Effect of viscosity on C sugar in Beet sugar factories

Mohammad Hojjatoleslamy[1] , Reza Shokrani[2] and Ahmad Karbasi[3]

[1] Department of food technology, College of agriculture, Shahre Kord branch, Islamic Azad University, Shahre Kord, IRAN
[2] College of Agriculture, Isfahan University of Technology, Isfahan, IRAN
[3] College of Agriculture, Shiraz University, Shiraz, IRAN

ABSTRACT

According to the Fick's law, viscosity affects mass transfer velocity. For studying effect of viscosity on C-sugar, viscosity reducing agent namely Uranus CB9 in three levels added to C massecuite in pan boiling operation. After finishing boiling operation and refrigeration period, effect of these levels on qualitative specifications of C-sugar and viscosity of molasses studied. During first campaign period held at 23 September to 23 October (sugar beet hasn't ripened and has poor quality), addition of 150 ppm Uranus CB9 led to massecuite matrix (Mother liquor) viscosity dropping from 187.7 to 167.7 poise at 40 °C. This caused decreasing C-sugar's color from 2653 to 1140 IU, conductivity ash from 0.74106% to 0.22536% and molasses viscosity from 172.9 to 121.7 poise.

In second operating period which sugar beet reached to enough maturation, after addition 150 ppm Uranus CB9 viscosity of matrix decreased from 182.8 to 159.6 poise. Viscosity reduction caused decreasing of C-sugar color from 1447 to 1136 IU, conductivity ash from 0.38142% to 0.29007% and molasses viscosity from 147.2 to 129.3 poise. On the basis of these results, using Uranus CB9 and other viscosity reducing agents, recommended for increasing of C-sugar and beet sugar processing quality.

INTRODUCTION

Fick`s law expressed substance diffusion in mass transfer phenomonia (Eq. 1)

$$d_s = D_f A \frac{d_c}{d_r} d_t \qquad (1)$$

Where:
d_s= Weight of dissolved substance through area A
D_f= Diffusion coefficient which depends on temperature according to Einstein correlation (Eq. 2)
$\frac{d_c}{d_r}$= Concentrated gradient of dissolved substance

$$D_f = \frac{k'T}{\eta} \qquad (2)$$

Where:
k'= Constant for the dissolved substance
T= Absolute temperature
η= Viscosity of solution (9)
According to the equations 1 and 2 viscosity affect on crystal growth in pan and crystallization (13, 14).

The rate of crystallization determined by degree of supersaturation, temperature, crystal surface area and nature of impurities. The viscosity is also influenced by the same factors (Fig. 1) and the limit to which the massecuite can be cooled depends on ability of the crystallization to handle the material physically at high viscosity. Viscosity is therefore a dominating factor in the technology of the process (1).

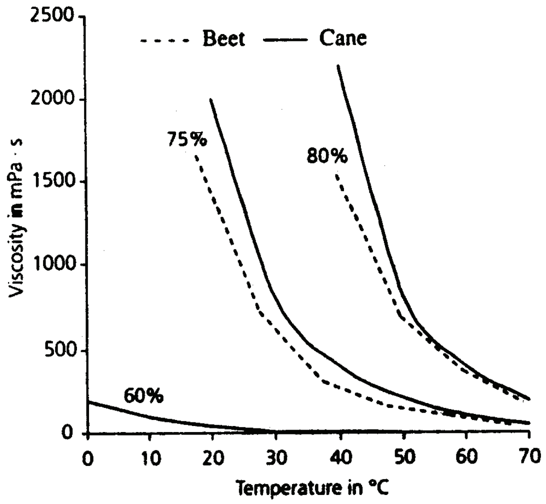

Figure 1. Effect of temperature and dry substance contents on the dynamic viscosities of cane and beet molasses (12)

It is recognized that the limit to the molasses exhaustion is often the mobility of factory equipment to handle high viscosity massecuite (11). In 1871, Feltz expressed that viscosity is the main factor in molasses formulation (8).

The viscosity of an individual molasses sample may be very different from that average molasses. It is lower at higher alkali salt concentration and higher with increased content of polysacharids (dextran, levan, starch pectin fragments etc) and alkali earth ions.The viscosity can be considerably lowered by the addition of urea (12).

By addition 2% calcium acetate molasses viscosity reduced from 70 to 50 poise and molasses and molasses purity decreased 0.87% (4).

Ehrenberg used Intrasol FK, by addition this agent molasses viscosity reduced and facilate centrifuge performance (3).

Kringer used viscosity reducing agents (pan aid) namely Hodag CB6 and Intrasol FK. Addition of these materials led to molasses`s purity reduction (6, 7).

Chou compared some viscosity reducing agents Flo1, Flo2, Flo3 and Hodag CB6 and explained by increasing concentration of them molasses purity reduced. He used 0, 50, 100 and 150ppm concentration (2).

Srinvansan et al. expressed that by addition 8 kg viscosity reducing agent namely Super A30 in 8ton capacity pan 0.8% purity of molasses decreased and purity of sugar increased by 0.7% (15).

Palanius compared GMS-S, Verin and Intrasol FK and expressed that GMS-S in 200ppm concentration is more effective than others and recommended use of this agent for sugar factories (10).

MATERIAL AND METHOD

Chaharmahal sugar factory campaign divided to two period. First period started at 23 September to 23 October which sugar beet hasn`t ripened and has poor quality and second period started at 24 October to 24 November which sugar beet has ripened enough. Viscosity reducing agent namely Uranus CB9 added to pan boiling stage by concentration 0, 50, 100 and 150 ppm in three replication. During the study all centrifuge stage conditions remain constant. After molasses exhaustion Brix (ºBx) determined by S&H DUR digital refractometer (±0.01) and sucrose content (ºZ) determined by Dr. Wolfgang Kernchen sucromat (±0.01). The purity calculated by equation 3.

$$Purity = \frac{°Z}{°Bx} \times 100 \quad (3)$$

C-sugar color determined by ICUMSA method GS1/3-7and conductivity ash determined by ICUMSA method GS1/2/3/4/7/8-13.

Molasses and matrix viscosity determined by using cylindrical viscometer HAAKE Rotovico R12 at 40ºC. results analysed by Duncan multiple range test at 95% confidence level

RESULTS AND DISCUSSION

Relationship between viscosity of molasses and Uranus CB9 dosage presented in tables 1 and 2.

Table 1. Relationship between viscosity of molasses and Uranus CB9 dosage in first campaign period

Uranus CB9 dosage (ppm)	Molasses viscosity (Poise)	Matrix viscosity (Poise)
0	172.9[a]	187.7[a]
50	177.5[a]	190.1[a]
100	137.3[b]	174.0[ab]
150	121.7[b]	167.7[b]

Table 2. Relationship between viscosity of molasses and Uranus CB9 dosage in second campaign period

Uranus CB9 dosage (ppm)	Molasses viscosity (Poise)	Matrix viscosity (Poise)
0	172.6[a]	182.8[a]
50	142.3[b]	174.1[b]
100	124.1[c]	166.0[c]
150	115.5[c]	159.6[d]

As shown in table 1, by increasing Uranus CB9 content, viscosity was reduced in both first and second campaign period. Minimum viscosity obtained by adding 150ppm Uranus CB9 to pan boiling in the second campaign period. Changes in sugar beet quality in second period Uranus CB9 cause more efficient viscosity reduction.

Figures 2 and 3 show as viscosity reduces, color decreased in both first and second period which affects on processing quality. In spite of color decrease in the first period because of wide variance range, results have no significant statistical difference but in second period results show more difference in viscosity lower than 160 poise. Maximum color decreased in the second period due to enough ripening.

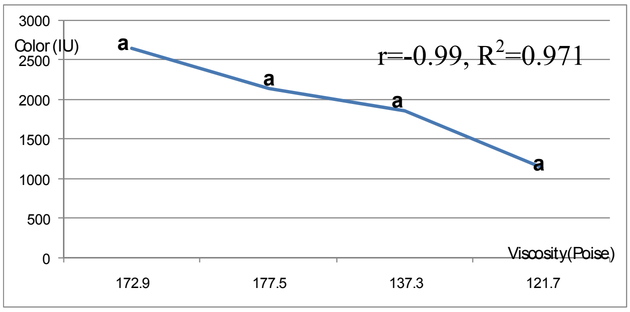

Fig. 2. Relationship between color and viscosity variation in first campaign period

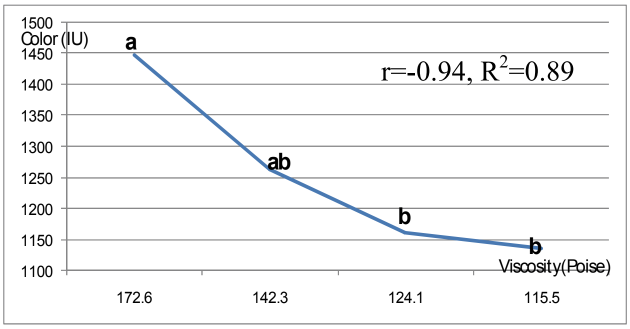

Fig. 3. Relationship between color and viscosity variation in second campaign period

High color in first campaign period may resulted by low raw juice purity and high nitrogen content in early campaign days which led to increase browning reactions. Uranus CB9 was more effective in first period but high initial color cause higher color even after addition of 150ppm Uranus CB9.

Figures 4 and 5 show as viscosity reduced, ash content also decreased. As described previously, low raw juice purity caused by high non sugar content eg. proteins, alkaline elements and pectic substances.

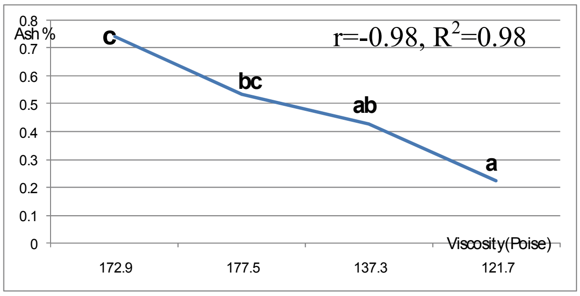

Fig. 4. Effect of viscosity reduction on C-sugar ash content in first period

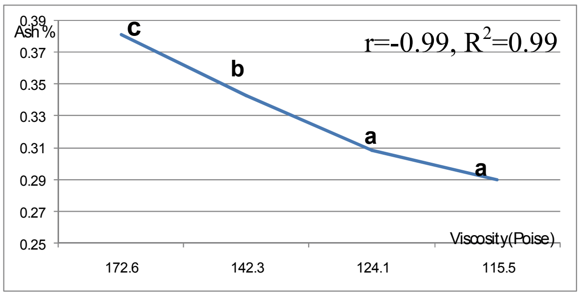

Fig. 5. Effect of viscosity reduction on C-sugar ash content in second period

Color and ash of C-sugar greatly depended on good molasses separation in continues centrifuges. Viscosity reduction improved centrifuges operation and non sugar separation. Good process adjustment and viscosity reducing agents consumption may prevent harmful effects of viscosity.

REFERENCES

1- Chou, C. C. (2000), "Handbook of Sugar Refining", John Wiley and Sons Inc. New York. p 324.

2- Chou, J. C. (1974), Reduction of Molasses Viscosity by Surface Active Chemicals", Int. Sugar J., **76**, 195-198.

3- Ehrenberg, J. (1968), "The Improving of Sugar Production Using Wetting Agent", Zucker, **21**, 688-691.

4- Galano, P. J., Gonzalez, C. R., and Jimenes, L. (1978), "Evalouation of Surface Active Agents in Process of Sugar Crystallization by Exhaustion in Industrial Scale", Centro Azucar, **11**, 91-96.

5- ICUMSA Method Book. (2007). Barten`s Pub. Berlin.

6- Kringer, O. (1972), "Boiling Low Grade Production with Addition of Intrasol FK Wetting agent", Zucker, **21**, 668-691.

7- Kringer, O. (1972), The Using of Wetting Agents for Boiling Low Quality Raw Product", Cukripar, **2**, 67-71.

8- McGinnis, R. A. (1978), "Exhaustion of Beet molasses. Sugar Tech. Rev., **5**, 115-285.

9- McGinnis, R. A. (1982), "Beet Sugar Technology", Beet Sugar Development Foundation Pub., Fort Collins. p. 121.

10- Michaels, A. S., and Colville, A. R. (1960), "The Effect of Surface Active Agents on Crystal Growth Rate and Crystal Habbit", J. Phys. Chem., **69**, 13-19.

11- Rein, P. (2007), "Cane Sugar Engineering", Barten`s Pub.

12- Van der Poel, P. W., Shiveck, H., and Schwartz, T. (1998). "Sugar Technology", Barten`s Pub. Berlin. p. 986.

13- Vanhook, A. (1945), "The Diffusivities of Concentrated Sucrose Solution", J. Am. Chem. Soc.,370-372.

14- Vanhook, A. (1945). "Kinetics of Sucrose crystallization", Ind. Eng. Chem. **37**, 782-785.

15- Srinvansan, S., Chinappan, N., Lokabiroman, R., Sengutuan, R., Deravaj, V., and Srinvansan, C. (1982), " A Study on Use Super A30 Surface Active Chemical Better Substitue for Low Grade Massecuite for Better Exhaustability of Final Molasses", Proc. 46th Annual Con. 45-47.