State of water during dehydration of sugar beet tissue

Viacheslav Mykhailyk, Tetiana Korinchevska

Department of Heat and Mass Transfer in Heat Technologies, Institute of Engineering Thermophysics of National Academy of Sciences of Ukraine, UKRAINE, Kyiv, 2 Academician Bulakhovsky Str.,
E-mail: mhlk45@gmail.com

Abstract – The DSC method was used to study the state of water in the process of dehydration of fresh, after long-term storage and de-sugared tissues of sugar beet root. It has been detected that the water-retaining properties of tissues are mainly determined by the hydration of sucrose. It has been shown that the specific content of bound water in a fresh root is ~ 2.3 times higher than a root after long-term storage.

Keywords – differential scanning calorimetry, sugar beet, free and bound water, hydration, sucrose

Introduction

Water plays an important role in plants during the growing season and in fruits during storage and processing. The state of water in plant raw materials and products of its processing is of great importance for the optimization of technological modes. The processes that take place at the root of sugar beet during storage are extremely complex, and the factors on which they depend are numerous. During storage, the root remains a living organism with its inherent complex of complicated processes of transformation of substances. The reasons, as a result of which the root loses its inherent stability and ability to be stored for a long time, are associated with a change in the state of the water in it. The loss of water by the cells causes profound physiological changes in the root and a marked activation of enzymes, which leads to the loss of sucrose. The water-holding capacity of cells is determined by the integral value of intermolecular forces and depends on the general physiological state of the plant. The rupture of hydrogen bonds during dehydration causes the destruction of the structure of plant tissues. Two states of water are noted in biological objects of plant origin. First state is similar to the state of pure water (free water). The other state arises as a result of beneficial energetic interactions with biopolymer macromolecules, molecules and ions of cell sap (bound water) [1].

The aim of this study was to investigate the changes in the state of water during dehydration of fresh, after long-term storage and de-sugared sugar beet root tissues.

Materials and methods

In this work, the method of differential scanning calorimetry (DSC) and the technique described in [2] were applied. Measurements were performed in a DSM-2M differential scanning microcalorimeter using the Water-5 software application. The object of the study were tissues of fresh and after storage for 8 months of sugar beet roots. Plates 1.5-2 mm thick were cut out in the middle part of the root perpendicular to its vertical axis, from which samples with a diameter of 5 mm were made. De-sugared tissues were obtained by triple extraction of sucrose with distilled water at 85 °C. The completeness of the extraction of sucrose was controlled by the refractometric method. Samples with different humidity were obtained by drying the original tissues with air at a temperature of ~ 50 ° C.

Results

Analysis of the obtained data shows that with a decrease in tissue moisture, the fractional composition of water is redistributed towards bound water (Fig. 1). The content of bound water in fresh beets is significantly higher than in beets after long-term storage at equal initial moisture values. This difference persists with dehydration. However, the difference in values decreases with decreasing moisture. In the fresh root, the ratio of the mass of bound to free water is ~ 1 : 3, after storage is ~ 1 : 7. This dependence is also observed in de-sugared tissues, but the content of bound water in them is somewhat higher than in beet tissues after storage.

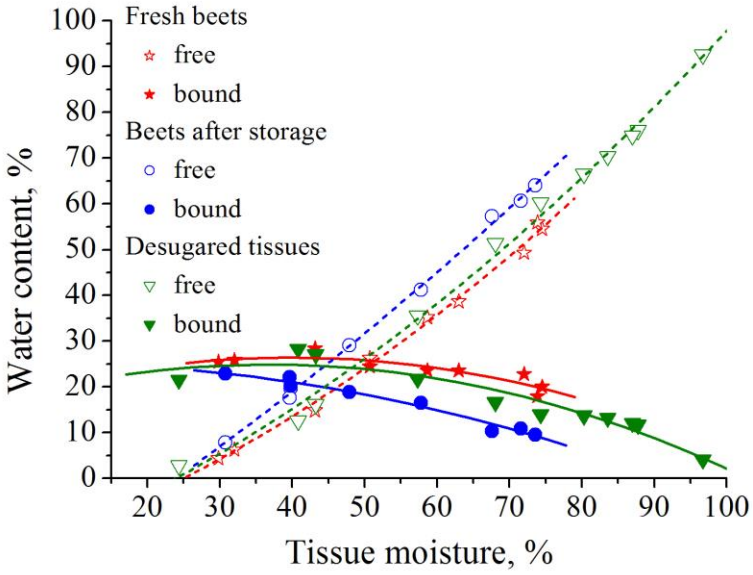

Fig. 1. Change in the content of free and bound water in fresh, after long-term storage and de-sugared tissues of the sugar beet root during dehydration.

Dependencies become more interesting if we represent the mass of bound water referred to the mass of dry matter (Fig. 2). It can be seen that in the process of dehydration, simultaneously with a decrease in the content of free water, the specific content of bound water (water retention) decreases. The observed phenomenon is a consequence of a decrease in the number of hydrophilic active centers with which water molecules can form hydrogen bonds.

The most significant component of sugar beet dry matter is sucrose, the hydration of which depends on the water content [3]. A quantitative assessment showed that in the tissues of fresh beets, about 90% of the bound water is retained by sucrose.

With dehydration, the amount of water bound by non-sugars also decreases. The reason for the loss of water-holding capacity is a change in the structure of biopolymers as a result of tissue shrinkage during dehydration. In the case of de-sugared tissues, the higher values of water retention can be explained by the freshness of the original tissues, as well as by the reaction of biopolymers to thermal effects in the water environment.

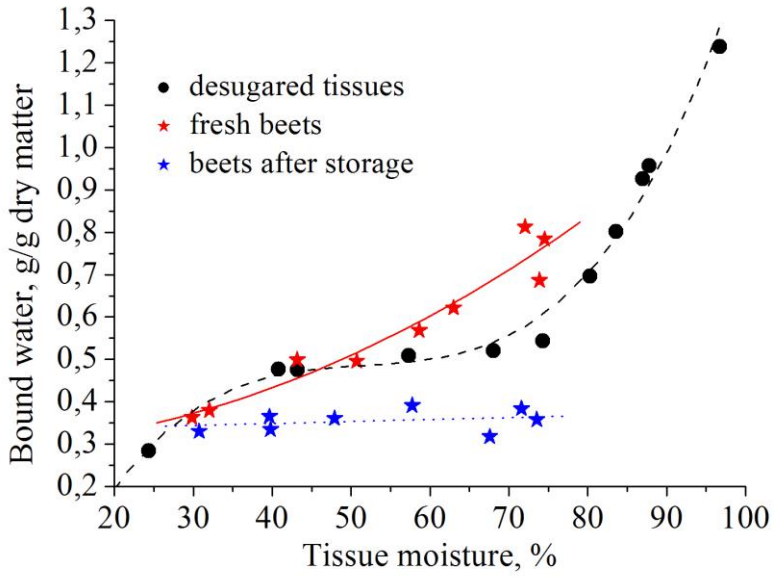

Fig. 2. Dependence of the specific content of bound water in fresh, after long-term storage and de-sugared tissues of the sugar beet root on moisture.

Conclusion

From the above, it follows that sucrose plays a decisive role in the water retention of parenchymal tissues of the root of fresh sugar beet. In the process of dehydration, the specific content of bound water in tissues decreases symbatically with a change in the hydration capacity of sucrose.

The general decrease in water retention by parenchymal tissues after storage is a consequence of biochemical processes that have occurred at the root. First of all, the change in the nature of water retention is explained by a decrease in the content of sucrose during storage. In addition, the destruction of biopolymers is accompanied by a weakening of their water-retaining capacity.

Received as a result of calorimetric research information about the state of water in the tissues of fresh root and root after long-term storage, confirms the possibility of changing the water-holding capacity to judge the degree of stability of plant cells.

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