lower the water content. According to SNI 3743: 2021, the maximum water content of palm sugar is 3%. In the chart, the lowest water content was obtained at 110 °C of 0.96% and the maximum was obtained at 92 °C of 3.26%.

This is because high cooking temperatures lead to low moisture content. It can be concluded that this research shows that the best products that meet the standards are products from temperature variations of 98 °C, 104 °C and 110 °C. The optimum temperature affects the duration of the heating process. The higher the heating temperature, the greater the evaporation of water.

The Effect of Added Whiting Lime on Ash Content

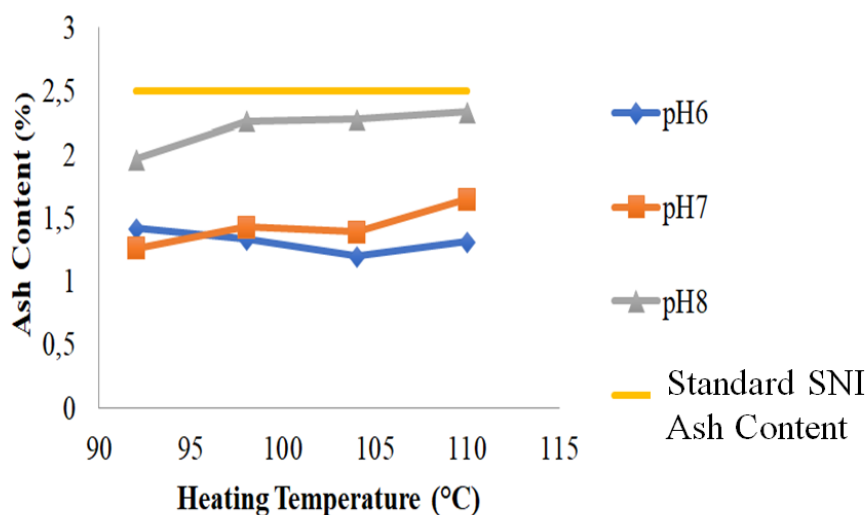


Figure 4. Chart of Effect of Cooking Temperature on Ash Content of Palm sugar from Coconut sap

Ash content is one of the important indicators to determine the quality of sugar, especially palm sugar. The purpose of measuring ash content is to determine the amount of inorganic material contained in palm sugar that does not evaporate during processing. Ash content refers to the amount of inorganic material that remains after heating in an ash furnace. Ash content is important to know whether the processing is good or not. In this experiment, the ash content of the nira increased due to the addition of $\text{Ca}(\text{OH})_2$ to raise the pH of the nira to the desired pH.

4. CONCLUSION

In this experiment, the optimum condition for making palm sugar products from coconut sap is at a temperature of 110°C and pH 7, adding Ca(OH)₂ as much as 0.25 grams. The analysis results show that the palm sugar products produced meet the standards of SNI 3743: 2021 standards. The moisture content is 1.03%, ash content is 1.65%, sucrose content is 86.93%, and metal content is negative. Simple applied technology with a crystallizer machine can save time and energy during the process of making palm sugar from coconut sap. In the research, "The Effectiveness of Aren Sugar Making Using Conventional and Modern Methods" the production process of making palm sugar takes quite a long time, which is approximately 5 hours, with the process of cooking nira, crystallization, sieving and drying carried out using conventional methods or human labour.

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