

Screening the Physicochemical Properties of Thermosonically Treated Pomelo Juice

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Abstract: Pomelo (*Citrus grandis* L. Osbeck) tastes sweet, slightly acidic with a hint of bitterness. It has many beneficial health effects. The aim of this study was to evaluate the effect of thermosonication treatment on physicochemical properties of pomelo juice by subjecting the juice to different times and temperatures. Thermosonication is a treatment where ultrasound is conducted at moderate temperature ranging between 37 and 75°C. Pomelo juice was treated with thermosonication for 2, 46 and 90 minutes with initial temperature ranging from 20°C, 35°C and 50°C. The treated juice were analysed for its physicochemical properties, such as colour values (L*, a* and b*), total soluble solids (TSS) content, pH, titratable acidity and electrical conductivity. Results showed that the lightness (L*), pH, titratable acidity and electrical conductivity of the pomelo juice does not changed during treatment. However, redness (a*) and yellowness (b*) and TSS showed highest reading at 50°C at 90 minutes.

Keyword: Juice; physical properties; pomelo; temperature; ultrasound.

1. Introduction

Dietary phytonutrients such as phenols and polyphenols, glucosinolates, flavonoids, isoflavones, and terpenes found in pomelos have a lot of medicinal and health benefits [1]. These benefits include reducing the risk of wide range of age-related diseases such as cancer, diabetes, cardiovascular and autoimmune disease [2]. Individuals can rely on polyphenol from plants to obtain high volume of antioxidants [1]. Citrus fruit such as pomelo is one of the plants which has high content of antioxidant [3, 4]. Due to progressive technology, consumers demand an improvement in the quality of fruit juice production, including its flavour, texture, colour and nutrition [5].

Farmers usually prefer an easier plantation activity due to various factors involving time, weather and economy. Pomelo has a higher natural defence mechanism to pests and bacteria than other citrus fruits such as sweet orange and tangerine [6]. This results in easier cultivation, higher productivity, and lower production cost than sweet orange and tangerine. Moreover, the large size of the fruit

facilitates easier harvesting. These advantages here can be seen as an encouragement for farmers to pursue on pomelo fruit plantation, so that more pomelo fruit will be planted and there will be enough supplies for commercial production of pomelo juice throughout the year.

Conventional fruit juice processing are preferred in the industry because it is cheaper, straightforward and simple. However, the involvement of heat in conventional processing methods to preserve fruit juices may affect the product quality and safety. Ultrasound can be used to overcome the deterioration of physical and antioxidant effects, including nutritional loss and change in organoleptic properties during high temperature treatments [7]. Ultrasound can also be used to slow down or prevent the activation enzymatic activity and microorganism, extend shelf life and improve the quality of food products [8]. It is renowned to enhance quality in many types of food processing in the industry [9].

The application of ultrasound enhances food processing thus offering advantages over other conventional techniques because it is

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fully automated, precise, non-destructive, and can be performed either in a laboratory or on line [10]. It eventually reduces the processing cost because it consumes lesser time and energy that are normally needed for conventional processes. Several mechanisms such as heating, agitation, turbulence, friction and surface instability can be activated by power ultrasound. Most of the mechanism involved in power ultrasound can be attributed to an occurrence of cavitation [9], where the formation of micro bubbles subjected to fast adiabatic compressions and expansions happens [12]. The occurrence of cavitation and mass transfer enhancement may be the reasons that contribute to the increase in quality of ultrasound-treated food [13].

Ultrasound, when simultaneously conducted at mild heat of 37 to 75 °C is called thermosonication. It is an emerging new potential technique to prevent the activation of enzymes and microbial [14]. Mild heat, when combined with ultrasound, showed synergistic effect towards microbial inactivation than sonication without any additional heat treatment [15]. Physical properties of pomelo juice are critical quality factors in industrial production and consumer preference. Colour is the first perception consumer use when selecting and purchasing a product. Other than that, flavour also affect sensory selection. pH and titratable acidity is associated with sourness. Hence, it is important for these properties to be most favourable by consumers. Sourness perception is very crucial because it becomes a major reason for children rejecting food [16]. The objective of this research was to determine the physiochemical properties including colour, total soluble solids content, pH, titratable acidity, and electrical conductivity of thermosonically treated pomelo juice.

2. Materials and methods

2.1 Pomelo juice

Ripe pomelo fruits which have yellow colour on the two-thirds of its peel surface [17] were purchased. Firstly, each fruit was screened and washed under running water. The pomelo fruit were peeled and its pulp was blended into juice using electric blender (HR2102, Philip, Netherland). The mash was strained through cheesecloth to get its single

strength juice prior to undergo thermosonication treatment.

2.2 Thermosonication treatment

The fruit juices were treated with ultrasound at different times, including 2 minutes, 46 minutes, 90 minutes, as well as at its different initial temperatures of 20°C, 35°C and 90°C. The range of temperature and time were selected based on previous studies on orange juice and grapefruit juice in order to compare the effect of thermosonication in this study and previous studies [18-19]. The experiments involved 10 different combinations of ultrasound treatment time and temperature (Table 1), which were generated from a commercial software (Design Expert Version 6.0.4, Stat-Ease Inc., Washington, U.S.) with central composite design setting. The tenth treatment was a control, in which no heat and ultrasound treatment were applied. The treatments were conducted using an ultrasonic cleaner (Elmasonic S 30H, Elma, Germany). The ultrasonic frequency and power are 37 kHz and 280 W, respectively. Pomelo juice was poured into a 250-ml glass beaker before subjected to the thermosonication treatment.

Table 1 Ultrasound treatment at different times and temperatures.

Treatment	Temperature (°C)	Time (min)
1	35	46
2	20	2
3	50	2
4	35	90
5	20	90
6	50	90
7	35	2
8	20	46
9	50	46
10	23	0

2.3 Colour analysis

The pomelo juice samples were prepared to measure the colour by using a colorimeter (EZ 4500L, Hunter Lab, USA) based on three colour coordinates, namely L*, a*, b*. The colour values were expressed as whiteness/darkness (L*), redness / greenness (a*) and yellowness / blueness (b*) [20]. The instrument were calibrated using white (L =

92.8; $a = 0.8$, $b = 0.1$) and black reference tiles [21]. Next, the colour values L^* , a^* and b^* were recorded.

2.4 Total soluble solid

TSS content was measured using a digital refractometer (PAL-1, Atago Co., Ltd, Japan) as °Brix approximately at room temperature (25°C) [14].

2.5 pH

pH was determined by using a digital pH meter (Ph700, Eutech Instruments, UK). The pH meter was calibrated using three different standards pH buffers (4.0, 7.0 and 10.0) [20]. Then, the electrode were transferred into 50 ml pomelo juice. The pH measurement was conducted at room temperature (25±2°C) and the reading was recorded.

2.6 Titratable acidity

Titrate acidity was measured by weighing 6 g of juice into a 100 ml beaker. 50 ml of water will be added to each sample. Next, each sample with 0.1 N NaOH was titrated to an end point of $\text{pH } 8.2 \pm 0.1$ using the pH meter. The volume (ml) of NaOH used was measured and converted to g citric acid/100 ml of juice [22]. The titratable acidity was obtained by calculation using Eq. 1.

$$\text{TA}\% = \frac{A \times 0.1 \text{ N NaOH} \times 0.067 \times 100}{B} \quad (1)$$

Where A is the volume of titrated NaOH and B is mass of pomelo juice in ml. 0.067 is milliequivalent factor for citrus fruit juice.

2.7 Electrical conductivity

The probe (pH700, Eutech Instruments, UK) were rinsed with distilled water before being used to get rid of any impurities adhering to the probe body. In order to avoid contamination of pomelo juice, the probe was rinsed with a small quantity of fruit juice. The probe was dipped into the sample to ensure that the liquid level was sufficiently poured above its upper steel band. The probe was stirred gently to create a uniform pomelo juice [14]. A period of time was needed for the reading to stabilise.

2.8 Statistical analysis

All measurements were done in triplicate. Regression was performed with temperature and time as factors. Significant difference was defined at $p < 0.05$. Experimental data was statistically analysed using Microsoft Excel (Excel 2013, Microsoft Inc., Washington, U.S.).

3. Results and discussion

3.1 Colour values

One of important sensory attributes in fruit juice selection is the colour of fruit juices perceived by human eyes. Hence, it is important to determine the effects of thermosonication treatment towards the pomelo juice colour. Based on Fig. 1 and Fig. 3, it can be observed that there is no significant difference for lightness (L^*) and yellowness (b^*) with $p = 0.7153$ and $p = 0.6733$ respectively. These results are consistent with Valero et al. [20] findings, who found that the ultrasound treatment caused no effect on the colour of orange juices tested. Based on Fig. 2, the redness (a^*) of treated pomelo juice showed significant difference ($p = 0.0135$) between temperature and times.

It can be observed that significant differences existed when pomelo juice were treated with thermosonication for 90 minutes compared to the untreated pomelo juice. Based on Fig. 2, the untreated sample showed the lowest colour values for redness (a^*) while thermosonication treatment causes redness (a^*) increment of pomelo juice. The changes in redness (a^*) in citrus fruit juices may be caused by the degradation of ascorbic acid which causes non-enzymatic browning [14]. Other than that, the occurrence of cavitation may be the reason to the colour changes during thermosonication. This is due to the induction of several physical, chemical and biological reactions, such as breakdown of susceptible particles and increased of diffusion rates [11].

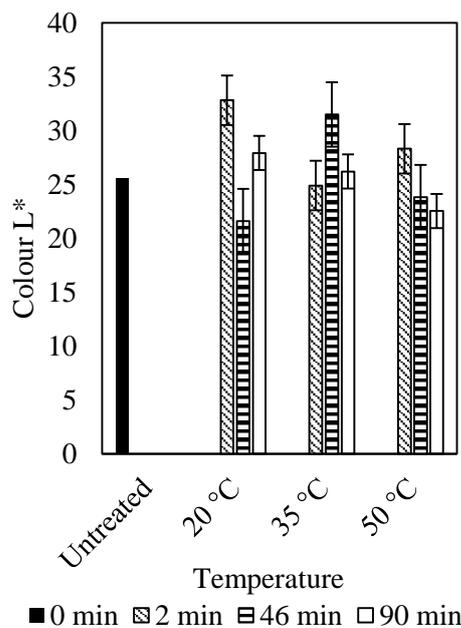


Fig. 1 Effect of treatment condition on lightness (L*) of pomelo juice

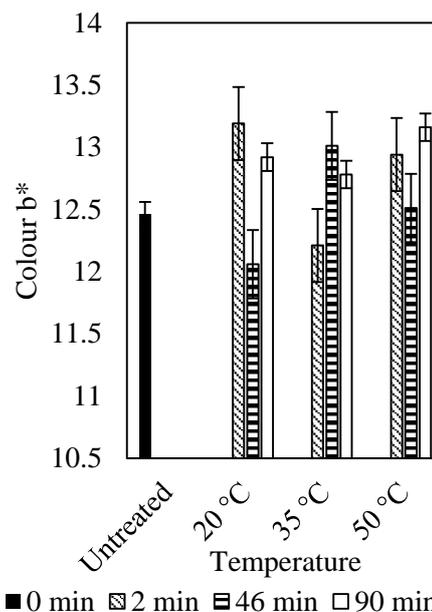


Fig. 3 Effect of treatment condition on yellowness (b*) of pomelo juice

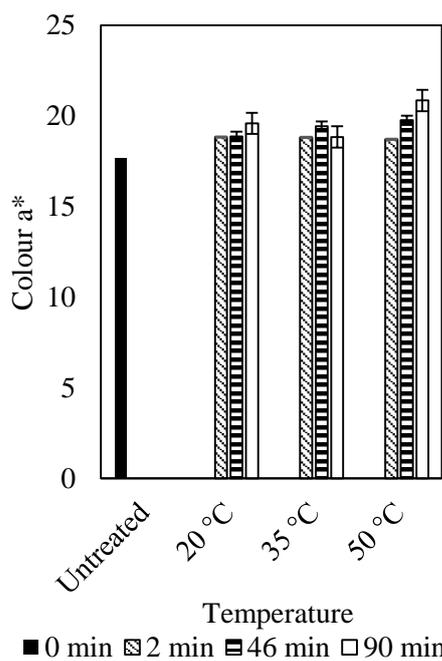


Fig. 2 Effect of treatment condition on redness (a*) of pomelo juice

3.2 Total soluble solids

ANOVA showed no significant difference ($p= 0.1398$) between time and temperature. The observations showed that thermosonication results in increment of TSS even at lowest treatment temperature 20°C. TSS has the highest reading at temperature of 50°C at 90 minutes. Previous case of ultrasound-treated juices showed an increase of TSS due to decreases in density which may be attributed by the homogenisation action of ultrasound [23]. However, no significant changes in TSS were observed in ultrasound-treated apple juice from previous research [24]. The quality of citrus juice can be determined from the TSS content. Citrus juices exist as a liquid–solid suspension system, which consist of a mixture of soluble and suspended solids [25]. Interestingly, it has been reported that the presence of sugars and pulp in citrus juices are responsible in the alteration of the headspace concentrations and aroma thresholds of citrus volatiles [26]. Hence, it is important to maintain the TSS to enhance the aroma thresholds of pomelo juice.

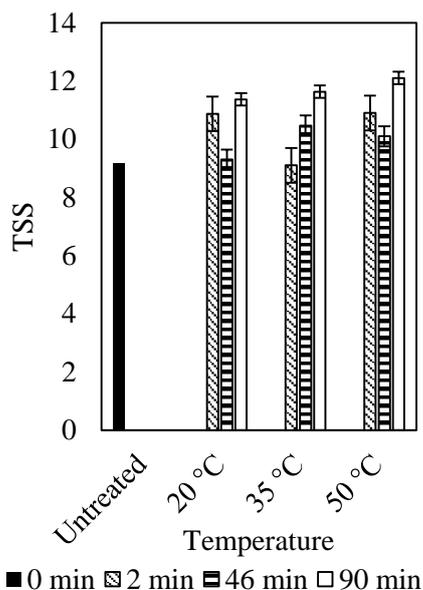


Fig. 4 Effect of treatment condition on total soluble solid of pomelo juice.

3.3 pH and titratable acidity

Other than that, recorded pH values showed no statistical significant difference ($p=0.4402$) between the untreated pomelo juice and thermosonicated samples, as illustrated in Fig. 5. The result is the same with the previous study which showed no significant changes in pH in tomato and orange juices treated with ultrasounds [21, 27]. pH properties of pomelo fruit is important because it can affect the bitterness of pomelo juice caused by an enzyme called limonin and naringin [28].

From the previous study, pH 3.8 (acidic) is the most favourable pH in citrus juice to suppress the bitterness originated from an enzyme called limonin. The reason for this optimum pH level can be related to the maximum enzyme reactions which occur in a small range of pH [29]. Regardless of the explanation, the bitterness suppression is substantial in the pH range 3.7 to 3.9 while the pH range in thermosonication is from pH 3.8 to 4 (acidic). Hence, thermosonication treatment is a reliable process because it does not alter the pH of pomelo fruit outside than the optimum pH range.

The analysis of titratable acidity showed that no significant differences were observed ($p=0.5509$). The highest value for titratable acidity was recorded at time: 46 minutes and temperature: 20°C, as shown in Fig. 6. Many studies have reported that sour taste intensity

increases with increasing titratable acidity at a given pH [30]. Hence, pH and titratable acidity are two correlated properties in maintaining the sour taste in pomelo juice.

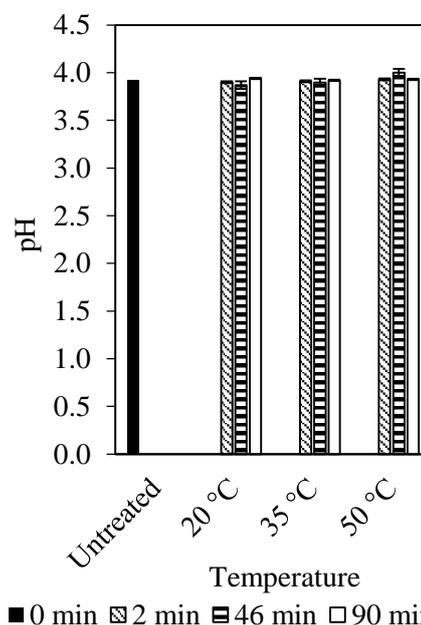


Fig. 5 Effect of treatment condition on pH of pomelo juice.

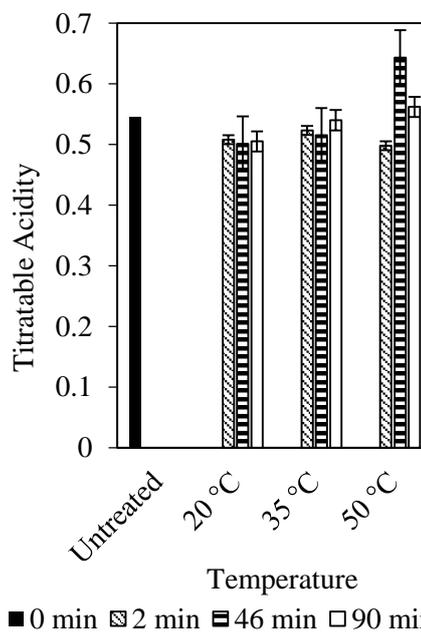


Fig. 6 Effect of treatment condition on titratable acidity of pomelo juice.

3.4 Electrical conductivity

Fruit juices can be classified as electrical conductors due to the presence of ions from nutrients such as proteins, fatty acids, minerals and vitamins [31]. The effect of thermosonication treatments on the electrical

conductivity of pomelo juice are shown in Fig. 7. Electrical conductivity analysis by ANOVA showed no statistical significant difference ($p=0.9429$) between every sample indicating that time and temperature does not affect the thermosonication treatment. The results are not the same as the previous study which showed significant increase in electrical conductivity for the ultrasound-treated grapefruit juice [6]. Some of the samples showed a decrease in electrical conductivity due to increment in heat or dropped in vitamin and mineral contents during thermosonication [21].

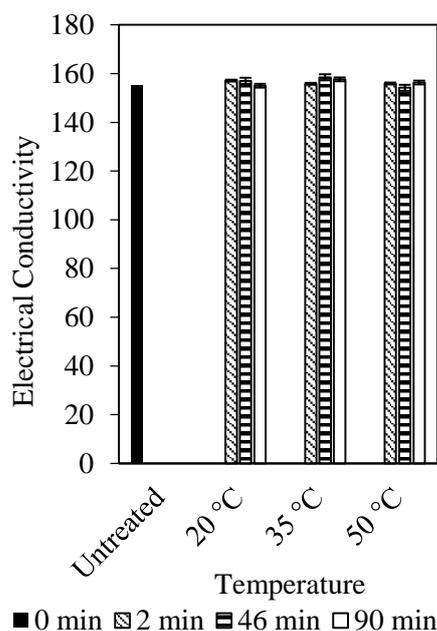


Fig. 7 Effect of treatment condition on electrical conductivity of pomelo juice.

4. Conclusion

In a nutshell, thermosonication demonstrates a potential process in fruit juice production. The results showed that the lightness (L^*), pH, titratable acidity and electrical conductivity of the pomelo juice does not change during treatment. However, redness (a^*) and yellowness (b^*) and TSS showed highest reading at temperature of 50°C at 90 minutes. A significant increase in a^* and b^* of pomelo juice can be negligible because the minor colour changes of the thermosonicated pomelo juice were not detectable to the naked eye. Thermosonication is able to keep the TSS in the desired range. The TSS of citrus juices are critical because it aids in altering the headspace concentrations and aroma thresholds of many citrus volatiles.

The obtained values of pH and titratable acidity of thermosonicated pomelo juice are in an optimum range, which may suppress the bitterness of pomelo juice. Lastly, there are no significant difference in electrical conductivity due to the insignificant changes in nutrient content in the pomelo juice during thermosonication treatment.

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