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The Influences of Cavitation Effects on the Electric Conductivity of Juices in Sugar Production

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Abstract

The paper presents the results of studies the influence cavitation effects arising from the juices steam treatment on cellular and diffusion juices in sugar production. In conducting parallel studies the juices treatment by steam and their usual heating and cooling structural transformations in the constituent parts of juices have been established which leads to an increase in electric conductivity. Thus ion carriers are releasing which will allow to increase the juice purity and the sugar-sand production amount.

Keywords: cellular juice, diffusion juice, sugar production, electric conductivity, steam-condensation cavitation, macromolecular compounds, colloidal dispersion substances

Diffusion juice is known to be a complex sucrose solution with a variety of organic and non-organic compounds. According to one of the hypotheses, most of them are contained in the associated and complex compounds form varying stability degrees, and the processes occurring during the diffusion juice purification by lime-carbon dioxide, are mainly the complexes transformations processes. The sucrose also takes part in this and eventually becomes into a free state.

To destroy and remove part of non-sugars from solution by coagulation, deposition or adsorption it is necessary to use heat or chemical reaction energy,

which is carried out according to the typical technological scheme of juice purification in the conditions of the previous and main defecation.

The heat energy is brought to the juice at all stages of purification mainly through recuperative heat exchange equipment. However, as practice suggests, the heating of juice through the heat exchange surface is not able to induce radical changes in the hydrated substances of the most common associate in the juice system, or in real complex compounds formed with the metals and other, mostly organic compounds participation which are always present in juice. This led to the fact that the radical destruction of natural associative in known purification methods is realized through the chemical reaction energy use, that is from reagent juice processing.

But this method is quite long and requires much chemical reagent consumption. At the same time, as the experiment proves, the destruction of associated structures is possible by another method, namely by the water steam introduction to the juice. This is especially noticeable in the method proposed by Bobrovnik in Cuba to clean the raw cane juice "mesclado" that is in the production where the consumption for cleaning are 0,03% to the mass of raw materials (while in sugar production they are 3,0%). During the method application an increase the purity of juice in more than 2 units and the sedimentation rate of the coagulated particles colloidal dispersion substances were noted.

Positive results were obtained in case of the diffusion juice treatment with water steam and simultaneous lime milk introduction. Using this method allowed not only to increase the juices purity and to reduce its colour, but also to reduce the lime milk consumption for cleaning.

The above-mentioned works cover mainly the final technological result, but the physical nature of the effects arising during hydrodynamic or steam-condensation cavitation treatment and the mechanisms of their manifestation for the diffusion juice compounds physic-chemical transformations, which are necessarily taking place, are not considered. This became the subject of our further research.

Physical phenomena that cause strong destructive or intensifying actions, despite the manifestation mechanism and forms diversity, unite the general pattern: they arise in liquid environments during a sudden change in external pressure and are accompanied by intense grows or splashes the formed bubbles if they are contained in a liquid. A distinctive feature of these phenomena is the space-time localization of energy which makes it possible to generate directed pulses of high power at a relatively low energy level.

The hydrodynamic cavitation effect intensity depends on the energy released by the collapse of the cavitation bubbles of appropriate sizes and concentrations. As a result the reaction of the treated medium and other physical and chemical properties is changing.

The information about the steam-condensation cavitation effects influences on the treated medium is not found in literary sources. It is possible that by analogy with hydrodynamic cavitation the energy released by the steam bubbles destruction is sufficient to destroy part of the complex and associated compounds. In this case the components released under these conditions will be ion-carriers and will be able to participate in reactions with the calcium ion. Indirect evidence of such destruction can be the change of the electric conductivity of juice which was determined in laboratory of the Processes and Equipment for Processing of Agricultural Production Department the National University of Life and Environmental Sciences of Ukraine.

The electric conductivity of juices was measured using an AC bridge P5021 with zero indicator and signal generator GZ-33. To control the values correctness parallel measurements were performed with the KHL-1M conductivity meter. The difference between a bridge and a conductivity meter lies in the fact that while determining the electric conductivity of the AC bridge both the active and reactive resistance components are taken into account and the voltage is applied to the electrodes at a 1000 Hz frequency. This minimizes the electrodes polarization result effect and hence destruction or formation of new substances in solution. Measurements were made in a special electrochemical cell in which the temperature of the juice was maintained constant using the thermostat.

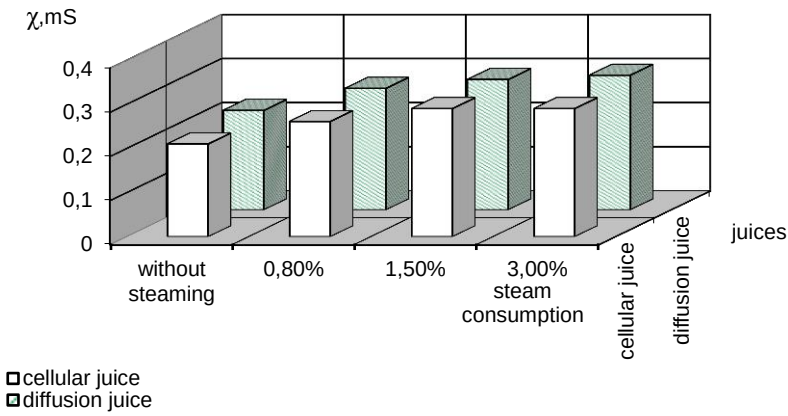

Figure 1. The dependence of juices electric conductivity on steaming them

Cellular and diffusion beet juices were used for the electric conductivity study. Samples were taken in a 40 ml volume of each juice and electric conductivity was measured. In Figure 1 it is evident that the electric conductivity of diffusion juice is higher than the electric conductivity of cellular juice. This can be explained by the fact that a part of cell juice associate collapses during extrac-

tion in a diffusion apparatus which causes the release certain of its constituent elements which are electric charge carriers. The same dependence was obtained for juice treated with different amounts of water steam (Figure 2). Despite the dilution caused by the steam condensation the electric conductivity of the processed diffusion juice is always higher than the electric conductivity of the raw juice.

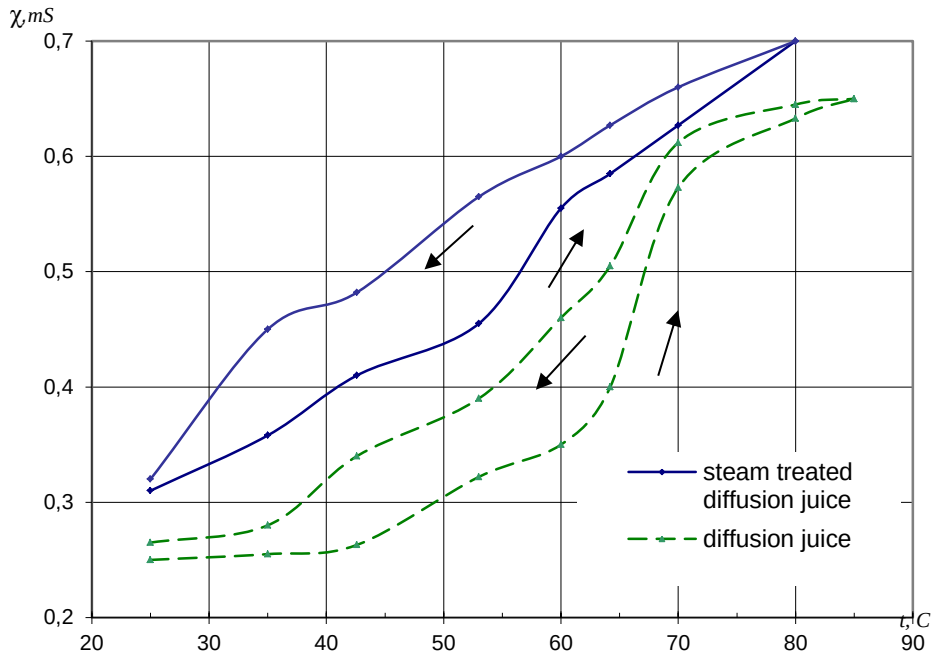

Figure 2. The dependence of diffusion juice electric conductivity on temperature during its heating and cooling

To ensure that the steam-condensation cavitation effects lead to the above-described phenomena rather than heating we conducted studies that determined the effect of juice heating through the heat exchange surface on the electric conductivity of the treated and untreated diffusion juice.

The diffusion juice obtained in industrial conditions was heated to 85°C in a water bath and then cooled to an initial temperature and electric conductivity was measured at each 5°C. The data presented in Figure 2 show that during the heating of juice the electric conductivity dependence on heating at different temperatures has a different nature. Thus, when the juice is heated to 45°C this dependence is characterized by almost a straight line and when the temperature raises from 45 to 65°C the nature of this dependence changes qualitatively which indicates complex transformations that occur primarily with protein-pectin sub-

stances. When the temperature rises above 65°C electric conductivity increases dramatically due to an increase in the mobility of ions during temperature rise as well as a decrease in the solution viscosity. During the cooling of the juice the electric conductivity decreases smoothly and the schedule characteristic curvature is not present.

For juice with steam processing the schedule characterizing the electric conductivity dependence on temperature does not have clearly expressed bends during heating in the temperature range 45–65°C which again verifies the structural transformations of the juice macromolecular compounds and their complexes structure during steam-condensation cavitation juice processing. When heated more than 65°C the character of the dependence is similar to the diffusion juice without processing. In general electric conductivity in the second case is always higher. The more rapid growth of electric conductivity in the first stage can be explained by the high-molecular compounds associative collapse in diffusion juice under the steam-condensation cavitation effects influence with the release of ion carriers. This is evidenced by the less rapid increase in the electric conductivity of the same juice at high temperatures as the basic processes of physical and chemical transformations occurred under the influence of the effects of steam-condensation cavitation.

Conclusion

Thus it is established that due to the steam-condensation cavitation effects the structural transformations of the diffusion juice macromolecular compounds and colloidal dispersion substances are occurring which leads to an increase in the electric conductivity of juice due to the colloidal dispersion substances disaggregation and the ion-carriers components releasing.

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