

Study of some factors affecting sugar colour At Elguneid sugar factory

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ABSTRACT

The objectives of this study are to investigate the parameters which affect colour formation and influence the sugar quality in addition to that is to find technical solution to improve commercial sugar colour.

All experiments of this research study were conducted in Elguneid Sugar Company by taking samples from different manufacturing stages during 2002–2003 production season.

The values for turbidity, colour, pH, purity, refractometric dry substances (RDS%), colour transfer factor, reducing sugars (RS%) and conductivity ash were studied. The results obtained were compared with the internationally accepted standards. The reducing sugars were found to be 0.87%, where the international value represented 0.04%. This increase in RS% may be due to a drop in exhaust steam pressure, which leads to long boiling periods, and the result was sucrose inversion.

The colour transfer factor was equal to 0.035, this means that the crystal colour was lower than the mother liquor colour, since the normal accepted value is 0.01. According to the Codex Standard, the colour of household sugar should be equal to 150 ICUMSA, however the studied samples had a colour value ranging from 618 to 677 ICUMSA. The colour levels of all intermediate products of Elguneid Company were found in IU as follows:

The primary juice was 16687, mixed juice was 16432, clarified juice was 17087, syrup was 14723, A-molasses was 32236, A-heavy molasses was 11584 and A light molasses was 10438. Some of these results were found to be within the standard range.

This study revealed that, the concentration of limemilk need to be diluted from 10 to 3 -5 Baume. Also a new clarifier should be installed to minimise the retention time in this station, while care should be taken to temperature and steam pressure in the boiling house.

INTRODUCTION

Colouring matter in sugar cane juice and syrup is an undesirable impurity due to its adverse effects on crystallization process and on finished sugar products (Hugot, 1972).

The organic non – sugars and some inorganics are colouring matters in sugar cane and they are transferred to the raw juice during extraction. The colour of the cane juice may be of two origins:

a) Colouring matters from the cane itself and are mostly organics and they are of four origins:

1) Chlorophyll 2) Anthocyanin 3) Saccharetin and 4) tannins

b) Chemical decomposition, mostly organic and inorganics and they are of three origins:

- 1) Colouration of the juice due to the decomposition of its constituents
- 2) colouration of the juice due to the presence of soluble iron salts (ferric) from equipment and,
- 3) colouration of the juice due to reaction of non – sugar with other substances (Mathur, 1981).

Colour formation in the evaporation process is much lower compared with the clarified juice ,juice from the sulphitation process and the clear juice from defecation respectively (Baikow,1982). This is due to inhibition effect of the sulphites on colour formation and also due to better elimination of colouring matter in the sulphitation process. Colour content of clear juice and colour of syrup from the sulphitation process are lower than that from defecation by 27.81% and 31.81% respectively (Cubay Azucar, 1968),the justification of this colour reduction is the effect of sulphitation as shown before.

Caramelization, inversion and colour formation are proportionally more marked with higher temperature in the vacuum pan therefore, the most favourable temperature for A and B massecuites is between 54.4 – 73.8 °C, colour formation and undesirable reaction causing decomposition are then minimal and the crystallization rate is satisfactory (Payne 1962).

The objectives of this research work are:

1. Study of some factors contributing in sugar colour formation and affecting sugar quality.
2. To propose technical solutions in order to enhance sugar colour.

MATERIALS AND METHODS

Standard laboratory equipment were used for weighing, heating, drying ...etc. The following instruments and apparatus were calibrated and used:

- pH – meter model MB 220.
- ABBE Refractometer .
- Conductivity – meter, Model MC.I Mark V.
- Shimadzu, Double – beam UV-150-02 spectrophotometer .

The following reagents were used:

- Hydrochloric acid solution approx 0.1 mol/L.
- Hydrochloric acid solution approx 0.5 mol/L.
- Benzoic acid.
- Ethylen diamintetracetic–acid (EDTA) solution :dissolve 20 g of EDTA in 500 ml water.
- Fehlings solution :Two solutions were prepared and kept separately and mixed in equal volume immediately before use.

Solution A: 69.28 gm of copper sulfate ($\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$) was dissolved in 1 liter volumetric flask by distilled water.

Solution B: 346.09 gm of solution potassium tartrate (Rochelle salt) was dissolved in liter distilled water.

- Phenolphthalein solution 1g /100 ml water.

- Sodium hydroxide solution approx .0.1 mol/L.
- TEA /HCl : Triethanamine solution 0.1 mol/L dissolve 7.460g liquid in 500 ml water with 400 ml from 8.9 HCl solution 0.1 M/L into 1 litter volumetric flask of water.

Measurements:

Refractometric dry substance (RDS%):

RDS% measurement was carried out with refractometer graduated in % sucrose (g/100g).

The refractometer was calibrated at 20°C to give zero reading when distilled water was used. The surface of a refractometer prism was cleaned by distilled water, then dried by filter paper.

pH :

Electrometric method employing pH meter model MB220 with glass electrode assembly was used for pH measurement. The pH meter was adjusted with the standard buffer solution.

Turbidity:

The determination of turbidity in clarified juice is a measurement of the efficiency of the clarification process (ICUMSA,1994). Briefly the measuring procedure was as follows:

The spectrophotometer was adjusted to zero reading at 900 nm by filling the 1.0 cm cell with distilled water and pressing calibration key then the cell was rinsed and filled with the clear juice sample. The absorbance at 900 nm was determined ,then the turbidity was calculated as follows :

Turbidity index $s = A/L$

Because (s) is small cm. Where (A) is the absorbance at 900 nm, (L) is the cell length in number , the turbidity is expressed as (S) where

Turbidity $S = 100 \times s$

Colour :

The juice sample was diluted by distilled water and filtered under vacuum through 0.45 μm membrane into a clean dry conical flask . Refractometer Brix was measured for the filtrate and by using ICUMSA tables, the factor corresponding to the measured Brix was obtained . The zero absorbance point of the spectrophotometer was adjusted at suitable wavelength by using distilled water and 1.0 cm cell. The cell was then rinsed and filled with juice sample and the absorbance reading was taken. Then the colour was calculated using the following equation :

ICUMSA colour = $10^8 \times A/(\text{corrected RDS}) \times \rho$ IU “International Unit” .(ICUMSA,1994).

Where A: absorbency of sample at suitable wavelength in MAU (milliabsorbance unit), corrected RDS is given by factor measured RDS%, ρ is density “Kg/m³” which was obtained from table by corrected RDS (ICUMSA,1994).

Conductivity Ash :

The sugar sample was prepared by dissolving 5 g of the sample in distilled water in a 100 ml flask at 20°C. Then mixed thoroughly and it was transferred to measuring cell. The reading was taken.

The conductivity ash was calculated as follows :

Conductivity Ash % = $(16.2 + 0.36D) + 10 - 4 \times C \times f$,(ICUMSA,1994).

Where D is the dry substance concentration of the solution tested in g /100 ml, S is the mass of sample in 100 ml i.e. $f=5/s$, $C = C_1 - C_2$ where C_1 is the measured conductivity in $\mu\text{S}/\text{cm}$ at 20°C and C_2 is the specific conductivity of water, f is the dilution factor of solution in comparison with 5g/ 100ml .

RS% :

The reducing sugars were determined by using standard lane and Eynon method (**volumetric copper reduction**), (ICUMSA ,1994).

The colour transfer factor : It was derived from a differential colour and material balance between the crystal and the surrounding mother liquor.

RESULTS AND DISCUSSION

RDS%

Table (1) shows the results of RDS% of primary juice , mixed juice , clarified juice, syrup, A-molasses and A-light and heavy massecuites . The Brix values obtained for the above mentioned materials lie within the acceptable range, except the brix of mixed and clarified juices which are influenced by the relatively less quantity of imbibition water which was adopted at Elguneid factory and found to be 25% on cane .The standard brix is considered to lie within 11-13% for mixed and clarified juices.

Table (1) RDS% for Primary , Clarified , Mixed juice ,Syrup, A-Molasses ,A- heavy and Light massecuites :

Sample	RDS%	Standard Values
Primary juice	19.98	20
Mixed juice	17.00	11
Clarified juice	16.60	12
Syrup	63.20	65
A- Molasses	82.42	81
A- heavy massecuite	92.90	92
A- light massecuite	94.00	93

Polarization :

Pol% of different samples was expressed in (table 2) . According to Rouillard,(1978) phosphate content in mixed juice influences Pol ratio in clear juice. Phosphate value greater than 300 ppm gave low Pol ratio. Phosphate value less than 250 ppm gave high non-Pol ratio. The obtained results for Pol% seem to comply with the standard values except for mixed and clarified juices .

Table (2) Pol% at different stages of juice during processing :

Sample	pol%	Standard values
Primary juice	18.74	19
Mixed juice	14.63	11
Clarified juice	14.88	12
Syrup	54.88	56

A- Molasses	59.98	58
A- sugar	98.64	99.7

Purity :

The increase in apparent purity between raw juice and clarified juice , formerly considered as a criterion of the efficiency of the clarification process and may actually be misleading (Meade and Chen, 1985).

But for Elguneid factory the purity increase between mixed and clarified juices, from 86.05 to 89.63, (as shown in Table 3) is mainly due to destruction of fructose which led to decrease in brix . Because purity is the percentage ratio between sucrose content and brix.

Table (3) Purity at different stages of processing :

Sample	Purity%	Standard values
Primary juice	93.79	88
Mixed juice	86.05	86
Clarified juice	89.63	86
Syrup	86.83	87
A- Molasses	72.77	73
A- massecuite	86.20	85

Turbidity :

Clarified juice turbidity is used as an indication of the efficiency of the clarification process (ICUMSA, 1994). The turbidity was found to be 18.1 for Elguneid sugar company clarified juice. The obtained turbidity value is considered high according to the international norm which should not exceed 10. To decrease the turbidity of the clarified juice at Elguneid Factory it is necessary to review and correct the factors comprising juice treatment, prior to clarification and the operation of the clarifiers and all can be done as follows:

- 1) The incoming temperature of the juice should not be less than 101 – 102°C .
- 2) The temperature of the juice leaving the clarifier should be approximately 99°C .
- 3) The retention time of juice clarification should be adjusted by correcting the capacity of clarifiers station to the increased present grinding rate for Elguneid Sugar Company .

4) Colour:

The result of ICUMSA colour values for different samples - from mixed juice to sugar – were tabulated in Table (4). The colour of some intermediate products at Elgunied company fall within the acceptable range

Table (4) Colour values for different sugar materials :

Sample	Colour IU
Primary juice	16687
Mixed juice	16432
Clarified juice	17087
Syrup	14723
A- Molasses	32236
A- heavy massecuite	11584

A – light masscuite	10438
A – sugar	677

However, the colour of the A- sugar was found to be 677 IU compared to the standard value 150 IU .

Value of mixed juice color of Eljunied company is 16432 as shown on Table (4). This value is higher than the optimum, which is considered to lie between 13000 – 15000 ICUMSA. The increase in color of mixed juice in Elgunied company may be attributed to the overdosing of limemilk. The destruction of monosaccharides occurs in the alkaline media.

Optimum clarifier juice color should not exceed 13000 ICUMSA. The color increase in clarified juice is affected also by flocculation of juice . The coloring materials in cane juice are generally in colloidal form and are eliminated in the flocculation process. The flocculant dosing rates at Elgunied company is in the neighbourhood of 1.5 ppm . This dosage should be increased to 3 ppm to have an efficient flocculation to enhance the clarified juice color .

Conductivity ash :

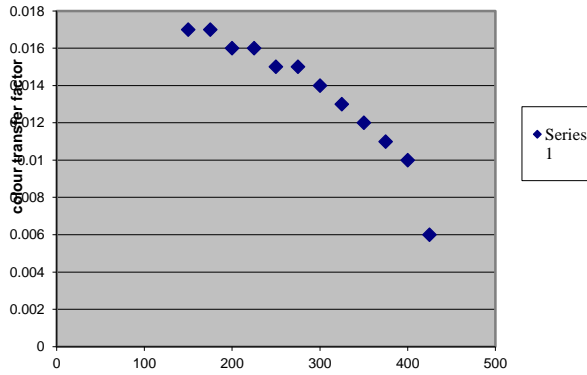
The conductivity ash was measured for A- sugar and found to be 0.12% whereas the standard value is 0.1% . The obtained results showed that the ash content lied within standard range.

Colour transfer factor :

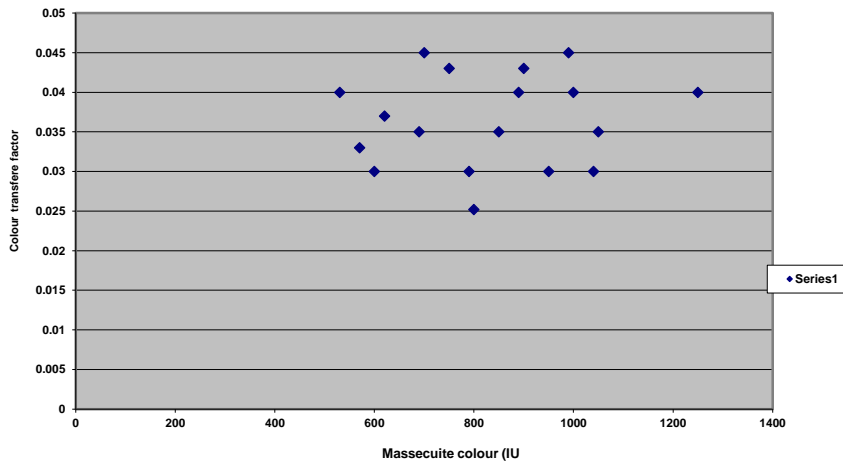
Donovan and Williams (1993) have defined colour transfer in refineries as the crystal color derived by the color of syrup from which it was boiled .

The crystal colour of sugar obtained from a sugar boiling process is influenced to a considerable extent by the quantity and quality of the colorants in the mother liquor. These factors in turn depend upon the characteristics of the mother liquor at the start of boiling and the degree to which it is exhausted during boiling .

For comparison purposes the results obtained at Elguneid sugar company were drawn in order to be compared with those obtained by Chio and Sloane (1980) in Hawaii for specific Hawaiian Sugar Factory (Fig.1). It is noticed that from Figures (1) and (2) in the case of the Hawaiian factory a straight line could be obtained, but for Elgunied company a straight line could not be drawn. This attributed to the fact that, the sugar produced at the Hawaiian factory had a low crystal color and pan boiling conditions were carefully controlled. Where as the sugar produced at Elgunied comp-any had a much higher crystal color and of poor quality, the color transfer factor at Elgunied factory was considerably higher than that for Hawaiian factory and the variability was much greater, suggesting a lesser degree of control over the boiling process .



Figure(1) Relationship Between Massecuite Colour and Colour Transfere Factor for a Hawaiian Sugar Factory
Source (ISSCT ,Feb 1980)



Figure(2) Relationship Between Massecuite Colour and Colour Transfere Factor for Elguneid Sugar Factory

CONCLUSION

The results obtained have led to the following conclusion :

1. The Pol % and Brix% are influenced to a great extent by the quantity of imbibition water which is adopted at Elgunied sugar company .The imbibition water system at Elgunied factory should be adjusted to 45-50% cane intead of 25% cane .

2. The concentration of lime milk which is added to mixed juice need to be diluted .The present lime milk concentration is 10 Baume, and this high concentration will directly lead to destruction of monosacch-arides and the result of that is color increase. To avoid this problem the concentration of limemilk can be lowered down to the range of 3-5 Baume
3. One of the factors which influences color increase at Elgunied company is the relatively high retention time at the clarifier station.
4. The main reason of that problem is the increased crushing rate which is over 400 mt/day recently, while the desined crushing rate is 250 mt/day. So, it is advisable to install a new clarifier to upgrade the existing clarifier station.
5. The boiling house also needs some remedy works . This is very clear from the analysis which was made to color transfer factor which was calculated and found to be 0.035 .And this indicated that the color of the commercial sugar obtained is high. This color should not exceed 0.01. So more attention should be paid to boiling techniques especially, exhaust steam pressure, temperature and vacuum , which to a great extent are influenced by boiler steam quality .

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دراسة بعض العوامل التي تؤثر على لون سكر مصنع الجنيد

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الخلاصة

هدف هذا البحث هو دراسة العوامل التي تؤدي لتكوين اللون والتأثير على جودة السكر المنتج ، كذلك ايجاد حلول تقنية لتحسين لون السكر التجاري.

اجريت كل التجارب التي تخص هذا البحث في مصنع سكر الجنيد وذلك بأخذ كل العينات من مراحل التصنيع المختلفة في موسم 2002-2003م.

تم تحليل وتحديد العكارة، اللون، الرقم الهيدروجيني، المواد الصلبة الجافة، معامل التحول اللوني، السكريات المختزلة وموصلية الرماد. تمت مقارنة نتائج التحليل مع الارقام القياسية العالمية السكريات المختزلة للسكر التجاري للجنيد كانت قيمتها % 0.87. مع العلم بأن القيمة القياسية العالمية لنفس نوع السكر تعادل % 0.04.

هذه الزيادة في السكريات المختزلة قد تكون نتيجة لتدني ضغط بخار التبلور او نتيجة لتكون طبقة من الرواسب على جدار انابيب الغلاية .

وجد ان معامل تحول اللون يعادل 0.035 مع ان الرقم العالمي القياسي يمثل 0.01. عدم التطابق هذا يدل على ان لون بلورات السكر اقل من لون المحلول الاصلى.

لون بلورات سكر الحنيد يقع في المدى من 618 الى 677 ايكومسا (ICUMSA) في حين ان اللون المعتمد بواسطة Codex يوجد في حدود 150 ايكومسا .

أما لون كل المنتجات الوسطية داخل مصنع الجنيد فكانت كالاتى : (بالوحدات الدولية IU) عصير الطاحونة الاولى 16687، العصير الخام 16432، العصير النقى 17087، الشربات 14323، مولاس 32723A، المولاس الثقيل 11584 A والمولاس الخفيف 10438 A بعض هذه القيم وجد انها تطابق الارقام القياسية.

أوضحت الدراسة انه من الضروري تخفيف تركيز لبن الجير من 10 الى 3-5 باوميه. وكذلك يجب اضافة مرسب للطين جديد لتقليل زمن بقاء العصير في هذه المحطة كما يجب مراقبة درجة الحرارة وضغط البخار في محطة البلورة.

