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The Physicochemical and Antioxidant Properties of Pomelo (*Citrus grandis* Osbeck) Extract from Three Thai Cultivars

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ABSTRACT

Background: Pomelo (*Citrus grandis* Osbeck or *Citrus maxima*) is the largest citrus fruit, which is commonly consumed in Asian countries. The pulp is available in red, pink and white colors, composed of large, spindle-shaped extract sacs. Pomelo extracts have a sharp taste and flavor, which contains high levels of vitamin C and citric acid.

Methods: Determining physical properties, phytochemical content including phenolics, flavonoids and tannins; to evaluate antioxidant activity among pomelo extracts from Kao Yai, Thong Dee and Siam Ruby cultivars, which were the members of the white, pink and red groups, respectively.

Result: The pomelo extracts were varied in color and turbidity. The odor and taste of them were citrus aromatic with a sour-sweet taste. The pomelo extracts from the Siam Ruby cultivar was the highest pH (4.01±0.3). However, Kao Yai pomelo extracts had the highest sweetness (°Brix = 0.5772%). The viscosity of pomelo extracts from Thong Dee cultivar was the highest and may contain high fibers and pectin. The color of Siam Ruby pomelo extracts was the most attractive color, while Kao Yai pomelo extracts were the tastiest. Total phenolic content (TPC), total flavonoid content (TFC) and tannin content (TC) were significantly different ($p<0.05$). Thong Dee pomelo extracts contained the highest TPC (45.74±8.12 mg GAE/100 ml) and TC (4.52±0.28 mg TAE/100 ml), while Siam Ruby pomelo extracts were the highest TFC (35.06±3.87 mg RE/100 ml). However, the DPPH scavenging capacities of the three pomelos extracts were not significantly different.

Key words: Antioxidant, *Citrus grandis* osbeck, *Citrus maxima*, Flavonoids, Polyphenols, Pomelo extracts.

INTRODUCTION

Pomelo (*Citrus grandis* Osbeck or *Citrus maxima*) is the largest citrus fruit. Mainly, pomelo is widely grown in China and Southeast Asia and the fruit is favored in raw fruit consumption. Therefore, the out-of-grade fruits are processed into extracts and preserved food products. Depending on cultivars, the fruits are 10-30 cm in diameter and weigh are range from one to three kg (Anmol *et al.*, 2021; Vijaylakshmi and Radha, 2015; Zhao *et al.*, 2021). In different areas, the fruit name varied, by the color of flesh and skin, such as white or pinkish pulp and yellowish or greenish peel. The drinking of pomelo extracts is popular due to their pleasant and refreshing flavor (Shah *et al.*, 2019; Zhang *et al.*, 2017). The pulp is available in red, pink and white colors and is composed of large, spindle-shaped extract sacs. (Sharma *et al.*, 2022; Vijaylakshmi and Radha, 2015; Al-Dosari and Abdellatif, 2024; Ghosh and Gangopadhyay, 2003). Pomelo extracts have a sharp taste and flavor, which contains high levels of vitamin C and citric acid. There is also naringin as a bitterness component and health-promoting polyphenolic compounds, including hesperidin, caffeic acid, *p*-coumaric acid, ferulic acid and vanillic acid. Pomelo extracts are derived from various cultivars, which exhibit significant antioxidant activity due to their rich phytochemical composition (Anmol *et al.*, 2021; Ali *et al.*, 2019; Shah *et al.*, 2014; Al-Sharqi *et al.*, 2025). The antioxidant properties of pomelo extracts are derived from high content of polyphenols, flavonoids and limonoids, which vary across different cultivars. These compounds also offer potential health benefits, making pomelo a valuable fruit for dietary and nutraceutical applications (Balmori *et al.*, 2023; Pichaiyongvongdee *et al.*, 2014; Sharma *et al.*, 2024; Toh *et al.*, 2013). In Thailand, the color of flesh and extracts is used to classify the pomelo into two groups: pink and white groups. The Thai cultivars within the pink group include Tong Dee and Tha Khoi. While the Thai cultivar members white group are Kao Yai, Kao Nam Pheung, Kao Phuang and Kao Taeng Kwa (Pichaiyongvongdee *et al.*, 2014). The bioactive compounds in pomelo extracts, such as naringin and hesperidin, are known for their health-promoting properties, including antioxidant, anti-inflammatory and potential cardiovascular

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prevention (Balmori *et al.*, 2023; Pichaiyongvongdee *et al.*, 2014; Sharma *et al.*, 2024; Sapkota *et al.*, 2022). These compounds can disrupt cholesterol micellization and inhibit pancreatic lipase activity, which provides their functional health benefits. Given its rich antioxidant profile, pomelo extracts can be utilized in developing functional foods and nutraceuticals (Anmol *et al.*, 2021; Balmori *et al.*, 2023; Sharma *et al.*, 2024). Additionally, the pomelo peel is a source of bioactive compounds, which have health benefits and sustainability, *i.e.*, food preservation and health supplements, which are implied to the utilization of all parts from the pomelo fruit (Tocmo *et al.*, 2020; Sharma *et al.*, 2024; Shah *et al.*, 2019). A previous study had analyzed fresh fruit extracts from red and white flesh pomelos and reported that white flesh pomelos have contents of phenols, tannins and flavonoids higher than red flesh pomelos (Abirami *et al.*, 2013; 2014). In contrast, Thai pomelos extract from pink cultivars, including Tong Dee and Tha Khoi has higher content of flavanones, limonoids and antioxidant capacity rather than white cultivars (Pichaiyongvongdee *et al.*, 2014; Kim and AlZubi, 2024; Min and Kim, 2024; Na and Na, 2024; Pham and Quan, 2025). Therefore, the white varieties have lower antioxidant capacity compared to the pink variety, which still provides significant health benefits and can be a valuable source of natural antioxidants (Toh *et al.*, 2013). Recently, the red group has been newly recognized as the Siam Ruby cultivar, which is the only Thai cultivar in the red group (Buakong, 2016). The pomelo extracts from different Thai varieties will provide a variety of antioxidant activity, which is important to consider the variability in phytochemical content within pomelo extracts across white, pink and red cultivars. This study aimed to determine physical properties, phytochemical content including phenolics, flavonoids and tannins; to evaluate antioxidant activity among pomelo extracts from Kao Yai, Thong Dee and Siam Ruby cultivars, which were the members of the white, pink and red groups, respectively.

MATERIALS AND METHODS

Cultivation area and fruit characteristics

White group pomelo

The Kao Yai cultivar is commonly cultivated in Samut Songkhram and this pomelo variety has also been registered as a geographical indication (GI) agricultural product from this province. The round fruit is large in size, weighing 1.2-2.3 kg and diameter is 14-18 cm. The ripe fruit is yellowish dark green and the peel (flavedo and albedo) is medium thick. Segment peel is white in color, which surrounds the 12-16 segment pulps/fruit. Each pulp is pale-yellowish white, containing sticky, large extract sacs. The taste of flesh is sweet with a slightly sour taste and a unique aroma.

Pink group pomelo

Thong Dee cultivar is a favored cultivar cultivated in Nakhon Pathum province. The quality and taste of this variety are higher than other varieties from white and pink pomelos. The round fruit is medium-sized without corks, weighing 0.94-1.1 kg and diameter is 14-16 cm. The ripe fruit was green in color. The fruit peel is smooth and relatively thin. The segment peel is pinkish white, which surrounds the 14-16 segment pulps/fruit. Each pulp is pale pink, containing soft and juicy extract sacs. The taste of flesh is sweet and has a unique aroma.

Red group pomelo

The Siam Ruby cultivar is a favorite cultivated in the upper area of Southern Thailand. This pomelo variety originated from Nakhon Si Thammarat Province and is registered as a GI agricultural product of this province. This variety is the most valuable in Thailand. The pear-shaped fruit is green and yellow and the upper part has a cork. The peel is thin and has small hair covering all over the fruit like velvet. The fruit is large in size, weighing 1.0-2.0 kg and diameter is 15-16.5 cm. The segment peel is pale pink colored, which surrounds the 10-13 segment pulps/fruit. The color of pulp varied from pink to red, like the color of a pomegranate, containing soft and juicier extract sacs. The taste of flesh was relatively sweet and had a unique aroma.

Pomelo extracts preparation

In this study, the varieties of white, pink and red groups included Kao Yai, Thong Dee and Siam Ruby cultivars, which were purchased from Samut Songkhram, Nakhon Pathum and Nakhon Si Thammarat, respectively. For each variety, three to four pomelo fruits were the raw material for one liter of extract preparation, which was kept in room temperature (25°C) for five to eight days until they were ripe. The pulp was carefully separated from peel and segments to prevent extracts bitterness. They were thoroughly pressed and filtered for extracts production and pomace removal, respectively. One liter of each variety of pomelo extracts was transferred to dark color and sterile glass bottle and stored at 4°C before extracts evaluation and analysis.

Physical characteristics

Acidity and total soluble solids

Acidity of pomelo extracts was measured using a pH meter, while total soluble solids (TSS) were measured using a refractometer. Results were expressed as pH and °Brix (%), respectively (AOAC, 2015).

Sensory evaluation

Instrumental measurements

The color of pomelo extracts was measured using a colorimeter (ColorQuest XE, HunterLab, USA) in the opacity section (Xsec mode). Each sample was measured ten times and results were expressed as L*, a* and b* values (Wrolstad and Smith, 2010), where L* represents lightness (0 = black, 100 = white), a* represents the red–green axis (positive = red, negative = green) and b* represents the yellow-blue axis (positive = yellow, negative = blue). Viscosity and related parameters, including shear stress (SS), shear rate (SR),

torque (%) and temperature, were measured using a Brookfield viscometer (Rao and Anantheswaran, 2005).

Visual assessment

A trained panel of 15 individuals (ages 25-45 years; 8 females, 7 males) with expertise in Thai cooking evaluated the appearance and color of pomelo extracts in a controlled laboratory (25°C, uniform lighting).

Hedonic testing

A separate panel of 30 untrained consumers (ages 20-50 years; 15 females, 15 males) evaluated coded samples for color, odor, flavor, perceived sweetness and sourness, texture and overall liking using a 9-point hedonic scale (1 = dislike extremely; 9 = like extremely). Samples were presented in randomized order in opaque cups to minimize bias (Lawless and Heymann, 1999; Meilgaard *et al*., 1999).

Ethics statement

This study was exempted from review by the Suan Sunandha University Ethics Committee (COE.1-048/2024).

Phytochemical contents

Total phenolic content

Total phenolic content (TPC) was determined by the colorimetric method, Folin-Ciocalteu assay. The absorbance of the chemical reaction between the sample and Folin-Ciocalteu reagent (Loba, Chemie, India), was determined at 765 nm by a UV-visible spectrophotometer. The range of gallic acid (Sigma-Aldrich, USA) concentrations was applied for the standard curve. TPC was represented as mg of gallic acid equivalent (GAE) per 100 ml (Singleton *et al.*, 1999).

Total flavonoid content

Total flavonoid content (TFC) was determined by the aluminum chloride colorimetric method, which was based on the formation of a complex between aluminum ions (Al^{3+}) and the hydroxyl groups of flavonoids. The complex produces a yellow color was measured at 415 nm using a UV-visible spectrophotometer. The sample was mixed with 2% aluminum chloride (Loba Chemie, India) and added potassium acetate (10:96:10). The mixture was incubated for 30 min at 25°C and the absorbance of the complex was measured by a microplate reader. The range of rutin (HWI Analytik GmbH, Germany) concentrations was measured and performed standard curve. TFC in the sample was calculated by using a standard curve and represented as mg of rutin equivalent (RE) per 100 ml (Chang *et al.*, 2002; Biju *et al.*, 2014).

Total tannin content

Total tannin content (TTC) was analyzed by the spectrophotometric-based method (lmax = 760 nm), the Folin-Denis assay. This analytical approach involved the use of the Folin-Denis reagent (Sigma Aldrich, USA) according to the establishment of the Association of Official Analytical Chemists, AOAC (2005) 952.03. A standard curve was performed by utilizing of the range of concentrations of tannic acid (Fluka, Switzerland) and TTC was represented as mg of Tannic acid equivalent (TE) per 100 ml (AOAC, 2015).

Antioxidant assay

The different varieties of pomelo extracts were determined to have antioxidant activity by the monitoring of 2,2-diphenyl-1-picrylhydrazyl, DPPH (Sigma Aldrich, USA) radicals. The reduction of DPPH radical absorbance in the presence of each sample was monitored at 550 nm by a microplate reader. The scavenging activity of DPPH radicals was expressed in mg of Trolox equivalent (TE) per 100 ml and in ascorbic equivalent (AE) per 100 ml (Katsube *et al.*, 2004).

Statistical analysis

Descriptive analyses were usually used to explain the differences in the data. Duncan's multiple range test was used to compare the differences in phytochemical content and antioxidant capacity among pomelo extracts. The significance was judged at $p<0.05$.

RESULTS AND DISCUSSION

Pomelo pulp and extract characteristics

The three pomelo cultivars, Kao Yai (white), Thong Dee (pink) and Siam Ruby (red), exhibited distinct differences in pulp morphology, color and texture, which were evident both visually and in sensory perception (Fig 1). Kao Yai fruits contained pale-white pulps with a relatively firm texture, while Thong Dee had pinkish pulps with moderate juiciness and Siam Ruby showed an intense red pulp color with a softer, juicier texture. These visual differences translated into distinct juice appearances: Kao Yai extracts were yellowish-white and slightly opaque, Thong Dee



Fig 1: The pomelo pulp (or flesh) from different cultivars: (left) Kao Yai; (middle) Thong Dee; and (right) Siam Ruby.

extracts appeared pinkish-white with higher turbidity due to suspended fibers and Siam Ruby extracts displayed an attractive pink coloration (Fig 2). The observed coloration corresponded well with the natural pulp pigments and confirmed findings from panelists, who consistently rated the extracts according to their visual appeal (Table 1).

Panelists also noted variations in aroma and taste. All extracts exhibited citrus aromatic notes characteristic of pomelo, but differences emerged in sweetness and sourness. Siam Ruby extracts were generally perceived as sweeter, while Kao Yai and Thong Dee extracts were described as more sour-sweet. This finding is consistent with earlier reports linking pulp pigmentation to perceived flavor intensity in citrus fruits (Anmol *et al*., 2021; Balmori *et al*., 2023). In particular, the strong red pigmentation of Siam Ruby likely indicates the presence of anthocyanins or other flavonoid derivatives, which may influence both sensory appeal and nutritional value. These initial sensory assessments suggested that cultivar-specific pulp coloration and composition play a major role in consumer perception.

Instrumental color and physical properties

Instrumental color measurements further confirmed the sensory observations (Table 2). Kao Yai and Thong Dee extracts displayed similar lightness (L* values ~36), whereas Siam Ruby had significantly lower lightness (L* = 28.04±0.28) due to its strong red pigmentation, reflected in the highest a* value (7.91±0.02). Conversely, Kao Yai showed the lowest a* value (2.3±0.03) and the highest b* value (6.84±0.09), corresponding to a green-to-yellow hue. Such cultivar-dependent color parameters are consistent with pigment variability reported in other pomelo varieties (Yin *et al*., 2022).



Fig 2: Comparison between pomelo extracts from (left) Kao Yai, (middle) Thong Dee and (right) Siam Ruby cultivars.

In terms of physicochemical properties, Siam Ruby extracts exhibited the highest pH (4.01±0.3), suggesting a lower acidity and aligning with its sweeter sensory profile. In contrast, Kao Yai extracts had the highest soluble solids (°Brix = 12.75), indicating higher sugar content despite being perceived as sourer. This highlights an interesting divergence between instrumental and sensory data: perceived sourness may be influenced not only by sugar content but also by the balance of organic acids and volatile compounds, as previously observed in citrus fruits (Sarker and Oba, 2019).

Viscosity analyses revealed that Thong Dee extracts had the highest viscosity (25.50 cP) and torque values, likely due to the presence of higher amounts of suspended fibers and pectin. This finding supports the sensory observation of greater turbidity and less desirable mouthfeel in Thong Dee juices. The presence of pectin-rich suspensions may be nutritionally beneficial, particularly in weight management contexts, but less appealing in terms of consumer preference for fresh juices. Previous studies have also highlighted the role of insoluble fiber in reducing the acceptability of fresh juice products, even though such fibers are desirable in functional beverages (Noor and Noranizan, 2018; Nishad *et al*., 2018).

Thus, instrumental data aligned with sensory evaluation: Siam Ruby was visually attractive and moderately sweet, Kao Yai combined higher °Brix with strong sour-sweet balance and Thong Dee exhibited high fiber-induced turbidity but lower consumer appeal as a fresh beverage.

Sensory evaluation and consumer preference

Table 3 summarizes the sensory evaluation results. Siam Ruby extracts scored highest for color attractiveness (8.4/9), which is not surprising given its intense red pigmentation. Kao Yai achieved the highest scores for flavor (8.1/9), reflecting consumer appreciation for its balanced sour-sweet taste. Thong Dee consistently received lower scores across most attributes, particularly for texture (5.9/9), due to its fibrous and viscous nature.

Overall liking scores (7.42 for Kao Yai, 7.45 for Siam Ruby and 7.00 for Thong Dee) suggest that all cultivars were moderately liked. However, consumer preference diverged by attribute: Siam Ruby was most visually appealing and suitable as a premium fresh juice, whereas Kao Yai was more versatile, being both a refreshing beverage and a potential ingredient for desserts and mixed drinks. Thong Dee, while less appealing for direct consumption, holds potential for functional beverages aimed at health-conscious consumers, especially given its fiber content. Similar trends have been reported in citrus product development, where consumer acceptance is

Table 1: Characteristics of pomelo extracts from different cultivars evaluated by panelists.

Pomelo extract	Pulp color	Physical appearance	Color	Odor	Flavor
Kao yai	White	Slightly opaque	Yellowish white	Citrus aromatic	Sour/sweet
Thong dee	Pink	Opaque with suspension	Pinkish white	Citrus aromatic	Sour/sweet
Siam ruby	Red	Opaque with suspension	Pink	Citrus aromatic	Slightlysour/sweet

Table 2: Physical properties of pomelo extracts from different cultivars.

Cultivar	L*	a*	b*	pH	°Brix (%)	Viscosity (cP)	Torque (%)	Temp (°C)	SS (N/m²)	SR (1/s)
Kao yai	36.37±0.15^{a}	2.30±0.03^{c}	6.84±0.09^{a}	3.65±0.10^{b}	12.75± 0.20^{a}	5.10±0.05^{b}	24.8±0.3^{a}	2.37±0.02^{a}	186±0^{a}	186±0^{a}
Thong dee	36.71±0.13^{a}	0.44±0.02^{b}	4.67±0.04^{b}	3.63±0.10^{b}	10.20±0.18^{b}	25.50±0.35^{a}	25.1±0.4^{a}	4.74±0.05^{b}	186±0^{a}	186±0^{a}
Siam ruby	28.04±0.28^{b}	7.91±0.02^{a}	4.08±0.04^{b}	4.01 ± 0.30 ^{a}	7.70±0.15^{c}	19.25±0.28^{a}	24.6±0.3^{a}	3.58±0.04^{c}	186±0^{a}	186±0^{a}

Values are mean±SD (n = 3). Values within the same column followed by different letters (a, b, c) are significantly different ($p<0.05$, Duncan's multiple range test). °Brix = Total soluble solids, representing extract sweetness. Viscosity = Measured in centipoise (cP). Temp = Temperature during measurement (°C). SS = Shear stress (N/m²), SR = Shear rate (1/s).

influenced not only by sweetness but also by visual appeal and texture (Gupta *et al*., 2021).

Phytochemical content and antioxidant properties

The three pomelo cultivars differed significantly in their phytochemical composition (Table 4). Thong Dee extracts contained the highest total phenolic content (TPC = 45.74±8.12 mg GAE/100 ml) and tannin content (TC = 4.52±0.28 mg TAE/100 ml), suggesting greater phenolic-derived antioxidant potential. Siam Ruby extracts, on the other hand, showed the highest total flavonoid content (TFC = 35.06±3.87 mg RE/100 ml). Kao Yai extracts exhibited comparatively lower phytochemical levels across most categories, though their values remained within ranges reported for other white-pulp pomelo cultivars (Abirami *et al*., 2014).

Despite these variations in phytochemical content, antioxidant activity measured by DPPH scavenging capacity did not differ significantly among the three cultivars (range: 78.54-83.25 mg TE/100 ml and 65.06-70.31 mg AE/100 ml). This finding suggests that while individual phytochemical components vary by cultivar, their combined antioxidant effects may reach a similar threshold. This observation supports previous reports of inconsistent correlations between phenolic content and antioxidant capacity in citrus species (Pichaiyongvongdee *et al*., 2014).

Interestingly, the higher TFC in Siam Ruby could be attributed to its red pigmentation, potentially from anthocyanins and related flavonoids. These compounds contribute not only to visual appeal but also to potential health benefits. However, their presence did not translate into significantly higher antioxidant activity *in vitro*, reinforcing the idea that antioxidant bioactivity depends on complex interactions among multiple phytochemicals rather than the concentration of individual groups.

Our findings echo but also expand upon earlier literature. Abirami *et al*. (2013, 2014) compared white and pink pomelo varieties and reported differences in phytochemical composition, with pink varieties generally showing higher phenolic contents. Our study confirms this trend but adds a new dimension by including a red cultivar (Siam Ruby), which demonstrated higher flavonoid levels. Similarly, Chia and Chong (2013) highlighted that pomelo flavor profiles are strongly linked to pulp pigmentation, a relationship also evident in our sensory evaluations.

However, while previous studies often reported stronger antioxidant activities in pigmented cultivars, our results challenge this assumption by showing comparable antioxidant activity across all three cultivars. This discrepancy may be due to methodological differences or to the balancing effects of other compounds, such as ascorbic acid, that contribute to antioxidant capacity but are not directly linked to pulp coloration.

The higher viscosity and turbidity of Thong Dee juice align with findings from Noor and Noranizan (2018), who reported that higher fiber and pectin content can reduce juice clarity and consumer acceptability. Nevertheless, as

Table 3: Likeness of pomelo extracts obtained from different cultivars.

Cultivar	Color	Odor	Flavor	Texture	Overall
Kao yai	7.8±0.2^{a}	7.5±0.3^{a}	8.1±0.2^{a}	6.3±0.4^{b}	7.42±0.25^{a}
Thong dee	7.5±0.3^{ab}	7.3±0.2^{a}	7.3±0.3^{b}	5.9±0.3^{c}	7.0±0.3^{b}
Siam ruby	8.4±0.2^{b}	7.6±0.2^{a}	7.7±0.3^{b}	6.1±0.4^{bc}	7.45±0.25^{a}

Overall score is the average of the four sensory attributes: color, odor, flavor and texture. Values are mean ± standard deviation (n = 30). Different letters within a column indicate statistically significant differences ($p<0.05$, Duncan's multiple range test).

Table 4: Phytochemicals and antioxidant capacity of pomelo extracts from different cultivars.

Cultivar	TPC (mg GAE/ 100 ml)	TFC (mg RE/ 100 ml)	TC (mg TAE/ 100 ml)	DPPH (mg TE/100 ml)	DPPH (mg AE/100 ml)
Kao yai	39.83±5.11^{b}	13.6±2.18^{c}	1.45±0.03^{b}	81.32±7.23^{a}	70.31±3.02^{a}
Thong dee	45.74±8.12^{a}	28.46±2.45^{b}	4.52±0.28^{a}	78.54±4.98^{a}	65.06±5.68^{a}
Siam ruby	41.67±4.91^{ab}	35.06±3.87^{a}	1.58±0.14^{b}	83.25±2.67^{a}	68.95±4.46^{a}

Values are mean ± standard deviation (n = 3). Different letters within a column indicate statistically significant differences ($p<0.05$, Duncan's multiple range test). TPC = Total phenolic content; TFC = Total flavonoid content; TC = Tannin content; DPPH = 2,2-diphenyl-1-picrylhydrazyl; GAE = Gallic acid equivalent; RE = Rutin equivalent; TAE = Tannic acid equivalent; AE = Ascorbic acid equivalent; TE = Trolox equivalent.

Chen *et al.* (2023) emphasized, such fiber-rich beverages may have added value as functional or weight-management drinks, offering opportunities for targeted product development.

Practical implications and potential applications

From a product development perspective, Siam Ruby extracts, with their striking color and sweet profile, appear most suitable for premium fresh juice markets targeting consumers who prioritize visual appeal and mild sweetness. Kao Yai extracts, balancing higher °Brix with a refreshing sourness, could serve both as a standalone beverage and as a flavor enhancer in desserts and cocktails. Thong Dee extracts, while less desirable for fresh juice consumption due to fibrous texture, could be leveraged in functional beverages, potentially marketed for digestive health or dietary fiber intake.

Nutritionally, the phytochemical diversity among cultivars underscores the importance of considering varietal differences in designing pomelo-based products. While no single cultivar outperformed others across all parameters, each exhibited unique strengths-Siam Ruby in flavonoids, Thong Dee in phenolics and tannins and Kao Yai in sugar content. Such diversity provides opportunities for cultivar-specific marketing and tailored health claims.

Overall, the study demonstrates that pomelo pulp color is strongly associated with sensory attributes and phytochemical composition, though not necessarily with *in vitro* antioxidant capacity. These findings contribute to ongoing debates in citrus research, where correlations between pulp pigmentation, phytochemical levels and bioactivity remain complex and cultivar-dependent. By integrating sensory evaluation, physicochemical analysis and phytochemical profiling, our results highlight the unique strengths and limitations of each pomelo cultivar, offering practical guidance for both consumers and food product developers.

CONCLUSION

The physicochemical properties of pomelo extracts from Kao Yai, Thong Dee and Siam Ruby cultivars varied in color, turbidity, pH, sweetness and viscosity. The TPC, TFC and TC were varied within pomelo extracts from three cultivars and significantly different ($p<0.05$). While the antioxidant properties within white, pink and red pomelo extracts were not significantly different and the phytochemical contents may not correlate with the *in vitro* antioxidant activity of pomelo extracts.

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Disclaimers

The views and conclusions expressed in this article are solely those of the authors and do not necessarily represent the views of their affiliated institutions. The authors are responsible for the accuracy and completeness of the information provided, but do not accept any liability for any direct or indirect losses resulting from the use of this content.

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Authors' contributions

All authors contributed toward data analysis, drafting and revising the paper and agreed to be responsible for all the aspects of this work.

Use of artificial intelligence

Not applicable.

Declarations

Authors declare that all works are original and this manuscript has not been published in any other journal.

Conflict of interest

Authors declare that they have no conflict of interest.

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