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Quality of Concentrate Mangosteen Juice Produced from Small-scale Industrial Juicer, Ranong, Thailand

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ABSTRACT

Mangosteen (*Garcinia mangostana* L.) juice shortages and excesses during harvest season can potentially be addressed by processing the juice. However, small-scale producers in Ranong, Thailand are unable to produce juice of a high grade due to financial limitations and a lack of technology transfer. This study aimed to develop "ready-to-use" small-scale industrial juicer technology to improve the taste and appearance of mangosteen juice. Anthocyanin and tannin contents present in juice and their antioxidant property were also evaluated by spectroscopic-based methods and DDPH radical scavenging activity test. The juice from the new procedure (CJ) had a better physical appearance and taste than the juice from the prior technique (C). The quality of the juice was improved with the use of the mangosteen juicer due to the decrease in turbidity and suspension as well as a lack of an astringent taste. However, the appearance and color did not reach to quality of industrialized commercial juice (I). The new procedure (CJ) contained the highest tannin content (40 mg/100 ml). While commercial juice (I) contained the highest anthocyanin content (16.2 mg/100 ml). The old technique (C) possessed the strongest DDPH radical scavenging activity (59.23 mg of Trolox equivalent/100 ml and 44.31 mg of ascorbic equivalent/100 ml) following in CJ and I, respectively. In addition, this new process can improve the quality of mangosteen juice, especially its color, taste and clearness, therefore additional pectinase usage and determination of condensed tannin will be implemented for further study.

Key words: Antioxidant activity, *Garcinia mangostana* L., Juice processing, Mangosteen, Post-harvesting technology.

INTRODUCTION

The Thai agricultural sector has experienced an oversupply during the COVID-19 pandemic, leading to challenges for farmers and the supply chain system, which are due to the restrictions on transportation and affected food production and employment (Tansuchat *et al.,* 2022; Pimoljinda *et al.,* 2023). Postharvest technologies are being used in Thailand to address the problem of agricultural oversupply. These technologies aim to solve the problem of oversupply in the agricultural industry, which either prolongs the shelf life of fresh produce or process agricultural goods into value-added products (Trakoontivakorn *et al.,* 2002; Maltare *et al.,* 2023; Kim and AlZubi, 2024; AlZubi, 2023). Mangosteen (*Garcinia mangostana* L.), a member of the Clusiaceae family, originated in Southeast Asia and has widely spread in various tropical regions, such as Thailand, Indonesia, Malaysia, southern India, northern Australia, Central America, Brazil and Hawaii. The Mangosteen fruit, commonly referred to as the "Queen of Fruits," exhibits a purple outer covering and contains a delectable white pulp that possesses a soft texture. This pulp is distinguished by its sweet taste and slightly acidic flavor. Brown pericarp or hull is encased in its pulp. In traditional Thai medicine, the pericarp of the mangosteen has been utilized in therapeutic practice for the treatment of diseases such as inflammation, infections, wounds and diarrhea (Ji *et al.,* 2007; Chairungsrilerd *et al.,* 1996; Lou *et al.,* 2021). Mangosteen provides a variety of health advantages i.e., anti-inflammation, antioxidative characteristics, anti-skin cancer, anti-acne, anti-obesity and tumor suppression, through the presence of numerous biologically active compounds such as phenolic acids, xanthones, tannins, flavonoids, alpha- and beta-mangostins and anthocyanidins (Saelee *et al.,* 2023).

Concentrated fruit juice is a juice-preserving product, that reduces the water activity of juice, prevents its spoilage from microbial growth and prolongs the shelf-life of the product. The quality of the product depends on the stability of its physical appearance including flavor, odor and texture. In addition, phytochemical containing and health promoting effects of juice products are also a concern (Weber and Larsen, 2017; Ilame and Satyavir, 2015; Sharma *et al.,* 2017; Lyu *et al.,* 2020; Maltare *et al.,* 2023; Meshram, 2015). Mangosteen harvested around 270,554 tons in 2009 and trended to increase as oversupply (Techawinyutham *et al.,*

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2024). Moreover, "out of standard" fresh mangosteens are unable to be exported and national consumption of them was limited. Mangosteen juice (100%) provides high potassium and various trace elements and the packed with phytochemical ingredients (*i.e.*, xanthones and tannins), while its calories are quite lower than other juices (Masullo *et al.,* 2022; Benatrehina *et al.,* 2018). Thus, the production of good quality mangosteen juice is one value-adding product that can solve the problem of oversupply and out-of-standard mangosteen in harvesting season. However, small manufacturer entrepreneurs are unable to produce high-quality juice as agricultural industries, which are due to limitations of investment and also technology transfer. Small manufacturer entrepreneurs (SMEs) in Ranong, Thailand are a large group of farmers who cultivate mangosteens and process concentrate juice. However, the quality of juice is still unsatisfactory due to its astringent taste and high turbidity with precipitation.

Hence, we transferred small-scale industrial juicers as "ready-to-use" technology that was suitable for SMEs and aimed to improve the quality of mangosteen juice *i.e.*, physical appearance and sensory test. The amount of anthocyanin and tannin contained in juice and its antioxidant properties were also evaluated.

MATERIALS AND METHODS

Cultivation area, harvesting and post-harvesting

The southern region of Thailand including Ranong province is considered to be the largest mangosteen cultivation area, which can produce good quality mangosteen due to an appropriate environment. Fruit has the uniqueness in the beautiful shape with good taste. A large plot of mangosteen farmers in Lam Liang subdistrict, Kra Buri district, Ranong province has been successful in the production of good quality mangosteens. This large plot is 1,178 rai (1.88 km2), which includes 520 farmer households and the average production is 700 tons/year.

The quality standard of fruits and its criteria is 1) oily skin, green (pedicel) hat and large size (80 g/fruit); 2) weight 70 grams/fruit; 3) mangosteen with striped skin, small size (< 70 grams/fruit); 4) very small size (< 60 grams/fruit) and 5) very small size (<60 grams/fruit) and black color. Out of standard mangosteens (numbers 3 to 5) were processed into juice and related products, such as jam and candy, which were included in our study.

The production of mangosteen juice

Conventional method

The mangosteen fruits were thoroughly washed and the pulp was manually separated from peel and seeds by hand. The pulp was transferred to boiling water (90°C) containing citrate as a preservative and gum as a thickener. The mixture was stirred until homogeneously and some drop of food colorant was after its cooldown. The juice was filled into a sterilized glass bottle, the cap was closed and stood for 7 mins in cooling water. The juice bottle was kept overnight after that shaking again until the texture of the juice in the container was homogeneously mixed. The juice from this method had an astringent taste and high turbidity with precipitation.

Conventional technique with small-scale industrial juicer

When pulp is manually separated, some resin and derbies may contaminate the juice due to the pulp's poor seed covering and potential attachment to the peel. We employed a small-scale industrial juicer to extract juice from the pulp and separate the remaining seeds, rather than manually separating the pulp. Additionally, the pulp separation process required less manpower and time and the juice's quality improved.

Small scale industrial juicer

The mangosteen juicer was invented at the Thailand Institute of Scientific and Technological Research's Centre of Expertise in Healthy Food (Fig 1) and is appropriate for small-scale production at the SME level. Its objectives are to decrease the number of stages in the labor-intensive manual juicing process, boost output, decrease labour costs and enhance juice quality by lowering contamination and bitterness. On average, the juicer can process 50 kg of fruit per hour. The machine consists of two main parts including a fruit container with a lid and a set of whisking blades. The fruit container has an aperture to filter and separate the pulp and seeds and it can store up to 10 kg of mangosteen. The fruit container is rotating and tilting and the user can easily discard the unwanted pulp and seeds. The whisking blades are made from highly flexible and heat-resistant silicone rubber that can effectively blend the fruit without bitterness. The machine is ensuring on hygiene and can be sanitized with scalding hot water to eliminate any potential microorganisms. The working principle of this juicer is

Fig 1: The small-scale mangosteen juicer is mobilized for and portable for SME production.

described as that the user can simply load the fruit into the container, close the lid and turn on the electrical control switch. In approximately 10 min, the whisk set will whisk the fruit, separating the pulp and seeds. The juice will flow into the container located at the bottom of the machine, while the pulp and seeds will remain inside the tank. The fruit container can be rotated and tilted to discard any pulp remaining and seeds (Center of Expertise in Healthy Food, 2024).

The quality of mangosteen juice

Sample handling

The juice products, which were made from the conventional method (C) and conventional method with a small-scale industrial juicer (CJ), were randomly collected. Another juice product was industrialized standard (I) and purchased from supermarket as external control. Ten bottles (200 ml) of each juice sample were pooled (~2.0 liters) and kept at 4°C before their quality testing.

Physical characteristics

Three juice samples including C, CJ and I were evaluated for physical characteristics including appearance, color, flavor and taste. Data was represented as quantitative explaining.

Sensory evaluation

Panelists (n= 30) were tasted with juice samples and filled in the forms for the sensory test. These forms were used on a 9-point hedonic scale (Lawless and Heymann, 1999; Meilgaard *et al.,* 1999) and asked to taste sensing of mangosteen juice about color, odor, flavor, texture and overall likeness.

Evaluation of phytochemicals

The determination of the tannin content in the mangosteen juice was carried out using a spectrophotometric method (lmax = 760 nm). This analytical approach involved the use of Folin-Denis reagent (Sigma Alrich, USA) in accordance with the established by the Association of Official Analytical Chemists, AOAC (2005) 952.03. In the procedure, juice sample (0.5 ml) was placed into a 100 ml conical flask. Following this, distilled water (50 ml) was added and the mixture was heated for 1 h. The mixture was filtered through cotton wool using a 50 ml flask and the volume was adjusted and cooled. An aliquot solution (1-3 ml) was transferred into a 100 ml volumetric flask, which contained distilled water (75 ml). Folin Denis reagent (5 ml) and 35% w/v saturated sodium carbonate (10 ml) were added and the volume was adjusted to 100 ml with distilled water. A standard curve was performed by utilizing of known concentration of tannic acid (Sigma-Aldrich, USA) (AOAC, 2005). The anthocyanin content in mangosteen juice was determined by pH differential method, which was modified from AOAC, official method 2005.2. Sample (0.2 ml) was diluted with 0.025 M potassium chloride (1.8 ml and pH 1.0) and with 0.4 M sodium acetate (1.8 ml and pH 4.5). Both tubes were homogeneously mixed and absorbance was measured at 520 and 700 nm, respectively. The anthocyanin content was calculated from both absorbance and dilution factors and reported as mg of cyanidin-3-glucoside equivalent per liter (AOAC, 2005).

Antioxidant determination

Mangosteen juices (C, CJ and I) were evaluated for antioxidant properties by the ability of DPPH radical scavenging activity. Each juice concentration (10 ml) was diluted with distilled water and transferred to a 96-well microplate. DPPH solution (185 ml) was added and the plate was shaken at room temperature for 5 min. The absorbance of the mixture was monitored by a spectrophotometer at 550 nm. Radical scavenging activity is represented as mg of Trolox equivalent (TE) per 100 ml and ascorbic equivalent (AE) per 100 ml on the basis of the 50% inhibitory concentration (Katsube *et al.,* 2004; Patel *et al.,* 2022).

Statistical analysis

Taste sensing of mangosteen juice and phytochemical content were calculated and represented as descriptive data. The differences in phytochemicals contained in mangosteen juice and antioxidant activity were analyzed by one-way ANOVA and each parameter was significant at p <0.05.

RESULTS AND DISCUSSION

We compared the physical characteristics of mangosteen juice from different processes including C, CJ and I. The Physical appearance of CJ was better than C, which implied that after applying the mangosteen juicer, the quality of juice including reduction of turbidity and suspension and lack of astringent taste (due to complete peel removal), was improved. However, CJ's appearance and color did not reach to quality of I as industrialized standard (Table 1). Taste sensing of mangosteen juices has also corresponded to the physical characteristics of juices. CJ was more likeness than C for all parameters, therefore there was still lower than I (Table 2).

Table 1: Physical characteristics of mangosteen juice from different sources of production.

Mangosteen juice process	Physical appearance	Color	Odor	Flavor
Conventional method	High turbidity/large precipitate	Darkness brown	Fruit aromatic /peel odor	Sweet and sour/ astringent
Conventional method with juicer	Low turbidity/some of precipitate	Lightness brown	Fruit aromatic	Sweet and sour
Industrialized standard	Transparent and clear	Darkness pink	Fruit aromatic	Sweet and sour

Table 2: Likeness on mangosteen juice obtained from different processes of production (n = 30) [a]

Mangosteen juice process	Color	Odor	Flavor	Texture	Overall
Conventional method	5.6	4.5	4.5	3.9	4.6
Conventional method with juicer	7.5	6.3	6.5	6.7	6.8
Industrialized standard	8.5	8.6	8.7	7.9	8.4

[a]Score of likeness: 1= dislike extremely, 2= dislike very much, 3= dislike moderately, 4= dislike slightly, 5= neither like nor dislike, 6= like slight, 7= like moderately, 8= like very much, 9= like extremely.

Table 3: Phytochemical contents and antioxidant properties of juice from different processes[a]

Mangosteen juice process	Tannin[b]* (mg/100 ml)	Anthocyanin[c] (mg/100 ml)	DPPH radical scavenging activity	
			mg TE/100 ml*	mg AE/100 ml*
Conventional method	34.00	Not detected	59.23	44.31
Conventional method with juicer	40.00	< 1.0	57.54	43.06
Industrialized standard	22.00	16.02	42.43	31.75

AE= ascorbic acid equivalent; TE= Trolox equivalent; [a]Data of all assays were calculated from triplicate experiments; [b]Tannic acid and [c]cyanidin-3-glucoside were used as standard curve; *Statistically significant at $p < 0.05$.

Mangosteen is mainly consumed fresh fruits; therefore, it is also processed as juice, preserves, jam and puree. Due to its biological effects, various authentic metabolites including xanthones, benzophenones, flavonoids, condensed tannins and anthocyanins have been identified from mangosteen fruits (Masullo *et al.,* 2022). In this study, we determined the tannin and anthocyanin contents of mangosteen juice from different processes, which were referred to as the astringent taste or shell contamination and the juice color, respectively (Table 3). CJ contained the highest tannin content followed by C and I, respectively. This finding was contrasted with the results from physical appearance and sensory likeness. Hence, our study may measure free tannin content including condensed tannins and there had astringent taste properties. We were suggested to determine only condensed tannins for the astringent or bitter taste of juice. I contained the highest anthocyanin content followed by C and I, respectively. Thus, the anthocyanin content of mangosteen fruits corresponded to the color of mangosteen juice and can be used to monitor the color of juice.

In this study, the antioxidant property of mangosteen juice was determined by DPPH radical scavenging activity. C possessed the strongest DPPH radical scavenging activity followed by CJ and I, respectively (Table 3). Antioxidant activity of I was significantly reduced when compared with C and CJ. In the same juice sample, the antioxidant units for AE were lower than TE, which implied that water-soluble antioxidants contained in juice were prone to degrade rather than fat-soluble antioxidants. The process of juice was affected by the antioxidant properties of juice and this impact may be related to various factors during juice processing especially temperature and mechanical usage (Durazzo *et al.,* 2019). This study was conducted on the use of small-scale mangosteen juicer-assisted conventional method and its evaluation. This new process can improve the quality of mangosteen juice, especially its color, taste and clearness, therefore additional pectinase usage and determination of condensed tannin will be implemented for further study.

CONCLUSION

Small-scale industrial juicer assisted mangosteen juice production for SMEs and improved the quality of juice, especially color and clearness. The juice from the new process also possessed DPPH radical scavenging activity better than industrialized products. However, the clearness can be improved by the use of pectinase.

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Author contributions

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

Data Availability Statement

Not applicable.

Declarations

Author(s) declare that all works are original and this manuscript has not been published in any other journal.

Declaration of conflicts of interests

The authors declare that they have no conflict of interest.

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