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CHANGES IN COLOUR INDEX OF CLARIFIED SUGARCANE SYRUP DURING STORAGE IN PAN SUPPLY TANKS

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ABSTRACT

The total phenolic content and the colour index of clarified syrup were analyzed during 5 months of crushing season. There was positive correlation between total phenolic content and colour index of sugarcane syrup. The effect of storage time and pH on the colour index of clarified syrup was also was determined. The result showed that the colour development was significant during storage, especially, when the acidity of clarified syrup is high (low pH).

Keywords: Clarifier, colour, polyphenol, syrup, sugarcane, syrup.

Sự thay đổi độ màu của mật chè tinh trong thời gian lưu trữ tại thùng chứa trước khi kết tinh đường

TÓM TẮT

Hàm lượng phenol tổng số và độ màu của mật chè tinh được phân tích trong 5 tháng mùa vụ sản xuất. Kết quả cho thấy có mối tương quan thuận giữa hàm lượng phenol tổng số và độ màu của mật chè. Sự ảnh hưởng của thời gian lưu trong thùng chứa và độ pH của mật chè đến sự thay đổi độ màu của mật chè cũng được phân tích nghiên cứu. Kết quả cho thấy độ màu mật chè tăng lên đáng kể theo thời gian lưu đặc biệt trong môi trường mật chè có độ acid cao (pH thấp).

Từ khóa: Đường mía, công nghệ lắng nổi, mật chè, màu sắc.

1. INTRODUCTION

In the *planco directo process* of sugar manufacture, syrup from the multiple effect evaporators is clarified by syrup clarifier for reducing viscosity and colour. Syrup clarification is not a standard operation in all raw sugar mills. It is becoming more widely used and gradually replaces the double sulphitation process, particularly in the production of sugars for direct consumption, either to remove suspended solids or colour or both. Because of the viscosity and greater density of the syrup, it is not possible to settle out the fine suspended solids. Flotation clarification does, however, work effectively when applied to syrup, without any sophisticated process requirements. The aerated phase is stable and does not require the extensive use of chemical to form and stabilize the scum layer as, for instance, flotation in mineral processing requires. As an alternative to filtration, flotation clarification can be considered as a simpler and cheaper option. It can be augmented with either sulphitation or phosphatation to achieve particular sugar quality criteria (Chen and Chou, 1993).

Normally, the colour index of clarified syrup is from 1600 to 1800 IU depending on some factors such as cane varieties, qualities of sugarcane, capacity of factory, etc. If factories would like to have good quality sugar products, they have to meet such colour index. The clarified syrup is temporarily stored in the supply tanks before being fed to vacuum pans for crystallization. The period of storage varies from few minutes to few hours depending upon various factors such as pan floor stock position, quantities and volume of pan, or halt due to technical breakdown (Chen and Chou, 1993). During this period the acidic syrup is under constant exposure to the atmospheric air and to the iron surface of the tank. Bleached syrup when exposed to air darkens again because of oxidation. The mechanisms involved in the formation and increase the colour are complicated. Little work has been done to elucidate the mechanisms involved, and the process has involved through empirical investigation to a viable process. In recent study, however, the results showed that the increase in colour was positively correlated with polyphenol concentration in sugarcane juice (Nguyen and Doherty, 2011). Polyphenols are the non sugars compounds present in sugarcane juice (0.01%) in colourless form but subsequently combining or reacting with other substances form colouring matter (Payet et al., 2006). Phenolic compounds in sugar juice react particularly with iron depreciated from equipments and atmospheric oxygen to form dark coloured compounds. The iron in raw juice is initially in the ferrous state but changes to ferric state, owing to the simultaneous presence of oxidising enzymes. In the absence of iron, the raw juice becomes brown upon exposure to air but with iron present it turns increasingly green (Mahadevaiah and Manohar, 2009). Quantitative studies on the iron content in sugar house products with reference to colour have been reported by Sethi. (1998). They observed a slight increase of iron content from unsulphited syrup to sulphited syrup due to pick up of iron traces from the equipments by the sulphited syrup but not have any information related to clarified syrup (Mahadevaiah and Manohar, 2009).

About 21 polyphenols have been identified in cane plant out of which ten are carried over up to the stage of Raw Sugar and four up to even Refined Sugar. Phenolic acids like chlorogenic acid and caffeic acid which are initially present in cane juice were identified in the white sugar as colorants (Guan, Tang et al., 2014). According to previous studies, the light coloured compounds associated with sugar crystals are phenolics which are not easily removable (Chen and Chou, 1993; Laksameethanasana et al., 2012). The increase of colour index of either sulphited or clarified syrup would strongly affect the quality and prices of sugar products. Therefore, this study aimed to find a relationship between total sugarcane polyphenol content and colour index and colour development of clarified syrup during storage in pan supply tanks.

2. MATERIALS AND METHODS

2.1. Materials

The clarified syrups (Bx 50 - 55) were collected for analyzing at Songcon Sugar Company. Samples were collected in 5 months and three samples per month.

2.2. Total polyphenol determination

Total polyphenol content of each extract was analysed by the Folin Ciocalteu method. A calibration curve was prepared and the results were presented as ppm of gallic acid equivalents (GAE) (Singleton and Orthofer, 1999).

2.3. Determination colour index

A syrup solution of 10^{o}Bx was prepared and filtered through membrane filter under vacuum. The pH of the filtrate was adjusted to 7.0 ± 0.1 using HCl or NaOH. The filtrate was deaerated by keeping in a vacuum desicator. The absorbance/optical density (OD) of the filtrate was measured at 560 nm against filtered deaerated double distilled water as reference. The concentration of total solids in the filtrate was determined by the refractometer (Method-GS-1/3-7 2011).

ICUMSA (International Commission for Uniform Methods of Sugar Analysis-ICUMSA) colour (IU) is given by As (10^4) / b.C

where,

As – Absorbance at 560 nm

b – Path Length (1cm), mm

C – Concentration of solids in solution (g/ml)

2.3. Statistical analysis

Statistical comparisons of the mean values for each experiment were performed by one-way analysis of variance (ANOVA), followed by the general linear model with repeated measured defined factors using SPSS 11.5 for Windows software. Significance was declared at $P \leq 0.05$.

3. RESULTS AND DISCUSSION

3.1. Total polyphenol content and colour index

The total polyphenol content of the cane sugar syrup wá determined according to the Folin-Ciocalteu method. The result, however, obtained with this assay was certainly overestimated due to the presence of sucrose, glucose, fructose, and Maillard reaction compounds in the sample such as syrups, massecuite molasses and sugar products, which may interfere with the test by enhancing the development of the blue color (Singleton, Orthofer et al., 1999). The total phenolic content for syrup varied during crushing season from 4.02 to 6.01 GAE/kg of dry content (Table 1). It could be due to harvest maturity and sugarcane varieties.

The result showed a positive correlation between total phenolic content and colour index of cane sugar syrup (R-squares value = 0.957) (Fig. 1). It is noteworthy that very high phenolic contents were observed for clarified sugarcane syrup because they are highly colored materials and phenolic compounds are strongly involved in the formation of this color.

Table 1. Total polyphenol content and colour index of cane sugar syrup

Month	November	December	January	February	March
Colour Index of Syrup (IU)	1580±25	1650±31	1710±18	1790±29	1840±19
GAE[a]	4.02±0.20	4.95±0.40	5.2±0.31	5.70±0.22	6.01±0.15

Note: [a]Grams of gallic acid equivalent per kilogram of dry content of sample, means (n=3)

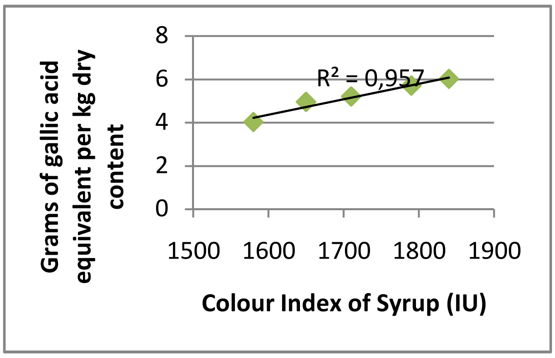

Fig 1. Relationship between colour index and total polyphenol content of sugar syrup

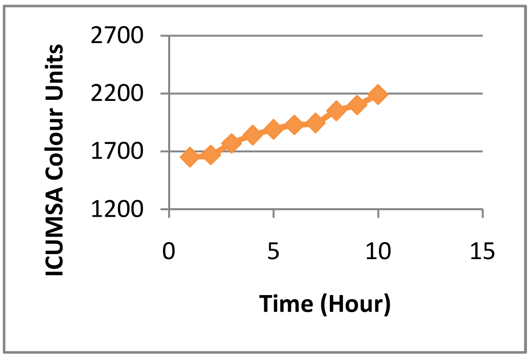

Fig 2. Colour index of clarified syrup at pH 6.02

3.2. Changes in colour with storage time and pH

The result showed that the colour development was significant during the second hour of storage. The average increase of colour of the syrup stored in mild steel tank from the initial hour to the final hour was approximately 32% (Table 2). This may be slightly less in actual practice due to syrup scale on the wall which lowers the depreciation of fresh iron from the surface to some extent. In some previous studies with sulphited syrup (pH ~ 5.0), a slight increase of iron content from unsulphited syrup to sulphited syrup due to pick up of iron traces from the equipments by the sulphited syrup was observed. These traces of iron react particularly with polyphenols to yield coloured products (Mahadevaiah and Manohar, 2009). Also, there could be colour development when bleached syrup is exposed to air as mentioned earlier (Nguyen and Doherty, 2011).

The clarified syrup is stored in supply tanks for varying periods of time may be from some minutes to several hours depend on actual production and capacity of boiling house, the colour increase is significant during prolonged storage which happens during shut downs (Fig. 2). The acidity of the bleached syrup was also demonstrated that effect to colour development of syrup. The results showed that the higher acidity, the lower the colour index. However, the average increase of colour of the syrup stored at pH 5.2 from the initial hour to the final hour is approximately 24%. Whereas that for the syrup which has the highest pH value was 14%. The significantly increasing in colour index during stored the syrup would greatly affect the colour of sugar products. The results also showed that the colour index at final hour of syrup stored at pH 5.2 is not significalty different from of syrup stored at pH 5.6 and 6.0. In addition, the sucrose will be converted to fructose and glucose in high acidity medium effect to the factory recovery. Therefore, the pH value should be control at a suitable value (pH ~ 6.0) and also keep stable during storage time. Hence, the sugarcane factories may think of closed tanks which are air-free, and also use good material for preventing to expose iron to clarified syrup. PVC tanks are recommended in this case which are free from annual maintenance and are more durable.

Table 2. The colour index of syrup in ICUMSA Units (IU)

Time (hr)	1	2	3	4	5	6	7	8	9	10
ICUMSA Colour Units	1650 ±22	1670 ±18	1770 ±25	1840 ±13	1890 ±19	1930 ±32	1945 ±21	2050 ±26	2100 ±31	2190 ±17

Table 3. The colour index of syrup inICUMSA Units (IU) upon storage time and pH

Time (hr)	pH 5.2	pH 5.6	pH 6.0	pH 6.5
	IU	IU	IU	IU
1	1510±22	1590±23	1640±19	1710±21
2	1535±25	1614±21	1652±32	1730±25
3	1640±29	1625±16	1742±24	1770±27
4	1678±17	1731±29	1764±21	1850±30
5	1746±27	1777±31	1794±26	1872±26
6	1776±21	1824±26	1856±18	1911±22
7	1875±20	1884±35	1898±33	1941±28
% Increase	24	18	16	14

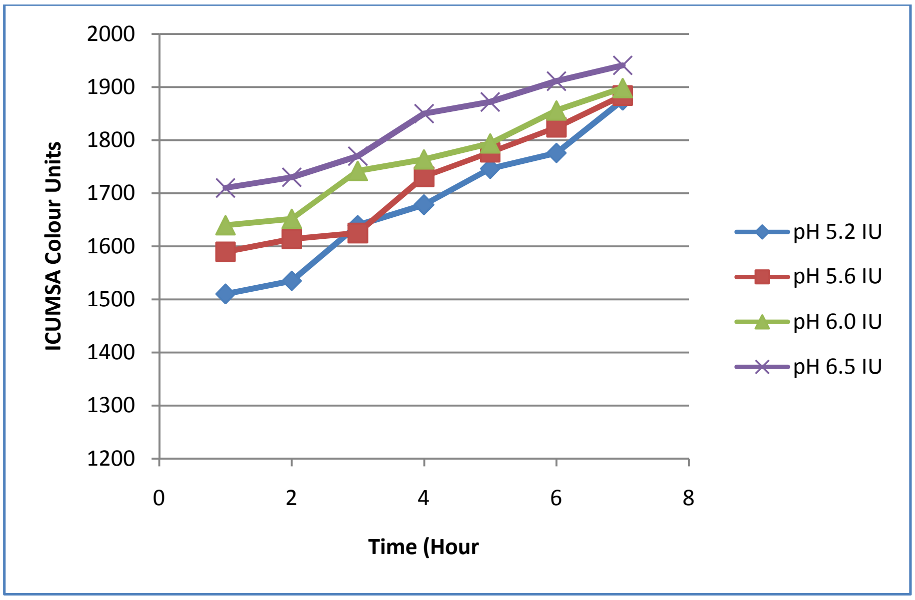

Fig 3. Colour index of clarified syrup upon storage time and pH

4. CONCLUSION

The results showed that, firstly the colour development was significant during the storage time and secondly, the positive correlation between total phenollic content and colour index of sugarcane syrup during 5 months of crushing season. This work would be gave a valuable information in operating production as well as selection a suitable material for equipments in processing.

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