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RESEARCH ARTICLE

Post-harvest deterioration of sugarcane with special reference to quality loss

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Abstract Six sugarcane varieties were grown and assessed for juice quality maintenance. Post harvest deterioration from 0-120 h and effect of treatments to maintain quality of harvested cane were also studied. The results revealed that when harvested at different maturity (12th to 14th month) cane varieties showed an increase in sucrose upto 13th month and a dip thereafter. Once harvested, there was a steady increase in moisture loss in canes from 24 h to 120 h. During post harvest storage, inversion of sucrose occurs and pol % decreased. Covering the canes with trash and sprinkling of water when stored in sun or sprinkling of water when stored in shade maintains the quality for a longer period.

Keywords sugarcane, post-harvest deterioration, staling losses, pol %, inversion

Introduction

Sugarcane crop, once severed from the ground can do little to manufacture new sugar. In between harvesting and milling, the time lag is generally one to three days during which the extraction of maximum sugar is feasible. On the contrary, once harvested, its capacity to lose stored sucrose increases tremendously due to intrinsic and extrinsic factors. In tropical India, the loss has been found to range from 1.5 to 2.3% for every 24 h storage after harvest during the season. Higher loss up to 25% has been reported during hot season. The reduction in cane weight ranged between 7.4 and 17.0 % and sugar recovery by about 2.0% at different places in India due to staling of cane for 96 h.

The quality loss in cane is primarily due to chemical (acid) and enzymatic inversion reactions, and those from microbial particularly, bacterial inversion through cut ends or damaged sites of stalks (Eggleston, 2002). A large number of factors such as ambient temperature, humidity, variety, period of storage, maturity status etc. are responsible for the difference in post harvest deterioration (Uppal and Sharma, 1999; Uppal *et al*., 2000; Solomon *et al*., 2003, 2007). During harvesting to milling, the activity of invertases and proliferation of acid, ethanol and polysaccharide producing microbes play a crucial role in loss of recoverable sugars in the cane and milled juice (Sharma *et al*., 1994; Solomon *et al*., 2006; Solomon, 2009).

Besides ambient temperature, varieties also play a major role in sustaining recoverable sugars and cause varied behaviour at harvest/ staling. Intrinsic factors such as genetic and biochemical constitution of genotypes, stage of maturity and cane quality at harvest affects the rate of post-harvest deterioration of canes. Therefore, the raw materials should be crushed as early as possible to avoid sugar losses due to staling. To help this cause, the present investigation was undertaken to assess the juice quality maintenance in the field in different varieties, and effect of staling up to 120 h from 12th to 14th months of age. Also, the effect of different treatments on retaining the juice quality and technological parameters was studied.

Materials and Methods

A field experiment was conducted at the research farm of Sugarcane Breeding Institute, Coimbatore (India) to assess

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the quality loss of cane at harvest. The average annual rainfall is 640 mm and major portion of the total rainfall is received through South West Monsoon during the months of October to December. The average mean maximum and minimum temperatures are 31.5°C and 21.0°C, respectively.

Two budded setts of six sugarcane varieties namely Co 85019, Co 86032, Co 86249, Co 91010, Co 94005 and Co 94008 were planted in the field in February in Randomized Block Design (RBD) replicated thrice. Recommended fertilizers and irrigation were provided and cultural operations were done as per schedule. Samples were collected from February to April for quality estimation and staling purposes. Each variety was kept from 0 to 120 h in open field condition for staling after harvest. The cane weight and juice quality analysis was carried out at 24 h interval. The data collected has been presented in the tables.

Canes were also subjected to various treatments like storing under sun or shade, with the canes either covered with trash or sprinkled with water or both covered with trash and sprinkled with water to study the extent of deterioration upto 96 h after harvest. The quality parameters viz., moisture loss and juice quality changes were estimated in the samples subjected to the above treatments.

Composite samples of randomly selected 20 canes from each replicate were used in this study for weight loss and evaluation of cane quality parameters. The juice quality was analyzed every day to assess post harvest quality losses.

Purity %: The purity % was calculated using the formula

$$\text{Purity\%} = \frac{\text{Sucrose}}{\text{Brix}} \times 100$$

Recoverable Sugars: The recoverable sugars were calculated using the formula

CCS% = 1.022 S – 0.292 B (where S = Sucrose and B = Brix)

The Brix in juice was recorded with Brix hydrometer and the clarified juice was analyzed for sucrose content with Polarimeter.

Reducing Sugars: Reducing sugars in juice were estimated by the methods of Nelson (1944).

Results and Discussion

Juice quality maintenance

In canes harvested in the 12th, 13th and 14th month (Table 1), almost each variety showed an increase in juice sucrose and purity per cent in the 13th month followed by a dip in the 14th month with exceptions. The variety Co 86249 continued to show increasing juice sucrose and purity values from 12th to 14th month whereas the variety Co 94008 showed a declining trend for both these characters from 12th to 14th month. The highest juice sucrose value of 19.9% was recorded in Co 86032 in the 13th month. Highest purity % of 92.5 was however recorded in Co 91010 in the 13th month.

Post harvest deterioration/ Effect of staling on juice quality

Moisture loss

A reduction in cane weight was recorded due to staling and the magnitude increased with increasing staling time (Table 2). There was a steady increase in moisture loss from 3% at 24 h to around 10% at 120 h. The loss of moisture over staling time was lowest when cane was harvested in the 13th month compared to the 12th or 14th month. Cane weight loss over time was highest when harvested in the 14th month. The increase in maximum and minimum temperatures from February onwards appears to be responsible for the increasing loss in cane weight due to driage. Similar results have been reported by Siddhant *et al.* (2008). Weight loss is mainly attributed to evaporatory losses and respiratory losses (Alexander, 1973).

Sucrose %

Pol % increased with increase in staling hours upto a certain point and then decreased. When harvested in the 12th month, highest pol % was recorded at 72 h while it was highest after 96 h when canes were harvested at 13th month. When harvested late in maturity at 14th month, deterioration in pol % sets in after 48 h itself, and is more pronounced. Higher loss in recoverable sugars and cane weight has been earlier reported by Solomon *et al*. (1997) and Singh and Solomon (2003). It is also observed that in harvested stored cane, decline in sucrose content is not proportional to the increase in the level of invert sugars. This may be due to the fact that invert sugars are continuously used in the process of respiration and other metabolic activities. These studies have indicated that many hydrolytic enzymes are also activated during storage of cane, which are responsible for decline in its quality. These enzymes in harvested cane play a major role in loss of sucrose.

Purity%

Staling beyond 48 h lead to decrease in purity % in the 13th and 14th months while reduction in pol % began after 24 h staling itself when canes were harvested at 12th month. The highly pronounced reduction in purity % implies that canes are to be processed within 24 to 48 h after harvest to obtain maximum recovery.

Table 1. Juice quality maintenance of certain varieties from 12 to 14 months

Variety	Sucrose%			Purity %			Titrable Acidity		
	12th month	13th month	14th month	12th month	13th month	14th month	12th month	13th month	14th month
Co 85019	18.5	19.5	19.0	84.5	89.6	87.5	0.21	0.38	0.32
Co 86032	17.4	19.9	18.3	83.1	86.4	87.5	0.23	036	0.38
Co 86249	16.3	17.1	17.6	80.4	86.6	87.4	0.23	0.26	0.33
Co 91010	18.3	19.1	18.9	84.8	92.5	91.4	0.21	0.21	0.25
Co 94005	18.1	19.3	18.8	81.5	89.1	87.5	0.31	0.30	0.39
Co 94008	18.1	17.8	17.3	82.7	87.3	88.4	0.30	0.41	0.41
Mean	17.8	18.8	18.3	82.8	88.6	88.3	0.25	0.32	0.35

Table 2. Effect of staling on juice quality parameters from 0 to 120 hours after harvest

Variety	Moisture loss %			Sucrose%			Purity %		
	12th month	13th month	14th month	12th month	13th month	14th month	12th month	13th month	14th month
Zero	-	-	-	17.8	18.8	18.3	83.0	89.0	88.0
24	3.3	3.1	3.0	19.7	19.2	18.8	90.0	90.0	88.0
48	5.5	4.8	5.6	19.5	19.4	19.0	87.0	90.0	88.0
72	7.5	6.4	7.9	19.9	19.5	18.8	87.0	87.0	84.0
96	9.0	7.2	9.4	19.7	19.7	18.4	86.0	86.0	82.0
120	10.6	9.2	11.3	19.6	19.1	18.4	82.0	83.0	80.0
Mean	7.2	6.1	7.4	19.4	19.3	18.6	85.8	87.5	85.0

Table 3. Effect of staling on juice quality parameters from 0 to 120 hours after harvest

Variety	Reducing Sugars %			Electrical Conductivity			Titrable Acidity		
	12th month	13th month	14th month	12th month	13th month	14th month	12th month	13th month	14th month
Zero	0.62	0.68	0.62	6.0	5.8	7.0	0.25	0.32	0.35
24	0.90	0.68	0.72	5.7	6.3	6.8	0.29	0.37	0.37
48	1.03	0.95	1.09	5.7	5.9	5.8	0.31	0.39	0.39
72	1.48	1.42	1.75	5.9	6.0	7.3	.33	0.36	0.39
96	1.71	1.55	2.41	5.9	6.4	7.1	0.29	0.29	0.40
120	2.46	2.58	3.58	6.0	7.8	7.3	0.34	0.39	0.42
Mean	1.40	1.30	1.70	5.9	6.4	6.9	0.30	0.40	0.40

Table 4. Effect of various treatments on post harvest quality parameters

Treatment	Moisture loss	Extrac-tion %	Sucrose %	CCS %	Purity %	RS %	Titrable acidity	EC (dS/m)
Sun control	7.6	48.5	16.5	11.0	82.6	1.01	0.22	4.77
Sun + trash cover	6.0	48.8	16.5	10.9	82.3	0.94	0.21	4.73
Sun + water sprinkle	5.4	47.7	16.5	11.0	82.0	1.02	0.23	4.79
Sun + trash + water	4.6	47.2	16.2	10.5	82.4	0.86	0.22	4.77
Shade control	4.7	48.4	16.8	11.4	82.9	0.89	0.24	4.73
Shade + trash cover	4.0	48.4	16.6	11.2	83.7	0.87	0.22	4.75
Shade + water sprinkle	4.3	48.5	16.7	11.3	84.6	0.94	0.23	4.81
Shade + trash + water	4.1	48.2	16.7	10.9	83.0	1.01	0.22	4.82

Reducing Sugars

Sucrose inversion to reducing sugars is an important indicator of cane quality deterioration. Earlier reports by Magdum *et al*. (1987), Ahmad and Khan (1988) and Guar and Desai (1988) have indicated increase in reducing sugars in juice after storage of the harvested canes. During five days of storage (Table 3), per cent increase in reducing sugars was more as staling time increased and also with increase in the age of crop at harvest ie. sucrose inversion to reducing sugars was quicker in canes harvested at 14th month than when harvested at 12th month. There was four to five fold increase in reducing sugars content of juice as staling time progressed from 0 to 120 h. During staling, juice gets concentrated (Uppal, 2003) due to loss in moisture which probably results in increase in invertase activity. The insulating effect provided by higher water content on cellular temperature gets diminished during storage due to loss of water, resulting in activity of invertases (Batta and Singh, 1991).

Technological Parameters - EC and Titrable acidity

The electrical conductivity values of juice showed increased values at 14th month as compared to 12th month. The titrable acidity values showed an increase with post harvest deterioration particularly at 14th month.

Effect of various treatments on post harvest quality parameters

The study revealed that covering harvested canes left under sun or shade with trash or covering with trash and sprinkling with water were able to reduce moisture loss and prevent the quality deterioration (Table 4). However, storage of canes in shade and covering with trash was found to bring down the moisture loss very much. The sucrose % , CCS % and purity % recorded higher values when stored under shade. Storage of canes under shade and sprinkling of water was able to maintain juice quality characteristics for a longer period.

When stored under sun, covering with trash or sprinkling with water maintained sucrose %, CCS % while sucrose inversion to reducing sugars was lowest when canes were covered with trash and sprinkled with water. Covering canes with trash when stored in sun reduced EC while EC was found to increase when stored under shade irrespective of the treatment.

Thus it can be inferred that, post harvest deterioration brings about qualitative and quantitative changes in the composition of juice. It appears that all sugarcane varieties are prone to losses in cane weight, sucrose and purity % in response to the delay in crushing after harvest. The losses become more pronounced with the age of canes at harvest and the staling time. Loss in sucrose could be due to increase in invertase and other hydrolytic enzymes activated during storage. When harvested canes are stored under sun, covering them with trash and sprinkling with water caused the lowest sucrose inversion. Storage of canes under shade and sprinkling of water maintains the juice quality for a longer period of time.

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