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RESEARCH PAPER

Comparative Study of Effect of different Processing Method on Preservation of Lime-flavored Dragon Fruit Juice

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ABSTRACT

Because of its nutritionally dense and health-promoting chemical composition, dragon fruit is currently gaining significant prominence in India among all tropical and subtropical fruits. The fruit lime is native to Gujarat, India. The physical, chemical, and nutritional profiles of red and white dragon fruit grown along Peru's central coast were studied in the current research. Here, the physicochemical makeup of dragon fruit, the chemical and nutritive qualities of lime, the thermal, chemical, and processing of juices were also discussed. The current study additionally evaluated the impact of temperature and storage conditions on the antioxidant and betalain content of juices. According to reviews, dragon fruit is a good source of phenols, vitamin C, and a variety of minerals. After reading through all of these reviews, it is clear that using dragon fruit to produce lime-flavored RTS beverages and extend their shelf lives is the most practical and convenient way to appeal to as many people as possible.

Keyword: Chemical, Dragon fruit, Juice, Lime-flavored, Microwave, Processing method, Preservation, Thermal

1. Chemical and nutritional composition

1.1. Dragon fruit

Dragon fruit contains many compounds such as, flavonoids, betalains, hydroxycinnamates, carotenoids (beta-carotene), lycopene, linoleic acid, and linolenic acid (Hossain *et al.* 2021) (Table 1).

Table 1: The chemical composition of different varieties of dragon fruit

Nutrient	Amount per 100g (*Hylocereus undatus*) edible portion	% Daily Value
Water (g)	87	NA
Protein (g)	1.1	2.1
Fat (g)	0.4	NA
Fiber (g)	3	3.4
Carbohydrates (g)	11	12
Thiamine (mg)	0.04	2.7
Riboflavin (mg)	0.05	2.9
Niacin (mg)	0.16	0.8
Ascorbic Acid (mg)	20.5	34.2
Calcium (mg)	8.5	0.9
Iron (mg)	1.9	10.6
Phosphorus (mg)	22.5	2.3

(Thokchom *et al.* 2021; Hossain *et al.* 2021)

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Jeronimo *et al.* (2015) studied physicochemical properties, proximate analysis, mineral profile, and fatty acid profile of dragon fruit as described in Table 2.

Table 2: Physicochemical characterization of dragon fruit pulp

Parameters	Dragon fruit pulp
Physicochemical parameters	
pH	5.05
Total acidity	1.82
Total soluble solids (ºBrix)	11.40
Proximate (%)	
Moisture	86.03
Fat	0.16
Crude fibre	1.15
Protein	2.27
Carbohydrates	10.79
Minerals (mg/100 g)	
Potassium	3.090
Manganese	2.230
Sodium	0.140
Chrome	1.250
Calcium	0.040
Phosphorus	0.003
Nickel	0.004
Fatty acid (mg/100g)	
Linoleic acid	253.340
Oleic acid	129.106
Palmitic acid	64.505
Stearic acid	27.333
Alpha Linolenic acid	5.331
Arachidic acid	4.587
Total saturated fatty acids (%)	20.580
Total unsaturated fatty acids (%)	79.408
(Jeronimo *et al.* 2015)	

Obregon-La Rosa *et al.* (2021) analysed physicochemical, and nutritional profile of red, and white dragon fruit cultivated in central coast of Peru (Table 3).

Table 3: Physicochemical, and nutritional profile of red, and white dragon fruit cultivated in central coast of Peru

Parameters	Red dragon fruit	Yellow dragon fruit
Physicochemical parameters		
pH	4.16	4.82
Total acidity	0.26	0.23
Total soluble solids (ºBrix)	13.83	16.70
Vit C (mg/100g)	14.74	11.34
Proximate (%)		
Moisture	84.15	84.46
Ash	0.57	0.56
Crude fibre	4.30	1.27
Protein	0.12	0.22
Carbohydrates	10.14	13.07
Minerals (mg/100 g)		
Potassium	215.83	98.41
Magnesium	29.88	16.09
Sodium	1.52	1.43
Calcium	20.10	11.73
Phosphorus	28.70	17.99
Sulfur	13.64	12.14
Zinc	5.39	4.35
Copper	0.82	1.34
Manganese	5.48	7.49
Iron	1.24	21.07
(Obregon-La Rosa *et al.* 2021)		

Also scientists worked on different varieties of dragon fruit from different region of India (Table 4).

Table 4: Physicochemical composition of dragon fruit

Parameters	Dragon fruit
Physicochemical parameters	
pH	5.10 ± 0.3
Titratable acidity	0.17 ± 0.07
Total soluble solids	9.15 ± 0.35
Proximate	
Moisture (g)	83.9 ± 0.7
Ash (g)	0.704 ± 0.1
Dietary fibre (g)	1.125 ± 0.1
Protein (g)	0.898 ± 0.1
Carbohydrates (g)	5.91 ± 0.22

Others	
Free amino acids (mg)	35.1 ± 2.0
TPC (mg/GAE)	53.2 ± 6.2
TFC (mg/CE)	37.6 ± 1.5
Betalains (mg BCE)	20.9 ± 1.2

Results are represented as mean ± standard deviation (n = 9) of three independent experiments; Proximate and other values are expressed as g/100 g of edible portion on fresh weight basis; Titratable acidity measured as % citric acid equivalent; TPC- Total phenolic content; TFC- Total Flavonoids content; GAE- Gallic acid equivalent; CE- catechin equivalent; BCE- Batacyanin equivalent.

(Arivalagan et al. 2021).

With 12% sugar, 0.01% potassium metabisulphite, four levels of juice content (8, 10, 12, and 14%), and four levels of citric acid content (0.2, 0.3, 0.4, and 0.5), Foke *et al*. (2018) prepared dragon fruit RTS. The sample with 12% juice content, and 0.4% citric acid content was determined to be the best for dragon fruit RTS beverage, and its TSS, acidity, pH, and vitamin C content were further examined. The pH, and vitamin C levels decreased throughout the course of the 50-day storage period, from 2.5 to 2.08, and 8.3 to 3.6 mg/100ml. TSS, and acidity increased from 14.2°Brix, and 0.51% to 14.9°Brix, and 0.07%, respectively.

Sharma (2016) created value-added products including jam, jelly, and RTS while researching the various characteristics of dragon fruit. The 89% moisture, 9.86% total carbohydrate, 0.46% protein, 0.12% fat, 4.5 pH, and 0.45% acidity made up the dragon fruit's chemical make-up. It included 19 mg of phosphorus, 6 mg of calcium, 0.40 mg of iron, and 15 mg of ascorbic acid, respectively.

By employing 300 ppm KMS as a preservative, Islam *et al*. (2012) evaluated the processing, and preservation of *Hylocereus undatus* jelly. They discovered that dragon fruit juice contains 9.90 mg of vitamin C per 100g, 87.90% moisture, 0.50% ash, 8.00% total sugar, 4.20 pH, 11.0°Brix TSS, and 0.45% acidity.

Two different types of dragon fruit were examined and their antioxidant activity was compared by Choo and Yong (2011). According to studies, *Hylocereus polyrhizus* pulp contains more vitamin C (32.65 mg/100g) than *Hylocereus undatus* pulp (31.05 mg/100g). In comparison to *Hylocereus polyrhizus* pulp, *Hylocereus undatus* pulp has a higher total phenolic component content (28.65 mg of GAE/100g).

According to Wu *et al*. (2006), the total phenol, flavonoid, and betacyanin content of fresh red pitaya flesh was 10.3 mg of betanin equivalents/100g, 7.21 mg of catechin equivalents/100g, and 42.4 mg of GAE/100g, respectively. According to the DPPH assay, fresh flesh has 22.4 μmol of vitamin C equivalents per g of antioxidant activity.

1.2. Lime

Mohanapriya *et al*. (2013) estimated the proximate composition, mineral, and vitamin profile of lime fruit (Table 5).

Ucan *et al.* (2016) analysed the bioactive compounds present in lime juice. After pasteurization at 90°C for 15 cec., total phenols in lime juice increased from 250.4 to 264.9 mg of GAE/L, and total carotenoid decreased from 44.72 to 36.74 μg/100mL (Table 5).

Table 5: Chemical composition of lime juice

Components	Content/100g
Carbohydrate (g)	9.32
Sugar (g)	2.50
Dietary fibre (g)	2.8
Fat (g)	0.30
Protein (g)	1.10
Thiamine (mg)	0.040
Riboflavin (mg)	0.020
Niacin (mg)	0.100
Vitamin C (mg)	53.0
Calcium (mg)	26
Iron (mg)	0.60
Magnesium (mg)	8
Phosphorus (mg)	16

(Mohanapriya *et al.* 2013)

2. Processing methods for juice

2.1. Thermal processing of juices

Feng *et al*. (2020) examined the impact of heat, ultrasound (US), and high hydrostatic pressure

(HHP) treatments on the quality of a strawberry, apple, and lime juice combination. The heat treatment was place at 86°C for one min. Results showed that the strawberry-apple-lime juice blend responded best to the high hydrostatic pressure treatment when compared to the other treatments. After HHP, and US, the initial level of total phenols (877.69 mg GAE/L) increased by 157.98 mg GAE/L, and 61.44 mg GAE/L, respectively. Total aerobic count declined from an initial level of 4.19 to 2.0 log10 cfu/ml, while the yeast and mold counts decreased from an initial level of 4.21 to 1.3 log10 cfu/ml.

Prickly pear (*Opuntia dillenii*) juice was pasteurized using a lab scale heating system, according to a study by Moussa-Ayoub *et al*. (2017). Juice pasteurization processing conditions were 6.6 L/h flow, 95°C holding time for 3 min. The ascorbic acid level of the prickly pear juice was reduced by 22%.

Kumar *et al.* (2017) investigated the effects of microwave pasteurization, and heat processing on the physical, and chemical characteristics of pomelo (*Citrus maxima*) juice. A recent study found that as compared to microwave pasteurization, heat pasteurization had a greater impact on phenolic content, ascorbic acid content, and pH. Total phenol content was reduced for heat pasteurization from 710 to 690.5 mg of GAE/L, ascorbic acid from 67.71 to 52.42 mg/100ml, and pH from 3.3 to 3.2. Total phenols, ascorbic acid, and pH content were all decreased via microwave pasteurization to, 705.3 mg of GAE/L, 54.29 mg/100ml, and 3.2, respectively.

Wong and Siow (2015) investigated the effects of processing dragon fruit (*Hylocereus polyrhizus*) juice at various temperatures (65, 70, 75, 80, 85, 90, and 95°C), times (10, 20, and 30 min), pH levels (3, 4, 5, 6, and 7), and ascorbic acid concentrations (0.25%, 0.50, 0.75, 1.0, 1.25, and 1.50%). When pasteurization at 65°C for 30 minutes, a combined effect of 4.0 pH, 0.25% ascorbic acid, and red flesh dragon fruit juice were used, the maximum retention of betacyanin concentration was found. The maximum retention was 0.83 mg/L for 10 min pasteurization at 65°C, 0.78 mg/L for pH 5, and 0.85 mg/L for 0.25% ascorbic acid incorporated juice from 1.0 mg/L, respectively.

In two distinct heat treatments, T_1 (95°C for 30 min), and T_2 (105°C for 60 min), Omidizadeh *et al*. (2014) investigated the decrease in total phenols, and antioxidant activity of *Hylocereus polyrhizus*. Total phenolic content for T_1, and T_2 was decreased from 21.41 mg of GAE/g of dried extract to 7.98 mg, and 8.49 mg, respectively, while antioxidant activity was decreased from 226.51 μmolar of vitamin C equivalent/g of dried extract to 135.15, and 151.39 μmolar of vitamin C equivalent/g, respectively.

The effects of thermal treatment (50, 60, 70, 80, and 90°C), and time (0, 10, 20, 30, 40, 50, and 60 min) on the puree of red, and white fleshed dragon fruit were investigated by Liaotrakoon *et al*. (2013). After 60 min processing at 90°C, 32.35% of the initial betacyanin concentration was still present. Both the white-fleshed, and red-fleshed dragon fruit purees showed an increase in antioxidative activity (upto 34 μg of GA/g) after being heated to 90°C for 60 min.

Purple pitaya (*Hylocereus polyrhizus*) juice was processed using a tubular heat exchanger system, a vapour heated double jacketed vessel, and an HTST system by Herbach *et al*. (2007) On the basis of betanin content retention, the HTST procedure was determined to be the best. For HTST pasteurization, the ideal processing parameters were 92°C temperature, 100 L/h flow rate, 7 sec of preheating, and 26 sec of holding. Betanin content retention was 67.8%.

The impact of temperature, and pH on the retention of betacyanin levels in purple *pitaya* juice was examined by Herbach *et al*. (2006a). Scientists discovered that the betacyanin level of purple pitaya juice could be stabilized more by ascorbic acid, citric acid, and iso-ascorbic acid. At pH 4, purple pitaya juice retained betacyanin more than at pH 6; the juice was adjusted at pH 4, and processed with 1% ascorbic acid at 85°C for one h, and 91% of the betacyanin was retained.

Herbach *et al*. (2004) conducted research on measuring the amount of betacyanin at 85°C for various time periods (including 1, 2, 3, 4, and 5 h). In juice treated at 85°C for 5 h, the betacyanin level retained was 25% (121.2 mg/L) of the initial amount (470.5 mg/L).

2.2. Microwave processing of juices

On Khoonphal (*Haematocarpus validus*) juice, Sasikumar *et al*. (2019) investigated the effects of ultrasound (US), microwave (MW), conventional, and ultrasound aided microwave treatment. The juice was microwave-treated for 30 sec at 900 W, and thermally treated for 30 sec at 78°C. The juice was scored according to the triplet value for the overall sensory score, with ultrasound aided microwave coming in at number one (59.86, 46.70, 37.22), followed by MW (55.14, 43.40, 38.66), US (54.82, 43.28, 38.59), and conventional (46.05, 38.01, 38.09). In comparison to previous treatments, the sample that was microwave-assisted by ultrasound was found to be more acceptable.

Siguemoto *et al*. (2018) studied the kinetics of *E. coli* 0157:H7 & *Listeria monocytogenes* inactivation in microwave-heated apple juice. Apple juice had 4×10^9 cfu/ml initial *Listeria monocytogenes* inoculation numbers, and 7×10^9 cfu/ml of *E. coli* 0157:H7. The samples of apple juice were heated using both traditional thermal methods, and microwaves. The samples were collected in capillary tubes, and heated in a circulating system at temperatures of 55, 60, 65, and 70°C for intervals of 10 to 180 sec. Heating was done using a microwave heating system at 4 distinct power levels (1000 W, 800 W, 600 W, and 400 W) and various time intervals (50-390 sec). According to the findings, microwave heating is a good substitute for traditional heating because it can inactivate upto 5 $\log_{10}$ cycles for both organisms.

The impact of thermal, microwave, and ultrasound treatment on the antioxidant activity, and phenolic content of five different juices was investigated by Saikia *et al*. (2015). The juice samples were thermally pasteurized using the traditional method for 3 min at 75±1°C. 20 ml of juice in a 254 ml glass tube was heated using microwaves at power levels of 600 W, and 900 W. At 600 W, and 900 W power levels, microwave heating of the sample produced temperatures of 75°C, and 80°C, respectively. Juice that had been microwaved, and sonicated had a higher phenol concentration. After normal heating, microwave pasteurization (600 W), microwave pasteurization (900 W), and ultrasound treatment, the initial total phenol content (145 mg GAE/100ml) in carambola juice increased to 158, 650, 700, and 743.50 mg GAE/100ml, respectively.

The impact of a continuous microwave heating system on blended juices was researched by Math *et al*. (2014). Fruits, and vegetables were blanched using a microwave heating device at 900 W, and 60-70°C. The homogenized blended juice was heated continuously in a microwave for 10 min at a flow rate of 250 ml/min. During a continuous heating system, temperatures at the intake, and outflow were monitored every 2 sec. With a flow rate of 250 ml/min and a power density of 4.73 W/g, it was possible to achieve temperatures up to 121°C, which were sufficient to eradicate all bacteria, yeast, mold, and *E. coli*. In blended juices, the bacterial and fungal count was reduced to 3 log.

Slavov *et al*. (2013) investigated how red beet's betacyanin, and betaxanthin content was affected by microwave treatment (450 W for 12 min). Juice's betaxanthin content grew from 18.5 mg/g to 34.6 mg/g whereas betacyanin concentration dropped from 45.2 mg/g to 37.3 mg/g. According to the findings, increasing microwave field power causes food to get hotter inside, which accelerates betalains' deterioration.

The impact of microwave heating, PEF (Pulse electric field), and HHP processing on the bioactive chemicals found in *Opuntia macrorhiza* juice was investigated by Moussa-Ayoub *et al*. (2011). The juice samples were treated enzymatically after being heated in a microwave at 90°C (324 kJ/kg). During microwave treatment, the vitamin C content of the juice dropped from 55 mg/100ml to 40 mg/100ml. Vit. C retention was comparable (49 mg/100ml) under PEF, and enzymatic treatment.

Saccharomyces cerevisiae, and *Lactobacillus plantarum* in apple juice were subjected to continuous flow microwave heating, and thermal processing at temperatures of 50, 55, 60, 70, and 80°C in Tajchakavit *et al*. (1998) study. Apple juice had an initial viable count of 10^5-10^6 cfu/ml. Apple juice heated using a microwave heating system with a power density of 700 W, and a frequency of 2450 MHz. The microwave heating system's exit temperatures were 52.5, 55, 57.5, 60, 62.5, and 65°C. D-value of *S. cerevisiae* was 0.413 sec, and *L. Plantarum* was 3.68 sec in a continuous flow microwave heating system (60°C). In conventional heating system (60°C), 10.4 sec required to eliminate 90% of *S. cerevisiae*, and 25.6 sec for *L. Plantarum*.

2.3. Chemical processing of juices

In their study of the betacyanin stability of *Hylocereus undatus* rind blossoms, Dey *et al*. (2022) discovered that betacyanin content degraded more quickly with increasing pH, and temperature. After adding 0.125 mg/ml ascorbic acid, and 0.125 mg/ml citric acid, the study also discovered a considerable stability of the betacyanin concentration. Retained betacyanin content was 0.8 mg/g at ambient temperature, and 1 mg/g at 4°C following 7 h after the addition of ascorbic acid. After 7 h of citric acid incorporation, the retained betacyanin concentration was 0.8 mg/g at ambient temperature, and 0.9 mg/g at 4°C.

Ascorbic acid's impact on the betacyanin stability for beetroot extract was investigated by Guo *et al*. (2021). Results showed that the amounts of betacyanin that were still present for UV aided beetroot extract after ascorbic acid (100 ppm) incorporation was 70%, and 30% after 36, and 72 h, respectively. The remaining betacyanin concentration was 58% for beetroot extract after 36 h, 70% for ascorbic acid incorporated beetroot extract after 36 h, 24% for beetroot extract after 72 h, and 30% for ascorbic acid incorporated beetroot extract after 72 h. After 15 days, the retention of betacyanin content increased non-significantly when ascorbic acid concentration was increased from 100 ppm to 300 ppm.

Vinod *et al*. (2020) examined the bacteriological and sensory quality of dragon fruit pulp mixed with potassium sorbate (750, 1000, and 1250 ppm), sodium benzoate (250, 500, and 750 ppm), and ascorbic acid (1000, 1500, and 2000 ppm) at -20±0.5°C temperature. After 3 months of storage, dragon fruit pulp containing 1000 ppm ascorbic acid had the lowest bacterial count (3.34×10^5 cfu/g), and the highest overall acceptability (7.83 out of 9).

The influence of temperature, and juice content on betacyanin stability during storage was examined by Siow and Wong (2016). The pH of juice (14.2°Brix TSS, 3.98 pH), and concentrate (54°Brix TSS, 4.05 pH) adjusted to 4 by 1M HCL, and 0.25% (w/w) ascorbic acid was added to both. Both juice and concentrate were pasteurized for 30 min at 65°C, and then kept at 4°C, and 25°C. At the conclusion of 8 weeks of storage, concentrate had a higher retention of betacyanin concentration (1.0 mg BCE) than juice (0.93 mg of betacyanin equivalent) at a storage temperature of 4°C.

In order to study the use of jamun juice, Priyanka *et al*. (2015) prepared blended RTS drinks with varying ratios of mango, grape, and pineapple. The different levels of jamun juice (25, 50, and 75%) were blended with 75, 50, and 25% levels of mango juice, grape juice, and pineapple juice individually. The prepared RTS beverage had 100 ppm sodium benzoate, 0.3% citric acid, and 10°Brix TSS. On the basis of a 90-day storage duration, the RTS beverage made from a mixture of 75% jamun juice, and 25% grape juice earned the highest overall acceptability score (8.25).

Khan and Giridhar (2014) studied chemical stability of betacyanin with or without addition of metal ions in thermally treated berry juice. Ascorbic acid was used 0.25 g/100ml, and 0.5 g/100ml with, and without addition of Se^{+4}, Zn^{+2}, and Cu^{+2}. Results suggested that the sample containing 0.25 g/100ml ascorbic acid, and 40 μg/ml Se^{+4} stored at 5°C showed 100% regeneration of betacyanin degraded during heat treatment, However, 0.25 g/100ml ascorbic acid addition in juice was found to significantly increase betacyanin regeneration compared to 0.5 g/100ml ascorbic acid addition. In the presence of ascorbic acid, the results also revealed no statistically significant difference in betacyanin regeneration with or without the addition of Se^{+4}.

Maama (2013) investigated how microbiological deterioration, and shelf life of passion fruit juice were affected by chemical preservation. For four weeks of storage, juice treated with 3.0% benzoic acid retained its color, aroma, and taste the best. On 14th day, the total aerobic plate count for passion fruit juice treated with 3.0% benzoic acid was zero, but during 21 days of storage, it was >3,00,000 APC/ml.

The impact of various chemical treatments on the preservation of passion fruit juice was investigated by Akpan and Kovo (2005). The individual effects of adding 4% sugar, 4% citric acid, and 3% benzoic acid, as well as the combined effects of adding 4% sugar, 4% citric acid, and 3.0% benzoic acid to drinks were studied. The passion fruit juice that had been processed with 3% benzoic acid was deemed suitable for storage for one month. The total viable count, and alcohol concentration grew to 5×10^4 cfu/ml, and 0.004%, respectively, after 28 days of storage. Juice pH was lowered from 4.05 to 3.74.

The effects of preservation technique, and storage conditions on the flavor, and color of passion fruit juice were examined by Namutebi (1998). Scientists investigated the differences between passion fruit juice that has been artificially preserved (potassium sorbate: 800 ppm), and pasteurized (75°C for 30–50 sec). Juice that had been pasteurized lacked the red, and yellow hues of chemically preserved juice. Juice that had been chemically preserved had L, a, and b values of 33.22, -4.95, and 15.47, respectively. Pasteurized juice had L, a, and b values of 24.66, -3.88, and 8.43, respectively. Juice that had been chemically preserved rather than pasteurized was deemed to be more acceptable based on higher L, a, b color values.

3. Effect of processing temperature, and storage conditions

3.1. Betalain and betacyanin

The betacyanin kinetics of pasteurized cactus pear juice during storage were studied by Bassama *et al*. (2021). Juice pasteurized at 90°C for 36 sec has improved quality, and safety. The stability of pasteurized juice at a storage temperature of 20°C was 2 months. After 40 days of storage, the betacyanin content at 45°C dropped from 0.9 to 0.2 g/kg. At 4°C temperature for 50 days of storage, the highest retention of betacyanin (0.8 g/kg) was noted.

After being pasteurized at 67 to 70°C for 30 min, Gomez-Covarrubias *et al*. (2020) discovered betacyanin degradation in *Opuntia joconostle* juice. Non-significant impact of pasteurization was discovered on pH, TSS, titratable acidity, or total phenols. However, betaxanthins, and betacyanin showed a considerable rise. The contents of betaxanthin, and betacyanin increased from 0.0050, and 0.0700 μg/g to 0.112, and 0.096 μg/g, respectively.

According to Nguyen *et al*. (2018), the betacyanin content of LD5 red-fleshed dragon fruit (*Hylocereus polyrhizus*) was affected by pH (3 to 7), ascorbic acid addition (0.1 to 0.5% w/w), heat treatment (65, 75, and 85°C for 10, 20, and 30 min), and storage conditions. The conditions that resulted in the highest retention of betacyanin were 4 pH, 0.3% ascorbic acid addition, 65°C for 10 min, storage in glass, and plastic packaging without exposure to light. After heating for a prolonged period of time, and at a higher temperature, a significant decrease was discovered. After heating at 65, 75, and 85°C for 10 min, the initial betacyanin concentration (204.11 mg/L) was reduced to 175.54, 140.85, and 114.31 mg/L. The least amount of betacyanin content was reduced (179.56 mg/L) at pH 4. After adding 0.1, and 0.2% ascorbic acid, non-significant difference was discovered. The highest level of betacyanin (171.18 mg/L) was reached after adding 0.3% ascorbic acid. Betacyanin retention after 5th week was shown to be higher in glass bottles kept in the dark.

The betacyanin retention of juice samples (14.2°brix TSS), and concentrate samples (54°brix TSS) held for 8 weeks at 4°C, and 25°C was examined by Fong and Ming (2016). After juice, and concentrate were pasteurized at 65°C for 30 min, and adjusted to a pH 4, 0.25% ascorbic acid was added, and betacyanin retention was carried out. The findings showed that at 4°C, and 25°C, concentrate samples retained more betacyanin than juice samples. After 8 weeks of storage, the concentrate sample stored at 4°C had the highest retention (1.00), followed by the juice sample at 4°C (0.93), the concentrate sample at 25°C (0.67), and the juice sample at 25°C (0.35).

Cruz-Cansino *et al*. (2015) compared the shelf life, physical, and chemical characteristics, antioxidant activity, and microbiological characteristics of purple cactus pear (*Opuntia ficus indica*) juice, pasteurized cactus pear juice (70°C for 30 min), and thermos-sonicated juice (150 W, constant frequency of 20 kHz at 80% amplitude for time periods of 15 or 25 min). After pasteurization, a non-significant drop in betanin, and betaxanthin content was seen. The level of betanin, and betaxanthin was reduced from 291.52 to 272.43 mg betanin equivalent/L, and 107.87 to 98.43 mg indicaxanthin equivalent/L, respectively. Antioxidant activity of juice (1016.07 µmol trolox equivalent/L) was increased after pasteurization treatment (1566.67 µmol trolox equivalent/L). After 28 days of storage, the antioxidant activity of controlled juice, and pasteurized juice increased from 1016.07, and 1566.67 µmol trolox equivalents per litre to 3084.52, and 1864.28 µmol trolox equivalents, respectively.

Naderi *et al*. (2012) characterized and quantified betacyanin from *Hylocereus polyrhizus* variety of dragon fruit. Ratio of fruit per solvent was 1/1 (w/v) for ethanol, and aqueous ethanol (50:50). Betacyanin content was found higher for control (811 mg/L), followed by aqueous ethanol extract (655.5 mg/L), and least content for ethanol extract (449 mg/L).

At particular temperatures, Manchali *et al*. (2012) investigated the degradation of betalains in red beetroot. The chosen temperature was in the range of 50–60°C, 60–75°C, and 70–80°C. At pH 3 to 7, betalain pigments were more durable. Herbach *et al*. (2006b) reported the same results regarding the impact of pH on betalain pigment.

Karthiga *et al*. (2012) investigated how light, temperature, and pH affected the betacyanin's stability in *Basella alba* fruit. According to studies, betacyanin's disintegration accelerated with higher temperatures, a higher pH, and exposure to light. With or without exposure to light, the betacyanin content of *Basella alba* fruit was more stable at pH 4.1, pH 6, and temperatures of 10, 20, and 30°C.

Tenore *et al*. (2012) investigated the pulp and peel of red-fleshed dragon fruits for their capacity to scavenge free radicals. The highest betacyanin fractions of the pulp (999.8 mol TE/100g), and peel (805.1 mol TE/100g) had better radical scavenging activity, according to the DPPH assay. The radical scavenging activities of the flavonoids in pulp, and peel was 39.7, and 25.6 µmol TE/100g, respectively. For pulp, and peel, phenolic acid produced 12.8, and 1.0 µmol TE/100g radical scavenging activity, respectively.

The stability of the betalain pigment, which is present in *Hylocereus polyrhizus*, was investigated by Woo *et al*. (2011) under various conditions, including pH, antioxidant addition, pre-heating, and light exposure. Without exposure to light, betalain pigment retention was shown to be greater at pH 5, and 4°C. In *Hylocereus polyrhizus*, betalain breakdown is accelerated by light exposure.

The stability of betacyanin, and the impact of processing, and storage on the juice color obtained from purple pitaya fruit were examined by Herbach *et al*. (2007). Purple pitaya juice was pasteurized at 92°C with varying holding times, preheating times, and flow rates. In pasteurized juice, the HTST pasteurizer, tubular heat exchanger, and processing vessel were able to preserve 63% to 77% of the betacyanin concentration.

3.2. Antioxidant activity

The blended RTS beverage developed by Pavithra and Mini (2022) based on dragon fruit. Lime, pineapple, and watermelon were combined in three separate blends, each with a different ratio. According to a sensory evaluation score, the ratios of dragon fruit to lime (80:20), pineapple (50:50), and watermelon (10:90) were optimal. The RTS with the highest overall acceptability was the dragon fruit lime combination. After 60 days of storage, pure dragon fruit had the highest antioxidant activity (57%), followed by a blend of dragon fruit and pineapple (49%), a blend of dragon fruit and lime (43%), and a blend of dragon fruit and watermelon (38%).

Chen *et al*. (2021) used the 2,2-Diphenyl-1-picrylhydrazyl (DPPH) assay, the ferric reducing antioxidant power (FRAP) assay, the 3-ethyl benzothiazoline-6-sulphonic acid (ABTS) assay, and the total antioxidant capacity (TAC) assay to estimate the antioxidant potential of white, and red-fleshed dragon fruit pulp, and peel. According to the DPPH experiment, red fleshed dragon fruit pulp had the highest activity (0.29 mg of AAE/g), followed by white fleshed pulp (0.09 mg AAE/g), and both white, and red fleshed fruit peel had a similar amount of antioxidant activity (0.07 mg AAE/g). White fleshed dragon fruit peel demonstrated considerably higher activity (25.50 mg AAE/g) than red fleshed dragon fruit peel (18.12 mg AAE/g) according to the FRAP assay, which revealed similarities to the DPPH assay. White fleshed fruit pulp, red fleshed fruit pulp, white fleshed fruit peel, and red fleshed fruit peel, respectively, had antioxidant activities of 0.31, 0.29, 0.20, and 0.19. Similar patterns for antioxidant activity were seen in the ABTS and TAC assays.

The free radical scavenging capacity of functional drinks made from dragon fruit peel, and roselle was studied by Suryaningsih *et al*. (2021). The outcomes pointed to antioxidant activity for extraction at various time-temperature combinations. For roselle at 60°C extraction temperature, and 5 min of extraction time, and dragon fruit peel at 100°C extraction temperature, and 25 min of extraction time, the highest antioxidant activity was 80.68, and 72.59%, respectively.

Prickly pear juice's physical, chemical, and biological characteristics were examined by Karabagias *et al*. (2019). The range for the total phenolic content was 3,234.5-7,592.1 mg GAE/L. In vitro antioxidant activity of prickly pear juice from Eastern Messinia, Lakonia, and Western Messinia was assessed by Karabagias *et al*. (2019). Western Messinia juice had the lowest antioxidant activity (67.33%), Lakonia juice came in second (69.90%), and Eastern Messinia prickly pear juice had the highest antioxidant activity (75.63%).

The antioxidant activity, total phenolic content, and total flavonoid content of pulp from *H. polyrhizus* at various dilution rates were studied by Manan *et al*. (2019). Maximum values for TPC, TFC, DPPH assay, ABTS assay, FRAP assay, and phosphomolybdate assay at a dilution factor of 2 were 32.90 mg GAE/100ml, 2.26 mg QE/100ml, 73.38%, 92.66%, 132.17 mol Fe^{2+}/100ml, and 28.94 mg AAE/100ml, respectively.

With the aid of a microwave, Thirugnanasambandham and Sivakumar (2017) extracted betalain from dragon fruit peels while researching antioxidant activity, and betalain concentration. Microwave assisted extraction at temperature 35°C, 20 g sample weight, and 8 min extraction time showed maximum betalain content (9 mg/L). According to the results, antioxidant activity rose along with extract concentration.

Jeronimo *et al*. (2015) examined the antioxidant capacity of dragon fruit. Peel had a higher EC_{50} value (445.2 g/ml) than pulp (1,266.3 g/ml).

The impact of thermal, and chemical treatment on the antioxidant activity of apple pulp was studied by Nisar *et al*. (2015). The IC_{50} (inhibitory concentration by 50%) value for radical scavenging activity for pulp that had not been treated, pulp that had been chemically treated (0.1% KMS + 0.1% citric acid), pulp that had been pasteurized (65°C for 30 min), and pulp that had undergone all four treatments was 0.17, 0.15, 0.12, and 0.12 μg/μL, respectively. Higher IC_{50} values indicate decreased antioxidant activity; the largest increase in antioxidant activity was seen following pasteurization, and combination treatment. The findings also revealed that chemical treatment boosted antioxidant activity.

In the pulp of *H. polyrhizus*, and *H. undatus*, Choo and Yong (2011) discovered similarities in the radical scavenging activity. The EC_{50} (50% effective concentration) value used to measure antioxidant activity was greater in *H. Undatus* fruit (14.61 mg/ml) than *H. polyrhizus* Fruit (11.34 mg/ml). There was non-significant change between the EC_{50} value for pulp of H. polyrhizus (9.93 mg/ml), and *H. undatus* (9.99 mg/ml).

Red, and white dragon fruit were compared for their phenolic content, and antioxidant activity by Kim *et al*.

(2011). For the red dragon fruit peel, red dragon fruit flesh, white dragon fruit peel, and white dragon fruit flesh, respectively, the total polyphenol content was 14.82, 4.91, 15.94, and 3.52 mg GAE/g. Antioxidant activity of white fleshed dragon fruit peels (68.1%), red fleshed dragon fruit peels (56.8%), red fleshed dragon fruit flesh (33.2%), and white fleshed dragon fruit flesh (23.8%), according to the same pattern of antioxidant activity. Direct correlation was found between antioxidant activity, and total phenol content.

Two types of dragon fruit were examined for their total phenolic content, and radical scavenging capacity by Nurliyana *et al*. (2010). Antioxidant capacity for *H. undatus peel*, *H. polyrhizus* peel, *H. undatus* pulp, and *H. polyrhizus* pulp was 87.02, 83.48, 27.45, and 16.56%, respectively, at 1 mg/ml of the sample concentration. TPC was found maximum in peel of *H. undatus* (36.12 mg/100g), followed by peel of *H. polyrhizus* (28.16 mg/100g), then pulp of *H. polyrhizus* (19.72 mg/100g), and minimum in pulp of *H. undatus* (3.75 mg/100g).

CONCLUSION

The tropical or subtropical fruit known as dragon fruit can fulfil various dietary needs while also providing numerous health advantages. Review papers have led to the conclusion that in order to boost the marketability of dragon fruit products, production must be expanded along with processing capacity. The fruit's availability and shelf life will both be extended by its use in other products. One of the cuisine categories that is commonly consumed around the world is ready to serve (RTS). Therefore, using dragon fruit in RTS beverages will give them a longer shelf life, a reduced price with greater market availability, and variation once they are blended with other juices and given additional juices as flavours. After thorough research, processing methods and parameters might be enhanced. Fruit juices can benefit from thermal, microwave, and chemical treatments to extend their shelf lives. According to reviews, dragon fruit is a good source of phenols, vitamin C, and a variety of minerals. After reading through all of these reviews, it is clear that using dragon fruit to produce lime-flavored RTS beverages and extend their shelf lives is the most practical and convenient way to appeal to as many people as possible.

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