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Egyptian raw cane sugar quality in relation to refining requirements

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Abstract

Samples of raw sugar were obtained from Kom-Ombo sugar factory during the 1997/1998 working season. Sucrose, reducing sugars, ash, starch, dextran, safety factor, filterability and colour were determined. Representative samples of raw sugar were affined at different temperatures to improve quality. The results revealed that the physico-chemical properties of raw sugar varied within the season. The raw sugar could not be stored directly since it was above the limit of the safety factor, therefore, should be melted immediately. The results showed good correlations between filterability and both starch and dextran contents. The quality of affined sugar increased with increase in temperature during the affination process. The sucrose, filtration rate and yield increased, whereas reducing sugars, ash, colour, starch and dextran decreased. The results showed that the optimum affination temperature was 70°C. © 1999 Published by Elsevier Science Ltd. All rights reserved.

1. Introduction

The main requirements of the refiner are: (1) sugar that will wash well in the affination process; (2) sugar that will work well in the clarification stage, and (3) sugar which is light in colour (James & Honig, 1965; Jenkins, 1966).

In the final stage of raw sugar production, a thin layer of syrup is intentionally kept on the crystal surface. The purity of this layer, covering the pure crystal, is not more than 55–60%. During the affination process, dry molasses film dilutes and separates from the crystals, allowing an average of 75% of colour and 60% of other impurities to be eliminated (Laszlo, 1984).

Average raw sugar contains 97.52% sucrose, 0.48% water, and 2% non-sucrose impurities. The composition of non-sucrose includes reducing sugars (23%); soluble ash (38.5%); suspended impurities (3%) and undetermined constituents (35.3%) (Max, Choen, Dionsio & Sanford, 1972).

Generally there is a relationship between the quality of raw sugar that is taken into a cane sugar refinery and the difficulties encountered in turning it into good quality white sugar (Waston & Wilson, 1975). One goal of the refining process is to remove non-sugars from the raw sugar imput. The first step in most refineries is an affination process (James, Clarke & Blanco, 1987). There are three factors that adversely affect the efficiency and effectiveness of the affination process, namely: (1) the level of impurities in the whole raw sugar; (2) the quality of the grain; and (3) the presence of the finely divided insoluble impurities (James & Honig, 1965).

Recognition of the importance of the physical and chemical characteristics of sugar, besides the polarization, has been increasing during the past years (Friml, 1970). Up to the present time, little information is available in the literature concerning the physico-chemical properties of Egyptian raw sugar.

This accounts for the interest in studying the physico-chemical properties of Egyptian raw sugar, as well as a need to improve affined sugar quality using different temperatures during the affination process.

2. Materials and methods

2.1. Materials

(a). Composite representative samples of raw sugar were prepared daily from Kom-Ombo sugar factory-Aswan governorate, Egypt, by mixing 100 grams of sugar taken from half the square root of the total numbers of sacks produced every day. Samples were collected to serve as a decade composite during the 1997/1998 working season.

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(b). Refined sugar was obtained from the Sugar and Integrated Industries Company (SIIC), Hawamdia, Egypt.

2.2. Methods

2.2.1. Affination method

A satisfactory affination method, as described by Beal (1963) for use by the California and Hawaiian Sugar Company was performed. This process used 66.0 refractometric Brix sugar syrup to wash 300 g of sample four times at 50, 60, 70 and 80°C. Each time involved 450 ml of syrup and draining that out by vacuum. Then the sugar was washed with methyl alcohol and isopropyl alcohol and dried under vacuum.

2.2.2. Analytical methods

Sucrose, reducing sugars, sulphated ash, moisture content and colour were determined according to ICUMSA (1974) methods.

Filterability was measured as described by Coll, Friloux, Cashen & Guilbeau (1963). The volume of the filtrate was measured for 10 min.

Starch was precipitated by the addition of 95% ethyl alcohol. After filtration and washing by 80% ethyl alcohol, the precipitated starch was redissolved by boiling with calcium chloride solution 30%, then determined spectrophotometrically according to the Association of Official Analytical Chemists (A.O.A.C., 1980) methods.

Dextran was determined according to Roberts (1983). Dextrans were precipitated as a cupper-dextran complex and determined spectrophotometrically at 485 nm using phenol and H_2SO_4.

All the data were statistically analysed according to the method described by Snedecor and Cochran (1967).

3. Results and discussion

Statistical analysis of physico-chemical properties of raw sugar indicated that there were highly significant differences, within the season, in sucrose, reducing sugars, moisture content and colour. It also revealed significant differences in ash content.

Table 1 shows that the sucrose content of raw sugar ranged from 99.33 to 99.55% with an average of 99.49%.

An increase in the content of reducing sugars at the begining of the season and a slight increase in ash concentration (decade No. 1) are combined to give a substantially higher reducing sugars/ash ratio of 1.1 compared to the ratios at the other decades (0.86–0.94). The low reducing sugars content in most decades may result from either mature cane low in reducing sugars or a substantial degree of decomposition of monosaccharide at high alkalinities and/or temperature (Saska, 1989).

Destruction of sugar by osmophilic yeasts could take place in the syrup film surrounding the crystal providing conditions are appropriate and the syrup film is sufficiently diluted (Waston & Wilson, 1975). Therefore, the safety factor relating the water content of the sugar to that of the impurities was determined. Table 1 shows that safety factors ranged from 0.28 to 0.40. The safe limit for this was originally fixed at a figure of 0.28 according to the Amstar Corporation (Waston & Wilson, 1975). Therefore, all samples were above the

Table 1
Physico-chemical properties of Egyptian raw sugar

Properties No. of decades	Sucrose %	Reducing sugars %	Ash %	Reducing sugars/ash ratio	Moisture %	Safety factor	Colour M.A.U
1	99.33 f	0.21a	0.19 a	1.1	0.23 a	0.34	667 a
2	99.38 e	0.16 b	0.17 abc	0.94	0.25 a	0.40	662 a
3	99.51 abc	0.13 cd	0.15 cd	0.87	0.14 c	0.29	477 i
4	99.48 c	0.15 bc	0.16 bcd	0.94	0.15 c	0.29	599 ed
5	99.53 ab	0.13 cd	0.15 cd	0.87	0.15 c	0.32	578 efg
6	99.53 ab	0.13 cd	0.15 cd	0.87	0.14 c	0.30	578 efg
7	99.53 ab	0.13 cd	0.15 cd	0.87	0.14 c	0.30	522 h
8	99.53 ab	0.13 cd	0.15 cd	0.87	0.14 c	0.30	574 fgh
9	99.54 ab	0.12 d	0.14 d	0.86	0.14 c	0.30	569 gh
10	99.43 d	0.16 b	0.18 ab	0.89	0.19 b	0.33	678 egh
11	99.50 bc	0.13 cd	0.15 cd	0.87	0.16 bc	0.32	637 bc
12	99.48 c	0.15 bc	0.17 abc	0.88	0.16 bc	0.31	659 ab
13	99.50 bc	0.14 bcd	0.16 bcd	0.87	0.14 c	0.28	634 c
14	99.54 bc	0.13 a,b	0.14 d	0.93	0.13 c	0.28	595 def
15	99.55 ab	0.14 a	0.15 cd	0.93	0.13 c	0.29	607 d
F test	**	**	*	–	**	–	**
LSD 5%	0.0449	0.027	0.0268	–	0.032	–	22.447

Table 2
Filterability, starch and dextran of Egyptian raw sugar

Number of decades	Filterability ml/10 min	Starch[a] ppm	Dextran[a] ppm
1	34 h	230 a	374 a
2	39 g	208 b	250 b
3	54 a	191 de	172 i
4	51 b	193 cde	141 k
5	42 ef	197 cd	188 g
6	47 cd	195 cde	164 j
7	41 egf	198 c	196 f
8	43 e	197 cd	211 d
9	55 a	190 e	204 e
10	40 gf	198 c	250 b
11	51 b	191 de	164 j
12	47 cd	195 cde	234 c
13	49 bc	193 cde	176 hi
14	56 a	190 e	172 i
15	46 d	196 cde	180 h
F test	**	**	**
LDS 5%	2.7458	6.7987	5.4965

[a] Mg per kg solids.

limit, and thus the sugar could not be stored without danger of substantial deterioration and sugar loss and should be melted immediately.

Table 1, shows that the colour of raw sugar at the begining of the season (667 M.A.U.) was darker than the sugar at the end of the season. Spencer and Mead (1959) reported that the amount and nature of the colour in raw sugar are of utmost importance to sugar refineries. The factors influencing colour of raw sugars were the nature of soil supplying the factory with cane, the ripeness of the cane, processing steps, such as clarification of juice, methods of pan boiling and prevention of overheating and caramelization.

Table 2 shows that there was good correlation between filterability and starch and dextran contents. Correlation coefficient between filterability and starch: $r = -0.744$, and correlation coefficient between filterability and dextran: $r = -0.714$, (Table 3), therefore indicate a low filtration rate due to the presence of these polysaccharides. Hidi and McCowage (1984) and Imrie and Tilbury (1972) reported that the dextran and other soluble polysaccharides give juices of high viscosity in the mills leading to poor clarification and filtration, which in turn leads to a reduction in the economic efficiency of the refining process.

The simplest way to reduce the ash content, reducing sugars and colour was through mixing of raw sugar with a sufficient quantity of granulated sugar syrup followed by centrifugation and washing. The affination process is designed to remove, as completely as possible, the impurities in the syrup film surrounding the sugar crystal in raw sugar which contains the bulk of the impurities. In fact, included impurities and colour in this process are inaccessible to affination. Therefore, the effectiveness of this unit process is determined by the proportions of included and excluded impurities.

Table 4 indicates that the temperature, during the affination process, has a highly significant effect on sucrose, reducing sugars and ash contents, as well as colour. The sucrose percentage is enhanced as the temperature of affination process increases. The sucrose content increases from 99.41% at 50°C to 99.63% at 80°C. The affination process of raw sugar diminishes the ash content from 0.13% at 50°C to 0.06% at 80°C. A similar decrease in reducing sugars was observed. However, the magnitude of reducing sugars reduction was less than that of the ash content, resulting in an increase of the reducing sugars/ash ratio. The correlation coefficient listed in Table 6 see below support these findings. These results confirm those reported by James (1967), who stated that the ash increase as a percentage of total non-sugar was due to the fact that the reducing sugars were removed from the sugar to a great extent during the affination process, whereas the removal of inorganic non-sugars followed a different pattern. Table 4 shows a gradual decrease in colour of affined sugar as the

Table 3
Correlation coefficient of measured traits

Properties	Decade	Sucrose	Reducing sugars	Ash	Reducing sugar/ash ratio	Moisture	Safety factor	Colour	Filterability	Dextran	Starch
Sucrose	0.508**										
Reducing sugars	−0.350**	−0.726**									
Ash	−0.262	−0.614**	0.496								
Reducing sugars/ash ratio	−0.167	0.309*	0.707**	−0.256							
Moisture	−0.508**	−0.831**	0.648**	0.562**	0.267						
Safety factor	−0.347**	−0.391**	0.393*	0.355*	0.121	0.831**					
Colour	0.124	−0.515**	0.502**	0.377*	0.252	0.521**	0.351*				
Filterability	0.415**	0.611**	−0.568**	0.516**	0.216	−0.590**	−0.381	−0.369*			
Dextran	−0.373	−0.764**	0.724**	0.575**	0.325*	0.696**	0.405**	0.444**	−0.714**		
Starch	−0.524**	−0.730**	0.714**	0.559**	0.316*	0.682**	0.415**	0.457**	−0.744**	0.861**	

Table 4
Effect of affination on quality of affined suger at different temperatures

°C	Sucrose %	Reducing sugurs %	Ash %	Reducing sugars/ash ratio	Colour M.A.U.
50	99.41 c	0.18 a	0.13 a	1.38 c	154 a
60	99.49 b	0.14 b	0.09 b	1.56 ac	133 b
70	99.62 a	0.11 c	0.06 c	1.83 a	128 c
80	99.63 a	0.11 c	0.06 c	1.83 ab	128 c
F test	**	**	**	*	**
LSD 5%	0.0378	0.0115	0.01	0.3117	0.28255

Table 5
Effect of affination on filterability, starch, dextran and yield at different temperatures

°C	Filterability ml/10 min	Starch[a] ppm	Dextran[a] ppm	Rendement %
50	56 d	193 a	224 a	98.76 c
60	74 c	181 b	216 b	99.04 b
70	93 b	173 c	188 c	99.32 a
80	95 a	173 c	186 c	99.33 a
F test	**	**	**	*
LDS 5%	1.9979	2.514	4.1188	0.0748

[a] Mg per kg solids.

Table 6
Correlation coefficients of measured traits

Properties	Temperature	Filterability	Starch	Dextran	Rendement	Sucrose	Reducing sugars	Ash	Reducing sugars/ ash ratio	Colour
Filterability	0.958**									
Starch	−0.920**	−0.974**								
Dextran	−0.942**	−0.965**	0.911**							
Yield	0.916**	0.957**	−0.965**	−0.917**						
Sucrose	0.947**	0.982**	−0.945**	−0.969**	0.974**					
Reducing sugars	−0.852**	−0.898**	0.923**	0.837**	−0.980**	−0.921**				
Ash	−0.874**	−0.918**	0.953**	0.862**	−0.990	−0.993**	0.991**			
Reducing sugars/ash ratio	0.752**	0.785**	−0.838**	−0.809**	0.889**	0.824**	−0.873**	−0.906**		
Colour	−0.858**	−0.928**	0.968**	0.820**	−0.927**	−0.883**	0.911**	0.930**	−0.772**	

temperature during affination was increased. The best colour was noticed at 70 and 80°C.

The colour of the crystals could be used with excellent success for judging the quality of raw sugar in affination and refining.

Table 5 shows a gradual increase in filtration rate as the temperature during affination increases, and a small decrease in starch and dextran contents. Increasing filtration rate may be due to the reduction of viscosity at high temperature.

Yield of sugar increased with increasing temperature of affination (98.76, 99.04, 99.32 and 99.33 at 50, 60, 70 and 80°C, respectively).

Mean comparisons presented in Tables 4 and 5 indicated no significant differences between effect of temperature at 70 and 80°C on most properties of affined sugar. Therefore, economically speaking, 70°C performed as optimum affination temperature.

4. Conclusion

Results of this work indicate that the studied samples of raw sugars are above the limit of safety factor and therefore, should be melted immediately. Low filtration rate was due to the presence of starch and dextran. The quality of affined sugar increased with an increase in temperature during affination. These results revealed that the optimum affination temperature was 70°C.

References

Association of Official Analytical Chemists (1980). *Official methods of analysis* (13th ed.). Washington, DC: Association of Official Analytical Chemists.

Beal, C. W. (1963). *Proc. Sugar Ind. Technicians, 22nd Meet., 22*(1), 34.

Coll, E. E., Friloux, J. J., Cashen, N. A., & Guilbeau, W. F. (1963). *Proc. Sugar Ind. Technicians, 22*(1), 18.

Friml, M. (1970). Evaluation of raw and white sugar. *Sugar Ind. Abstr., 32*(2), 189.

Hidi, P., & McCowage, R. J. (1984). Quantification of the effects of different impurities on filtration rate in carbonation refineries. Tech. Sess. Cane Sugar Refining Research.

ICUMSA (1974). International Commission for Uniform Methods of Sugar Analysis. Proc. 16th sess, Ankara, 22.

Imrie, F. K. E., & Tilbury, R. H. (1972). Polysaccharides in sugar cane and its products. *Sug. Tech. Rev., 1*, 291–361.

James, C. P. C. (1967). Sulfated ash and total nonsugars in Peruvian raw sugar. *Sugar Journal*, November, 9–13.

James, C. P. C., & Honig, P. (1965). Ash content of Peruvian raw sugars. *Sugar Journal*, October, 42–47.

James, A. M., Clarke, M. A., & Blanco, R. S. (1987). Recycling of non-sugars in refineries. *Sugar Journal*, January, 12–15.

Jenkins, G. H. (1966). *Introduction to cane sugar technology*. Amsterdam–London–New York: Elsevier Publishing Company.

Laszlo, T. (1984). Refining cane sugar in beet sugar factory. *Sugar Journal*, October, 7–12.

Max, A., Choen, O., Dionsio, G., & Sanford, J. D. (1972). Quality problems in refined cane sugar. *Sugar Journal*, January, 8–16.

Roberts, E. J. (1983). A quantitative method for dextran analysis. *International Sugar Journal, 85*, 10–14.

Saska, M. (1989). Composition of 1988 Lousiana final molasses. *Sugar Journal*, October, 13–15.

Snedecor, G. W., & Cochran, W. G. (1967). *Statistical methods*. Ames, Iowa: The Iowa State University Press.

Spencer, G. L., & Meade, G. P. (1959). *Cane sugar handbook* (8^{th} ed.). New York: John Wiley and Sons.

Waston, A. J., & Wilson, N. M. (1975). *Sugar technology reviews*. Amsterdam: Elsevier Publishing Company.