The calcium application to control yellow latex in mangosteen fruit (*Garcinia mangostana*)

S Yuniarti, S Lestari, M C Hadiatry and R Purba

Banten Assessment Institute for Agricultural Technology (AIAT). Jl. Ciptayasa
Km.01 Ciruas, Serang, Banten, 42182, Indonesia

E-mail: silvia_yuniarti@yahoo.com

**Abstract.** The main problem of mangosteen production is yellow latex in the rind and aril of the mangosteen fruit. The yellow latex occurs from the yellow latex channel's rupture and contaminates the arils or mangosteen rind. The rupture is thought due to the lack of calcium in the epithelial cell walls of the yellow latex ducts. The present study aimed to determine the effect of calcium in reducing yellow latex in the mangosteen fruit. The study was conducted in Luhur Jaya Village, Lebak Regency of Banten Province. The study used a randomized block design, consisting of 6 treatments and 5 replications with treatment P0=control, P1=dose of calcium/dolomite lime 2 kg/tree, P2=dose of calcium/dolomite lime 3 kg/tree, P3=dose of calcium/dolomite lime 4 kg/tree, P4=dose of calcium/dolomite lime 5 kg/tree, P5=dose of calcium/dolomite lime 6 kg/tree. The calcium was given when the mangosteen plant started to flower. From the results, the application of calcium using dolomite (CaMg(CO$_3$)$_2$) reduced yellow latex contamination in mangosteen rind at doses of 5 kg/tree. All doses of calcium applied (2, 3, 4, 5, and 6 kg/tree) reduced yellow latex contamination in arils. The application of calcium with dolomite (CaMg(CO$_3$)$_2$) did not affect fruit weight and dotted on mangosteen.

1. Introduction

Mangosteen (*Garcinia mangostana* L.) is a queen of tropical fruits [1], a tropical plant that can grow in the lowlands to the highlands 1,000 m above sea level. Optimal production will be obtained if it is at an altitude of 0-600 m above sea level with temperatures ranging from 25-30°C [2]. The mangosteen fruit is one of Indonesia's mainstays to several countries in Asia and Europe, with the volume of exports increasing every year. Based on data from Statistics Indonesia, mangosteen exports in 2018 reached 38,830 tons, increasing 324%, compared to 2017, which was only 9,167 tons [3]. Although the production continues to grow every year, it has not been followed by increased fruit quality. According to [4], only 20% of Indonesia's mangosteen fruit was eligible for export. The cause of the low quality of Indonesian mangosteen is due to yellow latex in the rind and aril of the mangosteen fruit.

Yellow latex is a natural sap produced in every organ of the mangosteen plant [5]. The yellow latex contamination occurs when the sap comes out of the broken channel and contaminates the arils (pulp) or mangosteen rind due to pressure that causes epithelial cells to break when the cell walls are weak. The weak and fragile cell walls are thought to be due to the lack of calcium in the walls of the epithelial cells of the yellow lymph channels [6]. The rupture of the lymph channels is related to the calcium content element. The calcium content of the pericarp of mangosteen contaminated with yellow latex is lower than usual fruit [7, 8, 9]. Lack of calcium in the mangosteen plant can increase the yellow latex contamination of the fruit [10].
Calcium is an important element in building cell walls. The calcium ions strengthen cell walls, pectin surface, and middle lamella, so that cell structure becomes stronger. It is a guideline for reducing yellow latex in mangosteen, caused by rupturing of yellow latex channels due to a weak wall structure [11]. In other fruit commodities such as lychees, calcium is also used to reduce fruit breaking [12].

Banten Province is one of the mangosteen-producing provinces that contribute to exports. Mangosteen quality improvement can be made through research in reducing yellow latex contamination. Therefore, the present study aimed to determine the effect of calcium in reducing yellow latex in the mangosteen fruit.

2. Materials and methods

2.1. Research site and materials

The research was conducted at the Hegar Jaya Farmers Group, Luhur Jaya Village, Cipanas District, Lebak Regency, Banten Province. The preparation of sample plant selection and calcium application was conducted from September to December 2014. The results were observed from January to April 2015. The materials used were mangosteen plants grown from seeds that were ± 20 years old, dolomite lime (CaMg\((CO_3)\_2\)), etc.

2.2. Design experiment and management of the crop

The study used a randomized block design with 6 treatments and 5 replications. Each experimental unit consist of 2 trees with a total of 60 mangosteen trees. The treatment was 6 levels of calcium dose, namely P0 = control, P1 = dose of calcium/dolomite lime 2 kg/tree, P2 = dose of calcium/dolomite lime 3 kg/tree, P3 = dose of calcium/dolomite lime 4 kg/tree, P4 = dose of calcium/dolomite lime 5 kg/tree, P5 = dose of calcium/dolomite lime 6 kg/tree.

Calcium was applied before flowering mangosteen. It was used by spreading it evenly in a circle under the canopy of the mangosteen plant. The soil around the canopy was hoed in a circle with a distance of 1.5 meters roots. Then the dolomite was spread on the hoed soil and then covered again with soil. The next stage was to provide labeling on the treatment tree.

Observations were conducted at the time of fruit harvesting. Each observation of mangosteen fruit was taken randomly, as many as ten fruits per tree, and observations were done four times with a span of one week of observation. The variables observed were fruit weight, dotted fruit, the contamination of yellow latex on the outer skin (pericarp), and the contamination of yellow latex on the inside of the fruit (arils). The observation of dotted fruit, the contamination of yellow latex on pericarp and arils were done based on a scoring method; present (1) and absent (0).

2.3. Data analysis

Data were analyzed statistically using Analysis of Variance (ANOVA). The difference in mean values was carried out by the Duncan Multiple Range Test (DMRT) at the level of 5%.

3. Result and discussion

The observations of total fruit weight and dotted fruit at week 1 to week 4 showed no significant differences for all levels of treatment doses (table 1). It means that calcium's addition does not affect weight gain or dots' appearance on the mangosteen fruit. These results are in line with the results study of [11], which showed no difference in fruit weight in the addition of dolomite. The results indicated that differences in the availability of calcium in the soil did not affect the formation of the cell walls that comprise the fruit's skin. They further explained that each calcium application treatment has the same ability to use Ca\(^{2+}\) ions as a constituent component of the middle lamellae in the cell wall. Thus, the addition of Ca\(^{2+}\) ions is not directly involved in increasing the size and weight of the fruit [11].
In the second week, the treatment dose was 4 to 6 kg/tree and the arils were tough. The results found that the calcium carbonate (CaCO₃) concentration at the 5 to 6 kg/tree treatment doses (P4 and P5) showed a reduction in yellow latex contamination. At the third week of observation, the yellow latex contamination reduced at the 5 to 6 kg/tree treatment doses (P4 and P5). As for the fourth-week observation, all the doses were not significantly different, which means the yellow latex contamination had started to reappear in the fourth week. From these results, it was found that the higher the dose of calcium given, the less yellow latex contamination of the fruit skin. However, the effect of calcium decreased in the last observation, namely in the fourth week. The results study found that the calcium chloride (CaCl₂) application by spraying it at the 6th, 7th, and 8th weeks after blooming caused the percentage of fruit that did not have yellow latex to increase [13]. It was related to an increase in the concentration of calcium in the skin and pulp of the mangosteen fruit caused by calcium chloride (CaCl₂). The results study of [11] also reported that the application of calcium at a dose of 3.5 tonnes/ha reduced the yellow latex on the mangosteen rind. Furthermore, the results study of [8] in 2016 found that the provision of calcium from both dolomite (CaMg(CO₃)₂) and calcite (CaCO₃) was able to reduce yellow latex contamination on arils and mangosteen rind. It also stated, based on efficiency and effectiveness, the dose of calcium calcite (CaCO₃) fertilizer of 1.6 kg/tree/year is a better dose than the treatment of 3.2 kg of calcium dolomite/tree/year [8].

**Table 2. Effect of various doses of calcium on yellow latex contamination in rind and arils.**

| Treatments | Yellow latex on mangosteen rind | Yellow latex on mangosteen aril |
|------------|--------------------------------|--------------------------------|
|            | 1st week | 2nd week | 3rd week | 4th week | 1st week | 2nd week | 3rd week | 4th week |
| Control    | 1.0ᵃ     | 1.0ᵇ     | 1.0ᵇ     | 1.0ᵃ     | 0.6ᵃ     | 0.8ᵇ     | 0.8ᵇ     | 1.0ᵇ     |
| P1         | 1.0ᵃ     | 1.0ᵇ     | 1.0ᵇ     | 1.0ᵃ     | 0.2ᵇ     | 0.0ᵇ     | 0.0ᵇ     | 0.0ᵇ     |
| P2         | 0.0ᵇ     | 0.6ᵇ     | 0.8ᵇ     | 0.8ᵃ     | 0.0ᵇ     | 0.2ᵇ     | 0.0ᵇ     | 0.0ᵇ     |
| P3         | 0.0ᵇ     | 0.6ᵇ     | 0.8ᵃ     | 0.8ᵃ     | 0.0ᵇ     | 0.2ᵇ     | 0.0ᵇ     | 0.0ᵇ     |
| P4         | 0.2ᵇ     | 0.2ᵇ     | 0.2ᵇ     | 0.8ᵃ     | 0.2ᵇ     | 0.0ᵇ     | 0.0ᵇ     | 0.0ᵇ     |
| P5         | 0.2ᵇ     | 0.2ᵇ     | 0.0ᵇ     | 0.8ᵃ     | 0.0ᵇ     | 0.0ᵇ     | 0.0ᵇ     | 0.0ᵇ     |

Calcium is the most important nutrient in maintaining the integrity of the cell walls and the elasticity of cell support in fruit trees. Fruit trees that are deficient in calcium will cause cell membranes to be weak and leaky. The fruit becomes soft and rotten and is susceptible to pests and diseases [14].

Table 2 also shows that all treatments from a dose of 2 to 6 kg/tree (P1-P5) for the yellow latex contamination on arils had a significant effect compared to controls starting at the 2nd week of observation the 4th week. These results showed that the addition of calcium could reduce yellow latex on arils. According to [2], the decreased percentage of yellow latex on fruit arils was thought to be related to the fulfillment of calcium and boron needs in the mangosteen rind, which caused the walls of the epithelial cells of the yellow latex channels in the fruit arils to be tough. The results study by [15] found that the provision of calcium using gypsum reduced the percentage of yellow gummy fruit.

**Table 1. Effect of various doses of calcium on fruit weight and fruit dots.**

| Treatments | 1st week | 2nd week | 3rd week | 4th week | 1st week | 2nd week | 3rd week | 4th week |
|------------|----------|----------|----------|----------|----------|----------|----------|----------|
| Control    | 79.56ᵇ   | 75.26ᵇ   | 76.50ᵇ   | 88.98ᵃ   | 1ᵃ       | 1ᵃ       | 1ᵃ       | 1ᵃ       |
| P1         | 80.44ᵇ   | 79.28ᵇ   | 60.06ᵇ   | 82.48ᵃ   | 1ᵃ       | 1ᵃ       | 1ᵃ       | 1ᵃ       |
| P2         | 89.44ᵃ   | 75.90ᵇ   | 70.72ᵇ   | 81.48ᵃ   | 1ᵃ       | 1ᵃ       | 1ᵃ       | 1ᵃ       |
| P3         | 88.66ᵃ   | 82.54ᵇ   | 80.70ᵃ   | 90.12ᵃ   | 1ᵃ       | 1ᵃ       | 1ᵃ       | 1ᵃ       |
| P4         | 75.70ᵇ   | 91.30ᵃ   | 69.82ᵇ   | 88.36ᵃ   | 1ᵃ       | 1ᵃ       | 1ᵃ       | 1ᵃ       |
| P5         | 70.19ᶜ   | 77.76ᵇ   | 77.84ᵃ   | 83.86ᵃ   | 1ᵃ       | 1ᵃ       | 1ᵃ       | 1ᵃ       |

Table 2 shows that the treatment of calcium doses 3-6 kg/tree (P2-P5) is significantly different from 2 kg/tree (P1) and control. It means that observation could reduce yellow latex in the mangosteen fruit at a dose of 3 to 6 kg/tree in the first week. In the second week, the treatment dose was 4 to 6 kg/tree (P3-P5) showed a reduction in yellow latex contamination. At the third week of observation, the yellow latex contamination reduced at the 5 to 6 kg/tree treatment doses (P4-P5). As for the fourth-week observation, all the doses were not significantly different, which means the yellow latex contamination had started to reappear in the fourth week. From these results, it was found that the higher the dose of calcium given, the less yellow latex contamination of the fruit skin. However, the effect of calcium decreased in the last observation, namely in the fourth week.
Furthermore, it also stated that the highest rate of fruits with no yellow latex was obtained at a dose of 6 kg of gypsum/tree.

4. Conclusion
The application of calcium using dolomite (CaMg(CO$_3$)$_2$) was able to reduce yellow latex contamination in mangosteen rind at doses of 5 kg/tree, and all doses of calcium applied (2, 3, 4, 5, and 6 kg/tree) were able to reduce yellow latex contamination in arils. The application of calcium with dolomite (CaMg(CO$_3$)$_2$) did not affect fruit weight and dotted on mangosteen.

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