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Red dragon fruit (*Hylocereus polyrhzus*) syrup: evaluation of parameters affecting the production process

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Abstract

Studies on the production of red dragon fruit syrup (*Hylocereus polyrhzus*) were carried out based on investigating the influence of concentration (0.1 - 0.4%) and hydrolysis time (15 - 45 mins) of pectinase enzyme on the process of pectinase hydrolyzed red dragon fruit juice. The recipe for red dragon fruit syrup with factors that change the concentration of citric acid (0.05 - 0.15%) and the concentration of Aspartame (0.1 - 0.5%) was investigated. At the same time, the concentration temperature was determined to achieve the quality syrup within the concentration temperature range (70 - 80°C). Research results showed that the 0.3% pectinase enzyme used for hydrolysis of fruit juice in 25 mins will yield a high juice recovery yield. Red dragon fruit juice (after hydrolysis) supplemented with 0.1% citric acid and 0.1% Aspartame at a concentrated temperature of 80°C will produce a red dragon fruit syrup with a mildly sour taste, pungent taste and colour characteristic of red dragon fruit.

1. Introduction

The dragon fruit tree has the scientific name *Hylocereus undatus* and the English name is Pitahaya, also known as Dragon Fruit, belonging to the *cactus* family, native to the desert regions of Mexico, Central and South America (Dam, 2013; Tran *et al.*, 2020). Dragon fruit grown in Vietnam belongs to the type of *Hylocereus undatus Britten Rose*. The oldest concentration areas are Phan Rang, Binh Thuan, Nha Trang, and Buon Me Thuot, and later the movement to grow dragon fruit flourished in the provinces of Tien Giang, Long An, and Tra Vinh (Hoa *et al.*, 2006).

Red dragon fruit (*Hylocereus polyrhzus*) contains high water content and many nutrients such as vitamin C (20.5 mg), fiber (0.71 g), fat (0.4 g), protein (0.53 g), total sugar (11.5 g), reduced sugar (6.1 g), potassium (212.2 mg), calcium (134.5 mg), magnesium (60.4 mg), is a potential source of raw materials for the fruit product processing industry, especially fruit juice products (Jamilah *et al.*, 2011; Ramli *et al.*, 2014; Susilo *et al.*, 2021). Because dragon fruit contains many nutrients, eating a lot of dragon fruit will help fight coughs, and asthma and heal wounds and cuts rapidly due to its high vitamin C content (Cheah *et al.*, 2016; Tran *et al.*, 2020). According to recent studies, the glucose in the red dragon fruit helps control blood sugar for people with diabetes. At the same time, dragon fruit contains high levels of phosphorus and calcium, which strengthen bones and play a role in tissue formation and strong teeth (Castro-Vazquez *et al.*, 2016; Pham *et al.*, 2020).

Betacyanin belongs to the group of natural pigments betalain, soluble in water and alcohol, and has a variety of colours: from yellow to orange, bright red, crimson, pink to purple red. It is found abundantly in the tubers, fruits, flowers, and leaves of various plants such as cactus flowers, beets, red radish, dragon fruit skin, and red flesh dragon fruit (Reshmi *et al.*, 2012). Because of the variety of colours, betacyanin is used as a colourant in the food industry, symbol: E162 (Moreno *et al.*, 2008). Betacyanin is also known as a compound with many biological activities for human health, such as antioxidant activity; thanks to its ability to capture free radicals, betacyanin also has an inhibitory role in ovarian cancer cells and bladder (Stintzing *et al.*, 2002; Zou *et*

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al., 2005; Wu *et al*., 2006). Recent studies have shown that betacyanin is an antioxidant thanks to its ability to capture free radicals that can cause cell mutations and metabolic disorders. The functional group (-NH) contributes to the effective absorption of betacyanin by antioxidants through the small intestine wall as well as across the cell membrane (Slimen *et al*., 2017).

Red dragon fruit is a product with a large output in Vietnam and has excellent potential in terms of economic value. However, at the time of the primary season, there is a backlog of a large amount, causing waste for this fruit. Besides, it can be seen that the trend of developing syrup products from succulent fruits is increasing. However, according to the overall assessment, not many studies have been recorded on the production process of syrup products from red dragon fruit. The research objective was to investigate the influencing factors (concentration and hydrolysis time of pectinase enzyme, citric acid concentration, the concentration of Aspartame sugar, concentration temperature) on product quality.

2. Materials and methods

2.1 Materials and chemicals

Red dragon fruit is grown in Tra Vinh province, Vietnam, and harvested one month after the tree flowers. Fruits showing signs of damage are examined and discarded. For better quality fruits, samples will be prepared or stored at 5°C for no more than seven days before use.

Chemicals used in the research process include ethanol 96% (China), pectinase enzyme, citric acid (China), Folin – Ciocalteu solution (Germany), Na_2CO_3 (China), NaOH (China), phenolphthalein (China), Aspartame sugar, saccharose sugar.

The production process of red flesh dragon fruit syrup is carried out as follows (Figure 1). First, remove the unsatisfactory berries. Wash to remove damaged fruit and then rub through a 0.5 mm sieve to remove seeds. Next, the enzyme was treated at the enzyme concentration of 0.3, the incubation time was 25 mins in the pH of the solution = 4.5, and the temperature was 45°C. Add sucrose to the Brix mixture to reach 20°, then add basic food additives. Finally, concentrate at 80°C for about 53 mins so that the Brix degree reaches 60° and the finished product is obtained.

2.2 Analysis method of physicochemical components of red dragon fruit

Moisture content was determined by drying 5 g of the sample at 105°C until a constant mass was recorded.

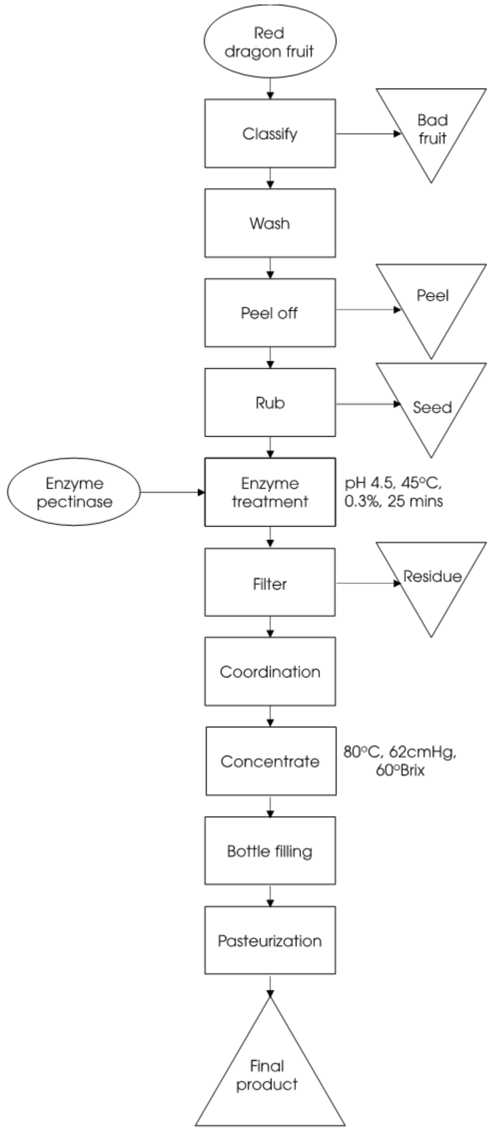

Figure 1. The production process of red dragon fruit syrup.

The ash content was determined according to the methods of AOAC (2000). Total dissolved solids (°Bx) content was measured by electronic refractometer Palette ATAGO PR-101 alpha, Japan. Total acid content (mg/100 mL) was determined by titration method with 0.1N NaOH according to TCVN 4598-1998. Viscosity (cP) was measured with a viscometer NDJ-9S, USA. The lipid content was determined using diethyl ether using a Soxhlet apparatus.

2.3 Analytical methods on the extract

2.3.1 Determination of recovery efficiency

After hydrolysis, the dragon fruit juice was filtered and weighed to determine the recovery efficiency according to the following formula:

$$H = \frac{M_2}{M_1 + M_3} \times 100$$

Where M_1: initial fluid volume (g), M_2: volume of fluid after hydrolysis (g) and M_3: weight of enzyme added (g).

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2.3.2 Analytical methods of the extract

Approximately 1 g of dragon fruit was weighed and ground with 50 mL of distilled water. After that, the mixture was put into the ultrasonic device for 15 mins and then filtered to get the solution. Conduct spectrophotometric determination at 538 nm to determine betacyanin content (mg/100 g db) (Rippe, 2014). Betacyanin content (mg/100 g) was calculated according to the formula:

$$\mathrm{BC} = \frac{A \times D \times M \times 100}{e \times L \times W \times (1 - AW)}$$

Where BC: total Betacyanin content (mg/100 g db), A: Absorbance, D: Dilution factor, M: Molecular mass of betacyanin (550 g/mol), e = 60,000 L/mol.cm, L: Cuvette thickness, W: Mass (g) and AW: Humidity (%).

2.3.3 Determination of total polyphenol content

Approximately 0.1 mL of the diluted red flesh dragon fruit juice sample was put in a test tube with 0.5 mL of 10% folin and then shaken vigorously for 5 s. After 2 mins, add 0.4mL of 7.5% Na_2CO_3, then shake again, cover and leave in the dark for 1 hr. Then, photometric measurements were performed at l = 765 nm (Castro-vazquez *et al*., 2016). Determination of polyphenol content according to the following formula:

$$TPC = \frac{A \times N \times V \times T}{N \times (100 - X)} \times 10^{-3}$$

Where TPC: Total phenolic content (mg GAE/g db), A: Gallic acid content determined from the standard curve (g/mL), N: Dilution of the test sample, V: Volume of extract (mL), T: Purity of standard gallic acid (%) and X: Sample moisture (%).

2.4 Data processing

The experiments were repeated three times. The results presented are the mean ± standard deviation (SD). Data were examined using Statgraphics Centurion XVI software (Statgraphics Technologies, Inc., Virginia, USA). Analysis of variance (ANOVA) and least significant difference (LSD) was performed, comparing the mean at the 0.05 level.

3. Results and discussion

3.1 Basic physicochemical composition of red dragon fruit

The experiment to investigate the physicochemical components of red fleshy pine fruit shown in Table 1 shows that the flesh of the dragon fruit has high polyphenol, Betacyanin, Lât, and water content. It is suitable for selection as a beverage (syrup).

Table 1. Physicochemical composition of red dragon fruit.

Targets	Red dragon fruit
Humidity (%)	80.97±0.77
pH	4.7±0.2
Brix (°Bx)	12.86±0.78
Viscosity (cP)	176.83±3.53
Ash content (%)	0.37±0.098
Lipid content (%)	3.59±0.1
Total acid content (mg/100 mL)	8.15±0.387
Polyphenol (mg/100 g db)	133.03±1.73
Betacyanin (mg/100 g db)	186.35±1.2

3.2 Effect of enzyme concentration and treatment time

Results in Figure 2 show that the concentration and time of enzyme treatment have a statistically significant influence on juice yield ($p<0.05$). There is also an interaction between these two factors ($p<0.05$). When increasing enzyme concentration, the efficiency of juice recovery increases. However, when increasing the concentration from 0.3% or more, the increase in efficiency was not significant ($p>0.05$). The reason is that because the substrate in the sample is reduced, the accumulated products partially inhibit the enzyme activity, and the cleavage efficiency is reduced, leading to a negligible increase in the recovery efficiency. When increasing the enzyme concentration, the reaction rate increases, but when the enzyme concentration is saturated with the substrate concentration, the reaction rate does not change or increase when increasing the enzyme concentration (Cheah *et al.,* 2016). At the same time, when increasing the enzyme treatment time, the filtrate recovery efficiency also increased. However, from 35 mins onwards, the recovery efficiency tended to decrease. After adding the enzyme to the juice, it takes a while to break down the pectin compounds in the juice. Because the pectin substrate in the flesh of the dragon

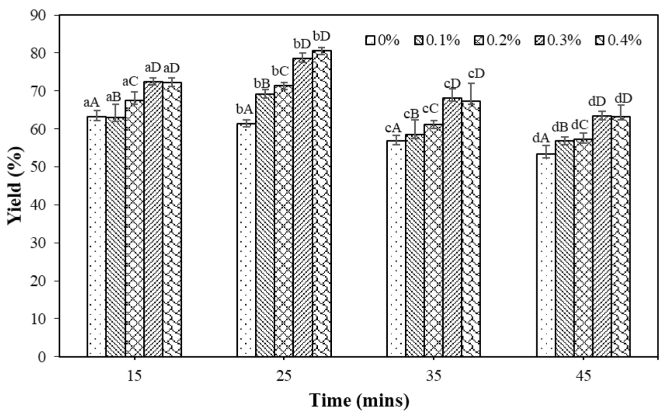

Figure 2. Efficiency of filtrate recovery after enzyme treatment. Bars with different uppercase letter superscripts are statistically significantly different over time while bars with different lowercase letter superscripts are statistically significantly different according to the concentration.

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fruit is now bound to pectinase, the excess amount of enzyme will not increase the extraction efficiency (Hogan *et al.*, 2001).

Results in Figure 3 show that enzyme concentration and hydrolysis time have a statistically significant influence on the viscosity of the filtrate ($p<0.05$). In general, when increasing enzyme concentration, the filtrate viscosity decreased ($p<0.05$), but when increasing concentration from 0.3% or more, the viscosity decrease was not significant ($p>0.05$). At the same time, when increasing the hydrolysis time, the filtrate viscosity decreased ($p<0.05$), but the filtrate viscosity increased from 35 mins or more. It can be explained that the longer the soaking time, the more gel the viscosity increases (Hoa *et al.*, 2006). The average lowest viscosity is 1.44±0.075 (cP) with a concentration of 0.3%. (mL/g) for 25 mins.

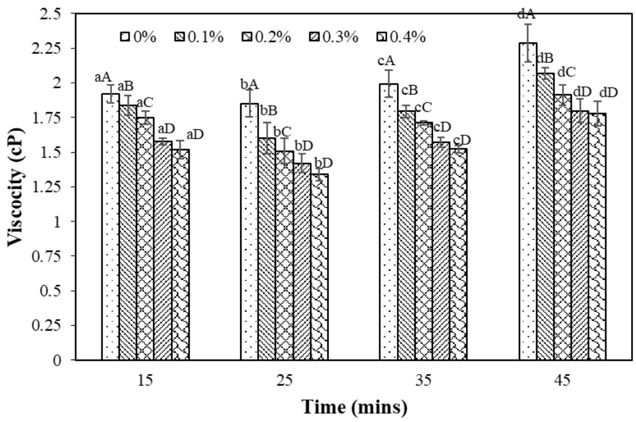

Figure 3. Effect of enzyme concentration and treatment time on the viscosity of filtrate. Bars with different uppercase letter superscripts are statistically significantly different over time while bars with different lowercase letter superscripts are statistically significantly different according to the concentration.

Based on the results, Figure 4 shows that the effect of enzyme concentration is significant ($p<0.05$). However, hydrolysis time does not affect betacyanin content ($p>0.05$). When increasing the concentration of enzyme treatment, the BC content in fruit juice did not change significantly. Thus, it can be concluded that enzyme concentration does not affect the degradation of betacyanin during hydrolysis. However, when increasing the hydrolysis time, the betacyanin content will gradually decrease because at the same temperature, in the prolonged hydrolysis time, betacyanin is partially decomposed by the factors of temperature, light and time (Woo *et al.,* 2011; Reshmi *et al*., 2012; Pham *et al.*, 2020). Based on the survey results, the enzyme concentration of 0.3% and the soaking time of 25 mins were used for the enzyme treatment.

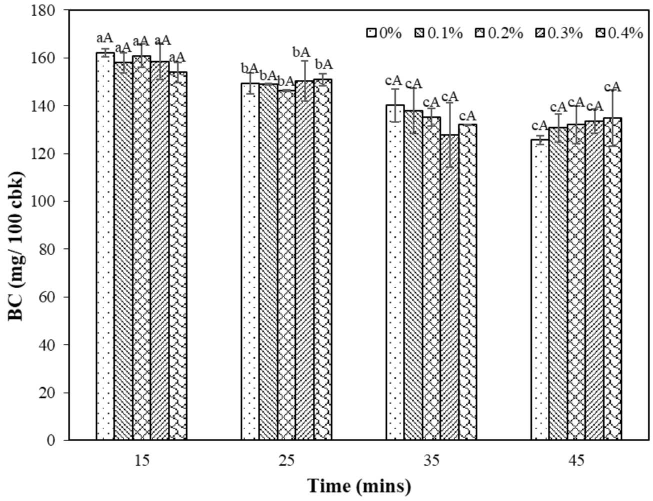

Figure 4. Effect of enzyme concentration and hydrolysis time on betacyanin content. Bars with different uppercase letter superscripts are statistically significantly different over time while bars with different lowercase letter superscripts are statistically significantly different according to the concentration.

3.3 Effect of the mixing process

3.3.1 Effect of citric acid on sensory

The selection and comparison of red dragon fruit juice concentrate at the same pressure and temperature conditions with the change of citric acid concentration is shown in Figure 5. Sensory evaluation results showed that the product achieved a high sensory score in all criteria (colour, taste, structure, and preference) when concentrated with a citric acid concentration of 0.1% g/g). The product is concentrated at a concentration of 0.1%, has the characteristic colour of red flesh dragon fruit, and has a faint aroma and a relatively sour taste. The product has a moderate consistency and consistency and is not delaminated during storage.

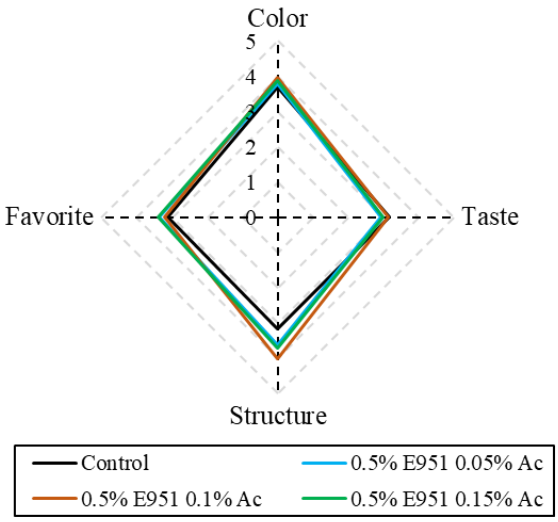

Figure 4. Effect of enzyme concentration and hydrolysis time on betacyanin content. Bars with different uppercase letter superscripts are statistically significantly different over time while bars with different lowercase letter superscripts are statistically significantly different according to the concentration.

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3.3.2 Effect of citric acid on betacyanin

Based on the results of Figure 6, it shows that the concentration of citric acid affects the betacynin content is statistically significant ($p<0.05$). When increasing citric acid concentration, BC content decreased from 100.48±0.97 (mg/100 g db) to 76.18±0.45 (mg/100 g db). When the concentration of citric acid is increased, the pH of the solution decreases; on the other hand, pH is one of the factors affecting betacyanin, so when pH decreases, betacyanin content decreases accordingly (Reshmi *et al*., 2012). The absorbance of betacyanin is high and stable in pH 4 to 5; in this range, betacyanin has a pink to dark pink colour (Rippe, 2014). In the pH range of less than 4, betacyanin will turn purple to dark purple; conversely, in an alkaline environment, pH greater than 5, the colour of betacyanin gradually turns yellow because betacyanin is decomposed into bright yellow betamic acid and cyclonic acid-Dopa-5-O-glycoside, which reduces the optical density value (Naderi *et al*., 2012; Susilo *et al*., 2021).

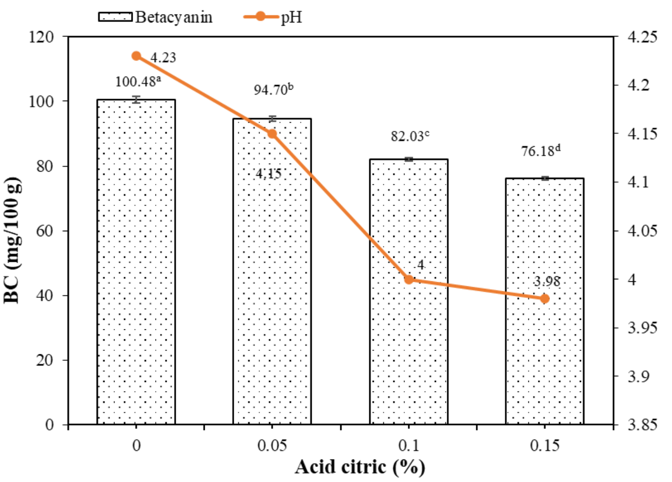

Figure 6. Effect of citric acid concentration on betacyanin content. Values are presented are mean. Values with different superscripts are statistically significantly different at 95% confidence level.

3.3.3 Effect of citric acid concentration on polyphenols

Results in Figure 7 shows that the effect of citric acid concentration on polyphenol content is significant ($p<0.05$). As the concentration of citric acid increased, the polyphenol content increased. Specifically, the polyphenol content reached the highest value of 16.66±0.52 (µg GAE/g db) when the citric acid concentration was increased to 0.1% (g/g). However, when the concentration of citric acid increased to 0.15%, the polyphenol content did not increase significantly ($p>0.05$). Reynoso - Camacho *et al.* have shown that citric acid has the effect of increasing the antioxidant content of foods, which are more synthetic stimulants than those with an antioxidant capacity (Reynoso-Camacho *et al*., 2006). In the study of author Lilia Salas-Pérez, it was found that increasing the concentration of citric acid helped increase the polyphenol content in the wheat germ (Preciado-Rangel *et al*., 2018). Based on the results of sensory evaluation, BC and polyphenol content, the concentration of 0.1% was used to conduct further studies to optimise theaa quality of the product.

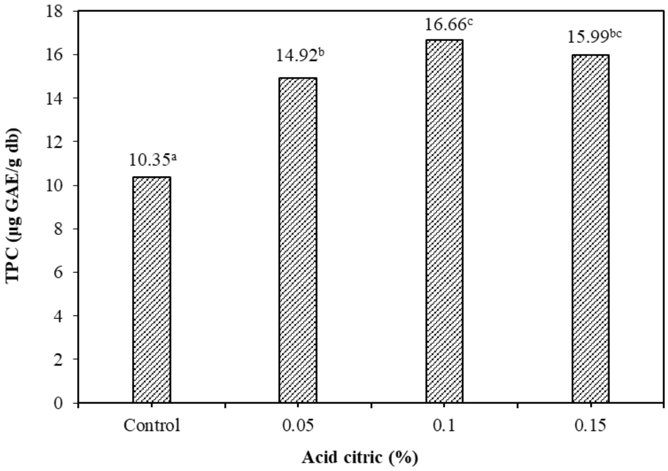

Figure 7. Effect of citric acid concentration on polyphenol content. Values are presented are mean. Values with different superscripts are statistically significantly different at 95% confidence level.

3.3.4 Effects of aspartame sugar concentration on sensory

The results of product's sensory evaluation results achieved the highest sensory scores in all the criteria (colour, taste, structure, and preference) when experimenting (Figure 8). Concentrated dragon fruit juice at Aspartame sugar concentration is 0.1% (g/g). The product retains the characteristic colour of red dragon fruit, light aroma, relative sweetness, and mild sourness. At the same time, the product has a smooth,

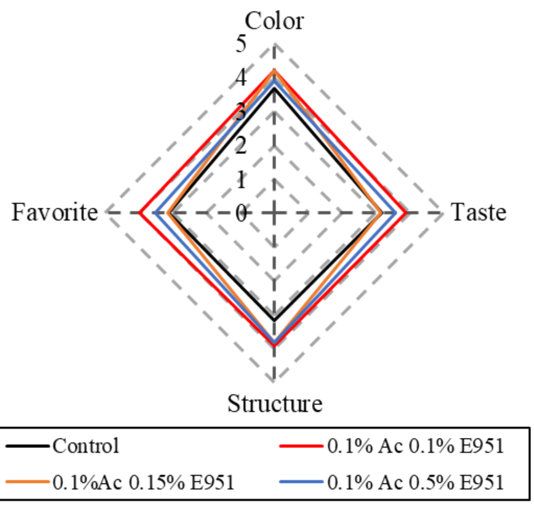

Figure 8. Radar diagram showing sensory values of concentrated dragon fruit juice examined with aspartame sugar concentration.

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moderatâ and does not separate during storage.

3.4 Effect of concentration

Based on the results, Figure 9 shows that temperature significantly affects betacyanin content in fruit juice ($p<0.05$). When increasing the concentration temperature, the betacyanin content increased from 57.09±0.03 (mg/100 g db) to 61.43±0.22 (mg/100 g db). The betacyanin content obtained at the concentration temperature of 80°C reached the highest value of 61.43±0.22 (mg/100 g db). When the temperature increases, the Betacyanin content will change because of the influence of polymerisation, reduction of carboxyl groups or the decomposition of betacyanin (Reshmi S.K. *et al.*, 2012). However, when concentrating at 80°C, the BC content was higher than that at 70°C, 75°C because concentration at 80°C, the concentration time was faster (52 mins, Table 2), so the BC content was determined to retain more than the concentrate at 70°C (120 mins, Table 2) and 75°C (85 mins, Table 2).

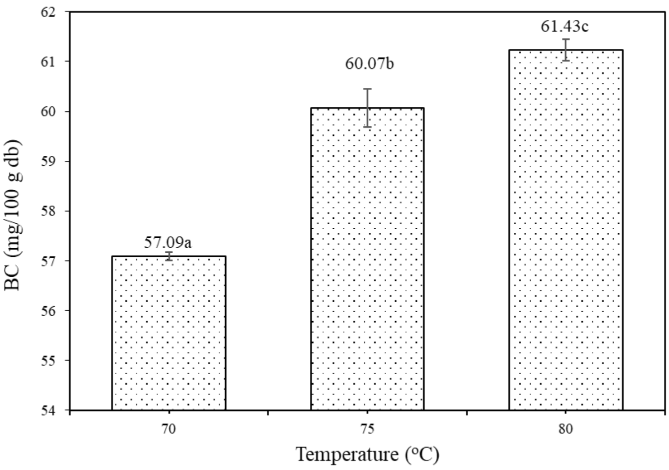

Figure 9. Effect of temperature on betacyanin content. Values are presented are mean. Values with different superscripts are statistically significantly different at 95% confidence level.

Table 2. Concentration time.

Temperature (°C)	Time (mins)
70	120
75	85
80	53

Figure 10 shows that the concentration temperature of polyphenol content is statistically significant ($p<0.05$). As the concentration temperature increases, the polyphenol content increases. Specifically, the polyphenol content increased from 34.23±0.92 (µg GAE/g db) to 57.40±1.21 (µg GAE/g db); in which the highest concentration of TPC at 80°C was 57.40±1.21 (µg GAE/g db) compared to the remaining temperature ranges. The polyphenol content increased as the concentration temperature increased from 70°C to 80°C. Although the concentration at low temperatures was lower, the polyphenol content was lower than that of the concentrated sample at 80°C. At low temperatures, the concentration-time was long (120 mins, Table 2), leading to the high polyphenol content in the sample. The solution was changed more than that of the concentrated sample at 80°C. However, the concentration was shorter (53 mins, Table 2), so the polyphenol content was retained more.

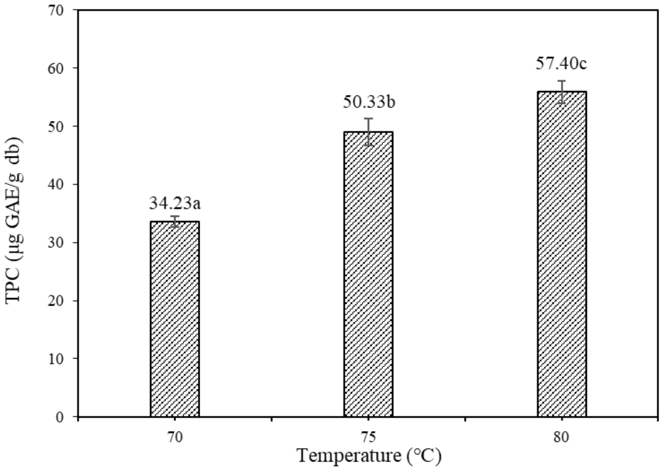

Figure 10. Effect of temperature on polyphenol content. Values presented are mean. Values with different superscripts are statistically significantly different at 95% confidence level.

4. Conclusion

Red dragon fruit juice treated with pectinase enzyme with a concentration of 0.3% for 25 mins will give a high yield of juice recovery, the low viscosity of liquid makes the filtration process more accessible. Adding 0.1% citric acid concentration and 0.1% Aspartame sugar concentration gives the product a harmonious sweet and sour taste, faint aroma, uniform structure with attractive color, very characteristic of the product. The product is concentrated at 80°C with 62 cmHg pressure for 53 mins to reach 60°C. It helps to keep the betacyanin content (remaining 32.95%) and polyphenol content (remaining 42.02%) high as possible.

Conflict of interest

The authors declare no conflict of interest.

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