The effect of time and duration of tapping and the addition of laru as natural preservative in coconut sap quality

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Abstract. This study was aimed to obtain the optimal quality of coconut sap at the tapping stage related to tapping time and duration and addition of natural preservative named laru. The study was designed as factorial design with complete randomized block. The factors applied were tapping time at morning to noon (06.00 - 14.00 AM) and at afternoon to evening (14.00 - 22.00 PM), tapping duration in 2, 4, 6, and 8 hours and laru addition in 0 and 2%. The results showed that the quality of coconut sap (volume, discharge, acidity level /pH and sucrose content) from tapping at afternoon to evening time was higher and better than tapping at morning to noon time. In tapping coconut sap without laru addition, the optimal time duration of tapping at the morning to noon is 6 hours, while tapping time at the afternoon to evening is 8 hours. In tapping coconut sap with the addition of laru, the optimal limit of tapping time at the morning to noon is 8 hours, while for tapping in the afternoon to night is more than 8 hours.

1. Introduction

The decline of coconut sap quality starting to occur at the early stages of handling coconut sap, namely tapping or harvesting stage of coconut sap. In Indonesia tapping the coconut sap is performed by farmers twice a day, namely morning tapping until evening around 06.00 AM- 16.00 PM and afternoon tapping until morning around 16.00 PM - 06.00 AM. Until now, it is not known when and at what time the optimal tapping is required to produce coconut sap with the most optimal volume and quality. Meanwhile, farmers are only doing tapping the coconut sap based on their habit at morning and evening. As their experience, 12-16 hours resulting in the decline of sap quality due to the influence of microbes and weather as temperature, humidity and rainfall [1]. The perishable quality of coconut sap will result in the variation of palm sugar quality produced. Optimization of tapping time is very important to be able to produce coconut sap with good volume and quality. It is related to the physical activities of coconut plants such as photosynthesis, respiration and transpiration and microbiological activities as well as micro-climate (weather) factors which will affect the productivity of the palm plant in producing coconut sap [2]. By knowing the right time and duration of tapping of coconut sap, it will increase the efficiency in the tapping or harvesting stage and at the same time able to maintain the quality of coconut sap from reduced quality.
Another common and known practice of tapping by farmers is to add natural preservatives to prevent the damage or fermentation of the sap known as laru. Laru is used in the form of synthetic, namely metabisulfite and the natural one is laru which comes from the mixture of lime, mangosteen peel extract, and jackfruit wood chips [3]. Until now, the optimal use of laru in maintaining the quality of coconut sap related to tapping time and duration has not been widely studied. In addition, using preservative has positive impact during tapping, it can prevent damage to coconut sap but also has a negative impact, namely high levels of ash, insoluble materials and reducing sugar in the resulted palm sugar so that it reduces product quality [4]. Therefore, it is necessary to optimize the use of laru in the coconut palm tapping stage, especially in relation to the time and duration of tapping.

2. Methods
This research was conducted in August-September 2019 in the coconut garden of Gandatapa Village, Kembaran District, Banyumas District. The location of the coconut plantation has an altitude of about 525 m above sea level with an average rainfall of 104 - 107 mm and with average temperature, humidity and sun intensity as shown in Table 1. The material used in this research was coconut sap which derived from coconut trees of the “Dalam” variety, which have an average age of 15-20 years. The natural preservative used is natural laru (a mixture of lime with mangosteen rind extract and betel leaf). The equipment used is a pH meter (Pen Type PH-009-A), Refractometer Brix (ATC-KW0600748), Digital Brix Refractometer (Hanna series H196801), Hygrometer, Light Meter (Model HS1010A) and temperature data logger (RC-4 Series. USB Elitech RC4).

Table 1. Average microclimate data for the study location during August-September 2019

| Tapping duration (/hour) | Temperature average (°C) | Humidity average (%) | Sun heat intensity average (Lux) |
|-------------------------|--------------------------|----------------------|-------------------------------|
|                         | Morning to noon (06.00-14.00) | Afternoon to evening (14.00-22.00) | Morning to noon (06.00-14.00) | Afternoon to evening (14.00-22.00) |
| 2                       | 27.4                      | 28.0                 | 68.3                          | 67.2                          | 33,244.4                    | 5,555.6                       |
| 4                       | 32.1                      | 25.6                 | 53.0                          | 77.4                          | 48,783.3                    | 0                            |
| 6                       | 35.3                      | 24.9                 | 43.8                          | 86.6                          | 81,966.7                    | 0                            |
| 8                       | 33.4                      | 24.1                 | 50.3                          | 87.0                          | 67,861.1                    | 0                            |

This research was carried out by experimental method using a randomized block design (RBD) with 16 treatment combinations, repeated 3 times to obtain 48 experimental units. The factors tested were tapping time (P), namely morning to noon 06.00 - 14.00 AM (P1) and afternoon to the evening 14.00 AM - 22.00 PM (P2), tapping duration (T) with time intervals of 2 hours (T1), 4 hours (T2), 6 hours (T3), and 8 hours (T4) and the addition of laru (L) is 0% (L0) and 2% (L1).

Research mathematical models, namely:

\[ Yijkl = \mu + \alpha_i + \beta_j + \gamma_k + (\alpha\beta)_{ij} + (\alpha\gamma)_{ik} + (\beta\gamma)_{jk} + (\alpha\beta\gamma)_{ijk} + p_l + \varepsilon (ijk) ] \]

Where Yijkl = observations on tapping time factor at level i, tapping time factor at level j, factor adding time to level k, and repetition to l.

\[ \mu = \text{general average} \]

\[ \alpha_i = \text{the main influence of tapping time factor} \]

\[ \beta_j = \text{the main influence of the tapping duration factor} \]

\[ \gamma_k = \text{the main effect of the addition of laru factor} \]

\[ (\alpha\beta)_{ij} = \text{interaction component of the tapping time factor and the tapping duration factor} \]

\[ (\alpha\gamma)_{ik} = \text{interaction component of tapping time factor and laru addition factor} \]

\[ (\beta\gamma)_{jk} = \text{interaction component of the tapping duration factor and laru addition factors} \]

\[ (\alpha\beta\gamma)_{ijk} = \text{interaction component of the tapping time factor, the tapping duration factor and laru addition factor} \]

\[ pl = \text{the effect of repetitions as a group} \]
ε (ijk) = random influence of interactions of the tapping time factor, the tapping duration factor and the laru addition factor of the spread of the normal spread (0, σ2).

j = 1, 2, j = 1, 2, 3, 4, j = 1, 2

Observations were made on the changes of physicochemical quality of coconut sap during the tapping process, namely volume and discharge of coconut sap (measuring cup), coconut sap pH (pH meter), and sucrose content (digital refractometer). The data obtained were analyzed using analysis of variant (F-test) at a significant level of 5 percent and if it shows a significant variation then followed by Duncan's Multiple Range Test (DMRT) with α = 0.05, as well as regression and correlation analysis [5]

3. Results and discussion

3.1. The effect of time and duration of tapping and addition of laru on the volume of coconut sap

The DMRT test results show that the tapping time factor (P) has a significant different effect on the volume of coconut sap at the tapping stage, as presented in table 2 below.

| Time of tapping           | Volume of coconut sap (ml) |
|---------------------------|-----------------------------|
| Morning to noon (06.00-14.00) | 466.34\(^b\)               |
| Afternoon to evening (14.00-22.00) | 511.32\(^a\)               |

Note: The mean value of treatment followed by the same letter is not significantly different based on the DMRT test α 5%.

The results showed that tapping from evening to night (14.00 - 22.00 PM) resulted in an average volume of coconut sap (511.32 ml) which was more than the volume of coconut sap (466.34 ml) tapped from morning to noon day (6.00 to 14.00 AM). This is strongly suspected because tapping time is affected by turgor pressure, the later the tapping time, the higher the temperature and sun intensity and the higher the transpiration, as a result the turgor pressure will be lower and the sap production from tapping will also be lower [3]. In other words, the amount of sap produced is due to the effect of the strength of turgor on the coconut tree. This means that the stronger the turgor, the more sap is released. This shows that tapping coconut sap from the afternoon to the evening is more productive in producing the volume of sap than the tapping time from morning to noon, as shown in Figure 1 below.

![Figure 1](image-url)  
**Figure 1.** The difference in volume (ml) of coconut sap at the tapping stage is due to differences in the tapping time factor (P)

3.2. Effect of time and duration of tapping and addition of laru on the discharge of coconut sap

Based on the results of the DMRT test, it is known that the interaction between tapping time with tapping duration (P*T) significantly influences the change in coconut sap discharge (ml / hour) during the tapping process, as described in table 3 below
### Table 3. DMRT test results the effect of the interaction between time with duration of tapping (P * T) on changes in the discharge (ml) of coconut sap

| Time of tapping | Duration of tapping (hour) | Discharge of coconut sap (ml) |
|-----------------|---------------------------|-------------------------------|
|                 | 2                         | 4                             | 6                              | 8                              |
| Morning to noon | 257.778<sup>b</sup>       | 180.556<sup>bc</sup>          | 150.000<sup>b</sup>            | 102.778<sup>a</sup>            |
| Afternoon to evening | 238.889<sup>b</sup>       | 197.222<sup>c</sup>          | 156.111<sup>b</sup>          | 174.722<sup>bc</sup>         |

Note: The mean value of treatment followed by the same letter is not significantly different based on the DMRT test at 5%.

It can be seen that at 6 hours of tapping time, the discharge of coconut sap produced between tapping in the morning to noon with tapping time in the afternoon to evening is relatively the same, but when entering the 8<sup>th</sup> hour (8 hours) there is a significant difference in the discharge of coconut sap. The result is that the discharge of coconut sap from tapping in the afternoon to evening is greater (174.72 ml / hour) than the discharge of coconut sap from morning to noon tapping (102.78 ml / hour). At the time of tapping in the morning until noon, after the 2<sup>nd</sup> hour of tapping, the discharge of coconut sap continues to decrease until the 8<sup>th</sup> hour, while at the time of tapping in the afternoon until evening, the discharge of coconut sap decreases until the 6<sup>th</sup> hour, but at the 8<sup>th</sup> hour tapping, discharge again increased significantly from 156.11 ml / hour to 174.72 ml / hour. The phenomenon of the difference in the change in coconut sap discharge between tapping time in the morning to noon with tapping time in the afternoon to evening is presented in Figure 2 below.

![Figure 2. Effect of interaction between treatment time with duration of tapping (P * T) on changes in the discharge (ml) of coconut sap](image)

This phenomenon is strongly suspected due to the influence of environmental conditions (temperature and humidity) and the physiological processes (metabolism) of coconut sap which differ between day afternoon and night. At night the ambient temperature conditions are relatively low and humidity is high so that transpiration is low and the turgor pressure is high. High turgor pressure will result in a high discharge / volume of coconut sap that comes out from the coconut tree “mayang”. The highest increase in turgor pressure occurs at night, especially at the 6<sup>th</sup> – 8<sup>th</sup> hour of tapping, which is around 22.00 - 24.00 PM, this is related to weather conditions at that time where environmental temperatures are low (around 24°C) and high humidity levels (86 - 87 %) (Table 1).

### 3.3. Effect of time and duration of tapping and addition of laru on the pH of coconut sap

Based on observations of the sensory properties of coconut sap from tapping for 8 hours, there was a striking difference between coconut sap without laru and coconut sap given laru. The coconut sap without laru looks cloudy white (frothy / foamy), the smell is slightly sour and the distinctive smell of coconut sap is reduced, while the coconut juice that is given 2% laru looks slightly brownish yellow,
clear (not cloudy / not foamy), has no smell. sour, the distinctive smell of coconut sap is still strong. The difference in sensory properties has something to do with the state of the acidity level (pH) of the tapped coconut sap, where the unripe coconut sap has undergone a fermentation process (acidic pH), while the coconut sap that has been treated has not undergone a fermentation process (neutral-alkaline pH).

Based on the results of the DMRT difference test, it is known that during 2 - 8 hours of tapping, there is a significant difference between the decrease in the pH of coconut sap that occurs during tapping in the morning to noon with a decrease in the pH of coconut sap during tapping in the afternoon to evening. This phenomenon can be seen in table 4. below

**Table 4.** DMRT test results influence the interaction factor of tapping time with tapping duration (P * T) on changes in the pH of coconut sap at the tapping stage

| Time of tapping       | Duration of tapping (hour) | 2     | 4     | 6     | 8     |
|-----------------------|----------------------------|-------|-------|-------|-------|
| Morning to noon       |                            | 7.517c| 7.039c| 6.289b| 5.656a|
| Afternoon to evening  |                            | 8.533d| 8.139e| 7.839e| 7.317e|

Table note: The mean value of treatment followed by the same letter is not significantly different based on the DMRT test α 5%

It can be seen that the decrease in the pH of coconut sap that occurs during tapping in the morning to noon is more intensive or faster (7.52 decreases to 5.66) compared to the afternoon to evening tapping time (8.53 drops to 7.32). At the time of tapping in the morning to noon for 8 hours, the decrease in the pH of the coconut sap looks very fast and has arrived at acidic conditions (pH < 6) meaning that the coconut sap has shown signs of damage due to fermentation, whereas in the tapping in the afternoon to evening, even though there is a decrease in the pH of coconut sap, but the decrease is relatively slow and is still in a safe condition because the final pH is still in the neutral category (pH ≥ 7), as shown in Figure 3 below.

**Figure 3.** The effect of the time interaction factor with tapping time (P * T) on changes in the pH of coconut sap at the tapping stage

The DMRT test results showed that at the tapping stage, the interaction between the tapping time factor and the addition of laru (P * L) had a significant effect on the pH of coconut sap. It can be seen that it turns out that giving laru to coconut tapping performed in the morning is able to increase and maintain the pH of coconut sap which is more optimal than giving laru to tapping at night. This can be seen from the average increase in the pH of coconut sap that occurs, where tapping in the morning to noon, giving laru can increase the pH of coconut sap by 2 scores (5.56 to 7.69), while tapping at the afternoon to evening or night increases the pH of sap the coconut is only 1 score (7.36 to 8.53), as shown in table 5 below.
Table 5. DMRT test results influence the interaction factor of tapping time with the addition of laru (P * L) on changes in the pH of coconut sap at the tapping stage

| Time of tapping             | Without of laru | + laru 2% |
|-----------------------------|-----------------|-----------|
| Morning to noon (P1)        | 5.561 a         | 7.689 c   |
| Afternoon to evening (P2)   | 7.361 b         | 8.553 d   |

Note: The mean value of treatment followed by the same letter is not significantly different based on the DMRT test α 5%

Based on the results of the analysis (table 5), it is known that in the afternoon to evening tapping, even though it is not given laru, the average pH condition of coconut sap is in good condition, namely neutral (7.36), while at tapping in the morning to noon the condition of coconut sap is not applied with laru have already experienced damage or acid, namely with a pH of around 5.5. This phenomenon is thought to occur because on tapping in the morning to noon the micro-climatic conditions (temperature and humidity) are more conducive to microbial activity in fermenting coconut sap compared to micro-climatic conditions during tapping at the afternoon to evening (night). So that the presence of laru is very necessary to prevent or inhibit the activity of these microbes. Based on this phenomenon, it can be concluded that to prevent damage to the coconut sap, giving laru to tapping at night is not necessity, while giving laru to tapping in the morning to noon is indispensable. The difference in the impact of laru application on the acidity level of coconut sap at different tapping times can be seen in Figure 4.

![Figure 4](image)

Figure 4. The effect of the interaction factor of tapping time with the addition of laru (P * L) on changes in the pH of coconut sap at the tapping stage

The DMRT test results showed that at the tapping stage, the interaction between the tapping time factor and the addition of laru (T * L) also had a significant effect on the pH of coconut sap. It can be seen that giving laru is quite effective in maintaining the pH of coconut sap for 8 hours of the tapping process, in fact, unrefined coconut sap has decreased its pH quite drastically and even reached an indication of damage (acid), as shown in Table 6.

Table 6. DMRT test results influence the interaction factor of tapping time with the addition of laru (T * L) on changes in the acidity level (pH) of coconut sap at the tapping stage

| Addition of laru | Duration of tapping (hour) |
|------------------|---------------------------|
|                  | 2                        | 4            | 6            | 8            |
| Without laru (L0)| 7.339 a                   | 6.917 c      | 6.211 b      | 5.378 c      |
| + laru 2% (L1)   | 8.711 e                   | 8.261 f      | 7.917 g      | 7.594 d      |

Note: The mean value of treatment followed by the same letter is not significantly different based on the DMRT test α 5%

It is known that during the 8-hour tapping process, if it is not treated with laru, the pH of coconut sap has decreased rapidly and drastically (acidic), which has decreased by 2 scores from 7.39 to 5.38, while for tapping that has been treated with addition of laru, even though the pH has decreased [6].
However, the decline was relatively slow and not drastic (pH is still normal), which decreased by 1 score from 8.71 to 7.59. This phenomenon can be seen in Figure 5 below.

**Figure 5.** The effect of the interaction factor of tapping time with the addition of laru (T * L) on changes in the acidity level (pH) of coconut sap

### 3.4. Effect of time and duration of tapping and addition of laru to the sucrose levels (% brix) of coconut sap

Based on the results of the DMRT test, it is known that during 2 - 8 hours of tapping, there is a significant difference between the changes in the coconut sap sucrose levels that occur during tapping in the morning to noon and the changes in the coconut sap sucrose levels during tapping in the afternoon to evening (at night), as shown in the Table 7.

**Table 7.** DMRT test results influence the interaction of tapping time with tapping time (P * T) on changes in sucrose levels (% brix) of coconut sap

| Time of tapping                     | Duration of tapping (hour) |
|-------------------------------------|-----------------------------|
|                                     | 2                           | 4                           | 6                           | 8                           |
| Morning to noon (P1)                | 14.133<sup>a</sup>         | 15.056<sup>b</sup>         | 15.867<sup>c</sup>         | 15.783<sup>c</sup>         |
| Afternoon to evening (night) (P2)   | 15.322<sup>b</sup>         | 15.439<sup>bc</sup>        | 15.333<sup>b</sup>         | 15.333<sup>b</sup>         |

Note: The mean value of treatment followed by the same letter is not significantly different based on the DMRT test α 5%

**Figure 6.** Effect of interaction between tapping time and tapping time (P * T) on changes in sucrose content (% brix) of coconut sap

It can be seen that during the 8 hours of the tapping process from morning to noon, the sucrose content of coconut sap fluctuates, namely from the 2<sup>nd</sup> to the 6<sup>th</sup> hour the sucrose levels seem to continue to increase, but at the 8<sup>th</sup> hour the sucrose content of coconut sap tends to decrease from 15.867% brix to 15.783% brix. This condition is different from the sucrose level of coconut sap tapped
in the afternoon until evening. It can be seen that from the 2nd hour to the 8th hour, the coconut sap sucrose content remains relatively stable in the range of 15.33% brix. This phenomenon can be seen in Figure 6.

This phenomenon of differences in trends in changes in the levels of sucrose of coconut sap is due to environmental condition. The environmental may affect to the temperature and humidity conditions and the pH of the coconut sap in the afternoon to night is less conducive for microbial activity to ferment or degrade sucrose sugar then the sucrose content is relatively stable. This is different from the condition when tapping in the morning until noon is more conducive for microbes to carry out the activity of changing sucrose sugar to reducing sugar and acid. This is in line with the decrease in pH (acid) which is more intensive during the tapping process of coconut sap from morning to noon than in the afternoon to evening.

The DMRT test results showed that at the tapping stage, the interaction between the tapping time factor and the addition of laru (P * L) had a significant effect on the sucrose content of coconut sap. It can be seen that the application of laru can significantly maintain or prevent the decrease in coconut palm sucrose levels during the tapping process, whether tapped in the morning until noon or tapped in the afternoon until evening. An interesting phenomenon that occurs is that there is a tendency that applying laru to tapping in the evening until at night is more effective in maintaining the sucrose levels of coconut sap than in the morning to noon tapping.

| Time of tapping | Addition of laru | Without laru | + laru 2% |
|-----------------|-----------------|--------------|-----------|
| Morning to noon | 14.836<sup>a</sup> | 15.583<sup>b</sup> |
| Afternoon to evening | 14.611<sup>a</sup> | 16.103<sup>c</sup> |

Note: The mean value of treatment followed by the same letter is not significantly different based on the DMRT test α 5%.

Based on observations, it is seen that the effectiveness of laru application on tapping in the afternoon to evening than in the morning to noon in maintaining the sucrose levels of coconut sap is thought to be its strong interaction between effects of laru and conditions of temperature and humidity which are conducive at night in inhibiting microbes’s activity. Hence, the levels of sucrose coconut sap in the afternoon to evening (night) are more sustainable and not easily decreased / damaged, as presented in Figure 7.

![Figure 7](image-url)

**Figure 7.** The difference in sucrose content (% brix) of coconut juice due to the interaction factor of tapping time with the addition of laru (T * L)

The DMRT test results showed that at the tapping stage, the interaction between the tapping duration factor and the addition of laru (T * L) had a significant effect on the sucrose content of coconut sap. In general, it is seen that giving laru during the supplying process can maintain the sucrose content of coconut sap better than without. It can be seen that although the changes in the levels of sucrose appear to be equally fluctuating, namely from the beginning it increased from the 2nd
hour to the 6th hour and began to decrease at the 8th hour, but with the provision of laru, the decrease in coconut sap sucrose levels was lower than without laru, as shown in Table 9 and Figure 8.

Table 9. The results of the DMRT test the effect of the interaction factor of the old bugging with the addition of laru (T * L) to changes in sucrose content (% brix) of coconut sap at the tapping stage

| Addition of laru | Duration of tapping (hour) | 2    | 4    | 6    | 8    |
|-----------------|----------------------------|------|------|------|------|
| Without laru    |                            | 13.861a | 14.639b | 15.211c | 15.183c |
| With 2% laru    |                            | 15.594d | 15.856de | 15.989e | 15.933e |

Note: The mean value of treatment followed by the same letter is not significantly different based on the DMRT test α 5%

Figure 8. The effect of the interaction factor of tapping time with the addition of laru (T * L) on changes in the levels of sucrose (% brix) of coconut sap

It can be seen that giving laru to the tapping process of coconut sap for 8 hours is quite effective in maintaining the sucrose content. This is because the function of laru, which contains pH neutralizing and antimicrobial substances, is to inhibit the fermentation process. This change is characterized by a decrease in pH and brix levels. The process of damage of sap begins with the change of sucrose to glucose and fructose and continues to ethanol and CO₂, and its will be ended with the conversion of ethanol to vinegar / acetic acid [7].

4. Conclusion
a. Tapping of coconut sap in the afternoon until evening (14.00 AM- 22.00 PM) produces an average volume, discharge, sucrose content and acidity levels (pH) of coconut sap that is better and higher than tapping morning to noon (06.00 - 14.00 AM).
b. The degradation or damage to the physicochemical quality of coconut sap (especially pH and sucrose content) is slower in tapping in the afternoon to evening (night) than during the tapping of morning to noon.
c. In tapping of coconut sap without laru, the optimal time duration of tapping in the morning to noon is 6 hours, while the tapping time in the afternoon to evening is 8 hours.
d. In tapping coconut sap with the addition of laru, the optimal limit of tapping time in the morning to noon is 8 hours, while for tapping in the afternoon to night is more than 8 hours.
e. The application of laru for quality control of coconut sap is urgently needed during tapping from morning to noon than during tapping in the afternoon to evening (on tapping in the afternoon to evening for 8 hours, does not require the additional of laru).

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