# The Effect of Betel Lime additionon the Physicochemical Characteristics of Sugar Palm Juice

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## Abstract

Palm sap is a sugary liquid obtained from tapping palm trees, commonly used to produce various forms of palm sugar, including liquid, solid, and powder. Reducing sugars, such as glucose and fructose, can inhibit crystallization by binding to sucrose crystals, resulting in smaller crystals and higher water content, which limits the production of molded or powdered sugar. Laru ia a regional term for a buffer solution which has antimicrobial properties which is used to stabilize the pH value of palm sap. To control reducing sugars, laru is added to prevent their formation. However, in KUP Kadhang Maju, laru is sometimes ineffective in maintaining pH and preventing microbial contamination, affecting the quality of extracted sap for palm sugar production. This study aims to optimize the amount of betel lime ($Ca(OH)_2$) in laru to produce optimal palm sap. Three $Ca(OH)_2$-to-water ratios were tested, with sap collected from afternoon until the following morning. The analyses included pH, reducing sugar content, viscosity, total dissolved solids, and color intensity. Statistical tests included normality, homogeneity, One-way ANOVA, and Duncan's post hoc tests. The optimal treatment, P2 (2 grams of $Ca(OH)_2$ per liter of water), resulted in ideal sap for crystallization, with a pH of 6.50, reducing sugar content of 3.76%, viscosity of 35.50 cP, total dissolved solids at 12.17 °Brix, and color values L* 26.81, a* 3.53, and b* 7.81.
**Keywords: $Ca(OH)_2$; Crystallization; laru; Palm sap**

## *Abstrak*

*Nira aren adalah cairan manis yang diperoleh dari penyadapan pohon aren, yang umumnya digunakan untuk menghasilkan berbagai bentuk gula aren, termasuk gula cair, padat, dan bubuk. Gula pereduksi, seperti glukosa dan fruktosa, dapat menghambat proses kristalisasi dengan mengikat kristal sukrosa, menghasilkan kristal yang lebih kecil dan kandungan air yang lebih tinggi, sehingga membatasi produksi gula cetak atau bubuk. Untuk mengendalikan gula pereduksi, ditambahkan laru (larutan penyangga dan antimikroba) untuk mencegah pembentukannya. Namun, di KUP Kadhang Maju, laru terkadang tidak efektif dalam mempertahankan pH dan mencegah kontaminasi mikroba, yang memengaruhi kualitas nira untuk produksi gula aren. Penelitian ini bertujuan untuk mengoptimalkan jumlah kapur sirih ($Ca(OH)_2$) dalam laru untuk menghasilkan nira yang optimal. Tiga rasio $Ca(OH)_2$ terhadap air diuji, dengan pengambilan nira dari sore hingga pagi hari berikutnya. Analisis yang dilakukan meliputi pH, kandungan gula pereduksi, viskositas, total padatan terlarut, dan intensitas warna. Uji statistik meliputi normalitas, homogenitas, ANOVA satu arah, dan uji post hoc Duncan. Perlakuan optimal, P2 (2 gram $Ca(OH)_2$ per liter air), menghasilkan nira yang ideal untuk kristalisasi, dengan pH 6,50, kandungan gula pereduksi 3,76%, viskositas 35,50 cP, total padatan terlarut 12,17 °Brix, dan nilai warna L* 26,81, a* 3,53, dan b* 7,81.*
***Kata Kunci: $Ca(OH)_2$ ; Kristalisasi; laru; Nira aren***

# INTRODUCTION

## 1.1. Research Background

Manggung is one of the hamlets located in Peron Village, Limbangan District, Kendal Regency, Central Java Province. Manggung Hamlet is able to produce various types of agricultural products such as rice, coffee, bananas, candlenuts, and various types of processed products from sugar palm trees. One type of product that is widely produced and sold by the people of Manggung Hamlet is palm sugar. Palm sugar is sugar made from palm tree sap *(Arenga pinnata Merr.)* which has gone through a crystallization process. Palm sugar itself consists of various forms, namely molded palm sugar, liquid palm sugar and ant palm sugar.

KUP *(Koperasi Usaha Perkebunan)* Kadhang Maju is a cooperative located in Manggung which works in the manufacture of palm sugar and its processed products. The work stage for making palm sugar starts from the processing stage of sap which is extracted from palm trees which is then processed into various forms of palm sugar and processed products such as bandrek powder drinks. The brand name of the KUP Kadhang Maju product is "*Bu Ayuk*". However, the economic potential of palm sap processing at KUP Kadhang Maju can be said to be quite hampered. This is due to various problems at various stages of palm sugar production by producers. One problem that has quite a big impact on palm sugar production is the sap extraction stage.

At this stage, the sap extracted from palm trees has a low pH. This can be seen from the increase in reducing sugar levels in sap. This high level of reducing sugar inhibits the crystallization process when making palm sugar. If crystallization is not successful, the palm sugar cannot be molded. This results in losses because the palm sugar cannot then be sold. To overcome this problem, palm tree sap tappers use laru. Laru is a regional term for a buffer solution which has antimicrobial properties which is used to stabilize the pH value of palm sap so that it does not become too acidic and form reducing sugars. Apart from that, laru is also used because of its antimicrobial aspect (Reference?). However, the buffer solution used by KUP Kadhang Maju is not effective in preventing changes in pH so that sometimes the extracted sap cannot be processed into molded palm sugar. The laru used is composed of 1 gram of limestone, 20 grams of jackfruit wood for each laru (Reference?). The limestone used by KUP Kadhang Maju is obtained from limestone which has been reacted with water, this has a risk to public health, this is because limestone contains respirable crystalline silica (RCS) which can cause silicosis which is fatal if inhaled in excess. so it is best to use betel ($Ca(OH)_2$) which has been further processed and is safe to use (Mankar et al. , 2019). Therefore, to reduce the losses faced by KUP Kadhang Maju, research needs to be carried out so that the sap extracted from palm trees can be definitely processed into palm sugar that can be sold.

## 1.2. Research Hypothesis

**$H_0$:** Does not happen change physicochemistry of sap sugar palm along enhancement concentration chalk betel at KUP, Dusun Manggung.
**$H_1$:** Happens change physicochemistry of sap sugar palm along enhancement concentration chalk betel at KUP, Dusun Manggung.

# METHODS

This study employed an experimental approach involving three treatment levels and three variable categories: independent, fixed, and dependent variables. The independent variable was the quantity of food-grade $Ca(OH)_2$ used in preparing *laru*, while the fixed variable was the consistent amount of jackfruit wood employed in *laru* production. The dependent variables included pH, color value, reducing sugar content, viscosity, and Brix degree, which were the parameters evaluated. Each treatment level was repeated three times, resulting in a total of nine experimental repetitions.

The research was conducted in two stages: a preliminary study and the main study. The preliminary study focused on refining the analytical methods and palm sap extraction techniques. The main study, carried out at three treatment levels with three repetitions each, aimed to determine the physicochemical properties of palm sap. These properties were analyzed and compared across different treatment levels. Physical parameters included color, measured using a chromameter, and viscosity, assessed with a viscometer. Chemical parameters comprised reducing sugar content, determined by the Lane-Eynon method, pH measured with a pH meter, and Brix degree assessed using a refractometer.

**Table 1.** Treatment in Research

| **Treatment** | $Ca(OH)_2$ **(grams/Liter of water)** | **Jackfruit wood (grams/Liter of water)** | **pH of the resulting Laru** |
|---|---|---|---|
| P1 | 1 | 20 | 10.44 |
| P2 | 2 | 20 | 11.60 |

## 2.3. Nira Extraction

The extraction process roomie was done by first preparing the equipment needed, such as a machete, hammer wood, and climbing tools. The stage is beating the flower male. This is done for injured flowers so fluid roomie sugar palms can flow. The beating process takes seven days, with one session every day. The tools used at the stage are a hammer and a wood climber. Furthermore, it stages shaking flower males.

The last stage in the extraction process roomie is to cut the flower male. Cutting is done to make it fluid, and the roomie can go out. After all these processes, the extraction process is carried out in roomie sugar palm. Then, the eavesdropper sugar palm fills each container with run away as much as 250 ml before the journey to the tree aren, tapper sugar palm, to climb the tree, the sugar palm uses tool help climbing made from a given bamboo hole and open tarpaulin used to cover flower male and container for prevent contamination from outside, containing container roomie then pulley down use rope. Male flowers were then cleaned and scraped using a machete before hanging the new container that had been filled. This work is depicted in Figure 1. The extraction process is prolonged from 16.00 – 06.00.

## 2.5. Making Laru

In the preparation of *laru*, 1 liter of water was heated in a pan containing 20 grams of jackfruit wood pieces. Once the water reached boiling, a predetermined amount of food-grade calcium hydroxide ($Ca(OH)_2$), corresponding to the specified treatment levels (P1–P3), was added to the pan and stirred thoroughly until evenly mixed. The heating process was discontinued when the mixture developed a darker color, after which it was allowed to cool before being utilized for sap extraction. Subsequently, 250 ml of the prepared solution was applied to each tree.

### 2.6. pH Value Analysis

The pH value test was carried out using a pH meter referring to Ramayanti & Amna (2019). First, the pH meter is calibrated using a buffer solution of pH 4 and 7 to ensure the accuracy of the pH meter. After calibrating, the pH meter is then dipped in distilled water to be cleaned. The pH value of the sap sample is then measured using a calibrated pH meter. When the test process is complete the results are recorded and the pH meter electrode is washed with clean water and wiped with a tissue.

### 2.7. Reducing Sugar Content Test

The reducing sugar content test was carried out using the Lane-Eynon method referring to the Japan Customs Analysis Method (JCAM). First, a 250 ml Erlenmeyer flask is filled with 5 ml of Fehling's solution A and 5 ml of Fehling's solution B, then a magnetic stirrer is placed in it. The burette is then filled with the sample solution and positioned on the hotplate, the Erlenmeyer containing Fehling's solution is then heated on the hotplate, when the solution has reached the boiling point, 4 drops of 1% methylene blue are added then continued with titration with the sample, when it has reached the end point of the titration (TAT ) the titration is stopped and the amount of titrant used is recorded. Each sample was titrated twice to ensure the accuracy of the titration (Reference)?.

The next stage is the calculation of reducing sugar content, the formula used is available below;

$$\%\ Reducing\ sugar = \frac{Ds}{S} x100$$

Notes;

DS: Concentration (mg/100mL) of reducing sugar titrant obtained from Lane table - Eynon

S: Mass (mg) of the sample weighed in making the sample solution (15 grams)

### 2.8. Viscosity Value Test

The viscosity value test was carried out using a viscometer with the Brookfield brand referring to the research method of Anderson et al. (2014). First, the viscometer is allowed to calibrate when it is turned on, after the calibration process is complete, the S62 spindle is installed. Then 250 ml of palm sap sample was measured and transferred to a 250 ml beaker. The beaker is then placed right in the middle of the calibrated viscometer, then the viscometer is turned on and the results are awaited, when the Cp value of the viscometer has stabilized the data is recorded, and the viscometer is stopped. The viscometer spindle is then cleaned with water and wiped using a tissue.

### 2.9. Brix Degree Test

The Brix degree test was carried out using a refractometer referring to the research method of Jaywant et al. (2022). First, the refractometer is calibrated using the screwdriver provided so that the white limiter is located exactly at 00. Then 2 – 3 drops of palm sap sample are dropped into the prism of the refractometer and the cover is closed, the Brix degrees can be seen through the lens. When the test process is complete the results are recorded and the refractometer is cleaned with water and wiped with a tissue.

### 2.10. Color Intensity Test

The color test was carried out using a chromameter referring to the research method of Keskin et al. (2018). First, the chromameter is calibrated using a white calibration plate so that it can ensure that the chromameter can function properly and accurately. Then 200 mL is put into clear plastic and tied as tightly as possible so that it forms a ball. Make sure that there is no liquid on the surface of the plastic because it can damage the chromameter. Analysis was then carried out three times for each palm sap sample to ensure data accuracy.

### 2.11. Data Analysis

Data analysis was carried out using SPSS 13.0 Version. with Oneway ANOVA test with Duncan's posthoc test at a confidence level of 95% ($P < 0.05$). Data on reducing sugar levels were passed post hoc Tukey's B because they had extreme data.

## RESULTS AND DISCUSSIONS

This study presents the results of physicochemical analyses of palm sap across different treatment levels of food-grade $Ca(OH)_2$ in laru preparation. Key parameters examined include pH, reducing sugar content, viscosity, total dissolved solids (Brix degrees), and color intensity, with each parameter's relevance to the quality of palm sap and its subsequent crystallization process being discussed. The findings will highlight how varying levels of $Ca(OH)_2$ influence these parameters, their implications for the quality of palm sap, and the identification of the optimal treatment for producing high-quality palm sugar. Additionally, the results will provide insights into the physicochemical mechanisms and the practical benefits of optimizing laru formulation for palm sap processing.

### 3.1. pH value Analysis

The pH (Potential of Hydrogen) value is a measure of the acidity of a solution. This acidity level is measured by measuring the number of hydrogen ions (H+) and ions (OH-) contained in the solution. If the measured pH value is <7 then the solution is acidic, if the measured value is >7 then the solution is basic, a solution with a pH value of =7 is neutral. pH measurements were carried out using a pH meter (Springer, 2014).

The pH value is a very important aspect of the quality of palm sap. This is because the pH value can affect various other aspects of the quality of palm sap such as the stability of sucrose and microbial growth, a pH that is too low will result in the sucrose being inverted into reducing sugar and an inappropriate pH value also results in microbial growth which can cause further damage to the sugar palm sap (Narendranath & Power, 2005; Erwinda & Susanto, 2014; Ramadhani et al., 2023).

**Table 2.** pH Value Based on $Ca(OH)_2$ Ratio Level

| Treatment | pH value |
|---|---|
| P1 | $6.47 \pm 0.12^{a}$ |
| P2 | $6.50 \pm 0.61^{a}$ |
| P3 | $6.91 \pm 0.27^{a}$ |

Note: 1) Superscript letters indicate values that have significant differences.

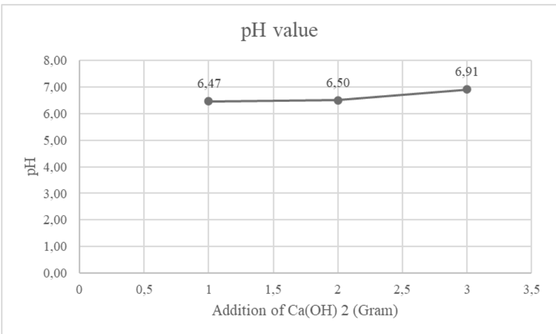

**Figure 2.** Graph of pH Values Based on $Ca(OH)_2$ Ratio Levels

Based on **Table 2,** it can be seen that there are no significant differences in pH values at all treatment levels. However, if analyzed using the histogram provided in **Figure 2,** it can be seen that there is a consistent increase in pH values from treatments P1 – P3. According to Suntoro et al. (2016), this increase in pH value is natural, a saturated solution of betel or $Ca(OH)_2$ has a pH value of around 11.8 – 12.5 which is very alkaline, this results in an increase in the pH value of palm sap which can seen from the increase in pH from P1 to P2 and from P2 to P3.

An increase in pH positively influences the quality of palm sap by inhibiting microbial growth that contributes to acid production, which can degrade sap quality. Microorganisms such as *Saccharomyces calbergensis*, naturally present in palm sap, and contaminant species like *Saccharomyces cerevisiae* exhibit optimal growth within a pH range of 4 to 6, while *Acetobacter aceti* thrives between pH 4 and 7 (Awad et al., 2012; Narendranath & Power, 2005). Elevating the pH to approximately 7 effectively prevents microbial proliferation and inhibits the inversion process in palm sap, thereby maintaining low levels of reducing sugars and preserving sucrose content. This stabilization of sucrose is crucial for determining palm sap quality. Additionally, the risk of inversion increases if contamination occurs during sap extraction or processing, especially at extreme pH levels (Erwinda & Susanto, 2014; Ramadhani et al., 2023).

### 3.2. Reduced Sugar Contens

The reducing sugar content is one of the most important quality criteria for palm sap, this is because the amount of reducing sugar contained in palm sap determines its crystallization ability. A reducing sugar content that is too high prevents the crystallization of palm sap so that it can only form liquid palm sugar (Sonya & Lydia, 2021; Verma et al., 2021).

**Table 3.** Reducing Sugar Levels Based on $Ca(OH)_2$ Levels

| Treatment | Reduced Sugar Levels |
|---|---|
| P1 | 5.92 ± 0.25 [c] |
| P2 | 3.76 ± 0.52 [a] |
| P3 | 4.66 ± 0.74 [b] |

Note: 1) Superscript letters indicate values that have significant differences

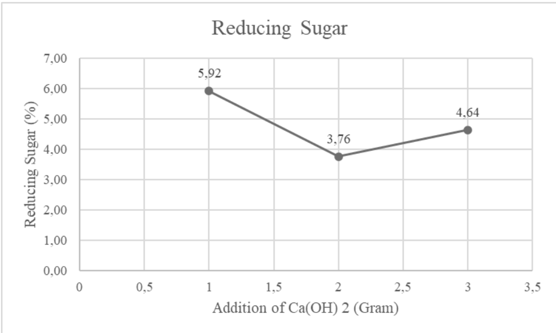


**Figure 3.** Graph of Reducing Sugar Content based on Ca(OH)2 Ratio Level

Based on Table 3, a significant difference in reducing sugar content was observed across all treatments. A reduction in reducing sugar levels was evident from treatment P1 to P2, suggesting that an increased use of betel lime ($Ca(OH)_2$) effectively suppresses reducing sugar levels in palm sap. However, an opposing trend was noted between treatments P2 and P3, where reducing sugar levels increased. This increase is undesirable as it negatively impacts the crystallization process of palm sap, hindering the formation of solid palm sugar and *ant sugar*. The observed increase may result from an excessive amount of betel lime used in *laru* preparation.

According to Erwinda and Susanto (2014), while a higher pH is beneficial for reducing sugar stability in palm sap, the pH should not exceed 8. Excessively high pH levels can destabilize sucrose, leading to its breakdown into reducing sugars like glucose and fructose. Overuse of $Ca(OH)_2$, as in the P3 treatment, should therefore be avoided, as it can result in the formation of undesirable compounds that may adversely affect various quality attributes of palm sugar, such as taste, safety, and color.

Furthermore, Verma et al. (2021) highlight that reducing sugar content significantly influences sugar crystallization. Lower reducing sugar levels allow for faster crystallization and larger crystal sizes, whereas higher reducing sugar content inhibits crystal growth and results in smaller crystals. Additionally, higher reducing sugar content reduces the overall yield during the crystallization process, emphasizing the importance of controlling reducing sugar levels to optimize palm sugar quality and production efficiency.

According to Sukmana et al. (2022), the length of storage time significantly affects the reducing sugar content in palm sap. The longer the sap is stored, the higher its reducing sugar content becomes. However, beyond a certain point, the reducing sugar content decreases drastically due to fermentation, which converts the sugars in the sap into ethanol and organic acids. To prevent this, the sap extraction process should be carried out more frequently, ensuring the sap is not stored for extended periods before processing.

### 3.3. Viscosity Value

The viscosity value, measured in centipoise (cP), indicates the thickness of a liquid, with higher cP values corresponding to thicker liquids (Anderson et al., 2014). As shown in Table 4 and Figure 4, significant differences in viscosity were observed across treatments P1 to P3. While treatment P1 was not significantly different from P2, it was significantly different from P3. Similarly, treatment P2 was not significantly different from either P1 or P3, suggesting a gradual increase in viscosity with higher levels of $Ca(OH)_2$.

**Table 4.** Viscosity Values Based on $Ca(OH)_2$ Ratio Levels

| Treatment | Viscosity |
|---|---|
| P1 | $19.00 \pm 12.76^{a}$ |
| P2 | $35.50 \pm 21.70^{ab}$ |
| P3 | $56.50 \pm 7.40^{b}$ |

Note: 1) Superscript letters indicate values that have significant differences

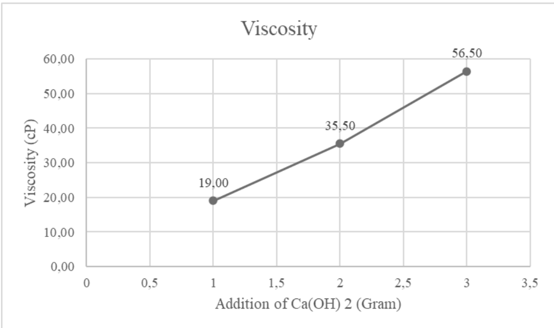


**Figure 4.** Graph of Viscosity Values Based on $Ca(OH)_2$ Ratio Levels

This increase in viscosity is primarily attributed to the higher ratio of $Ca(OH)_2$ used in laru preparation. According to Karseno et al. (2013), higher $Ca(OH)_2$ levels prevent the inversion of sucrose into reducing sugars, which play a crucial role in determining viscosity. Reducing sugars are hygroscopic, meaning they absorb water from the environment, leading to increased water content in the sap, diluting it, and consequently lowering its viscosity. By preventing sucrose inversion, higher $Ca(OH)_2$ levels contribute to thicker sap.

The viscosity of palm sap significantly affects the quality of the resulting palm sugar. High water content in palm sap leads to softer palm sugar with higher moisture, making it more prone to microbial contamination, such as bacteria, molds, and yeasts, and thus shortening its shelf life. Controlling the viscosity by optimizing the $Ca(OH)_2$ ratio is therefore critical to ensuring the production of high-quality palm sugar with better texture and improved shelf stability (Karseno et al., 2013).

### 3.4. Total Dissolved Solids

Brix degrees, which measure the sugar content or dissolved solids in a liquid, are crucial indicators of palm sap quality. A higher Brix degree correlates with increased yield, making it a key parameter in evaluating the sap. The total dissolved solids in palm sap can be influenced by several factors, including the use of food additives, growth conditions of the palm trees, and the trees' age (Farikha et al., 2013; Sukoyo et al., 2014).

**Table 5.** Total Dissolved Solids Based on $Ca(OH)_2$ Ratio Levels

| Treatment | Brix degrees |
|---|---|
| P1 | $13.33 \pm 1.53^{a}$ |
| P2 | $12.17 \pm 2.02^{a}$ |
| P3 | $12.00 \pm 2.18^{a}$ |

Note: 1) Superscript letters indicate values that have significant differences

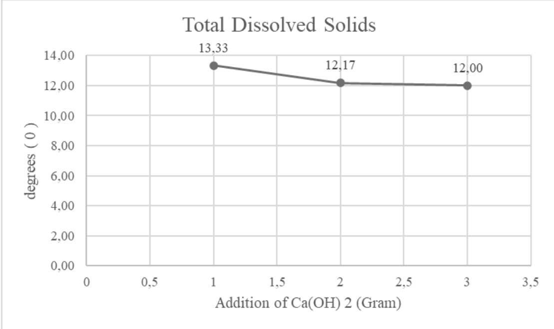


**Figure 5.** Graph of Total Dissolved Solids Based on Ca(OH)2 Ratio Levels

As shown in Table 5 and Figure 5, no significant differences in Brix degrees were observed among the treatments, ranging from 12.00 to 13.33 °Brix. This lack of variation could be attributed to two primary factors: the ratio of $Ca(OH)_2$ used in *laru* preparation was not large enough to induce significant changes, and the indirect addition of $Ca(OH)_2$ through *laru* had minimal impact on the total dissolved solids.

In addition to food additives, external factors significantly affect dissolved solids. Optimal growth conditions for sugar palm trees, such as altitudes of 500–700 meters above sea level, temperatures of 20–25 °C, and rainfall between 1200–3500 mm/year, play a critical role in sap quality. Fertile and humus-rich soil also supports optimal tree growth and sap production (Charis et al., 2022). Tree age further influences dissolved solids; trees around 15 years old exhibit the highest total dissolved solids due to peak anabolism during this stage (Fatriani et al., 2012; Gulo et al., 2018).

The dissolved solids measured in this study (12.00–13.33 °Brix) fall within the normal range for palm sap (11.05–15.57 °Brix), indicating that the total dissolved solids across all treatments are within acceptable limits for high-quality palm sap.

### 3.5. Color Intensity

Color is a critical determinant of food quality, as it significantly influences consumer perception and purchasing decisions. Consumers rely on visual appearance as the primary indicator of a product's quality, and deviations from characteristic colors often result in reduced appeal. Similarly, palm sugar craftsmen use visual assessment to evaluate the quality of palm sap extracted or harvested from palm trees.

Color parameters are quantified using three coordinate values: L*, a*, and b*. The L* value measures lightness, with higher values indicating lighter colors and lower values indicating darker tones. The a* value represents the red-green spectrum, where higher values denote a reddish hue and lower values indicate a greenish hue. The b* value corresponds to the yellow-blue spectrum, with higher values reflecting a yellowish color and lower values a bluish color. The range of L* is from 0 to 100, while a* and b* range from -128 to 127 (Rolle & Guidoni, 2007). These parameters provide a standardized method for objectively assessing and describing the color attributes of food products.

**Table 6.** Color Intensity Based on $Ca(OH)_2$ Ratio Levels

| **Treatment** | **Color** | | |
|---|---|---|---|
| | **L*)** | **a*** | **b*** |
| P1 | 21.49 ± 5.85 [a] | 2.77 ± 1.39 [a] | 7.57 ± 2.58 [a] |
| P2 | 26.81 ± 3.51 [a] | 3.53 ± 0.67 [a] | 7.81 ± 2.46 [a] |
| P3 | 27.19 ± 11.49 [a] | 3.61 ± 1.78 [a] | 8.67 ± 2.37 [a] |

Description : 1) Superscript letters indicate value that has difference real 2) The ')' sign indicates that the data does not is normal and homogeneous

Table 6 shows a consistent but statistically insignificant increase in L*, a*, and b* values across treatments, likely due to minor variations in the $Ca(OH)_2$ ratio used in *laru* preparation. Color changes in palm sap are primarily attributed to the degradation of sucrose into simpler compounds such as glucose, fructose, and hydroxy-methyl-furfural (HMF), which imparts a brown color. These compounds may further degrade into organic acids, phenolic compounds, and other derivatives like glyceraldehyde, acetone, and dioxyacetone, influencing sap color. The heating process during palm sugar production intensifies these changes by triggering the Maillard reaction, where reducing sugars and amino acids form melanoidin, a compound with a brown hue (Erwinda & Susanto, 2014; Andrews et al., 2002). Excessive $Ca(OH)_2$ use enhances this effect, producing a darker brown color compared to the lighter brown associated with moderate $Ca(OH)_2$ use (Erwinda & Susanto, 2014).

### 3.6. Best Treatment

According to Erwinda & Susanto, (2014) reducing sugar content is one of the most important factors in the palm sugar crystallization process. According to Karseno et al. (2014), the viscosity of palm sap also influences the final quality of the palm sugar produced, therefore viscosity is a secondary factor in determining the quality of palm sap. In terms of quality, the best treatment is the P2 treatment, this is because the analysis results for the P2 treatment show the best results overall. The reducing sugar content in treatment P2 has the lowest value of all treatments, treatment P3 has a higher viscosity value which indicates that the water content is lower, but there is an increase in reducing sugar content in treatment P3 which is the main quality criterion for palm sap in the process crystallization. The chemical characteristics of P2 are a pH value of 6.50 and a reducing sugar content of 3.76%. The physical characteristics of P2 are a viscosity value of 35.50 cP, total dissolved solids of 12.17 0 brix, and color intensity L* 26.81, a* 3.53, and b* 7.81.

This change in the formulation for making laru has had a positive impact on the crystallization of palm sugar at KUP Kadhang Maju, so that palm juice can be more securely processed into palm sugar. This is due to the lower levels of reducing sugar which have the ability to prevent crystallization of palm sap.

## CONCLUSION

In conclusion, increasing the ratio of $Ca(OH)_2$ in the preparation process significantly impacts the chemical parameter of reducing sugar content and the physical parameter of viscosity in sugar palm sap. However, it does not have a substantial effect on the pH value, total soluble solids, or color intensity. The reduction in sugar levels observed between treatments P1 and P2 reverses in P3, with significant differences noted among all treatments. The rise in reducing sugar content is attributed to excessive $Ca(OH)_2$, which promotes sucrose degradation. The viscosity of sugar palm sap increases linearly with higher $Ca(OH)_2$ ratios, with statistical differences noted between P1 and P3, likely due to increased dissolved solids and a reduction in hygroscopic sugar formation. Total soluble solids remain within a normal range (11-15 °Brix), with no substantial differences among treatments. Similarly, color intensity shows minimal changes. Among all treatments, P2 is the optimal condition, providing the lowest reducing sugar content while maintaining favorable levels for other parameters.

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