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Thermal, chemical and bio-chemical interventions for enhancing the shelf-life of sugarcane juice

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SUMMARY :

Sugarcane juice is a popular drink in India, but in most cases it is unavailable in hygienic condition and due to its poor shelf-life it is often sold fresh. It deteriorates very rapidly due to physical, chemical and microbial changes. Attempts were made to preserve sugarcane juice by combining the effects of pasteurization, preservatives and enzymes. Sugarcane juice was pasteurized at 85°C for 10 minutes followed by addition of fresh lemon juice to maintain its pH at 4.2 and was immediately bottled. Ascorbic acid (40 ppm), potassium sorbate (120 ppm) and sodium benzoate (120 ppm) were added as chemical preservatives. Cinnamon oil was used as bio preservative and pectinase enzyme as enzymatic treatment. The juices were bottled and pasteurized in hot water at 85°C for 10 minutes and stored under ambient and refrigerated conditions. Physico-chemical (pH, T.S.S, browning index), microbiological (total plate counts, yeast and mould growth) and sensory (overall acceptability) observations were recorded. Chemical preservatives enhanced the shelf-life for upto 40and 60 days at ambient and refrigerated conditions, respectively. However, thermally treated juice also showed acceptable sensory and microbial properties upto 20 days of storage at ambient conditions and 60 days under refrigerated condition.

KEY WORDS : Sugarcane juice, Heat treatment, Storage, Sensory evaluation, Shelf-life

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Sugarcane juice is a popular drink that can be consumed solo or with added fruit juice. Moreover, the drink is able to replenish the energy rapidly because of its simple sugar content. The sugarcane juice has an excellent hydrating capacity. It refreshes and energizes the body instantly as it is rich in carbohydrates, iron and vitamins.

Sugarcane juice of 100 ml provides 40 Kcal of energy, 10 mg of iron and 6 µg of carotene. It contains water (75 to 85%), non-reducing sugars (sucrose, 10 to 21%), reducing sugars (glucose and fructose, 0.3 to 3%), organic substances (0.5 to 1%), inorganic substances (0.2

to 0.6%) and nitrogenous bodies (0.5 to 1) (Swaminathan, 1995).Sugarcane juice is rich in enzyme and possesses many medicinal and therapeutic properties (Banerji *et al.*, 1997). According to (Hudson *et al.*, 2000 and Hollman, 2001), the flavonoids which are present in sugarcane juice have the abilities to protect cells from degenerative processes and to reduce the development of cancer and cardio-vascular diseases. However, the sugarcane juice gets spoiled quickly after crushing due to presence of simple sugars. Biodegradation of juice is chiefly by micro-organisms of *Leuconostoc* spp. (*L. mesenteroides* and *L. dextranium*). Soon after the harvest of sugarcane; endogenous invertase enzyme is activated and it acts as a cause of deterioration. The main problem associated with fresh sugarcane juice is its short shelf-life. This contributes to the variation in the total soluble solutes (TSS) of the fresh juice and cause changes in flavour and other sensory attributes. Thus, processing and marketing of sugarcane juice is limited by its rapid deterioration (Prasad and Nath, 2002 and Yusof *et al.*, 1999). Ultra heat temperature (UHT) sterilization at 140ºC and holding for 4 seconds could maintain the sugarcane flavours and provide the more favourable juice than those at 135ºC for 10 seconds (Jittanit *et al.*, 2010). Singh *et al.*, 2012 optimized the proportions of sugarcane juice with curd in the RTS beverage. Sugarcane juice with curd was preserved and packed in 200 ml glass bottles and kept for different storage periods (0, 5, 15 and 20 days). Beverages prepared from 4:1 proportion of juice and curd were found superior even after 15 days of storage. Preservation of aonla blended sugarcane juice with different proportions of aonla juicewas done by Sangeeta *et al.* (2013). The addition of aonla juice resulted in the lowering of pH of juice blend which gave preservative action by inhibiting the growth of micro-organisms during storage. The blended juice samples remained acceptable upto 20 days at room temperature and 50 days at refrigerated temperature and 5 per cent aonla sugarcane juice blend was highly acceptable among all. Rawat and Pokhriyal, 2014 observed that the moisture content, ascorbic acid, viable bacterial count and viable yeast and mold count were decreased significantly ($P > 0.05$) by irradiating the juice with 0.25, 0.5 and 1.0 kg where as no significant effect was observed on reducing and total sugars in cane juice. Singh *et al.*,2014 studied the quality of fresh sugarcane juice with the help of optimized parameter and hurdle technology. The sensory parameters of colour, flavour, taste and overall acceptability were evaluated with 10 trained panelist based on 9 point. The rate of spoilage of juice was greater at room temperature as compared to the refrigerated temperature. Kumar and Singh (2016) studied the effect of Indian herbs and chemical on shelf-life of sugarcane juice. Pudina and *Tulsi* treated juice have shown the maximum values of sensory attributes. Development of effective treatments or procedures to keep the fresh quality of sugarcane juice would allow it to be more widely marketed and would enhance its quality and safety as well. Therefore, the objective of the study was to investigate the effect of thermal, chemical and bio-chemical treatments for shelf-life enhancement of fresh sugarcane juice.

EXPERIMENTAL METHODS

The fully matured sugarcane stems of variety CoLk 94184 were harvested from the field of ICAR-Indian Institute of Sugarcane Research, Lucknow. The stems were washed, de topped, peeled and scrubbed with the help of peeler. Juice was extracted by table crusher and filtered through muslin cloth to remove the extraneous matter. The filtered juice was immediately cooled in the refrigerator to minimize any kind of deterioration.

Selection of treatments :

Three different temperatures (80º C, 85º C and 90º C) for time intervals (5minutes, 10 minutes and 15 minutes), respectively for selection of T_1. Three different concentrations of ascorbic acid (20, 40, 60 mg/ 100 ml), sodium benzoate (100, 120, 140 ppm) and potassium sorbate (100, 120, 140 ppm) were studied for selection of T_2. Cinnamon oil (0.25, 0.50, 0.75ml) was added with to optimize the T_3 and pectinase (100 ppm, 300 ppm and 500 ppm) were studied for selection of T_4.

Highest overall acceptability scores were awarded to juice heated at 85ºC for 10 minutes. The panelist awarded highest scores to the sugarcane juice with concentration of ascorbic acid 40 mg/ 100 ml, concentration of potassium sorbate 120 ppm, concentration of sodium benzoate 120 ppm. 0.25 ml of cinnamon oil was found sufficient for providing the characteristic flavour to the juice whereas pectinase enzyme at 500 ppm concentration obtained the highest sensory scores. Hence, the final treatments are listed in Table A.

All the bottles were tightly capped followed by

Table A : Selected treatment

Sr. No.	Treatments	Description
1.	T_1	Heat treated juice (85ºC for 10 min)
2.	T_2	Juice fortified with chemical preservatives (ascorbic acid – 40mg/100ml, sodium benzoate - 120 ppm and potassium sorbate - 120 ppm)
3.	T_3	Juice fortified with bio preservative (cinnamon oil- 0.5ml)
4.	T_4	Pectinase (500 ppm)

pasteurization at 85ºC for 10 minutes; the bottles were kept in refrigerator overnight. All the bottles were stored for 60 days at ambient and refrigerated condition. The samples were drawn and analyzed for physico-chemical, microbiological and sensory attributes at an interval of 5 days.

pH:

pH was determined by using Hanna pH instrument.

Total soluble solids (TSS):

TSS was determined by means of the refractometer (LCD digital bench-ATAGO Pocket Refractometer).

Colour values:

The basic purpose of colour measurement was to get an idea of comparative change in colour in different treatments. In the present study L, a, b values are determined using a colour reader (CR 10). The browning index was determined by the following formula:

$$\textbf{Browning index} = [100(x-31)]/0.17$$

where, $x = \frac{(a + 1.75L)}{(5.645L + a - 3.012b)}$

Microbiological analysis :

The quality of sugarcane juice was based on the number and type of micro-organism present which can be assessed by serial dilution and plating method for the differential enumeration of bacteria, yeast and fungi (Ranganna, 2007). Determination of total microbial counts (bacteria, yeast and mould) for juice was carried out at every 5 days interval.

Overall acceptability:

Juice samples were also evaluated for sensory attribute namely overall acceptability using a 10 members panel following a 9 point Hedonic scale. The panel members were requested to assemble at one place prior to evaluation, as the samples were required to be judged immediately when opened. Each member was provided with the sensory evaluation rating scales based on which the rating was given to various samples. The average values of the ratings given by all the members were then calculated and used for further analysis.

Statistical analysis :

The experiments were conducted by adopting Completely Randomized Design. The data recorded during the course of investigation were statistically analyzed by the 'analysis of variance' (ANOVA). Analysis of variance was used in all the analysis for detection of significant differences among samples. The significant effect of treatment was judged with the help of 'F- test' (variance ratio). Calculated F value was compared with the tabulated value of F. If calculated value exceeded the tabulated value the effect was considered to be significant. Standard error and critical difference were calculated on the basis of ANOVA Table A.

EXPERIMENTAL FINDINGS AND ANALYSIS

Fresh sugarcane juice sample spoiled within 6 h at

Table 1: Effect of treatments on pH

	Storage duration (days)										
	Ambient condition					Refrigerated condition					
T	0	10	20	30	40	10	20	30	40	50	60
T_1	4.23	4.22	4.17	-	-	4.21	4.22	4.21	4.20	4.18	4.17
T_2	4.28	4.20	4.16	4.11	4.04	4.29	4.29	4.28	4.27	4.28	4.28
T_3	4.26	4.13	4.11	4.07	4.01	4.27	4.26	4.26	4.25	4.25	4.22
T_4	4.26	4.23	4.19	-	-	4.24	4.22	4.20	4.18	4.17	4.16
F-test	S	S	S	S	S	S	S	S	S	S	S
C.D. (P=0.05)	0.016	0.014	0.012	0.014	0.011	0.009	0.011	0.015	0.01	0.015	0.026
S.E.±	0.005	0.004	0.004	0.003	0.003	0.003	0.003	0.004	0.003	0.004	0.008

S=Significant

room temperature, therefore, results for control could not be obtained for the entire storage period. Similar results were observed by Chauhan *et al.* (2002). Under the ambient conditions the chemical and biological preservatives have maintained the various physical, chemical and biological attributes upto 40 days of storage. However, heat treatments have also showed promising results upto 20 days of storage. The keeping quality was improved upto 60 days under the refrigerated storage condition.

Effect on pH values of sugarcane juice:

The pH values of sugarcane juice decreased significantly with the advancement of storage time (Table 1). However, the chemical preservatives and cinnamon oil have significantly reduced the lowering of pH of sugarcane juice. At the end of the storage studies maximum pH was observed in T_2 (4.04 at ambient conditions and 4.28 under refrigerated conditions). These findings were in conformation with the results of Sangeeta *et al.* (2013). Addition of preservatives restricted the microbial activity during storage resulting in significantly less reduction in pH.

Effect on total soluble solids (ºBrix) values of sugarcane juice:

The total soluble solids decreased significantly during storage of sugarcane juice at room as well as refrigeration temperature, however, the decrease was of lesser extent at refrigeration temperature (Table 2). After 40 days of storage under refrigerated conditions maximum T.S.S. was observed in T_2 (19.5 ºB) followed by T_3 (18.7ºB). A similar decrease in total soluble solids on storage was observed by Khare *et al.* (2012) and this may be due to the conversion of sugars into acids by micro-organisms. The use of high temperature and preservatives act upon the microbial flora which causes such changes and prolong the shelf-life of sugarcane juice (Chauhan *et al.*, 2002).

Effect on browning index of sugarcane juice :

Browning index increased significantly in all the treatments during storage period as depicted in the Table 3 under ambient as well as refrigerated conditions,

Table 2 : Effect of treatments onTSS

	Storage duration (days)										
	Ambient condition					Refrigerated condition					
T	0	10	20	30	40	10	20	30	40	50	60
T_1	20.4	20.2	19.9	-	-	19.5	19.5	19.4	19.3	19.0	18.8
T_2	20.1	19.9	19.7	19.4	19.1	19.9	19.9	19.8	19.7	19.7	19.5
T_3	20.2	19.9	19.4	18.7	17.9	19.5	19.5	19.3	19.1	18.9	18.7
T_4	20.3	20.2	19.8	-	-	19.9	19.9	19.6	19.4	19.2	18.8
F-test	S	S	S	S	S	S	S	S	S	S	S
C.D. (P=0.05)	0.191	0.175	0.221	0.232	0.232	0.191	0.191	0.191	0.191	0.191	0.175
S.E.±	0.058	0.053	0.067	0.058	0.058	0.003	0.003	0.004	0.003	0.004	0.008

S=Significant

Table 3 : Effect of treatments on browning index

	Storage duration (days)										
	Ambient condition					Refrigerated condition					
T	0	10	20	30	40	10	20	30	40	50	60
T_1	0	5.9	7.9	-	-	0.0	5.9	7.9	9.8	9.8	9.8
T_2	0	5.9	5.9	11.8	11.8	0.0	3.9	5.9	5.9	9.8	11.8
T_3	0	5.9	11.8	17.7	19.6	0.0	5.9	9.8	11.8	17.6	21.5
T_4	0	5.9	11.8	-	-	0.0	3.9	9.8	9.8	11.8	13.7
F-test	NS	NS	S	S	5.588	NS	NS	NS	NS	S	S
C.D. (P=0.05)	-	-	3.257	0.019	1.386	-	-	-	-	4.605	5.609
S.E. ±	-	0.005	0.983	0.005	11.8	-	1.391	1.703	1.391	1.391	1.694

S= Significant NS= Non-significant

respectively. Under ambient conditions, the minimum increase in browning index was observed in T_2 (11.8) followed by T_3 (19.6) after 40 days of storage. The observations of T_1 (7.9) and T_4 (11.8) are statistically at par after 20 days of storage. Under refrigerated conditions, increase in browning index was observed minimum in T_1 (11.8) and maximum in T_3 (21.5) after 60 days of storage. This may be due to the increase in enzymatic activity on storage.

Effect on microbiological properties of sugarcane juice :

It was evident from Table 4 and 5 that the total plate count and yeast and mould count increased significantly during storage of sugarcane juice. The extent of increase in microbial population was also higher at room temperature as compared to refrigeration temperature. Under the refrigerated conditions, the maximum total plate count was observed in T_1 and minimum in T_2. After 40

Table 4 : Effect of treatments on total plate count

	Storage duration (days)										
	Ambient condition					Refrigerated condition					
T	0	10	20	30	40	10	20	30	40	50	60
T_1	0.0	1.2	2.6	-	-	0.0	0.1	0.1	0.2	0.3	0.2
T_2	0.0	0.1	0.3	0.5	0.7	0.2	0.4	0.3	0.7	0.4	0.1
T_3	0.0	0.3	0.4	0.8	1.3	0.4	0.8	1.3	1.5	1.0	0.6
T_4	0.0	0.1	1.4	-	-	0.1	0.3	0.8	1.2	1.2	0.4
F-test	NS	S	S	S	S	S	S	S	S	S	S
C.D. (P=0.05)	N/A	0.087	0.102	0.146	0.147	0.043	0.089	0.058	0.044	0.173	0.055
S.E.±	0.009	0.026	0.031	0.036	0.036	0.013	0.027	0.017	0.013	0.052	0.017

NS= Non-significant S= Significant

Table 5 : Effect of treatments on yeast and mould count

	Storage duration (days)										
	Ambient condition					Refrigerated condition					
T	0	10	20	30	40	10	20	30	40	50	60
T_1	0.0	1.3	3.7	-	-	0.5	0.7	1.1	1.3	1.6	1.3
T_2	0.0	0.7	1.9	2.6	3.3	0.3	0.4	0.7	0.9	1.5	1.1
T_3	0.0	1.8	2.3	3.2	3.6	0.8	1.2	1.3	1.5	2.1	1.4
T_4	0.0	1.0	2.7	-	-	0.5	0.8	1.0	1.3	1.5	1.2
F-test	NS	S	S	S	S	S	S	S	S	S	S
C.D. (P=0.05)	N/A	0.091	0.171	0.135	0.087	0.079	0.122	0.073	0.081	0.067	0.09
S.E. ±	0.017	0.027	0.052	0.033	0.022	0.024	0.037	0.022	0.024	0.02	0.027

NS= Non-significant S=Significant

Table 6 : Effect of treatments on overall acceptability

	Storage duration (days)										
	Ambient condition					Refrigerated condition					
T	0	10	20	30	40	10	20	30	40	50	60
T_1	8.7	8.2	7.3	-	-	7.5	7.2	6.6	6.3	6.1	5.7
T_2	9.1	8.5	8.2	7.9	7.2	8.5	8.0	7.5	7.2	6.6	6.3
T_3	8.0	7.7	7.5	7.1	6.5	7.3	7.1	6.6	6.2	5.9	5.3
T_4	8.5	7.9	7.3	-	-	7.5	7.2	6.9	6.5	6.2	5.6
F-test	S	S	S	S	S	S	S	S	S	S	S
C.D. (P=0.05)	0.191	0.276	0.349	0.251	0.380	0.221	0.135	0.336	0.156	0.166	0.247
S.E.±	0.058	0.083	0.105	0.062	0.094	0.067	0.041	0.101	0.047	0.050	0.075

S= Significant

days of storage under ambient conditions and 60 days of storage in refrigerated conditions, the minimum total plate count was recorded in T_2. Similar trend was observed for yeast and mould count. The results are in accordance with Kumar and Singh (2016) who reported that the preservatives had significant influence on the reduction of microbial spore load.

Effect of treatments on overall acceptability of sugarcane juice :

The sensory scores for overall acceptability reduced significantly with the advancement of storage (Table 6). However, the reduction in sensory scores of samples stored at room temperature was of significantly greater magnitude than those stored at refrigerated temperature. Under the refrigerated conditions, the maximum scores for overall acceptability was awarded to T_2 (6.3).

Conclusion :

The pasteurized juice without chemical preservative (T_1) showed acceptable quality parameters and sensory scores upto 20 days of storage at ambient conditions and upto 60 days of storage under refrigerated conditions. The incorporation of chemical preservatives in the juice maintained the quality of juice for longer period of storage and was observed fit for consumption upto 45 days of storage under ambient conditions and 60 days of storage under refrigerated conditions.

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