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Effect of Pre-Treatments and Clarificants on Sugarcane Juice Characteristics

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Enzymatic browning, sedimentation and loss of its typical flavour are the major problems encountered during storage and thermal processing of sugarcane juice. Top 5 cm of sugarcane was found to give juice of very dark colour. Therefore, it was removed before juice extraction. Topped sugarcanes were peeled to obtain juice of lower objective colour value (82.79–111.62) than juice of unpeeled samples (89.78–150.54). Natural pH of sugarcane juice was 5.6. During preparation of sugarcane juice based beverage, sugarcane juice is required to be made acidic. Acidification of sugarcane juice from the peeled samples to pH below 5 reduced colour but it was found to increase turbidity. Therefore, sugarcane juice was clarified using deaola, okra, semal and lime. Use of deola extract gave maximum clarifying effect; it reduced colour from its initial value of 98.87 to 18.49 and turbidity from 4.985 to 0.259.

Key words: Sugarcane juice, Clarificant, Clarification, Colour, Turbidity.

INTRODUCTION

Sugarcane is an important commercial cash crop that provides raw material for the second largest agro-industry in India It belongs to the family Gramineae of genus Saccharum. There are five recognised species in this genus, *viz.*, *S. spontanum* (wild cane), *S. sinense* (Chinese cane), *S. barberi* (Indian species), *S. officinarum* (noble cane) and *S. robustum*. Among them *S. officinarum* is rich in sucrose and relatively low in fibre content. Stems are vigorous, long and are used for commercial sugar production[1]. India stood second in 1998 in terms of acreage (3.96 million hectare) and production (265.00 million tonnes) of sugarcane, next to Brazil (4.94 million hectare and 338.35 million tonnes)[2]. This crop is mainly utilized for the production of sweeteners, *i.e.*, white sugar, jaggery and khandsari. A small quantity is used to produce juice, which is consumed as soft drink for its flavour, nutritive and therapeutic values[3]. At present sugarcane juice is extracted by small vendors often under unhygienic conditions during 2–3 months only. Despite vast potential sugarcane juice is not being commercially processed and

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available due to its short shelf life and problems faced during processing such as browning, sedimentation and loss of its typical aroma and taste. Inadequate clarification reduces shelf life of the sugarcane juice[4]. Chemical clarification of sugarcane juice using lime and carbonation or sulphitation is used for commercial sugar production. However, no work has been reported on clarification of sugarcane juice for use in fruit beverages. The present study was undertaken with a view to study the effect of various pre-treatments of sugarcane and vegetative clarificants on the clarification characteristics of sugarcane juice.

EXPERIMENTAL

Sugarcane (var. CoPant 84212) was procured from Crop Research Center (CRC) of G.B. Pant University of Agriculture and Technology, Pantnagar. Healthy sugarcanes (stalk thickness ≥ 2 cm and cane weight ≥ 0.75 kg) free from disease and insect infestation were selected for the investigation. Three vegetative clarificants used were semal (*Bombax malabarica*) bark, deola (*Hibiscus ficulneus*) and okra (*Hibiscus esculentus*) stems. The clarificants were obtained from Indian Institute of Sugarcane Research, Lucknow.

Sugarcane topping: All the leaves were removed from the freshly harvested cane stalk. The tip of sugarcane which was not having clear-cut differentiation between nodes and internodes was marked as growing part and next to it was considered as node number zero. Subsequent parts of the cane stalk were subdivided into nodes and internodes and were numbered as 1, 2, 3 and so on. Further peels were removed from the internodes to get the pith. Respective portions were soaked separately in distilled water sufficient to submerge them and allowed to stand for 2 h under ambient conditions. Aqueous extracts of nodes, peels and pith were filtered through glass wool and filtrates were used for comparing their colour and deciding the portion causing maximum discoloration of sugarcane juice.

Effect of pre-treatments: Pretreatments on topped sugarcanes were carried out in two stages. For the first stage of experiment, three batches of topped sugarcanes were taken: the first batch was washed, the second batch was peeled lightly to remove buds (actively growing part of cane stalk), waxy bloom, dirt and dust from the sugarcane surface, and the third batch was kept unwashed and unpeeled to serve as control. Sugarcanes of the above three batches were cut separately into three equal parts, namely, bottom, middle and top portions. Juice from each batch was extracted separately at room temperature using a double-roller hand-operated cane crusher. The cane crusher was washed thoroughly with distilled water after each extraction. Juice from each batch was collected in separate flasks, stoppered and used within 1 h for analysis.

In the second stage of experiment, lightly peeled, topped canes were cut into three equal parts. Each part was blanched in a steam chamber at atmospheric pressure for 0, 3, 5, 15 and 30 min. They were subsequently air-cooled to room temperature and crushed in the cane crusher to extract juice for determining the effects of portions and efficacy of blanching.

Effect of pH: The pH of extracted sugarcane juice was maintained in the range of 3 to 11 using citric acid or milk of lime respectively and evaluated for the respective objective colour value and turbidity.

Chemical clarification: Sugarcane juice was clarified using hydrated lime. Saturated clear solution of calcium hydroxide in 10% sucrose solution was used as milk of lime. For clarification, sugarcane juice was heated to 67–70°C and milk of lime was added with constant stirring to hot juice to bring its pH to 7.1–7.2 and then allowed to stand for 10 min, followed by decantation. The decanted clear sugarcane juice was analyzed for objective colour value, indicator value and turbidity.

Vegetative clarification: Vegetative clarificants, *i.e.*, semal bark, deola and okra stems were ground, soaked in water (20 times of their weight) for 5 min, under ambient conditions, macerated manually and strained through muslin cloth. The extracts were used as clarificant. To determine level of clarificant required for juice clarification, sugarcane juice was heated and 0 to 1000 ppm clarificant was added to juice just before boiling commenced, and scum formed during boiling was carefully removed. The clarified juice was air-cooled and determining objective colour value assessed the degree of clarity. Based on preliminary experiments optimum dose was found to be 400 ppm for deola stem and 500 ppm for okra stem or semal bark.

Objective colour value, indicator value and turbidity: Samples of sugarcane juice were adjusted to pH 4, 7 and 9 using buffers of appropriate pH. Buffers of pH 4, 7 and 9 were prepared, by mixing 1 N ammonia and 1 N acetic acid in appropriate proportion using pH meter. It was used with juice sample to a dilution factor of 5 or 10 and optical density (A420) of these samples was measured at 420 nm. Objective colour value was calculated as 10A420 at pH 7 and indicator value as ratio of A420 at pH 9 to A420 at pH 4[5,6]. To determine the turbidity of the sample its OD was measured at 720 nm using UV-VIS spectrophotometer (Beckman DU-7).

Statistical analysis: The experimental data were subjected to analysis of variance (ANOVA), standard error for mean (SEM), critical difference at 5% level of significance ($CD_{5\%}$) and coefficient of variation (CV).

RESULTS AND DISCUSSION

Sugarcane topping: Growing portion and portion numbered zero could not be differentiated into node and internode. Therefore, extracts of these two portions were prepared and their objective colour values (OCV) were 32.82 and 22.00, respectively. Objective colour value of aqueous extract of node, peel and pith of portions 1 to 20 were found to vary from 1 .98 to 17.21, 1.75 to 78.19 and 0.46 to 15.23, respectively (Fig. 1). It shows that growing parts contributed maximum to the darkening of sugarcane juice. Mathur[7] has reported similar results. Fig. 1 shows that among nodes and pith and peel of internodes, peel extract was darkest and the corresponding pith extracts were of lightest colour. Colour of node showed that the colour of nodes up to 5th number were significantly different with a $CD_{5\%}$ 0.87. Similarly the colour of peel extract upto 6th internode portion and colour of pith extract up to number 5 were significantly different. Pith is the major juice bearing portion of sugarcane. A comparison of colour and indicator value of the aqueous extract shows that the maximum colour-contributing constituents are present in the growing part of sugarcane and up to portion number 5. Therefore, their removal was found to be necessary before juice extraction to get juice of lighter colour.

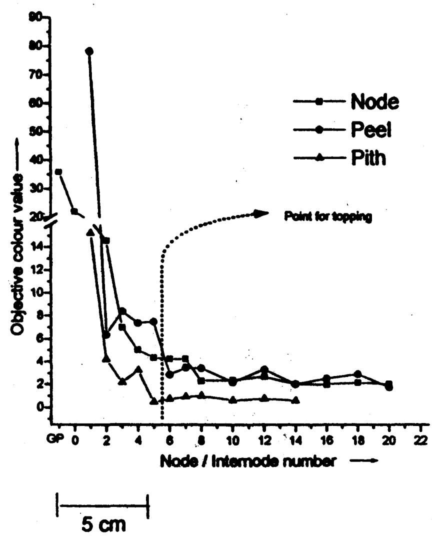

Fig. 1. Colour of aqueous extract of nodes, peels and pith of cane stalk numbered from top of sugarcane

Effect of washing and peeling: Juice of top sugarcane portion was of darkest colour (OCV 116.62–169.58), exhibited maximum turbidity (4.196–6.055) and these characteristics were found to decrease from top downwards (Fig. 2). The only exception was bottom portion of the control sugarcane, which gave maximum colour value and high turbidity because its surface contained soil particles, which may not have been completely removed by wiping with dry cloth and could have got incorporated into the juice. Sugarcane surface contains waxy bloom, dirt, dust that could add to the colour of juice. Therefore two treatments, *i.e.*, washing and peelings were tried. Washing gave darker and more turbid juice because the gummy substances present on cane surface swelled up on contact with water and their larger quantity got extracted in the juice. Objective colour values of juice from peeled bottom, middle and top portions were 82.79, 87.07 and 116.62 and corresponding indicator values were 2.34, 2.25 and 1.83, respectively (Fig. 2). It shows that peeling effectively removed the colouring matter present on sugarcane surface.

Effect of blanching sugarcane stalk: Darkening of the sugarcane juice colour could be due to enzymatic or non-enzymatic changes. Nodes of sugarcane contained polyphenol oxidase (PPO). Objective colour value of unheated juice containing active enzyme was found to increase during ambient holding as

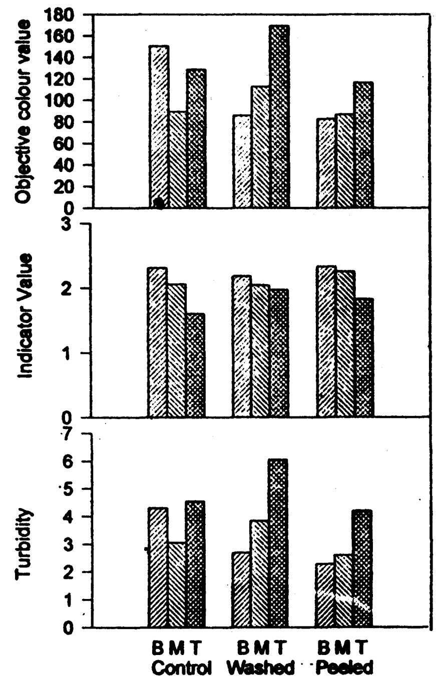

Fig. 2. Effect of washing and peeling on objective colour value, indicator value and turbidity of sugarcane juice obtained from bottom (B), middle (M) and top (T) portions of topped sugarcane

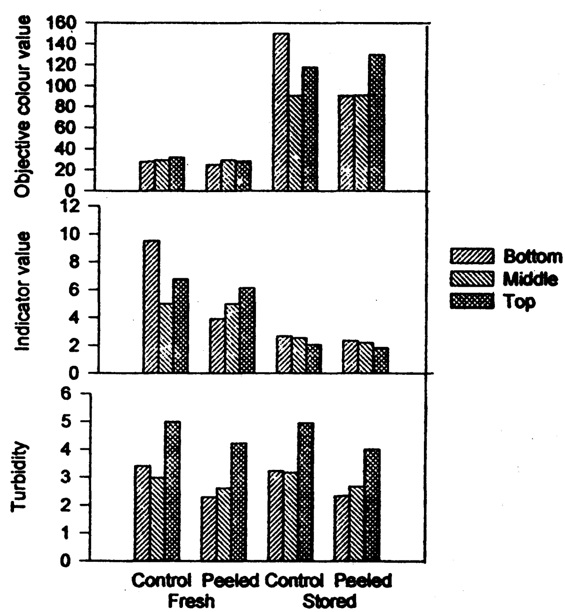

Fig. 3. Effect of ambient holding of juice from different portions of topped and peeled sugarcane for objective colour value, indicator value and turbidity

compared to heated samples under similar conditions (Fig. 3). It showed that polyphenol oxidase was responsible for darkening of sugarcane juice during storage. Steam blanching of bottom, middle and top portions of peeled sugarcanes up to 30 min reduced the OCV of juice and there was a sudden drop in OCV after 3 min of blanching due to inactivation of polyphenol oxidase and subsequent reductions were slow (Table-1). But drop in OCV was accompanied by an increase in turbidity and indicator value. Indicator value and turbidity of bottom, middle and top portions increased to 1.896, 1.662, 2.098 and 3.11, 2.91, 2.47 from initial value of 1.146, 1.298, 1.337 to 2.18, 2.03, 1.83, respectively. But blanching softened sugarcane tissues, as a result of which more fine cellular tissues got extracted into the juice and therefore it increased the turbidity of juice.

TABLE-1
EFFECT OF BLANCHING TOPPED AND PEELED SUGARCANE ON OBJECTIVE COLOUR VALUE, INDICATOR VALUE AND TURBIDITY OF SUGARCANE JUICE

Blanching time (min)	Objective colour value			Indicator value			Turbidity		
	Bottom	Middle	Top	Bottom	Middle	Top	Bottom	Middle	Top
0	83.34	86.78	118.75	2.18	2.03	1.83	1.146	1.298	1.337
3	58.17	59.45	69.80	2.23	2.04	1.90	1.254	1.408	1.440
5	57.04	56.72	59.75	2.33	2.25	2.26	1.399	1.481	1.992
15	52.73	46.35	56.72	2.64	2.31	2.38	1.469	1.563	2.036
30	43.68	46.30	48.15	3.11	2.91	2.47	1.896	1.662	2.098

Effect of heating sugarcane juice: Objective colour value of juice from topped peeled sugarcanes decreased during heating at 70 ± 2°C. Depending on duration of heating OCV decreased from 103.86 to 90.80, whereas the indicator value increased slightly from 2.09 to 3.02; changes in turbidity were minor (Table-2). A decrease in OCV and increase in indicator value indicated that during heating some polymeric colour is converted into pH sensitive colour. This finding is in agreement with the observations of Paton *et al.*[8] who reported that regeneration of chlorogenic acid from polymeric colour compounds during heating might cause chemical changes subsequently.

TABLE-2
EFFECT OF HEATING (70 ± 2°C) SUGARCANE JUICE ON OBJECTIVE COLOUR VALUE, INDICATOR VALUE AND TURBIDITY

Heating time (min)	Objective colour value	Indicator value	Turbidity
0	103.86	2.09	3.007
15	98.59	2.44	3.016
30	95.03	2.76	3.016
45	90.80	3.02	3.190

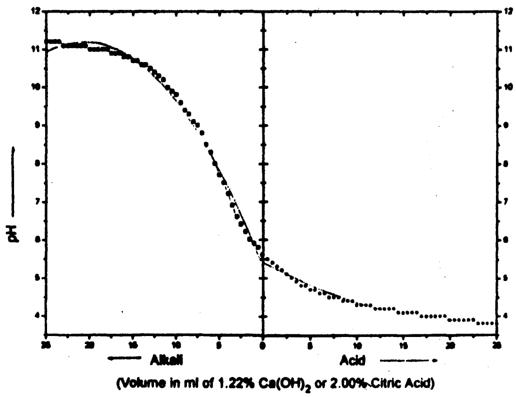

Fig. 4. Effect of acid and alkali on pH of sugarcane juice

Effect of pH on sugarcane juice: The typical pH curve (Fig. 4) for unclarified sugarcane juice shows that addition of citric acid or hydrated lime brought about a rapid significant ($P \leq 0.05$) change in pH at initial stages. This change in colour of juice may be due to an increase in conjugation and structural changes from benzenoid to quinonoid structure, which shift the absorbance (λ_{max}) towards longer wavelength, *i.e.*, from UV region to visible range[9]. A change in pH from 3 to 11 was accompanied by an increase in OCV from 77.41 to 186.45; the increase was slow up to pH 6.5 and thereafter the change was rapid (Fig. 5).

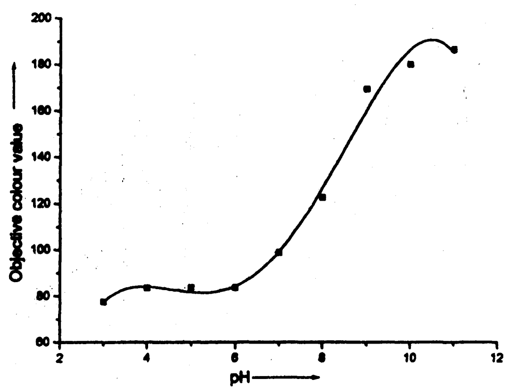

Fig. 5. Effect of pH on objective colour value of sugarcane juice

Turbidity of the sugarcane juice (Fig. 6) increased on changing the pH on either side of natural value (pH 5.6). This may be due to the formation of insoluble calcium phosphate at higher pH and denaturation of protein under acidic conditions.

Clarification of sugarcane juice: Objective colour value of sugarcane juice clarified with okra extract reduced from 94.87 to 49.51, whereas use of deola extract or semal extract yielded a juice of 18.49 or 30.23 OCV. Use of lime as

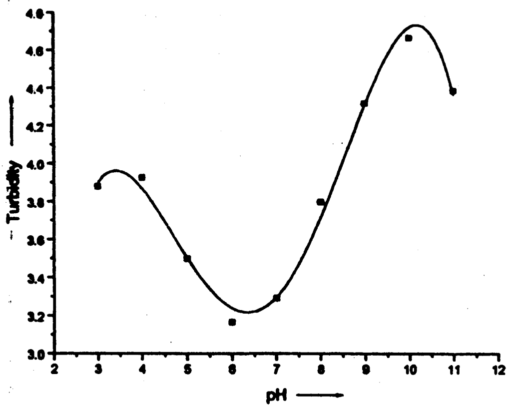

Fig. 6. Effect of pH on turbidity of sugarcane juice

chemical clarificant gave cane juice of OCV 21.77. The indicator values of sugarcane juice showed a reverse trend, which further confirms that polymeric colour compounds were removed during juice clarification. Minimum turbidity (0.259) of sugarcane juice was observed in juice clarified with deola extract followed by lime, semal extract and okra extract. The above result shows that deola extract was the most effective clarificant (Fig. 7). The results are in agreement with Shahi[10], who reported deola to be most effective in clarifying

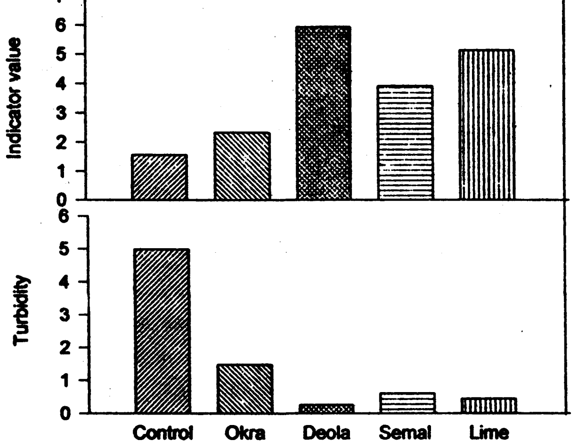

Fig. 7. Effect of clarificants on objective colour value, indicator value and turbidity of sugarcane juice

sugarcane juice for gur manufacture. Differences in OCV, indicator value and turbidity were found to be significant at $P \leq 0.05$ level. Flocks formed during clarification of sugarcane juice with deola extract were compact and easy to remove, whereas flocks formed upon use of other clarificants dispersed easily during removal, which made their separation difficult.

Conclusion

The sugarcane variety (CoPant 84212) was used in this study. Its top 5 cm portion constitutes growing part, which should be removed before extraction of juice. Peeling sugarcane before extraction yielded juice of lighter colour; its objective colour was 82.79–116.62 as compared to 89.78–150.54 for juice from unpeeled sugarcane. Blanching of peeled sugarcane inactivated polyphenol oxidase and reduced browning of juice but resulted in development of turbidity and jaggery-like flavour. Among vegetative clarificants (deola, semal and okra) deola extract used at 400 ppm was found to be the best in clarifying sugarcane juice. The quality of clarified sugarcane juice obtained using deola extract was superior to chemically (milk of lime) clarified juice. It can be inferred that deola extract rendered maximum clarifying effect as compared to the other vegetative and chemical clarificants.

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