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NaCl floatation method on physicochemical quality of Kaew Kamin Mango during harvesting indices

Lueangprasert, K.[1], Pattanayaiying, R.[2], Chuajedton, A.[3], Choojit, S.[4] and Saelim, K.[1*]

[1]Faculty of Agriculture Technology, Burapha University Sakaeo Campus, Sakaeo, Thailand; [2]Faculty of Science and Technology, Suan Sunandha Rajabhat University, Bangkok, Thailand; [3]Faculty of Science, Lampang Rajabhat University, Lampang, Thailand; [4]Faculty of Science and Technology, Muban Chombueng Rajabhat University, Ratchaburi, Thailand.

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Abstract It was found that harvesting stages were significantly affected the fruit quality. Fruit weight of Kaew Kamin mango followed a sigmoidal pattern. NaCl floatation method was not appropriated for determination of harvesting indices (HI) but could be used in cases where indicator for the quality assessment of fruits. SG2 group showed good properties for unripe mangoes, considering as physiological mature. The highest number of fruits in SG2 group (more than 80%) was harvested at 98 DAFB and considered as optimum physiological maturity stage for harvesting Kaew Kamin mango. Conclusively NaCl floatation method could be separated the Kaew Kamin mango quality grading in commercial and physiological maturity period.

Keywords: Kaew Kamin mango, Harvesting indices, NaCl floatation method

Introduction

Kaew Khamin mango (*Mangifera indica* L.) is a fruit product with economic value in Sa Kaeo Province, which has a total production of approximately 50,205 tons and an average production of 1,486 kilograms per rai. Mango orchards are found in many districts, such as Wang Nam Yen, Aranyaprathet, Watthana Nakhon, Khao Chakan, Wang Sombun, and Mueang District, etc. There are also many popular mango varieties, such as Kaew, Nam Dok Mai, Khiew Sawoey, Chokanan, and Fa Lan, etc. Farmers in Sa Kaeo province can produce a large amount of products, with production for domestic consumption and export. Entrepreneurs were use Kaew mango to produce processed products such as pickled mango, mango juice, and dried mango. However, in 2015, the ASEAN Economic Community (AEC) policy had a significant impact on Thai mango farmers, resulting in a large amount of Kaew

[*]**Corresponding Author:** Saelim, K.; **Email:** kriyot@buu.ac.th

Lamiad mango (Kaew Khamin mango or Kaew Khmer) from Cambodia being imported into the Thai mango market.

Kaew Khamin mango is similar to Thai Kaew mango. Its distinctive features are that when mature, the flesh fruit pulp is turmeric yellow. The unripe fruit is light green. The pulp mango tastes sweet and sour, and it is very crispy. The fruit is large. It is popularly eaten unripe with sweet fish sauce or in other menus, such as mango salad and mango papaya salad. If the fruit is ripe, the skin is light yellow, the flesh fruit pulp is yellowish red, few fibers, and tastes sweet and delicious, which it caused this mango variety highly accepted by consumers in Thailand. Currently, Kaew Khamin mango is produced in large quantities. Most of the harvesting depends on the expertise of farmers. It is not possible to control the quality to be consistent. Therefore, it is a major problem in assessing the quality of the product to the needs of consumers, including the difficulty of guaranteeing the quality of the product for domestic sales and exports.

At present, there are many methods to evaluate the quality and completeness of agricultural products, such as counting the number of days after full bloom (DAFB), peel and flesh pulp color, shape, fruit weight, starch content, TSS/TA content, and fruit firmness, etc. Each type of product uses different criteria to classify the maturity, for example, the Thong Dam mango uses counting the days after flowering between 97-106 DAFB, fruit firmness between 1.18-1.32 kg/cm2, grey-orange flesh color 163-168, TSS/TA content between 42.79-49.48 (Ketsa *et al*., 1991). The specific gravity (SG) value was used to classify the mature of the three-year mango variety. SG has less values than 1,000 (floating water), 1,000-1,015 (sinking fruit but floating in 2% sodium chloride; NaCl) 1,015-1,028 (sinking fruit in 2% NaCl but floating in 4% NaCl) 1,028-1,042 (sinking fruit in 4% NaCL but floating in 6% NaCL) etc. (Siripattanakul *et al*., 2002). In Kaew Kamin mango, the SG value at 1.000-1.015 (sinking in water but floating in 2 % NaCl) solution was a method for separating mango quality and can be indicate commercial maturity stage at 91 DAFB (Lueangprasert *et al*., 2023). However, the popular evaluation methods are often non-destructive, easy to do, convenient and fast for farmers or those who want to export.

The objective of this study was to compare quality indexes of Kaew Kamin mango with different NaCl floatation methods and to identify the best harvesting time.

Materials and methods

Plant materials

Kaew Kamin mango fruits (*Mangifera indica* L.) were conducted from the Thung Na Tan Na Chay Dan farm in Aranyaprathet, Sakaeo province, Thailand, between November 2022 to June 2023. The forty mango trees were selected and randomly tagged at 70% of flowering inflorescences. The mango fruits were harvested every week between 70 – 105 days after full bloom (DAFB). On harvest day, 60 fruits were harvested. The mango fruits were cleaned and divided into three groups: those floating in water (specific gravity; SG less than 1.000; SG1), those sinking in water but floating in 2% sodium chloride (NaCl) solution concentration (SG 1.000 to 1.015; SG2) and those sinking in water and 2% sodium chloride (NaCl) solution concentration (SG > 1.015; SG3). For each group of Kaew Kamin mango, physicochemical changes were investigated.

Change of fresh weight, peel and pulp color and firmness

The weight of fruits was measured using a digital balance to an accuracy of 0.1 g, and the average weight of the fresh fruits was calculated and express in grams per fruit.

Peel and pulp color of mango fruits were randomly measured in the center portion with two measurements per fruit by using a colorimeter (3nh, NR110, 3NH Technology CO., LTD., Chaina). The color values were recorded as L*, a*, b*, C* and Hº values. Color values were expressed as Lightness/darkness (L* value), redness/ greenness (a* value), yellowness/blueness (b* value), chroma (C* value) and Hue angle (Hº value).

Firmness of mango fruit was measured using a fruit hardness tester (DESIK, GY-4 series, Germany Desik instruments group limited, Germany) fitted with 8 mm diameter stainless stell cone-shape probe. The probe was allowed to penetrate to a final depth of 5 mm. Firmness was expressed as Newtons (N) for firmness value.

Change of total soluble solids and titratable acidity

Total soluble solids (TSS) content of mango pulp was assessed using hand refractometer (HM, SCM-1000, HM Digital, Korea). A drop of mango pulp was put on the refractometer. TSS was expressed as percentage brix (% brix).

Titratable acidity (TA) content of mango pulp was determined using AOAC method (1995). 10 g of mango pulp was homogenized in deionized (DI) water. The homogenate was filtered and titrated using 0.1 N NaOH and 1-2 drops of 0.1% phenolphthalein as an indicator (end point at pH = 8.2). The TA was expressed as % citric acid (with equivalent weight of 0.07) using the following formula:

Titratable acidity (% citric acid) = [(N x V x 0.07) /weight of sample (g)] x100
Where N, and V are a concentration of NaOH (N), and volume of NaOH (ml), respectively.

Change of ascorbic acid

Ascorbic acid (AA) content of mango pulp was measured in accordance with AOAC method (2000). Briefly, 10 ml of standard AA (10 mg AA in 100 ml of 0.4% oxalic acid solution; 100 µg/ml) was titrated with 2,6-dichlorophenol-indophenol dye solution until the appearance of pink color (V_1). 10 g of mango pulp (W) was homogenized with 0.4% oxalic acid solution and then adjusted to 100 ml with the same solution. The mixture was filtered through a Whatman No.1 filter-paper. A 10-ml aliquot was taken for titration with 2,6-dichlorophenol-indophenol dye solution until the appearance of pink color (V_2). The AA content was calculated using the formula:
Ascorbic acid (mg/100g) = [(V_2 x 1 mg x 100 ml / (V_1 x ml x W)] x 100 g)

Change of electrolyte leakage

Electrolyte leakage (EL) of mango pulp was determined by modified method of Hong and Gross (1998). Briefly, 15 pieces (approx. 10 g) of mango pulp cylinders were cut into 1 cm thick and 1 cm diameter by using cork borer. Samples were cleaned with DI water and dried with tissue paper. After that, the samples were soaked in 350 ml of 0.4 M mannitol solution at room temperature for 1 h. The conductivity of the EL in the mannitol solution was measured using a conductivity meter (Mettler Toledo, S230, Switzerland) as EL_1. After that, the samples were heated at at 121°C for 30 min using autoclave. After cooling at room temperature, the final electric conductivity was measured and recorded as EL_2. %EL value was calculated according to formula.
Electrolyte leakage (%) = (EL_1 x 100) / EL_2

Total antioxidant activity and total phenolic content

For ethanolic extraction, the mango pulp (1 g) was extracted with 25 ml of 80% ethanol and homogenized for 1 min at 4 °C. The extract solution was centrifuged at 12,000 rpm for 30 min at 4 °C (Hermle centrifuge Z326k, Germany). The supernatant was collected for further analysis.

Total antioxidant activity

Total antioxidant activity of ethanolic extracts of mango pulp was determined by modified method of Mun'im *et al.* (2003). 100 µl of samples was

added in 400 µl of 0.3 M acetate buffer (pH 5.5) and 2.5 ml of 0.10 mM 1,1-Diphenyl-2-picrylhydrazyl (DPPH) in 80% ethanol. The reaction mixture was mixed and incubated in complete darkness for 30 min at room temperature (25 ± 2 ºC). The absorbance was measured at 517 nm using the UV-Vis spectrophotometer (C-7200 Peak Instrument Co., Ltd. Chaina). 100 µl of 80% ethanol in place extract was used as the blank. Total antioxidant activity was calculated using regression equation between Trolox concentration and the percentage of DPPH inhibition and were expressed as micromole per 100 g of fresh weight (µmol/100 g FW).

Total phenolic content

Total phenoic content was performed by modified Folin-Ciocalteu methods of Singleton and Rossi (1965). 2 ml of samples were pipetted into 10 ml of 10% Folin-Ciocalteu's phenol reagent and kept at room temperature. After 8 min, 8 ml of 7.5% Na_2CO_3 solution was added and incubated at room temperature for 2 h before measuring the absorbance at 765 nm using the UV-Vis spectrophotometer. Total phenolic content was calculated as milligrams per 100 g of fresh weight (mg/100 g FW) by using gallic acid calibration curve.

Total carotenoid content

The total carotenoid content was modified according to the method of More and Rao (2019). 1 g of mango pulp (W) was extracted with 14 ml of cold extractant (hexane: acetone, 3:2 v/v) and incubated in complete darkness for 1.5 h at 4 ºC. And then, the extract samples were centrifuged at 10,000 rpm for 10 min at 4 ºC. The mixture was adjusted to 25 ml with the same extractant solution. The absorbance was measured at 450 nm using the UV-Vis spectrophotometer (A_{450}). The total carotenoid content was calculated following the formula and expressed as µg per g FW.

Total carotenoid (µg/ g FW) = [(A_{450} x 4) /weight of sample (g)] x 100

Where 4 is a coefficient of equations.

Statistical analysis

For this experiment, the statistical difference analysis of mean results was performed using analysis of variance (ANOVA) and Independent-Samples T-Test. The test for differences in means of treatment combinations was using T-Test and Duncan's multiple range test of post hoc multiple comparisons by IBM SPSS statistic 26 (Trial version) program, comparing means at a 95% confidence level ($p<0.05$).

Results

Fresh weight, peel and pulp color and firmness value

Fruit weight of Kaew Kamin mango follows a typical sigmoidal pattern. Fruit weight of Kaew Kamin mango significantly increased during fruit development (p<0.05). Fresh weight of kaew Kamin mango increased rapidly up to 70 days after full bloom (DAFB). At 98 DAFB, the highest fruit weight was recorded in SG3 with a value of 474.96 g/fruit, followed by SG2, and SG1, which had weights of 465.28 and 440.39 g/fruit, respectively (Figure 1). Moreover, fresh weight showed an increasing tendency between groups at the same days. Fresh weight was slightly increased in both SG2 and SG3 (p<0.05), but significantly decreased in SG1 (p<0.05). There were no significant differences in fresh weight both SG2 and SG3 (p>0.05).

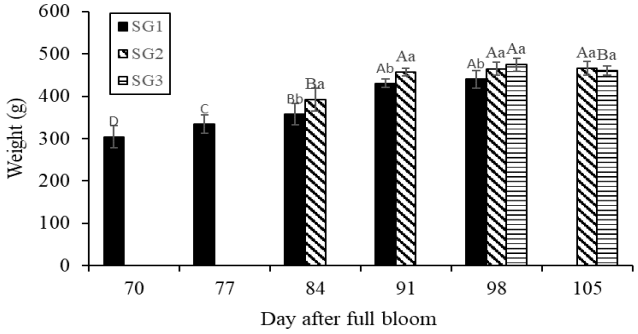

Figure 1. Changes in mango fresh weight during fruit development in floating in water (SG1), sinking in water but floating in 2% NaCl solution (SG2) and sinking in water and 2% NaCl solution (SG3): Error bars showed standard errors of the means. Capital letters above the columns indicate significant differences between the days of the same group. Lowercase letters above the columns indicate significant differences between the groups at the same days (Duncan, $p < 0.05$)

The color changes of mango peels showed as L*, a*, b*, C*, and Hº values (Figure 2). Peel color significantly increased during fruit development (p<0.05). There was a significant difference in the L*, a*, b*, C*, and Hº values of peel color between the days of the same group. Except for L* (both SG2 and SG3), b* (SG3), and Hº (SG3) values did not change during fruit development (p>0.05). L*, a*, b*, and C* values slightly increased between groups at the same days, while Hº values decreased. In addition, no significant differences of peel color were observed between groups at the same days (p>0.05), except at 84 - 91 DAFB, which showed that C* value was significantly higher in SG2 than in SG1 (p<0.05).

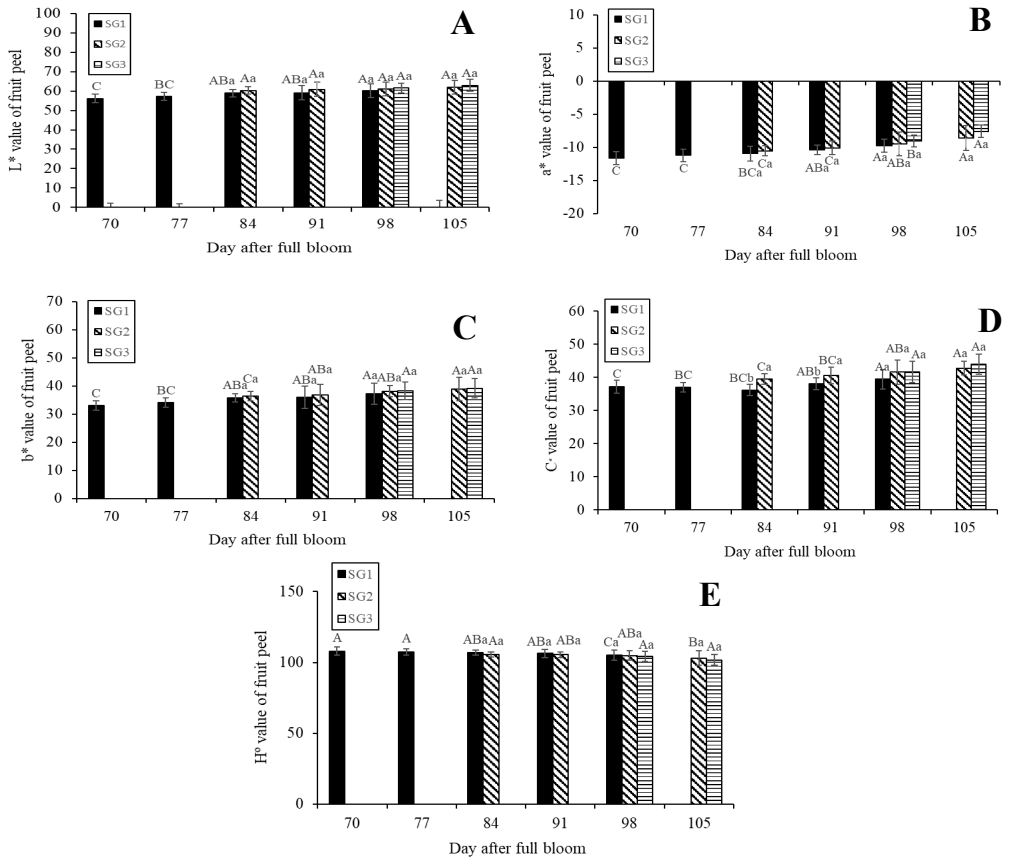

Figure 2. Changes in mango peel color during fruit development. L* (A), a* (B), b* (C), C* (D) and Hº (E) values in floating in water (SG1), sinking in water but floating in 2% NaCl solution (SG2) and sinking in water and 2% NaCl solution (SG3): Error bars showed standard errors of the means. Capital letters above the columns indicate significant differences between the days of the same group. Lowercase letters above the columns indicate significant differences between the groups at the same days (Duncan, $p < 0.05$)

The color changes of mango pulps showed as L*, a*, b*, C*, and Hº values (Figure 3). Pulp color significantly increased during fruit development ($p<0.05$). There was a significant difference in the a*, b*, and C* values of pulp color between the days of the same group. Except for L* (both SG2 and SG3), b* (SG3), C* (SG3), and Hº (SG3) values did not change during fruit development ($p>0.05$). a*, b*, and C* values slightly increased between the days of the same group, while L*, and Hº values decreased. Furthermore, the values of a*, b*, and C* of pulp color showed an increasing tendency between groups at the same

days, whereas Hº value of pulp showed a decreasing tendency. No significant differences of L* value of pulp color was observed between groups at the same days (p>0.05). the highest a*, b*, and C* values was recorded in SG3, followed by SG2, and SG1, respectively.

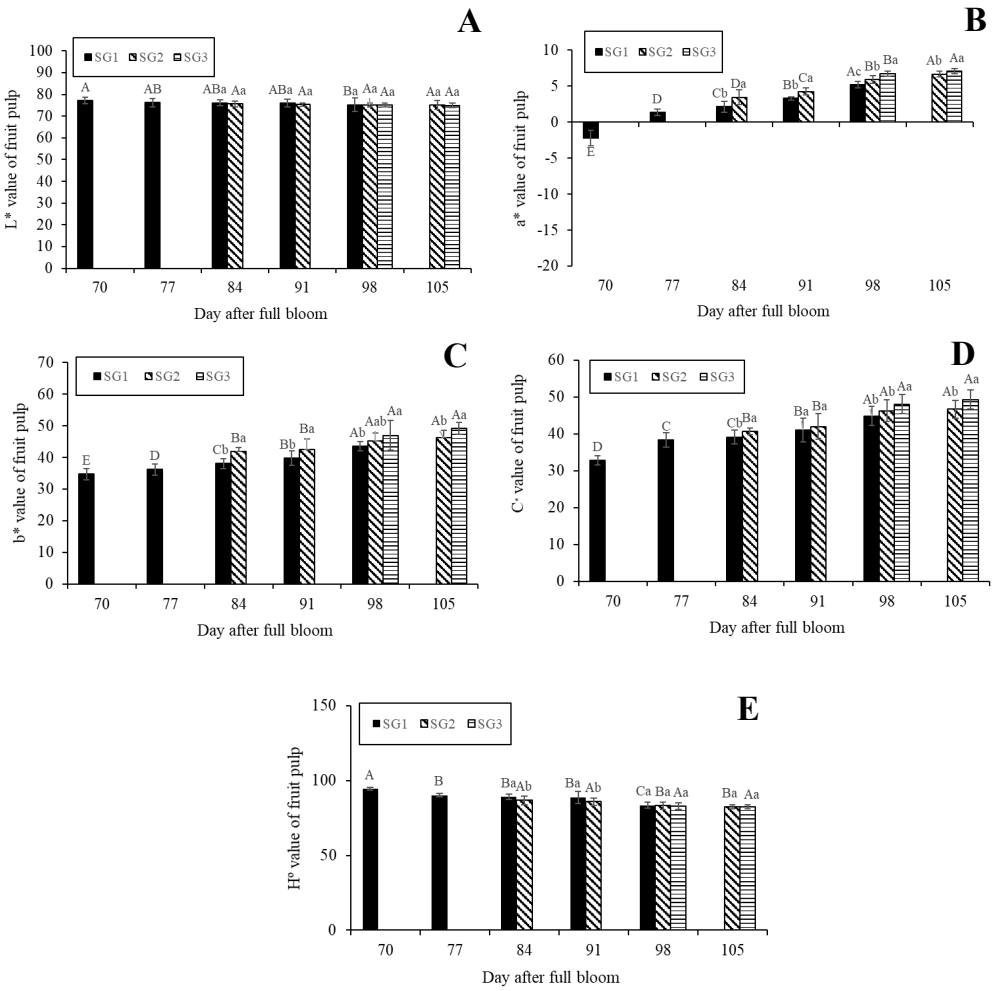

Figure 3. Changes in mango pulp color during fruit development. L* (A), a* (B), b* (C), C* (D) and Hº (E) values in floating in water (SG1), sinking in water but floating in 2% NaCl solution (SG2) and sinking in water and 2% NaCl solution (SG3): Error bars showed standard errors of the means. Capital letters above the columns indicate significant differences between the days of the same group. Lowercase letters above the columns indicate significant differences between the groups at the same days (Duncan, $p < 0.05$)

The firmness changes of mango pulps during fruit development are presented in Figure 4. Pulp firmness significantly increased between groups at the same days and between the days of the same group (p<0.05) until 91 DAFB and then slowly decreased. The highest pulp firmness was recorded in SG2 with a value of 170.78 N, followed by SG1, which had a pulp firmness of 165.16 N.

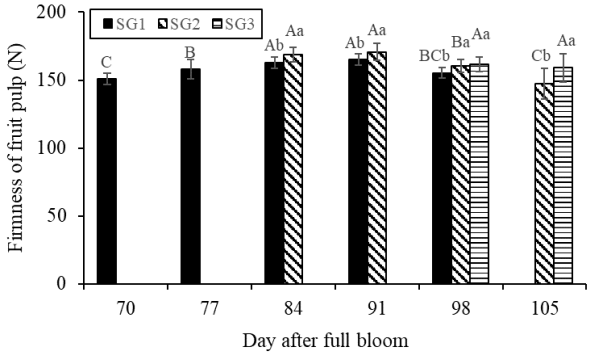

Figure 4. Changes in pulp firmness of Kaew Kamin mango during fruit development in floating in water (SG1), sinking in water but floating in 2% NaCl solution (SG2) and sinking in water and 2% NaCl solution (SG3): Error bars showed standard errors of the means. Capital letters above the columns indicate significant differences between the days of the same group. Lowercase letters above the columns indicate significant differences between the groups at the same days (Duncan, $p < 0.05$)

Total soluble solids and titratable acidity content

Total soluble solid (TSS) and titratable acidity (TA) changes of mango pulps during fruit development are presented in Figure 5. TSS significantly increased between groups at the same days and between the days of the same group (p<0.05), while TA significantly decreased between groups at the same days and between the days of the same group (p<0.05). At difference DAFB, TSS increased slightly until 91 DAFB and then increased slowly. At 91 DAFB, the highest pulp TSS was recorded in SG2 with a value of 9.24 %Brix, followed by SG1, which had a pulp TSS of 8.68 %Brix. Moreover, SG1 showed highest TA at 91 DAFB, while SG2 and SG3 showed lowest TA at 105 DAFB.

Ascorbic acid content

The ascorbic acid content (AA) changes of mango pulps during fruit development are presented in Figure 6. Pulp AA significantly decreased during fruit development (p<0.05). Pulp AA of kaew Kamin mango decreased rapidly

up to 91 DAFB. TA of SG1 was significantly higher than that of SG2 and SG3. SG1 and SG3 showed the lowest TA at 98 DAFB, while SG2 showed the lowest TA at 105 DAFB.

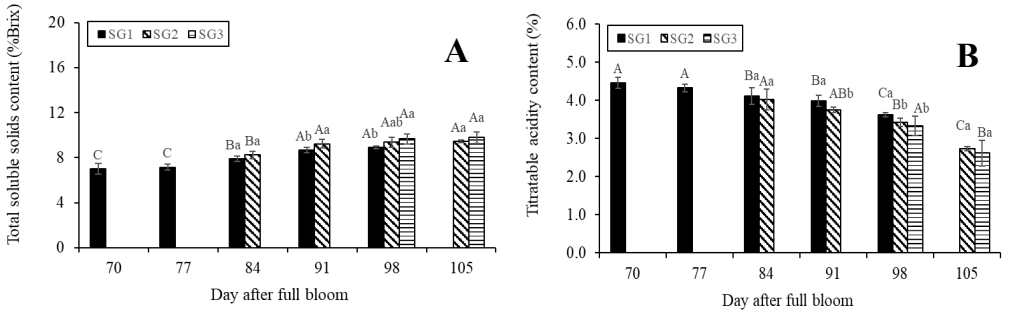

Figure 5. Changes in total soluble solid content (A) and titratable acidity (B) of Kaew Kamin mango during fruit development in floating in water (SG1), sinking in water but floating in 2% NaCl solution (SG2) and sinking in water and 2% NaCl solution (SG3): Error bars showed standard errors of the means. Capital letters above the columns indicate significant differences between the days of the same group. Lowercase letters above the columns indicate significant differences between the groups at the same days (Duncan, $p < 0.05$)

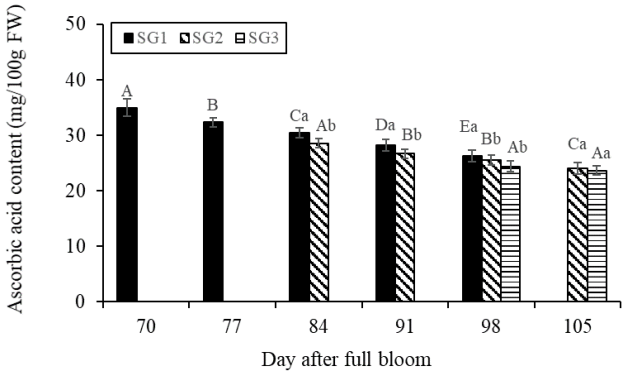

Figure 6. Changes in Ascorbic acid content of Kaew Kamin mango during fruit development in floating in water (SG1), sinking in water but floating in 2% NaCl solution (SG2) and sinking in water and 2% NaCl solution (SG3): Error bars showed standard errors of the means. Capital letters above the columns indicate significant differences between the days of the same group. Lowercase letters above the columns indicate significant differences between the groups at the same days (Duncan, $p < 0.05$)

Electrolyte leakage

The electrolyte leakage (EL) changes of mango pulps during fruit development are presented in Figure 7. Pulp EL significantly decreased between groups at the same days and between the days of the same group (p<0.05). EL of SG1 was significantly higher than that of SG2 and SG3 (p<0.05). At 98 DAFB, the highest EL was recorded in SG1 with a value of 28.03%, followed by SG2 and SG3, which had a pulp EL of 26.16 and 25.33%, respectively.

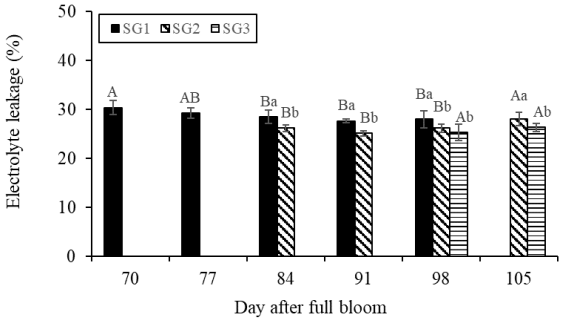

Figure 7. Changes in Electrolyte leakage (EL) of Kaew Kamin mango during fruit development in floating in water (SG1), sinking in water but floating in 2% NaCl solution (SG2) and sinking in water and 2% NaCl solution (SG3): Error bars showed standard errors of the means. Capital letters above the columns indicate significant differences between the days of the same group. Lowercase letters above the columns indicate significant differences between the groups at the same days (Duncan, $p < 0.05$)

Total antioxidant activity and total phenolic content

Total antioxidant activity and phenolic changes of mango pulps during fruit development are presented in Figure 8. Total antioxidant activity significantly increased during fruit development (p<0.05). There was a significant difference in total antioxidant activity between the days of the same group and between the groups of the same day. Total antioxidant activity slightly decreased between the days of the same group, while total antioxidant activity increased between the groups of the same day. total antioxidant activity of SG1 was significantly lower than that of SG2 and SG3 (p<0.05) (Figure 8A). In addition, total phenolic content significantly increased between groups at the same days and between the days of the same group (p<0.05) until 98 DAFB and then slowly decreased. total phenolic content of both SG2 and SG3 was significantly higher than that of SG1 (p<0.05). However, there were no significant differences in total phenolic content between SG2 and SG3 (p>0.05) (Figure 8B).

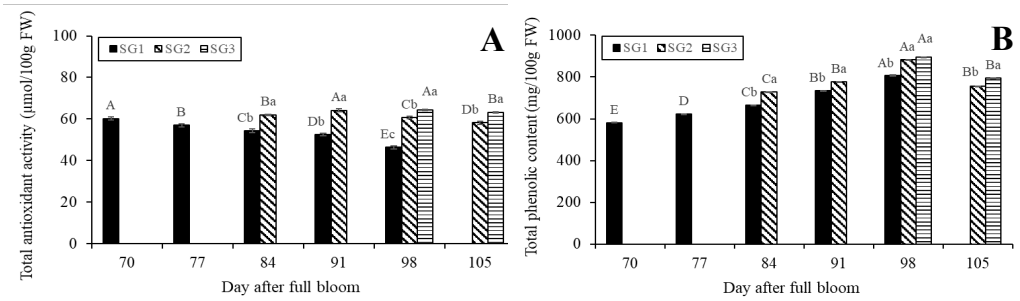

Figure 8. Changes in total antioxidant activity (A) and Total phenolic content (B) of Kaew Kamin mango during fruit development in floating in water (SG1), sinking in water but floating in 2% NaCl solution (SG2) and sinking in water and 2% NaCl solution (SG3): Error bars showed standard errors of the means. Capital letters above the columns indicate significant differences between the days of the same group. Lowercase letters above the columns indicate significant differences between the groups at the same days (Duncan, $p < 0.05$)

Total carotenoid content

Total carotenoid changes of mango pulps during fruit development are presented in Figure 9. There was a significant difference in total carotenoid content between the days of the same group and between the groups of the same day. Total carotenoid content significantly increased during fruit development (p<0.05). At 105 DAFB, the highest was recorded in SG3 with a value of 2,720 µg/100 g FW, followed by SG2, which had total carotenoid content of 2,427 µg/100 g FW.

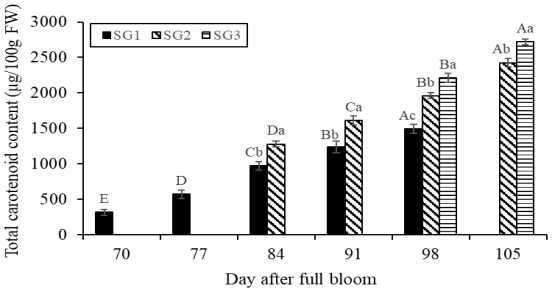

Figure 9. Changes in total carotenoid content of Kaew Kamin mango during fruit development in floating in water (SG1), sinking in water but floating in 2% NaCl solution (SG2) and sinking in water and 2% NaCl solution (SG3): Error bars showed standard errors of the means. Capital letters above the columns indicate significant differences between the days of the same group. Lowercase letters above the columns indicate significant differences between the groups at the same days (Duncan, $p < 0.05$)

Discussion

From the experimental results, the fresh weight of mango fruits tends to increase continuously throughout the growth period from 70 DAFB and weight value increases rapidly until 91 DAFB, when the fruit enters the maturity stage. The use of SG by NaCl floating can indicate the quality assessment of the fruits well. It was found that the SG2 group had a SG of 1.000-1.015, more than 50%, which was consistent with the experiment on Nam Dok Mai mango by testing from a SG of less than 1.000 as an immature fruit and a specific gravity of more than 1.020 as a mature fruit (Sombatpraiwan *et al*., 2012). The period before entering the mature stage is the period of beginning to form and accumulate a large amount of starch, causing the weight to increase rapidly and the specific gravity increase when entering the mature stage (Sarma *et al*., 2020). When the fruit was 98 DFAB, the SG2 and SG3 groups were found to combine more than 80%. The fruit will enter the physiological mature stage, which has accumulated higher starch than SG1. After that, it was stabilized fruit weight and there were not statistically differences in the physiological maturity stage, which will develop into the ripening process.

The color of mango peel was decreased with increasing a* and L* values in the immature stage and the peel color developed to yellow color with increasing b* and C* values and decreasing Hº. This is consistent with the study of Nam Dok Mai and Mahachanok mangoes which found that after the fruit development to the mature stage, there was an increase in chlorophyll degradation, with an increase in the activity of chlorophyllase enzyme, and an increase in the production of beta-carotene. The fruit peel was changed from green to yellow when the fruits reached ripening stage (Ketsa *et al*., 1999; Kanda *et al*., 2008). However, specific gravity could not tell the difference in peel color of fruits.

The fruit pulp showed a continuous increase in yellow color throughout the growth period, with increasing a*, b* and C* values and total carotenoid content. The SG of floating in NaCl can indicate the fruit quality well, which was found to be statistically significant when the fruit was 98 DAFB. During fruit development, chlorophyll degradation was increased due to increased of chlorophyllase activity, and carotenoid synthesis (Tucker, 1993). This is consistent with the study in Nam Dok Mai mango (Ketsa *et al*., 1999), which found that flesh pulp changed to yellow more in the mature fruit and developed after the mature fruit. The mango fruits were 119-133 DAFB, with increased a*, b*, and C* values during the growth period.

The firmness of Kaew Khamin mango pulp tends to increase with reverse to the EL value decreasing. In the early stages of growth, the cell wall

continuously synthesizes various components in the cell wall structure, especially in the egg box area, which is an area with higher calcium accumulation when the fruit is older until it reaches maturity, resulting in increased fruit firmness and decrease in EL (Sarma *et al*., 2020). When the fruit reaches maturity, the firmness was decreased and increased EL. This is due to the activity of polygalacturonase (PG) and cellulase enzymes, which will break down cellulose molecules to break down the structure and make the fruit softer (Roe and Bruemmer, 1981; Ueda *et al*., 2000). The fruit with higher maturity (high specific gravity) will have a slower decrease in firmness than the fruit with less maturity, which is consistent with the mango variety Mahachon at 98 days after flowering. Firmness decrease was slower in fruits 112 days after flowering (Kanda *et al*., 2008). In older mango fruits, when ripened, firmness decreases were faster than young mango fruits. This is because older fruits contain less pectin than young fruits (Subramanyam *et al*., 1976). In addition, the enzymes pectinesterase (PE), polygalactronase (PG) and cellulase play important roles in the changes in cell wall and middle lamella composition of fruits leading to pulp softening during ripening (Selvaraj and Kumar, 1989).

TSS of mango pulp tended to increase continuously in all treatment groups throughout the growth period from 70 DAFB. This period of mangoes was stored the higher starch than sugar (Fuchs *et al*., 1980). Therefore, the amount of TSS did not change much in each treatment group due to the decomposition of starch and will decompose when the fruit reaches the ripening stage (Subramanyam *et al*., 1976). When the fruit reaches the maturity stage, TSS will be found to increase continuously and after the maturity stage, the substance will change to TSS rapidly.

TA of mango pulp tended to decrease continuously in all treatment groups throughout the growth period. The amount of TA that increased in the beginning was the result of the accumulation of various acids. When the fruit reached the maturity stage, the acidity decreased. In this acid is used in the respiration process via the Kreb's cycle (Mattoo *et al*., 1975). This is consistent with the report in the Alphonso mango cultivar, where the acid content was reduced to only 3% at the time of harvest, while in the Florida cultivar, the acid content was low at 0.5-1.0% at the time of harvest (Steven, 1980). In mango fruits at 98 DAFB, the TA content decreased rapidly and continued to decrease with increasing maturity.

The ascorbic acid content of mango pulp showed a tendency to decrease continuously in all experimental groups throughout the growth period, which is consistent with the study on mango cultivars Amini, Mullgoa, Pico and Turpentine. The ascorbic acid (vitamin C) content in mango during 5 weeks after fruit set until reaching maturity was decreased approximately 66%. The ascorbic acid content is another factor that can indicate the maturity of mango fruits and

readiness to ripen. In mango cultivar Amini, the ascorbic acid content was significantly lower at 11 mg/100 g fresh weight in the 16 weeks of fruit set (Spencer *et al*., 1955). In Tongdum mango, the ascorbic acid content was decreased rapidly in fruits 4 weeks after fruit set until ripening (Ketsa *et al*., 1991).

Total antioxidant activity of mango pulp tended to decrease during fruit development, which is similar result with the study in Ozark Golden, Starkinson and Kosztela apples, which showed higher antioxidant capacity during unripe (60 DAFB) than ripe stage (145 DAFB). In addition, the antioxidant capacity was significantly reduced in mature leaves (Wojdylo and Oszmiański, 2020). Consistent with this, in Gala, Granny Smith and Fuji apples, the antioxidant activity decreased from the beginning of fruit development (26 DAFB) until harvest (124, 156 and 175 DAFB, respectively) (Maldonado *et al*., 2022).

The total phenolic content of mango pulp in all experimental groups tended to increase, which may be due to the establishment of various compounds during cell division during fruit development, with high activity levels of enzymes, including phenylalanine ammonia-lyase, chalcone isomerase and glycosyltransferase. The consistent with Gala, Granny Smith and Fuji apples, which had a high increase in total phenolic compounds content towards the end of the season (Maldonado *et al*., 2022).

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