

Fruit morphological characteristics and fruit quality of pomelo cv. Tabtim Siam grown in Nakhon Pathom and Nakhon Si Thammarat Provinces

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Abstract

The objective of this study is to evaluate fruit morphological characteristics and potential production of “Tabtim Siam” pomelo in Sam Pran district, Nakhon Pathom province; and to compare to those from Pak Panang district, Nakhon Si Thammarat Province. Five to six years old tree (3 orchards/area and 3-5 trees/orchard) was selected to evaluate fruit morphological characteristics and a harvesting index at 5, 6, 7 and 8 old months after fruit set. The result showed that fruit morphological characteristics from two areas were similar. The harvesting of pomelo fruit at 6-month old presented the highest overall acceptance in both areas. In Sam Pran, total soluble solid (TSS), titratable acidity (TA) and TSS/TA ratio of fruits were 10.4 °Brix, 0.56 % and 20.3, respectively. At Pak Panang, TSS, TA and TSS/TA ratio were 10.8 °Brix, 0.58 % and 18.6, respectively. The soil analysis of Sam Pran district, showed an optimal level of pH (5.1-6.7) and high organic matter (1.4-3.8%). The soil of Pak Panang district showed high value of pH (6.8-7.3) and low organic matter (0.8-1.6%). The amount of phosphorus, potassium, calcium and magnesium of both areas were high to very high levels.

Keywords: “Tabtim Siam” pomelo, fruit quality, harvesting index

Article history: Received 16 July 2018, Accepted 28 February 2019

1. Introduction

Pomelo is an economic fruit crop of Nakhon Pathom province. Production area is located in Sam Phran and Nakhon Chi Sri district. The main cultivar is “Thong Dee” and “Khaonamphueng”. Most “Thong Dee” and “Khaonamphueng” orchards were severely damaged by flooding in 2011. After flooding, those replanting a new orchard were difficult due to shortage of shoot cutting plant [1]. Some pomelo growers decided to introduce “Tabtim Siam” cultivar into the area because “Tabtim Siam” fruit has a high price (200-500 baht/fruit) in domestic market [2] and also increased choices for consumers.

Pomelo var. Tabtim Siam was very new to Sam Phran and Nakhon Chi Sri district. Although, fruit grower had a good experience for pomelo orchard management but they lacked relevant information of harvesting index of pomelo var. Tabtim Siam in these areas. The harvesting index information of “Tabtim Siam” pomelo is limited as most research has only focused on the effect of tree age and fruit age on fruit quality in Pakpanang district, Nakhon Si Thammarat province. For pomelo var. Tabtim Siam, fruit quality of 6 to 8 years old trees were suitable for harvesting at 7 and 7.5 months fruit age [3]. Wallada Nualsri and *et al.* [4] reported the harvesting

index of 4 and 7 years old of pomelo were 160 and 220 days after fruit set, respectively. In addition, fruit quality of pomelo depended on planting area such as soil nutrients, microclimate and cultural practice of grower. Flavors and some morphological characters of pomelo fruit in each area were different [5]. Thus, the objective of this research was to evaluate fruit morphological characteristics and potential production of “Tabtim Siam” pomelo in Sam Pran district, Nakhon Pathom and Pak Panang district, Nakhon Si Thammarat provinces.

2. Materials and methods

2.1 Evaluation of fruit morphology and fruit quality

The research was conducted in two production areas consisting of 1) Sam Phran district, Nakhon Pathom province and 2) Pak Panang district, Nakhon Si Thammarat province during January – September 2017. The day and night temperatures at Sam Phran district were 32-35 and 20-25 degree celsius, respectively and at Pak Panang district were 31-34 and 23-25 degree celsius, respectively [6]. Five to six years old of uniform trees (3 orchards/area and 3-5 tree/orchard) were selected. The pomelo growers collaborating in this research were

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Figure 1 Fruit shape, peel color and pulp color of different fruit age of pomelo var. Tabtim Siam grown in Sam Phran district, Nakhon Pathom province where M = month number

expert in pomelo orchard management with an experience of more than 10 years. After blooming stage, pomelo fruits were selected and tagged in January 2017. The fruit at the age of at 5, 6, 7 and 8 months after fruit set (2 fruits/fruit age) were collected to evaluate in June to September 2017 for 1) fruit morphology including fruit shape, fruit weight, pulp weight, peel weight, fruit diameter, fruit height and peel thickness and 2) harvesting indexes including peel color, pulp color, total soluble solid (TSS), titratable acidity (TA), TSS/TA ratio. Peel and pulp color were measured with a colorimeter (Model CR 400, Minolta, Japan). Sensory test was estimated by consumers that evaluated the fruit for color, flavor, aroma and overall acceptance with a score of 5 = very good, 4 = good, 3 = acceptable, 2 = bad and 1 = very bad [7, 8].

2.2 Soil property analysis

Five soil samples were collected from each orchard at depth 0-15 cm below the surface near pomelo tree were collected and mixed together [9]. The composite soil samples were done 2 times: the 1st time in January 2017 (pre-harvest) and the 2nd time in September 2017 (post-harvest) and taken to the Soil Plant and Agricultural Material Testing and Research Unit, Central Laboratory, Kasetsart University, Kamphaeng Saen campus for soil property analysis. Soil samples were analyzed for pH, organic matter, P, K, Ca and Mg concentrations. Levels of soil pH were determined by soil and water method in 1:1 ratio [10]. Levels of soil organic matter were determined using Walkley Black modified acid-dichromate digestion [11]. Levels of available P were determined using Bray II method [12]. Levels of extractable K, Ca and Mg were

extracted by 1M NH_4OAc pH7 and determined using an atomic absorption spectrophotometer [13].

2.3 Statistical analysis

All traits were statistically tested by using general linear model (GLM) and compared the mean by using polynomial contrast analysis at the 0.05 significant levels. The comparison of fruit quality in Sam Phran district, Nakhon Pathom province and Pak Panang district, Nakhon Si Thammarat province were statistically by using T-Test at the 0.05 significant levels.

3. Results and discussion

'Tabtim siam' fruits from three orchards grown in Sam Phran district, Nakhon Pathom province were obovoid and piriform shape (Figure 1). Fruit age had effect to fruit growth and development of pomelo var. Tabtim siam except fruit height and peel thickness (Table 1). The relationship between fruit age and fruit growth showed in linear trend. Fruit weight, pulp weight, peel weight and fruit diameter showed tendency to increase when fruit age was increasing. The 8-month old fruits after fruit set showed the highest fruit weight, pulp weight, peel weight and fruit diameter than other fruit ages. In a previous report, six to eight years old of pomelo var. Tabtim siam grown in Pak Panang district, Nakhon Si Thammarat province, had significant difference in pulp weight and peel weight at different fruit age. The 7 and 7.5 months old fruits had the highest pulp weight and the lowest peel weight [3]. The distinction between this current study and that previous report might be accounted by the different tree age of pomelo used. Pomelo fruit growth and development exhibited a sigmoid curve pattern. During the first to 5th month after fruit set, fruit weight increase of pomelo was mainly in peel portion more than pulp portion; and after 5th months the pulp developed more than the peel [14].

Peel color of pomelo var. Tabtim Siam was light green to dark green with a hairy cover. The greenness of fruit peel decreased with age. The relationship between fruit age and peel color showed in linear trend. The 5-month old fruit was dark green and the 8-month old fruit was yellowish green (Table 2). Pulp color of pomelo var. Tabtim Siam was dark red similar with a ruby (Figure 1). Pulp color of difference ages were not significantly difference.

The TSS values of fruit of pomelo var. Tabtim siam did not differ with age. Then, an important factor that had effect to taste of pomelo fruit was TA value. Fruit age had effect to TA and TSS/TA ratio of fruit and showed relation by linear trend (Table 3). The TA value of fruit decreased with age whereas TSS/TA ratio increased with age. To be regarded as a high fruit quality in Thailand pulp fresh fruit must have a TSS

Table 1 Fruit weight, pulp weight, peel weight, fruit diameter, fruit height and peel thickness of “Tabtim Siam” pomelo cultivar grown in Sam Phran district, Nakhon Pathom province

Fruit age (month)	Fruit weight (kg.)	Pulp weight (g.)	Peel weight (g.)	Diameter (cm.)	Fruit height (cm.)	Peel thickness (cm.)
5	1.1±0.2	642.4±61.7	411.8±20.1	13.9±0.5	15.7±1.2	1.2±0.2
6	1.4±0.2	840.9±75.2	462.4±85.4	14.5±1.8	16.6±2.3	1.1±0.1
7	1.6±0.1	916.9±116.6	500.2±50.5	15.1±0.5	17.0±1.0	1.1±0.1
8	1.7±0.1	937.4±119.3	591.8±100.8	15.9±1.0	17.6±1.5	1.1±0.2
Linear	*	*	*	*	ns	ns
Quadratic	ns	ns	ns	ns	ns	ns

Statistical significance for the differences among values was assessed where ns = non-significant and * = significant at $P \leq 0.05$

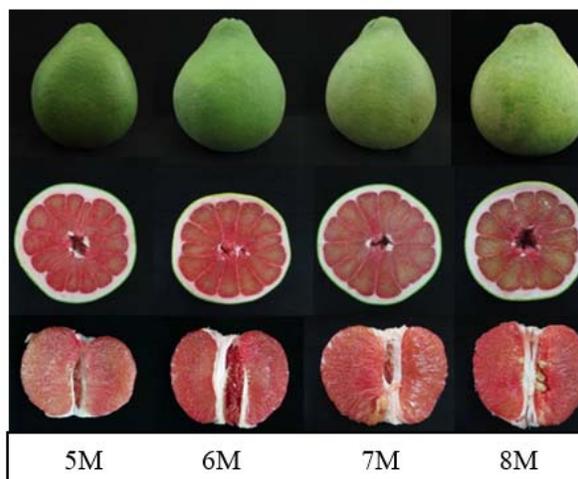
Table 2 Peel and pulp color of “Tabtim Siam” pomelo cultivar grown in Sam Phran district, Nakhon Pathom province

Fruit age (month)	Peel color			Pulp color		
	L	a	b	L	a	b
5	46.0±0.9	-13.9±1.7	30.4±1.6	2.2±2.7	7.5±0.5	10.6±1.1
6	47.8±2.1	-10.6±3.6	31.8±2.9	6.6±1.6	8.3±1.7	10.3±0.7
7	51.4±3.2	-10.0±1.5	34.4±2.7	3.9±0.5	8.9±2.3	9.8±0.6
8	56.6±1.4	-6.2±1.7	37.2±1.1	7.8±1.0	9.7±0.8	11.0±1.1
Linear	*	*	*	ns	ns	ns
Quadratic	ns	ns	ns	ns	ns	ns

Statistical significance for the differences among values was assessed where ns = non-significant and * = significant at $P \leq 0.05$

value more than 8 °Brix [15]. The TSS/TA ratio of pomelo fruit should be more than 15:1 which presented a good flavor for consumers [16]. Thus, pomelo var. Tabtim siam of the 5-6 years old tree possessed a good fruit quality. For pomelo var. Tabtim siam at Pak Panang district, the previous report presented TSS value of 10-14 °Brix and TA value of 0.37-0.71 % [17] and TSS and TA value in the previous report showed a higher value than in this research. Usually, pomelo growers in Sam Phran district harvested fruits at age about 6-7 months old after flowering by their experience because older fruit age on pomelo tree induced granulation in pulp. Granulation of pomelo fruit was induced by fruit age increasing or fruiting at young tree age or over supply of nitrogen fertilizer [18].

Sensory evaluation for color, flavor, aroma and overall acceptance was done by consumers. The relationship between fruit age and sensory evaluation showed in quadratic trend (Table 3). The consumers accepted the pulp color, flavor and overall acceptance of pomelo var. Tabtim siam at 6 and 7 months old with the scores more than 4 (good). At 8-month old, the scores of these parameters decreased less than 3.5. Therefore, pomelo var. Tabtim siam grown in Sam Phran district should be harvested at the 6-month old because the taste was good and protected from granulation in pulp fruit. The pomelo growers in Sam Phran district harvested a

**Figure 2** Fruit shape, peel color and pulp color of different fruit age of pomelo var. Tabtim Siam grown in Pak Panang district, Nakhon Si Thammarat province where M = month number

pomelo var. Tabtim siam at the 6-months of age which helped to reduce the cost of orchard maintenance as compared to the main pomelo cultivar of Sam Phran district including Thong Dee and Khaonamphueng were usually harvested at 7-8 months.

Table 3 Total soluble solid (TSS), titratable acidity (TA) and TSS/TA ratio and overall acceptance of “Tabtim Siam” pummelo cultivar grown in Sam Phran district, Nakhon Pathom province

Fruit Age (month)	TSS (°Brix)	TA (%)	TSS/TA	Sensory test (score)			
				Pulp Color	Flavor	Aroma	Overall acceptance
5	9.2±0.9	0.63±0.1	14.6±1.4	3.4±0.7	3.0±0.4	3.8±0.5	3.2±0.2
6	10.4±0.6	0.51±0.0	20.3±2.2	4.0±0.2	4.1±0.1	3.8±0.3	4.2±0.2
7	10.1±1.4	0.31±0.0	32.3±5.1	4.1±0.2	4.1±0.3	3.5±0.2	4.0±0.1
8	9.5±1.0	0.27±0.1	35.4±3.7	3.5±0.5	2.5±0.9	2.9±0.4	2.5±0.2
Linear	ns	*	*	ns	ns	ns	ns
Quadratic	ns	ns	ns	*	*	*	*

Statistical significance for the differences among values was assessed where ns = non-significant and * = significant at $P \leq 0.05$

Table 4 Fruit weight, pulp weight, peel weight, fruit diameter, fruit height and peel thickness of “Tabtim Siam” pomelo cultivar grown in Pak Panang district, Nakhon Si Thammarat province

Fruit age (month)	Fruit weight (kg.)	Pulp weight (g.)	Peel weight (g.)	Diameter (cm.)	Fruit height (cm.)	Peel thickness (cm.)
5	1.1±0.1	678.9±93.2	337.8±64.2	12.9±0.5	14.4±0.8	0.8±0.1
6	1.3±0.2	838.1±126.7	353.3±78.3	13.6±0.7	14.8±1.5	0.9±0.2
7	1.4±0.2	948.3±150.2	370.2±90.1	14.1±0.8	14.6±1.2	0.8±0.1
8	1.6±0.3	1,100.8±130.6	475.8±118.3	15.2±1.5	16.1±0.7	0.9±0.2
Linear	*	*	ns	*	ns	ns
Quadratic	ns	ns	ns	ns	ns	ns

Statistical significance for the differences among values was assessed where ns = non-significant and * = significant at $P \leq 0.05$

Table 5 Peel and pulp color of “Tabtim Siam” pomelo cultivar grown in Pak Panang district, Nakhon Si Thammarat province

Fruit age (month)	Peel color			Pulp color		
	L	a	b	L	a	b
5	46.9±1.3	-11.7±2.7	30.6±2.4	39.4±1.8	5.5±0.4	11.9±1.9
6	47.1±2.3	-12.5±1.3	32.7±2.2	37.7±0.9	6.8±1.0	15.6±7.0
7	49.8±2.3	-11.5±1.6	34.9±0.8	34.7±2.4	8.6±0.8	10.8±0.9
8	55.3±6.6	-7.4±4.7	35.0±2.0	34.4±1.5	9.2±1.2	10.5±0.6
Linear	*	ns	*	*	*	ns
Quadratic	ns	ns	ns	ns	ns	ns

Statistical significance for the differences among values was assessed where ns = non-significant and * = significant at $P \leq 0.05$

Pomelo var. Tabtim Siam in Pak Panang district, Nakhon Si Thammarat province showed obovoid and piriform shape (Figure 2). Fruit age had effect to fruit growth and development of pomelo var. Tabtim siam except peel weight, fruit height and peel thickness (Table 4). The relationship between fruit age and fruit growth showed in linear trend. Fruit weight, pulp weight and fruit diameter showed tendency to increase when fruit age was increasing. The 8-month old fruits after

fruit set showed the highest fruit weight, pulp weight and fruit diameter than other fruit ages.

Peel color of pomelo var. Tabtim Siam in Pak Panang district was light green to dark green with a hairy cover. The lightness (L value) and yellow color intensity (b value) of peel color increased with increasing fruit age. The relationship between fruit age and peel color (L and b value) showed in linear trend. The greenness of the peel was not significantly different (Table 5). In contrast, peel color development of pomelo

var. Tabtim Siam grown in Sam Phran district due to the different causing by different environments. progressed faster when grown in Pak Panang district

Table 6 Total soluble solid (TSS), titratable acidity (TA) and TSS/TA ratio and overall acceptance of “Tabtim Siam” pomelo cultivar grown in Pak Panang district, Nakhon Si Thammarat province

Fruit age (month)	TSS (°Brix)	TA (%)	TSS/TA	Sensory test (score)			Overall acceptance
				Pulp Color	Flavor	Aroma	
5	9.0±0.5	0.71±0.1	12.9±1.5	3.4 ± 0.5	3.1 ± 0.5	3.8 ± 0.1	3.3 ± 0.6
6	10.8±0.5	0.58±0.0	18.6±1.6	3.9 ± 0.3	4.2 ± 0.3	4.3 ± 0.1	4.3 ± 0.1
7	11.3±0.7	0.42±0.0	27.1±2.1	4.0 ± 0.5	4.0 ± 0.1	4.1 ± 0.2	4.0 ± 0.1
8	11.2±1.5	0.29±0.0	39.2±5.2	4.3 ± 0.2	3.4 ± 0.4	3.7 ± 0.2	3.4 ± 0.2
Linear	*	*	*	*	ns	ns	ns
Quadratic	ns	ns	ns	ns	*	*	*

Statistical significance for the differences among values was assessed where ns = non-significant and * = significant at $P \leq 0.05$

Table 7 Comparisons of total soluble solid (TSS), titratable acidity (TA) and TSS/TA ratio and overall acceptance of 6-month old fruit of “Tabtim Siam” pomelo cultivar grown in Sam Phran district, Nakhon Pathom province and Pak Panang district, Nakhon Si Thammarat province

Area	TSS (°Brix)	TA (%)	TSS/TA	Sensory test (score)			Overall acceptance
				Pulp Color	Flavor	Aroma	
Sam Phran	10.4±0.6	0.51±0.0	20.3±2.2	4.0±0.2	4.1±0.1	3.8±0.3	4.2±0.2
Pak Panang	10.8±0.5	0.58±0.0	18.6±1.6	3.9±0.3	4.2±0.3	4.3±0.1	4.3±0.1
T-test	ns	ns	ns	ns	ns	ns	ns

Statistical significance for the differences among values was assessed where ns = non-significant at $P \leq 0.05$

The air temperature of orchard in Sam Phran district (32-35 °C) higher than in Pak Panang district (31-34 °C). The high or warm temperature induced the loss of chlorophyll and induced of carotenoids [19]. Pulp color of pomelo var. Tabtim Siam was dark red similar with a ruby (Figure 2) and the red color intensity increased with fruit age in linear trend. The 8-month old fruit was the highest value of pulp color than other fruit ages (Table 5).

The relationship between fruit age and TSS, TA and TSS/TA ratio showed in linear trend. The TSS and TSS/TA ratio of fruit increased whereas the TA value of fruit decreased with age (Table 6). The result showed the 6-month old or older fruit of pomelo var. Tabtim siam in Pak Panang district from 5-6 years old tree presented a high fruit quality because the TSS value was more than 8 °Brix [15] and TSS/TA ratio was more than 15:1 [16]. But fruit age of 7 or 8 months developed granulation of the pulp. Somsak Maneepong [17] reported pomelo var. Tabtim siam in Pak Panang district presented TSS value of 10-14 °Brix and TA value of 0.37-0.71 %. Wallada Nualsri and *et al.* [4] presented the harvesting index of the 4 years old tree of pomelo var. Tabtim siam was 160 days after fruit set (5 months and 10 days) with TSS value of 9 °Brix and TA value of 0.58% and the 7 years old tree of pomelo

required 220 days after fruit set (7 months and 10 days) with TSS value of 9.3 °Brix and TA value of 0.30%. Therefore, the fruit quality of pomelo var. Tabtim siam depended on many factors including fruit age, tree age, plantation area and time evaluation.

Sensory evaluation for color, flavor, aroma and overall acceptance was done by consumers. The relationship between fruit age and pulp color showed in linear trend whereas fruit age and flavor, aroma and overall acceptance showed in quadratic trend (Table 6). The consumers accepted the pulp color of pomelo var. Tabtim siam at 7 and 8 months and accepted the flavor, aroma and overall acceptance at the 6 and 7 months old with the scores more than 4 (good). Therefore, pomelo var. Tabtim siam grown in Pak Panang district could be harvested at the 6-month old because they possessed the best and did not develop granulation in pulp fruit was observed at this age.

The harvesting index of pomelo var. Tabtim siam at 5-6 years old tree of both regions consisting of Sam Phran district and Pak Panang district was the 6-month old fruit after fruit set because the fruit quality was good and no granulation. The comparison of fruit quality of each region at 6-month old fruit, the result showed the fruit qualities between two regions were not significantly different (Table 7). Then, pomelo var.

Tabtim siam was suitable for grown in Sam Phran in Pak Panang district. district because the fruit quality was similar with grown

Table 8 Soil properties of pomelo orchards in Sam Phran district, Nakhon Pathom province and Pak Panang district, Nakhon Si Thammarat province

Area	time	orchard	pH	organic matter (%)	P (mg/kg)	K (mg/kg)	Ca (mg/kg)	Mg (mg/kg)
Nakhon Pathom	1 st	1	5.1	2.3	262	404	3,201	864
		2	6.7	3.4	690	340	4,377	80
		3	5.5	1.4	80	119	2,679	1,567
	2 nd	1	5.4	3.8	269	467	3,272	1,181
		2	6.6	2.6	515	447	3,633	1,019
		3	5.3	1.8	143	213	2,868	1,477
Nakhon Si Thammarat	1 st	1	7.2	1.6	106	310	3,779	1,911
		2	7.3	0.8	143	422	3,629	1,658
		3	7.2	1.1	77	229	2,999	1,558
	2 nd	1	7.3	1.4	102	307	4,297	1,598
		2	7.2	1.0	271	378	2,318	1,786
		3	6.8	1.3	106	540	3,484	1,925
Standard level			5.5-6.5	1.5-2.5	15-25	100-150	1000-2000	120-240

In addition, pulp color, flavor, aroma and overall acceptance were accepted by the consumer.

The pomelo orchards at Sam Phran district located on the lowland with clay and silty clay soil which is poorly drained. Growers grow their trees on raised berm to manage this drainage issue. The soil sample of three grower's orchard at Sam Phran district, Nakhon Pathom province were collected and analyzed for plant nutrition both before and after fruits harvesting. The analysis was compared with the recommendation of suitable soil properties for pomelo cultivation by Somsak Maneepong [17]. The result showed that soils pH was at the optimum level. The first and second pomelo orchard showed an appropriate to high level of soil organic matter both before and after fruits harvesting, while the third orchard showed a quite low level of organic matter before fruit harvesting then showed a appropriate level of organic matter after fruit harvesting. Then, this was because organic matters were applied during the fruit development stage on the third pomelo orchard. The amount of phosphorus, potassium, calcium and magnesium at the three orchards was high to very high (Table 8). Therefore, to properly manage the fertilizer program for all three orchards, an amount of phosphorus, potassium calcium and magnesium applied should be reduced.

The pomelo orchard at Pak Phanang district located on the lowland with clay which was also poorly drained and often experiencing flood problem. Consequently the growers grow the trees on a raised berm. Soil sample from the three grower's orchard at Pak Phanang district, Nakhon Si Thammarat province were collected and analyzed for plant nutrition both before and after fruits harvesting. The results showed quite high level of pH with value of 6.81-7.32. Optimum levels of soil pH

which suitable for plants growing well were 5.5-6.5. However, Somsak Maneepong [17] reported that pomelo plants, which has been grown at Khlong Noi Sub-District, Pak Phanang district where soil pH, was 7.5-8.2 were producing a favorable taste pomelo for consumers. The soil organic matters of all three orchards were quite low. However, the amount of phosphorus, potassium calcium and magnesium of all three orchards were quite very high (Table 8). Therefore, to manage the suitable fertilizer program for all three orchards, a organic matter fertilizer application should be increased; whereas a phosphorus, potassium calcium and magnesium fertilizer application should be reduced.

The soil texture of the orchards in both regions at Sam Phran district, Nakhon Pathom province and Pak Phanang district, Nakhon Si Thammarat province were similar. They located at the lowland where soil at Sam Phran district was clay and silty clay and the soil at Pak Phanang district was clay. Given the sufficient nutrient content of the soils and the long experience of the growers in managing pomelo orchards, the fruit of the pomelo var. Tantim siam was of excellent quality and flavor.

4. Conclusions

Fruit shape of pomelo var. Tabtim siam from Sam Pran district, Nakhon Pathom and Pak Panang district, Nakhon Si Thammarat provinces were similar. The specific fruit shape of this cultivar was obovoid and piriform. Fruit peel color was light green to dark green with a hairy cover. Peel color development of pomelo var. Tabtim siam grown in Sam Phran district developed faster than when grown in Pak Panang district. Pulp

color was dark red similar with a ruby. The harvesting index of the 5-6 years old pomelo tree in these production regions was at 6-month old after fruit set presenting the highest overall acceptance. In Sam Pran, total soluble solid (TSS), titratable acidity (TA) and TSS/TA ratio were 10.4 °Brix, 0.56% and 20.3, respectively. At Pak Panang, TSS, TA and TSS/TA ratio of pomelo fruit were 10.8 °Brix, 0.58% and 18.6, respectively.

Pomelo orchards at Sam Phran district were on the lowland with clay and silty clay and at Pak Phanang district located on the lowland with clay. The soil property analysis of Sam Pran district, showed an optimal value of pH (5.1-6.7) and high organic matter (1.4-3.8%). The soil of Pak Panang district showed high value of pH (6.8-7.3) and low organic matter (0.8-1.6%). The amount of phosphorus, potassium, calcium and magnesium in soil of the two regions were high to very high levels.

Acknowledgements

This research was supported by the Thailand Research Fund and Nakhon Pathom Rajabhat University under the research project of Integrated Research Innovation on Pomelo for Social and Economic Development of Nakhon Pathom in the 2nd Phase.

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