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THE EFFECT OF NONSUCROSE COMPOUNDS ON SUGAR BEET MOLASSES SATURATION AND DESUGARIZATION
UTICAJ NESAHAROZNIH JEDINJENJA NA ZASIĆENOST I DESAHARIFIKACIJU MELASE ŠEĆERNE REPE

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ABSTRACT

In sugar industry molasses represents a syrup obtained in final stage of crystallization. In production of sugar from sugar beet, for cause of higher rentability, phase of crystallization needed to be conducted so that the less quantity of molasses is obtained in which, under optimal conditions, remains around 12 % of total beet sugar quantity. On forming molasses affect present nonsucrose compounds forming with sucrose complex easily soluble additive compounds, which have higher solubility than sucrose, due to which saturation coefficient increases. Depending on technological quality of sugar beet, from sucrose introduced in processing, 88 – 92 % of white sugar can be obtained. Sugar in molasses is the highest loss of sugar in sugar beet processing. High visosity is one of the reasons for which significant quantities of sucrose can not be crystallized on the final stage of crystallization by the usual technological procedure. Test include determination of the parameters of molasses saturation and viscosity as a function of nonsucrose compounds.

Key words: *molasses, nonsucrose compounds, viscosity, sucrose solubility.*

REZIME

U industriji šećera melasa predstavlja sirup dobijen na poslednjem stepenu kristalizacije. Pri proizvodnja šećera iz šećerne repe, u cilju što veće rentabilnosti, potrebno je fazu kristalizacije sprovesti tako da se dobije što manja količina melase u kojoj pod optimalnim uslovima rada ostaje oko 12% od ukupne količine šećera iz repe. Melasa predstavlja tečnu smešu šećera, nešećera i vode iz koje se ni pod povoljnim tehničkim uslovima ne može dobiti saharoza u obliku relativno čistih kristala, a da njena proizvodnja ima ekonomsku opravdanost. Melasa sadrži oko 50% saharoze, 30-35% nešećera i 15-20% vode. Na obrazovanje melase utiču prisutni nešećeri obrazujući sa saharozom kompleksna lako rastvorljiva adiciona jedinjenja koja imaju veću rastvorljivost od saharoze, usled čega se povećava koeficijent zasićenosti. U zavisnosti od tehnološkog kvaliteta šećerne repe, od saharoze unete u proces prerade može se dobiti od 88% do 92% belog šećera. Šećer u melasi predstavlja najveći gubitak šećera u procesu prerade šećerne repe. Viskozitet melase predstavlja ograničavajući faktor u vođenju procesa kristalizacije saharoze jer otežava centrifugiranje poslednje šećerovine. Veliki viskozitet predstavlja jedan od uzroka zbog koga se značajne količine saharoze uobičajenim tehnološkim postupkom ne mogu izdvojiti na poslednjem stepenu kristalizacije. Viskozitet melase zavisi od sadržaja suve materije melase i temperature, te se sa povećenjem suve materije i smanjenjem temperature on jako povećava. Istraživanja su izvedena na uzorcima melase proizvedene preradom šećerne repe u srpskim fabrikama šećera. U radu su prikazani rezultati ispitivanja uticaja nešećera prisutnih u melasi na viskozitet i rastvorljivost saharoze u melasi. Ispitivanja obuhvataju određivanje melasotvornih koeficijenata, odnosno parametara rastvorljivosti saharoze, zasićenosti melase i vikoziteta u funkciji nesaharoznih jedinjenja. Rezultati pokazuju veoma promenljiv sadržaj nešećera u melasi u procesu prerade repe, kao i veliku varijabilnost kvocijenata čistoće melase što utiče na različito iscrpljenje melase.

Ključne reči: *melasa, nesaharozna jedinjenja, viskozitet, rastvorljivost saharoze.*

INTRODUCTION

Molasses represents liquid mixture of sugar, nonsucrose compounds and water from which, even under the favorable technical conditions, sucrose in form of relatively pure crystals, can not be obtained so that its production would be economically justified.

Sugar in molasses is the cause of the largest yield loss in a sugar beet factory.The molasses yield is affected by quality of sugar beet and all technological steps during sugar production, especially by technology design and control of individual operations. In processing of better sugar beet quality, the molasses yield is lower. Nonsucrose substances influence on the solubility and crystallization rate of sucrose (van der Poel et al., 1998). Ratio of the solubility of sucrose in a technical saturated solution and a pure saturated solution at the same temperature present the saturation coefficient. Minimizing sugar content in molasses requires: suitable supersaturation in the cooling crystallizers by adjusting of temperature; low viscosity of the mother liquor for centrifugation of C massecuite; steady flow of C massecuite into a battery of cooling crystallizers and its uniform quality. Molasses viscosity is the limiting factor in sucrose crystallization process because it makes centrifugation of after product massecuite harder to do. In this paper, investigations were performed on molasses samples obtained by processing sugar beet in domestic sugar factory. It was examined the impact of nonsucrose compounds on saturation and viscosity of molasses.

MATERIAL AND METHOD

Basic quality parameters of molasses, were determined according to methods described in handbook for the laboratory control of sugar processing (Milic et al., 1992). The methods are in accordance with the regulations guided by the International Commission for Uniform Methods of Sugar Analysis (ICUMSA, 2003).

The saturation test of molasses was carried out according to the method published in a handbook (Milić et al., 1993). The rheological behavior of molasses was determined according to the IRIS method (1984).

The obtained data were processed using StatSoft Statistica, for Windows version 10. Basic statistical descriptors were calculated (Hadživuković and Čobanović,1994).

RESULTS AND DISCUSSION

The average values and statistical analysis of the molasses basic quality parameters are presented in Table 1. Variations of this group of indicators are influenced by sugar beet technological quality and characteristics of the processing conditions, used in the sugar factory. The largest coefficients of variation were observed in the content of reducing substances which imply to the fact that this parameter is largely dependent of nonsucrose compounds content in sugar beet.

Table 1. Basic quality parameters of the molasses

Parameter in %	Min.	Max.	Average	Standard deviation	Coefficient of variation
Dry matter	80.20	88.80	83.64	2.231	2.668
Polarization	46.70	55.10	50.86	2.581	5.075
Purity quotient	56.64	61.73	59.62	1.565	2.624
pH value	7.23	8.87	7.90	0.520	6.578
Reducing substances	0.65	1.61	1.06	0.283	26.686

Table 2 presents coefficients of sucrose saturation function and saturation coefficients determined by the saturation test according to Wagnerowski equation. Results show great variations, as a result of sugar beet processing very different technological quality. This indicates the great variations of sucrose solubility in molasses also, that is important from aspect of the final stage of industrial crystallization i.e. C (after product) crystallization (*Grbić and Jevtić-Mučibabić, 2010*).

Table 2. Parameters of the molasses saturation

Test No.	$y_{sat} = m \cdot q_{NS/W} + b$		
	m	b	y_{sat}
1.	0.238	0.776	1.29
2.	0.179	0.958	1.54
3.	0.176	0.975	1.32
4.	0.235	0.873	1.36
5.	0.266	0.732	1.18
6.	0.300	0.627	1.21
7.	0.217	0.908	1.26
8.	0.187	0.874	1.26
9.	0.207	0.894	1.24
10.	0.214	0.963	1.41

A linear dependence between the saturation coefficient of molasses and nonsucrose content was found. It is presented in Figure 1. The minimal molasses purities, that can be achieved at the centrifugation temperature of 50 °C and supersaturation coefficient of 1.00, 1.05 and 1.10 are presented in Table 3. It is related to the nature and amount of nonsucrose compounds present in the molasses. The results in Figure 2, show the statistically significant dependence between calculated purity and nonsucrose/water ratio. The tabular value of the correlation coefficient has to be 0.950 for 2 (4 - 2) degree of freedom and a significance level of 0.05 (*Hadživuković, 1994).*

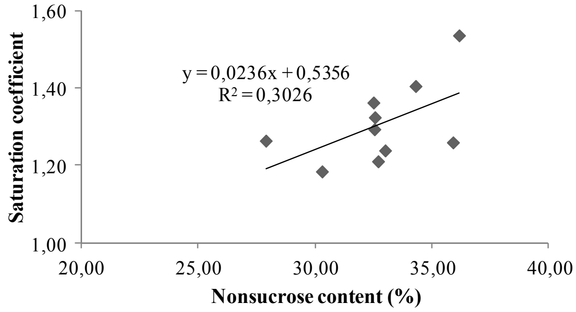

Fig. 1. Saturation coefficient as function of nonsucrose content in molasses

Table 3. Calculated purity of molasses at 50 °C

Calculated purity in %	Supersaturation coefficient		
	1.00	1.05	1.10
Minimum	56.00	57.95	59.62
Maximum	57.55	59.36	61.09
Average	56.74	58.62	60.36
Standard deviation	0.792	0.705	0.687
Coefficient of variation	1.395	1.202	1.139

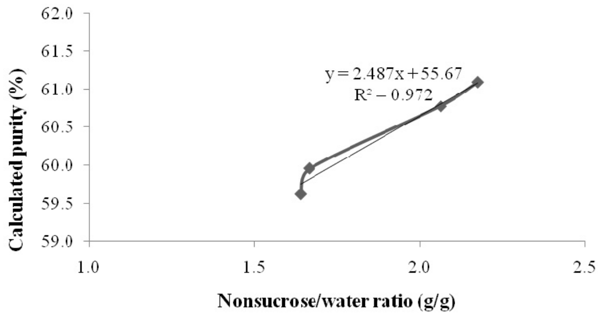

Fig. 2. Dependence between nonsucrose/water ratio and calculated purity of molasses

Purity of molasses achieved in manufacturing process in the function of calculated minimal purity is presented in Figure 3.

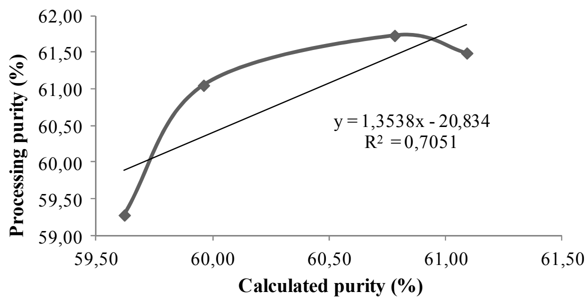

Fig. 3. Processing purity as function of calculated purity of molasses

Processing purity of molasses is a very important parameter, which is a measure of sugar content in molasses and factory sugar loss. The most important sugar loss in a sugar beet factory results from the sugar in molasses which can not be crystallized. The problem of molasses exhaustion and the factors influencing the same can be considered from two aspects: compositional and operational factors. Composition of molasses depends of the sugar beet quality and efficiency of sugar beet processing. Content and composition of nonsucrose compounds determine solubility of sucrose and minimum value of molasses purity that can be achieved under optimal conditions during cooling crystallization (*Grbić and Jevtić-Mučibabić, 2011, Grbić et al., 2011*). Operational factors are presented by conditions during after product crystallization: evaporating, cooling, reheating and centrifugal separation of the after product massecuite.

The parameters of the viscosity function and the maximum dry substance content of molasses which can be achieved at 50 °C, the temperature of centrifugation, are given in Table 4.

Table 4. Parameters of the molasses viscosity function and dry substance content

Test No.	Viscosity function at 50 °C log μ = a · n + k		Dry substance concentration	
	a	k	n	RDS in %
1.	14.404	0.210	0.230	85.04
2.	14.195	0.069	0.294	88.80
3.	13.316	0.292	0.212	83.60
4.	12.401	0.479	0.222	84.40
5.	16.822	-0.425	0.196	82.20
6.	12.374	0.427	0.207	83.20
7.	11.314	0.532	0.204	83.00
8.	11.765	0.478	0.200	82.60
9.	12.617	0.269	0.176	80.20
10.	13.080	0.077	0.209	83.40

The viscosity of molasses increases exponentially with the increase in sucrose molar concentration (or dry substance). The nonsucrose compounds affect the viscosity which is presented by the values of the parameters of viscosity function. The maximum dry substance content is related to the maximum viscosity at the centrifugation temperature of 50 °C and nature and amount of the nonsucrose compounds. The viscosity of molasses is an important parameter for the crystallization and centrifugation of an after-product massecuite (*Schick et al., 2003*).

CONCLUSION

On the basis of the results the following conclusions can be made:

- The parameters of the molasses saturation i.e. solubility and viscosity varied in the wide range in the investigation period and were related to the nonsucrose compounds content.
- The statistical analyses showed the significant dependence of the calculated purities, the minimal molasses purities that can be achieved at the centrifugation temperature of 50 °C, on the non-sucrose/water ratio.
- Composition of molasses and processing conditions influenced on the purity of molasses produced in sugar factory.
- Parameters of the saturation and viscosity functions are reliable datas for conducting the after product crystallization.

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