CRYSTALLIZATION OF SUGAR SOLUTIONS

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ABSTRACT

The properties of supersaturated glucose, fructose and sucrose solutions were characterized and the changes appearing in their crystallization investigated. It was found that a_w, hardness and stickiness of glucose and fructose solutions were identical. The glucose and sucrose solutions crystallized with one week and one day, respectively. The fructose solution didn't crystallize. During crystallization the water activity of the sugar solutions increased.

INTRODUCTION

Sugars have frequently been used in food and pharmaceutical fields. The crystallization of sugars is important in the food industry as evidenced by the many processes where the degree of crystallinity of sugars is critical to acceptance of the final product, i.e., storage stability (Gallo et al., 2003). Supersaturation is the major force of crystallization. The appearance of nuclei generally occurs after the organization of hydrated sugar molecules in swarms during the period of pre-nucleation (Hartel, 2001). Temperature of storage, magnitude of temperature fluctuations, and relative humidity can all affect the changes in crystalline structures and rate of crystallization that take place during the storage and distribution of amorphous sugar solutions (Mazzobre et al., 2003). To control the crystalline microstructure in food systems and understanding of the crystallization during processing and storage is required.

The purpose of the present work was to characterize the properties of supersaturated glucose, fructose and sucrose solutions and investigate the changes appearing in their crystallization.

MATERIALS AND METHODS

Materials
Crystalline sucrose, glucose and fructose were gift from „Kalev" enterprise.

Sample preparation
The supersaturated aqueous sugar solutions were prepared from distilled water and crystalline sugars in the stirred boiling vessel by evaporating the water from saturated sugar solutions and cooling solutions down according to the preset temperature profile.

Methods
Concentration of water was determined using Karl Fischer titrator DL38 (Mettler Toledo, USA) connected to computer. The water activity measurements were performed on the water activity analyser AquaLab CX3 (Decagon, USA).

The hardness and stickiness analysis were performed with a computer-controlled TA-XT2i texture analyser manufactured by Stable Micro Systems (England). This instrument pushed a 3 mm diameter cylinder into a test specimen to a depth 5 mm at a rate of 1 mm/s at 20°C and subsequently moved the cylinder to the starting position.

For microscopy the specimens of sugar solutions were placed on the base glass and the cover glass was tightly sealed with silicone in order to prevent the moisture diffusion.

Three replications were analysed and average values were reported in all analysis.

RESULTS AND DISCUSSION

The supersaturated sugar solutions were made by heating the aqueous solutions to certain boiling point to give different moisture concentration (Figure 1). The sucrose solution re-crystallized at 120°C and couldn't be saturated to more than 15% water content. In order to characterize the properties of sugar solutions the effect of moisture content on i) water activity, ii) hardness and iii) stickiness was investigated. The water activity was increasing with water content. The sorption isotherms of glucose and fructose solutions were similar and different from that of sucrose (Figure 2).

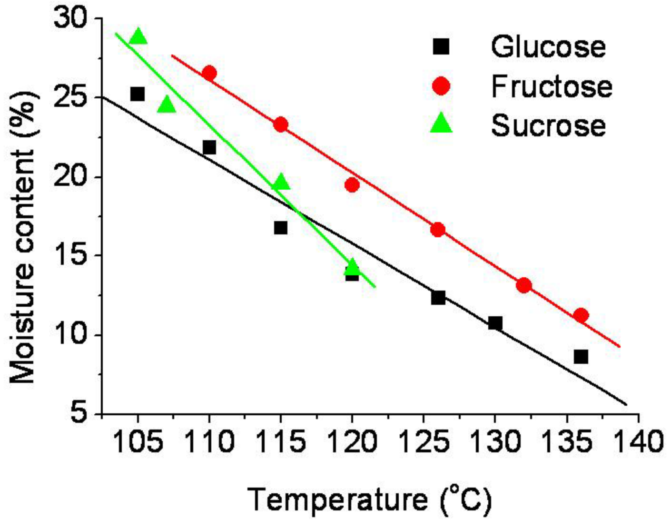


Figure 1. The dependence of water content on the temperature of glucose, fructose and sucrose solutions

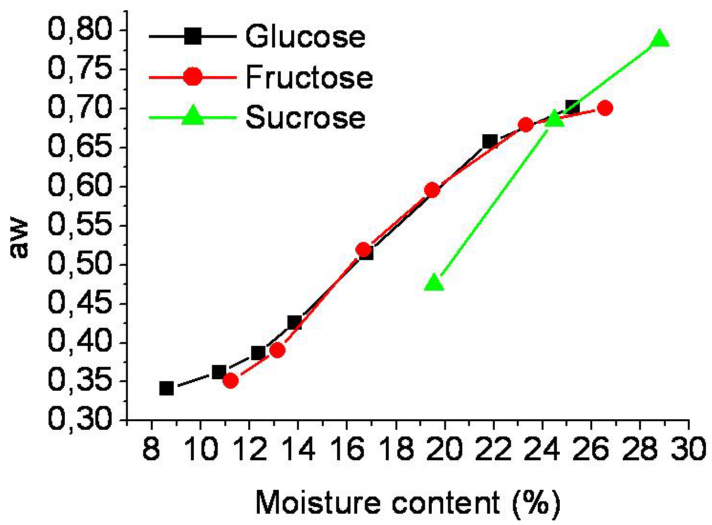


Figure 2. The sorption isotherm of glucose, fructose and sucrose solutions

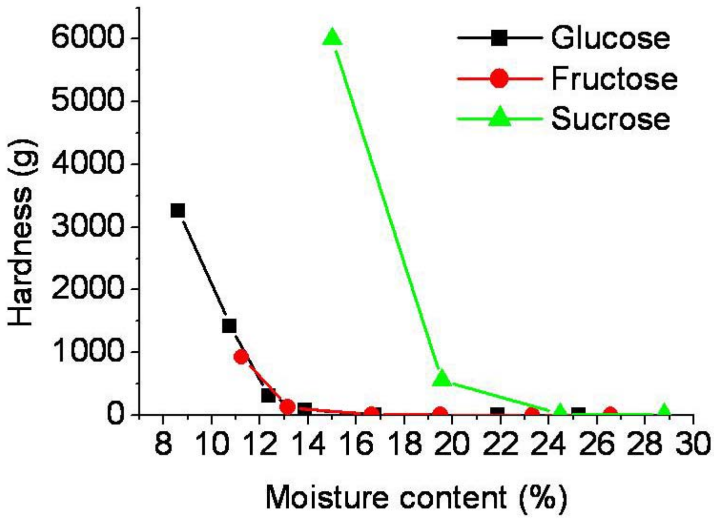


Figure 3. The dependence of hardness on the water content of glucose, fructose and sucrose solutions

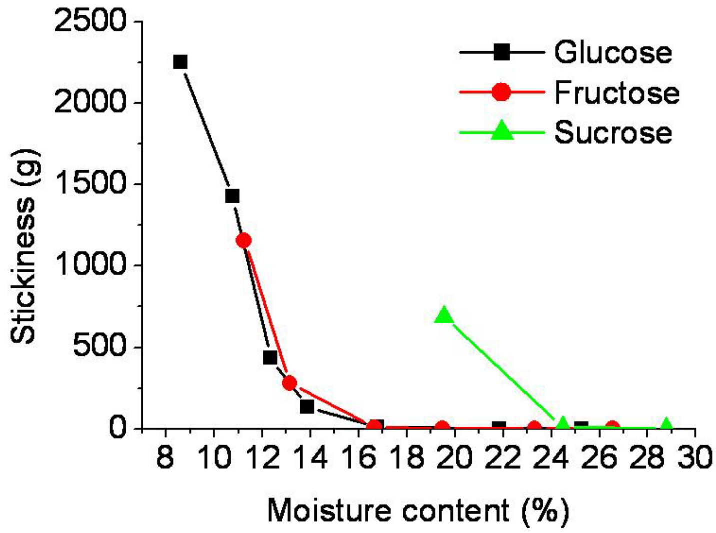


Figure 4. The dependence of stickiness on the water content of glucose, fructose and sucrose solutions

The hardness and stickiness of all sugar solutions were increasing with decreasing the moisture content (Figure 3, 4). For glucose and fructose the high water content solutions were soft and free flowing. Around 14% of water the solutions became very thick and sticky giving rise of hardness and stickiness. The sucrose solution gave harder and stickier solution already at water content of 24%. The glucose and fructose supersaturated solutions had similar sorption isotherms, hardness and stickiness of the solution.

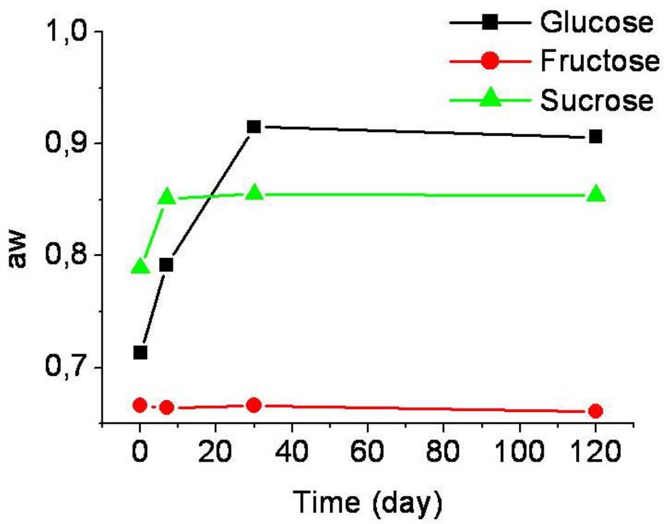
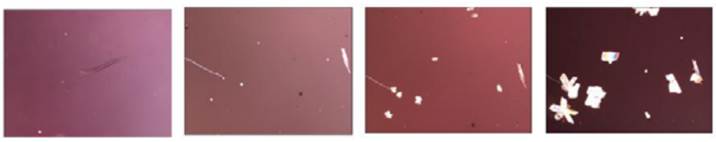


Figure 5. The dependence of water activity on the time of storage of 70% aqueous sugar solutions.



Time (day) **0** **1** **7** **28**

Figure 6. The formation of glucose crystals in time under the microscope

During crystallization process of 70% of water solutions the water activity sucrose solution increased up to equilibrium a_w value in few days and that of glucose to during a month (Figure 5). Figure 6 shows the appearance and growth of glucose crystals under the microscope. It can be seen that for glucose the nucleation happens within 1 week and major crystallization within 1 month. For sucrose the crystallization take place within 1 day and fructose didn't crystallize.

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