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RESEARCH ARTICLE

Post harvest quality deterioration in sugarcane under different environmental conditions

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Abstract Post harvest changes in the juice quality parameters in relation to storage time were investigated in three sugarcane genotypes varying in maturity behaviour viz.CoJ83 (early),CoJ88 (mid) and S70/00(late) under different environmental conditions i.e in the month of November, January and March. A gradual decrease in cane weight, % juice extraction, sucrose (% juice), purity (% juice) and pH with simultaneous increase in TSS%, titrable acidity, dextran , reducing sugars and activities of acid and neutral invertases was found in juice during 12 days of cane storage in all genotypes under all environmental conditions. Irrespective of the genotype and environmental condition, the level of neutral invertase was found to be higher as compared to acid invertase except in genotype S70/00, where higher activity of acid invertase was found as compared to neutral invertase during the month of November. The rate of decrease/increase per day of all the quality parameters on staling was highest during the late crushing period i.e. March than during November and January in all genotypes. More deterioration in quality parameters was found in genotype CoJ83 during March and in genotype S70/00 during November, which may be due to their over mature and immature conditions, respectively, at that time. Hence, the variation in the rate of change in quality parameters during staling may be attributed to the difference in maturity level among genotypes during these three months.

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Introduction

India ranks second in the world with respect of cane production. However, sugar recovery and sugar productivity per unit area per unit time in India is the lowest among the top six sugar producing countries. The existing cane harvesting and supply management system operating in India, especially in sub-tropical cane growing belt is a serious impediment in attaining higher sugar recovery. Due to poor management of cane and constraints of labour for transporting cane from field to factory, time lag between harvesting to milling sometimes ranges between 3 to 10 days which leads to staling of cane resulting sugar recovery below economic limits. Nearly one fourth of cane crushed in Indian sugar factories has been found to be stale in quality (Sharma and Batta, 1993). The average annual loss to Indian Sugar Industry, as a result of lower sugar recovery, had been estimated to be about Rs. 1600 crores (~32 x 10^7 US$) (Solomon, 1994). Despite huge monitory losses to sugar industry, the management approach to curb post-harvest sucrose losses is almost non-existent. It may be due to lack of much information regarding the post-harvest sucrose losses in commercial cane genotypes grown under different agro-climatic conditions.

Sugarcane juice quality is principally determined by its sucrose content. Sucrose, which is synthesized in leaves, is translocated through sheath to stalk where it is accumulated in cell vacuoles. Both cell wall bound and intracellular localized soluble invertases are thought to play distinct roles during translocation of sucrose from apoplasm to symplasm of sugarcane (Hawker and Hatch, 1965) and in mobilization of sucrose stored in the cell vacuole (Gayler and Glasziou, 1972). These enzymes do remain active in the harvested cane and in the milled juice, thereby causing massive hydrolysis of sucrose. In addition to sucrose hydrolysis by endogenous invertases, production of polysaccharides by bacteria also contributes to post-harvest deterioration of cane juice. Among the polysaccharides, dextran (an α-1, 6-linked glucose polymer with random α-1, 3 and α-1, 4 branching), which is synthesized from sucrose by enzyme dextransucrase secreted by bacterium *Leuconostoc mesenteroides* (Clarke *et al*., 1980), has received much attention. Polysaccharide dextran, in addition to its effect on sugar recovery, is infamous for its anti-filtration, anti-evaporation and anti-crystallization properties during sugar manufacturing (Hylton,1997). A large number of factors such as ambient temperature, humidity, genotype, period of storage, maturity status, pre milling cane preparation etc. have been found to be responsible for variation in post-harvest deterioration rate (Uppal and Sharma, 1999; Uppal *et al.*,2000,2008; Solomon,2000, 2009; Solomon *et al.,* 2003, 2006; Siddant *et al*., 2008). So it is imperative that post-harvest quality profile of cane genotypes which are recommended for commercial cultivation, be worked out to assess the magnitude of sucrose losses during different crushing periods and also to organize cane supply on scientific lines. The present study was undertaken with the objective to quantify sucrose transformation to invert sugars and soluble polysaccharides in relation to juice quality as a function of time of storage of sugarcane genotypes differing in maturity behavior under different environmental conditions.

Materials and Methods

Three sugarcane genotypes differing in maturity behaviour viz. CoJ 83 (early maturing), CoJ88 (mid maturing) and S70/00 (late maturing) were raised at Punjab Agricultural University Sugarcane Research Farm at Ladhowal, following the recommended agronomic and cultural practices. The sugarcane plants were harvested at different stags of crop development in late fortnight of November, January and March. Samples were collected always in morning (i.e 9.00 A. M) so as to minimize diurnal variations. Canes were topped (i.e. leaves and trash removed) and were stored under natural conditions upto 12 days. Representative samples of 10 stalks in each of three replications were crushed on 0^{th}, 2^{nd}, 4^{th}, 6^{th},8^{th} 10^{th} and 12^{th} day of storage and extraction % was measured. Juice was analysed for quality parameters by standard methods. Brix was measured by hydrometry. The clarified juice was analysed with sucromat (digital automatic saccharimeter) for sucrose and purity. Reducing sugars in juice were estimated by the method of Nelson (1944). Juice was dialysed and soluble invertase activity was measured by the method of Hatch *et al.* (1963). Titrable acidity was measured by the method of AOAC (1990). Polysaccharide dextran was estimated by the method of Roberts et al (1983). The linear regression coefficients for different quality parameters were calculated (Gomez and Gomez, 1984).

Results and Discussion

Storage of canes for 12 days resulted in gradual decrease in cane weight, extraction %, purity %, sucrose %, pH of juice with concomitant increase in total soluble solids, titrable acidity, dextran, reducing sugars and activities of soluble invertases regardless of the genotype or environmental conditions. The loss in cane weight during 12 days storage period was highest in genotype S70/00 (9.95%) in November as compared to CoJ 83 (9.52%) and CoJ88 (8.88 %). However, during the late crushing period i.e in March, the loss in cane weight was found to be more in genotype CoJ83 (28.72%) (Table 1). Cane weight loss is mainly attributed to evaporation losses (Sharma *et al*.,2004). Lowest cane weight loss was found to be in genotype CoJ88 under all environmental conditions. Cane weight loss between 7.14 % and 15 % was also observed by Solomon (1994) under subtropical conditions. Depending upon genotype and environmental condition decrease in percent juice extraction and increase in TSS during 12 day storage period ranged from 3.79 to 28.49 % and 5.93 to 39.39 % respectively (Tables 2,3). This may be due to moisture loss which resulted in increase in juice viscosity. In November and January, S70/00 showed comparatively more decline in percent juice extraction (19.05% and 7.97 %) as well as rate of decline (1.67 and 0.57) as compared to other genotypes. However, in March decline in percent juice extraction and rate of decline was more in CoJ 83 (28.49%, 2.80) than S70/00 (19.10%, 1.73) and CoJ88 (23.83%,2.01). Irrespective of the genotype, more decrease in cane weight, percent juice extraction, and increase in TSS was found in March as compared to November and January which is a reflection of more moisture loss in harvested canes during the month of March due to higher ambient temperature. Higher moisture losses during late crushing season have been reported earlier (Uppal and Sharma, 1999). A significant decline in sucrose (% juice) and purity was also found in stale cane with advancement in storage period (Table 4). Lowest rate of decrease in sucrose percent per day (i.e b value) was found in January in all the genotypes. Loss in juice purity (Table 5) was attributed to decrease in sucrose (Table 4) and increase in TSS (Table 3) during storage. Steel and Trost (2006) reported that the presence of bacteria reduced the sugar purity, which may be another reason for reduction of purity on staling. A gradual increase in titrable acidity with parallel decline in pH of juice was also observed in all the genotypes during storage. However, this effect was more pronounced during late crushing period i.e at high temperature as reported by Mao *et al*. (2006). Sucrose inversion to reducing sugars is an important indicator of cane quality deterioration. Levels of reducing sugars enhanced during 12 days of storage

Table 1. Changes in single cane weight (kg) with increase in storage time

Days of storage	November			January			March		
	CoJ83	CoJ88	S70/00	CoJ83	CoJ88	S70/00	CoJ83	CoJ88	S70/00
0	0.578	0.518	0.442	0.944	0.872	1.129	0.853	0.628	1.097
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
2	0.568	0.511	0.434	0.922	0.859	1.108	0.838	0.619	1.072
	(1.73)	(1.35)	(1.81)	(2.33)	(1.49)	(1.86)	(1.76)	(1.43)	(2.28)
4	0.557	0.503	0.424	0.919	0.854	1.102	0.767	0.585	0.989
	(3.63)	(2.90)	(4.07)	(2.65)	(2.06)	(2.39)	(10.08)	(6.85)	(9.85)
6	0.547	0.496	0.418	0.914	0.851	1.093	0.733	0.575	0.960
	(5.36)	(4.25)	(5.43)	(3.18)	(2.41)	(3.19)	(14.07)	(8.44)	(12.49)
8	0.539	0.491	0.413	0.899	0.843	0.958	0.701	0.557	0.931
	(6.75)	(5.21)	(6.56)	(4.77)	(3.33)	(15.15)	(17.82)	(11.31)	(15.13)
10	0.527	0.483	0.406	0.889	0.837	0.944	0.628	0.526	0.871
	(8.82)	(6.76)	(8.14)	(5.83)	(4.01)	(16.39)	(26.38)	(16.24)	(20.60)
12	0.523	0.472	0.398	0.885	0.835	0.933	0.608	0.518	0.863
	(9.52)	(8.88)	(9.95)	(6.25)	(4.24)	(17.36)	(28.72)	(17.52)	(21.33)
b value	0.821	0.712	0.805	0.499	0.340	1.681	2.562	1.551	1.895
R^2 value	0.992	0.992	0.992	0.955	0.959	0.863	0.982	0.981	0.969

b value- Rate of per cent decrease per day R^2 value- Regression co-efficient
Values in parentheses represent per cent decrease w.r.t. 0 day

Table 2. Changes in per cent juice extraction with increase in storage time

Days of storage	November			January			March		
	CoJ83	CoJ88	S70/00	CoJ83	CoJ88	S70/00	CoJ83	CoJ88	S70/00
0	57.92	54.52	59.21	50.17	52.81	51.92	50.89	50.40	50.43
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
2	57.37	54.27	57.72	49.48	52.51	50.75	50.25	48.44	48.39
	(0.95)	(0.46)	(2.52)	(1.38)	(0.57)	(2.25)	(1.26)	(3.89)	(4.05)
4	55.93	52.43	56.90	48.99	52.43	49.92	46.38	44.48	47.70
	(3.44)	(3.83)	(3.90)	(2.35)	(0.72)	(3.85)	(8.86)	(11.75)	(5.41)
6	53.67	51.30	54.43	48.79	52.20	49.69	39.19	42.37	42.92
	(7.34)	(5.91)	(8.07)	(2.75)	(1.16)	(4.30)	(22.99)	(15.93)	(14.89)
8	52.87	50.59	53.70	48.61	51.70	49.21	37.65	41.91	42.40
	(8.72)	(7.21)	(9.31)	(3.11)	(2.03)	(5.22)	(26.02)	16.85)	(15.92)
10	52.18	48.25	48.60	47.96	51.30	48.98	36.58	39.46	41.16
	(9.91)	(11.50)	(17.92)	(4.41)	(2.75)	(5.66)	(28.12)	(21.71)	(18.38)
12	51.02	47.55	47.93	47.74	50.81	47.78	36.39	38.39	40.80
	(11.91)	(12.78)	(19.05)	(4.84)	(3.79)	(7.97)	(28.49)	(23.83)	(19.10)
b value	1.055	1.142	1.671	0.382	0.305	0.574	2.798	2.008	1.726
R^2 value	0.973	0.976	0.944	0.966	0.953	0.944	0.896	0.959	0.923

b value- Rate of per cent decrease per day R^2 value- Regression co-efficient
Values in parentheses represent per cent decrease w.r.t. 0 day

Table 3. Changes in total soluble solids (%) with increase in storage time in three sugarcane cultivars under different environmental conditions

Days of storage	November			January			March		
	CoJ83	CoJ88	S70/00	CoJ83	CoJ88	S70/00	CoJ83	CoJ88	S70/00
0	20.25	20.00	17.45	21.25	21.00	20.45	22.90	21.45	21.45
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
2	20.30	20.40	17.60	22.00	21.25	21.00	23.70	22.00	22.80
	(0.25)	(2.00)	(0.86)	(3.53)	(1.19)	(2.69)	(3.49)	(2.56)	(6.29)
4	20.45	20.50	17.70	22.20	21.45	21.05	25.35	22.75	25.00
	(0.99)	(2.50)	(1.43)	(4.47)	(2.14)	(2.93)	(10.70)	(6.06)	(16.55)
6	20.60	20.55	17.75	22.35	21.60	21.35	26.45	23.50	26.50
	(1.73)	(2.75)	(1.72)	(5.18)	(2.86)	(4.40)	(15.50)	(9.56)	(23.54)
8	20.85	20.75	17.85	22.45	21.75	21.45	26.80	25.50	27.10
	(2.96)	(3.75)	(2.29)	(5.65)	(3.57)	(4.89)	(17.03)	(18.88)	(26.34)
10	21.25	21.10	18.10	22.50	22.20	21.60	26.95	25.65	28.45
	(4.94)	(5.50)	(3.72)	(5.88)	(5.71)	(5.62)	(17.69)	(19.58)	(32.63)
12	21.45	21.40	19.05	22.80	22.40	21.90	28.35	28.00	29.90
	(5.93)	(7.00)	(9.17)	(7.29)	(6.67)	(7.09)	(23.80)	(30.54)	(39.39)
b value	0.522	0.523	0.610	0.496	0.546	0.520	1.899	2.479	3.230
R^2 value	0.947	0.947	0.738	0.841	0.976	0.944	0.947	0.950	0.993

b value- Rate of per cent decrease per day R^2 value- Regression co-efficient
Values in parentheses represent per cent decrease w.r.t. 0 day

Table 4. Changes in sucrose (% juice) with increase in storage time

Days of storage	November			January			March		
	CoJ83	CoJ88	S70/00	CoJ83	CoJ88	S70/00	CoJ83	CoJ88	S70/00
0	17.22	17.33	17.27	18.76	18.32	18.17	20.58	18.72	20.04
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
2	17.06	17.28	17.21	18.71	18.29	17.45	19.77	18.66	19.49
	(0.93)	(0.29)	(0.35)	(0.27)	(0.16)	(3.96)	(3.94)	(0.32)	(2.74)
4	17.00	16.40	16.24	18.44	18.19	16.49	17.83	15.75	16.31
	(1.28)	(5.37)	(5.96)	(1.71)	(0.71)	(9.25)	(13.36)	15.87)	(18.61)
6	16.99	15.59	15.43	18.32	17.96	16.48	17.13	15.08	15.78
	(1.34)	(10.04)	(10.65)	(2.35)	(1.97)	(9.30)	(16.76)	(19.44)	(21.26)
8	16.84	15.51	15.31	18.12	17.93	16.02	15.77	14.32	15.48
	(2.21)	(10.50)	(11.35)	(3.41)	(2.13)	(11.83)	(23.37)	(23.50)	(22.75)
10	16.42	15.04	14.30	17.87	17.86	15.93	14.83	13.34	15.37
	(4.65)	(13.21)	(17.20)	(4.74)	(2.51)	(12.33)	(27.94)	(28.74)	(23.75)
12	16.30	15.00	13.81	17.69	17.64	15.90	14.24	12.90	14.78
	(5.34)	(13.44)	(20.01)	(5.70)	(3.71)	(12.49)	(30.81)	(31.09)	(26.25)
b value	0.437	1.276	1.774	0.369	0.309	1.106	2.692	2.823	2.218
R^2 value	0.890	0.926	0.973	0.961	0.956	0.848	0.982	0.932	0.820

b value- Rate of per cent decrease per day R^2 value- Regression co-efficient
Values in parentheses represent per cent decrease w.r.t. 0 day

Table 5. Changes in purity (% juice) with increase in storage time

Days of storage	November			January			March		
	CoJ83	CoJ88	S70/00	CoJ83	CoJ88	S70/00	CoJ83	CoJ88	S70/00
0	81.51	86.64	85.30	88.27	86.80	87.34	89.86	87.27	93.46
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
2	79.88	84.70	84.79	85.04	86.07	84.29	83.42	84.82	85.48
	(2.00)	(2.25)	(0.60)	(3.66)	(0.84)	(3.55)	(7.17)	(2.80)	(8.53)
4	79.08	79.99	83.36	83.07	84.81	79.29	70.34	69.24	65.24
	(2.99)	(7.68)	(2.28)	(5.89)	(2.29)	(9.22)	(21.72)	(20.66)	(30.19)
6	78.85	75.87	81.51	82.28	83.74	77.77	64.78	64.16	59.53
	(3.26)	(12.43)	(4.44)	(6.78)	(3.52)	(10.96)	(27.91)	(26.48)	(36.30)
8	77.54	74.74	80.05	80.73	82.38	75.76	58.84	56.17	56.97
	(4.87)	(13.74)	(6.16)	(8.54)	(5.08)	(13.27)	(34.53)	(35.63)	(39.04)
10	74.15	71.27	67.31	80.18	80.74	73.91	55.04	52.01	53.71
	(9.03)	(17.74)	(21.09)	(9.17)	(6.98)	(15.38)	(38.76)	(40.40)	(42.53)
12	69.82	70.07	64.40	79.20	78.75	73.20	50.23	46.07	49.43
	(14.35)	(19.12)	(24.50)	(10.27)	(9.27)	(16.20)	(44.10)	(47.21)	(47.11)
b value	1.056	1.689	2.119	0.795	0.768	1.365	3.767	4.149	3.903
R^2 value	0.861	0.973	0.822	0.928	0.981	0.941	0.964	0.968	0.882

b value- Rate of per cent decrease per day R^2 value- Regression co-efficient
Values in parentheses represent per cent decrease w.r.t. 0 day

Table 6. Changes in reducing sugars (mg/ml of juice) with increase in storage time

Days of storage	November			January			March		
	CoJ83	CoJ88	S70/00	CoJ83	CoJ88	S70/00	CoJ83	CoJ88	S70/00
0	0.66	0.83	2.92	0.36	0.97	0.81	1.17	1.72	1.73
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
2	0.73	1.07	4.14	0.65	1.45	1.41	8.64	5.62	4.80
	(10.6)	(28.9)	(41.78)	(80.6)	(49.5)	(74.1)	(638.5)	(226.7)	(177.5)
4	1.28	1.39	5.16	1.47	3.60	2.77	13.89	12.66	8.85
	(93.9)	(67.5)	(76.71)	(308.3)	(271.1)	(241.9)	(1087.2)	(636.0)	(411.6)
6	1.57	1.73	6.45	5.81	7.01	8.16	22.64	20.85	9.49
	(137.9)	(108.4)	(120.89)	(1513.9)	(622.7)	(907.4)	(1835.0)	(1112.2)	(448.5)
8	1.80	2.19	8.03	6.42	8.17	9.34	56.67	55.11	59.12
	(172.7)	(163.9)	(175.00)	(1683.3)	(742.3)	(1053.1)	(4735.0)	(3104.1)	(3317.3)
10	2.19	2.53	8.84	7.22	14.13	16.88	71.17	83.94	61.68
	(231.8)	(204.8)	(202.74)	(1905.6)	(1356.7)	(1983.9)	(5982.9)	(4780.2)	(3465.3)
12	2.36	3.07	11.13	7.86	18.8	20.85	72.99	84.67	62.8
	(257.6)	(269.9)	(281.16)	(2083.3)	(1835.0)	(2474.1)	(6138.5)	(4822.7)	(3528.3)
b value	23.16	22.52	22.619	201.84	153.83	215.84	586.38	466.35	359.33
R^2 value	0.981	0.989	0.988	0.908	0.934	0.932	0.928	0.910	0.824

b value- Rate of per cent decrease per day R^2 value- Regression co-efficient
Values in parentheses represent per cent decrease w.r.t. 0 day

Table 7. Changes in dextran (µg/ml of juice) with increase in storage time

Days of storage	November			January			March		
	CoJ83	CoJ88	S70/00	CoJ83	CoJ88	S70/00	CoJ83	CoJ88	S70/00
0	18.97	20.36	21.16	28.84	34.56	28.31	51.25	52.67	55.35
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
2	19.69	23.75	22.64	39.95	38.22	37.50	59.82	60.63	58.21
	(3.80)	(16.65)	(6.99)	(38.52)	(10.59)	(32.46)	(16.72)	(15.11)	(5.17)
4	21.83	33.66	33.67	41.52	45.45	40.49	69.30	63.71	64.73
	(15.06)	(65.32)	(59.12)	(43.97)	(31.51)	(43.02)	(35.22)	(20.96)	(16.95)
6	29.24	40.36	58.93	56.43	73.75	62.91	70.36	66.87	70.18
	(54.14)	(98.32)	(178.50)	(95.67)	(113.40)	(122.22)	(37.29)	(26.96)	(26.79)
8	39.74	51.17	90.31	60.40	75.89	74.91	75.35	75.94	73.75
	(109.49)	(151.33)	(326.80)	(109.43)	(119.59)	(164.61)	(47.02)	(44.18)	(33.24)
10	47.50	60.45	93.39	78.84	82.15	87.41	147.05	142.50	143.27
	(150.40)	(196.91)	(341.35)	(173.37)	(137.70)	(208.76)	(186.93)	(170.55)	(158.84)
12	47.69	75.89	95.18	82.83	92.86	94.02	166.07	167.86	165.09
	(151.40)	(272.74)	(349.81)	(187.21)	(168.69)	(232.11)	(224.04)	(218.70)	(198.27)
b value	15.074	22.643	35.552	16.051	15.186	20.953	18.344	17.735	16.451
R^2 value	0.932	0.976	0.919	0.969	0.939	0.974	0.790	0.778	0.772

b value- Rate of per cent decrease per day R^2 value- Regression co-efficient
Values in parentheses represent per cent decrease w.r.t. 0 day

Table 8. Changes in acid invertase activity (µmol Sucrose hydrolysed/min/ml of juice) with increasing storage time

Days of storage	November			January			March		
	CoJ83	CoJ88	S70/00	CoJ83	CoJ88	S70/00	CoJ83	CoJ88	S70/00
0	245.2	153.8	143.9	131.04	120.68	52.60	86.6	93.1	16.0
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
2	287.3	190.1	183.6	210.0	183.7	84.9	316.3	244.7	33.9
	(17.1)	(23.6)	(27.6)	(60.3)	(52.2)	(61.5)	(265.4)	(162.7)	(111.9)
4	307.1	223.4	296.8	274.6	244 .6	228.3	574.5	336.5	51.7
	(25.2)	(45.2)	(106.3)	(109.6)	(102.7)	(334.0)	(563.6)	(261.5)	(222.5)
6	391.8	263.3	372.9	486.0	438.5	291.2	635.1	443.8	73.3
	(59.7)	(71.2)	(159.2)	(270.9)	(263.3)	(453.7)	(633.6)	(376.5)	(357.5)
8	562.8	439.8	570.8	561.0	496.3	307.0	706.2	592.3	100.4
	(129.5)	(185.9)	(296.7)	(328.1)	(311.2)	(483.7)	(715.8)	(535.9)	(526.5)
10	677.4	553.1	698.2	630.8	568.5	386.6	851.0	743.4	118.5
	(176.2)	(259.6)	(385.3)	(381.4)	(371.1)	(634.9)	(883.0)	(698.1)	(639.5)
12	704.3	663.3	768.2	706.5	636.7	441.9	1087.5	948.0	149.4
	(187.2)	(331.3)	(433.9)	(439.2)	(427.6)	(740.9)	(1156.2)	(917.0)	(832.4)
b value	17.61	28.77	39.52	38.99	38.11	62.94	86.88	73.37	69.03
R^2 value	0.941	0.929	0.975	0.973	0.973	0.963	0.959	0.987	0.993

b value- Rate of per cent decrease per day R^2 value- Regression co-efficient
Values in parentheses represent per cent decrease w.r.t. 0 day

Table 9. Changes in neutral invertase activity (µmol Sucrose hydrolysed/min/ml of juice) with increase in storage time

Days of storage	November			January			March		
	CoJ83	CoJ88	S70/00	CoJ83	CoJ88	S70/00	CoJ83	CoJ88	S70/00
0	260.7	188.2	135.8	261.1	278.4	168.6	287.1	281.9	199.7
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
2	298.6	226.5	167.3	413.8	418.4	271.8	933.6	725.1	416.3
	(14.5)	(20.3)	(23.2)	(58.5)	(50.3	(61.22)	(225.2)	(157.3)	(108.4)
4	315.7	268.4	274.6	541.3	558.8	719.3	1809.4	1005.3	624.2
	(21.1)	(42.6)	(102.2)	(107.3)	(100.7	(326.64)	(530.3)	(256.7)	(212.5)
6	413.7	321.6	342.2	915.8	943.2	898.2	2087.5	1229.3	857.5
	(58.7)	(70.8)	(152.0)	(250.8)	(238.7)	(432.7)	(627.1)	(336.2	(329.4)
8	576.3	498.8	534.2	1084.6	1139.9	971.4	2319.5	1768.5	1228.6
	(121.1)	(165.0)	(293.5)	(315.4)	(309.4)	(476.1)	(707.9)	(527.4)	(515.2)
10	683.2	661.3	652.5	1208.9	1249.7	1229.3	2687.8	2137.5	1461.6
	(162.1)	(251.3)	(380.6)	(363.0)	(348.8)	(629.1)	(836.2)	(658.3)	(631.8)
12	728.6	806.3	713.5	1378.3	1449.4	1383.0	3467.6	2781.6	1845.4
	(179.5)	(328.4)	(425.5)	(427.9)	(420.5)	(720.2)	(1107.9)	(886.9)	(824.0)
b value	16.72	28.10	39.07	37.60	37.00	61.67	84.51	70.40	68.41
R^2 value	0.946	0.925	0.972	0.980	0.979	0.967	0.962	0.981	0.989

b value- Rate of per cent decrease per day R^2 value- Regression co-efficient
Values in parentheses represent per cent decrease w.r.t. 0 day

Table 10. Changes in starch (µg/ml of juice) with increase in storage time

Days of storage	November			January			March		
	CoJ83	CoJ88	S70/00	CoJ83	CoJ88	S70/00	CoJ83	CoJ88	S70/00
0	18.7	32.2	21.1	28.8	39.1	57.6	128.0	128.4	132.20
2	15.1	21.1	17.1	16.6	17.1	52.9	52.6	51.1	54.4
4	13.2	11.9	6.6	11.1	11.6	9.1	46.1	38.8	39.9
6	4.6	5.4	3.5	3.7	4.7	2.9	37.7	37.5	35.3
8	2.0	2.2	1.9	1.6	2.1	2.1	32.6	26.1	31.6
10	1.0	1.5	1.2	0.5	0.7	1.7	25.2	13.0	16.0
12	Traces	Traces	Traces	Traces	Traces	Traces	6.5	4.5	8.5

and this enhancement was more pronounced during late crushing season (Table 6). Solomon (1994) had also indicated that rate of inversion in the harvested cane increased during late crushing period. During 12 days staling period, lowest increase in reducing sugars and lowest decrease in sucrose was found in CoJ 83 in November, while this change was lowest in CoJ 88 and S70/00 during January and March, respectively, (Tables 4 &6) depending upon their maturity status. Varietal differences existed in ability to resist moisture loss, reduction in sucrose and increase in reducing sugars. The variation in the decrease in quality parameters in different genotypes may be attributed to the difference in the maturity level of genotype among three months. CoJ 83 being an early maturing genotype was fully mature in November indicating less deterioration i.e less percent decline in sucrose %, purity and less increase in reducing sugars. CoJ88, being mid maturing showed less deterioration in January and S70/00 being late maturing genotype showed still less deterioration in March. More deterioration in CoJ83 during March and in S70/00 during November may be probably due to their over mature and immature conditions, respectively, at that time. Bhite *et al* (2006) also observed significant varietal differences while evaluating the relative performance of 10 sugarcane genotypes to post harvest sugarcane losses. The biological losses such as inversion of sucrose by plant and microbial invertases, formation of organic acids and dextran by microorganisms are largely responsible for loss of recoverable sugar after harvesting of cane and its subsequent processing in mill (Solomon *et al.*, 2003). The genotypes differed significantly among themselves with respect to initial dextran content in different months (Table7). Solomon *et al.* (2003) also reported that level of dextran synthesis varies with climate, cane genotype and cut to crush delays. Increase in dextran content in March as compared to other months may be due to synergetic effect of rise in temperature on growth of bacteria (Solomon 2000) which resulted in dextran formation. Moreover, maturity status of genotype also influenced the increase in dextran content as the genotypes CoJ88, CoJ83 and S70/00 were mature in January, November and March, respectively, and also showed minimum increase in dextran content during staling among themselves in respective months. Irrespective of the genotype or environmental condition, the level of neutral invertase remained high as compared to acid invertase except in late maturing genotype S70/00 during November, where high activity of acid invertase was found as compared to neutral invertase due to its immature nature in this month (Tables 8& 9). Higher acid invertase activity has been reported in immature internodes of sugarcane (Sachdeva *et al*., 2003). Enhancement in the acid invertase activity during storage was more than that of neutral invertase in all the genotypes under all environmental conditions. These results were in contradiction to those reported by Kapur and Kanwar (1982) who reported less increase in activity of acid invertase as compared to neutral invertase. However, Batta and Singh (1991) reported 7 folds increase in activity of acid invertase as compared to 4 folds increase in neutral invertase after 12 day storage. Endogenous invertases may get activated soon after the harvest of sugarcane due to the rapid loss of moisture , lack of any internal physiological and biochemical control mechanism (Solomon, 1994) resulting in increase in the activities of invertases. Higher water content in fresh cane provided an insulation effect on the cellular temperature, so on storage due to loss in moisture level this effect is diminished which resulted in increase in invertase activity (Batta and Singh,1991). More increase in activity of soluble invertases in March as compared to other months resulted in higher increase in invert sugars and higher decline in sucrose % juice in March as compared to other months. The decrease in the level of sucrose was, however, not proportional to the increase in level of invert sugars indicating that invert sugars were continuously utilized during the storage of canes. The starch content in stale canes also declined (Table 10), which may be due to high amylase activity. However, it seems to have a secondary role in metabolic process. Presence of amylases in stale cane has been reported (Das and Prabhu, 1988). The hydrolytic enzymes present in juice get activated during storage of cane resulting in loss of quality. Thus it appears that all sugarcane genotypes are prone to quality deterioration during storage and these quality losses are relatively higher at higher temperatures. Variation in rate of deterioration in different genotypes during staling may be attributed to the difference in the maturity level among genotypes.

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