AJH
eISSN- 0976-724X

THE ASIAN JOURNAL OF HORTICULTURE
Volume **11** | Issue 2 | December, 2016 | 373-378
Visit us -*www.researchjournal.co.in*

RESEARCH PAPER

DOI : 10.15740/HAS/TAJH/11.2/373-378

Article history :
Received : 21.09.2016
Revised : 10.11.2016
Accepted : 22.11.2016

Thermal and chemical treatments for enhancing the shelf-life of sugarcane juice

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ABSTRACT : Present study was carried out to enhance the shelf-life of sugarcane juice so that it is available on commercial scale. Sugarcane juice were subjected to heat treatment at 85°C for 10 minutes followed by the addition of fresh lemon juice to maintain the pH of 4.2. After this the juice was subjected to the following treatments: in the first treatment (T_1) the juice was immediately bottled, in the second treatment (T_2), ascorbic acid (40 ppm), potassium sorbate (120 ppm) and sodium benzoate (120 ppm) were added. In the third treatment (T_3) cinnamon oil (0.4 ml) was added.The treated juices were bottled and pasteurized in hot water at 85°C for 10 minutes and stored under ambient conditions (30±5°C). Physico-chemical and microbiological observations like pH, total soluble solutes (T.S.S), colour (browning index), total plate counts, yeast and mould counts were taken along with sensory evaluation. The chemical preservatives used in T_2 enhanced the shelf-life for up to 45 days. However, the pasteurized juice T_1 also showed acceptable sensory and microbial properties upto 20 days of storage.

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

HOW TO CITE THIS ARTICLE : Verma, Ayushi, Kumar, Dilip, Singh, Priyanka and Yadav, Kailash Chandra (2016). Thermal and chemical treatments for enhancing the shelf-life of sugarcane juice. *Asian J. Hort.*, **11**(2) : 373-378, **DOI : 10.15740/HAS/TAJH/11.2/373-378.**

Sugarcane is an important industrial crop cultivated in tropical and subtropical regions of the world. India is the second largest producer of sugarcane in the world. In 2014-15 the total production of sugarcane was around 359.33 million tonnes (Anonymous, 2016a), producing nearly 273.07 million tonnes white sugar and 45.63 million tonesgur and khandsari (Anonymous, 2016b). Sugarcane juice of 100 ml provides 40 Kcal of energy, 10 mg of iron and 6 µg of carotene. It contains water (75%-85%), reducing sugar (0.3-3.0%), non-reducing sugar (10-21%) (Krishnakumar *et al*., 2013). Sugarcane juice is rich in enzyme and possesses many medicinal and therapeutic properties (Banerji *et al*., 1997). Sugarcane juice is very useful in scanty urination. It has been used to cure jaundice and liver-related disorders in Indian systems of medicine (Kadam *et al*., 2008). According to Ayurveda, it is oleaginous, diuretic, tonic, cooling, aphrodisiac and useful in fatigue, thirst, anaemia, ulcers etc., while according to the Unani system it is laxative, diuretic, aphrodisiac and good for lungs (Karthikeyan and Samipillai, 2010). However, the sugarcane juice gets spoiled quickly after crushing due to presence of simple sugars. Hygiene standards are usually not maintained during the transport of sugarcanes from field to the point of extraction and preparation of juice. Further the juice is consumed unpasteurized; therefore, it is possible that the sugarcane juice gets contaminated and poses health hazards. The main problem associated with fresh sugarcane juice is its short shelf-life and heat sensitivity. This contributes to the variation in the total solid content (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*., 2000). 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. Keeping in view of the above facts, the present experiment, "Thermal and chemical treatments for enhancing the shelf-life of sugarcane juice" has been taken up together with the information on changes of pH, total soluble solutes,colour (browning index), total plate count, yeast and mould count and overall acceptability.

RESEARCH METHODS

The fully matured sugarcane sticks were harvested from the farms of Indian Institute of Sugarcane Research, Lucknow. The sugarcane sticks were then washed, graded, deeply peeled and scrubbed with the help of peeler. Sugarcane juice was extracted by crusher and filtered through muslin cloth to remove the extraneous matter. The filtered juice was then immediately kept for cooling into the refrigerator to prevent any kind of deterioration.

Selection of treatments:

Different temperature combinations (80º C, 85º C, 90º C) for different time intervals (5minutes, 10 minutes, 15 minutes) were studied for selection of T_1. Different concentrations of ascorbic acid (20, 40, 60 mg/ 100 ml), different concentrations of sodium benzoate (100, 120, 140 mg/ lit.) and different concentrations of potassium sorbate (100, 120, 140 mg/ lit.) were studied for selection of T_2. Different amount of cinnamon oil (0.4, 0.6 and 0.6 ml) was added to optimize T_3.

Sensory evaluation study revealed that product obtained highest sensory scores for overall acceptability when pasteurized at 85ºC for 10 min. 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. The results also depicted that 0.4 ml of cinnamon oil was found sufficient for providing the characteristic flavour to the juice. Hence, the standardization of sugarcane beverage was done and listed in Table A.

For treatment T_1, juice was filled in glass bottles and was pasteurized at 85ºC for 10 min with their lids loosely capped. For treatment T_2, chemical preservatives like ascorbic acid (40mg/100ml), sodium benzoate (120ppm) and potassium sorbate (120 ppm) were added. Juice was filled in glass bottles and was pasteurized at 85ºC for 10 min with their lids loosely capped. For treatment T_3, natural preservative like cinnamon oil (one drop for each bottle) was added. Juice was filled in glass bottles and was pasteurized at 85ºC for 10 min with their lids loosely capped.

Table A : Selected treatments

Sr. No.	Treatments	Description
1.	T_1	Heat treatment (85ºC for 10 min)
2.	T_2	Chemical treatment (ascorbic acid – 40mg/100ml, sodium benzoate - 120 ppm and potassium sorbate - 120 ppm)
3.	T_3	Natural treatment (Cinnamom oil 0.4 ml)

In all the treatments (T_1, T_2 and T_3) the loosely capped bottles were further tightly capped followed by pasteurization at 85ºC for 10 mins, the bottles were kept in refrigerator overnight. All the bottles were stored for 60 days at room temperature. The samples were drawn periodically and analyzed for physico-chemical, microbiological and sensory attributes at an interval of 5 days at room temperature.

Physico-chemical and microbiological analysis :

pH :

Hanna pH Meter, (model No. HI 5521), made in Romania was used to determine pH. It consists of a probe for measuring pH. The sugarcane juice sample was taken in a beaker. The digital pH meter electrode was dipped inside the beaker and the readings were noted down that was appeared on the screen.

Total soluble solutes (T.S.S.):

LCD digital bench- ATAGO Pocket Refractometer, PAL-MAPLE (Made in Japan), model number B623777 was used to determinethe total soluble solutes in sugarcane juice. The refractometer prism surface was cleaned and dried. A small amount of sugarcane juice (a couple of drops) was placed onto the prism of the Refractometer. The start button was pressed to get the soluble solids reading in ºBrix.

Browning index :

Deterioration of juice colour was measured in terms of browning index (BI). It was calculated as BI = [100

(x - 0.31)]/0.17). where,

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

L, a, b values were observed with Colour Reader: CR-10 of company Konica Minolta Sensing Inc. (Made in Japan), model number 41112097.

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. 1 ml of juice from each storage temperature was taken into a test tube containing 9 ml of sterile water. The mixture was homogenized. This homogenate represented 10^{-1} dilution. From here, serial dilutions of 10^{-2} and 10^{-3}were prepared. The plates were then incubated at room temperature for 24 h for bacteria and four days for yeast and mould. Enumeration of bacteria and yeast and fungi was counted by nutrient agar media and rose bengal media, respectively, with 10^{-3} dilutions. The results (number of colony forming units) were obtained after the incubation time using the following formula:

$$\text{Number of colony forming units (CFU's) per gram of sample} = \frac{\text{Mean No. of CFU's x Dilution Factor}}{\text{Amount of solution taken in x dilution}}$$

Overall acceptability :

Juice samples were also evaluated for sensory attributes namely appearance, flavour and overall acceptability using a 10 member panel using 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 table value the effect was considered to be significant. Standard error and critical difference were calculated on the basis of anova table.

RESEARCH FINDINGS AND DISCUSSION

Fresh sugarcane juice sample spoiled within 3-4 h at room temperature therefore, results for control could not be obtained for the storage period. Similar results were observed by Chauhan *et al*. (2002).Under ambient condition T_1 was not available for study after 20 days of storage as the samples were rejected during sensory analysis (flavour).

Effect of treatments on pH values of sugarcane juice:

Fig.1 clearly indicated that initially the pH was maintained at 4.2 for all the treated juice T_1 (4.23), T_2 (4.28) and T_3 (4.26). After 45 days of storage, the minimum decrease in pH was observed in T_2 (4.03) followed by T_3 (4.01). The results were found to be similar with the results reported by Kumar and Singh (2016).

Krishnakumar and Devadas (2004) reported that the pH of stored sugarcane juice was slowly decreased during storage period due to acetic acid production.

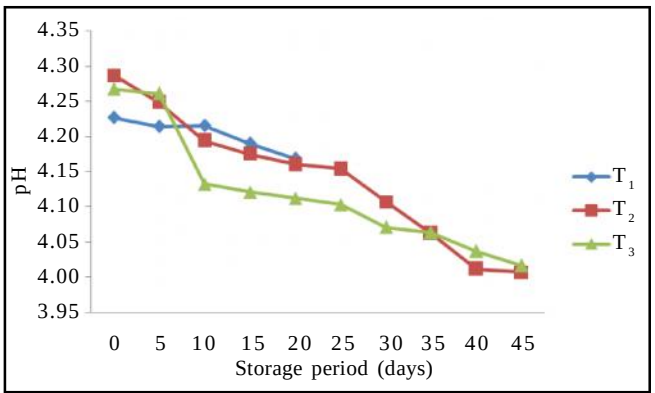

Fig. 1 : Effect of treatments on pH of sugarcane juice stored under ambient condition

Effect of treatments on total soluble solutes (°Brix) values of sugarcane juice :

Fig. 2 clearly indicated that the TSS was decreased significantly in all the treatments at all the levels of storage under ambient conditions. Initially, the TSS was maintained at 20 °Brix for all the treated juice T_1(20.4°B),

T_2 (20.1 ºB)and T_3 (20.2 ºB). After 45 days of storage, the minimum decrease in TSS was observed in T_2 (18.8 ºB) followed by T_3 (17.4 ºB).

Damane *et al.* (2015)reported that the decrease in TSS was due to the conversion of sugars to acids during storage because of the biochemical reactions in the juice. However, the decrease was of lesser extent in T_2, which contained chemical preservatives.

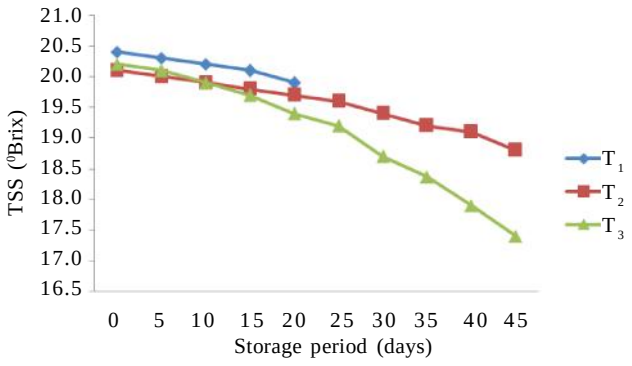

Fig. 2 : Effect of treatments on TSS (ºBrix) of sugarcane juice stored under ambient condition

Effect of treatments on browning index values of sugarcane juice :

During the present investigation, browning index increased significantly in all the treatments at all the levels of storage as depicted in the Fig. 3. Under ambient conditions, after 45 days of storage, minimum increase in browning index was observed in T_2 (13.7) and the maximum in T_3 (23.5). The browning index of the juice was less in initial stages when the microbial load was less. With the increase in microbial load and polyphenol oxidase activity, the juice starts turning brown in colour, indicating the juice spoilage. Therefore with the storage time, the increase was minimum in T_2 and maximum was observed in T_3.

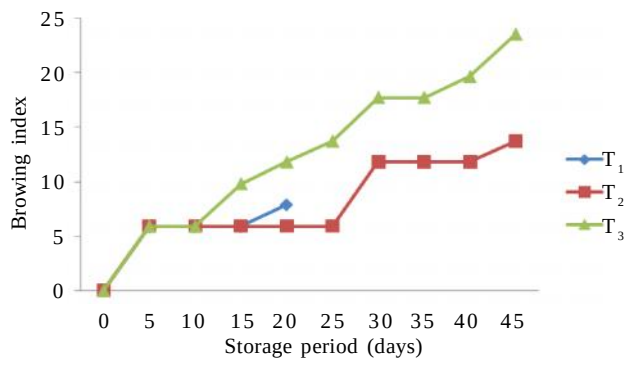

Fig. 3 : Effect of treatments on browning index of sugarcane juice stored under ambient condition

Effect of treatments on total plate count (cfu/ml) sugarcane juice :

From the results of the present study as presented in the Fig. 4 it was clear that total plate count was increased significantly in all the treatments at all the levels of storage. Under ambient conditions, the bacterial growth was increased upto 40 days of storage (maximum increase in T_3, 1.3cfu/ml) and then the value started decreasing. After 45 days of storage, the minimum decrease was observed in T_2 (0.6cfu/ml) followed by T_3 (0.7cfu/ml)

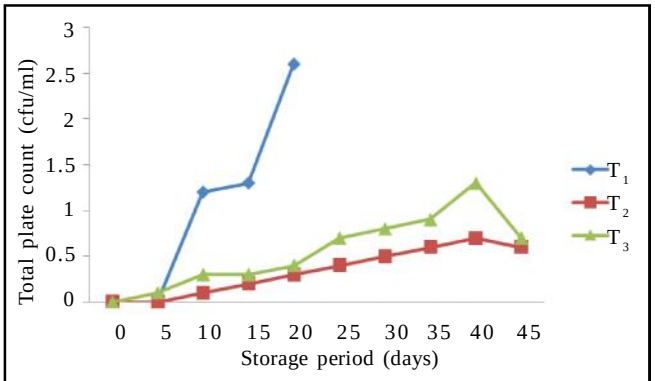

Fig. 4 : Effect of treatments on total plate count of sugarcane juice stored under ambient condition

Pelczar *et al.* (1993) reported that there was increase in the total plate count due to the increase in the microbial count which rises with time. Presence of *Escherichia coli*, enterococci and other coliforms indicate faecal contamination of sugarcane juice, suggesting possible risk of infection involved with drinking such sugarcane juice. There was an increase in bacterial count under ambient conditions showing maximum growth at T_3 and minimum at T_2. Bacteria were found to decrease in T_2 and T_3 after 40 days of storage. This may be due to the production of acetic acid.

Effect of treatments on yeast and mould count (cfu/ml) of sugarcane juice :

During the present investigation, yeast and mould countincreased significantly in all the treatments at all the levels of storage as depicted in the Fig. 5. Under ambient conditions, the growth increases upto 40 days of storage with the minimum increase in T_2 (3.3cfu/ml) followed by T_3 (3.6cfu/ml) and then the value started

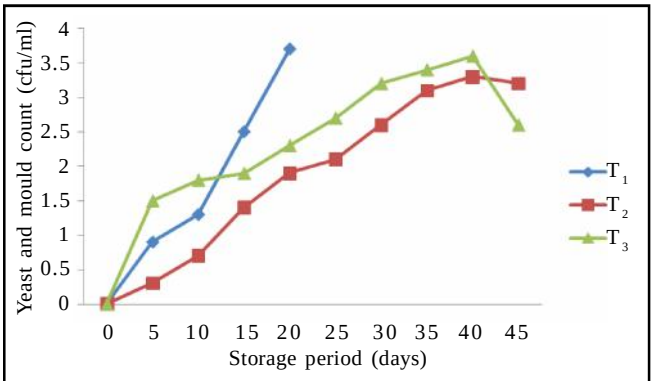

Fig. 5 : Effect of treatments on yeast and mould count of sugarcane juice stored under ambient condition

decreasing. After 45 days of storage, the minimum decrease was observed in T_2 (3.2cfu/ml) followed by T_3 (2.6cfu/ml). The result was good accordance with the result of Krishnakumar *et al.* (2013).

Effect of treatments on overall acceptability of sugarcane juice :

The sensory scores for overall acceptability as depicted from Fig. 6, reduced significantly with the advancement of storage. This may be due to the browning of juice caused by polyphenol oxidase and invertase. The flavour also gets affected due to slight fermentation of the juice and gas production at later stage. The degradation of colour and flavour attributes adversely affects the overall acceptability of the juice.

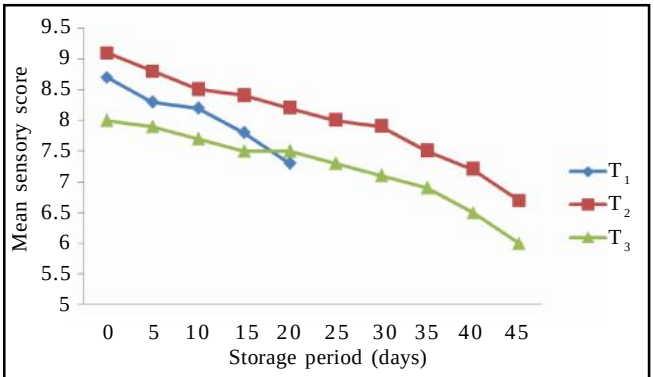

Fig. 6 : Effect of treatments overall acceptability of sugarcane juice stored under ambient condition

Conclusion :

Among three treatments (*i.e.* T_1, T_2 and T_3), T_2 sample was found to be the best depending upon different sensory attributes like appearance, flavour and overall acceptability. This was because the values for all the sensory attributes were maximum for sample T_2 as compared to other treatments. The incorporation of chemical preservatives in the juice enhanced the quality of juice which was observed fit for consumption even after the 45 days of storage under ambient conditions. The pasteurized juice (T_1) also showed acceptable sensory and microbial attributes upto 20 days of storage. Hence, such pasteurized juices which are made without the addition of preservatives have a potential to be commercialized as a beverage.

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