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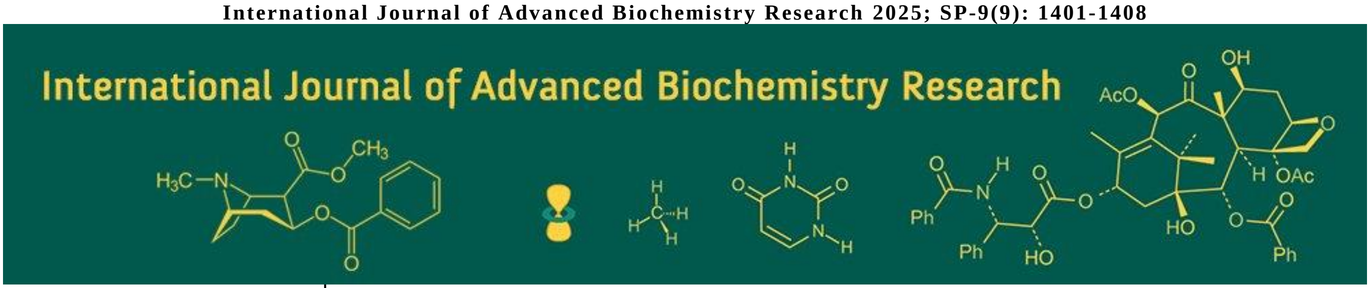

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Studies on changes in chemical composition of carbonated RTS beverage from tender coconut (*Cocos nucifera* L.) water during storage

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Abstract
A study was conducted during 2021-2023 at the Post Harvest Technology Laboratory, College of Horticulture, Dr. B.S. Konkan Krishi Vidyapeeth, Dapoli, to explore value addition in coconut by developing a carbonated ready-to-serve (RTS) beverage using tender coconut water. The experiment followed a factorial completely randomized design (F.C.R.D) with 18 treatment combinations, involving six carbonation pressures as 10, 15, 20, 25, 30 and 35 psi and three juice levels as 30, 40 and 50 percent. Key chemical changes were observed during six months of storage. Total soluble solids (TSS), total sugars, and pH increased during the initial two months and declined thereafter, while titratable acidity exhibited the inverse trend. Reducing sugars showed a steady increase, whereas protein, potassium, and calcium contents gradually decreased over time. The results indicate that storage significantly influenced the chemical quality of the carbonated RTS beverage, with noticeable changes after two months of storage.

Keywords: Carbonated beverage, tender coconut water, storage, chemical composition

Introduction

Coconuts play a vital role in the Indian economy, serving both household consumption and industrial processing. Notably, about 16 percent of coconuts are used for their water, valued as a natural, refreshing drink (Bhatt *et al*., 2020) [4]. Tender coconut water (TCW) is a sterile, natural beverage that is considered one of the richest sources of electrolytes, containing sugars, vitamins, minerals, potassium, magnesium, fiber, proteins, and antioxidants (Silva *et al*., 2009) [21]. Additionally, TCW has a relatively high content of essential minerals such as iron, phosphorus and zinc. Due to its rich nutritional profile, maintaining the quality of TCW after extraction becomes challenging, as its sensitive composition makes it susceptible to spoilage (Pereira, 2013) [14].

The enzymes present in TCW, such as polyphenol oxidase (PPO) and peroxidase (PO), along with microorganisms like yeasts and lactic acid bacteria, contribute to the spoilage and cause pink discoloration in the beverage (Gordan, 2017) [7]. Given that tender coconuts are mainly used as a thirst-quencher and in culinary applications, there is minimal processing of TCW on a commercial scale. Thus, it becomes essential to explore methods for making TCW available throughout the year while maintaining its quality and nutritional value. One promising method for the preservation of TCW is carbonation, which involves adding carbon dioxide (CO_2) to the liquid. This process not only causes the product to release gas in the form of tiny bubbles but also imparts a distinct flavour and enhances the beverage's appeal when served (Anon., 2021) [3]. The primary benefit of carbonation is its ability to inhibit bacterial growth, which can effectively extend the shelf-life of perishable liquids like TCW (James, 1984) [9]. Consequently, carbonation can serve as a practical preservation technique, enabling the development of a carbonated ready-to-serve (RTS) beverage from TCW. Developing a carbonated RTS beverage from tender coconut water, aligns with consumer demand for healthy, natural beverages and functional foods. Hence, by leveraging carbonation technology, TCW can be preserved for longer durations without compromising its nutritional and sensory qualities, thus making it commercially viable throughout the year.

Materials and Methods

The experiment was conducted in the factorial completely randomized design with 18 treatment combinations, involving six carbonation pressures (10-35 psi) and three juice concentrations (30-50%) and three replications at the Post Harvest Technology Laboratory, College of Horticulture, Dr. B. S. Konkan Krishi Vidyapeeth, Dapoli, Dist. Ratnagiri (M.S.) India.

Collection of raw material

The tender nuts (6-7 months) of cultivar banawali were collected from the Coconut Nursery, College of Horticulture, Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli, Dist. Ratnagiri (M.S.), India-415 712.

Preparation of carbonated RTS beverage

For the preparation of carbonated RTS beverages tender coconuts of 6-7 months old were harvested. After harvesting disease-free and uniformly mature nuts were selected. Coconut water was extracted from these nuts and used for experimentation. As per the treatment details, the tender coconut water required for the preparation of the carbonated RTS beverage was calculated and taken into a stainless steel vessel. Then the quantity of sugar and citric acid was calculated to maintain 12.5 °Brix TSS and 0.20 percent acidity in the final product. In this mixture, potassium metabisulphite and ascorbic acid were added @ 24 mg per 200 ml bottle (120 ppm) and 40 mg per 200 ml (200 mg/L). Then the quantity of mixture required as per the juice levels for a 200 ml bottle was weighed and added to the pre-sterilized bottles. For the preparation of carbonated RTS, potable water was passed through a sand filter and chilled at 7 °C in chiller. Then this water was passed through the carbonator at 10, 15, 20, 25, 30, and 35 psi CO_2 pressure as per the treatments and finally mixed with the juice mixture taken into the 200 ml capacity glass bottles and immediately sealed with crown caps. The carbonated RTS bottles were then stored at a cold storage temperature of 12±1 °C.

Observations recorded

Samples of the carbonated RTS beverage were analysed at an interval of 0, 2, 4 and 6 months of storage and analysed for chemical composition using standard methods. The methods used for the estimation of different parameters are described below.

Chemical Analysis

The chemical analysis of the carbonated RTS beverage was carried out for various quality parameters. Total soluble solids (°Brix) were determined using a Hand Refractometer (Erma Japan, 0 to 32 °Brix) as per the method described by Anonymous (1975) [1]. Titratable acidity was estimated by titrating a known quantity of sample against 0.1 N sodium hydroxide using phenolphthalein indicator, and the results were expressed as percent anhydrous citric acid (Anonymous, 1975) [1]. Total sugars were estimated following the Lane and Eynon (1923) method as described by Ranganna (1986) [17]. The pH of the beverage was measured using a digital pH meter (Model Systronics µ pH system 361), calibrated with standard buffer solutions of pH 4.0 and 7.0. Protein content was determined by the Kjeldahl method using Pelican kelplus equipment, with crude protein calculated by multiplying the nitrogen content with a factor of 6.25 (Anonymous, 1990) [2]. Potassium content was analyzed using a flame photometer and expressed as mg/100 ml (Tandon, 1993) [20], while calcium content was determined by the Versanate Titration Method suggested by Cheng and Bray (1951) [5].

Statistical Analysis

The data obtained during storage study were statistically analyzed as per the method suggested by Panse and Sukhatme (1995) [12].

Treatment Combinations

Treatment Combinations		Details of treatment combination
C_1W_1	:	10 psi CO_2 + 30% juice
C_1W_2	:	10 psi CO_2 + 40% juice
C_1W_3	:	10 psi CO_2 + 50% juice
C_2W_1	:	15 psi CO_2 + 30% juice
C_2W_2	:	15 psi CO_2 + 40% juice
C_2W_3	:	15 psi CO_2 + 50% juice
C_3W_1	:	20 psi CO_2 + 30% juice
C_3W_2	:	20 psi CO_2 + 40% juice
C_3W_3	:	20 psi CO_2 + 50% juice
C_4W_1	:	25 psi CO_2 + 30% juice
C_4W_2	:	25 psi CO_2 + 40% juice
C_4W_3	:	25 psi CO_2 + 50% juice
C_5W_1	:	30 psi CO_2 + 30% juice
C_5W_2	:	30 psi CO_2 + 40% juice
C_5W_3	:	30 psi CO_2 + 50% juice
C_6W_1	:	35 psi CO_2 + 30% juice
C_6W_2	:	35 psi CO_2 + 40% juice
C_6W_3	:	35 psi CO_2 + 50% juice

Collection of tender nuts
↓
Washing
↓
Extraction of coconut water
↓
Standardization of TCW to TSS 12.5 °Brix & Acidity 0.20 percent using sugar & citric acid as per treatment combinations (adjusted in all treatment combinations)
↓
Addition of preservative (KMS @ 24 mg per 200 ml and ascorbic acid @ 40 mg per 200 ml final product)
↓
Filling above prepared coconut water in the pre sterilized glass bottles of 200 ml capacity as per treatment details
↓
Filling of carbonated water in the bottles with different CO_2 pressures
↓
Sealing the bottles
↓
Storage of RTS beverage at cold storage (12±1 °C)

Fig 1: Flow chart of carbonated RTS beverage from tender coconut water

Result and Discussion

The chemical composition of carbonated ready-to-serve (RTS) beverage prepared from tender coconut water under different treatment combinations were evaluated, and the results were subjected to statistical analysis and are presented below.

1. Total Soluble Solids

The TSS content of carbonated RTS beverage increased from 0 month (13.14 °B) to 2 months (13.41 °B) and slightly decreased from 2 months (13.41 °B) to 6 months (13.04 °B) during storage, irrespective of carbonation and juice levels. The slight decrease from 2 months to 6 months during storage, may be due to initiation of microfermentation. In case of carbonation levels, TSS showed no specific trend, irrespective of juice levels at 6 months storage. In case of juice levels, TSS content increased with increase in juice levels from W_1 to W_3, irrespective of carbonation levels at 6 months storage. This may be the impact of original TSS content of the juice, which increased with increase in juice levels. Similar conclusions were drawn by Jori *et al*. (2013) [10] for carbonated pineapple juice, where an increase in TSS was observed with higher juice percentages as 12.14 °B at 10 percent, 13.00 °B at 12 percent, and 13.80 °B at 15 percent juice level. The maximum TSS during 6 months of storage was recorded for C_6W_3 (13.35 °B), which was at par with C_1W_3 (13.23 °B), C_3W_2 (13.15 °B), C_3W_3 (13.28 °B) and C_6W_2 (13.18 °B), while lowest for C_2W_1 (12.65 °B), which was at par with C_4W_1 (12.83 °B). Highest TSS recorded for interaction C_6W_3 may be the combined effect of 50 percent juice and 35 psi CO_2 pressure, which might have exhibited higher TSS by restricting the fermentation of beverage.

2. Titratable Acidity (%)

The titratable acidity of the carbonated ready-to-serve (RTS) beverage exhibited a slight decline from 0.24% at 0 months to 0.23% at 2 months, followed by a gradual increase to 0.26% at 6 months of storage, irrespective of carbonation and juice levels. The initial decrease in acidity from 0 to 2 months may be attributed to an increase in pH, while the subsequent rise in acidity from 2 to 6 months could be due to a corresponding decrease in pH, as acidity and pH are inversely related. Furthermore, the increase in acidity from 2 months (0.23%) to 6 months (0.26%), along with a slight reduction in total soluble solids (TSS) from 13.14 °B to 13.04 °B during the same period, may indicate the onset of microfermentation activity during storage. These findings are in line with those reported by Park *et al*. (2020) [13] for carbonated apple juice, wherein the acidity initially decreased from 0.55% to 0.46% over two weeks, increased from the fourth week, remained stable through the sixth week, and showed a decline by the end of the experiment. At 6 months of storage, the titratable acidity showed increasing trend from C_1 (0.24%) to C_4 (0.26%) and remained stable at C_5 and C_6 (0.26%), with respect to carbonation levels. In case of juice levels, the titratable acidity showed increasing trend with increase in juice levels from W_1 to W_3, irrespective of carbonation levels. Increasing trend with increase in juice percentage from W_1 (30% juice) to W_3 (50% juice), might be due to native acid present in original juice, which increased from W_1 to W_3. A similar trend was reported by Rammiya *et al*. (2019) [16] for carbonated guava juice where acidity was increased with increase in juice levels from 10 percent (0.3%) to 30 percent (0.5%). In case of interaction effect, C_4W_3, C_5W_3 and C_6W_3 (0.28%) recorded highest titratable acidity at 6 months storage. Highest titratable acidity recorded for interactions C_4W_3, C_5W_3 and C_6W_3, may be the combined effect of 50 percent juice and 25, 30 and 35 psi CO_2 pressure.

3. Reducing sugars (%)

The reducing sugar content of carbonated RTS beverage showed increasing trend throughout the storage from 0 months (1.69%) to 6 months (3.42%), irrespective of carbonation and juice levels. The increase in reducing sugars during storage may be due to the inversion of non-reducing sugars into reducing sugars, the hydrolysis of complex polysaccharides into simple sugars, and the conversion of acids into sugars. Similar observations were made by Faizi (2022) [6] for carbonated RTS beverage from Nagpur mandrain, where reducing sugars increased during 180 days of storage. Joshi *et al*. (2014) [11] for carbonated jamun juice also reported increase in reducing sugars from 7.70 (0 month) to 8.28 percent (2 months). In case of carbonation levels, no specific trend was observed for the reducing sugar content at 6 months storage. In case of juice levels, reducing sugar content showed increasing trend with increase in juice levels from W_1 to W_3, irrespective of carbonation levels. This may be the impact of increased juice levels, as native reducing sugars increases with increase in juice levels. Analogous results were noted by Salma (2015) [19] for carbonated RTS beverage of Aphonso mango. In case of interaction effect, the interaction C_2W_3

(4.29%) recorded highest reducing sugars during 6 months of storage, which was statistically superior over others.

4. Total sugars (%)

The total sugar content of the carbonated RTS beverage increased from 0 months (9.64%) to 2 months (10.82%) and decreased from 2 months (10.82%) to 6 months (9.61%) during storage, irrespective of carbonation and juice levels. The slight decrease in total sugars from 2 months to 6 months during storage, may be due to initiation of microfermentation, at 4 months of storage, which was further increased at 6 months. Similar findings were noted by Rajashri (2023) [15] for carbonated kokum juice, where total sugars increased from 0 month to 3 months and decreased at 6 months during storage. In case of carbonation levels, no specific trend was observed for the reducing sugar content at 6 months storage, irrespective of juice levels. In case of juice levels, total sugars showed increasing trend with increase in juice levels from W_1 to W_3, irrespective of carbonation levels. In case of interaction effect, the treatment combination C_3W_3 (10.43%) recorded the highest total sugar content during 6 months of storage. The highest total sugar content recorded by above interaction may be the effect of higher juice levels at W_3 (50%) with different carbonation levels.

5. pH

The pH of the carbonated RTS beverage increased from 0 months (3.31) to 2 months (3.49) and decreased from 2 months (3.49) to 6 months (3.24) during storage, irrespective of carbonation and juice levels. Increase in pH from 0 to 2 months and decrease in pH from 2 to 6 months of storage, might be due to the decrease in acidity from 0 to 2 months and increase in acidity from 2 to 6 months, as pH is inversely proportional to acidity. After 2 months due to microfermentation acids might have formed and hence increase in acidity observed. Parallel findings were highlighted by Park *et al*. (2020) [13] where pH of carbonated apple juice increased from 4.15 to 4.20 during the first 2 weeks, then declined at 4 weeks, but increased again between 6 and 8 weeks, reaching 4.21 by the end of the storage period. In case of interaction effect, the pH showed increasing trend from C_1 to C_4 and decreasing from C_4 to C_6, at 6 months of storage. In case of juice levels, pH showed increasing trend with increase in juice levels from W_1 to W_3, irrespective of carbonation levels. In case of interaction effect, the lowest pH was observed for C_1W_1 (3.03) during 6 months of storage, which was superior over others. At 6 months of storage, interaction C_1W_1 (3.03) recorded lowest pH, which might be combined effect of juice concentration (30%) and 10 psi CO_2 pressure.

6. Protein (%)

The protein content of the carbonated RTS beverage declined gradually from 0 months (0.85%) to 6 months (0.80%) of storage, irrespective of carbonation and juice levels. The decrease in protein content could be explained by the action of microorganisms that would use the nutrients for food, thus making the medium poor in nitrogenous substances, in amino acids. Analogous findings were noted by Renuka (2021) [18] for spice-blended tender coconut water (*cv*. Banawali), where the protein content of tender coconut water slowly decreased from 0.50 percent to 0.17 percent during 3 months of storage under cold storage conditions. In case of carbonation levels, no specific trend was observed for the protein content at 6 months storage, irrespective of juice levels. In case of juice levels, protein content showed increasing trend with increase in juice levels from W_1 to W_3, irrespective of carbonation levels. The maximum protein content during 6 months of storage was recorded for interaction C_1W_3, C_2W_3, C_4W_3 (1.43%), which was superior over rest of others.

7. Potassium (mg/100 ml)

The potassium content of the carbonated RTS beverage showed decreasing trend from 0 months (116.97 mg/100 ml) to 6 months (105.77 mg/100 ml) during storage, irrespective of carbonation and juice levels. Even though carbonation helps preserve the beverage, some microbes may still grow during long storage. Comparable results were documented by Hassan and Emifoniye (2018) [8] for soft drinks in Nigeria where potassium content decreased during storage of 3 weeks. In case of carbonation levels, no specific trend was observed for the protein content at 6 months storage, irrespective of juice levels. In case of juice levels, protein content showed increasing trend with increase in juice levels from W_1 to W_3, irrespective of carbonation levels. In case of interaction effect, the highest potassium content during 6 months of storage was recorded for C_3W_3 (134.86 mg/100 ml). In general highest potassium content recorded for higher juice level (W_3) and different carbonation levels may be due to combined effect of high (50%) juice level and different carbonation levels.

8. Calcium (mg/100 ml)

The gradual decline in the calcium content of the carbonated RTS beverage was observed over the storage period, decreasing from 0.86 mg/100 ml at 0 months to 0.60 mg/100 ml at 6 months, irrespective of carbonation pressure and juice levels. Although carbonated beverages have some level of preservation due to carbonation, microbial activity over extended storage periods can alter the composition of the beverage, potentially affecting the stability and availability of calcium. Consistent results were acknowledged by Renuka (2021) [18] for spice-blended tender coconut water (*cv*. Banawali), where the calcium content of tender coconut water slowly decreased from 41.40 mg/100 ml to 27.92 mg/100 ml during 3 months of storage under cold storage conditions. In case of carbonation levels, no specific trend was observed for the calcium content at 6 months storage, irrespective of juice levels. In case of juice levels, calcium content showed increasing trend with increase in juice levels from W_1 to W_3, irrespective of carbonation levels. The significantly highest calcium content during 6 months of storage was recorded for interaction C_1W_3 (0.90 mg/100 ml). The highest calcium content, observed in the interaction C_1W_3 (1.10 mg/100 ml), can likely be attributed to the combined influence of a high juice concentration (50%) and a CO_2 pressure of 10 psi.

Table 1: Changes in TSS, titratable acidity and reducing sugars of carbonated RTS beverage

Treat. Comb.	TSS				Titratable Acidity				Reducing Sugars			
	0 Month	2 Month	4 Month	6 Month	0 Month	2 Month	4 Month	6 Month	0 Month	2 Month	4 Month	6 Month
C_1	12.89	13.50	13.18	13.07	0.23	0.22	0.23	0.24	1.70	2.80	3.06	3.67
C_2	13.09	13.22	12.97	12.87	0.23	0.22	0.23	0.25	1.69	2.54	3.29	3.56
C_3	13.21	13.40	13.26	13.14	0.24	0.23	0.24	0.25	1.74	2.45	3.04	3.30
C_4	13.09	13.33	13.12	12.96	0.24	0.23	0.25	0.26	1.69	2.45	2.70	3.45
C_5	13.36	13.44	13.27	13.01	0.25	0.24	0.26	0.26	1.68	2.34	2.91	3.31
C_6	13.18	13.58	13.33	13.20	0.25	0.24	0.26	0.26	1.66	2.36	2.92	3.23
Average	13.14	13.41	13.19	13.04	0.24	0.23	0.25	0.26	1.69	2.49	2.99	3.42
F-Test	SIG	SIG	SIG	SIG	SIG	SIG	SIG	SIG	SIG	SIG	SIG	SIG
S.E.m±	0.02	0.01	0.01	0.03	0.001	0.002	0.001	0.001	0.004	0.005	0.005	0.006
CD at 1%	0.09	0.04	0.05	0.12	0.004	0.007	0.005	0.005	0.016	0.020	0.018	0.022
W_1	12.99	13.24	12.98	12.90	0.23	0.22	0.23	0.24	1.36	2.04	2.57	3.03
W_2	13.13	13.40	13.18	13.08	0.24	0.23	0.25	0.26	1.66	2.46	2.94	3.33
W_3	13.29	13.59	13.40	13.15	0.25	0.24	0.26	0.27	2.06	2.96	3.45	3.89
Average	13.14	13.41	13.19	13.04	0.24	0.23	0.25	0.26	1.69	2.49	2.99	3.42
F-Test	SIG	SIG	SIG	SIG	SIG	SIG	SIG	SIG	SIG	SIG	SIG	SIG
S.E.m±	0.02	0.01	0.01	0.02	0.001	0.001	0.001	0.001	0.003	0.004	0.003	0.004
CD at 1%	0.07	0.03	0.03	0.08	0.003	0.005	0.003	0.004	0.012	0.014	0.013	0.015
C_1W_1	12.60	13.35	12.95	12.87	0.22	0.20	0.21	0.23	1.32	2.19	2.62	3.42
C_1W_2	12.92	13.50	13.20	13.13	0.23	0.23	0.24	0.25	1.58	2.80	3.12	3.72
C_1W_3	13.15	13.65	13.40	13.23	0.24	0.24	0.25	0.26	2.18	3.41	3.45	3.87
C_2W_1	12.85	13.00	12.75	12.65	0.22	0.21	0.22	0.23	1.36	2.00	2.82	3.17
C_2W_2	13.15	13.20	13.00	12.93	0.23	0.21	0.23	0.25	1.66	2.29	3.22	3.21
C_2W_3	13.27	13.45	13.15	13.03	0.25	0.23	0.26	0.27	2.06	3.31	3.83	4.29
C_3W_1	13.03	13.25	13.04	13.00	0.23	0.22	0.23	0.24	1.48	1.96	2.54	2.74
C_3W_2	13.20	13.35	13.25	13.15	0.24	0.23	0.25	0.26	1.74	2.51	2.94	3.15
C_3W_3	13.40	13.60	13.50	13.28	0.25	0.24	0.26	0.27	2.02	2.88	3.63	4.01
C_4W_1	13.10	13.15	12.95	12.83	0.23	0.22	0.23	0.25	1.39	2.04	2.31	2.94
C_4W_2	13.00	13.30	13.05	12.96	0.25	0.24	0.26	0.27	1.65	2.52	2.73	3.31
C_4W_3	13.18	13.55	13.35	13.10	0.25	0.25	0.27	0.28	2.03	2.78	3.05	4.12
C_5W_1	13.25	13.27	13.10	12.97	0.24	0.23	0.24	0.25	1.34	1.98	2.51	3.00
C_5W_2	13.35	13.45	13.25	13.13	0.25	0.24	0.26	0.26	1.64	2.23	2.91	3.35
C_5W_3	13.48	13.60	13.45	12.93	0.26	0.25	0.27	0.28	2.05	2.81	3.31	3.58
C_6W_1	13.10	13.45	13.10	13.08	0.24	0.24	0.25	0.26	1.26	2.05	2.62	2.92
C_6W_2	13.18	13.60	13.35	13.18	0.25	0.24	0.26	0.27	1.72	2.43	2.73	3.26
C_6W_3	13.25	13.70	13.55	13.35	0.27	0.25	0.28	0.28	2.00	2.60	3.40	3.49
Average	13.14	13.41	13.19	13.04	0.24	0.23	0.25	0.26	1.69	2.49	2.99	3.42
F-Test	SIG	SIG	SIG	SIG	SIG	SIG	SIG	SIG	SIG	SIG	SIG	SIG
S.E.m±	0.04	0.02	0.02	0.05	0.002	0.003	0.002	0.002	0.007	0.009	0.008	0.010
CD at 1%	0.16	0.07	0.08	0.20	0.006	0.011	0.008	0.009	0.028	0.035	0.032	0.037

Table 2: Changes in total sugars and pH of carbonated RTS beverage

Treat. Comb.	Total Sugars				pH			
	0 Month	2 Month	4 Month	6 Month	0 Month	2 Month	4 Month	6 Month
C_1	8.84	11.56	10.13	9.95	3.28	3.47	3.32	3.21
C_2	9.83	10.95	10.19	9.50	3.29	3.50	3.34	3.25
C_3	9.12	10.63	9.80	9.82	3.29	3.51	3.33	3.25
C_4	10.20	10.56	10.16	9.70	3.30	3.49	3.35	3.27
C_5	10.39	10.81	9.16	9.13	3.38	3.51	3.38	3.25
C_6	9.44	10.38	9.80	9.58	3.31	3.49	3.41	3.24
Average	9.64	10.82	9.87	9.61	3.31	3.49	3.36	3.24
F-Test	SIG	SIG	SIG	SIG	SIG	SIG	SIG	SIG
S.E.m±	0.02	0.02	0.03	0.03	0.003	0.003	0.004	0.004
CD at 1%	0.08	0.06	0.10	0.11	0.013	0.013	0.016	0.015
W_1	9.20	10.43	9.48	9.32	3.12	3.30	3.16	3.11
W_2	9.61	10.86	9.84	9.60	3.31	3.50	3.38	3.24
W_3	10.10	11.15	10.30	9.92	3.50	3.67	3.53	3.38
Average	9.64	10.82	9.87	9.61	3.31	3.49	3.36	3.24
F-Test	SIG	SIG	SIG	SIG	SIG	SIG	SIG	SIG
S.E.m±	0.01	0.01	0.02	0.02	0.002	0.002	0.003	0.003
CD at 1%	0.05	0.04	0.07	0.08	0.009	0.009	0.012	0.011
C_1W_1	8.31	11.15	9.75	9.63	3.07	3.24	3.12	3.03
C_1W_2	8.99	11.74	10.08	9.88	3.30	3.49	3.36	3.23
C_1W_3	9.21	11.80	10.57	10.36	3.49	3.67	3.48	3.36
C_2W_1	9.27	10.47	9.85	9.27	3.07	3.32	3.15	3.13
C_2W_2	9.65	10.95	10.17	9.58	3.30	3.50	3.39	3.24
C_2W_3	10.57	11.44	10.57	9.65	3.49	3.67	3.50	3.39
C_3W_1	8.82	10.33	9.24	9.30	3.09	3.33	3.17	3.13
C_3W_2	9.10	10.57	9.47	9.75	3.29	3.51	3.31	3.25
C_3W_3	9.44	11.00	10.68	10.43	3.50	3.68	3.51	3.38
C_4W_1	10.05	10.39	9.67	9.54	3.10	3.33	3.18	3.14
C_4W_2	10.23	10.60	10.26	9.69	3.31	3.48	3.37	3.27
C_4W_3	10.33	10.70	10.56	9.87	3.50	3.66	3.52	3.39
C_5W_1	9.75	10.16	8.83	8.87	3.31	3.31	3.19	3.15
C_5W_2	10.44	10.84	9.23	9.09	3.32	3.53	3.41	3.19
C_5W_3	10.99	11.43	9.41	9.43	3.50	3.68	3.56	3.42
C_6W_1	9.00	10.12	9.56	9.33	3.09	3.28	3.19	3.12
C_6W_2	9.27	10.46	9.83	9.63	3.33	3.50	3.45	3.26
C_6W_3	10.05	10.57	10.03	9.79	3.50	3.69	3.60	3.36
Average	9.64	10.82	9.87	9.61	3.31	3.49	3.36	3.24
F-Test	SIG	SIG	SIG	SIG	SIG	SIG	SIG	SIG
S.E.m±	0.03	0.03	0.05	0.05	0.006	0.006	0.007	0.007
CD at 1%	0.13	0.11	0.18	0.19	0.023	0.022	0.028	0.026

Table 3: Changes in protein, potassium and calcium content of carbonated RTS beverage

Treat. Comb.	Protein				Potassium				Calcium			
	0 Month	2 Month	4 Month	6 Month	0 Month	2 Month	4 Month	6 Month	0 Month	2 Month	4 Month	6 Month
C_1	0.98	0.97	0.95	0.94	114.48	110.39	108.57	103.12	1.05	0.92	0.80	0.72
C_2	0.82	0.81	0.79	0.78	117.53	115.42	108.69	107.74	0.85	0.77	0.67	0.57
C_3	0.66	0.64	0.63	0.61	117.71	112.21	108.77	106.42	0.92	0.83	0.75	0.65
C_4	0.99	0.98	0.96	0.94	118.55	115.33	111.47	107.70	0.77	0.68	0.60	0.53
C_5	0.83	0.81	0.79	0.78	117.78	114.67	109.02	105.35	0.77	0.70	0.60	0.55
C_6	0.83	0.81	0.79	0.77	115.74	110.20	105.07	104.26	0.83	0.78	0.72	0.60
Average	0.85	0.83	0.82	0.80	116.97	113.03	108.60	105.77	0.86	0.78	0.69	0.60
F-Test	SIG	SIG	SIG	SIG	SIG	SIG	SIG	SIG	SIG	SIG	SIG	SIG
S.E.m±	0.01	0.02	0.02	0.01	0.53	0.41	0.35	0.37	0.01	0.01	0.01	0.01
CD at 1%	0.06	0.09	0.07	0.05	2.03	1.57	1.35	1.42	0.02	0.04	0.03	0.04
W_1	0.49	0.48	0.46	0.44	93.74	89.83	85.36	81.11	0.70	0.63	0.55	0.47
W_2	0.74	0.73	0.71	0.70	116.64	112.78	109.85	108.19	0.88	0.78	0.68	0.60
W_3	1.32	1.30	1.28	1.26	140.52	136.50	130.58	128.00	1.01	0.93	0.83	0.74
Average	0.85	0.83	0.82	0.80	116.97	113.03	108.60	105.77	0.86	0.78	0.69	0.60
F-Test	SIG	SIG	SIG	SIG	SIG	SIG	SIG	SIG	SIG	SIG	SIG	SIG
S.E.m±	0.01	0.02	0.01	0.01	0.37	0.29	0.25	0.26	0.005	0.01	0.01	0.01
CD at 1%	0.04	0.06	0.05	0.04	1.43	1.11	0.96	1.00	0.02	0.03	0.02	0.03
C_1W_1	0.50	0.48	0.46	0.45	97.79	92.64	90.17	81.89	0.85	0.75	0.65	0.55
C_1W_2	0.98	0.97	0.95	0.94	114.34	111.21	109.96	106.91	1.05	0.90	0.80	0.70
C_1W_3	1.48	1.47	1.45	1.43	131.30	127.33	125.59	120.56	1.25	1.10	0.95	0.90
C_2W_1	0.49	0.48	0.45	0.45	92.64	90.40	84.02	82.97	0.65	0.60	0.50	0.40
C_2W_2	0.50	0.48	0.46	0.46	114.28	111.84	109.05	107.93	0.85	0.75	0.65	0.55
C_2W_3	1.48	1.46	1.45	1.43	145.66	144.00	133.00	132.32	1.05	0.95	0.85	0.75
C_3W_1	0.49	0.48	0.46	0.45	92.77	86.72	82.79	77.34	0.75	0.65	0.60	0.50
C_3W_2	0.50	0.49	0.47	0.46	118.71	111.21	108.12	107.07	0.95	0.85	0.75	0.65
C_3W_3	0.99	0.96	0.95	0.94	141.67	138.69	135.41	134.86	1.05	1.00	0.90	0.80
C_4W_1	0.50	0.48	0.47	0.45	91.91	88.50	86.78	81.26	0.65	0.60	0.50	0.45
C_4W_2	0.99	0.98	0.97	0.95	118.71	116.90	114.97	111.47	0.80	0.70	0.60	0.55
C_4W_3	1.48	1.47	1.45	1.43	145.03	140.59	132.66	130.37	0.85	0.75	0.70	0.60
C_5W_1	0.50	0.48	0.47	0.45	92.77	89.43	81.54	79.90	0.65	0.60	0.50	0.45
C_5W_2	0.99	0.97	0.96	0.95	114.33	111.89	107.66	104.01	0.80	0.70	0.60	0.55
C_5W_3	1.00	0.98	0.96	0.95	146.25	142.67	137.87	132.15	0.85	0.80	0.70	0.65
C_6W_1	0.50	0.48	0.45	0.44	94.55	91.27	86.89	83.30	0.65	0.60	0.55	0.45
C_6W_2	0.51	0.48	0.46	0.46	119.46	113.62	109.35	111.76	0.85	0.80	0.70	0.60
C_6W_3	1.49	1.47	1.45	1.42	133.22	125.70	118.96	117.72	1.00	0.95	0.90	0.75
Average	0.85	0.83	0.82	0.80	116.97	113.03	108.60	105.77	0.86	0.78	0.69	0.60
F-Test	SIG	SIG	SIG	SIG	SIG	SIG	SIG	SIG	SIG	SIG	SIG	SIG
S.E.m±	0.03	0.04	0.03	0.02	0.91	0.71	0.61	0.64	0.01	0.02	0.01	0.02
CD at 1%	0.10	0.15	0.11	0.09	3.51	2.72	2.34	2.45	0.04	0.06	0.05	0.07

Conclusion

Storage had a significant effect effect on the quality of the carbonated RTS beverage. TSS, total sugars, and pH increased up to 2 months and then declined, while titratable acidity showed reverse trend. Reducing sugars continued to rise upto 6 months. Protein and mineral contents decreased gradually during storage. Juice concentration consistently improved beverage quality, whereas carbonation did not show a definite trend. Overall, higher juice levels (50%) with moderate carbonation helped maintain stability up to 6 months, but the beverage showed better stability up to 2 months storage.

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