Madras Agric. J., 100 (1-3): 251-256, March 2013
https://doi.org/10.29321/MAJ.10.001284

Effect of Storage Conditions on Physico- Chemical, Microbial and Sensory Quality of Ready-to-Serve Banana Beverage

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Studies were conducted to prepare Ready To Serve beverage from banana pulp with the sugar level i.e. 1.25, 1.00 and 0.75 kg /kg of pulp. The desired amount of sugar was added and blended with pulp/juice in the ratio of 1:0.75(T1), 1:1(T2) and 1:1.25(T3). The RTS bottles were stored under refrigeration condition (5$_o$C), BOD incubator (25$_o$C) and room temperature (30-35$_o$C), up to 90 days to determine the effect of sugar ratio on quality of banana (RTS) beverage. The qualities were evaluated for fresh as well as stored samples after 15, 30, 45, 60, 75 and 90 days of storage. The TSS, acidity and optical density of banana RTS beverage increased with increase in the storage periods on particular temperatures. It was observed that the microbial growth increased with increase in the temperatures and storage period irrespective of storage conditions.

Key words: Banana RTS, Total Plate Count, Sensory evaluation and Sugar ratio

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Banana *(Musa paradisiaca* L.) belongs to the family *Musacea.* The average world production of banana during the year 2010 was about 102.0 million metric tones (FAO STAT Agriculture Data 2010). India ranks first in production (29.8 million metric tones) followed by Brazil, China, Equador and Philippines (FAO STAT Agriculture Data 2010). In India, Tamilnadu is the largest banana producing state followed by Maharashtra, Gujarat, Karnataka, Andhra Pradesh, Bihar, Madhya Pradesh, Assam, West Bengal, Kerala and others (Quarterly Agricultural Outlook Report April-June 2012). In India the rate of consumption of banana has been reported as 12.7 kg/capita/annum (FAO 2000). Banana has 8.7 mg of the vitamin-C, 358 mg of potassium and 2.6 mg of dietary fibre per 100 gm for good health. It also helps in protein metabolism, red blood cell formation and function of the central nervous system. The vitamin-C in banana also helps to heal and defend against infection. Bananas contain more digestible carbohydrates than any other fruit. The advantage is that the body burns off calories from carbohydrates more quickly and easily than calories from protein or fat. Eating two bananas provides enough energy to see one through a strenuous 90 minute gym workout. Banana contains no fat, cholesterol or sodium. The New England Journal of Medicine reported that eating a banana per day can cut the risk of death from a stroke by as much as 40 per cent.

Beverages are consumed by all groups as social drinks. In India, cold drinks are in demand for

the greater part of the years. Inclusion of concentrated fruit juices in the soft drinks not only impart characteristics colour and flavour but also provides the available nutrients (EI-Wakeli *et al*., 1974). Since the demand for soft drinks is increasing every year, we can exploit this trend by developing enriched fruit juice beverages, as the consumers are becoming conscious of the ways in which diet is linked to the healthy life style (Anon 1999) . Aseptically processed and packaged retail packs of (Ready To Serve) beverages are emerging in the market. If fruit juices are added to sweeten aerated water, they provide nutrients. Coupled with increasing the demand for soft drinks, there is considerable scope for developing naturally exsisting nutrients rich fruit juice beverage. The pulp/ juice of mango, pineapple, banana, orange and other fruits are easily digestible, highly refreshing, thirst quenching, appetizing and nutritionally far superior to many synthetic and aerated drinks. A variety of soft drinks are being produced in our country e.g. sweetened carbonated (aerated) soft drinks, still beverage containing fruit juice/pulp and soda water. It has been suggested by researchers that (RTS) beverage should be stored in the bottles. Banana juice is useful to combat many diseases viz. anemia, blood pressure, heart diseases, ulcer, seasonal effective disorder, etc.

Materials and Methods

Matured, fresh and fully ripe bananas (Robusta L), free from diseases and insects, were procured from the local market and use for the present investigation. Other raw materials including sugar,

glass bottles, chemicals and preservatives were also procured from the local market for the present study. Potassium metabisulphite (KMS) was used as preservative. The entire study was conducted in the Department of Agricultural Engineering and Food Technology, S.V.P. University of Agric. & Technology, Meerut (U.P.). Instruments/equipments used were knife, trays, power operated grinder, sieve, electronic balance, digital pH meter, digital spectrophotometer, laminar flow, BOD incubator, autoclave and colony counter etc.

Preparation of banana RTS beverage: Ripe bananas were washed and peeled manually. The peeled fruits were sliced and mashed in a grinder to make fine pulp. The mashed pulp was strained with muslin cloth to get banana juice. Sugar was added and blended with pulp/juice in the ratio of 1:0.75 (T1), 1:1 (T2) and 1:1.25 (T3). Water is added at the level of 7 lt per kg of pulp and heated for 15 minutes over gas burner for proper dilution. Potassium metabisulphite (KMS) and citric acid were added as preservative 70 ppm and 2% per kg of pulp, respectively. The RTS beverage was filled in clean sterilized bottles and sealed with crown caps with the help of crown corking machine. The RTS bottles were then labeled and stored under refrigeration condition (5$_o$C), BOD incubator (25$_o$C) and room temperature (30-35$_o$C) upto 90 days to determine the physico-chemical, microbial and sensory quality of beverage during, storage at an interval of 15 days.

Determine the physico-chemical properties of banana RTS beverage: TSS ($_o$Brix) and acidity (%) measurement of banana RTS beverage was evaluated using the method as recommended by Ranganna (2001). Microbial analysis was done to determine the Total Plate Count (TPC) of the samples on nutrient agar media for bacterial count as the method suggested by Harrigan and Mc Cance (1966). Sensory quality attributes viz. colour, flavour, taste and overall acceptability of the samples were evaluated using 9-point Hedonic rating test recommended by Ranganna (2001). Factorial Random Block Design (FRBD) was used for statistical analysis of collected data.

Results and Discussion

The effect of storage conditions on TSS, pH, acidity and optical density, microbial load and overall acceptability of banana RTS were determined. The results are presented under the following sections.

TSS ($_o$Brix): The TSS increased with increase in storage period irrespective of the level of sugar and storage temperatures (Table 1). The TSS value after 90 days storage were observed 15.00, 18.00 and 21.00 $_o$Brix for the samples stored at 5$_o$C under refrigeration storage condition. It is explicit that effect of sugar level and storage period were found significant at <0.05 level of significance.

Table 1. Changes in TSS ($_o$Brix) of banana RTS beverage during storage at different temperatures

Storage Period(Days)	Samples								
	$B_{1.0}$ $S_{0.75}$ (T1)			$B_{1.0}$ $S_{1.0}$ (T2)			$B_{1.0}$ $S_{1.25}$ (T3)		
	5$_0$ C	25$_0$ C	35$_0$ C	5$_0$ C	25$_0$ C	35$_0$ C	5$_0$ C	25$_0$ C	35$_0$ C
0	12.00	12.00	12.00	15.20	15.20	15.20	18.10	18.10	18.10
15	13.00	13.30	14.00	15.50	16.00	16.50	18.50	19.00	19.50
30	13.00	13.50	14.50	16.00	16.50	17.00	18.80	19.30	19.50
45	13.333	14.00	15.00	16.50	17.00	17.50	18.80	19.50	19.80
60	14.50	15.00	15.50	16.50	17.83	18.167	19.80	20.00	20.50
75	15.00	15.50	16.00	17.50	18.00	19.00	20.00	20.50	21.00
90	15.00	16.50	17.00	18.00	18.50	19.50	21.00	21.50	22.00
	CD(P<0.05)	SEm±							
A	0.2232	0.0797							
B	0.2530	0.0904							
Interaction (A×B)	0.669	0.2399							

$B_{1.0}$ $S_{0.75}$: Banana pulp 1.0 Kg and Sugar 0.75 Kg
$B_{1.0}$ $S_{1.00}$: Banana pulp 1.0 Kg and Sugar 1.00 Kg
$B_{1.0}$ $S_{1.25}$: Banana pulp 1.0 Kg and Sugar 1.25 Kg
A: Storage B: Composition with temperature

Table 1(a): ANOVA for changes in TSS ($_o$Brix) of Banana RTS beverage during storage

Source	df	SS	MSS	F calculated	F tabulated	
Replication	2	0.23	0.12		5%	1%
Storage (A)	6	200.95	33.49	195.21	2.09	2.80
Composition (B)	8	834.17	104.27	607.76	1.94	2.51
Interaction (A×B)	48	23.30	0.49	2.83	1.00	1.00
Error	124	21.27	0.17			
Total	188	1079.93				

Acidity: The acidity of the samples increase with storage period at different storage temperatures. The acidity values after 90 days of storage were observed as 0.453%, 0.533% and 0.573% for the samples stored at 5$_o$C temperature for T1, T2 and

Table 2. Changes in acidity (%) of banana RTS beverage during storage at different temperatures

Storage Period(Days)	Samples								
	$B_{1.0}S_{0.75}$ (T1)			$B_{1.0}S_{1.0}$ (T2)			$B_{1.0}S_{1.25}$ (T3)		
	5₀ C	25₀ C	35₀ C	5₀ C	25₀ C	35₀ C	5₀ C	25₀ C	35₀ C
0	0.353	0.353	0.353	0.437	0.437	0.437	0.507	0.507	0.507
15	0.377	0.393	0.453	0.463	0.493	0.513	0.520	0.535	0.540
30	0.393	0.417	0.460	0.487	0.517	0.530	0.527	0.540	0.560
45	0.403	0.437	0.477	0.503	0.517	0.540	0.527	0.553	0.573
60	0.427	0.440	0.500	0.517	0.530	0.547	0.547	0.570	0.583
75	0.433	0.457	0.517	0.533	0.553	0.560	0.563	0.577	0.585
90	0.453	0.463	0.527	0.533	0.560	0.570	0.573	0.580	0.593
	CD(P<0.05)	SEm±							
A	0.1094	0.0391							
B	0.1240	0.0443							
Interaction (A×B)	0.328	0.1172							

T_1- Banana pulp 1.0 Kg and Sugar 0.75 Kg
T_2- Banana pulp 1.0 Kg and Sugar 1.00 Kg
T_3- Banana pulp 1.0 Kg and Sugar 1.25 Kg
A: Storage B: Composition with temperature

Table 2(a). ANOVA for changes in acidity (%) of Banana RTS beverage during storage

Source	df	SS	MSS	F calculated	F tabulated	
Replication	2	0.08	0.04		5%	1%
Storage (A)	6	3.99	0.67	16.14	2.09	2.80
Composition (B)	8	1.75	0.22	5.30	1.94	2.51
Interaction (A×B)	48	4.63	0.10	2.34	1.00	1.00
Error	124	5.11	0.04			
Total	188	15.55				

T3 respectively, (Table 2). It is evident that the effects of sugar level and storage periods were found significant. The highest value of acidity was observed 0.593% in case of highest sugar level 1:1.25 (T3) under ambient storage conditions after 90 days storage. Similar trend were reported by Hamaran and Amuth (2007).

Table 3. Changes in pH content of banana RTS beverage during storage at different temperatures

Storage Period(Days)	Samples								
	$B_{1.0}S_{0.75}$ (T1)			$B_{1.0}S_{1.0}$ (T2)			$B_{1.0}S_{1.25}$ (T3)		
	5₀ C	25₀ C	35₀ C	5₀ C	25₀ C	35₀ C	5₀ C	25₀ C	35₀ C
0	4.210	4.213	4.213	4.147	4.147	4.147	4.123	4.123	4.123
15	4.207	4.173	4.142	4.137	4.130	4.107	4.100	4.060	4.040
30	4.167	4.150	4.130	4.127	4.120	4.093	4.087	4.050	4.030
45	4.160	4.147	4.117	4.103	4.100	4.087	4.077	4.045	4.010
60	4.140	4.120	4.097	4.093	4.080	4.060	4.047	4.023	4.000
75	4.093	4.077	4.053	4.040	4.000	3.950	4.030	4.000	3.887
90	4.067	4.050	4.023	4.000	3.920	3.780	3.850	3.75	3.660
	CD(P<0.05)	SEm±							
A	0.1094	0.0391							
B	0.1240	0.0443							
Interaction (A×B)	0.328	0.1172							

T_1- $B_{1.0}$ $S_{0.75}$: Banana pulp 1.0 Kg and Sugar 0.75 Kg
T_2- $B_{1.0}$ $S_{1.00}$: Banana pulp 1.0 Kg and Sugar 1.00 Kg
T_3- $B_{1.0}$ $S_{1.25}$: Banana pulp 1.0 Kg and Sugar 1.25 Kg
A: Storage B: Composition with temperature

Table 3 (a): ANOVA for changes in pH of Banana RTS beverage during storage

Source	df	SS	MSS	F calculated	F tabulated	
Replication	2	0.08	0.04		5%	1%
Storage (A)	6	3.99	0.67	16.14	2.09	2.80
Composition (B)	8	1.75	0.22	5.30	1.94	2.51
Interaction (A×B)	48	4.63	0.10	2.34	1.00	1.00
Error	124	5.11	0.04			
Total	188	15.55				

pH: The pH significantly decreased with increase in storage periods (Table 3). The pH decreased with storage period irrespective of sugar level and storage temperatures. The pH values after 90 days of storage were observed as 4.067 4.000 and 3.850 for the samples (T1) stored at 5₀C under refrigerated

Table 4. Changes in optical density of banana RTS beverage during storage at different temperatures

Storage Period(Days)	Samples								
	(T1)			(T2)			(T3)		
	5_0 C	25_0 C	35_0 C	5_0 C	25_0 C	35_0 C	5_0 C	25_0 C	35_0 C
0	0.012	0.012	0.012	0.020	0.020	0.020	0.024	0.024	0.024
15	0.014	0.019	0.025	0.022	0.027	0.034	0.026	0.030	0.037
30	0.018	0.024	0.030	0.027	0.032	0.036	0.031	0.035	0.042
45	0.019	0.025	0.031	0.028	0.033	0.036	0.032	0.037	0.044
60	0.021	0.026	0.031	0.030	0.034	0.038	0.033	0.037	0.045
75	0.022	0.026	0.032	0.030	0.036	0.038	0.035	0.038	0.047
90	0.024	0.029	0.035	0.034	0.039	0.040	0.037	0.038	0.051
	CD(P<0.05)	SEm±							
A	0.0006	0.0002							
B	0.0007	0.0002							
Interaction (A×B)	0.002	0.0006							

T_1- $B_{1.0}$ $S_{0.75:}$ Banana pulp 1.0 Kg and Sugar 0.75 Kg
T_2- $B_{1.0}$ $S_{1.00:}$ Banana pulp 1.0 Kg and Sugar 1.00 Kg
T_3- $B_{1.0}$ $S_{1.25:}$ Banana pulp 1.0 Kg and Sugar 1.25 Kg
A: Storage B: Composition with temperature

Table 4 (a). ANOVA for changes in optical density of Banana RTS beverage during storage

Source	df	SS	MSS	F calculated	F tabulated	
Replication	2	0.00	0.00		5%	1%
Storage (A)	6	0.00	0.00	386.41	2.09	10.92
Composition (B)	8	0.01	0.00	845.51	1.94	8.65
Interaction (A×B)	48	0.00	0.00	2.67	1.00	
Error	124	0.00	0.00			
Total	188	0.01				

storage condition. The study also revealed that pH decreased with increase in storage period irrespective of storage conditions. The lowest pH value was observed as 3.660 in case of sample (T3) having sugar level of 1.25 under ambient storage condition after 90 days of storage. Similar trends were reported in case of banana and sapota beverage stored at different temperatures for 180 days (Hamaran and Amuth (2007).

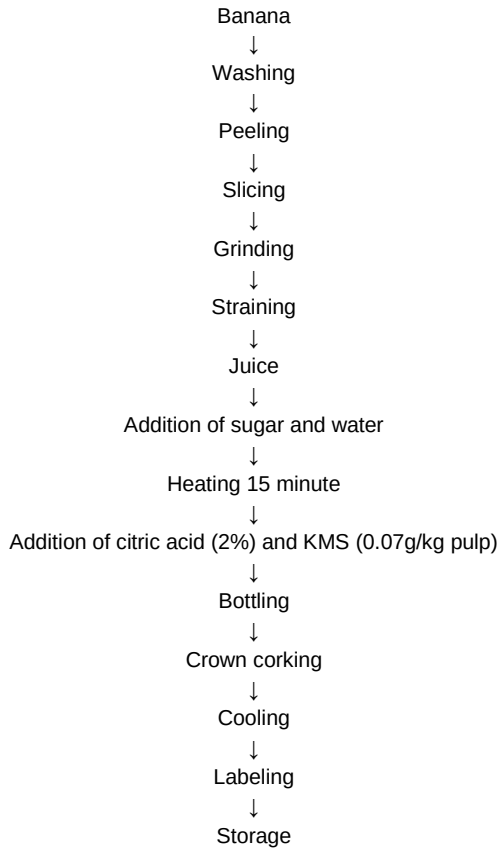

Fig.1. Flow chart for preparation of banana RTS beverage

Optical density: Table 4 shows that the O.D. values increased with storage period irrespective of pulp to sugar ratio and storage temperature. The O.D. values after 90 days of storage were observed as 0.024 (T1), 0.034 (T2) and 0.037 (T3) for the samples stored at 5_0C under refrigerated condition. The optical density of the samples increased with increase in the level of sugar at a particular storage temperature. The O.D. values of banana RTS beverage were observed as 0.012, 0.020 and 0.024 for the pulp to sugar ratio of 1:0.75 (T1), 1:1 (T2) and 1:1.25 (T3), respectively just after preparation.

Microbial growth: From Table 5 it was noted that the microbial growth increased with storage periods irrespective of sugar level and storage temperatures. The TPC values after 90 days of storage were observed as 1.104 $x10_5$ (T1) and $1.076x10_5$ (T2) cfu/ml and $1.067x10_5$ (T3) cfu/ml for the samples stored at 5_0C under refrigerated storage condition with different sugar level. The highest microbial growth was observed as 1.172 $x10_5$ (T1) cfu/ml in case of sample having sugar level of 0.75 under ambient storage conditions after 90 days of storage. The microbial growth of banana RTS beverage decreased with increase in level of sugar because of preservation properties of sugar. The TPC values were observed as 1.026 $x10_5$ cfu/

Table 5. Changes in TPC (x10$_5$cfu/ml) of banana RTS beverage during storage at different temperatures

Storage Period(Days)	Samples								
	(T1)			(T2)			(T3)		
	5$_0$ C	25$_0$ C	35$_0$ C	5$_0$ C	25$_0$ C	35$_0$ C	5$_0$ C	25$_0$ C	35$_0$ C
0	ND	ND	ND	ND	ND	ND	ND	ND	ND
15	1.026	1.067	1.095	1.015	1.064	1.093	1.005	1.05	1.082
30	1.038	1.082	1.099	1.028	1.065	1.094	1.075	1.098	1.099
45	1.056	1.094	1.103	1.04	1.082	1.099	1.026	1.085	1.099
60	1.072	1.099	1.123	1.055	1.097	1.11	1.037	1.099	1.111
75	1.084	1.115	1.138	1.072	1.109	1.122	1.05	1.111	1.12
90	1.104	1.156	1.172	1.076	1.11	1.128	1.067	1.118	1.135
	CD(P<0.05)	SEm±							
A	0.0021	0.0007							
B	0.0025	0.0009							
Interaction (A×B)	0.006	0.0022							

T$_1$- B$_{1.0}$ S$_{0.75}$: Banana pulp 1.0 Kg and Sugar 0.75 Kg
T$_2$- B$_{1.0}$ S$_{1.00}$: Banana pulp 1.0 Kg and Sugar 1.00 Kg
T$_3$- B$_{1.0}$ S$_{1.25}$: Banana pulp 1.0 Kg and Sugar 1.25 Kg
A: Storage B: Composition with temperature

Table 5 (a). ANOVA for changes in TPC (x10$_5$cfu/ml) of Banana RTS beverage during storage

Source	df	SS	MSS	F calculated	F tabulated	
Replication	2	0.00	0.00		5%	1%
Storage (A)	5	0.07	0.01	935.39	3.09	4.81
Composition (B)	8	0.11	0.01	900.07	4.31	3.21
Interaction (A×B)	40	0.02	0.00	36.21	2.04	2.70
Error	106	0.00	0.00			
Total	161	0.20				

ml, 1.015 x10$_5$ cfu/ml and 1.005x10$_5$ cfu/ml for sugar level of 0.75, 1 and 1.25 / kg pulp, respectively, after 15 days of storage. Chitra (2000) reported the microbial population (total bacterial count) of banana RTS beverage in the range of 1-12x10$_6$ and 1-6x10$_6$ cfu/ml for samples stored at room temperature and refrigeration condition up to 300 days of storage. Saravana and Manimeglai (2005) reported the microbial load as 1- 2x10$_6$ bacteria, 1-2x10$_4$ fungi and 1x10$_5$ per gram yeast in whey based papaya

Table 6. Changes in overall acceptability of banana RTS beverage during storage at different temperatures

Storage Period(Days)	Samples								
	B$_{1.0}$ S$_{0.75}$ (T1)			B$_{1.0}$ S$_{1.0}$ (T2)			B$_{1.0}$ S$_{1.25}$ (T3)		
	5$_0$ C	25$_0$ C	35$_0$ C	5$_0$ C	25$_0$ C	35$_0$ C	5$_0$ C	25$_0$ C	35$_0$ C
0	6.880	6.880	6.880	7.800	7.800	7.800	7.450	7.450	7.450
15	6.710	6.353	6.030	7.780	7.670	7.500	7.320	7.120	6.950
30	6.570	6.227	5.950	7.750	7.560	7.270	7.170	6.980	6.820
45	6.330	5.970	5.760	7.550	7.330	7.100	6.900	6.750	6.680
60	6.060	5.820	5.570	7.280	7.100	6.830	6.710	6.600	6.380
75	5.850	5.60	5.250	7.150	6.930	6.710	6.460	6.350	6.170
90	5.620	5.367	5.070	6.950	6.700	6.360	6.260	6.100	5.960
	CD(P<0.05)	SEm±							
A	0.0620	0.0221							
B	0.0703	0.0251							
Interaction (A×B)	0.186	0.0664							

T$_1$- B$_{1.0}$ S$_{0.75}$: Banana pulp 1.0 Kg and Sugar 0.75 Kg
T$_2$- B$_{1.0}$ S$_{1.00}$: Banana pulp 1.0 Kg and Sugar 1.00 Kg
T$_3$- B$_{1.0}$ S$_{1.25}$: Banana pulp 1.0 Kg and Sugar 1.25 Kg
A: Storage B: Composition with temperature

Table 6 (a). ANOVA for changes in overall acceptability of Banana RTS beverage during storage

Source	df	SS	MSS	F calculated	F tabulated	
Replication	2	0.07	0.04		5%	1%
Storage (A)	6	24.15	4.02	304.05	2.09	2.80
Composition (B)	8	53.18	6.65	502.26	1.94	2.51
Interaction (A×B)	48	9.09	0.19	14.31	1.00	1.00
Error	124	1.64	0.01			
Total	188	88.13				

juice blended RTS beverage upto 90 days of storage in refrigeration condition, which was considered safe for consumption.

Overall acceptability*:* Results of the study revealed that the fresh samples having pulp to sugar ratio of 1:0.75 (T1) had the overall score of 6.880 (like slightly). However, samples prepared with pulp to sugar ratio of 1:1 (T2) and 1:1.25 (T3) were rated as 7.800 (like very much) and 7.450 (like moderately), respectively at the time of storage (Table 6). It is explicit that the fresh samples prepared with equal amount of banana pulp and sugar level 1:1 (T2) had the maximum score of 7.800, Whereas the minimum score of 5.070 (neither like nor dislike) was noted pulp to sugar ratio 1:0.75 (T1) after 90 days of storage at room temperature.

Conclusion

The refrigerated storage (5_oC) method was found to be superior over other methods for storage of banana RTS beverage followed by BOD incubator and ambient storage conditions.

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Received: July 27, 2012; Accepted: December 14, 2012