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Scientific Research

The effect nonionic surface-active components on cold crystallization in sugar industry

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ABSTRACT

Many studies have been performed on the effect of viscosity on the qualitative characteristics of hot crystallization in the cooking stage of beet factories. In this study, we tried to investigate the effect of newer viscosity reducing agents based on sucrose esters on the quality of cold crystallization. For this purpose, a substance called Sisterna® which is a sucrose ester as a viscosity reducing agent in four levels 0 , 33, 66 and 100 ppm were used in weak effluent from centrifuge cooking of a beet factory at 55 ° C and its effect on viscosity, crystallization efficiency, color of extracted sugar solution and purity percentage was investigated. The results showed that the addition of this substance reduced the viscosity. Crystallization efficiency increased to 66 ppm and then decreased at higher concentrations. The color of the extracted sugar solution and the purity percentage of the effluent produced by centrifugation and separation of the solid phase from the liquid decreased to this concentration of surfactant and at higher concentrations these parameters increased. In general, the use of these materials in cold crystallization of sugar factories can increase the efficiency and reduce the waste of beet factories.

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1- Introduction

In sugar factories, crystallization is divided into two stages, cold and hot, and increasing the efficiency of each can improve the factory's performance significantly.[1]The process of crystallization and the growth of crystals becomes slower. For this reason, cold crystallization method is used to improve and complete the crystallization. Crystallization by cold method is based on reducing the temperature and bringing the baking to a supersaturated state. In this case, due to the lowering of the temperature, the baking viscosity increases significantly. The viscosity also acts as a resisting force in the crystallization, with the increase in the viscosity, the amount of molasses produced and the amount of sugar added to it is increased. increases, which reduces the quality and amount of sugar produced and reduces the efficiency and performance of sugar extraction, and as a result, the income of the factories decreases [1].

In general, the process of extraction and crystallization is according to the general laws of diffusion, which is a result of random thermal conduction of sugar and water molecules. These molecules normally diffuse from an area of higher concentration to an area of lower concentration. The diffusion tendency increases with increasing concentration difference. According to the first law of fic[2] Diffusion speed is directly proportional to the constant diffusion coefficient, concentration gradient and particle surface and inversely proportional to the distance of particles from each other. In 1905, according to the equation he presented, Einstein showed that viscosity has a reducing effect on the diffusion constant and increasing temperature increases it.

A large number of researchers have been looking for a way to reduce the viscosity of sugar solutions during the crystallization stages since 1875, and one of these methods is the use of compounds and surface active substances [2]. It has been almost 70 years that the use of surfactants as materials to reduce viscosity has been investigated [3].

Surfactant is a substance that acts on the surface and when it is spread on the surface of a liquid, it reduces the surface tension to a great extent. This material is made of two components soluble in water (hydrophilic) and insoluble in water (hydrophobic). Hydrophobic sources typically include natural fats and oils. Hydrophilic groups usually define the primary classification of surfactants, which can be anionic, cationic, or nonionic compounds.

Chow[3] The effect of several viscosity-reducing substances under the brand name Flo[4] and Hadak[5] (9CB) investigated the hot crystallization process in beet sugar factories and obtained favorable results from the effect of these substances [4]. Size et al., the effect of intrasol surfactants[6]FK and Hadak CB9 with slovapan material[7] investigated and evaluated the effect of these materials on the viscosity of the final firings as very low [5]. Kolinchenko[8] et al investigated the effect of several surfactants on improving the quality of extracted white sugar and increasing the speed of hot crystallization and emphasized the effect of these substances on improving the quality

[1]- Matrix
[2]- Got

[3]- Chou
[4]- flo
[5]- Hodak
[6]- Intrasol
[7]- The slop
[8]- Kulinchenko

parameters [6]. Palanius[9] The effect of surfactants GMS-S, Varin-3[10] and investigated Intrasol on final firings and found that GMS-S surfactant is more effective in reducing viscosity in hot crystallization [7]. Hojjat al-Islami et al. on the use of isopropyl myristate surfactants[11] and 9CB found that the use of these surfactants improves the efficiency of hot crystallization, reduces the color of chlorinated sugar and improves sugar extraction from molasses [8 and 9]. Hakimzadeh et al. using Tween 20 non-ionic surfactants[12] found that the use of these surfactants in the enhanced ultra-refining (MEUF) process reduces raw sugar impurities, turbidity, soluble color and total dissolved matter (TDS) [10].
Reducing the percentage of purity of sugar effluents from the centrifuge and separating sugar crystals in the last stages of the process can improve the overall efficiency in sugar factories and improve the extraction coefficients in this industry. In addition, by increasing the speed of crystallization, we will see more utilization of the production capacity.

According to the studies conducted and considering that cold crystallization, like hot crystallization, has a significant role in reducing the waste of beet sugar factories, in this research, different concentrations of non-ionic surfactants were used.[13] Cisterna, which is a sucrose ester, has been used on the weak effluent syrup obtained from the cooking centrifuge 1 at a constant temperature of 55 degrees Celsius, and the purpose of this research is to investigate the effect of this surfactant on the efficiency of cold crystallization in the cooking 2 of beet sugar factories.

2- Materials and methods

2-1- Raw materials

2-1-1- Sugar solution

In general, white sugar is extracted from cooking 1 and the effluent produced in the process of centrifugation and separation of white sugar crystals is called weak effluent of cooking 1, and because this effluent is used as feed for subsequent cooking, and in the process of crystallization of this effluent, it is sent to cooking 2 and so on. It is transferred as cooking base 3, the importance and necessity of increasing the efficiency of extraction from it is much higher than other effluents and syrups [11].

2-1-2 - Surfactant

Stressors[14]SP50 as a surfactant was prepared from Sisterna (Netherlands) and its chemical structure is presented in Figure 1. Its side chain is the alkyl group of the fatty acid. Fatty acids react with one or more (primary) hydroxyl groups of sucrose to form mono-, di-, or tri-esters. SP represents stearate esters and 50 represents the percentage of monoesters. This saccharoster has[15] HLB It was equal to 11 and part of it is soluble in water between 25 and 80 degrees Celsius.

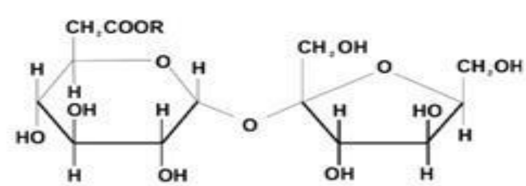


Figure 1: Chemical structure of sucrose ester [12].

9- Palanius
10- verin3
11- Isopropyl myristate
12- Tween 20
13 - Non-ionic surfactant
14- Sucrose Stearate patrician (%Mono Ester 50)
15 - Hydrophilic-Lipophilic Balance

In this research, its effect on the weak effluent sample obtained from the cooking centrifuge of a sugar beet factory "Shirvan-Qochan-Bojnoord" was investigated.

2-3- Tests

2-3-1- amount of sugar (polarity)

The basis of sugar percentage measurement is the deviation of polarized light or polarization. Asymmetric carbon deflects polarized light. Due to having asymmetric carbon, sugars deflect polarized light to the left or right according to their chemical structure, and the amount of this deviation is proportional to the concentration. The amount of dissolved sugar by a polarimeter device (modelSchmidt, Germany) according to instructionsCUMSUAwas determined.]13[.

2-3-2-percent puritypurity)

It indicates the percentage of sucrose in the dry matter of the sample, which is obtained from equation 1 [11].

Equation 1

$$purity(\%) = \frac{S}{DS}$$

2-3-3-breaks[16] or dry matter[17](DS)

In sugary industrial syrups, the refractometric method is used to determine the amount of dry matter (brix) based on the deflection of a ray of radiation when it hits the surface of a solution. Brix of the sample by refractometerSchmidt's, DUR-S. Germany) was determined [11].

2-3-4-viscosity

Viscosity of samples by viscometerBROOKFIELD LV ,DV-III ULTRA). Made in America) with spindle number 418SC at shear speed at shear speed s/1 35 andrpm 27 was tested at the desired temperature.

2-3-5-Efficiency and content of crystals

To determine the efficiency and crystal content, a certain amount of the weak effluent of baking one was removed and the amount of dry matter, polarimetry and its purity percentage were determined. Then surfactant was added to the sample in different concentrations and the crystallization process was performed by cooling it non-continuously. Muscovites[18](Mixture of solid and liquid phase) the result of the analysis and dry matter, percentage of sugar and percentage of its purity were determined. After that, a specific amount of muscoite was weighed and then centrifuged, and during this process, sucrose crystals (solid phase) were separated from the background or mother effluent (liquid phase). Next, the amount of dry matter, percentage of sugar and percentage of purity of the resulting effluent (liquid phase) were determined. The content of sucrose crystals was calculated based on the change of refractometric dry matter and purity according to equation 2 [3].

[16] -Brix

[17]- Dry substant

[18]- Massecuite

$$CC = \frac{DSm(Pm-Pml)}{100-Pml} = \frac{Sm-Sml}{100-Sm} * 100$$

Relationship 2

In this regard DS_m[19] Muscovites dry matter, P_m[20]: Purity percentage of muscoite, P_{ml}[21]Purity percentage of mother syrup, S_m[22] The amount of sucrose muscovit and S_{mlL}[23] The amount of sucrose in mother syrup is in percentage.

2-3-6-color of sugar solution

The color of a sugar solution is determined based on the decrease in the intensity of monochromatic light that passes through the solution. This reduction is due to the absorption of the rays emitted by the colored substances in the solution. The color of the extracted sugar solution, after the centrifugation process, sampling of the resulting sugar and the color of its solution with a colorimeterINSTRUMENTS,INDEX . Made in England) by spectrophotometric method at a wavelength of 420 nm using a quartz cell with a diameter of 1 cm [9, 14].

2-4-Statistical analysis

All tests were performed in 3 repetitions and to compare the averages, Duncan's statistical scheme was used[24] It was used based on a completely random design at a confidence level of 95% ($p>0.05$). The software used for analysis of variance and comparison of averagesSPSS It was version 16.

3. Results and Discussion

Brix values, degree of polarization and degree of purity of waste 1 used are listed in Table No. 1, as it can be seen, the values are in the acceptable range for weak waste of cooking 1 [11 and 15].

Table 1- Results of chemical tests of weak effluent used

	Brix	**Pol°**	**Purity %**
Acceptible range	*78-80*	*66-68*	*85-88*
Sample	**78.60±0.34**	**66.90±0.31**	**85.4±0.59**

3-1- The effect of different surfactant concentrations on viscosity

The results of the analysis of variance and the comparison of the average value of viscosity at different concentrations of surfactant at 55 °C presented in (Figure 2) showed that the effects of different concentrations of surfactant on the viscosity parameter were significant at the 5% probability level ($p<0.05$)..

19- Dray substance of massecuite (%)
20- Purity of massecuite (%)
21- Purity of mother liquor (%)
22- Sucrose content ofmassecuite (%)
23- Sucrose content ofmassecuite (%)
24- Duncan

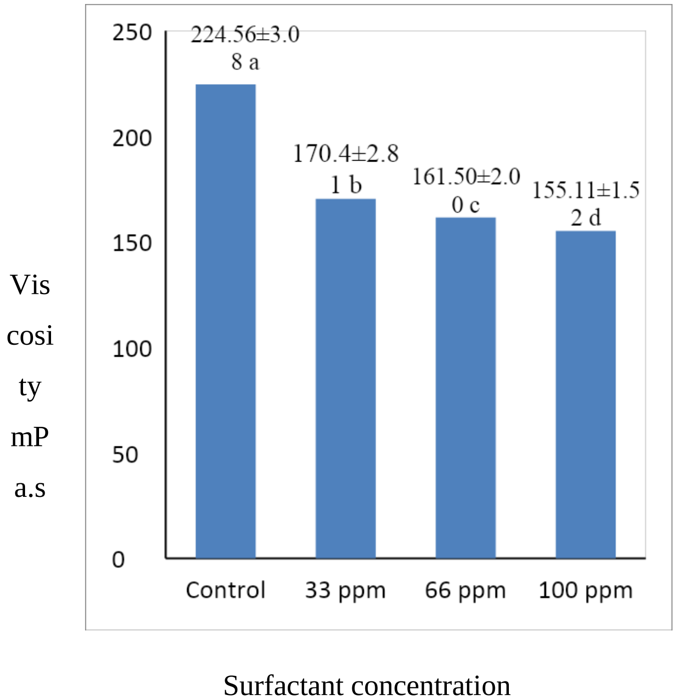


Figure**2: Investigation of the effect of adding surfactant in different concentrations at 55 ° C on viscosity**

**The lower-case letters indicate a statistically significant difference in the 95% confidence level*

Considering that the surfactant used is a non-ionic saccharose, the mechanism of action of this surfactant in the sample is such that the sucrose molecule in the head (hydrophilic) part of the surfactant joins with the sucrose molecules dissolved in the non-sugar compounds of the sample, and the tail part of the surfactant, which is made of acids Stearic (hydrophobic) fat is formed and connected with other non-sugar compounds, considering that the basis of surfactant action is basically the reduction of surface tension on the basis of the reduction of repulsive forces between the solvent molecule and the hydrophobic solvent group, in fact, the electrostatic repulsion force between the solvent-loving groups and the van der Waals force of attraction. between the tail (tail) groups of the surfactant reduces the surface tension between sucrose and non-sugar compounds [16]. It is necessary to explain that if the amount of surfactant used in the sample is not enough, the surface tension will not decrease and the necessary coating will not be created to create electrostatic repulsion and compensate van der Waals attraction [17].

2-3- The effect of different concentrations of surfactant on the content of crystals

According to the results and listed in Table No. 2, by adding surfactant to a concentration of 66 ppm, the purity of the solid phase increased and, accordingly, the purity of the liquid phase decreased due to the diffusion phenomenon, which ultimately increased the amount of crystal content. which indicates the increase of crystallization efficiency in this concentration of surfactant. As shown by Scheibler et al. in 1875, viscosity can have an inhibitory effect on crystal growth. According to the results obtained in graph number 1, it can be seen that adding the amount of surfactant has significantly reduced the viscosity of the sample. According to Fick's law, it is expected to have a significant effect on the crystal growth rate. Similar results have been reported by Hojat al-Islami et al. [8] and Palanius et al. regarding the use of surfactants and their effect on the growth rate of crystals on matrix viscosity [18].

Contrary to what was expected based on Fick's law, adding surfactant at a higher concentration decreased the crystal content. which corresponds to Figure 3 and the obtained results agree with the results reported by Hojjat

Al-Islami et al. [1 and 9] and Siz et al. [5]. The reason for this can be based on the theory of Silin et al., 1955, that the presence of any non-sugar substance, even water, prevents crystallization during the crystallization of sucrose. Therefore, the positive effect of reducing the viscosity can have a positive effect on the growth of crystals to some extent, and more than that, the molasses effect of these materials will decrease the growth and decrease the crystallization efficiency [1].

3-3- The effect of different concentrations of surfactant on the color of sugar solution

According to the results of Table No. 2, it can be seen that adding viscosity reducers up to a concentration of 66 ppm reduces the color of the sugar crystals solution, and at higher concentrations, it is probably because Silin et al. have mentioned that by increasing the effect of non-sugar substances, the color of the solution increases compared to 66 ppm. become] 3[.

melanoid [25]The most common are colorants that have a major effect on the color of sugar through the Maillard reaction[26] (non-enzymatic browning) which are formed between reducing sugars and amine-containing compounds, some of which have gone through the syrup purification stage in the condensation and crystallization stage in the vicinity of heat. In fact, colored substances are among the non-sugar compounds in the sample, which are formed by electrostatic forces between them and surfactant monomers, which play the role of joining and forming spherical masses called micelles.[27]are absorbed by the micelles and cause a decrease in the solubility of sucrose in these compounds, as can be seen in Table No. 2, the use of surfactant up to a concentration of 66 ppm reduces the color of the produced sugar solution, and as a result, the impurities are reduced and the purity percentage of the liquid phase (wastewater) maternal) has decreased. It should be noted that the increase in the difference in the degree of purity between wastewater and muscoite indicates the greater success of the crystallization process [10, 19, 20, 21].

[25] - Melanoidins

[26] - Maillard

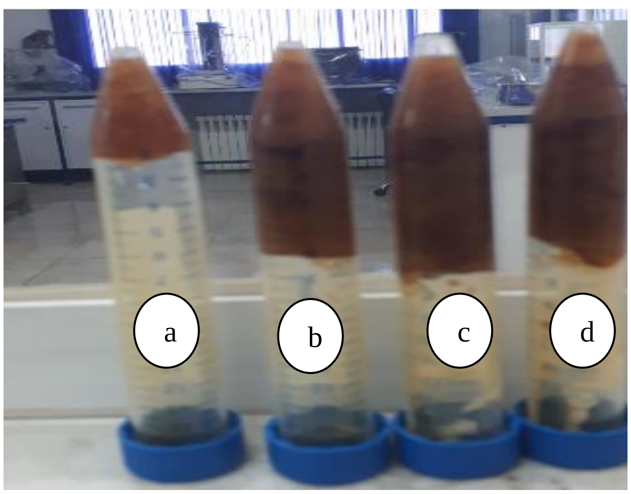
[27]- Micelle

Table 2: The effect of surfactant addition at 55 °C on pan boiling process and color of obtained sugar

	Dry substance of Massecuite (%)	Purity of massecuite (%)	Purity of Mother liquor (%)	Crystal content (%)	Color Of sugar solution
Control	78.6±0.13[c]	86±0.21[c]	85±0.21[c]	4.68±0.67[c]	1315±9.07[a]
33ppm	79.48±0.22[b]	89.29±0.35[b]	85.33±0.15[b]	21.45±1.34[b]	1200±22.27[b]
66 ppm	79.8±0.19[a]	91.0±0.36[a]	85.36±0.26[a]	30.73±2.07[a]	989±41.98[c]
100ppm	79.63±0.22[b]	89.3±0.24[b]	84.61±0.14[b]	23.27±1.77[b]	1218±12.09[b]

*a, b,c…. indicatd significant difference in $p<0.05$

As can be seen in Figure 3, adding viscosity-reducing substances to the sample, in addition to increasing the crystallization efficiency, has increased the amount of crystals per unit weight. These results confirm the results of Hojjat al-Islami and colleagues [2].



a: 0 ppm, b: 33ppm, c:66ppm,d:100ppm

Figure 3: Images of sugar Solid phase

4 - Conclusion

The results of this research showed that the reduction of viscosity in the sample with the help of Cisterna non-ionic surfactant (SP50) was quite evident and increased the amount and content of sugar crystals. It also reduced the colored compounds in the produced sugar and caused the amount of impurities in the produced product to decrease. As a result, it causes a significant increase between the purity percentage of muscoite and effluent obtained in the cold crystallization. At the concentration of 66 ppm of the surfactant used and the temperature of 55 degrees Celsius, the efficiency of the cold crystallization has increased, so that the amount and content of the crystals are at their maximum value, i.e. 30.73% and the color of the sugar solution has decreased to 989 icomsa. At higher concentrations, as expected, the growth rate and crystallization efficiency have decreased, which is due to the molasses-forming properties of non-sugar compounds in sugar solutions.

5- Thank

The authors of the article appreciate and thank the respected management of the Shirvan-Qochan-Bojnoord sugar production company for providing all the facilities for the investigation and research in this article.

6- Resources

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مقاله علمی_پژوهشی

بررسی اثر ماده فعال سطحی غیر یونی کاهنده ویسکوزیته بر کارآیی کریستالیزاسیون سرد کارخانه‌های قند

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چکیده

مطالعات بسیاری روی اثر ویسکوزیته بر ویژگی‌های کیفی کریستالیزاسیون گرم در مرحله طباخی کارخانجات چغندری انجام شده است. اما در این تحقیق سعی شد تا اثر موادکاهنده‌ی ویسکوزیته جدیدتری همچون استرهای ساکارز بر کیفیت کریستالیزاسیون سرد مورد تحقیق قرار گیرد. برای این منظور از ماده فعال سطحی با نام تجاری سیسترنا که یک استر ساکارزی می باشد بعنوان ماده کاهنده ویسکوزیته در چهار سطح صفر، ۳۳، ۶۶ و ۱۰۰ ppm در پساب ضعیف حاصل از سانتریفوژ پخت یک کارخانه‌های چغندری در دمای ۵۵ درجه سانتی‌گراد استفاده شد و تاثیر آن بر روی ویسکوزیته ، راندمان کریستالیزاسیون ، رنگ محلول شکر استحصالی و درصد خلوص پساب حاصل از سانتریفوژ مورد بررسی قرارگرفت. نتایج نشان‌داد که افزودن این ماده باعث کاهش چشم‌گیری در ویسکوزیته گردید. راندمان کریستالیزاسیون نیز تا غلظت ppm ۶۶ افزایش یافت اما در غلظت‌های بالاتر از آن کاهش یافت. همچنین رنگ محلول شکر استحصالی و درصد خلوص پساب تولیدی حاصل از سانتریفوژ و جداسازی فاز جامد از مایع تا این غلظت از سورفکتانت کاهش یافته و در غلظت‌های بالاتر از آن، این پارامترها نیز افزایش یافتند. لذا استفاده از این مواد در بخش کریستالیزاسیون سرد می‌تواند باعث افزایش راندمان و کاهش ضایعات کارخانه‌های چغندری شود.