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IMPACT OF TEMPERATURE AND STORAGE TIME ON SUCROSE CONTENT IN SUGAR BEET

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Abstract: *During storage the chemical composition of sugar beets changes as harvested sugar is lost due to respiration by the living beet root. The efficiency of sugar manufacturing depends largely on the quality of the raw beet material. Good processing quality is characterized by a combination of high sucrose concentration and low concentration of non sucrose substances that impair white sugar recovery. Long –term storage of sugar beet is a solution to extend the processing period of sugar factories. The sugar companies consider prolonging the processing campaign in order to reduce the fixed costs of their factories. In future, the storage period will thus be extended, too, and the amount of stored beets will increase. The aim of this study is to determine the temperature and storage time influence on the variation of sucrose content of new sugar beet hybrids adapted to the new climate conditions of Europe. Sugar beet has been stored at the temperatures of 2, 6, 10, 15 and 20 ^oC and analyses of the sucrose content after 5, 10, 20, 30, 40, 50 and 60 day-storage periods have been made. All along storage the sucrose content decreased in inverse ratio to the storage temperature and direct ratio to storage period having specific variations for all cultivars analyzed.*

Keywords: *sugar beet, storage, temperature, sucrose content.*

1. Introduction

Facing the changes in the EU sugar regime which will fall the price for sugar, the sugar industry has to reduce the cost of production by all possible means. Prolonging the processing and storage period is an option to reduce fixed costs of sugar factories [1]. In doing so, it is crucial to optimize storage conditions. Even if sugar beet is harvested in autumn, by storage its processing period extension is ensured in sugar factories and in winter as well until the end of December. The quality of sugar beet which is to be processed after having been stored is extremely important, its parameters influencing directly the sugar productivity of the factory. The main change in the chemical composition of sugar beet is the decrease in its sucrose mass. The respiration process usually accounts for 50 to 80 % of the total sucrose loss during storage [2]. The remainder is the result of the sucrose conversion into invert sugar, raffinose and other organic compounds. Additional sugar losses occur via microbiological activity in cuts and especially in bruises [3].Sucrose catabolism in sugar beet is mainly due to the activities of acid and alkaline invertase and sucrose synthetase.

These enzymes reduce the yield of extractable sucrose from the sugar beet crop directly by their ability to degrade sucrose and indirectly by producing invert sugars, which increase the loss of sugar during storage [4]. It is known that the most important effect on the change of sugar beet quality in the period after harvest is exerted by temperature [5]. The new climate conditions of Europe have imposed the cultivation of some new hybrids of sugar beet adapted to these ones. Knowing the behavior of these hybrids during storage and how high quality of sugar beet can be obtained after its storage is very useful. The behavior of sugar beet has been studied for 60 days as this is usually the maximum storage period of sugar beet after harvest until processing.

2. Materials and methods

The beet subject to analysis is of cultivars Victor Z type, Solea N/Z type and Markus Z type, cultivated in the county of Brasov. It has been stored together with its adherent impurities at the temperatures of 2, 6, 10, 15 and 20 ^{o}C and analyses of the sucrose content after 5, 10, 20, 30, 40, 50 and 60 day-storage periods have been made. Determination of sucrose was made using polarimetric method ICUMSA Method GS6-1 [6]. The information obtained was statistically processed using software Excel in Microsoft Office 2003 Suite in order to find values of correlation coefficients (r) between storage time and temperature and variations of sucrose content of the sugar beet analyzed. The bi-factorial analysis ANOVA has been used to determine whether the temperature variation and storage period influence significantly the experiment in view.

3. Results and discussion

During storage, considerable changes in beet quality occurred. In the first days of storage, a significant decrease in sugar content is noticed as a result of a more intense respiration due to sugar beet root's adaptation to the new life conditions in all types analyzed proportionally with the storage temperature.

The variation of sucrose content depending on storage period and temperature for Victor type Z can be seen in the graph of figure 1.

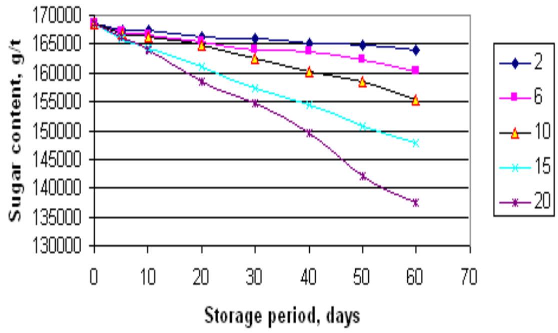

Figure 1. Sugar content as a function of temperature and duration storage for Victor Z type Sugar beet

Following the graph in figure 1 one can notice that there is a stabilizing tendency of sucrose content for the end of storage interval when using the temperature levels of 10, 15 and 20 ^{o}C. This phenomenon might be explained by slowing down the biochemical processes subject to analysis and reaching a relative equilibrium state in the metabolism of the sugar beet root after 50-day storage at temperatures of 15 and 20 C.

Figure 2 shows the variation of sucrose content of Solea type N/Z.

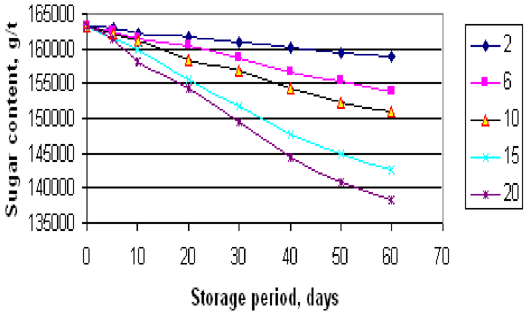

Figure 2. Sugar content as a function of temperature and duration storage for Solea N/Z type Sugar beet

In the case of Solea type N/Z there is a clear separation on temperature groups of variation curves of sucrose content. The first group consists of the curves corresponding to the temperatures of 2, 6 and 10 ^oC, being characterized by a smaller slope whereas the second corresponding to the temperatures of 15 and 20 ^oC has a more pronounced slope. The curves' grouping shows that the metabolism change of Solea type N/Z has the critical temperature limit close to the value of 10 ^oC. The variation slope of curves is relatively constant throughout the storage period for all temperature levels analyzed.

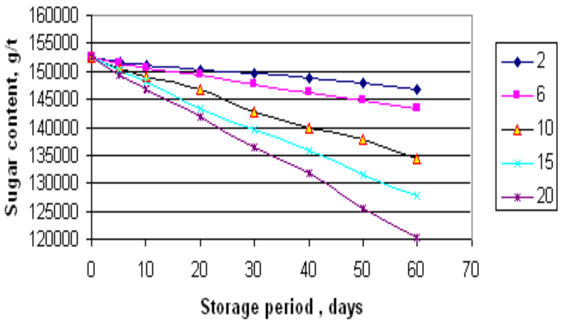

Figure 3. Sugar content as a function of temperature and duration storage for Markus Z type Sugar beet

In the case of Markus type Z there is some emphasis of the slope of variation curve after a 40-day storage period, especially in the case of storing at the temperatures of 15 and 20 ^oC. This fact implies a favorable storage period for this hybrid with a shorter period of 40 days in order to avoid fast depreciation of sugar beet at these higher temperatures.

The graph in figure 4 shows the data resulted from the calculus of average losses in sucrose

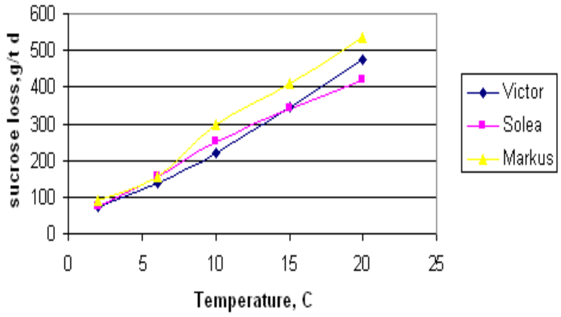

Figure 4. Daily sugar losses as a function of beet temperature during 60 days storage

By analyzing the graph of figure 4 one can see that average sucrose losses of the hybrids analyzed vary on storage temperature. Thus, in the interval 2-10 ^oC the biggest sucrose losses are registered by the hybrid Markus, followed by Solea and Viktor. At the temperature of 15^oC Solea and Viktor have the same average of daily sucrose losses per tone, being exceeded by Viktor. At the superior limit of the temperatures tested, that is 20 ^oC, Markus registered the biggest losses of sucrose, followed by Viktor and Solea in the last place.

For all three hybrids analyzed the bi-factorial statistical calculus ANOVA led to the values of F exceeded F_{cr} and to the conclusion that temperature variation and storage period influence significantly with a probability of 95% the experiment made. The statistical analysis made shows very strong correlations of the same sense between storage temperature variation and sucrose losses registered. The values of correlation coefficients between sucrose losses determined and storage temperature are given in table 1.

Table 1.
Correlation coefficients between sucrose losses and variation of storage temperature

Nr. crt.	Hybrid	r
1	Viktor	0.995504
2	Solea	0.996183
3	Markus	0.995627

The highest value of correlation coefficient is registered by the hybrid Solea, followed by Markus, Viktor being the last one.

4. Conclusions

Storage duration and temperature have significant effects on the changes in sugar content of sugar beet. At low temperature, changes in beet quality could be kept at minimum. We noticed that for all cultivars analyzed the storage at 2-10 ^oC led to relatively reduced losses of sucrose throughout the storage period in view. Besides temperature the storage period has also a significant influence on sucrose losses of sugar beet. As a result of graphs' analysis, a decrease of sucrose content is not uniform throughout storage. Thus, in the first 5 days of storage the decrease is higher due to respiration phenomenon and adaptation of sugar beet to new life conditions. Then a period when sucrose losses are relatively constant depending on storage temperature follows. Great differences occur at the storage temperatures of 15 and 20 ^oC, especially towards the end of storage period. Thus the cultivar Viktor has a tendency of relative decrease of daily sucrose losses after 50-day storage period whereas the cultivar Markus shows a tendency of increasing them after 40-day storage period. The different behavior of sugar beet cultivars at storage might be the consequence of different enzyme activity. Further research is necessary to examine whether genetic variability in the activity of sucrolytic enzymes of sugar beet exists. This could be the basis for the selection of cultivars with better storability

5. References

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