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Effect of delayed extraction and storage on quality of sugarcane juice

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A study was conducted to determine the quality of sugarcane juice extracted from stored canes, as well as changes in quality of fresh juice stored at different temperatures. Cane stems were stored at 10 and 30°C, while the fresh juice was stored at 5 and 30°C. The parameters studied were juice yield, total soluble solids, total sugar content, titratable acidity, pH, viscosity, total microbial count and sensory evaluation for colour and flavor. Results showed that low temperature storage (10°C) of canes was able to maintain the quality of juice for 10 days, while low temperature storage (5°C) of juice could last for only 4 days. Spoilage of cane stored at 30°C occurred faster than that stored at 10°C. Fresh sugarcane juice became spoilt within a day when stored at 30°C. Microbial count (bacteria, yeast, fungi) especially lactic acid bacteria count increased, during storage of cane juice.

Key words: Cane stems, sugarcane juice, storage temperature, juice quality.

INTRODUCTION

Sugarcane (*Saccharum officinarum* L.) is one of the most important commercial crops in the world. As per Sugarcane Statistical Report (2008), India is the second largest producer of sugarcane in the world next to Brazil. In India, sugarcane is grown mainly for producing sweeteners such as sugar, jaggery and khandasari. The composition of sugarcane juice varies with variety, maturity, climatic and soil conditions and also the portion of the stalk from which it is extracted. Among the varieties grown in India, variety CoP 92226 is popular because of its high juice yield and sensory qualities (Chauhan et al., 2002). Sugarcane juice is a type of drink commonly found in Southeast Asia, South Asia and Latin America, and also in other countries where sugarcane is grown commercially. Sugarcane juice is very popular delicious drink and it is rarely available commercially in packaged form.It is extracted by crushing sugarcane between roller crusher and consumed with (or) without ice. Sugarcane juice 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 has many medicinal properties, often it is used as a remedy for jaundice in traditional medicine (Subbannayya et al., 2007). Sugarcane juice, very useful in scanty urination, keeps the urinary flow clear and helps kidneys to perform their functions properly. Sugarcane juice of 100 ml provides 40 Kcal of energy, 10 mg of iron and 6 µg of carotene (Parvathy, 1983). Due to its commercial

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importance, it is envisaged that sugarcane juice production can become a profitable business provided efforts to be made to preserve its fresh quality during storage. In general, sugarcane juice is spoiled quickly due to presence of simple sugars (Krishnakumar and Devadas, 2006a). The quality of cane juice is also affected by chemical (acid) and enzymatic inversion (Singh et al., 2006). At present situation, harvested canes are often stored in the shed at ambient temperature before they are processed. Once the juice is extracted, it should be chilled and stored immediately at chilling temperature before distribution. The delay in extraction of harvested sugarcanes is reported to cause some changes in the juice quality (Densay et al., 1992). It has been observed that low temperature storage able to extend the shelf life of the juice for a few days. However, no study has been conducted to elaborate these parameters. Developing scientific knowledge of these aspects is very essential to the emerging industry. Therefore this study was sought to determine the effects of storing the canes on the quality of juice obtained, as well as to predict the physicochemical and microbiological changes in fresh sugarcane juice stored at different temperatures.

MATERIALS AND METHODS

Sugarcanes (10 ± 11 months old) were cut approximately 1 inch above the field surface and the stems were harvested at an average height of 20 inches. Harvested canes were immediately brought to the laboratory. The study was conducted in two parts. The first part of the study was to monitor changes in the quality of juice extracted from canes that was stored at 10 and 30°C. The second part of the study was to monitor the quality of juice stored at 5 and 30°C.

Quality of juice from stored sugarcanes

Upon arrival to the laboratory, sugarcane stems (CoP 92226) were cleaned and stored at 10 and 30°C for 15 days. Every day four canes were removed from storage for juice extraction. The physico-chemical tests carried out were yield of juice, total sugars, total soluble solids, titratable acidity, pH and sensory evaluation for colour and flavor (Ranganna, 1995). The total soluble solids were measured using an ERMA hand refractometer.

Extraction of sugarcane juice

Canes were cleaned, and cut into pieces of uniform length about 10 inches and washed them into fresh water so as to remove the dust and dirt particles. Extraction was done by three roller crusher. Juice was filtered through a four layer muslin cloth. The extracted juice was collected in a chilled container and chilled immediately before being analyzed. The chilling step is very essential to retain the original colour and flavour of the fresh sugarcane juice.

Quality of stored fresh sugarcane juice

Freshly extracted juice was used. The chilled juice were filled into pre sterilized glass bottles and stored at 5 and 30°C. The juices were subjected to similar physicochemical parameter analysis daily as above until they were considered no longer fit for consumption. Viscosity and microbial counts were also conducted. The viscosity of the juice was measured by digital viscometer (Brookfield Synchro-Lectric viscometer, USA) using spindle No.1 at 60 rpm. All the experiments were carried out in triplicates. Each reading was an average of three samples.

Microbiological analysis

The quality of sugarcane juice was based on the number and type of microorganism present which can be assessed by serial dilution and plating method for the differential enumeration of bacteria, yeast and fungi. Determination of total microbial counts (bacteria, yeast and fungi) for juice was carried out at 0 h and every 24 h. One milliliter 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}, 10^{-3}, 10^{-4}, 10^{-5} and 10^{-6} were prepared. The plates were then incubated at room temperature for 48 h for bacteria and four days for fungi and yeast (Rao, 1986). Enumeration of bacteria was counted by nutrient agar media (Allen, 1953) with 10^{-6} dilutions. Yeast and fungi was counted by yeast extract agar media (Phaff, 1990) with 10^{-4} dilutions and martin's rose bengal medium (Martin, 1950) with 10^{-3} dilutions. The results (number of colony forming units) were obtained after the incubation time using the following formula:

$$\text{Number of Colony Forming Units (CFU's) per gram of sample} = \frac{\text{Mean number of CFU's} \times \text{Dilution Factor}}{\text{Quantity of sample on weight basis}}$$

Sensory evaluation

Sensory evaluation of the juice extracted from stored canes was carried out by 20 panelists. The panelists rated the sample for colour, flavour, taste and acceptability using 9-point hedonic rating test method (1=dislike very much, 9=like very much) as recommended by Ranganna (1995). The evaluation of stored fresh sugarcane juice was carried out by 10 trained panelists using a triangle test. The panelists were asked to identify the odd sample in terms of colour, flavour and taste compared to a freshly extracted juice.

Statistical analysis

Data were subjected to statistical measurement of analysis of variance (ANOVA) using Agres package.

RESULTS AND DISCUSSION

Analysis of sugarcane juice from stored canes yield

Yield

The yield of juice obtained from stored canes seemed to decrease with increase in time of storage (Figure 1). The decrease in juice yield was more in canes stored at ambient temperature (30°C) than stored at 10°C. The yield started to decrease from the first day onwards until

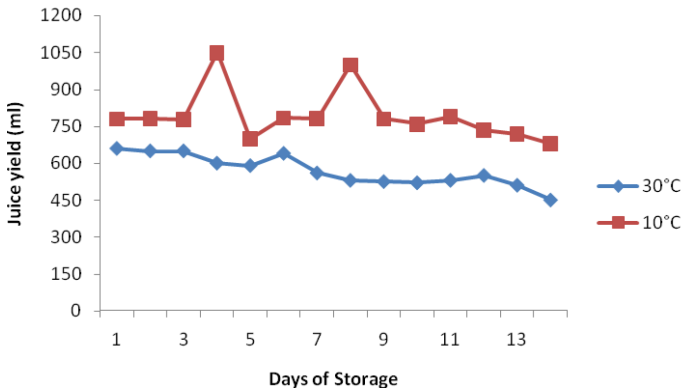

Figure 1. Juice yield from sugarcanes stored at 10 and 30°C.

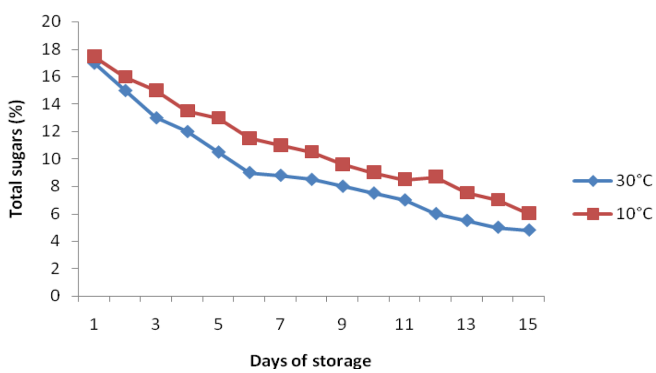

Figure 2. Total sugars contents of juice extracted from sugarcanes stored at 10 and 30°C.

the end of the storage period of 15 days. After 15 days, the yield decreased by 44.5% for canes that were stored at 30°C compared to only 10.5% for those stored at 10°C. In India, the small or road side sugarcane juice sellers get their supply of canes on weekly basis. Before they are extracted, the bundles of canes stored under tree. This study shows that storage at the normal atmospheric temperature would incur great losses in juice yield and is certainly not a wise practice to continue. Meanwhile canes that were stored at 10°C only started to fluctuate in yield after three days of storage.

Total sugars

Storage of cane caused a decrease in total sugars content of the extracted juice (Figure 2). A significant decrease ($p<0.05$) in total sugar content of juice was observed at room and low temperature. The decrease in the sugar content of stored canes at 30°C was faster than at 10°C. The decrease in total sugars content may be due to breakdown of total sugars into reducing and other sugars. Similar results were reported by Sneh sankhla et al. (2012), Chauhan et al. (2002), Bhupinder et al. (1991)

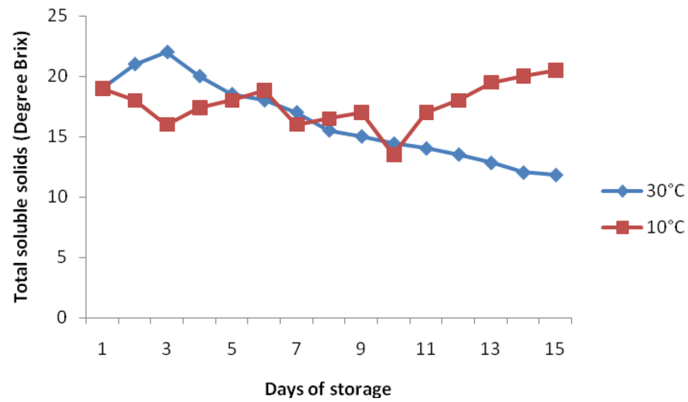

Figure 3. Total soluble solids contents of juice extracted from sugarcanes stored at 10 and 30°C.

for storage of sugarcane juice. Densay et al. (1992) reported that delayed extraction of the juice caused a loss in sugar content.

Total soluble solids (TSS)

There was an initial increase in the TSS content of juice extracted from canes stored at 30°C for the first 3 days of storage and after that it was decreased (Figure 3). This may indicate that, within the three days period, maturation of canes may have continued, resulting in an increase in sweetness. After three days, the TSS content decreased probably due to the onset of senescence. The canes stored at 10°C showed irregular values for TSS up to 9 days, but when the canes became stabilized the value began to increase as in the initial stage of storage at 30°C.

Titratable acidity

The titratable acidity of extracted juice increased during storage (Figure 4). The increase occurred on day 6 for both treatments. Sugarcane stems stored at 30°C recorded higher acidity increases compared to those stored at 10°C. This was perhaps caused by the utilization of sugar during respiration of the cane stem itself. The acidity increase was not identified by panelists until day 9. A similar result of high acidity in sugarcane juice was found out by Bhupinder et al. (1991).

pH

The pH value of juices extracted from canes stored at 30 and 10°C both decreased at about equal rates until day 9 Figure 5). After that the juice of cane stem stored at (30°C had a faster drop compared to the juice of cane stems stored at 10°C. Similar results were reported by

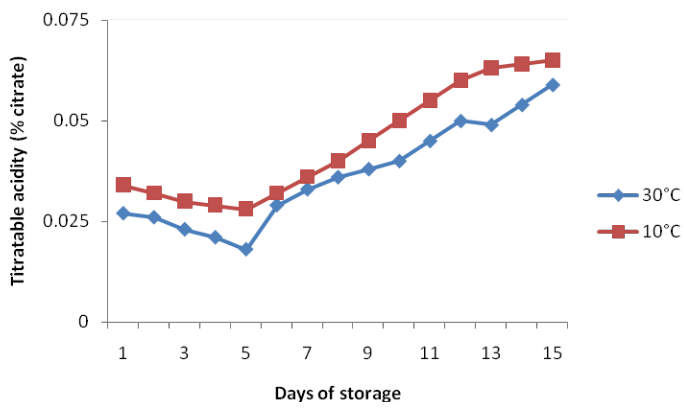

Figure 4. Titratable acidity values of juices extracted from sugarcanes stored at 10 and 30°C.

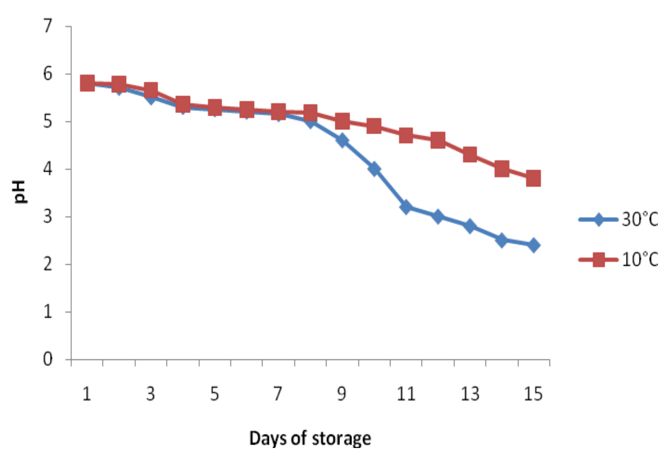

Figure 5. pH values of juice extracted from sugarcanes stored at 10 and 30°C.

Chauhan et al. (1997) for storage of sugarcane juice.

Sensory evaluation

The panelists did not indicate any significant change ($p>0.05$) in the colour of juices that were extracted from canes stored for 3 and 6 days at both storage temperature. However, on day 9 there was a significant difference ($p<0.05$) in the colour among the juices from both types of canes. The canes that were stored at 10°C produced juices that were rated higher in colour (6.8 out of 9) than cane stems stored at 30°C (3.9 out of 9.0). The mean ratings for flavor of the juice samples stored under the two temperature treatments were found to be significantly different also on day 9 ($p<0.05$). The flavor of the juice obtained from cane stems stored at 10°C for 9 days was high (7.53 out 9). This means that sugarcanes may be stored at low temperature (10°C for 9 days) without affecting the flavor of the juice while storage of canes at ambient temperature for 9 days results in development of objectionable flavour. Similar results were reported by Sneh Sankhla et al. (2012) for storage of sugarcane juice using hurdle technology.

Analysis of stored fresh juice

Total sugars

Results indicated that, as storage time increased the total sugars content of sample decreased. The samples stored at 5°C decreased gradually within the storage period of 15 days while the ones stored at 30°C decreased sharply within 3 days (Table 1). The sharp drop in total sugars content that occurred in samples stored at 30°C was perhaps caused by microbes that utilized the sugars and in the end resulted in spoilage of juice. Chauhan et al. (1997) and Puspha Singh et al. (2002) also found similar results in sugarcane juice during storage. Microorganism present in juice leads to decrease total sugars content by formation of organic acid and ethanol (Sneh Sankhla et al., 2012). Major bacteria responsible for spoilage are *Leuconostoc,Enterobacter, Flavobacteruim, Micrococcus, Lactobacillus* and *Actinomyces* (Frazier and Westhoff, 1995).

TSS, titratable acidity and pH

There was an increase in the TSS content of juice stored at 5°C at the initial stage (up to 8 days), but the value decreased with time (Table 1). The juice sample stored at 30°C also showed an increase in TSS before it became spoilt. The increase was perhaps due to the breakdown of total sugars into simple sugars and acids during storage as a result of action of microorganism present in the juice. These observations are in agreement with the findings of Bhupinder et al. (1991). Acidity of juice increased with storage time (Table 1). Similar results were reported by Bhupinder et al. (1991) in sugarcane juice during storage. The increase in acidity caused a concomitant decrease in pH value (Table 1). A similar result reported by Abbo et al. (2006) revealed that there is a corresponding reduction in pH as the acidity increased in Soursoup juice. The reason for high acid and low pH could be due to acetic acid and lactic acid production.

Viscosity

The viscosity of juice stored at 5°C (Table 1) initially decreased within 10 days, after that it increased. Meanwhile the sample that was stored at 30°C recorded a decrease in viscosity. The increase in viscosity of juice stored at low temperature might be due to the development of dextran, that is, a gummy substance produced by bacteria such as *Leuconostoc mesenteroides*.

Table 1. Mean values for the physico-chemical characteristic of sugarcane juice stored at different temperatures.

Temperature (°C)	Storage duration (Days)	Total sugars (%)	Viscosity (cps)	TSS (°Brix)	Titratable acidity (%)	pH (%)
5	0	16.50^{a}	3.00^{a}	16.0^{g}	0.055^{b}	5.72^{a}
	1	16.10^{ab}	3.10^{ab}	17.4^{de}	0.045^{b}	5.79^{a}
	2	15.78^{ab}	3.08^{ab}	17.0^{ef}	0.052^{b}	5.76^{ae}
	3	14.82^{ab}	3.15^{ab}	17.7^{bcd}	0.053^{b}	5.76^{a}
	4	14.32^{ab}	2.72^{ab}	17.7^{bcd}	0.053^{b}	5.69^{ab}
	5	13.84^{abc}	2.49^{b}	18.0^{abc}	0.056^{b}	5.69^{ab}
	6	13.33^{abc}	2.29^{ab}	18.4^{a}	0.058^{b}	5.67^{ab}
	7	13.21^{abc}	2.40^{ab}	18.5^{a}	0.070^{b}	5.66^{ab}
	8	13.12^{abc}	2.50^{ab}	18.2^{ab}	0.063^{b}	5.63^{ab}
	9	13.03^{abc}	2.55^{ab}	17.5^{cd}	0.079^{b}	5.61^{ab}
	10	12.29^{abc}	2.55^{ab}	16.1^{g}	0.088^{b}	5.61^{ab}
	11	12.09^{abc}	2.61^{ab}	18.2^{ab}	0.094^{b}	5.49^{abc}
	12	12.06^{bc}	2.70^{ab}	18.0^{abc}	0.108^{b}	5.37^{abc}
	13	11.08^{cd}	2.77^{ab}	18.1^{ab}	0.058^{b}	5.15^{bcd}
	14	11.01^{cd}	3.11^{a}	17.4^{de}	0.054^{b}	5.05^{cd}
	15	08.78^{d}	3.20^{a}	16.8^{g}	0.149^{a}	4.67^{d}
30	0	16.50^{a}	3.00^{a}	16.0^{b}	0.055^{a}	5.72^{a}
	1	12.60^{b}	2.91^{a}	16.7^{ab}	0.170^{bc}	3.77^{bc}
	2	12.33^{b}	2.42^{ab}	16.10^{b}	0.200^{b}	3.80^{b}
	3	12.18^{b}	2.12^{b}	17.4^{a}	0.220^{c}	3.67^{c}

[a]Means for each storage duration followed by the same letter are not significantly different p>0.05.

Table 2. Mean values for the microbial count of sugarcane juice stored at different temperature.

Storage duration	Temperature (°C)	Bacteria count (Cfu's)	Yeast count (Cfu's)	Fungi count (Cfu's)
1	5	3.27^{a}	0^{b}	0^{b}
	30	3.54^{b}	3.25^{a}	2.12^{a}
3	5	3.72^{b}	0^{a}	0^{a}
	30	4.42^{a}	3.46^{b}	2.16^{b}
6	5	3.74^{a}	0^{a}	2.40^{b}
	30	0.93^{b}	6.15^{b}	6.15^{a}
9	5	5.01^{a}	0^{a}	0^{a}
	30	5.45^{b}	4.41^{b}	4.53^{b}
12	5	2.35^{a}	0^{a}	-
	30	0.35^{b}	5.81^{b}	-
15	5	1.44^{a}	0^{a}	-
	30	0.27^{b}	5.98^{b}	-

[a]Means for each storage duration followed by the same letter are not significantly different p>0.05.

This phenomenon was found by Lotha et al. (1994) who reported that the viscosity of mandarin juices increased during refrigerated storage and decreased when stored at ambient temperature.

Microbiological analysis

There were significant differences (p<0.05) in the bacteria, yeast and fungi of stored juice between storage temperature and duration (Table 2). Microbial count of the juice rises with time. There was an increase in bacteria and yeast count in juice stored at both temperature treatments. However the growth of fungi was detected in juice stored at 5°C on day 6 while no yeast was detected during the total storage period of 15 days. 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 (Pelczar et al., 1993). Richa Karmakar et al. (2011) reported that bacterial contamination may occur at different stages of juice processing such as by contamination of sugarcane, roller crusher, collecting vessel, ice, hands of the personnel and filter cloth. The low temperature storage may have retarded the growth of the organism. The growth of yeast and fungi in juice stored at 30°C increased significantly ($p<0.05$) after 6 days, but bacteria were found to decrease at the later stage of storage.

Conclusion

The yield and quality of juice obtained are essential economic criteria in sugarcane juice business. Results of the study indicate that it is advisable to store sugarcanes at low temperatures to maintain the juice yield. The canes may be stored at 10°C for 9 days and still produce good quality juice, to a maximum of 11 days. Beyond that, the canes suffer chilling injury. The total sugar content of juice decreased after 3 days of storage. The colour and flavor of juice obtained were also superior to canes stored at high temperature. Storage of canes at 30°C for more than 4 days reduced the juice yield drastically. The colours of juice obtained were darker (more brown and less green) than the juices obtained from canes stored at 10°C and the flavour was also different. In the second part of the experiment, it was found that the freshly extracted unpasteurized juice could be kept at 5°C for only 4 days. Beyond that, the quality deteriorated, which could be observed by the colour and flavour change followed by increase in viscosity. The juice became spoilt within a day when kept at 30°C.

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