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POST HARVEST MANAGEMENT OF STALED SUGARCANE FOR JAGGERY PROCESSING

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Abstract: *The experiment was carried out to test efficacy of post harvest physico-chemical practices against staling losses of sugarcane and its effect on jaggery quality. The chemical practices viz; waxing of cut ends, spraying of benzalkonium chloride as anti-inversion & antibacterial solution, spraying of sodium hypochlorite as electrolyzed water and spraying of normal water were applied in combination with physical practices like, heaping of sugarcane and heap covering with sugarcane trash. Harvested sugarcane was staled for 24, 48, 72, 96 and 120 hrs. The physico-chemical practice of spraying of sodium hypochlorite @ 2000 ppm and heaping of sugarcane found superior for minimizing the staling losses of sugarcane in terms of weight loss, jaggery recovery and jaggery quality loss even at 120 hours of staling period under high ambient temperature during summer season (April to May).*

Key words: *Post harvest management, staled sugarcane, jaggery processing, weight loss, jaggey recovery, jaggery quality.*

Introduction:

Sugarcane is an important cash crop which has direct impact on socio-economic condition of the rural areas. Besides sugar, sugarcane is also utilized for production of jaggery, the natural sweetener, in all parts of the country. Sometimes delay in transportation of harvested sugarcane from field to processing plant, delay in crushing due to electricity failure etc the sugarcane gets staled. Staling of sugarcane is defined as the loss of recoverable sugar between the time of cutting and the time of grinding ("cut to crush"). Sugarcane suffers heavy losses in recoverable sugar due to post harvest deterioration of the stale cane.

Solomon *et. al.* (2006), reported that post-harvest application of anti-bacterial formulations have shown reduction in sucrose loss after harvest. Jagjeet Singh *et. al.* (2015) reported that application of chemicals (1% Sodium Azide and Picric acid) as well as (5% Neem cake and dried leaves extract) aqueous solution sprays on harvested canes showed remarkable results in minimization of sugar losses during staling. Besides antibacterial solution, there is need to spray anti-inversion solution and sanitizer solution along with some physical treatments, in combination, to minimize the staling loses. The experiment is undertaken with objective to test efficacy of post harvest physico- chemical practices against staling losses of sugarcane and its effect on jaggery quality.

Material and Methods:

The experiment was carried out under the AICRP on Post Harvest Engineering and Technology at the research farm of the Regional Sugarcane and Jaggery Research Station, Kolhapur during the year 2012-13, 2013-14 and 2014-15.Well matured sugarcane (var. Co 92005) having brix more than 21^0 was harvested. Cane was cleaned by removing top 2 to 3 immature internodes, leaves and rootlets and heaped in the field. The phyiso-chemical treatments were applied to the cane as per given treatments. The experiment was carried out in FRBD design with two replications during summer season (April to May).

Treatment details:

A) Physico-chemical treatments:

1) Heaping of sugarcane (Control)
2) Heaping and covering with trash

3) Water spraying + heaping and covering with trash
4) Waxing of cut ends + heaping
5) Spraying of Benzalkonium chloride (Anti-inversion & Antibacterial) @ 2000 ppm + heaping
6) Spraying of sodium hypochlorite (electrolyzed water) @ 2000 ppm + heaping

B) Sugarcane staling period (hrs.): 24, 48, 72, 96 and 120.

Sugarcane was weighed daily as per treatments and weight loss was calculated. Sugarcane was crushed through horizontal type three roller crusher. Juice was filtered through two stage filtration system. Stainless steel boiling pan and Kolhapur type furnace system was used for jaggery processing. Application of inputs viz; okra plant mucilage, lime, arsenic free phosphoric acid, groundnut oil etc was applied during juice processing for production of jaggery as per standard procedure (Patil *et al.*, 2007).

The jaggery samples were analyzed for quality parameters viz; Reducing Sugars, Non Reducing Sugars, pH, and olour intensity. The reducing sugar was determined by Lane - Eynon volumetric method (A.O.A.C., 1960). The non reducing sugar was determined by using polarimeter. The colour intensity (Optical Density, OD) was measured by using spectrophotometer at 540 nm wavelength.

Results and Discussion:

The data on effect of post harvest physico-chemical practices on staled sugarcane in terms of sugarcane weight loss and jaggery recovery for the years 2012-13, 2013-14 & 2014-15 are pooled and presented in table 1.

Sugarcane weight loss:

The sugarcane weight loss is mainly attributed to evaporation losses (Mahadevaiah and Dezfuly, 2013) and increased respiration (Verma *et al.*, 2012). The lowest sugarcane weight loss (5.62 %) was recorded by the treatment T_6 (Spraying of sodium hypochlorite @ 2000 ppm + heaping). However, significantly highest sugarcane weight loss (11.69 %) was noticed by the control treatment T_1 (Heaping of sugarcane). Among the staling period, the 24 hours staling of sugarcane after harvest recorded significantly lowest weight loss (2.69 %).However it showed increasing trend from 24 to 120 hours of staling period .At the end 120 hours the weight loss was 13.22 per cent indicating the 2.64 per cent average weight loss per day .

The interaction effect between treatment of physico-chemical practices and staling period on sugarcane weight loss was found significant. The treatment T_6 (Spraying of sodium hypochlorite @ 2000 ppm + heaping) and 24 hours of staling period was recorded lowest weight loss of sugarcane (1.82 %) which was on par with treatment combination of T_5 with 24 hours of staling period (1.88 %) and followed by the treatment combination of T_3 with 24 hours of staling period (2.26 %). However the treatment combination of T_6 with 96 hours of staling period was recorded the significantly lowest sugarcane weight loss (7.19 %) & followed by the treatment combination of T_6 with 120 hours of staling period (8.92 %). While significantly highest sugarcane weight loss (19.22 %) was noticed by the treatment combination of control treatment T_1 with 120 hours of staling period. Similar type of results on cane weight loss after 120 hrs was reported by Solomon *et al.* (1997).

Jaggery recovery:

The highest jaggery recovery was recorded by the T_4 (11.09) which were on par with the T_3 (11.08) and T_6 (Spraying of sodium hypochlorite @ 2000 ppm + heaping) (11.02 %). Significantly lowest recovery of 10.45 percent was observed due to control treatment i.e. sugarcane heaping. In case of staling period, at 24 hours of staling of sugarcane significantly highest jaggery recovery of 11.65 per cent was recorded which showed decreasing trend and at the end of 120 hours of sugarcane staling jaggery recovery was 10.15 per cent. This indicated only 0.3 per cent loss in recovery per day due to physico-chemical practices adopted against staling losses. This results are supported by Chiranjivi Rao (1989).

The interaction effect between treatments of physico-chemical practices and staling period on jaggery recovery was found non-significant.

Jaggery quality: The three years pooled data on effect of physico-chemical practices on staled sugarcane in terms of jaggery quality have been recorded and presented in table 2.The effect of post harvest physico-chemical practices and staling periods on quality parameters of jaggery was found significant. Similarly their interaction effect on pH, RS (%), colour intensity (O.D.) and MC (%) of jaggery was also found significant.

The lowest pH (5.71) was recorded by the treatment T_5 (Spraying of Benzalkonium chloride @ 2000 ppm + heaping) which was on par with treatment T_4 (Waxing of cut ends + heaping) (5.73). Among the staling period, significantly the lowest pH (5.62) was recorded by the 96 hours of sugarcane staling period which was on par with the 120 hours of sugarcane staling period (5.65). The interaction effect between physico-chemical practices and staling period on pH of jaggery was found significant. The treatment combination T_3 with 96 hours of sugarcane staling period was recorded lowest pH (5.55 %) which was on par with the combinations of treatment T_5 with the 96 hours of sugarcane staling period (5.55) and T_4 with the 96 hours of sugarcane staling period (5.60).

Amount of non reducing and reducing sugars available in jaggery are the most important constituent which decides loss of jaggery quality due to staling. The highest NRS (80.48 %) was recorded by the treatment T_6 (Spraying of sodium hypochlorite @ 2000 ppm + heaping) which was on par with treatment T_5 (80.18 %). This may be due to maintaining juice quality parameters *viz*; CCS and juice purity by application of electrolyzed water in the form of sodium hypochlorite. Similar type of result was observed by the Soloman and Singh, 2009. Among the staling period, significantly the highest NRS (81.78 %) was recorded by 24 hours of sugarcane staling period. The interaction effect between physico-chemical practices and staling period on non reducing sugar (NRS) was found non-significant.

The lowest reducing sugar (RS %) were recorded by the physico-chemical treatment T_6 (10.02 %). Among staling period, the significantly lowest RS (9.75 %) was observed at the 24 hours of sugarcane staling period. The treatment combination T_2 and 24 hours of sugarcane staling period was recorded lowest RS (9.52 %) however it was on par with the treatments combination T_6 and 24 hours of sugarcane staling period (9.61) & T_6 and 72 hours of sugarcane staling period (9.63).

The effect of post harvest physico-chemical practices on jaggery colour intensity was found significant. Significantly lowest colour intensity (0.064 OD) was recorded by the treatment T_5 which was on par with T_4 (0.067 OD) and T_6 (Spraying of sodium hypochlorite @ 2000 ppm + heaping) (0.067 OD). Among staling period, the significantly lowest colour intensity was obtained due to staling of sugarcane for 24 hours of harvest (0.056 OD). The interaction effect between treatment of physico-chemical practices and staling period on jaggery colour intensity was found significant. The treatment combinations of T_4, T_5 & T_6 with 24 hours of period was observed lowest colour intensity (0.055 OD) which was on par with the treatment combinations of T_1, T_2 & T_3 with 24 hours of staling period and T_3, T_4, T_5 & T_6 with 48 hours of staling period.

The lowest moisture content (6.32 %) was noticed by the control treatment T_1 and followed by the treatment T_3 (6.51 %). Among staling period, the 24 hours of harvest recorded significantly lowest moisture content of jaggery (5.54 %). The interaction effect between treatment of physico-chemical practices and staling period on moisture content of jaggery was found significant. The treatment combination T_1 with 24 hours of staling period recorded lowest MC (4.90 %). The 7.04 % moisture content was noticed due to treatment combination of 48 hours of staling period with T_1. However, 7.25 % of moisture content was recorded in the treatment combination of 120 hours of staling period with T_1.

Cost analysis: Data on various parameters of cost analysis are presented in table 3. It is revealed from the table that post harvest physico-chemical practice of spraying of sugarcane with sodium hypochlorite @ 2000 ppm + heaping, recorded significantly highest jaggery yield (113.130 kg) and gross monetary returns (Rs. 4525/-). However, benefit cost ratio was significantly highest due to heaping of sugarcane (1.20). As regards to staling period, significantly highest jaggery production (116.889 kg), gross monetary returns (Rs. 4676/-) and B:C ratio (1.20) was observed due to 24 hours of sugarcane staling. The interaction effect of post harvest physico-chemical practices and staling period on jaggery production and gross monetary returns was found non significant.

Conclusion:

Spraying of sodium hypochlorite @ 2000 ppm and heaping found superior for minimizing the staling losses of sugarcane (weight and jaggery quality loss) even after 120 hours of harvest at high ambient temperature.

Table 1: Effect of post harvest physico-chemical practices against staling losses of sugarcane, jaggery and scum recovery
(Pooled means for the years 2012-13, 2013-14 and 2014-15)

Treatment	Parameters	
	Sugarcane weight loss (%)	Jaggery Recovery (%)
A) Main treatment		
T_1.Heaping of sugarcane (Control)	11.69	10.45
T_2 Heaping and covering with trash	9.44	10.83
T_3.Water spraying + heaping and covering with trash	7.92	11.08
T_4.Waxing of cut ends + heaping	8.91	11.09
T_5.Spraying of Benzalkonium chloride @ 2000 ppm + heaping	6.12	10.78
T_6.Spraying of sodium hypochlorite @ 2000 ppm + heaping	5.62	11.02
SE+	**0.05**	**0.07**
CD 0.05	**0.14**	**0.20**
B) Staling period (hrs.)		
24	2.69	11.65
48	4.34	11.15
72	9.47	10.86
96	11.69	10.57
120	13.22	10.15
SE+	**0.05**	**0.07**
CD 0.05	**0.13**	**0.18**
Interaction (A x B)		
SE+	**0.11**	**0.16**
CD 0.05	**0.31**	**NS**

Table 1a: Interaction effect of post harvest physico-chemical practices and staling period on per cent weight loss of sugarcane

Treatment	Staling period (hrs.)					
	24	48	72	96	120	Mean
T1	4.10	6.39	13.00	15.73	19.22	11.68
T2	2.97 (27.56)	4.87 (23.79)	10.85 (16.54)	13.68 (13.03)	14.85 (22.74)	9.44
T3	2.26 (44.88)	3.92 (38.65)	8.92 (31.38)	12.19 (22.50)	12.30 (36.00)	7.92

T4	3.12 (23.90)	5.05 (20.97)	9.70 (25.38)	12.81 (18.56)	13.87 (27.84)	8.91
T5	1.88 (54.15)	2.96 (53.68)	7.05 (45.77)	8.55 (45.65)	10.17 (44.09)	6.12
T6	1.82 (55.61)	2.85 (55.40)	7.30 (43.85)	7.19 (54.29)	8.92 (53.59)	5.62
Mean	2.691	4.34	9.47	11.69	13.22	
SE±	0.11					
CD 0.05	0.31					

Figures in parenthesis indicate per cent reduction in weight loss over control

Table 2: Effect of post harvest physico-chemical practices on quality parameters of jaggery (Pooled means for the years 2012-13, 2013-14 and 2014-15)

Treatment	Jaggery quality parameters				
	pH	NRS (%)	RS (%)	Colour Intensity (OD)	MC (%)
A) Main treatment					
T1.Heaping of sugarcane (Control)	5.77	79.53	10.78	0.074	6.32
T2. Heaping and covering with trash	5.75	79.67	10.90	0.072	6.93
T3.Water spraying + heaping and covering with trash	5.77	79.70	10.87	0.071	6.51
T4. Waxing of cut ends + heaping	5.73	79.85	10.87	0.067	6.66
T5. Spraying of Benzalkonium chloride (Anti- inversion & Antibacterial) @ 2000 ppm + heaping	5.71	80.18	10.43	0.064	6.53
T6. Spraying of sodium hypochlorite @ 2000 ppm (electrolyzed water) + heaping	5.78	80.48	10.02	0.067	7.06
SE±	0.018	0.129	0.043	0.001	0.013
CD 0.05	0.050	0.367	0.122	0.002	0.036
B) Staling period (hrs.)					
24	5.85	81.78	9.75	0.056	5.54
48	5.89	80.79	10.17	0.059	6.06
72	5.72	79.59	10.33	0.068	6.87
96	5.62	79.12	10.79	0.077	7.27
120	5.65	78.24	12.17	0.085	7.60
SE±	0.016	0.118	0,.039	0.001	0.012
CD 0.05	0.045	0.335	0.111	0.002	0.033
C) Interaction (A x B)					
SE±	0.039	0.289	0.096	0.001	0.028
CD 0.05	0.111	NS	0.272	0.004	0.081

Table 2a: Interaction effect of post harvest physico-chemical practices and staling period on per cent jaggery pH

Treatment	Staling period (hrs.)					
	24	48	72	96	120	Mean
T1	5.80	5.90	5.75	5.70	5.70	5.77
T2	5.70	5.90	5.85	5.70	5.60	5.75
T3	5.90	5.95	5.85	5.55	5.60	5.77
T4	5.90	5.90	5.65	5.60	5.60	5.73
T5	5.90	5.85	5.60	5.55	5.65	5.71

T6	5.95	5.85	5.65	5.65	5.80	5.78
Mean	5.85	5.89	5.72	5.62	5.65	
SE±	0.039					
CD 0.05	0.111					

Table 2b: Interaction effect of post harvest physico-chemical practices and staling period on RS (%)

Treatment	Staling period (hrs.)					
	24	**48**	**72**	**96**	**120**	**Mean**
T1	9.75	10.24	10.43	10.53	12.98	10.78
T2	9.52	9.98	10.95	11.48	12.57	10.90
T3	9.94	10.23	10.43	10.94	12.80	10.87
T4	9.99	10.41	10.45	11.20	12.32	10.87
T5	9.72	10.38	10.14	10.55	11.38	10.43
T6	9.61	9.79	9.63	10.07	11.00	10.02
Mean	9.75	10.17	10.33	10.79	12.17	
SE±	0.096					
CD 0.05	0.272					

Table 2c: Interaction effect of post harvest physico-chemical practices and staling period on colour intensity (OD)

Treatment	Staling period (hrs.)					
	24	**48**	**72**	**96**	**120**	**Mean**
T1	0.057	0.060	0.072	0.083	0.097	0.074
T2	0.057	0.064	0.071	0.079	0.090	0.072
T3	0.057	0.058	0.071	0.083	0.086	0.071
T4	0.055	0.057	0.069	0.076	0.079	0.067
T5	0.055	0.057	0.064	0.068	0.075	0.064
T6	0.055	0.058	0.064	0.073	0.084	0.067
Mean	0.056	0.059	0.068	0.077	0.085	
SE±	0.001					
CD 0.05	0.004					

Table 2d: Interaction effect of post harvest physico-chemical practices and staling period on moisture content (MC%)

Treatment	Staling period (hrs.)					
	24	**48**	**72**	**96**	**120**	**Mean**
T1	4.90	5.83	6.59	7.04	7.25	6.32
T2	5.75	6.21	7.25	7.55	7.88	6.93
T3	5.18	5.91	6.95	7.08	7.45	6.51
T4	5.90	6.27	6.80	6.95	7.37	6.66
T5	5.45	5.91	6.56	7.29	7.45	6.53
T6	6.04	6.26	7.08	7.71	8.21	7.06
Mean	5.54	6.06	6.87	7.27	7.60	
SE±	0.028					
CD 0.05	0.081					

Table 3: Cost analysis of post harvest physico-chemical practices against staling losses of sugarcane (2015)

Treatment	Cost of jaggery production (Rs. /ton of sugarcane)	Jaggery production (kg/ton of sugarcane)	Gross monetary returns (Rs.)	B:C ratio
A) Main treatment				
T1.Heaping of sugarcane (Control)	3562	107.112	4285	**1.20**
T2 Heaping and covering with trash	3662	108.448	4338	1.18
T3.Water spraying + heaping and covering with trash	3862	110.347	4414	1.14
T4. Waxing of cut ends + heaping	**4662**	111.316	4453	0.95
T5. Spraying of Benzalkonium chloride (Anti-inversion & Antibacterial) @ 2000 ppm + heaping	3758	111.327	4453	1.18
T6. Spraying of sodium hypochlorite @ 2000 ppm (electrolyzed water) + heaping	3912	**113.130**	**4525**	1.15
SE+	**1.015**	**0.711**	**28.41**	**--**
CD 0.05	**2.870**	**2.018**	**80.65**	**--**
B) Staling period (hrs.)				
24	3903	**116.889**	**4676**	**1.20**
48	3903	113.054	4522	1.16
72	3903	110.782	4431	1.13
96	3903	107.834	4313	1.10
120	3903	102.840	4114	1.05
SE+	**0.926**	**0.649**	**25.94**	**--**
CD 0.05	**NS**	**1.843**	**73.62**	**--**
C) Interaction (A x B)				
SE+	**2.269**	**1.590**	**63.54**	**--**
CD 0.05	**NS**	**NS**	**NS**	**--**

References:

A.O.A.C. 1960. Official Methods of Analysis. Association of Official Agricultural Chemists. 9th edition. Washington D.C.USA. PP : 427.

Mahdevaiah and Dezfuly, A.M. 2013. Studies on effective of flocculants on stale sugarcane juice settling. Int. J. Recent Sci.Res. 4(2): 151-153.

Patil. D. S., Nevkar G. S., More S. M., Nale V. N. and Jadhav B.S.. 2007. Jaggery processing and production technology. Marathi bulletin No. MPKV/ PUB/ 323/ 2007.

Rao Chiranjivi, K.1989. Recent advances in pre and post harvest technology of sugarcane. Bhartiya Sugar. pp: 9-12

Singh Jagjeet, Kumar Anoop and Zafar Abbas .2015.Post harvest qualntity and quality losses of sugarcane crop. J. Biol.& Chem. Research.32(2),pp: 711-719

Soloman S, Banerji Raman , Shrivastava Ashok K. and Sawnani Anita .2006. Postharvest deterioration of sugarcane and chemical methods to minimize sucrose losses.Sugar Tech March 2006, 8(1):74-78 ·

Solomon. S. 2009. Post harvest deterioration of sugarcane. Sugar Tech 11(2): 109-123.

Soloman S. and Priyanka Singh.2009. Efficiency of electrolyzed water to minimize post harvest sucrose losses in sugarcane. Sugar Tech.11(2): 228-230.

Solomon S., Shrivastva, A.K., Shrivastva B.L. and Madan V.K. 1997. Pre –milling sugar losses and their mangemnet in sugarcane. Technical Bulletin No.7. Indian Institute of Sugarcane Rsearch, Lucknow,pp: 12-17.