Study of Calcium Spraying to Reduce Yellow Latex on Mangosteen Fruits (*Garcinia mangostana* L.)

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Abstract

Yellow latex is the main problem in mangosteen agribusiness, because it is one factor lowering the fruit quality. Calcium is one of the important elements that strengthening cell wall which was binding with the pectin as a middle lamella component. The objectives of this research were to study the effect of fruit spraying using various kinds of calcium namely $CaCl_2$, $Ca(OH)_2$, and $Ca(NO_3)_24H_2O$ with the concentration of 22.5, 12.33, and 35.757 g/l subsequently and various dosages of $CaCl_2$ namely 0, 5, 15, 22.5 and 30 g/l on the incidence of yellow latex spots, physical and chemical properties on the mangosteen fruit. Calcium spraying in the first year was carried out 5 times at the 2^{nd}, 4^{th}, 6^{th}, 8^{th}, and 10^{th} week after anthesis (WAA), while in the second year the spraying was conducted 7 times at the 2^{nd}, 4^{th}, 6^{th}, 8^{th}, 10th, 12^{th}, and 14^{th} WAA. Randomized block design was applied with three replications. Various calcium applications namely $CaCl_2$, $Ca(OH)_2$, and $Ca(NO_3)_24H_2O$ in the first year were ineffective to reduce yellow latex spot on the outer part of the fruit, but effectively reduced yellow latex spot in aril. $CaCl_2$ applications on various dosages in the second year were effective to reduce yellow latex spot either on the outer part of fruit or in the aril of the fruit, but insignificant among $CaCl_2$ dosage levels. Statistically, calcium content in the exocarp, mesocarp and endocarp of the fruit in the first year was significantly different. Calcium content in the exocarp, mesocarp and endocarp of the fruit in the first year on several calcium spraying treatments was higher than control treatment. In the second year, the calcium content of the pericarp on the 22.5g/l $CaCl_2$ was higher than control treatment but insignifanctly different with other $CaCl_2$ spraying treatments. Fruit spraying treatment in the first and second year were significantly different on the physical and chemical properties of mangosteen fruit except on the vitamin C content and total soluble solid and total titrated acid ratio.

INTRODUCTION

Yellow latex pollutant found on the outer part of the fruit and fruit aril can reduce the number of mangosteen fruits qualified to be exported to various countries. Dorly *et al* (2008) stated that yellow latex found in aril was latex exuded because of the damage of epithelial cell wall of yellow latex secretory ducts in the endocarp and not bacterial exudate. The cause of yellow latex secretory duct damage has not been able to be proven and it was assumed related to the low calcium content in the mongosteen fruit. Calcium is different from the other nutrients because it is transported to the fruit in small number, compared to the leaves. Although calcium is available in the soil, calcium deficiency becomes a problem on several fruits and vegetables (Saure, 2005). To make the calcium application to the fruit effectively conducted, therefore direct spraying of calcium to the fruit was carried out so that it can supply calcium.

Calcium is an element related to physiological disorder on various kinds of fruits and vegetables (Shear, 1975; Harker & Venis, 1991; Ryugo, 1988; Jones & Lunt, 1967; Sharma & Singh, 2009; Chiu, 1980). The low calcium content in pericarp cells related to fruit cracking on various plants such as lychee (Huang *et al.*, 2005; Kanwar *et al.*, 1972), sweet cherry (Brown *et al.*, 1995; Fernandez and Flore, 1998; Sekse *et al.*, 2005), and tomato (Astuti, 2002).

Calcium enters to the fruit through the cuticula, lenticell, trichome base, and stomata (Saure, 2005; Huang , 2005; Bangerth 1979; Schonerr and Bukovac, 1972), however calcium penetration to the fruit is very difficult(Shear, 1975), Therefore, in this research various kinds of calcium application namely $CaCl_2$, $Ca(OH)_2$, and $Ca(NO_3)_2$ $4H_2O$ with spraying repeated freguency at the 2^{nd}, 4^{th}, 6^{th}, 8th, and 10^{th} week after anthesis in the first year and application of various dosages of $CaCl_2$ at the 2^{nd}, 4^{th}, 6^{th}, 8^{th}, 10^{th}, 12^{th}, and 14^{th} week after anthesis in the second year.

This article reported study results which objectives were to know the effecs of calcium fruit spraying to reduce yellow latex pollutant on mangosteen fruit and to study the effect of calcium on physical and chemical properties of mangosteen fruit.

MATERIALS AND METHOD

Time and Location of Research

The research was conducted from September 2006 to March 2007 in the first year and from October 2007 to April 2008 in the second year in mangosteen production center in Leuwiliang subdistrict, Bogor resident. Physical and chemical properties of fruit analysis were conducted in Center for Tropical Fruit Studies (PKBT) Bogor Agriculture University. While calcium content in pericarp analysis was conducted in the Laboratory of Soil Science, Bogor Agriculture University.

Research Methods

Various kinds of calcium spraying treatment of $CaCl_2$, $Ca(OH)_2$, $Ca(NO_3)_2$,$4H_2O$ and various dosages of $CaCl_2$ on fruit were conducted on approximately 30 years old mangosteen trees.

Fruit labelling was carried out on 20 flowers per tree to determine fruits which would be treated with calcium spraying. Fruits were harvested approximately 112 days after anthesis.

Research in the first year was fruit spraying using various kinds of calcium, namely $CaCl_2$, $Ca(OH)_2$, $Ca(NO_3)_2$,$4H_2O$. Calcium fruit spraying treatments were given either solely or combined with chelating agents i.e. citric acid and auxin compound, NAA, consisted of

1. control
2. $CaCl_2$ 22.5 g/l
3. $CaCl_2$ 22.5 g/l + NAA 40 mg/l
4. $CaCl_2$ 22.5 g/l + citric acid 27 mmol/l
5. $CaCl_2$ 22.5 g/l + NAA 40 mg/l + citric acid 27 mmol/l
6. $Ca(OH)_2$ 12.33 g/l
7. $Ca(OH)_2$ 12.33 g/l + NAA 40 mg/l
8. $Ca(OH)_2$ 12.33 g/l + citric acid27 mmol/l
9. $Ca(OH)_2$ 12.33 g/L + NAA 40 mg/l + citric acid 27 mmol/l
10. $Ca(NO_3)_2 4H_2O$ 35.757 g/l
11. $Ca(NO_3)_2 4H_2O$ 35.757 g/L + NAA 40 mg/l
12. $Ca(NO_3)_2 4H_2O$ 35.757 g/l + citric acid 27 mmol/l
13. $Ca(NO_3)_2 4H_2O$ 35.757 g/l + NAA 40 mg/l + citric acid 27 mmol/l.

Whereas research in the second year was fruit spraying using various dosages of $CaCl_2$ which consisted of:

1. control
2. $CaCl_2$ 5 g/l+ citric acid 5 g/l
3. $CaCl_2$ 15 g/l + citric acid 5 g/l
4. $CaCl_2$ 22.5 g/l + citric acid 5 g/l
5. $CaCl_2$ 30 g/l + citric acid5 g/l

Calcium was diluted with 1 liter of water, then prostiker surfactanct was added with concentration of 0.5 ml/l solution. Calcium spraying using hand sprayer was conducted directly on the fruit until the fruit was thorughly wet with approximately 10 ml each fruit at the 2^{nd}, 4^{th}, 6^{th}, 8^{th} and 10^{th} week after anthesis in the first year and at the 2^{nd}, 4^{th}, 6^{th}, 8^{th}, 10^{th}, 12^{th}, 14^{th} week after anthesis in the second year. Randomized block design was applied with three replications.

The major parameter observed was measurement of yellow latex pollutant on the outer part of fruit and aril of mangosteen fruit. The measurement was conducted by using Kartika (2004) scoring. Calcium content in pericarp was determined with AAS (Atomic Absorption Spectrophotometer, Perkin Elmer Model 1100B). Calcium content was observed in exocarp, mesocarp and endocarp in the first year, while in the second year calcium content in the fruit was measured in pericarp only. The observation of fruit weight, fruit skin weight, aril weight, seed weight of mangosteen used analytical balance. Transversal and longitudinal diameters and skin thickness were measured by calipers. Edible portion was stated in percentage. Total soluble solid (^{o}brix) was measures using refractometer. Total titrated acid (%) was measured through titrated acid. Total soluble solid and total titrated acid ratio was obtain from the ratio of total soluble solid and total titrated acid.

RESULTS AND DISCUSSION

Yellow Latex in Mangosteen Fruit

Table 1 showed various calcium spraying namely $CaCl_2$, $Ca(OH)_2$, $Ca(NO_3)_2$,$4H_2O$ without or combined with chelating agent i.e. citric acid and growth controling agent, naphthalele-acetic acid (NAA), with spraying repeated frequencies through fruit at the 2nd, 4th, 6th, 8th and 10th week after anthesis in the first year were not effective to reduced the yellow latex pollutant on the outer part of the fruit, but effective to reduced the yellow latex incident in the fruit aril.

The score of yellow in fruit aril was lower at the $CaCl_2$+NAA and $Ca(OH)_2$ + NAA spraying treatments and was not significantly different from other treatments except from $CaCl_2$+Ca and $Ca(NO_3)_2 4H_2O$+CA. It seen that $Ca(OH)_2$ played bigger role to reduce yellow latex in the fruit aril compare with $Ca(NO_3)_2,4H_2O$. The response of plant to the calcium type to reduce damage fruit was not same. Callan (1986) reported that $Ca(OH)_2$ was more effective compare with $CaCl_2$ to reduced cracking fruit rate on sweet cherry, whereas Huang (2005) reported that $Ca(NO_3)_2$ solution was more effective to reduce fruit cracking on lychee compared with $CaCl_2$. The yellow latex score in the outer part of fruit and aril did not show linear, quadratic or cubic response pattern.

Table 1 The effect of various calcium spraying on yhe yellow latex score in the first year.

Treatment	Yellow latex score (1-5) Outer part of fruit skin	Fruit aril
Control (1)	1.81	1.21 ab
$CaCl_2$ (2)	1.57	1.16 ab
$CaCl_2$+CA (3)	1.58	1.46 a
$CaCl_2$+NAA (4)	1.42	1.02 b
$CaCl_2$+CA+NAA (5)	1.42	1.17 ab
$Ca(OH)_2$ (6)	1.55	1.23 ab
$Ca(OH)_2$+CA (7)	1.77	1.15 ab
$Ca(OH)_2$+NAA (8)	1.51	1.09 b
$Ca(OH)_2$+CA+NAA (9)	1.52	1.16 ab
$Ca(NO_3)_2 4H_2O$ (10)	1.70	1.15 ab
$Ca(NO_3)_2 4H_2O$ +CA (11)	1.69	1.44 a
$Ca(NO_3)_2 4H_2O$ +NAA (12)	1.62	1.35 ab
$Ca(NO_3)_2 4H_2O$ +CA+NAA (13)	1.43	1.19 ab
Response curve		
- Linear	-	-
- Quadratic	-	-

Note: Number followed by different letter on the same column showed significant difference based on DMRT test at 5% level. Response curve was examined by finding its optimum value; * = significant at 5% test level; ** = significant at 1% test level; - = no significant difference.

The addition of growth controlling agent NAA in this research showed significantly different to reduce yellow latex score in aril compared with chelating agent (CA). Growth controlling agent NAA capable of raising the transport and accumulation of calcium to the fruit. Nevertheless, calcium addition with chelating agent was better compared with mere calcium application without chelating agent. This is accordance with research reported by Combrink *et al.* (1995) and Brown *et al.* (2005) in Huang *et al.* (2005) that calcium addition with chelating agent could reduce fruit cracking on melon and sweet cherry. Huang (2005) reported that the addition of chelating agent CA and growth controlling agent NAA to $CaCl_2$ could reduce fruit cracking on lychee compare with mere $CaCl_2$.

Application of $CaCl_2$ on various dasages combined with chelating agent CA with the repeated frequency of spraying on the fruit at the 2nd, 4th, 6th, 8th, 10th, 12th, 14th week after anthesis in the second year were effective to reduce yellow latex incident either on the outer part of the fruit or in the fruit aril, however there were no significant differences among various dosages of $CaCl_2$ (Table 2).

Table 2 The effect of various dosages of calcium spraying on the yellow latex score in the second year

Treatment	Yellow latex score (1-5) Outer part of fruit	Yellow latex score (1-5) Fruit aril
Control	4.25 a	2.52 a
$CaCl_2$ (5g/l) + CA (5g/l)	3.07 b	1.60 b
$CaCl_2$ (15g/l) + CA (5g/l)	2.97 b	1.27 b
$CaCl_2$ (22.5g/l) + CA (5g/l))	2.79 b	1.19 b
$CaCl_2$ (30g/l) + CA (5g/l)	2.34 b	1.35 b
Response curve		
- Linear	**	*
- Quadratic	**	**
- Qubic	**	**

Note: Number followed by different letter on the same column showed significant difference based on DMRT test at 5% level. Response curve was examined by finding its optimum value; * = significant at 5% test level; ** = significant at 1% test level; - = no significant difference.

Calcium was directly applied to the fruit in this research because it was applied through the leaves it did not guarantee to increase calcium in the fruit. It was related to the immobile characteristic of calcium and very little possibility it was transported through phloem (Bangerth, 1979). Calcium was transported inside through apoplast diffusion namely through cell wall system and intercellular space into fruit pericarp (Saure, 2005; Glen *et al.*, 1985). The dynamic and factors affecting the path or absorbtion of calcium into the fruit up to now have not entirely understood yet (Saure, 2005). Saure (2005) reported that calcium concentration in the apple fruit can change during fruit development and is not uniform in the whole fruit parts. In the mature fruit the highest calcium concentration in apple fruit was found in the skin, and the lowest in the fruit aril.

Calcium application on fruit was added surfactant compound, i.e. non-ionic (un charge) prostiker which function was to wet calcium compound so that it can easily penetrated into fruit pericarp. Chemistry compounds of cell wall components are particularly cellulose, pectin, hemicellulose and lignin, whereas cuticula, cutin,suberin, and wax compounds are cell wall components of fruit epidermis or exocarp (Esau, 1974; Nobel 1999; Taiz and Zeiger, 1991).

The aim of spraying repeatation was to raise calcium concentration in fruit pericarp. Huang el. (2005) reported the application of $CaCl_2$ with the repeated frequency, namely at the 4th, 6th, 6th and 8th week after anthesis on the lychee were more effective to reduce fruit cracking compared with control. On tomato, two and three times calcium salt $CaCl_2$ preharvest spraying could raise calcium content in tomato fruit on the control became 0.907 mg/g in the two application times and 0.977 mg/g in the three aplication times (Astuti, 2002). Furthermore Marscner (1995) suggested because of calcium immobility, therefore repeated spraying application to fruit will be more effective.

Calcium Content of Fruit Pericarp

Calcium content in the fruit exocarp, mesocarp and endocarp in the first year were significantly different statiscally (Table 3). The highest calcium content in the fruit exocarp was found on the treatments of $Ca(OH)_2$ + NAA and $Ca(OH)_2$ +CA+NAA. The highest calcium content in the fruit mesocarp was also found on the $Ca(OH)_2$+NAA treatment, whereas the highest calcium content in the endocarp was found in the $Ca(NO_3)_2 4H_2O$ +CA+NAA. The highest calcium content in the exocarp and mesocarp on $Ca(OH)_2$ + NAA treatment was assumed related to the low score of yellow latex in the aril.

Table 3 The effect of various calcium fruit spraying on calcium content in mangosteen fruit pericarp in the first year.

Treatment	Calcium content in fruit pericarp (%)		
	Exocarp	Mesocarp	Endocarp
Control (1)	0.42 b	0.36 bc	0.39 bc
$CaCl_2$ (2)	0.36 c	0.33 cde	0.30 ef
$CaCl_2$+CA (3)	0.29 e	0.24 f	0.26 f
$CaCl_2$+NAA (4)	0.35 cd	0.34 bcd	0.39 bc
$CaCl_2$+CA+NAA (5)	0.44 ab	0.32 cde	0.37 cd
$Ca(OH)_2$ (6)	0.33 cde	0.31 cde	0.30 ef
$Ca(OH)_2$+CA (7)	0.35 cde	0.30 cdef	0.34 cde
$Ca(OH)_2$+NAA (8)	0.49 a	0.44 a	0.42 ab
$Ca(OH)_2$+CA+NAA (9)	0.48 a	0.32 cde	0.32 de
$Ca(NO_3)_2 4H_2O$ (10)	0.35 cd	0.28 def	0.32 e
$Ca(NO_3)_2 4H_2O$ +CA (11)	0.31 cde	0.40 ab	0.39 bc
$Ca(NO_3)_2 4H_2O$ +NAA (12)	0.29 e	0.29 cdef	0.30 ef
$Ca(NO_3)_2 4H_2O$ +CA+NAA (13)	0.30 de	0.27 ef	0.46 a

Note: Number followed by different letter on the same column showed significant difference based on DMRT test at 5% level.

In the second year, the calcium content on the pericarp of the 22.5 g $CaCl_2$ treatment was higher than that in control, but insignificantly different from the other $CaCl_2$ spraying. Research result in the second year showed that fruit spraying with various dosages of $CaCl_2$ significantly affected the raise of calcium content in the fruit pericarp compared with control. In tomato, $CaCl_2$ preharvest spraying could raise the calcium content in tomato fruit (Astuti, 2002), while in lychee fruit, fruit cracking resistant variety showed higher calcium content compared with susceptible variety.

Table 4 The effect of various dosages of calcium fruit spraying on calcium content in mangosteen fruit pericarp in the second year.

Treatment	Calcium content in fruit pericarp (%)
Control	0.16 b
$CaCl_2$ (5g/l) + CA (5g/l)	0.24 ab
$CaCl_2$ (15g/l) + CA (5g/l)	0.17 ab
$CaCl_2$ (22.5g/l) + CA (5g/l)	0.25 a
$CaCl_2$ (30g/l) + CA (5g/l)	0.23 ab

Note: Number followed by different letter on the same column showed significant difference based on DMRT test at 5% level.

Physical Properties of Mangosteen Fruit

The results of measurement in the first year in Table 5 indicated that every spraying treatment of various calcium significantly affected on the transversal and longitudinal diameters, fruit and seed weigh. Compared with control, spraying treatments of various calcium did not raise either fruit transversal diameter or fruit longitudinal diameter, fruit and seed weight. This is in accordance with the research conducted by Callan (1986) that reported application of various calcium on sweet cherry did not affect on fruit measurements.

Measurement results in the second year in Table 6 showed that every spraying treatment of various calcium significantly affect on the transversal diameter, weight and epicarp hardness level. Table 6 indicated that the highest transversal diameter and fruit weight were found on fruit spraying treatment with 15 g $CaCl_2$ were significantly different from fruit spraying treatment with 5 and 30 g/l but were not significantly different from control.

Table 5 The effect various calcium spraying on fruit diameter, fruit and seed weight of mangosteen in the first year.

Treatment	Transversal diameter (cm)	Longitudinal diameter (cm)	Fruit weight (g)	Seed weight (g)
Control (1)	5.64 ab	5.23 ab	87.04 ab	1.50 abc
$CaCl_2$ (2)	5.51 abc	5.11 abc	83.17 abc	1.54 abc
$CaCl_2$+CA (3)	5.74 a	5.41 a	93.82 a	1.19 bc
$CaCl_2$+NAA (4)	5.51 abc	5.20 ab	83.24 abc	1.71 abc
$CaCl_2$+CA+NAA (5)	5.36 bcd	5.10 abc	72.71 bc	1.29 bc
$Ca(OH)_2$ (6)	5.55 abc	5.27 ab	87.31 ab	1.88 ab
$Ca(OH)_2$+CA (7)	5.44 abc	5.10 abc	78.46 abc	1.03 c
$Ca(OH)_2$+NAA (8)	5.12 d	4.76 c	66.50 c	1.31 bc
$Ca(OH)_2$+CA+NAA (9)	5.36 bcd	4.99 bc	79.91 abc	1.91 ab
$Ca(NO_3)_2 4H_2O$ (10)	5.45 abc	5.14 abc	73.89 bc	2.22 a
$Ca(NO_3)_2 4H_2O$ +CA (11)	5.54 abc	5.24 ab	87.64 ab	1.73 abc
$Ca(NO_3)_2 4H_2O$ +NAA (12)	5.31 cd	4.94 bc	73.42 bc	1.52 abc
$Ca(NO_3)_2 4H_2O$ +CA+NAA (13)	5.44 abc	4.97 bc	79.20 abc	1.64 abc

Note: Number followed by different letter on the same column showed significant difference based on DMRT test at 5% level.

Table 7 showed that fruit spraying with various calcium in the first year affected significantly on the thickness and hardness of fruit pericarp and edible portion. The thickest pericarp were found on control treatment and fruit spraying with $Ca(OH)_2$ namely 0.71 cm but insignificantly different from the treatments of 2, 3, 4, 5, 7 and 11.

Table 6 The effect of various dosages of calcium spraying on the diameter, fruit weight and pericarp hardness of mangosteen in the second year.

Treatment	Transversal diameter (cm)	Fruit weight (g)	Pericarp hardness (kg)
Control	5.95 a	114.51 a	0.75 a
$CaCl_2$ (5g/l) + CA (5g/l)	5.54 bc	94.90 bc	0.71 ab
$CaCl_2$ (15g/l) + CA (5g/l)	5.98 a	115.03 a	0.68 b
$CaCl_2$ (22.5g/l) + CA (5g/l)	5.74 ab	105.34 ab	0.69 b
$CaCl_2$ (30g/l) + CA (5g/l)	5.31 c	82.34 c	0.7 ab

Note: Number followed by different letter on the same column showed significant difference based on DMRT test at 5% level.

Table 7 The effect of various calcium fruit spraying on the thickness and hardness of fruit pericarp and edible portion in the first year.

Treatment	Skin thickness (cm)	Fruit skin hardness (kg)	Edible portion (%)
Control (1)	0.71 a	1.52 ab	31.81abcd
$CaCl_2$ (2)	0.65 abc	1.56 ab	31.62abcd
$CaCl_2$+CA (3)	0.67 abc	1.75 a	32.07abcd
$CaCl_2$+NAA (4)	0.67 abc	1.56 ab	29.97 cd
$CaCl_2$+CA+NAA (5)	0.65 abc	1.64 ab	31.08 bcd
$Ca(OH)_2$ (6)	0.71 a	1.41 b	29.73 d
$Ca(OH)_2$+CA (7)	0.70 ab	1.75 a	33.19 ab
$Ca(OH)_2$+NAA (8)	0.61 c	1.60 ab	29.99 cd
$Ca(OH)_2$+CA+NAA (9)	0.61 c	1.43 b	31.94 abcd
$Ca(NO_3)_2 4H_2O$ (10)	0.58 c	1.47 b	33.85 a
$Ca(NO_3)_2 4H_2O$ +CA (11)	0.63 abc	1.57 ab	33.28 ab
$Ca(NO_3)_2 4H_2O$ +NAA (12)	0.62 bc	1.62 ab	32.03 abcd
$Ca(NO_3)_2 4H_2O$ +CA+NAA (13)	0.61 c	1.64 ab	32.45 abc

Note: Number followed by different letter on the same column showed significant difference based on DMRT test at 5% level

Table 7 showed that the highest fruit pericarp hardness (1.75 kg) was found on calcium fruits spraying treatment of $CaCl_2$ + CA and $Ca(OH)_2$ +CA but insignificantly different from the treatments of control, 2, 4, 5, 8, 11, 12 and 13. Satuhu (2004) stated that soaking fruit in the $CaCl_2$ solution could improve fresh fruit texture. Fruit texture became harder so that the either transpiration or respiration rate could be suppressed.

Chemical Properties of Mangosteen Fruit

The effect of fruit spraying using various calcium in the first year was significantly different on the total soluble solid (TSS) and total titrated acid (TTA). However it was insignificantly different on the TSS/TTA ratio (Table 8). In Table 8, the highest TSS was found in the fruit spraying treatment with $CaCl_2$ + CA+NAA eventhough it was insignificantly different from control and other calcium spraying treatments except with $Ca(OH)_2$ +CA.

On Table 8, eventhough TSS and TTA value among treatments were significantly different but the TSS/TTA ratio were insignificantly different. Therefore, the fruit spraying treatments did not affect mangosteen quality.

Table 9 showed that fruit spraying treatment with various dosages of calcium in the second year were significantly different for TSS, TTA, and TSS/TTA ratio. This table showed that $CaCl_2$ fruit spraying treatments raised TSS value compared with control. This is in accordance with Callan research (1986) that reported $Ca(OH)_2$ spraying application on sweet cherry fruit raised TSS compared with control. The highest TSS value (19.82 ^{o}brix) was found on 5 g/l $CaCl_2$ fruit spraying treatment eventhough it was insignificantly different from the 15 to 30 g/l $CaCl_2$ dosages.

On Table 9 the lowest TTA value (0.55%) was found on fruit spraying treatment with 22.5 g/l $CaCl_2$. On the same treatment TSS/TTA ratio value was the highest, and sigficantly different from control and other $CaCl_2$ dosages. Sjaifullah (1986) stated that TSS described sweet taste and fruit maturity degree. Calcium ion played a role in regulation and α-amylase synthesis on barley and rice (Jones and Carbonell, 1984; Mitsui *et al.*, 1984). Therefore the higher α-amylase enzyme level, the higher amylum substance hydrolysis to become sugar would raise so that fruit sweetness level was affected by calcium content in the fruit. Sugar/acid ratio was one of the parameters to assess the fruit quality (Lod and Pantastico, 1986).

The results of this research showed that various calcium spraying application on fruit could reduce yellow latex pollutant on fruit. Direct spraying of various calcium on fruit was very difficult to be applied if it was conducted in quite wide mangosteen plantation because skilful worker was required. From this research was known that calcium application could reduce yellow latex incident on mangosteen. However the calcium application method carried out was not effective and economical enough. Therefore further research is required to be carried out to improve the calcium application so that it will be more effective and economical.

Table 8 The effect various calcium spraying on total soluble solid (TSS), total titrated acid (TTA), and TSS/TTA ratio in the first year.

Treatment	TSS (°brix)	TTA (%)	TSS/TTA ratio
Control (1)	19.64 ab	0.23 ab	85.32
$CaCl_2$ (2)	19.90 ab	0.23 ab	86.63
$CaCl_2$+CA (3)	20.15 ab	0.23 ab	84.45
$CaCl_2$+NAA (4)	19.66 ab	0.24 a	81.87
$CaCl_2$+CA+NAA (5)	20.49 a	0.22 ab	91.16
$Ca(OH)_2$ (6)	19.68 ab	0.23 ab	85.08
$Ca(OH)_2$+CA (7)	18.25 b	0.23 ab	81.24
$Ca(OH)_2$+NAA (8)	20.26 a	0.23 ab	88.70
$Ca(OH)_2$+CA+NAA (9)	19.94 ab	0.23 ab	84.56
$Ca(NO_3)_2 4H_2O$ (10)	20.32 a	0.23 ab	89.42
$Ca(NO_3)_2 4H_2O$ +CA (11)	19.55 ab	0.21 b	94.36
$Ca(NO_3)_2 4H_2O$ +NAA (12)	20.49 a	0.23 ab	90.99
$Ca(NO_3)_2 4H_2O$ +CA+NAA (13)	19.58 ab	0.23 ab	87.16

Note: Number followed by different letter on the same column showed significant difference based on DMRT test at 5% level.

Tabel 9 The effect of various dosages of calcium spraying on total soluble solid (TSS), total titrated acid (TTA), and TSS/TTA ratio in the second year

Treatment	TSS (°brix)	TTA (%)	TSS/TTA ratio
Control	18.57 b	0.61 b	30.60 b
$CaCl_2$ (5g/l) + CA (5g/l)	19.82 a	0.65 ab	30.35 b
$CaCl_2$ (15g/l) + CA ((5g/l)	19.41 ab	0.69 a	28.34 b
$CaCl_2$ (22.5g/l) + CA (5g/l)	19.06 ab	0.55 c	34.66 a
$CaCl_2$ (30g/l) + CA (5g/l))	19.38 ab	0.63 b	30.78 b

Note: Number followed by different letter on the same column showed significant difference based on DMRT test at 5% level.

CONCLUSION

1. Applications of various calcium namely $CaCl_2$, $Ca(OH)_2$, dan $Ca(NO_3)_2 4H_2O$ without or combined with chelating agent i.e. citric acid (CA) and growth regulating substance 1-naphthalene-acetic acid (NAA) in the first year were

ineffective to reduce yellow latex pollutant on the outer part of fruit, but effective to reduce yellow latex pollutant in fruit aril.

2. The applications of various dosages of $CaCl_2$ combined with chelating agent CA in the second year were effective to reduce yellow latex pollutant either on the outer part of fruit or in fruit aril, but insignificantly different among $CaCl_2$ dosages levels.
3. Calcium content in fruit exocarp, mesocarp and endocarp in the first year was significantly different statistically. The high calcium content in fruit exocarp, mesocarp and endocarp on $Ca(OH)_2$+NAA treatment resulted low score of yellow latex in fruit aril. In the second year, calcium content of fruit pericarp on 22.5 g/l $CaCl_2$ treatment was higher than control but insignificantly different from other $CaCl_2$ spraying.
4. Fruit spraying treatment with different calcium in the first year did not raise physical and chemistry properties of mangosteen fruit compared with control. Whereas fruit spraying with various dosages of calcium in the second year was significantly different on the physical and chemical properties of mangosteen fruit. The highest transversal diameter and fruit weight were found on control, 15 and 22.5 g/l $CaCl_2$, TSS value on 5 g/l $CaCl_2$ was higher compared with control, while the highest TSS/TTA ratio was found on 22.5 g/l $CaCl_2$ treatment.

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