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Studies on development of carbonated sugarcane juice beverages blended with fruit juices

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Abstract
The carbonated sugarcane juice beverages containing juices of kinnow and aonla each 2-3%; lemon and ginger each 1.5% and sugarcane juice 41-43% were found superior while beverage contained only lemon and ginger juice 1.25% each with sugarcane juice 47.5% was found acceptable. The pasteurization temperature of 82 ^{0}C for 5 min was found optimum for blended juices which was used as base for the carbonated sugarcane juice beverages. The beverages carbonated at 80psi carbonation level containing 60ppm sodium benzoate were found superior. The beverages stored at refrigerated temperature (4 ^{0}C) scored slightly high score for all the sensory and chemical parameters than the stored at room temperature (30±4 ^{0}C). The significant reduction in CO_2 content of beverages was observed during storage for 6 months and beverages were found acceptable. The more CO_2 retention was observed in refrigerated samples than stored at room temperature but statistically no significant difference.

Keywords: Aonla juice, carbonated beverage, Kinnow juice, lemon juice, sugarcane juice

Introduction
Sugarcane (*Saccharum officinarum*) is widely cultivated in tropical and subtropical regions of the world as a major crop. India is the second largest producer of sugarcane having 5.06 million ha area under cultivation and annual crop production of 366.8 million tonnes (Anonymous 2016) [2]. The share of sugarcane is 80 per cent to meet the world demand of sugar and the rest is from sugar beet. Sugarcane juice is a common drink in most of the Asian countries, Latin America and also in other countries where sugarcane is grown commercially. In India, sugarcane juice is extracted by crushing the sugarcane by hand or mechanically operated small machines or sometimes wooden charkas operated by manually or bullock in rural and urban areas. The both urban and rural population is acquainted with thirst quenching and delicious drink made up from sugarcane juice with lemon, mint and ice. The sugarcane juice has many medicinal properties as strengthens the stomach, kidneys, heart, eyes, brain and sex organs. It is very useful in scanty urination. It keeps the urinary flow clear and helps kidneys to perform their functions properly. It is also valuable in burning micturation due to high acidity, gonorrhoea, enlarged prostate and cystitis (Karthikeyan and Samipillai 2010) [12].
Kinnow mandarin has attractive colour, distinctive flavour and being rich source of vitamin C, calcium and phosphorous and used in beverages, industrial and medicinal products (Sogi and Singh 2001) [21]. The fresh fruit of aonla is very rich source of ascorbic acid (454.40 mg/100ml) and appreciable source of total sugar, calcium, iron and phosphorus (7.53, 14.91, 0.62 and 11.81 mg/100ml, respectively) and also has great potential for processing (Dachiya and Dhawan 2001) [6]. Aonla is used in the treatment of haemorrhage, dysentery, diarrhoea, gastric disorders, constipation, headache, jaundice, diabetes, cough and enlargement of liver (Anand 1970, Parrotta 2001, Goyal *et al.* 2007) [1, 18, 9]. Ginger (*Zingiber officinale*) is important to cure gallstones, to decrease joint pain from arthritis. Ginger has blood thinning and cholesterol lowering properties hence useful for treating heart disease (Fahlberg 1969) [8].
The present study was undertaken by considering the importance of these juices and to understand the problem of juice extraction, packaging and preservation for their consistent use in the improvement of human health. Sugarcane, kinnow, aonla and lemon are valued very much for their refreshing juice with nutritional and medicinal properties. Ginger juice also has anti-bacterial and anti-fungal properties with pleasant flavour. Therefore, blending these fruit juices for the preparation of sugarcane juice beverages is thought to be a convenient and economic alternative for utilization of these fruits. The sugarcane juice has a great demand in the market due its nutritional and medicinal value, but the problem of its safety processes and storage life.
The carbonated beverages have a great demand in the market. The FSSAI have made compulsion to add fruit juice at least 5% in existing carbonated drinks.

The development of carbonated beverages containing fruit juices is the need of the day for the healthy nation. The juices of sugarcane, kinnow, aonla, lemon and ginger are valued for their refreshing, nutritional and medicinal properties. In this investigation explored these sources for the development of carbonated sugarcane juice beverages blended with fruit juices without addition of sugar and acids for its commercialization and wide circulation.

Materials and Methods

Extraction of juices of sugarcane, kinnow, aonla, lemon and ginger

Sugarcane The sugarcane var. CoPb-91 from Punjab Agricultural University Research Station Kapurtala, kinnow, aonla, lemon and ginger from local market were procured. Sugarcane was cleaned, cut into 2.5 feet length, washed by clean by mechanical washer, skin and nodes were scrapped with special curved blade stainless steel (SS) knife and again washed in mechanical washer for 2 min and surface dried in perforated SS trays using fans. The juice of sugarcane was extracted with double extraction using mechanical crusher (SS make). The extracted juice was first filtered through the SS screen and then filtered through the four fold clean muslin cloth. Kinnow were washed, peeled manually using hand gloves and SS knife. The juice was extracted through juice extractor and filtered through the double folded muslin cloth. Fresh aonla fruits were sorted graded, washed and heat treated in hot water (95 ^{0}C) till the fruit colour changes to pale yellow. The seeds were removed manually and segments were separated. The juice was extracted from segments using juice extractor with addition of equal quantity of clean water for extraction. Juice and pulp was then filtered through the four fold muslin cloth. The lemon fruits were sorted, graded, washed, drained for water removal and then surface dried. The lemons were halved using stainless steel knives and juice was extracted using manually operated machine and then filtered through the four fold muslin cloth. The fresh ginger was washed, peeled manually, cut into small pieces and grinded in mixer with double quantity of water. The slurry was then filtered through the double folded muslin cloth and kept for 2hr in cylindrical transparent plastic container to settle the sediment at bottom. Clear extract is then filtered through 4 fold muslin cloth.

Experimental design

The 17 combination of treatments for blending fruit juices were used. The combination of treatments were made in such a way that there was no need to add external sugars in the beverages. The optimization of pasteurization temperature and time was undertaken at 78, 80, 82, 84 and 85 ^{0}C for different periods (2, 3, 4, 5 and 6 min). The preservative sodium benzoate at different levels viz. 50, 55, 60 and 65ppm were tested for the sensory quality and storage stability of the bottled products. The ratio of juice volume: carbonated water used for the carbonated sugarcane juice beverages was 1:1 (v/v). The different levels of carbonation viz. 70, 80, 90 and 100 psi were used and carbonated by using manually operated carbonation machine.

Method for preparation of beverages

The sugarcane juice blends were prepared as in Table 1 and heated to the optimum temperature (82 ^{0}C) for 5 minutes and then cooled to room temperature. The required sodium benzoate was added (120ppm) and mixed well. The juice blends were cooled to 15 ^{0}C temperature. Then required quantity of juice blends (100ml) was filled in sterile glass bottles of 200ml capacity. The carbonation was carried out at different carbonation levels by using manually operated carbonation machine and simultaneously bottles were sealed and coded. The bottles of the products were stored at room and refrigerated temperature for storage study.

Standardization of recipe for carbonated sugarcane juice beverages

The different blends for the carbonated sugarcane juice beverages were made using 17 treatments (TC00 to TC27) as shown in the Table 1 for the standardization of recipe. The sugarcane juice was considered as a natural source for sweetening of the beverages and lemon juice for citric acid. The required quantity of sugar level was maintained for the better acceptability of the beverages.

Sensory quality evaluation

The samples prepared during product formulation and standardized samples of sugarcane juice beverages were evaluated fresh as well as during storage study for sensory quality by a panel of semi trained judges (15 No.) for appearance, mouth feel, aroma, taste, consistency and overall acceptability using 9-Point Hedonic Scale as described by Larmond (1970) [14].

Physicochemical and phytochemical analysis

The beverages were analyzed for the physicochemical characteristics viz. moisture content, total solids, ash, content, titratable acidity and ascorbic acid (Ranganna 2015) [19]; pH using digital pH meter (Elico India) which was calibrated according to method of AOAC (2005) [4]; antioxidant activity by DPPH (Brand-William *et al.* 1995) [5]; total phenols by Folin–Ciocalteau method (Singleton and Rossi 1965) [20]; total flavonoids (Marinova *et al.* 2005) [15], total sugars (Dubois *et al.* 1956) [7]; reducing sugars (Nelson 1944 and Somogyi 1952) [17, 22]; viscosity using RV model viscometer, mineral content by Inductively Coupled Plasma- Atomic Emission Spectrophotometer (ICP-AES).

Carbon dioxide gas volume in bottled beverage

To measure the CO_2 gas pressure and gas volume in the carbonated drink, CO_2 gas pressure tester was used by using the method described by Ranganna (2015) [19] and the volume of CO_2 gas dissolved was then calculated by referring to gas volume test chart (Jacobs 1951).

Carbon dioxide

The CO_2 (w/v) in the carbonated sugarcane juice beverages was determined according to the AOAC (2005) [4] with slight modifications.

Storage studies

The best samples of carbonated sugarcane juice beverages packed in 200 ml glass bottles were stored at room temperature (30 ± 4 ^{0}C) and refrigeration (4 ^{0}C) temperature for six months. The effect of storage on TSS, titratable acidity, pH, ascorbic acid, antioxidant activity, total phenols, total flavonoids, total sugars, reducing sugars and viscosity was studied at fixed interval of one month.

Statistical analysis

The data related to sensory and physicochemical attributes of fresh and stored samples of sugarcane juice beverages were statistically analyzed to find out the effect of storage period

and temperature on the sensory and physicochemical characteristics of the products with the help of Analysis of Variance (ANOVA) as described by Gomez and Gomez (2010).

Results and Discussion

Standardization of recipe for carbonated sugarcane juice beverages

The different blends of juices for combination treatments (TC00 to TC27) were formulated according to the combinations shown in the Table 1. It was observed from the data depicted in Table 5 that the treatments TC27 (94% sugarcane juice, 3% lemon juice and 3% ginger juice), TC21(84% sugarcane juice, 5% kinnow juice, 5% aonla juice, 3% lemon juice and 3% ginger juice), TC23(86% sugarcane juice, 4% kinnow juice, 4% aonla juice, 3% lemon juice and 3% ginger juice) and TC24 (82% sugarcane juice, 6% kinnow juice, 6% aonla juice, 3% lemon juice and 3% ginger juice) for juice base and carbonation level at 80 psi scored high for overall acceptability on sensory evaluation as compaired to the other levels of carbonation (70, 90 and 100 psi). The treatment TC24 scored high values for the overall acceptability followed by TC21, TC23 and TC27. The score observed for overall acceptability of the treatments TC27 (control), TC21, TC23, TC24 were 7.66, 8, 8, 8.33, respectively. The overall acceptability score for other treatments was observed less and statistically significance difference was observed among all treatments. The sample prepared of treatment TC27 was considered as control for further study of the best treatments viz. TC21, TC23 and TC24. Kadam *et al.* (2014) [10] reported that RTS beverage prepared by using the 20% sweet orange juice along with 0.3% acidity, 11.7 ^{0}Brix TSS and carbonated at 100 psi pressure was found significantly superior while Wagh *et al.* (2014) [23] reported that the RTS beverage prepared from Bhagwa cultivar of pomegranate by using 60^0 Brix sugar juice of 0.5% acidity and 80 psi CO_2 pressure was found superior in organoleptic characteristics. Mehtre *et al.* (2012) [16] reported best results at 15% pomegranate juice, 12% sugar, 0.3 per cent acidity and 80 psi carbonation level..

Table 1: Combination of treatments used for recipe standardization of carbonated sugarcane juice beverages

Treatment	Juices/extract (per cent)				
	Sugarcane	Kinnow	Aonla	Lemon	Ginger
TC00	95	-	-	2.5	2.5
TC11	90	-	-	5.0	5.0
TC12	90	2.5	2.5	2.5	2.5
TC13	85	2.5	2.5	5.0	5.0
TC14	85	3.5	3.5	4.0	4.0
TC15	85	4.0	4.0	3.5	3.5
TC16	80	5.0	5.0	5.0	5.0
TC17	80	7.0	5.0	4.0	4.0
TC18	80	5.0	5.0	4.0	6.0
TC19	80	5.0	10.0	2.5	2.5
TC20	80	10	5.0	3.0	2.0
TC21	84	5.0	5.0	3.0	3.0
TC22	88	3.0	3.0	3.0	3.0
TC23	86	4.0	4.0	3.0	3.0
TC24	82	6.0	6.0	3.0	3.0
TC25	88	4.0	4.0	2.0	2.0
TC26	92	2.0	2.0	2.0	2.0

Optimization of pasteurization temperature, time, preservative level and carbonation level for the juice base of beverages

The pasteurization at 82 ^{0}C temperature for 5 min with 120 ppm of sodium benzoate as a preservative was found optimum for juice base used for the carbonated beverages. The products were found stable for 6 months but there was difference in sensory scores. The carbonated beverages prepared at 80psi carbonation level were found superior over the other levels of carbonation as shown in Fig.1.

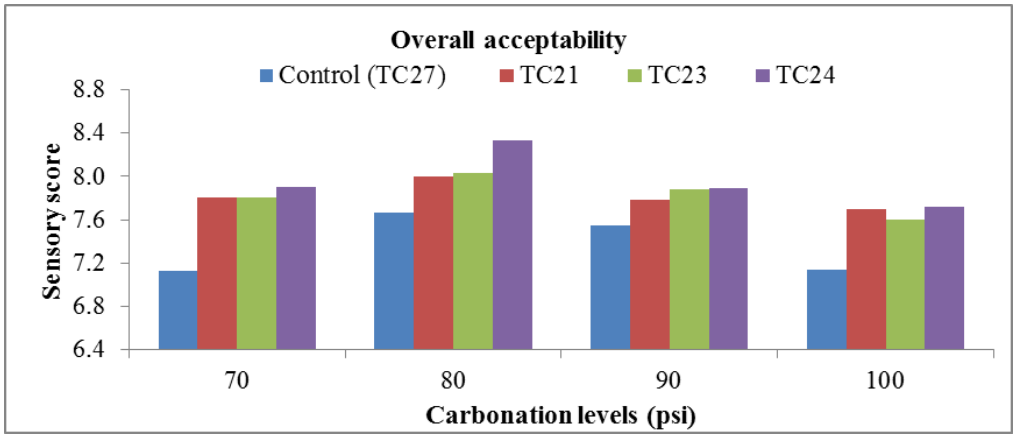

Fig. 1: Effect of carbonation levels on sensory qualities of carbonated sugarcane juice beverages

Sensory evaluation of carbonated sugarcane juice beverages

It was observed that the among the carbonated beverages prepared at 80psi carbonation level using treatment TC24 was found superior over all the treatments for all the parameters of sensory qualities followed by TC21, TC23 and TC27 depicted in Fig.1. The sensory score for treatment TC24 for appearance, mouth feel, aroma, taste, consistency and overall acceptability was 8.33, 8.33, 8, 816, 7.83 and 8.33, respectively as shown in table 2. There was a significant difference in sensory score among the other treatments. The treatments TC21, TC23 and TC27 were found superior on sensory evaluation of the products for the appearance, mouth feel, aroma, taste, consistency and overall acceptability scored 8, 8.16, 7.83, 8.16, 7.83, 8; 7.83, 7.83, 7.83, 7.83, 7.66, 8; 7.33, 7.67, 7.6, 7.4, 7.16, 7.66, respectively. The sample TC27 was considered as a control sample for the further study of carbonated sugarcane juice beverages blended with the juices of kinnow, aonla, lemon and ginger. The treatments TC21, TC23 and TC24 were continued for the further study along with TC27 as a control.

Table 2: Sensory evaluation of carbonated sugarcane juice beverages at 80 psi carbonation level

Treatment	Appearance	Mouth feel	Aroma	Taste	Consistency	Overall acceptability
TC00	7.66	7.66	7.50	7.56	7.66	7.66
TC11	7.50	7.16	7.66	6.83	7.50	6.83
TC12	7.50	7.50	7.66	6.33	6.66	6.33
TC13	7.16	7.00	7.33	7.50	7.33	7.33
TC14	7.33	6.83	6.83	7.16	7.16	6.83
TC15	7.16	7.16	6.83	7.16	7.16	7.33
TC16	7.50	6.83	7.53	7.16	7.53	7.33
TC17	7.33	7.00	7.43	7.33	7.60	7.33
TC18	7.33	7.16	7.50	7.16	7.53	7.40
TC19	7.33	6.33	7.16	6.66	7.33	6.66
TC20	7.33	7.33	7.43	7.16	7.16	7.33
TC21	8.00	8.16	7.83	8.16	7.83	8.00
TC22	6.50	6.33	6.66	7.00	7.16	7.16
TC23	7.83	7.83	7.83	7.83	7.66	8.00
TC24	8.33	8.33	8.00	8.16	7.83	8.33
TC25	7.66	7.00	7.16	6.66	7.33	6.83
TC26	6.66	6.33	6.50	6.33	6.66	6.33
TC27	7.33	7.67	7.60	7.40	7.16	7.66
CD at 5%	0.56	0.72	0.51	0.50	0.50	0.56

Physicochemical characteristics of carbonated sugarcane juice beverages

The best samples of carbonated sugarcane juice beverages viz. TC27 (control), TC21, TC23 and TC24 were analyzed for physicochemical characteristics as depicted in Table 3. It was observed that total soluble solids were found higher (14.6 ^{0}B) in control sample than TC21, TC23 and TC24. The per cent values for ash content, acidity, total sugars and reducing sugars of carbonated sugarcane juice beverages TC27 (control), TC21, TC23 and TC24 were 0.13, 0.33, 11.73, 0.3; 0.13, 0.34, 11.7, 0.3; 0.11, 0.34, 11.72, 0.28 and 0.13, 0.38, 11.6, 0.31, respectively. Also the values for the ascorbic acid (mg/100ml), antioxidant activity (% inhibitionl), total polyphenols (mg GAE/100ml and total flavonoids (mgQE/100ml) for respective beverages were observed as 2.17, 32.3, 247.2, 3.6; 8.8, 74.1, 291.4, 7.8; 7.4, 73.2, 287.3, 7.1; 9.72, 74, 300.1, 8.72, respectively. The viscosities (cp) of the treatments were ranged between 3.16 to 4.03 showed significant differences. The mineral content values (mg/100ml) for the carbonated sugarcane juice beverage samples viz. TC27, TC21, TC23 and TC24 were found at par and showed good amount of minerals in the beverages as depicted in Table 4. The mineral content values (mg/100ml) were found in the range as calcium (10.35-12.45), iron (1.39-1.43), potassium (36.7 - 42.55), sodium (2.16 - 2.44), phosphorus (14.90 - 16.26), sulphur (20.87-23.3), zinc (0.31-0.37), magnesium (4.37- 5.62), copper (0.13 - 0.18) and nickel (0.01). Mehtre *et al.* (2012) [16] reported that that carbonation at various pressures had no influence on physicochemical properties of beverage.

Table 3: Physicochemical and phytochemical constituents of carbonated sugarcane juice beverages (80psi carbonation)

Parameters	Carbonated beverages				CD at 5%
	Control (TC27)	TC21	TC23	TC24	
Moisture content (%)	85.39	86.76	86.72	86.79	0.01
Total solids (%)	14.60	13.23	13.28	13.21	0.06
TSS(^{0}Brix)	12.74	12.73	12.76	12.66	NS
Ash (%)	0.13	0.13	0.11	0.13	0.01
Titratable acidity(%)	0.33	0.34	.0.34	0.38	0.01
pH	3.56	3.53	3.54	3.62	0.03
Ascorbic acid (mg/100ml)	2.17	8.80	7.40	9.72	0.13
Antioxidant activity (% inhibition)	32.30	74.10	73.20	74.00	0.41
Total polyphenols (mg GAE/100ml)	247.20	291.40	287.30	300.10	0.11
Total flavonoids (mg QE/100ml)	3.60	7.80	7.10	8.72	0.06
Total sugars (%)	11.73	11.70	11.72	11.60	0.05
Reducing sugars (%))	0.30	0.30	0.28	0.31	0.01
Viscosity (cp)	4.03	3.85	4.01	3.16	0.43

Table 4: Mineral content of the of carbonated sugarcane juice beverages (mg/100ml)

Mineral	Carbonated beverages				CD at 5%
	Control (TC27)	TC21	TC23	TC24	
Calcium	12.45	10.35	12.43	11.96	0.01
Iron	1.43	1.42	1.39	1.39	0.09
Potassium	36.70	42.55	39.37	39.10	0.10
Sodium	2.38	2.28	2.16	2.44	0.04
Magnesium	5.62	5.02	4.92	4.57	0.01
Copper	0.13	0.13	0.14	0.18	0.01
Phosphorous	15.50	15.32	16.26	14.90	0.02
Manganese	0.35	0.35	0.34	0.35	0.01

Zinc	0.34	0.33	0.31	0.37	0.01
Sulphur	23.30	21.37	21.33	20.87	0.07
Nickel	0.01	0.01	0.01	0.01	NS

Effect of storage period and storage temperature on sensory qualities of carbonated sugarcane juice beverages

The effect of storage period on sensory qualities of carbonated sugarcane juice beverages (TC27 (control), TC21, TC23 and TC24) were studied for the 6 months at room (30 ± 4 ^{0}C) and refrigeration (4 ^{0}C) temperature and the periodic observations were noted after each month. The results depicted in Fig.2 showed that all the samples of carbonated sugarcane juice beverages were found acceptable with slight decreased sensory score by semi trained panel during the storage of 6 months for all parameters viz. appearance, mouth feel, aroma, taste, consistency and overall acceptability though the beverages were found stable during the storage period. The effect of storage temperature both at room (30 ± 4 ^{0}C) and refrigeration (4 ^{0}C) on sensory qualities of carbonated sugarcane juice beverages depicted in Fig.3 showed that the beverages stored at refrigerated temperature scored slightly high for all the sensory parameters than the stored at room temperature and differences were found statistically non significant. The carbonated sugarcane juice beverages were found slightly superior in quality at refrigerated storage for 6 months over the storage at room temperature but both beverages were scored well on sensory evaluation.

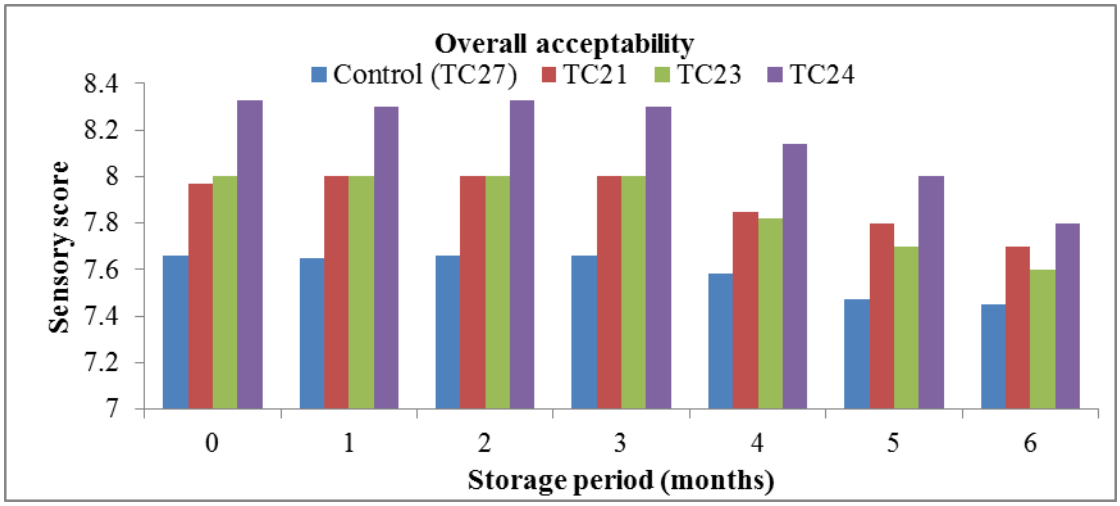

Fig 2: Effect of storage period on sensory qualities of carbonated sugarcane juice beverages

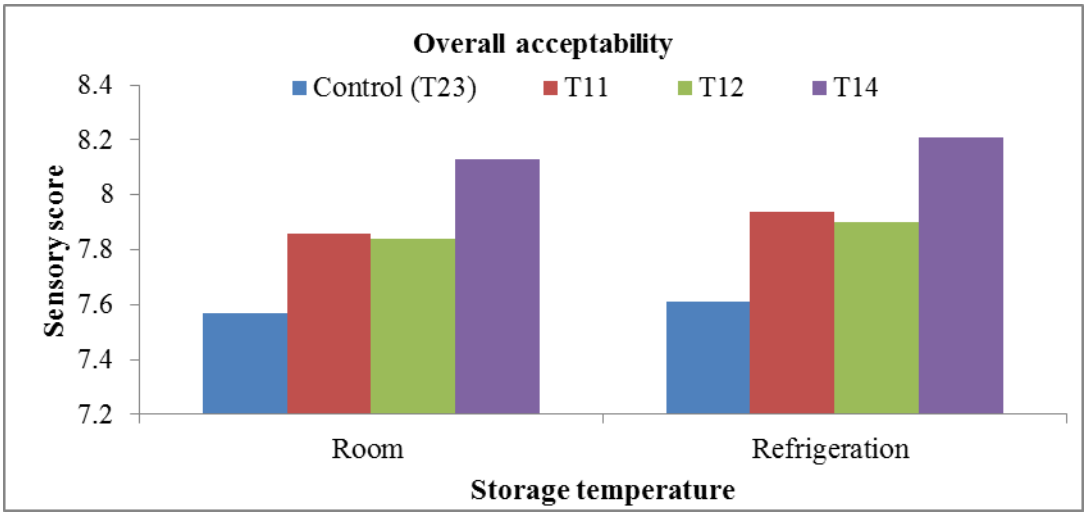

Fig 3: Effect of storage temperature on sensory qualities of carbonated (80 psi) sugarcane juice beverages (6 months storage)

Effect of storage period on physicochemical and phytochemical constituents of carbonated sugarcane juice beverages

The effect of storage period on physicochemical characteristics of carbonated sugarcane juice beverages ((TC27, TC21, TC23 and TC24)) during 6 months storage at room (30±4 ^{0}C) and refrigeration (4 ^{0}C) temperature is noted in Table 5. The observations showed that there was slight decrease in values of total soluble solids (1.27%), pH (2.73%), ascorbic acid (5.11%), total sugars (2.11%) and viscosity (1.85%) for all the beverages after 3 months during storage of 6 months. The values for the phytochemical viz. total polyphenol and total flavonoids were decreased by 20 per cent while the antioxidant activity was decreased by 25 per cent during the storage of six months. The same trend has been reported by Karpagavalli and Amutha (2015) [11]. The values for titratable acidity and reducing sugars were increased 18% and 14.9%, respectively during the storage of 6 months; however the beverages showed stability till 3 months while further storage slightly decreased the values. The products were found acceptable after six months storage.

Table 5: Effect of storage period on physicochemical and phyto chemical constituents of carbonated (80 psi) sugarcane juice beverages

Treatment	Storage period (months)						
	0	1	2	3	4	5	6
	Total soluble solids (^{0}B)						
Control (TC27)	12.74	12.74	12.74	12.73	12.71	12.65	12.56
TC21	12.73	12.73	12.73	12.73	12.65	12.63	12.56
TC23	12.76	12.76	12.76	12.15	12.72	12.65	12.57
TC24	12.66	12.66	12.66	12.61	12.55	12.55	12.55
CD at 5%	NS						
	Titratable acidity (%)						
Control (TC27)	0.33	0.33	0.33	0.33	0.36	0.39	0.44
TC21	0.34	0.34	0.34	0.34	0.39	0.41	0.43
TC23	0.34	0.34	0.34	0.34	0.39	0.41	0.43
TC24	0.38	0.38	0.38	0.38	0.41	0.42	0.45
CD at 5%	0.01						
	pH						
Control (TC27)	3.56	3.56	3.55	3.55	3.53	3.51	3.47
TC21	3.53	3.53	3.53	3.53	3.51	3.50	3.42
TC23	3.54	3.54	3.54	3.53	3.50	3.47	3.43
TC24	3.62	3.62	3.62	3.62	3.60	3.59	3.54
CD at 5%	NS						
	Ascorbic acid (mg/100ml)						
Control (TC27)	2.17	2.17	2.17	2.16	2.16	2.15	2.14
TC21	8.80	8.80	8.80	8.80	8.75	8.70	8.67
TC23	7.40	7.40	7.40	7.40	7.37	7.36	7.34
TC24	9.80	9.80	9.80	9.79	9.75	9.73	9.71
CD at 5%	0.01						
	Total polypolyphenols (mgGAE/100ml)						
Control (TC27)	247.20	240.00	233.30	225.50	218.40	209.60	200.50
TC21	291.40	285.50	280.45	269.84	260.42	249.30	240.65
TC23	287.30	280.33	277.65	265.44	258.32	247.45	238.74
TC24	300.20	293.45	286.35	278.50	267.55	254.36	242.68
CD at 5%	0.11						
	Total flavonoids (mg QE/100ml)						
Control (TC27)	3.60	3.41	3.20	3.00	2.94	2.92	2.90
TC21	7.80	7.61	7.43	7.22	6.89	6.62	6.32
TC23	7.10	7.00	6.91	6.81	6.72	6.65	6.60
TC24	8.72	8.65	8.52	8.45	8.36	8.25	7.12
CD at 5%	0.06						
	Antioxidant activity (% inhibition of DPPH)						
Control (TC27)	32.30	31.20	29.10	28.30	26.2	25.42	24.30
TC21	74.10	72.5	70.25	67.65	64.35	60.32	56.80
TC23	73.20	70.32	67.35	64.55	61.25	57.77	54.30
TC24	74.00	71.65	69.24	66.20	62.63	58.36	55.79
CD at 5%	0.41						
	Total sugars (%)						
Control (TC27)	11.73	11.73	11.73	11.70	11.67	11.63	11.53
TC21	11.70	11.70	11.70	11.67	11.57	11.53	11.46
TC23	11.72	11.72	11.72	11.70	11.65	11.56	11.49
TC24	11.60	11.60	11.60	11.60	11.50	11.46	11.35
CD at 5%	NS						
	Reducing sugars (%)						
Control (TC27)	0.39	0.39	0.39	0.39	0.42	0.45	0.49
TC21	0.30	0.30	0.30	0.30	0.31	0.32	0.33
TC23	0.28	0.28	0.28	0.28	0.29	0.30	0.31
TC24	0.30	0.30	0.30	0.30	0.31	0.32	0.33
CD at 5%	0.01						
	Viscosity (CP)						
Control (TC27)	4.04	4.04	4.04	4.04	4.01	3.96	3.93
TC21	3.85	3.85	3.85	3.84	3.83	3.82	3.82
TC23	4.01	4.01	4.00	3.98	3.96	3.93	3.91
TC24	3.16	3.16	3.16	3.15	3.14	3.13	3.12
CD at 5%	0.01						

Effect of storage temperature on physicochemical and phytochemical constituents of carbonated sugarcane juice beverages

The effect of storage temperature on physico-chemical characteristics of carbonated sugarcane juice beverages (TC27, TC21, TC23 and TC24) during 6 months storage at room (30±4 ^{0}C) and refrigeration (4 ^{0}C) temperature is noted in Table 6. It was observed that, the all treatments (TC27, TC21, TC23 and TC24) beverages stored at refrigerated temperature depicted slightly high values for all physico-chemical parameters than the samples stored at room temperature. The values for the phytochemical viz. total polyphenol showed 20% loss of polyphenols at room temperature while 18 per cent loss was observed at refrigeration storage for six months. The total flavonoids were decreased by 20 per cent both at room and refrigerated storage while, while the antioxidant activity was decreased by 25 per cen at room temperature and 20 per cent at refrigerated storage of six months. The same trend has been reported by Karpagavalli and Amutha (2015) [11]. The carbonated sugarcane juice beverages were found slightly superior in quality those stored at refrigerated storage for 6 months over the storage at room temperature but both beverages showed non significant changes in the values of all parameters.

Table 6: Effect of storage temperature on physicochemical and phytochemical constituents of carbonated sugarcane juice beverages (6 months storage)

Storage temperature	Carbonated beverage			
	Control (TC27)	TC21	TC23	TC24
	Total soluble solids (^{0}B)			
Room	12.68	12.65	12.68	12.60
Refrigeration	12.71	12.70	12.71	12.63
CD at 5%	0.005			
	Titratable acidity (%)			
Room	0.37	0.38	0.37	0.40
Refrigeration	0.35	0.36	0.35	0.39
CD at 5%	0.004			
	pH			
Room	3.53	3.49	3.49	3.59
Refrigeration	3.54	3.51	3.51	3.61
CD at 5%	NS			
	Ascorbic acid (mg/100ml)			
Room	2.14	8.67	7.34	9.71
Refrigeration	2.19	8.74	7.41	9.78
CD at 5%	NS			
	Total polypolyphenols (mgGAE/100ml)			
Room	200.50	240.65	238.74	242.68
Refrigeration	203.10	244.25	241.36	246.24
CD at 5%	NS			
	Total flavonoids (mg QE/100ml)			
Room	2.90	6.32	6.60	7.12
Refrigeration	2.89	6.32	6.59	7.12
CD at 5%	NS			
	Antioxidant activity (% inhibition of DPPH)			
Room	24.30	56.80	54.30	55.79
Refrigeration	25.56	59.02	57.20	58.66
CD at 5%	0.01			
	Total sugars (%)			
Room	11.57	11.57	11.64	11.52
Refrigeration	11.65	11.654	11.67	11.54
CD at 5%	0.01			
	Reducing sugars (%)			
Room	0.43	0.30	0.29	0.32
Refrigeration	0.41	0.30	0.28	0.31
CD at 5%	0.001			
	Viscosity(cp)			
Room	4.00	3.83	3.98	3.14
Refrigeration	4.01	3.85	3.99	3.15
CD at 5%	NS			

Effect of storage period and storage temperature on CO_2 gas volume of sugarcane juice carbonated beverages

The effect of storage period on CO_2 gas volume (CO_2 gas dissolved by one volume of water) shown in Fig. 4 and Fig. 5, it was observed that, no significant change was observed in CO_2 gas volume during storage of 6 months and all the treatments had the same gas volume, while the refrigerated samples (2.09) showed greater values than stored at room temperature (2.01) but statistically no significant difference.

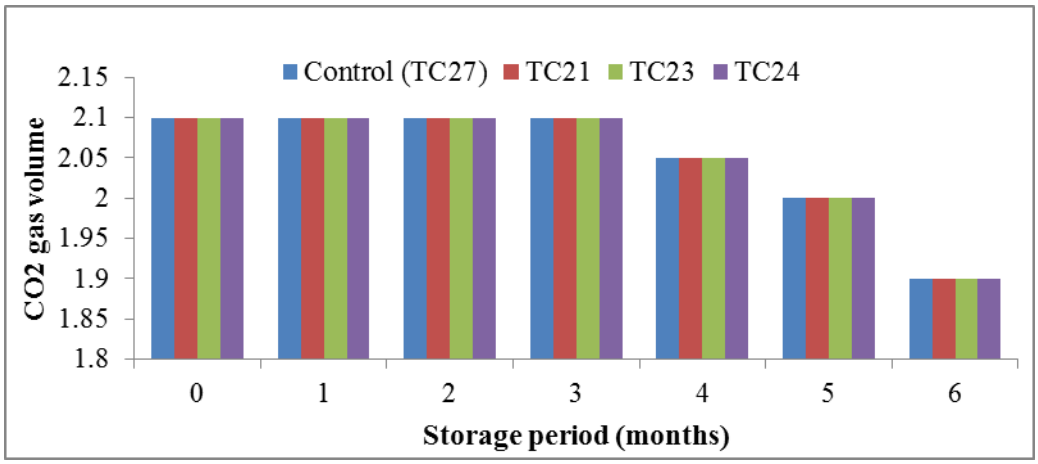

Fig. 4: Effect of storage period on CO_2 Gas: Volume (CO_2 Gas dissolved by I volume of water) of carbonated sugarcane juice beverages

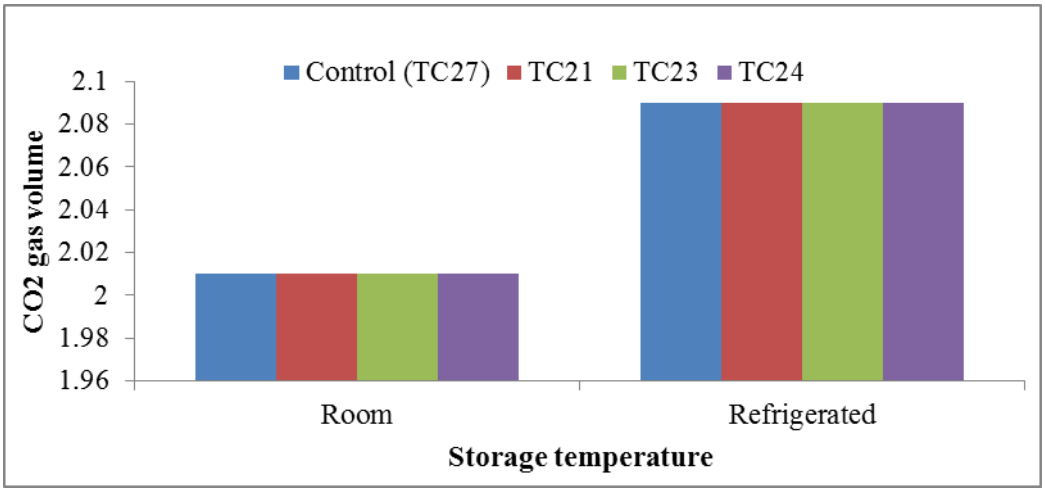

Fig. 5: Effect of storage temperature on CO_2 Gas: Volume (CO_2 Gas dissolved by I volume of water) of carbonated sugarcane juice beverages

Effect of storage period and storage temperature on CO_2 gas absorption of carbonated sugarcane juice beverages

The effect of storage period on CO_2 content in carbonated sugarcane juice beverages is shown in table 7, it was observed that the significant reduction in CO_2 content was observed in all treatments TC27, TC21, TC23, TC24 and reduction found was 4.56%, 4.55%, 4.55%, 4%, respectively during storage of 6 month. The more CO_2 retention was observed in refrigerated samples than room temperature but statistically no significant difference.

Table 7: Effect of storage period and storage temperature on CO_2 absorption (mg/100ml) of carbonated sugarcane juice beverages

Treatment	Carbonated sugarcane juice beverages			
	TC27 (Control)	TC21	TC23	TC24
Storage period (months)				
0	570	571	570	574
1	570	571	570	574
2	568	569	569	572
3	563	563	563	570
4	557	557	558	563
5	550	551	551	556
6	544	545	544	551
CD at 5%	0.32			
Storage temperature				
Room	555	556	555	560
Refrigerated	565	566	566	571
CD at 5%	NS			

Conclusion

The high quality and quantity nutrients in the carbonated sugarcane juice beverages (TC27, TC21, TC23 and TC24) which were made from blending of only juices of kinnow, aonla, lemon and ginger without addition of sugar and acids. Sugarcane juice had sufficient sweetness and lemon juice was used as a source for acids, with use of limited preservative (60ppm of sodium benzoate) within permissible limit along with ginger as a natural preservative, with use of natural source of ascorbic acid (kinnow, lemon, aonla) which made it highly acceptable also other juices enriched the phytochemical compounds. The taste was found highly acceptable during sensory evaluation. The carbonated sugarcane juice beverages containing 50 per cent natural

juices will be the boon for healthy nation and also to the soft drink industry for their sustainability as Laws of Govt. of India have made compulsion for 5 per cent juice addition in soft drinks.

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