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EFFECT OF THERMAL AND CHEMICAL PROCESSING ON BIOACTIVE COMPOUND, ANTIOXIDANT ACTIVITY AND SENSORY QUALITY OF LIME-FLAVORED DRAGON FRUIT RTS BEVERAGE

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ABSTRACT

The current study was planned to standardize the lime juice in dragon fruit RTS beverage, and to examine the impact of thermal, and chemical processing on betacyanin content, antioxidant activity, and sensory quality of lime-flavored dragon fruit RTS beverage. According to preliminary trials, dragon fruit RTS beverage having 0.1% citric acid, 12% fruit juice and 12°Brix TSS was incorporated with 3% lime juice on sensory basis. The prepared lime-flavored dragon fruit RTS beverage subjected to thermal (70, 80 and 90°C for 5, 10, 15 min), and chemical processing (500, 1000 and 1500 ppm ascorbic acid incorporation) and analyzed for betacyanin content, antioxidant activity and sensory evaluation. Among all the thermal treatments RTS processed for 5 min at 70°C was found best on betacyanin content (23.80 mg/L), 73.43% antioxidant activity and overall acceptability score (7.55 out of 9); However, chemically treated lime-flavored dragon fruit RTS beverage had non-significantly higher betacyanin content (38.00 mg/L) and significantly higher antioxidant activity (68.37%). The chemically treated lime-flavored dragon fruit RTS beverage retained more betacyanin content than thermally processed RTS beverage. However, antioxidant activity was higher for thermally processed lime-flavored dragon fruit RTS beverage.

Key words : Antioxidant activity, Ascorbic acid, Betacyanin, Dragon fruit RTS, Thermal.

Introduction

The dragon fruit (*Hylocereus polyrhizus*) originated in tropical, as well as subtropical forest regions of Latin America, and Mexico due to less water requirement to grow (Stintzing *et al*., 2002). According to Jalgaonkar *et al*. (2020), the dragon fruit is referred to by a variety of names, including pitaya, pitahaya, strawberry pear, thangloy in Vietnam, la pitahaya rouge in French and pitayaroja in Spanish. Kumar *et al*. (2018) suggested that the consumption of dragon fruit can lower the blood pressure and diabetes. The flavonoids, hydroxyl-cinnamates and betalains are antioxidant compounds greatly present in pitaya (Moshfeghi *et al*., 2013). According to Mahdi *et al*. (2018), the pitahaya has a healthy level of phytochemicals, and antioxidants. West Indian lime scientifically known as *Citrus aurantifolia* was originated in Malaysia or India (Langgut, 2017; Liu *et al*., 2022). Limonnene (54%), γ-terpinene (17%) and β-pinene (13%) are three major essential oils found by Costa *et al*. (2014). Vast production of lime fruit in west India aspecially in Gujarat state leads to utilization of lime juice in many beverages or juice blends. Our study also focused on the effect of thermal and chemical processing of dragon fruit RTS beverage incorporated with lime juice of RTS.

According to Wong and Siow (2015), *Hylocereus polyrhizus* juice pasteurized for 30 min at 65°C with combined effect of 4 pH and 0.25% ascorbic acid, maximum retention of betacyanin was found, whereas betacyanin retention was 0.83 mg/L for 10 min heating at 65°C, 0.78 mg/L for pH 5 and 0.85 mg/L for 0.25% ascorbic acid from 1 mg/L, respectively. Total phenolic content was decreased from 21.41 mg GAE/g to 7.98, and 8.49 mg GAE/g for 30 min at 95°C and 60 min at 105°C; while antioxidant activity decreased by 40 and 33%, respectively for pitaya as per the study of Omidizadeh *et al*. (2014). The retention of betanin content was 67.8% for purple pitahaya juice HTST pasteurized at 92°C with 100 L/h flow rate, 7 sec of preheating, and 26 sec of holding time (Herbach *et al*., 2007). According to research conducted by Nguyen *et al*. (2018), betacyanin was more stable individually at pH 4 (179.56 mg/L), 0.3% ascorbic acid incorporation (171.18 mg/L), and 10 min heating at 65°C (175.54 mg/L) from initial betacyanin content of 204.11 mg/L for dragon fruit juice. The concentrated sample (54°Brix TSS) had more retention of betacyanin content than juice sample (14.2°Brix TSS) at 4°C and 25°C after 8 weeks of storage (Fong and Ming, 2016). The betacyanin's disintegration accelerated with higher temperatures, a high pH, and exposure to light (Karthiga *et al*., 2012; Woo *et al*., 2011; Herbach *et al*., 2006).

Dey *et al*. (2022) Found that the betacyanin content after 7 h of 0.125 mg/ml Vit. C incorporation was retained 0.8, and 1 mg/g at ambient and 4°C temperature, respectively. The betacyanin content of beet root was non-significantly increased ($p>0.05$), when concentration of Vit. C increased from 100 to 300 ppm (Guo *et al*., 2021). According to study by Vinod *et al*. (2020), dragon fruit pulp having 1000 ppm ascorbic acid incorporation had lower microbial growth (3.34×10^5 cfu/g), and higher overall acceptability (7.83 out of 9) than other chemical treatments. Thermally treated berry juice incorporated with 0.25 g/100ml ascorbic acid, and 40 µg/ml Se^{+4} reported 100% regeneration of betacyanin content after storage at 5°C (Khan and Giridhar, 2014). Significant increase in regeneration of betacyanin content was found for 0.25 g/100ml ascorbic acid addition than 0.50 g/100ml ascorbic acid; However, non-significant change was observed for addition of Se^{+4}.According to study of Nisar *et* al. (2015), the radical scavenging activity for thermally treated apple pulp for 30 min at 65°C (IC_{50}: 0.12 µg/µl) was higher than pulp treated with 0.1% KMS and 0.1% citric acid (IC_{50}: 0.15 µg/µl).

Current study was conducted to standardize the lime juice in dragon fruit RTS beverage and toevaluate the effect of thermal and chemical processing on the parameters such as betacyanin content, antioxidant activity and sensory evaluation of prepared RTS beverage.

Materials and Methods

Lime-flavored dragon fruit RTS beverage preparation

The 1, 2, 3 and 4% lime juice was incorporated in dragon fruit RTS containing 0.1% citric acid, 12°Brix TSS, and 12% fruit juice content. Fresh dragon fruits purchased from Kachchh, Gujarat, India was used to prepare dragon fruit RTS beverage (Fig. 1) and lime fruit purchased from local market were squeezed to extract lime juice with help of lemon squeezer.

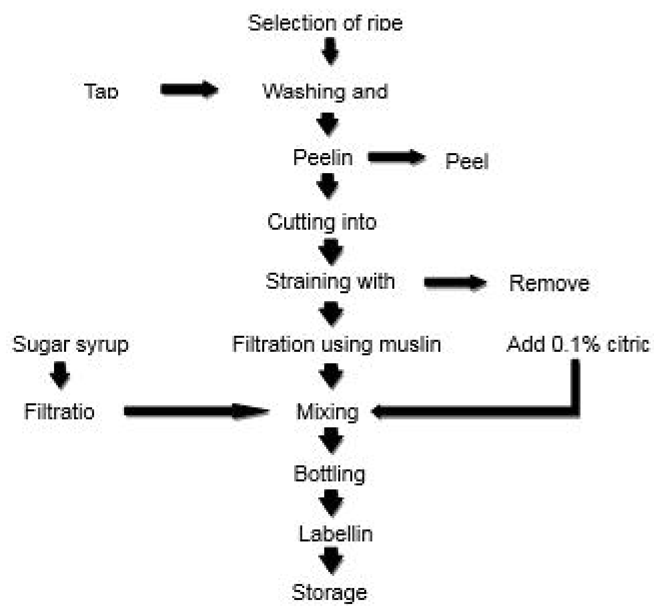

Fig. 1 : Process flowchart for preparation of RTS beverage.

Chemicals

Food grade ascorbic acid purchased online from Loba Chemie Pvt. Ltd. Other chemicals required for analysis were provided by Department of Food Safety and Quality Assurance, College of Food Processing Technology & Bioenergy, Anand Agricultural University, Anand, Gujarat, India.

Details of thermal and chemical treatments for lime-flavored dragon fruit RTS beverage

The treatment details for thermal and microwave treatment for lime-flavored dragon fruit RTS beverage was mentioned in Tables 1 and 2, respectively. The thermal processing for lime-flavored dragon fruit RTS beverage done in glass beaker, placed in waterbath with continuously moinitering temperature with thermometer at treatment cabinet. After cooling, Rts was packed in PET bottles and stored at refrigerated conditions for further analysis. A food grade ascorbic acid was weighted as per calculations, and directly added to lime-flavored dragon fruit RTS beverage.

Table 1 : Time-temperature combinations for thermal treatment of lime-flavored dragon fruit RTS beverage.

Treatment	Temperature (°C)	Time (min)
T_1t_1	70	5
T_1t_2	70	10
T_1t_3	70	15
T_2t_1	80	5
T_2t_2	80	10
T_2t_3	80	15
T_3t_1	90	5
T_3t_2	90	10
T_3t_3	90	15

Table 2 : Treatment details for chemical processing of lime flavored dragon fruit RTS beverage.

Treatment	Ascorbic acid (ppm)
C_1	500
C_2	1000
C_3	1500

Estimation of betacyanin content

A slight modification in spectrophotometric method described by Naderi *et al*. (2012) was used to analyze betacyanin content. RTS was diluted 50 times.

Estimation of antioxidant activity

A slight modification in spectrophotometric method described by Nadeem *et al*. (2018) was used to analyze betacyanin content. Methanol was used in place of Ethanol.

Sensory evaluation

A semi-trained judges used nine-point hedonic scale to evaluate sensory quality of RTS. The attributes of color, taste, body, flavor and overall acceptance were utilized to evaluate sensory quality of the RTS beverage.

Statistical analysis

Replicate data for all experiments were analyzed at agriculture statistics department, Anand Agricultural University, Anand, Gujarat, India.

Results and Discussion

Effect of lime juice incorporation in dragon fruit RTS beverage on sensory score

The effect of lime juice incorporation in dragon fruit RTS beverage on sensory score was tabulated in Table 3. The non-significant change for color, and body score was reported for lime-flavored dragon fruit RTS beverage. The significantly higher taste score was 7.94, flavor score was 7.86 and overall acceptability was 7.92 for dragon fruit RTS beverage incorporated with 3% lime juice. So, 3% lime juice incorporation in dragon fruit RTS beverage was found best on the basis of sensory evaluation.

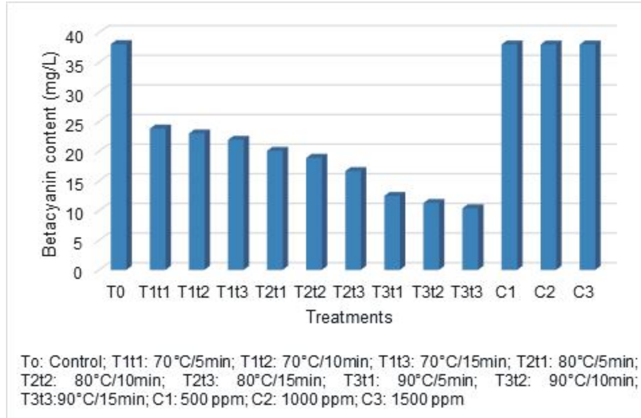

Fig. 2 : Effect on betacyanin content of lime-flavored dragon fruit RTS beverage.

Thermal processing of lime-flavored dragon fruit RTS beverage

Effect of thermal treatment on betacyanin content of lime-flavored dragon fruit RTS beverage

The effect of thermal treatment on betacyanin content of lime-flavored dragon fruit RTS beverage was presented in Table 4 (Fig. 2). The effect of processing time, interaction of time with temperature was non-significant, whereas temperature affects significantly. Maximum betacyanin content was observed for 70°C processing time. The betacyanin content was reported non-significantly higher for T_1t_1 (23.80 mg/L) than T_1t_2 (22.98 mg/L) and T_1t_3 (21.92 mg/L).The significant decrease was observed in betacyanin content for increasing temperature, while non-significant decrease was reported as increase in processing time. Similar findings about heat sensible betacyanin were given by Herbach *et al*. (2006), Moussa-Ayoub *et al*. (2017) and Herbach *et al*. (2007).

Effect of thermal treatment on antioxidant activity of lime-flavored dragon fruit RTS beverage

The effect of thermal treatment on antioxidant activity of lime-flavored dragon fruit RTS beverage was presented in Table 5 (Fig. 3). The effect of processing temperature, processing time, and interaction of time with temperature was non-significant. The breakdown of the cells present in RTS releases the phenolic compound responsible for higher antioxidant activity. However, longer exposure time leads to deformation of phenols. According to Moussa-Ayoub *et al*. (2017), amino acids and reducing sugars reacted at higher temperature produces melanoidins,

Table 3 : Effect of lime juice incorporation in dragon fruit RTS beverage on sensory score.

Treatment	Color	Taste	Body	Flavor	Overall acceptability
T_1	8.10 ± 0.07	7.22 ± 0.17^c	7.80 ± 0.10	7.36 ± 0.19^b	7.24 ± 0.13^c
T_2	8.08 ± 0.11	7.54 ± 0.09^b	7.83 ± 0.11	7.51 ± 0.07^b	7.48 ± 0.04^b
T_3	8.15 ± 0.08	7.94 ± 0.15^a	7.85 ± 0.13	7.86 ± 0.16^a	7.92 ± 0.17^a
T_4	8.05 ± 0.10	7.17 ± 0.11^c	7.80 ± 0.11	7.27 ± 0.17^b	7.12 ± 0.15^c
C.D. (5%)	NS	0.18	NS	0.21	0.18
SEm	0.04	0.06	0.05	0.07	0.06
CV%	1.17	1.18	1.47	2.05	1.80

n: Mean of five repetitions; T_1: 1% lime juice; T_2: 2% lime juice; T_3: 3% lime juice; T_4: 4% lime juice; NS: non-significant.

Table 4 : Effect of thermal treatment on betacyanin content (mg/L) of lime-flavored dragon fruit RTS beverage.

Temperature (°C)	Time (min)			Mean T
	t_1	t_2	t_3	
T_1	23.80	22.98	21.92	22.90
T_2	20.06	18.85	16.64	18.52
T_3	12.45	11.26	10.36	11.36
Mean t	18.77	17.70	16.31	
Factor	T	t	T × t	
C.D. (5%)	2.27	NS	NS	
SEm	0.77	0.77	1.33	
CV%	13.05			

T: temperature; T_1: 70°C; T_2: 80°C; T_3: 90°C; t: time; t_1: 5 min; t_2: 10 min; t_3: 15 min; T × t: interaction of temperature, and time; NS: non-significant.

Table 5 : Effect of thermal treatment on antioxidant activity (%) of lime-flavored dragon fruit RTS beverage.

Temperature (°C)	Time (min)			Mean T
	t_1	t_2	t_3	
T_1	73.43	70.40	67.86	70.56
T_2	74.48	72.62	72.16	73.07
T_3	76.19	73.75	73.56	74.50
Mean t	74.69	72.25	71.19	
Factor	T	t	T × t	
C.D. (5%)	NS	NS	NS	
SEm	2.37	2.37	4.11	
CV%	9.80			

T: temperature; T_1: 70°C; T_2: 80°C; T_3: 90°C; t: time; t_1: 5 min; t_2: 10 min; t_3: 15 min; T × t: interaction of temperature, and time; NS: non-significant.

which act as antioxidant. Liaotrakoon *et al.* (2013) observed similar increase for phenolic content and antioxidant activity.

Effect of thermal treatment on sensory evaluation of lime-flavored dragon fruit RTS beverage

A nine-point hedonic scale used by panel to evaluate a thermally treated lime-flavored dragon fruit RTS beverage for color, taste, body, flavor and overall acceptability. Effect of thermal treatment on sensory evaluation of lime-flavored dragon fruit RTS beverage was discussed below.

The color, taste, body and flavor score of thermally treated lime-flavored dragon fruit RTS beverage were found non-significant for processing temperature, time, and interaction of temperature with time. The overall acceptability score of lime-flavored dragon fruit RTS beverage was significant for processing temperature, while non-significant for time, and temperature, and time interaction (Table 6).

Chemical treatment for lime-flavored dragon fruit RTS beverage

Effect of chemical treatment on betacyanin content of lime-flavored dragon fruit RTS beverage

The effect of chemical treatment on the betacyanin content of a lime-flavored dragon fruit RTS beverage was shown in Table 7 (Fig. 2). For the betacyanin content of the chemically treated lime-flavored dragon fruit RTS beverage, no significant variation was found. For lime flavored dragon fruit RTS beverages treated with ascorbic acid at values of 500, 1000 and 1500 ppm, respectively, the betacyanin concentration was 38.00, 37.98 and 37.99 mg/L.

Effect of chemical treatment on antioxidant activity of lime-flavored dragon fruit RTS beverage

The impact of chemical processing on the antioxidant activity of lime-flavored dragon fruit RTS beverage was mentioned in Table 7 (Fig. 3). The antioxidant activity of the lime-flavored dragon fruit RTS beverage after

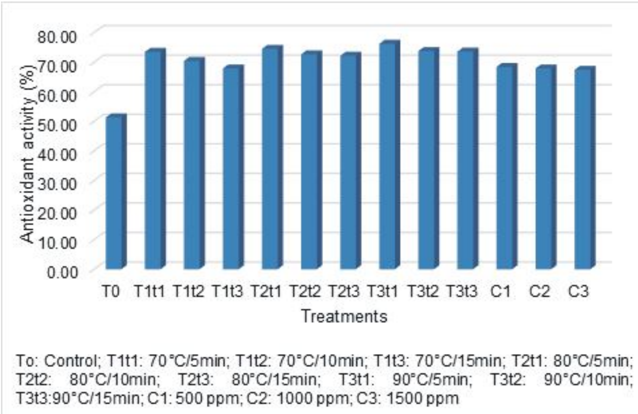

Fig. 3 : Effect on antioxidant activity of lime-flavored dragon fruit RTS beverage.

Table 6 : Effect of thermal treatment on overall acceptability score of lime-flavored dragon fruit RTS beverage.

Temperature (°C)	Time (min)			Mean T
	t_1	t_2	t_3	
T_1	7.55	7.60	7.53	7.56
T_2	7.55	7.49	7.37	7.47
T_3	7.40	7.49	7.36	7.42
Mean t	7.50	7.53	7.42	
Factor	T	T	T × t	
C.D. (5%)	0.09	NS	NS	
SEm	0.03	0.03	0.05	
CV%	1.20			

T: temperature; T_1: 70°C; T_2: 80°C; T_3: 90°C; t: time; t_1: 5 min; t_2: 10 min; t_3: 15 min; T × t: interaction of temperature, and time; NS: non-significant.

Table 7 : Effect of chemical treatment on betacyanin content (mg/L) and antioxidant activity of lime-flavored dragon fruit RTS beverage

Treatment	Betacyanin content (mg/L)	% Antioxidant activity
C_1	38.00 ± 0.22	68.37 ± 0.39[a]
C_2	37.98 ± 0.09	67.87 ± 0.17[b]
C_3	37.99 ± 0.36	67.41 ± 0.37[c]
C.D. (5%)	NS	0.45
SEm	0.12	0.15
CV%	0.73	0.48

n: Mean of five replications; C_1: 500 ppm; C_2: 1000 ppm; C_3: 1500 ppm; NS= non-significant.

68.37%). Accordingly, a sample that had been exposed to 500 ppm of ascorbic acid (C_1) was chosen as having the highest antioxidant activity. Ascorbic acid also shows the antioxidant effect might be the reason for increase in antioxidant activity.

Effect of chemical treatment on sensory evaluation of lime-flavored dragon fruit RTS beverage

To access the effect of chemical treatments on the sensory evaluation of the lime-flavored dragon fruit RTS beverage (Table 8) a panel of semi trained judges were selectedto evaluate a lime-flavored dragon fruit RTS beverage for color, taste, body, flavor and overall acceptability a nine-point hedonic scale. A non-significant variation was found for color, taste, body, flavor and overall acceptability score for chemically treated lime-flavored dragon fruit RTS beverage.

Table 8 : Effect of chemical treatment on sensory evaluation of lime-flavored dragon fruit RTS beverage.

Treatment	Color	Taste	Body	Flavor	Overall acceptability
C_1	7.86 ± 0.07	7.82 ± 0.06	7.88 ± 0.04	7.68 ± 0.05	7.75 ± 0.06
C_2	7.86 ± 0.05	7.80 ± 0.04	7.88 ± 0.04	7.70 ± 0.04	7.73 ± 0.05
C_3	7.86 ± 0.07	7.79 ± 0.03	7.88 ± 0.04	7.70 ± 0.04	7.81 ± 0.11
C.D. (5%)	NS	NS	NS	NS	NS
SEm	0.03	0.02	0.02	0.02	0.04
CV%	0.78	0.55	0.57	0.55	1.05

n: Mean of five repetitions; C_1: 500 ppm; C_2: 1000 ppm; C_3: 1500 ppm; NS= non-significant.

chemical treatment varied significantly depending on the level of ascorbic acid. For lime flavored dragon fruit RTS beverage treated at various concentrations of ascorbic acid ranges from 500, 1000 and 1500 ppm, respectively, reported antioxidant activity was 68.37, 67.87 and 67.41%. Significantly, the sample treated with 500 ppm ascorbic acid showed the highest level of antioxidant activity (C_1:

The effect of chemical processing on betacyanin content, sensory attributes like; color, taste, body, flavor and overall acceptability was non-significant. However, effect of chemical processing was significant for antioxidant activity of lime-flavored dragon fruit RTS beverage. Antioxidant activity was observed higher (68.37%) for RTS incorporatedwith500ppmascorbicacid.

Conclusion

The betacyanin content degradation was increased with increase in temperature, and treatment time duration for thermal treatment. The reduction of betacyanin content was more for thermal treatment than chemical treatment. The antioxidant activity was increased with increasing temperature due to release of phenolic compounds from cells, but at the same time exposure of long time at higher temperature can lead to degradation of that compounds resulted in decrease in antioxidant activity. Chemical treatment can increase antioxidant activity; however, increased concentration ofascorbic acid leads to reduction in antioxidant activity. For deep understanding about antioxidant activity response behavior, study related to total phenols is needed. Thermal treatment for 5 min at 70°C was retained 23.80 mg/L of betacyanin content, and 73.43% antioxidant activity, whereas for 500 ppm ascorbic acid incorporation in RTS was retained 38.00 mg/L betacyanin and 68.37% antioxidant activity.

Conflict of interest : All authors declare that they have no conflict of interest.

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