Betacyanin, antioxidant activity and shelf-life evaluation of thermally, microwave, and chemically processed lime-flavored dragon fruit RTS beverage

Abstract

Standardizing lime juice in dragon fruit RTS beverages, optimizing thermal, microwave, and chemical treatments, and studying shelf life were the goals of this study. Dragon fruit RTS beverage was made with 12% fruit juice, 12°Brix TSS, and 0.1% citric acid after a preliminary sensory study. Dragon fruit RTS with 3% lime juice tasted best. The standardized RTS beverage was thermal (70, 80, and 90°C for 5, 10, and 15 min), microwave (900 W power density for 30, 60, 90, 120, 150 sec), and chemical (500, 1000, and 1500 ppm ascorbic acid incorporation) treated to optimize betacyanin content, antioxidant activity, and sensory evaluation. RTS beverage thermally treated at 70°C for 5 min, on betacyanin, antioxidant activity, and sensory basis, a 30-second microwave treatment at 900 W and RTS beverage with 500 ppm ascorbic acid were best. The optimized RTS beverage's shelf life was tested at room temperature and refrigerated. During ambient and refrigerated storage, pH, TSS, betacyanin content, and sensory qualities varied significantly. On the 6th day of ambient storage, lime-flavored dragon fruit RTS beverage with 500 ppm ascorbic acid retained 10.04 mg/L betacyanin and 5.57 overall acceptability. For refrigerator storage, lime-flavored dragon fruit RTS beverage with 500 ppm ascorbic acid retained 24.26 mg/L betacyanin and 5.68 overall acceptability on the 60th day. Additionally, lime-flavored dragon fruit RTS beverage with 500 ppm ascorbic acid retained betacyanin better than other treatments during ambient and refrigerated storage.

Keywords: Antioxidant activity, Betacyanin, Lime-Flavored Dragon fruit RTS,Microwave,Thermal

Introduction

The member of *Cactaceae* family recognized as "Buah-naga" in Malaysia, and scientifically recognized as "*Hylocereus polyrhizus*"(Jaafar et al. 2009). Among more than sixteen varieties of pitahaya fruit were cultivated, and marketed in exotic fruit market of Europe (Bellecet al.2006). Nutritional rich profile of pitahaya is abundant source of some minerals, phenols, bioactive compounds, essential fatty acids (Ariffin et al.2009; Jaafaret al.2009; Liaotrakoon et al.2013). It is good source of polyphenols, flavanols, flavonoids, tannins, and betacyanin (Pasko et al.2021). It containing flavonoids such as myricetin, rutin, and quercetin, polyphenols such as gallic acid, caffeic acid, and protocatechuic acid, bioactive compounds such as betanin, indicaxanthin, isobetanin, phyllocactin, isophyllocactin, hylocerenin, and isohylocerenin (Wybraniecet al.2007; Pasko et al.2021). The member of *Rutaceae* family,lime fruit scientifically known as "*Citrus aurantifolia*' or "*Citrus latiflia*" was originated in East India or Malaysia (Liuet al.2022). ~~The lime-fruit had variety of names in different countries; Kagzi nimbu in India, Lime in English, Citronnier in France, Lima acida in Italy, Limoo in Egypt, Lamoentsji in Netherlands, Manao in Thailand, Lima agria in Spain, Limah in Arab, Zhi qiao in China, Jeruknipis in Indonesia, Jeruk~~

~~alit in Bali, Chanh ta in Vietnam, and Limone in Germany (Narang & Jiraungkoorskul, 2016;Manner et al.2006).~~ Lime is good source of Vit C, potassium, calcium, iron, copper, manganese, and zinc (Rangelet al.2011). The utilization of local fruit juice (lime) into dragon fruit RTS had more sensorial acceptance with cheaper price of beverage.

Foke et al.2018 prepared dragon fruit RTS having 12% sugar, 0.01% potassium metabisulphite, 12% fruit juice content, and 0.4% citric acid content,. The pH was decreased from 2.5 to 2.08, Vit C also decreased from 8.3 to 3.6 mg/100ml, while TSS was increased from 14.2°Brix to 14.9°Brix upto 50 days of storage. According to Bassama et al.(2021), the betacyanin content of cactus pear juice heated for 36 sec at 90°C was decreases form 0.9 g/kg to 0.2 g/kg for juice stored at 45°C, and 0.8 g/kg for juice stored at 4°C after 40 days. The pitahaya juice storaged without light exposure can retent more betacyanin content (Nguyen et al.2018). Increase in betacyanin content from 0.005 to 0.112 µg/g for xoconostole juice heated for 30 min at 67-70°C. the antioxidant activity, phenols, and bioactive compounds for tomato juice were more preserved in storage after treated with potassium metabisulphite than sodium benzoate, and thermal processing (Kaur and Aggarwal, 2015). The total phenolic content of pineapple juice was reduced during ambient storage after mild heat treatment (65°C for 15 min), and thermal processing for 15 min at 85°C; Also, reduction was observed in pH, while TSS was increased with storage period(Lagnika et al.2017). According to Woo et al. (2011), light exposure was the major reason for reduction in betacyanin content. Heating of pitahaya juice for 1 h at 85°C leads to isoindicaxanthin, indicaxanthin formation in juice, while approximately 91% of pigment retention was observed in thermally treated juice adjusted at 4 pH, and incorporated with 1% ascorbic acid (Herbach et al.2006).

The current study was conducted to standardize the lime juice in dragon fruit RTS beverage, to optimize the thermal, microwave, and chemical treatment, and to analyze the effects of storage conditions on the parameters such as pH, TSS, betacyanin content, microbial quality, and sensory evaluation of thermally, microwave, and chemically treated lime-flavored dragon fruit RTS beverage.

Materials and Methods

Lime-flavored dragon fruit RTS preparation

Freshly ~~precured~~procured dragon fruit from farmer of Kachchh district of Gujarat, India was used to make dragon fruit RTS beverage. The primary trials were carried out to standardize the 12°Brix TSS, 0.1% citric acid, and 12% fruit juice content for preparation of dragon fruit RTS beverage on sensory basis. The 1, 2, 3, and 4% lime juice incorporation into dragon fruit RTS beverage was also standardized on the basis of sensory evaluation. The standardized lime juice incorporated dragon fruit RTS beverage was processed further with thermal, microwave, and chemical treatment, and optimized on the basis of betacyanin content, antioxidant activity, and sensory evaluation. The processing steps for making dragon fruit RTS beverage was presented in Fig. 1.

Thermal, microwave, and chemical processing of lime-flavored dragon fruit RTS beverage

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For the thermal treatment RTS was processed for 5, 10, and 15 min at 70, 80, and 90°C, and best treatment was optimized on the basis of betacyanin content, antioxidant activity, and sensory evaluation. The best micowave treatment at 900 W power density for 30, 60, 90, 120, and 150 sec was optimized. Similarly, best treatment from RTS incoerporated with 500. 1000, and 1500 ppm ascorbic acid was optimized. The one optimized treatment from each processing along with control RTS beverage were stored at ambient, and refrigeration storage conditions for shelf-life study.

pH

A digital pH meter (Made: Systronics) was used to calculate the hydrogen's potential of lime-flavored dragon fruit RTS beverage after being calibrated with pH 4, and 9.2.

TSS (total soluble solids)

A hand refractometer (ATC, Erma Inc., Tokyo, Japan) was used to determine TSS of the lime-flavored dragon fruit RTS beverage after being calibrated with distilled water.

Betacyanin content

The betacyanin content of lime-flavored dragon fruit RTS beverage was measured using the Spectrometric method mentioned by Naderi et al. (2012) with minor modifications.

Total plate count, yeast & mold count, and coliform count

TPC, Y&M, and Coliform count were analyzed using method given by Ranganna, 2004.

Sensory evaluation of lime-flavored dragon fruit RTS beverage

A semi-trained panel member used nine-point hedonic scale for sensory evaluation of lime-flavored dragon fruit RTS beverage. The attributes color, taste, body, flavor, and overall acceptability were utilized to evaluate sensory acceptance of RTS beverage.

Shelf-life study

Thermally, microwave, and chemically treated lime-flavored dragon fruit RTS beverage packed in PET bottles, and stored at ambient, and refrigerated storage condition for further shelf-life study. RTS beverage was analyzed for pH, TSS, betacyanin content, total plate count, yeast & mold count, coliform count, and sensory evaluation at ambient temperature after each 3 days for interval, and at refrigerated temperature after each 15 days of interval.

Statistical analysis

The factorial Completely Randomized Design was used to analyze data of shelf-life study. Triplicate data for all experiments were analyzed at agriculture statistics department, Anand Agricultural University, Anand, Gujarat, India.

Results and Discussion

Lime juice standardization in dragon fruit RTS beverage

Among 1%, 2%, 3%, and 4% addition of lime juice in prepared dragon fruit RTS beverage, 3% lime juice incorporation was selected best on the sensory basis. The significantly higher taste score (7.94), flavor score (7.86), and overall acceptance (7.92) was reported for Dragon fruit RTS incorporated with 3% lime juice.

Optimization of thermal, microwave, and chemical processed lime-flavored dragon fruit RTS beverage

The thermal processing for 5 min at 70°C (T_1t_1) had higher betacyanin content (23.80 mg/L), antioxidant activity (73.43%), and overall acceptance (7.55).

The RTS microwaved at 900 W for 30 sec (MW_1) had higher antioxidant activity (54.31%), while 29.87 mg/L of betacyanin content was observed.

The RTS being incorporated with 500 ppm ascorbic acid (C_1) had maximum antioxidant activity of 68.37%, whereas non-significant change was noticed for betacyanin content (38.00 mg/L).

The lime-flavored dragon fruit RTS beverage being thermally processed for 5 min at 70°C, microwave processed for 30 sec, and incorporated with 500 ppm ascorbic acid were optimized, and packed in PET bottles for further shelf-life study.

Effect of ambient storage condition on pH of developed lime-flavored dragon fruit RTS beverage

Summary of the effect of ambient storage conditions on the pH of developed lime-flavored dragon fruit RTS beverage is presented in Table 1. (Fig. 2.). The pH of newly produced lime-flavored dragon fruit RTS beverages was significantly influenced by each individual treatment, the number of storage days, and the interaction of treatment with storage days. The pH of the RTS beverage significantly decreased while being stored in ambient conditions. Similar findings for dragon fruit RTS beverage was reported by Foke et al. (2018). The pH of the lime-flavored dragon fruit RTS beverage decreased as a result of chemical reactions that occurred during storage, and produced organic acid. Percent decrease in pH was 15.40, 15.48, 15.99, and 16.11%, respectively for control sample, thermal, microwave, and chemical treated sample stored at ambient conditions.

Effect of ambient storage condition on TSS of developed lime-flavored dragon fruit RTS beverage

The effect of ambient storage conditions on the TSS of developed lime-flavored dragon fruit RTS beverage is presented in Table 1. (Fig. 2.). On the TSS of newly developed lime-flavored dragon fruit RTS beverages, the individual effects of treatment, storage days, and interaction of treatment with storage days were significant. Significant increase in TSS of RTS beverage was reported during ambient storage conditions. Similar results were reported by Foke et al. (2018). Chemical reactions during storage causes conversion of complex polysaccharides into simple sugars resulted into increase in TSS of lime-flavored dragon fruit RTS beverage. TSS was significantly enhanced during storage with increasing storage days for developed lime-flavored dragon fruit RTS beverages. On 6^{th} day, percent increase in TSS was 10.75, 15.21, 11.29, and 12.63%, respectively for control sample, thermal, microwave, and chemical treated sample stored at ambient conditions.

Effect of ambient storage condition on betacyanin content of developed lime-flavored dragon fruit RTS beverage

The effect of ambient storage conditions on the betacyanin content of the developed lime-flavored dragon fruit RTS beverage is shown in Table 1. (Fig. 3.). The betacyanin level of

developed lime-flavored dragon fruit RTS beverages was significantly impacted by the individual effects of treatment, storage days, and interaction of treatment with storage days. During ambient storage conditions, a significant decrease in the betacyanin level of RTS beverage was noted. Similar findings were reported by Liaotrakoon *et al*. (2013), Herbach *et al*. (2006), and Bassama *et al*. (2021). The betacyanin content of lime-flavored dragon fruit RTS beverage decreased as a result of the betacyanin being degraded by heat, light, and pH. Percent retention of betacyanin was 11.73%, 17.27%, 12.63%, and 26.42%, respectively for control sample, thermal, microwave, and chemical treated sample stored at ambient conditions.

Effect of ambient storage condition on sensory evaluation of developed lime-flavored dragon fruit RTS beverage

A panel of judges used a nine-point hedonic scale to evaluate developed lime-flavored dragon fruit RTS beverages for color, taste, body, flavor, and overall acceptability. Table 2. summarizes the effect of ambient storage conditions on the color score of a produced lime-flavored dragon fruit RTS beverage. On the color score of newly produced lime-flavored dragon fruit RTS beverages, the individual effects of treatment, storage days, and interaction of treatment with storage days were significant. Due to the loss of coloring pigment from the beverage, a significant fall in the color score of the RTS beverage was noted during ambient storage conditions. For produced lime-flavored dragon fruit RTS beverages, the color score was noticeably diminished as storage days increased.

The effect of ambient storage conditions on taste score of the dragon fruit RTS beverage is discussed in Table 2. The developed lime-flavored dragon fruit RTS beverages had a significant individual effect of treatment, storage days, and interaction of treatment with storage days. RTS beverage taste rating significantly decreased under ambient storage conditions, according to reports. For developed lime-flavored dragon fruit RTS beverages, the taste score was noticeably worse with longer storage times. The control sample's maximum score (7.88) was recorded on day 0, and dropped to 5.08 on day 6 of storage.

The impact of ambient storage conditions on the body score of a developed lime-flavored dragon fruit RTS beverage is tabulated in Table 2. The body score of developed lime-flavored dragon fruit RTS beverages was significantly impacted by the individual effects of treatment, storage days, and interaction of treatment with storage days. RTS beverage's body score was reported to have significantly decreased during ambient storage conditions. For developed lime-flavored dragon fruit RTS beverages, the body score drastically decreased as storage days increased.

The effect of ambient storage conditions on the flavor rating of a developed lime-flavored dragon fruit RTS beverage is presented in Table 3. The flavor score of specially produced lime-flavored dragon fruit RTS beverages was significantly influenced by the individual effects of treatment, storage days, and combination of treatment with storage days. With longer storage times, a significant decline in flavor score of RTS beverage was noted.

The effect of ambient storage conditions on the developed lime-flavored dragon fruit RTS beverage's overall acceptability score is summarized in Table 3.(Fig. 3.). The developed lime-flavored dragon fruit RTS beverages' overall acceptability score was significantly influenced by

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the individual effects of treatment, storage days, and treatment's interaction with storage days. With longer periods of storage under ambient conditions, a significant decline in overall acceptability score of RTS beverage was noted.

Effect of ambient storage condition on microbial quality of developed lime-flavored dragon fruit RTS beverage

As per the FSSAI regulations, TPC and yeast & mold count for RTS beverage should not more than 50, and 2 cfu/ml, respectively, and coliform should not present in 100ml sample. Control, thermal, microwave, and chemically treated samples evaluated for TPC, coliform and yeast & mold count during storage study. Total plate count, and yeast & mold count were below the permissible limit given by FSSAI, and coliform was absent in control, thermal, microwave, and chemically treated samples.

The optimized lime-flavored dragon fruit RTS beverage incorporated with 500 ppm ascorbic acid had higher betacyanin content (10.04 mg/L), and overall acceptability score (5.57) on 6^{th} day as compared to control, thermal, and microwave treatment stored at ambient storage conditions. So, 500 ppm ascorbic acid incorporated lime-flavored dragon fruit RTS beverage was found best at ambient storage conditions.

Effect of refrigerated storage condition on pH of developed lime-flavored dragon fruit RTS beverage

Summary of the effect of refrigerated storage conditions on the pH of developed lime-flavored dragon fruit RTS beverage is presented in Table 4. (Fig. 4.). On the pH of developed lime-flavored dragon fruit RTS beverages, the individual effects of treatment, storage days, and combination of treatment with storage days were significant. Over a period of 60 days in refrigeration storage conditions, the pH of RTS beverage drastically fell. Similar findings were reported by Foke et al. (2018). The pH of the lime-flavored dragon fruit RTS beverage decreased as a result of chemical reactions that occurred during storage, and produced organic acid.

Effect of refrigerated storage condition on TSS of developed lime-flavored dragon fruit RTS beverage

The effect of refrigerated storage conditions on the TSS of developed lime-flavored dragon fruit RTS beverage is discussed Table 4. (Fig.4.). On the TSS of newly developed lime-flavored dragon fruit RTS beverages, the individual effects of treatment, storage days, and interaction of treatment with storage days were significant. Under refrigerated storage conditions, there was a documented significant increase in TSS of RTS beverage. Similar findings were reported by Sharma (2016); and Foke et al. (2018), respectively. The TSS of a lime-flavored dragon fruit RTS beverage increased as a result of chemical processes that occurred during storage that resulted in the conversion of complex polysaccharides into simple sugars.

Effect of refrigerated storage condition on betacyanin content of developed lime-flavored dragon fruit RTS beverage

The effect of refrigerated storage conditions on the betacyanin concentration of the developed lime-flavored dragon fruit RTS beverage is tabulated in Table 5. (Fig. 5.). The betacyanin level of developed lime-flavored dragon fruit RTS beverages was significantly affected by the

individual effects of treatment, storage days, and interaction of treatment with storage days. During refrigerated storage conditions, a significant drop in the betacyanin level of RTS beverage was noted. Similar findings were reported by Liaotrakoon *et al.* (2013), Herbach *et al.* (2006), and Bassama *et al.* (2021). The degradation of betacyanin of the lime-flavored dragon fruit RTS beverage caused by exposure to temperature, light, and pH.

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On 60th day at refrigerated storage condition, percent reduction in betacyanin content was 46.74%, 47.55%, 48.89%, and 36.15%, respectively for control sample, thermal, microwave, and chemical treated sample stored at refrigerated conditions. Control sample (T_o) had maximum betacyanin content (38.04 mg/L) which was then decreased to 20.26 mg/L. Percent retention of betacyanin on 60th day was 53.26%, 52.45%, 51.11%, and 63.85%, respectively for control sample, thermal, microwave, and chemical treated sample stored at refrigerated conditions. Decrease in betacyanin content was relatively lower for samples stored at refrigerated conditions than ambient conditions. So, betacyanin content in lime flavored dragon fruit RTS beverage was more stable at refrigerated storage condition than ambient storage conditions. The ascorbic acid in RTS beverage improve the significant retention of betacyanin content in lime flavored dragon fruit RTS beverages stored at refrigerated conditions.

Effect of refrigerated storage condition on sensory quality of developed lime-flavored dragon fruit RTS beverage

A panel of judges used a nine-point hedonic scale to evaluate developed lime-flavored dragon fruit RTS beverages for color, taste, body, flavor, and overall acceptability. Table 5. summarizes the effect of refrigerated storage conditions on the color score of a produced lime-flavored dragon fruit RTS beverage. On the color score of developed lime-flavored dragon fruit RTS beverages, the individual effects of storage days, and their interactions with treatment were significant. However, the influence of refrigerated storage conditions on treatment was non-significant. Due to loss of coloring pigment from the beverage, a significant fall in color score of RTS beverage was found during refrigerated storage conditions.

The developed lime-flavored dragon fruit RTS beverage's taste score was affected by the refrigerated storage condition is shown in Table 6. The developed lime-flavored dragon fruit RTS beverages were stored under refrigerated conditions, and each of the independent effects of treatment, storage days, and treatment's interaction with storage days had a significant effect on the taste score. RTS beverage taste rating significantly decreased under refrigerated storage conditions, according to reports.

The effect of refrigerated storage conditions on the body score of a developed lime-flavored dragon fruit RTS beverage is presented in Table 6. Over the course of the refrigerated storage period, the developed lime-flavored dragon fruit RTS beverages' body score was significantly affected by individual treatment, storage day, and the interaction of treatment with storage days. The body score of the RTS beverage significantly decreased under refrigerated storage conditions, according to results.

The effect of refrigerated storage conditions on the flavor rating of a developed lime-flavored dragon fruit RTS beverage is tabulated in Table 7. The flavor score of developed lime-flavored

dragon fruit RTS beverages was significantly influenced by the individual effects of treatment, storage days, and combination of treatment with storage days. With longer periods of refrigerated storage, a significant decline in flavor score of RTS beverage was noted.

The effect of refrigerated storage conditions on the developed lime-flavored dragon fruit RTS beverage's overall acceptability score is presented in Table 7. (Fig. 5.). The developed lime-flavored dragon fruit RTS beverages' overall acceptability score was significantly influenced by the individual effects of treatment, storage days, and treatment's interaction with storage days. With longer periods of refrigerated storage, the RTS beverage's overall acceptability score drastically declined.

Effect of refrigerated storage condition on microbial quality of lime-flavored dragon fruit RTS beverage

As per the FSSAI regulations, TPC and yeast & mold count for RTS beverage should not more than 50, and 2 cfu/ml, respectively, and coliform should not present in 100ml of sample. Control, thermal, microwave, and chemically treated lime-flavored dragon fruit RTS beverages evaluated for TPC, coliform and yeast & mold count during refrigerated storage conditions. Total plate count, and yeast & mold count of lime-flavored dragon fruit RTS beverages were below the permissible limit given by FSSAI, and also, coliform was absent in control, thermal, microwave, and chemically treated lime-flavored dragon fruit RTS beverages. So, microbial study found that the lime-flavored dragon fruit RTS beverages were microbiologically safe to consume upto 60^{th} day of refrigerated storage conditions.

The optimized lime-flavored dragon fruit RTS beverage incorporated with 500 ppm ascorbic acid had higher betacyanin content (24.26 mg/L), and overall acceptability score (5.68) on 60^{th} day than control, thermal, and microwave treatment stored at refrigerated storage conditions.

The optimized lime-flavored dragon fruit RTS beverage with 500 ppm ascorbic acid incorporation stored at refrigerated, and ambient conditions has better retention of betacyanin content, and overall acceptability score as compared to other treatment stored at refrigerated, and ambient conditions.

Conclusions

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The significant ($p<0.05$) reduction was observed in pH of lime-flavored dragon fruit RTS beverage stored at ambient well as refrigerated temperature. The pH of control lime-flavored dragon fruit RTS beverage, processed with optimized thermal, microwave, and chemical treatment was decreased by 17.44, 17.78, 18.67, and 18.86% at ambient storage conditions, while it was decreased by 17.54, 13.97, 16.99, and 14.33% at refrigerated storage conditions, respectively. The storage days, treatment, and interaction of storage days with treatment had Significant ($p<0.05$) impact on TSS of the RTS beverage. With increasing storage period, TSS was increased by 12.30, 17.52, 12.97, and 14.30% for control, optimized thermal, microwave, and chemically treated lime-flavored dragon fruit RTS beverage at ambient storage condition, whereas it was increased by 4.96, 5.61, 4.23, and 6.92% at refrigerated storage condition, respectively. The betacyanin content of RTS beverage was decreased faster for samples stored at ambient temperature than stored at refrigerated temperature. The betacyanin content was

significantly reduced by the individual impact of storage days, treatment and interaction of storage days with treatment. The betacyanin content of control lime-flavored dragon fruit RTS beverage, processed with optimized thermal, microwave, and chemical treatment was decreased by88.28, 82.73, 87.37, and 73.58% at ambient storage condition, while it was reduced by 46.74, 47.55, 48.89, and 36.15% at refrigerated storage condition, respectively. The color, taste, body, flavor, and overall acceptability scores for developed lime-flavored dragon fruit RTS beverage decreased significantly with increasing storage period at ambient conditions as well as refrigerated conditions. The optimized lime-flavored dragon fruit RTS beverage incorporated with 500 ppm ascorbic acid had higher betacyanin (10.04 mg/L), and overall acceptability score (5.57) on 6^{th} day as compared to control, thermal, and microwave treated samples stored at ambient storage conditions. Lime flavored dragon fruit RTS beverage with 500 ppm ascorbic acid was found best at ambient conditions up to 3 days. The optimized lime-flavored dragon fruit RTS beverage incorporated with 500 ppm ascorbic acid had higher betacyanin content (24.26 mg/L), and overall acceptability score (5.68) on 60^{th} day than control, thermal, and microwave treated samples stored at refrigerated storage conditions upto 60 days. The 500-ppm ascorbic acid incorporated lime-flavored dragon fruit RTS beverage found best than control, thermal, and microwave processing methods used for the preservation of RTS beverage at refrigerated as well as ambient temperature.

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Comment [N3]: Follow journal rules of referencing

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Table 1. Effect of ambient storage condition on pH, TSS, and betacyanin content (mg/L) of developed lime-flavored dragon fruit RTS beverage

pH					TSS					Betacyanin content (mg/L)				
Treatments	Storage days			Mean T	Treatments	Storage days			Mean T	Treatments	Storage days			Mean T
	0	3	6			0	3	6			0	3	6	
T_o	3.96	3.49	3.35	3.6	T_o	12.09	12.89	13.39	12.79	T_o	38.04	7.81	4.46	16.77
T_1t_1	3.94	3.46	3.33	3.57	T_1t_1	12.12	13.38	13.96	13.16	T_1t_1	23.8	7.29	4.11	11.73
MW_1	3.94	3.44	3.31	3.56	MW_1	12.05	12.9	13.41	12.78	MW_1	26.69	6.53	3.37	12.2
C_1	3.91	3.4	3.28	3.53	C_1	12	13.01	13.51	12.84	C_1	38	19.19	10.04	22.41
Mean S	3.94	3.45	3.32		Mean S	12.06	13.05	13.57		Mean S	31.63	10.2	5.5	
Factor	C.D. (5%)	SEm	CV%		Factor	C.D. (5%)	SEm	CV%		Factor	C.D. (5%)	SEm	CV%	
T	0.008	0.003			T	0.018	0.006			T	0.704	0.24		
S	0.007	0.002	0.181		S	0.016	0.005	0.142		S	0.61	0.208	4.56	
T X S	0.013	0.005			T X S	0.031	0.011			T X S	1.22	0.415		

T: treatment; S: storage days; T_o: control Sample (standardized sample); T_1t_1: optimized thermal treatment (70°C for 5 min); MW_1: optimized microwave treatment (30 sec); C_1: optimized chemical treatment (500 ppm); T X S: interaction of treatment with storage days

Table 2. Effect of ambient storage condition on color, taste, and body score of developed lime-flavored dragon fruit RTS beverage

Color score					Taste score					Body score				
Treatments	Storage days			Mean T	Treatments	Storage days			Mean T	Treatments	Storage days			Mean T
	0	3	6			0	3	6			0	3	6	
T_o	8.18	7.03	5.53	6.91	T_o	7.88	7.05	5.08	6.67	T_o	7.86	7.29	5.55	6.9
T_1t_1	8.01	7.1	5.58	6.9	T_1t_1	7.7	7.17	5.18	6.68	T_1t_1	7.54	7.37	5.65	6.85
MW_1	8.06	7.12	5.64	6.94	MW_1	7.78	7.26	5.28	6.77	MW_1	7.49	7.32	5.59	6.8
C_1	7.93	7.57	5.88	7.13	C_1	7.82	7.39	5.44	6.88	C_1	7.87	7.36	5.65	6.96

Mean S	8.05	7.2	5.65	Mean S	7.79	7.22	5.24	Mean S	7.69	7.34	5.61
Factor	C.D. (5%)	SEm	CV%	Factor	C.D. (5%)	SEm	CV%	Factor	C.D. (5%)	SEm	CV%
T	0.081	0.028		T	0.083	0.028		T	0.059	0.02	
S	0.007	0.024	1.19	S	0.072	0.024	1.25	S	0.051	0.017	0.88
T X S	0.014	0.048		T X S	0.014	0.049		T X S	0.103	0.035	

T: treatment; S: storage days; T_o: control Sample (standardized sample); T_1t_1: optimized thermal treatment (70°C for 5 min); MW_1: optimized microwave treatment (30 sec); C_1: optimized chemical treatment (500 ppm); T X S: interaction of treatment with storage days

Table 3. Effect of ambient storage condition on flavor, and overall acceptability score of developed lime-flavored dragon fruit RTS beverage

Flavor score					Overall acceptability score				
Treatments	Storage days			Mean	Treatments	Storage days			Mean
	0	3	6	T		0	3	6	T
T_o	7.76	7.39	5.13	6.76	T_o	7.83	7.19	5.32	6.78
T_1t_1	7.49	7.24	5.23	6.65	T_1t_1	7.55	7.22	5.41	6.72
MW_1	7.59	7.33	5.26	6.73	MW_1	7.61	7.26	5.44	6.77
C_1	7.64	7.29	5.30	6.74	C_1	7.87	7.40	5.57	6.95
Mean S	7.62	7.31	5.23		Mean S	7.71	7.27	5.43	
Factor	C.D. (5%)	SEm	CV%		Factor	C.D. (5%)	SEm	CV%	
T	0.059	0.020			T	0.074	0.025		
S	0.051	0.017	0.89		S	0.064	0.022	1.12	
T X S	0.101	0.035			T X S	0.129	0.044		

T: treatment; S: storage days; T_o: control Sample (standardized sample); T_1t_1: optimized thermal treatment (70°C for 5 min); MW_1: optimized microwave treatment (30 sec); C_1: optimized chemical treatment (500 ppm); T X S: interaction of treatment with storage days

Table 4. Effect of refrigerated storage condition on pH, and TSS of developed lime-flavored dragon fruit RTS beverage

pH							TSS						
Treatments	Storage days					Mean	Treatments	Storage days					Mean
	0	15	30	45	60	T		0	15	30	45	60	T
T_o	3.96	3.82	3.43	3.34	3.28	3.57	T_o	12.09	12.29	12.61	12.66	12.67	12.46
T_1t_1	3.94	3.85	3.56	3.45	3.41	3.64	T_1t_1	12.12	12.27	12.51	12.75	12.77	12.49
MW_1	3.94	3.78	3.46	3.34	3.31	3.57	MW_1	12.05	12.32	12.41	12.45	12.53	12.35
C_1	3.91	3.83	3.54	3.43	3.37	3.62	C_1	12.00	12.38	12.71	12.76	12.80	12.53
Mean S	3.94	3.82	3.50	3.39	3.34		Mean S	12.06	12.32	12.56	12.66	12.69	
Factor	C.D. (5%)		SEm		CV%		Factor	C.D. (5%)		SEm		CV%	
T	0.014		0.005				T	0.017		0.006			
S	0.016		0.006		0.538		S	0.019		0.007		0.184	
T X S	0.032		0.011				T X S	0.038		0.013			

T: treatment; S: storage days; T_o: control Sample (standardized sample); T_1t_1: optimized thermal treatment (70°C for 5 min); MW_1: optimized microwave treatment (30 sec); C_1: optimized chemical treatment (500 ppm); T X S: interaction of treatment with storage days

Table 5. Effect of refrigerated storage condition on betacyanin content (mg/L), and color score of developed lime-flavored dragon fruit RTS beverage

Betacyanin content (mg/L)	Color score

Treatments	Storage days					Mean
	0	15	30	45	60	T
T_o	38.04	29.20	22.27	22.00	20.26	26.35
T_1t_1	23.80	19.17	16.58	13.93	12.48	17.19
MW_1	26.69	21.74	15.08	15.48	13.64	18.53
C_1	38.00	34.47	25.88	24.49	24.26	29.42
Mean S	31.63	26.14	19.95	18.98	17.66	
Factor	C.D. (5%)		SEm		CV%	
T	0.750		0.261			
S	0.838		0.292		4.43	
T X S	1.677		0.584			

Treatments	Storage days					Mean
	0	15	30	45	60	T
T_o	8.18	7.76	7.72	7.47	7.43	7.71
T_1t_1	8.01	7.77	7.73	7.47	7.44	7.68
MW_1	8.06	7.76	7.72	7.48	7.44	7.69
C_1	7.93	7.76	7.72	7.48	7.44	7.66
Mean S	8.05	7.76	7.72	7.48	7.44	
Factor	C.D. (5%)		SEm		CV%	
T	NS		0.013			
S	0.041		0.014		0.64	
T X S	0.081		0.028			

T: treatment; S: storage days; T_o: control Sample (standardized sample); T_1t_1: optimized thermal treatment (70°C for 5 min); MW_1: optimized microwave treatment (30 sec); C_1: optimized chemical treatment (500 ppm); T X S: interaction of treatment with storage days; NS: non-significant

Table 6. Effect of refrigerated storage condition taste, and body score of developed lime-flavored dragon fruit RTS beverage

Taste score						
Treatments	Storage days					Mean
	0	15	30	45	60	T
T_o	7.88	7.58	7.33	6.36	5.34	6.90
T_1t_1	7.70	7.60	7.40	6.32	5.49	6.90
MW_1	7.78	7.63	7.48	6.25	5.44	6.91
C_1	7.82	7.72	7.58	6.57	5.67	7.07
Mean S	7.79	7.63	7.44	6.38	5.48	
Factor	C.D. (5%)		SEm		CV%	
T	0.057		0.020			
S	0.064		0.022		1.11	
T X S	0.128		0.045			

Body score						
Treatments	Storage days					Mean
	0	15	30	45	60	T
T_o	7.86	7.67	7.65	7.48	7.45	7.62
T_1t_1	7.54	7.68	7.67	7.49	7.47	7.57
MW_1	7.49	7.66	7.64	7.50	7.47	7.55
C_1	7.87	7.68	7.65	7.51	7.48	7.64
Mean S	7.69	7.67	7.65	7.49	7.47	
Factor	C.D. (5%)		SEm		CV%	
T	0.040		0.014			
S	0.045		0.016		0.71	
T X S	0.089		0.031			

T: treatment; S: storage days; T_o: control Sample (standardized sample); T_1t_1: optimized thermal treatment (70°C for 5 min); MW_1: optimized microwave treatment (30 sec); C_1: optimized chemical treatment (500 ppm); T X S: interaction of treatment with storage days

Table 7. Effect of refrigerated storage condition flavor, and overall acceptability score of developed lime-flavored dragon fruit RTS beverage

Flavor score						
Treatments	Storage days					Mean
	0	15	30	45	60	T
T_o	7.76	7.63	7.09	6.35	5.30	6.83

Overall acceptability score						
Treatments	Storage days					Mean
	0	15	30	45	60	T
T_o	7.83	7.76	7.21	6.36	5.32	6.89

T_1t_1	7.49	7.50	7.03	6.31	5.52	6.77	T_1t_1	7.55	7.58	7.22	6.31	5.50	6.83
MW_1	7.59	7.50	7.06	6.23	5.47	6.77	MW_1	7.61	7.57	7.27	6.24	5.46	6.83
C_1	7.64	7.68	7.20	6.56	5.69	6.95	C_1	7.87	7.79	7.39	6.56	5.68	7.06
Mean S	7.62	7.57	7.10	6.36	5.50		Mean S	7.71	7.67	7.27	6.37	5.49	

Factor	C.D. (5%)	SEm	CV%
T	0.062	0.022	
S	0.069	0.024	1.23
T X S	0.139	0.048	

Factor	C.D. (5%)	SEm	CV%
T	0.060	0.021	
S	0.067	0.023	1.18
T X S	0.134	0.047	

T: treatment; S: storage days; T_o: control Sample (standardized sample); T_1t_1: optimized thermal treatment (70°C for 5 min); MW_1: optimized microwave treatment (30 sec); C_1: optimized chemical treatment (500 ppm); T X S: interaction of treatment with storage days

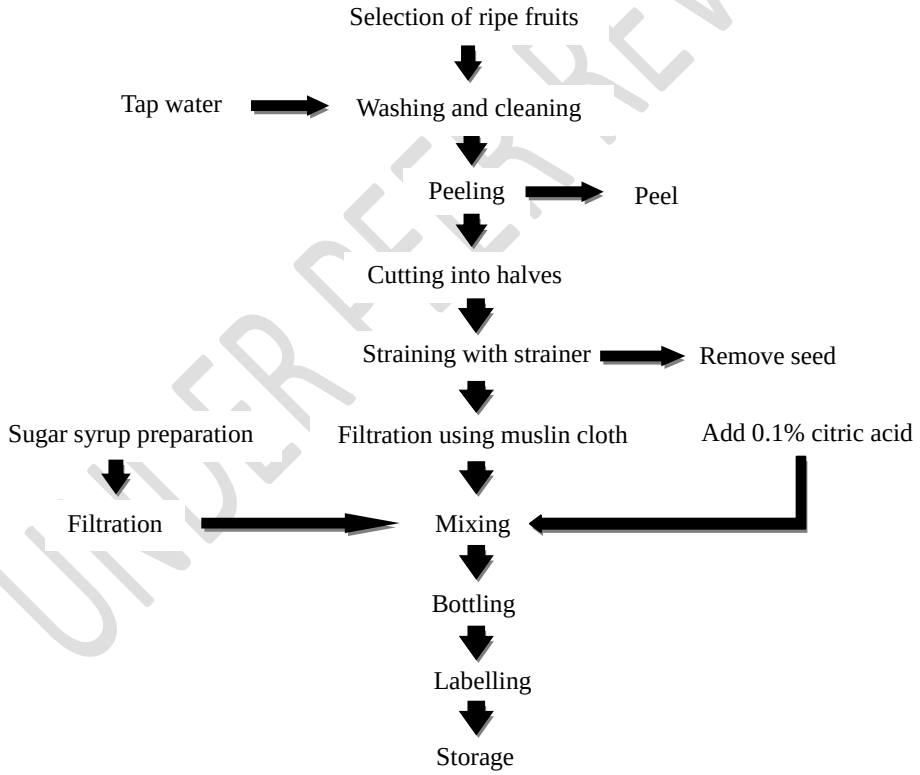

Figure1. Process flowchart for preparation of RTS beverage

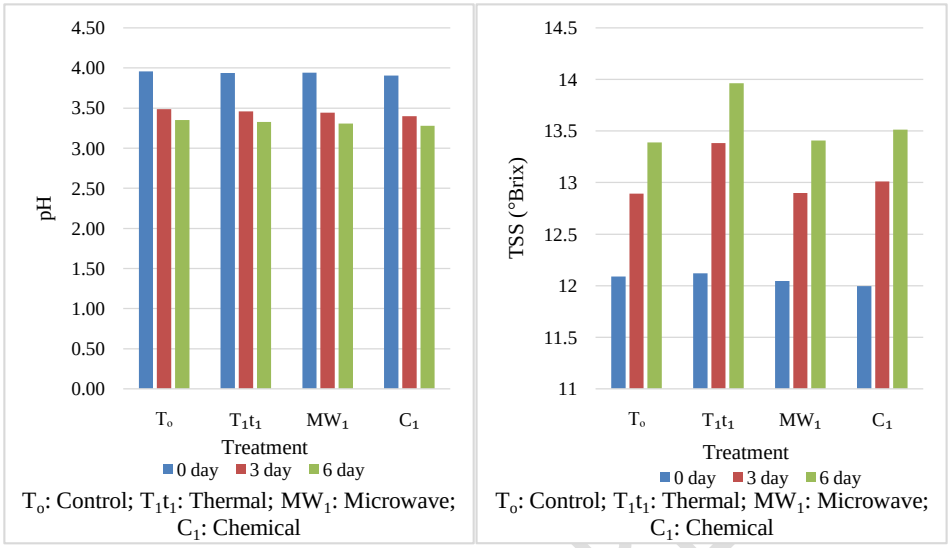

Figure2. Effect of ambient storage condition on pH, and of developed lime-flavored dragon fruit RTS beverage

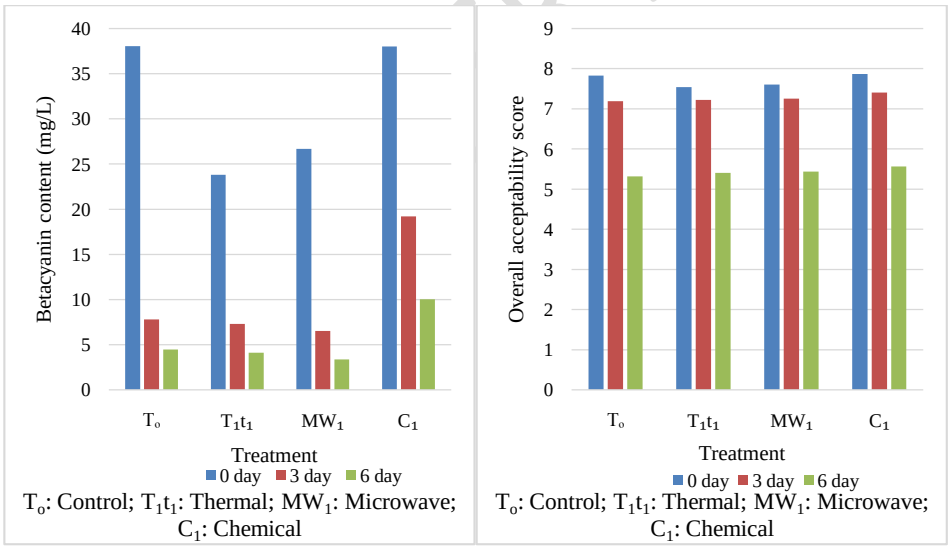

Figure 3. Effect of ambient storage condition on betacyanin content, and overall acceptability of developed lime-flavored dragon fruit RTS beverage

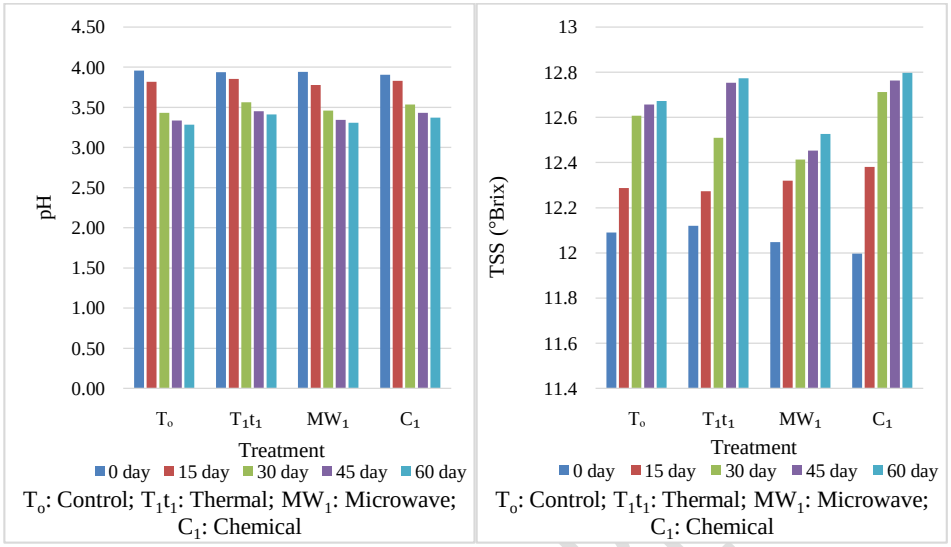

Figure4. Effect of refrigerated storage condition on pH, and TSS of developed lime-flavored dragon fruit RTS beverage

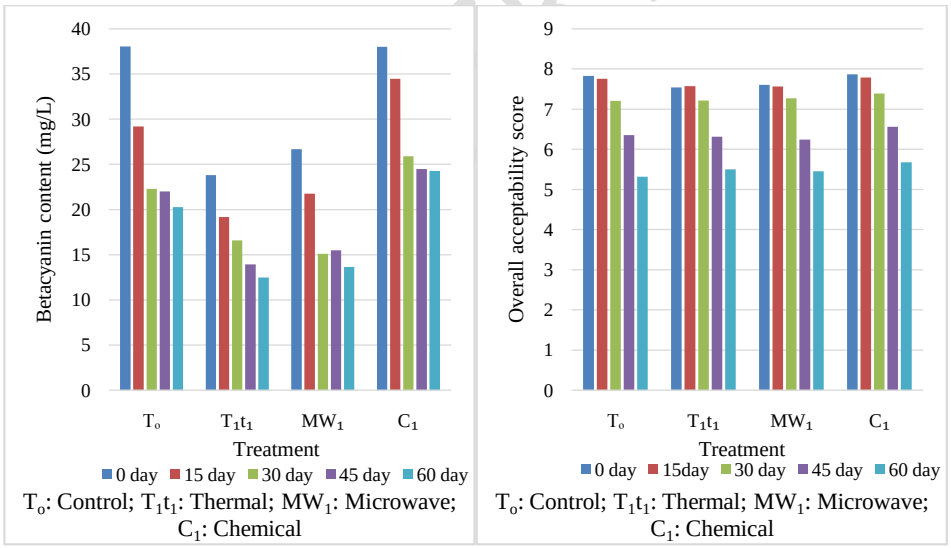

Figure5. Effect of refrigerated storage condition on betacyanin content, and overall acceptability of developed lime-flavored dragon fruit RTS beverage