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Research article

Comparison of Early and Late Season Phytochemical Content in Mon Thong Durian Cultivar (*Durio zibethinus Murray*)

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Abstract

This is the first study that compared the phytochemical content of early and late season Mon Thong durian (*Durio zibethinus* Murray) samples from five orchards in Chanthaburi province, Thailand, crop year 2022-2023. The results showed that total phenolics, total flavonoids, total tannins, anthocyanins and DPPH radical scavenging activity in early season samples were significantly higher than late season samples ($p<0.05$), whereas β-carotene was not different ($p>0.05$). The phytochemical content in durian samples correlated with flowering and fruit setting management. The early season flowering had the high numbers of inflorescences. Therefore, the quality of the early season durian production was greater than the late season. Decreases in temperature and rainfall were environmental stress that affected durian trees, leading to increased synthesis of phytochemicals including phenolics, flavonoids, tannins, and others. Such a reaction might be called plant self-defense system to tolerate challenging conditions. The individual orchard soil pH and organic matter also affected the nutrients available for durian production. The orchard that had the acidic soil, and lower organic matters, P, K, nitrate and ammonium, produced durians of lower phytochemical content. In case of several flowering generations, the early inflorescence flowers were kept or thinned for preventing nutrient deficiency. Sufficient nutrient concentration during fruit setting led to the production of durians of higher quality and phytochemical levels.

Keywords: phytochemicals; Mon Thong durian; *Durio zibethinus* Murray; early and late season

1. Introduction

Durian (*Durio zibethinus* Murray) is an evergreen-tropical fruit cultivated in Southeast Asia. It is popular in many countries, such as in Thailand, Malaysia, Vietnam, China, Hong Kong and Taiwan. In Thailand, durian is one of the economic tropical fruits with high export value.

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There are more than 200 different varieties of durian (Ashraf et al., 2011), but Mon Thong is the variety with the highest planting area and yield. Its flesh is golden yellow and smooth, with small seeds (Buasap, 2008). Besides its delicious taste, durian has been reported to possess health benefits, connected with many phytochemicals such as fatty acids, phenolic compounds, flavonoids, carotenoids, and other antioxidants. It had been reported that durian extracts lowered the LDL (low density lipoprotein) level, reduced heart disease, increased fibrinogen synthesis, and also decreased the risk of cancers (Leontowicz et al., 2008; Haruenkit et al., 2010; Rai et al., 2010). Toledo et al. (2008) noted that the antioxidants activity in Mon Thong cultivars was the highest, compared with Chanee, Kan Yao, Kradum and Puang Manee varieties. The study of Gorinstein et al. (2010) showed that the total flavonoids, flavonols, anthocyanins, ATBS, DPPH CUPRAC and FRAP antioxidant activity in Mon Thong cultivars were high. The nutritional values of 100 g dry weight of Mon Thong were 7.5-9.1 g dietary fiber, 62.9-70.7 g carbohydrate, 47.9-56.4 g sugar and 289±45 mg gallic acid equivalent of total phenolics. The DPPH, FRAP and ORAC antioxidant activities were 8± 1, 16± 2 and 62± 12 μmol Trolox equivalent, respectively. In addition, the monounsaturated fatty acid (MUFA) was 6.1-7.8 g/100 g DM, saturated fatty acid (SFA) was 4.2-5.7 g/100 g DM and polyunsaturated fatty acid (PUFA) was 0.8-1.5 g (Charoenkiatkul et al., 2016).

Phytochemical contents in durian are affected by many factors including cultivars, ripening stage, temperature, rainfall, soil fertility, and flowering and fruiting periods. A fertile durian tree can flower once or twice per year, resulting in early and late seasonal durian production. In Thailand, the first flowering and fruiting period of durian begins from December to April. The second flowering and fruit setting period is delayed by 2 weeks-2 months after the first flowering. A durian tree produces approximately 20,000 flowers per tree and consumes about 48 kg of nutrient which is sufficient for 64 fruits (Chanthaburi Horticultural Research Center, 2008). Because the nutrient level in a durian tree decreases during flowering, it is necessary to thin out the inflorescent flowers which is smaller than 2 cm at the terminal of the branch. The inflorescent flowers left on the tree should not be more than two generations of development. Flower pruning is the process to avoid nutrient competition and deficiency.

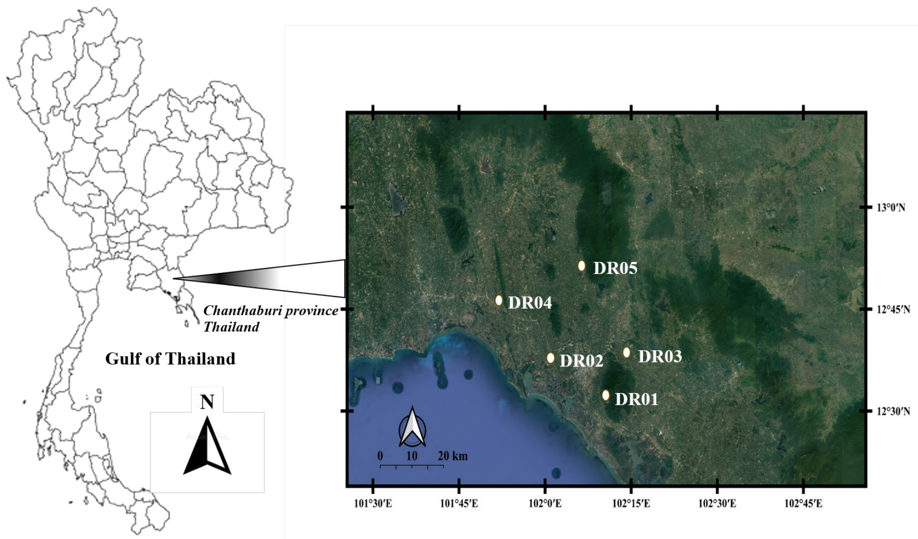
From the preliminary survey of the durian farmers in Chanthaburi, which is the province of Thailand with the most durian planting crop, the early season durian production offers better quality with marketable acceptance due to proper care and attention, whereas late season production usually lacks attention due to the chaos of the fruit harvesting, selling and marketing. Differences in fruit caring and management lead to differences in fruit quality and phytochemical concentration. Little information was available on the differences in the phytochemical content of early and late season durian fruit. Hence, the purpose of this research was to compare the phytochemical content of early and late season Mon Thong durian cultivar (*Durio zibethinus* Murray) grown in the crop year 2022-2023 in Chanthaburi province, Thailand. Supporting data such as orchard management, soil analysis, average rainfall and temperature were also investigated.

2. Materials and Methods

2.1 Durian samples

Mon Thong durian samples were harvested during April-June 2023 (crop year 2022-2023) from five orchards in five districts: Mueang (DR 01), Tha Mai (DR 02), Khlung (DR 03), Na Yai Am (DR 04) and Khao Khitchakut (DR 05); in Chanthaburi province, Thailand (Figure

1). Three durian trees in each orchard that were the same age and fertility, and that showed flowering of two generations of development; the early season (E) and the late season(L), were selected. When the durian fruits were mature, one fruit of the selected tree in each orchard was harvested at the same stage of ripening using various physical harvesting indices; day count from full bloom (about 120 days for Mon Thong cultivar), rind color, spine, peduncle surface and acoustic method. Samples were picked within one day of ripening. The flesh was cut, kept at -20°C, freeze-dried (Martin Christ Freeze-dryer BETA 1-8 LDplus), ground and mixed. The samples were kept in a plastic bag in a refrigerator before analysis.



DR01 Khombang, Mueang Chanthaburi District (12° 32′ 28.2″ N, 102° 09′ 33.4″ E)
DR02 Khao Baisi, Tha Mai District (12° 38′ 52.5″ N, 102° 00′ 22.3″ E)
DR03 Map Phai, Khlung District, (12° 36′ 27.9″ N, 102° 14′ 47.5″ E)
DR04 Chang Kham, Na Yai Am District, (12° 46′ 44.9″ N, 101° 52′ 05.2″ E)
DR05 Pluang Khao Khitchakut District (12° 51′ 00.6″ N, 102° 06′ 15.9″ E)

Figure 1. Orchard sites in Chanthaburi province, Thailand

2.2 Soil samples, average rainfall and temperature

The supporting data of orchards were also investigated. Soil samples were collected according to the methods of Attanandana & Chancharoensook (1999) and Poovarodom et al. (2001b). Two to four points of soil under the durian trees at a depth within 20 cm were collected, air-dried, and ground. The pH was determined using the water suspension technique, with soil to water ratio 1:1. Dried soil samples were taken for organic matter analyses using the Walkley Black method, which involved the oxidation of soil organic matter with chromate in sulfuric acid followed by spectrophotometric analysis at 600 nm of wavelength. Available phosphorous was determined according to the Bray II method, which involved the extraction of phosphorous from soil using ammonium fluoride with concentrated hydrochloric acid followed by colorimetric analysis at 882 nm, and exchangeable potassium was analyzed using inductively coupled plasma-optical emission spectrometry; ICP-OES according to Van Reeuwijk (2002), which involved the leaching of potassium from soil with ammonium acetate followed by the measurement at wavelength of 766.5 nm. Moreover, salinity as chloride was assayed using the Mohr method (the titration with AgCl), and ammonia and nitrate were determined using a Kasetsart NPK pH Test Kit for soil. The average rainfall and temperature in Chanthaburi during the year 2022-2023 were obtained from Chanthaburi Provincial Agriculture and Cooperatives Office and the Open Government Data website. Orchard management data for the five orchards sampled in this research were collected using questionnaire.

2.3 Chemicals

Chemicals used in the study were of analytical reagent grade: gallic acid, quercetin, DPPH (2,2-diphenyl-1-picryl hydrazyl) and trolox were products of Sigma-Aldrich; USA. Sodium nitrite ($NaNO_2$), potassium chloride (KCl), sodium acetate (CH_3COONa), sodium carbonate (Na_2CO_3) and aluminium chloride ($AlCl_3$) were purchased from Univar Ajax Finechem; New Zealand. Tannic acid was a product of Alfa Aesar; UK. Ethanol and methanol were obtained from Merck; Germany. Folin-Ciocalteu phenol reagent was a product of Loba Chemie; India. Hydrochloric acid (HCl), acetone and acetic acid (CH_3COOH) were purchased from Fisher Scientific; UK. Hexane was purchased from Kemaus; Australia.

2.4 Extraction

Durian flesh was extracted using the method of Toledo et al. (2008) with a little modification. A 0.5 g dried sample was extracted with 5 mL of 60% methanol:water and heated at 60°C for 3 h. The mixture was cooled, diluted to 10 mL and centrifuged for 5 min at 4,000 rpm (FRONTIER 5706 OHAUS centrifuge). The supernatant was kept to further analysis.

2.5 Phytochemicals analysis

2.5.1 Total phenolic content

Total phenolic content was measured using the Folin-Ciocalteu phenol reagent method as described by Lu et al. (2007). A 1.0 mL of supernatant sample was mixed with 2.5 mL of 10% v/v Folin-Ciocalteu phenol reagent, left for 5 min, and followed by 2.0 mL of 7.5% w/v Na_2CO_3. After 1 h, the mixture was measured at 765 nm using a UV-Visible spectrometer (Lambda 365 Perkin Elmer). Total phenolic content was expressed as mg gallic acid equivalent per 100 g dry sample (mg GAE/100 g).

2.5.2 Total flavonoid content

Total flavonoid content was performed using the Aluminium chloride method according to Gursoy et al. (2009). A 0.45 mL of supernatant was mixed with 1.65 mL of double-distilled water. Then, 0.45 mL of 5% w/v $NaNO_2$ was added, followed by 0.45 mL of 10%w/v $AlCl_3$. The mixture was kept in the dark for 10 min and measured at 415 nm. Total flavonoid content was expressed as mg quercetin equivalent per 100 g dry sample (mg QE/100 g).

2.5.3 Total tannins content

Total tannin content was analyzed using the Folin-Ciocalteu phenol reagent method as described by Lu et al. (2007). A 1.0 mL of supernatant was reacted with 2.5 mL of 10% v/v

Folin-Ciocalteu phenol reagent. After 5 min, a 2.0 mL of 7.5% w/v Na_2CO_3 was added into the mixture and left at room temperature for 1 h. The absorbance at 765 nm was measured. Total tannin content was expressed as mg tannic acid equivalent per 100 g dry sample (mg TNE/100 g).

2.5.4 Total anthocyanin content

Total anthocyanin content was estimated using the pH difference method of Golmohamadi et al. (2013). An aliquot of 1.0 mL of supernatant was filled in two test tubes; 1 and 2. For test tube 1, 4.0 mL of KCl-HCl pH 1 was added. For test tube 2, 4.0 mL of acetate buffer pH 4.5 was added. After standing for 1 h, the absorbance of the solutions was read at 520 and 700 nm. Total anthocyanin content was calculated from the equation (1):

$$\text{Anthocyanin} = \frac{[(A_{520,pH1} - A_{700,pH1}) - (A_{520,pH4.5} - A_{700,pH4.5})]}{\text{Molar extinction coefficient}} \times \text{M.W.} \times 1{,}000 \tag{1}$$

Where $A_{520,pH1}$ and $A_{700,pH1}$ were the absorbances at 520 and 700 nm of the solutions at pH 1 in test tubes 1 and 2, respectively. $A_{520,pH4.5}$ and $A_{700,pH4.5}$ were the absorbance at 520 and 700 nm of the solutions at pH 4.5 in test tubes 1 and 2, respectively. Molecular weight (M.W.) of cyanidin-3-glucoside (449.2 g/mol) and molar extinction coefficient of cyanidin-3-glucoside was 26,900 L/cm-mol. Total anthocyanin content was expressed as mg cyanidin-3-glucoside per 100 g dry sample (mg Cyd-3-glu/100 g).

2.5.5 Antioxidant activity

The antioxidant activity was evaluated using the DPPH assay method of Sanchez-Moreno (2002) with minor modifications. A 1.0 mL of supernatant was reacted with 2.0 mL of 0.075 mM DPPH for 30 min. The absorbance was measured at 517 nm. The DPPH radical scavenging activity was expressed as mM Trolox equivalent per 100 g dry sample (mM TE/100 g) and percent radical scavenging activity.

2.5.6 The β-carotene content

The β-carotene content of the extract was determined using the method of Nagata & Yamashita (1992). A 0.5 g of sample was dissolved in 10 mL of 2:3 v/v of acetone:hexane. The mixture was homogenized for 2 min and left for 24 h. The mixture was centrifuged at 3,000 rpm for 3 min. The supernatant was collected and measured at 663, 645, 505 and 453 nm. The β-carotene content was calculated from the equation (2).

$$\beta\text{-carotene (mg/100 g)} = 0.216A_{663} - 1.22A_{645} - 0.304A_{505} + 0.452A_{453} \tag{2}$$

Where A_{663}, A_{645}, A_{505} and A_{453} were the absorbances of the solution at 663, 645, 505 and 453 nm, respectively.

2.6 Statistical analysis

Each sample was analyzed in triplicate and the results were presented as mean±SD. The difference between the phytochemical values of the early and the late season samples was tested by the independent sample T-test at 0.05 level of significance (SPSS version 25 for window).

3. Results and Discussion

3.1 Soil analysis

The results of soil analysis from five durian orchards are shown in Table 1. The soil pH of the sampling orchards ranged from 3.87 (extremely strong acidic) to 7.57 (slightly alkaline), while the optimum pH for durian growth was 5.5-6.0 (Asia- Pacific Association of Agricultural Research Institutions, 2018). Soil organic matter was 1.80-6.02%, available phosphorous (P) was 284-1,280 mg/kg, and exchangeable potassium (K) was 66-599 mg/kg. The correlation coefficient (R^2) analysis between pH and organic matter revealed that the higher soil acidity (low pH), the lower the organic matter (R^2=0.5857). Organic matter usually releases H^+ which lowers the pH of the soil. However, the mineralization of organic anions in organic matter to the surrounding water may cause the pH in soil to increase (Ritchie & Dolling, 1985). Soil pH inversely correlated with available P and exchangeable K (R^2=0.2625 and 0.4360, respectively). It affected the nutrients available for the durian trees. Phosphorous (P) and potassium (K) are macronutrients that are more available in soil pH 6.0-7.0 and become less available in acidic soil. Thus, P and K were uselessly left in the extremely acidic soil.

It was also found that when available P increased, the exchangeable K increased (R^2=0.9320). While soil organic matter showed a good relationship with available P and exchangeable K (R^2=0.8628 and 0.8926, respectively) due to the fact that many exchangeable sites of organic matter were able to bind more ions and nutrients. The assessment of ammonia nitrogen (NH_3-N) and nitrate nitrogen (NO_3-N) showed that ammonia level was high to very high, whereas nitrate level was low to medium. That was because the nitrification was low in the soil pH below 6 (McCauley et al., 2009). Soil pH, organic matter, available P, exchangeable K, ammonia nitrogen, and nitrate nitrogen content influenced the growth, development and phytochemical synthesis in the durian trees. However, these factors also depended on the orchards management, fertilization, irrigation and weather.

3.2 Average rainfall and temperature

The average monthly rainfall and temperature data in Chanthaburi province, Thailand (crop year 2022-2023) are shown in Figure 2, Tables 2 and 3, respectively.

After the harvesting season in June, the average monthly rainfall was still high (not below 400 mm). The maximum rainfall was recorded in September 2022 and ranged from 377.3 to 852.8 mm (average 644.2 mm), and the mean temperature declined simultaneously (28.1-29.1°C). During the first flowering period in late November 2022 to early January 2023, the average rainfall decreased drastically (0 mm), while mean temperature was low (25.6-26.8°C). Moreover, the lowest temperature (16.7°C) was recorded in December 2022. Meanwhile, the durian fruit development in the early season started, the second age of flowering occurred in early January 2023. The average rainfall slightly increased in February to April (21-161.9 mm) and largely increased in May-July (110.0-589.0 mm). Mean temperature continually rose (28.1-29.9°C) and the highest temperature (36.4°C) was recorded in June 2023.

Table 1. Soil samples analysis

Districts	Orchard ID	pH	Organic Matter (%)	Available P (mg/kg)	Exchangeable K (mg/kg)	Salinity as Cl^- (g/kg)	Ammonia	Nitrate
Mueang	DR01	4.82 (Very strongly acidic)	5.34 (Very high)	284	144	nd.	Very high	Low
Tha Mai	DR02	7.57 (Slightly alkaline)	6.02 (Very high)	430	66	nd.	Very high	Medium
Khlung	DR03	5.73 (Moderately acidic)	5.76 (Very high)	409	137	nd.	Very high	Low
Na Yai Am	DR04	4.68 (Very strongly acidic)	4.52 (Very high)	420	106	nd.	Very high	Low
Khao Khitchakut	DR05	3.87 (Extremely acidic)	1.80 (Medium)	1,280	599	nd.	High	Low

nd. = not detected
Soil parameters classification was referenced from The Office of Science for Land Development (2019).

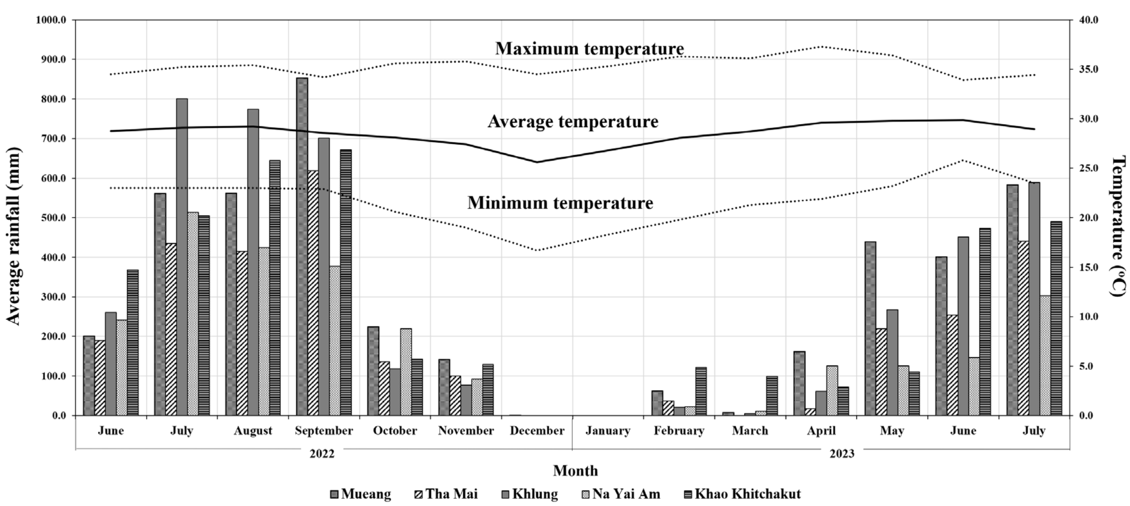


Figure 2. Average monthly rainfall and temperature in Chanthaburi province, Thailand

Table 2. Average monthly rainfall in Chanthaburi Province, Thailand (crop year 2022-2023) (Chanthaburi Provincial Agriculture and Cooperatives Office, 2023)

Districts	Orchard ID	Average Monthly Rainfall (mm)													
		2022							2023						
		June	July	August	September	October	November	December	January	February	March	April	May	June	July
Mueang	DR01	200.4	560.5	562.1	852.8	224.3	141.7	0.6	0.0	62.0	7.5	161.9	439.6	400.8	583.0
Tha Mai	DR02	189.9	434.8	415.0	619.1	136.0	100.2	0.0	0.0	37.0	0.0	17.3	219.4	254.2	440.7
Khlung	DR03	260.5	800.1	774.1	700.8	117.7	77.0	0.0	0.0	21.0	5.0	62.0	267.0	451.0	589.0
Na Yai Am	DR04	241.4	513.3	424.1	377.3	219.5	91.8	0.0	0.0	22.1	10.9	125.7	125.9	146.5	302.8
Khao Khitchakut	DR05	368.0	504.5	645.0	671.0	143.0	130.0	0.0	0.0	122.0	99.0	72.0	110.0	473.0	490.0

Table 3. Average monthly temperature in Chanthaburi Province, Thailand (crop year 2022-2023) (The Open Government Data, 2023)

Levels	Average monthly temperature (^{O}C)													
	2022							2023						
	June	July	August	September	October	November	December	January	February	March	April	May	June	July
maximu	34.5	35.2	35.4	34.2	35.6	35.8	34.5	35.3	36.3	36.1	37.3	36.4	33.9	34.4
minimum	23.0	23.0	23.0	22.9	20.6	19.0	16.7	18.3	19.8	21.3	21.9	23.2	25.8	23.5
average	28.8	29.1	29.2	28.6	28.1	27.4	25.6	26.8	28.1	28.7	29.6	29.8	29.9	29.0

3.3 Orchard management survey data

In order to get more supporting data about the sampled orchard's management, a survey was done using a questionnaire. The results were as follows:

3.3.1 Background data

The durian trees in the sampling orchards were 10 years old on average. They grew on plain and sandy-loam land, which was the most favorable soil type for durians (Amran et al., 2023). The irrigation system was a sprinkler system from small freshwater reservoir. All orchards cultivated durians with other tropical fruits, such as mangosteens and rambutans. A good mix of durian cultivars; for example, Mon Thong, Chanee, Puang Manee, Kan Yao and Kradum, was preferable, but Mon Thong was dominant in all orchards.

3.3.2 Tree caring

Under normal conditions, fertilization frequency was 3-6 times per year. Foliar fertilizer was also directly applied to promote the development of flower buds and fruit sets, supplying the sufficient nutrients to the trees, especially in the flowering and fruiting period. Pesticides and herbicides were commonly used together with bioproducts for pest and disease control. When durian flowers were blooming, 60% of the orchardists kept only two generations of inflorescences at early and late seasons. These two generations were about two weeks to two months apart. About 40% of the orchardists paid more attention to the early or the first durian production of the season because of the higher productivity and market price. In addition, 80% of the orchardists stated that the productivity of the early durian season was greater than the second one, and 60% said that the quality of first season fruit was better than that of the later season. They supported the idea that higher productivity and quality were the result of more tree care.

3.4 Phytochemical content and antioxidant activity

The phytochemical content and antioxidant activity of Mon Thong samples are presented in Figure 3 and Table 4. The results showed that total phenolics, total tannins, total flavonoids, total anthocyanins and DPPH radical scavenging activity in early season durian samples were significantly 12.05-27.29% higher than those of late season samples ($p<0.05$), whereas β-carotene in the early and late season samples were not different ($p>0.05$) (Table 5).

Considering each sampling site (DR01-DR05), the early season durian samples from Mueang (DR01E) and Khlung (DR03E) districts had significantly higher concentration of total phenolics, total flavonoids, total tannins, total anthocyanins and antioxidant activity than the late season samples (DR01F and DR03F), whereas β-carotene was also higher but not significantly. The total phenolics, total tannins, total anthocyanins, β-carotene and antioxidant activity in the early season samples from Na Yai Am district (DR04E) were higher than those of the late season samples (DR04L), while total flavonoids were not significantly higher. The content of total flavonoids, total anthocyanins, β-carotene and antioxidant activity in the early season durian samples in Khao Khitchakut district (DR05E) were significantly higher than those of the late season samples (DR05L). The total phenolics and total tannins were higher but not significantly.

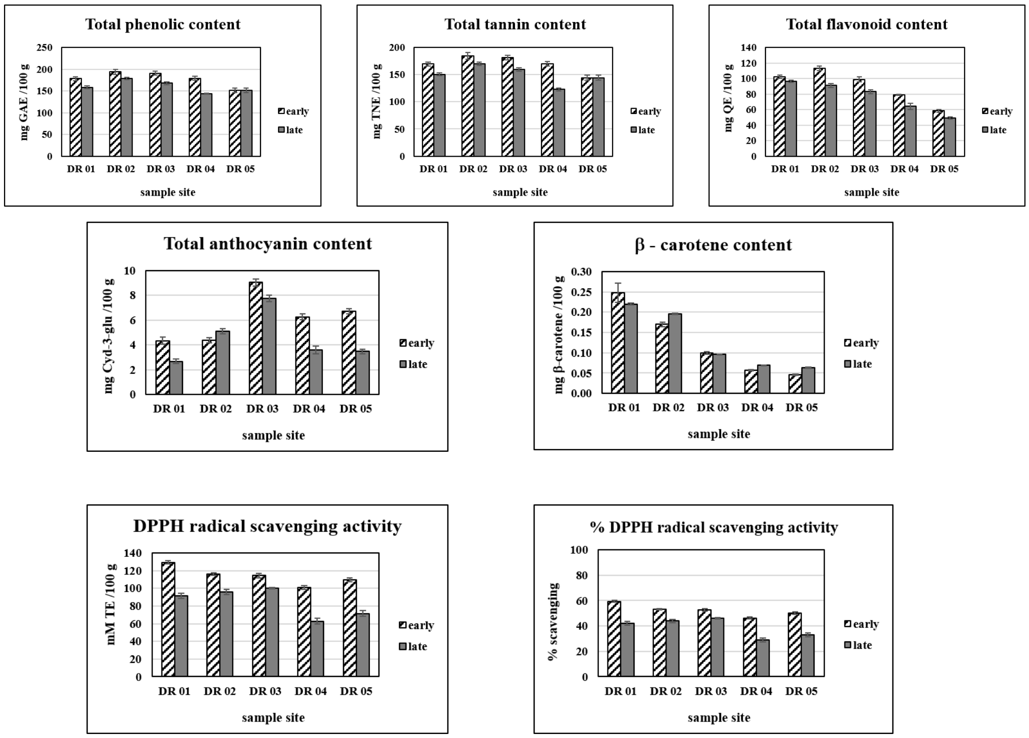


Figure 3. Phytochemical content in Mon Thong durian (*Durio zibethinus* Murray) samples

From the results, phytochemical content corelated with orchard management and caring. The farmers took better care of the trees during the early or the first flowering and fruiting period because of the higher yield and price. The inflorescent flowers on the trees were kept for not longer than two same stages of development to avoid nutrient competition and deficiency. Normal and foliar fertilizer were applied to improve durian flowering, fruit setting, growth, and development. On the contrary, farmers did not take as much care with the late season durian fruits due to the chaos of the fruit harvesting. Thus, the early season durian samples showed higher content of total phenolics, total tannins, total anthocyanins, total flavonoids, β-carotene and DPPH radical scavenging activity than the late season samples. Poovarodom et al. (2001a) & Lim et al. (2008) reported that the nutrient levels in durian trees (*Durio zibethintts* Murray) fluctuated. The macronutrients, N, P and K, and some micronutrients, Zn, Mn, Cu, Ca and Fe, decreased during the flowering and fruit setting period. Insufficient fertilizer supply might lead to the deficiency of nutrients during the second generation in late season fruit production. Therefore, adequate fertilizer was necessary to maintain the synthesis of primary and secondary metabolites in durian trees through the crop season.

Table 4. Phytochemical content in Mon Thong durian (*Durio zibethinus* Murray) samples from five orchards in Chanthaburi province, Thailand (crop year 2022-2023).

Districts	Samples ID	Total phenolics (mg GAE/100 g)	Total tannins (mg TNE/100 g)	Total flavonoids (mg QE/100 g)	Total anthocyanins (mg Cyd-3-glu /100 g)	β - carotene (mg β-carotene /100 g)	DPPH radical scavenging activity	
							scavenging activity (mM TE/100 g)	%scavenging
Mueang	DR01E	178.40±4.19	169.66±3.98	102.25±2.42	4.34±0.27	0.248±0.024*	129.30±1.65	59.26±0.75
	DR01L	158.52±2.75	150.75±2.62	96.72±1.41	2.68±0.20	0.220±0.002*	91.57±2.98	42.09±1.36
Tha Mai	DR02E	193.96±6.27	184.46±5.97	113.24±3.00	4.37±0.23	0.170±0.005	115.99±1.63	53.20±0.74
	DR02L	178.73±2.88	169.97±2.74	91.10±2.52	5.09±0.21	0.196±0.001	95.51±2.89	43.88±1.31
Khlung	DR03E	190.99±4.25	181.62±4.04	99.03±3.31	9.03±0.30	0.100±0.003*	114.43±2.32	52.49±1.05
	DR03L	168.03±3.45	159.79±3.28	83.18±2.56	7.75±0.24	0.096±0.001*	100.45±0.80	46.13±0.36
Na Yai Am	DR04E	179.00±4.42	170.23±4.20*	79.04±0.89	6.27±0.21	0.057±0.002	100.93±2.09	46.35±0.95
	DR04L	143.64±0.82	122.88±2.29*	64.20±4.19	3.58±0.30	0.069±0.001	62.83±3.51	29.02±1.60
Khao Khitchakut	DR05E	151.70±4.95*	144.27±4.71	58.33±1.87*	6.72±0.21	0.046±0.002	109.40±2.22	50.20±1.01
	DR05L	151.84±5.25*	144.40±4.99	49.21±1.50*	3.47±0.20	0.063±0.002	71.60±3.14	33.00±1.43

An asterisk (*) next to the data shows the non-significant difference between the early and the late season of the same site ($p<0.05$)
E=the early season sample, L=the late season sample

Table 5. Percentage of difference in phytochemical content between the early and late season samples (average from all districts)

Phytochemicals		Average Value		%difference
		Early	Late	
Total phenolics (mg GAE/100 g)		178.81±15.98[a]	149.56±16.68[b]	16.36
Total tannins (mg TNE/100 g)		170.05±15.20[a]	149.56±16.68[b]	12.05
Total flavonoids (mg QE/100 g)		90.38±20.25[a]	80.68±17.23[b]	10.73
Total anthocyanins (mg Cyd-3-glu/100 g)		6.15±1.81[a]	4.52±1.87[b]	26.56
β – carotene (mg β-carotene/100 g)		0.12±0.08[a]	0.13±0.07[a]	-3.59
DPPH radical scavenging activity	scavenging activity (mM TE/100 g)	114.01±9.75[a]	84.39±15.27[b]	25.98
	% scavenging	52.30±4.44[a]	38.03±7.81[b]	27.29

Superscript letters ([a, b]) in each row show significant difference ($p<0.05$).

Rainfall and temperature affected the durian quality and quantity. These factors influenced not only the size, shape, texture, and flavor of durian fruits, but also the synthesis of many phytochemicals. The crop year 2022-2023 started in July 2022 when the average monthly rainfall was still high, and the maximum rainfall was recorded in September 2022. After this period, the level of precipitation and temperature declined gradually. The dry conditions and low temperatures induced the flowering of durian trees. During the flowering period, there was no rainfall recorded in December 2022 to January 2023, and the lowest temperature was noted in December. These conditions initiated the first flowering, and the fruit setting continued developing until April. This was the early season durian fruit. The results revealed that the antioxidant activity, total phenolics, total flavonoids, total tannins, anthocyanins and β-carotene in this generation (the early season) durian samples were significantly higher than those of the late season samples. It can be implied that the phytochemical content in plants was influenced by climatic conditions, especially precipitation and temperature (Suwanseree & Yapwattanaphun, 2017). Our results were in agreement with the report of Kumar et al. (2017) who noted that the antioxidant potential in *Aloe vera* (L.) Burm.f. from India was more pronounced in cold and dry weather. The decrease in temperature and rainfall was an environmental stress that affected plants, leading to the synthesis of various types of phytochemicals, such as phenolics, flavonoids, tannins, and others. It might be called “plant self-defense system” to tolerate these challenging conditions (Chalker-Scott, 1999; Iqbal & Bhanger, 2006).

The second period of durian flowers occurred in early January 2023, and the late season fruit setting continued until June. The average rainfall slightly increased from February to April and largely increased from May to July. Mean temperature continually rose and the highest temperature was recorded in June. Environmental stress decreased during this period, resulting in decreasing of phytochemicals synthesis. So, the phytochemical content and radical scavenging activity of the late season durian samples were lower than the early season samples.

The individual orchard soil pH and organic matter also affected the nutrients available for durian. Some nutrients (N, P, K) were more available in soil of pH of 6.0-7.0, and became less available in acidic soil. Nitrification was low in the soil pH below 6

(McCauley et al., 2009). Organic matter plays an important role in the exchange of some ions between soil and plants. Thus, the orchards that had acidic soil, and low organic matter, P, K, nitrate and ammonium produced fruits of lower phytochemical content. However, soil composition was one of the factors that affected phytochemical content in durian samples**.**

4. Conclusions

Although there were many studies on the antioxidant activity in Durian (*Durio zibethinus* Murray), there were no reports attempted to its difference between early and late season fruits. This is the first study that provides extensive data about the differences in phytochemical content of early and late season of Mon Thong durian cultivars. Our results show that some phytochemicals and antioxidant activities in the early season durian samples were higher than the late season samples. Our results may be of benefit to durian production since the early season durian fruit contained higher levels of phytochemicals, offering not only delicious flavor but also more health benefits to the consumers. The results may perhaps be used to elevate market price for the premium product of durians.

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6. Conflicts of Interest

The authors declare that we have no conflict of interest.

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