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Quality Assessment of Indian Sugar Standards

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A B S T R A C T

In this study one of the most important physical parameters identifying purity of cane sugar solutions is investigated. ICUMSA color values of S grades, M grades and L grades cane sugar are investigated of the season 2019-2020 at room temperature (25°C). The determination of color in solid phase was carried out by using Photovolt Reflectance meter. Obtained results for S grades, M grades and L grades cane sugar with different impurities are compared at such a given temperature. Color analysis proves that SS-31 grade of sugar has minimum impurity whereas; L-30 shows maximum impurities. It is evident that both ion solvent and the electrolyte - non-electrolytes is predominant in these systems, and the hydration of ions and the bonding tendency of sucrose and water also play an important role.

Key words: Color, Cane sugar, Cane juices, Quality assessment, Electrolytes solution

The quality of sugar crystal is based on the determination of various parameters viz. Brix, Pol, Purity, % reflectance and ICUMSA color values (Mehrotra and Siesler 2003, Nawi *et al*. 2014, Cadet and Offmann 1997). One goal has been to find different procedures to obtain good quality sucrose for commercial use (Brown and Levy 1973). Some researchers have focused on the procedures and mechanism in order to refine the sugar by melting, re crystallization, or other processes in order to obtain pure sugar (Beckett *et al*. 2006, Paula *et al*. 2004). A variety of methods has been developed to measure and test the refined products in order to specify the purity of the produced refined sugar. For example, the color of the solution has been one of the important physical quantities in this respect. For many applications sugar solution is grouped into pure and raw depending on the percentage of impurities (Kumar *et al*. 2011).

Sucrose substance can be in form of liquid or solid phase. Pure sugar is a clear, white, and having good crystal structure that is chemically made up carbon, hydrogen and oxygen atoms. Measurement of color of sugar solution is not possible on solid state, so there is need of solvent to dissolve the sugar crystal such as water. This powerful substance is a good medium for many reactions, which is used as a universal solvent. Physical and chemical properties of water result from strong attraction that hydrogen atoms have for each other in water molecules.

In sugar aqueous solutions, the relative concentrations of these ions are unequal and one ion is increased by one order of magnitude while the other one shows some decrease, but the relationship is constant and the ion product is always constant. ICUMSA color values of sugar solution have been studies for several reasons such as studying the process of salvation (Kumar *et al*. 2010), assessment of sugar polarization (Sonad 2009), assessment of sugar quality and purity measurement of sugar house products (Kumar *et al*. 2009). Such processes depend on association and transparent properties of ions in different solvent media, the charge, radius, and hydrate numbers of ions and the nature of solvent. We report in this paper our results as well as some data from the literature to illustrate the effect of some selected impurities on the growth rate and morphology of sucrose crystal. Factors such as the super saturation of solution and size of sugar crystal are studied.

MATERIALS AND METHODS

This study was taken up with the plantation white sugar of different ICUMSA (International Commission for

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Uniform Methods of Sugar Analysis) color values and different sizes collected from various sugar mills. Plantation white sugar samples were collected from fifteen sugar factories situated in India. All the growth samples were subjected to sieving and fractions obtained in three size ranges, viz. 0.6 - 1.18 mm (average 0.89 mm), 1.18- l.7mm (average 1.4 mm) and 1.7- 2.36 mm (average 2.03 mm), termed small (S), medium (M) and large (L), respectively. These are larger crystals than commonly found outside India where the average size ranges generally between 0.05 and 0.4 mm. The sugar samples were categorized randomly into 7 grades of sugars. Presently, the global market certification is based on ICUMSA method (GS1/3-7) wherein the color is measured in solution phase, ICUMSA color value was determined by the following method:

50 g sugar was dissolved in 50 ml of double distilled water (50% w/w); the solution was filtered through a membrane filter (pore size 0.45 µm). The first few ml of the filtrate was discarded and the pH was adjusted to 7.0±0.2 by means of a standard buffer solution. The absorbency index (a_s) was determined at 420 nm in a 40 mm cell with a double beam UV-Vis spectrophotometer:

$$a_s = \frac{A_s}{bc} = \frac{-\log T_s}{bc}$$

Where,
T_s = Transmittance
A_s= Absorbance
b= cell length (cm)
c= concentration of total solid (g/ml)

It was calculated with the help of refractometric Brix and specific gravity table for pure sucrose solution.

ICUMSA color unit is given by the value of absorbency index multiplied by 1000:

$$I.U. = \frac{A_s}{bc} \times 1000$$

Whereas, in India color, is determined in solid phase at λ 550 against magnesium oxide as white base. However, the present Indian standards which are being followed for the purpose of sale of plantation white sugars. The determination of color in solid phase was carried out by using Photovolt Reflectance meter of USA make Model No. 577. The determination of reflectance value is based on an average basis of four sides of the bottle containing sugar crystals in a packed form. The method of determination involves the packing of sugar crystals in bottles which are free from tinge, transparent glass having a smooth surface without cracks, pinholes, sharp edges or broken bubbles after sieving through Tyler sieves.

RESULTS AND DISCUSSION

Production of ICUMSA color

Comparative study of the color producing ability of various sugars is summarized in (Table 1). Only L-30 grade of sugar was found to generate higher values of color when dissolved in distilled water. The color generating potential of L-30 grade was comparable to well -known coloring sugar likes, L-31, M-31, M-30, S-31, and SS-31.

Dose response studies

The generation of color from L-30 grade was found to be concentration dependent. A linear relation was found between the concentration of L-30 (50% W/V) and the value of color produced. The relationship between color and concentration of test compounds was observed in dilute solution only. At higher concentration the linearity was disturbed due to low solubility of L-30 (Fig 1). At concentration higher above 50%, the sugar samples started precipitating and studied were hampered (Sanyal *et al*. 2004, Gillett 1949).

Table 1 Reflectance and color analysis of Sugar standards of season 2019-2020

Size of sugar crystal (mm)	Sugar grades	Reflectance values	Color (ICUMSA)
0.21-0.60	SS -31	65.8	142
0.60-1.18	S-31	55.5	185
0.60-1.18	S-30	55.3	204
1.18-1.70	M-31	48.5	227
1.18-170	M-30	46.4	243
1.70-2.36	L-31	42.3	237
1.70-2.36	L-30	39.8	279

Another experiment showing relationship between color of 50% w/v of various sugars viz. L-31, M-31, M-30, S-31, and SS-31 (Fig 2).

As can be seen the ICUMSA color ranging from a low value of 142 IU (SS-31 grade) to high value 279 IU (L-30 grade). The value of the ICUMSA color is given for the room temperature of 25°C for all samples.

Production of percent reflectance

In Indian sugar industry, the qualities of sugar samples were checked by color measurement with Photovolt meter. The percent reflectance values were taken for sugar standardization. It has been previously experienced by author that luster is an inverse function of the grain size. The smaller is the grain, more is the luster, and lower will be the color as observed in this investigation (Fig 2). It was interesting to know that L-30 and L-31 the two sugar grades which gave a lower value for percent reflectance, were found to produce color in appreciable yields (Table 1, Fig 3). In the next study variations of color in respect to the impurity concentration for the different grades of sugars are investigated. Figure 3 shows the variation of color of sugar

solutions as a function of impurity. Impurity concentration is taken in terms of reflectance values of sugar standards. It is established fact that higher the reflectance values of sugar standards, higher will be the purity of sugar. So, Impurity concentration is varied from 39.8 to 65.8 reflectance values for the sugar standards. As can be seen in (Fig 2), color shows increase by increasing the amount of the foreign impurity at the given temperature. L-30 produced color in almost the same quantity as produced by L-31 and M-31.M-30 produced color comparable to S-31 and SS-31 produced lower amounts of color values in comparison others.

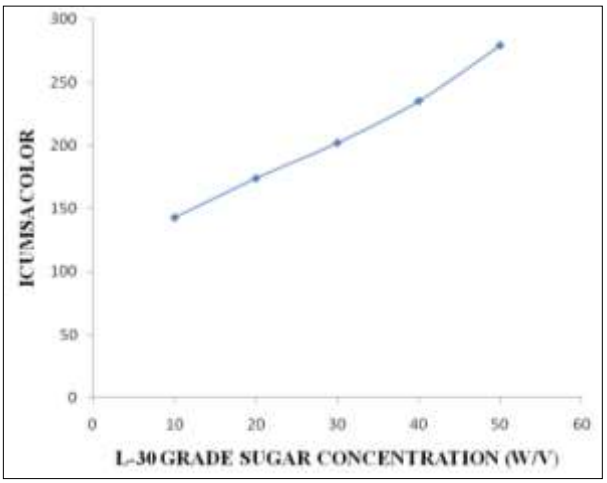

Fig 1 Color vs concentration of L-30 grade sugar

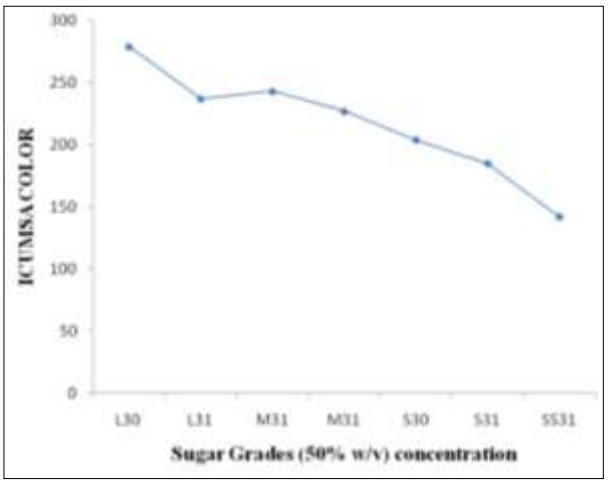

Fig 2 Color vs concentration of different sugar standards

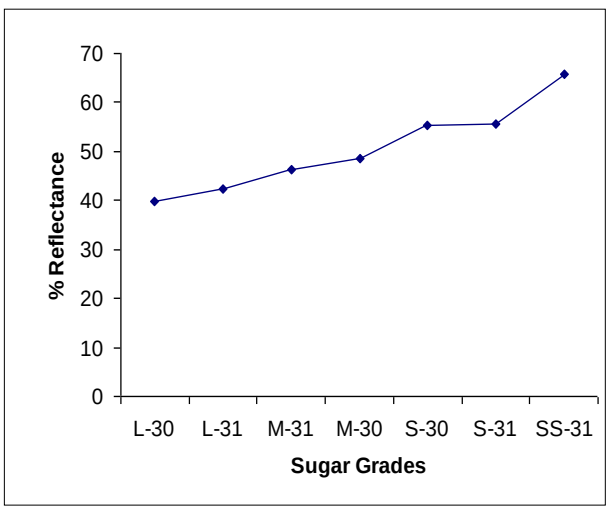

Fig 3 Percent reflectance values of all sugar grades of sugar standards

Selected sugar, S-31, SS-31 grades most commonly used in sugar industry for their ability to produce color in distilled water under normal condition with a view of investigate the possible water - sugar interaction. Sugars were found to produce color of non-sugar depending upon the concentration of the salts, L-31, M-31, M-30 (50% sugar concentration by weight). At higher concentration, the linearity was disturbed due to low solubility of sugar and various other unknown factors.

In (Table 1) variation of color of S grades of sugars as a function of impurity is shown. Here, typical reflectance value is increased from 55.36 to 65.8 for the S-30, S-31 and SS-31 sugar grades samples as shown in (Table 1). A very interesting elucidation comes out from this study. Data in (Table 1) shows that there is increase in color of all 30 numbers grades of sugar i.e. S-30, M-30, L-30. Results may further explain by taking 31 grades of sugars i.e. SS-31, S-31, M-31, and L-31. The above grades also show an increase in color value. The above color value clearly shows that if size of sugar crystal increases, there is possibility of adherence more impurities during crystallization. The above results are good agreements with previous work (Kumar *et al*. 2011). The above study also proves the process of crystallization. In solution phase, the sucrose molecules remain in solvated condition with another of water molecule associated through hydrogen bonding. The crystallization of sucrose is apparently a simple physical process involves the solvent – solute interaction and steric factor.

From the foregoing it will be clear that the balance of impurities aid color during crystallization is a function of the diffusion process. Entrapped impurities in the growing crystals cause color development even during ageing. The occlusion of impurities is a noticeable factor and mainly depends on diffusion phenomenon which has also been cited in the literature (Prasad *et al*. 1999). It is well established that change in size and shape of sugar crystal makes sugar crystal more reactive towards water vapor (Roge and Mathlouthi 2003). The present study also proves that the small sugar crystal behaves as softer as compared standards sugar i.e. analytical grade sugar. The larger sugar crystals are fragile due to the defect of inclusion and elongation. The present study is good agreements of previous works as discussed elsewhere (Mantovani *et al*. 1983, Roge and Mathlouthi 2000).

Results may be further explained by taking into account for their structural features, solvent -water, hydrogen bonding capabilities and hydration characteristics of sucrose molecule, and the structural behavior of various ions in

aqueous system. Water is known to be highly associated liquid. The presence of non-electrolytes in sucrose tend to strengthen the hydrogen bonds between the water molecules near the large solute, and a relatively "iceberg 'is effectively formed - them. Structure -making /-breaking properties of various electrolytes influence model to different extent and that explains the variation in the divergence of straight line for different systems. A final aspect of such a transition concerns the possibility of cooperative in the solvent structure induced by the solute (Vaslow 1969, Kumar *et al*. 2012). The physical evidence of changes consists in relatively abrupt changes in the slope or curvature of the various properties. It is evident that both ion solvent and the electrolyte - non-electrolytes is predominant in these systems, and the hydration of ions and the bonding tendency of sucrose and water also play an important role.

A practical application for analyzing the color of different grades of sugar and electrolytes are reported in this study. The presence of impurity inside the sugar crystal play important roles in the determination of the color and results for the concentration variation for given substances are given in this study. In the present analysis, we have use ICUMSA method of sugar solution to understand the quality of Indian Sugar Standards and especially to explain the role of crystal size distribution in sugar manufacturing process.

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