INFLUENCE OF TECHNOLOGICAL PARAMETERS OF THE ULTRAFILTRATION PROCESS OF CITRUS JUICES ON THEIR QUALITY

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Abstract: Fresh fruit juices contain organic acids and mineral substances (potassium, calcium, iron, copper, magnesium, phosphorus, manganese, molybdenum, boron, iodine), and their salts, large amounts of fiber, pectin and enzymes - complex substances, that contribute to the food processing and absorption of nutritional elements. Natural citrus juices contain essential vitamins and nutrients for the human body. Therefore, they represent a good opportunity for the treatment and prevention of various diseases. With the vitamins, taken through the juice, the human body becomes more resistant to viruses and infections, stressful situations and intense physical stress, and the body's metabolism becomes normalized. Beverages, prepared from juices improve intestinal motility and thus contribute to improving the allocation of toxic substances and slags from the organism.

The purpose of this work is the development of technological parameters of the ultrafiltration process to obtain natural juices which are sterile, resistant to precipitation and turbidity, and have a long shelf life. This paper examines the performance of the ultrafiltration process of citrus juices (lemon, tangerine, orange) and its dependence on the pressure and duration of the process, type and porosity of the membrane, the nature of the juice, and acidity. The juice composition was studied before and after ultrafiltration. It was established, that the productivity of the ultrafiltration process depends on: the duration of the process and this dependence is determined by the nature of the process: membrane type, in particular, filtration material and pressure: with an increase in membrane porosity and pressure, the productivity of the process, the volume of filtered juice, filtering speed and duration increases; the productivity of the ultrafiltration process, during the filtration both in dynamic and static mode, depends on the type and consistency of the juice: it increases with the increase of juice acidity. It was established: the general acidity (1.17%), density (1.038 g/cm³), the content of dry substances (9.9%), sugars (7.8%), including invert (7.2%), ash (0.26%), and vitamin C (20mg/ 100gr.), do not change in the course of ultrafiltration of tangerine juice. The viscosity, the content of carotenoids, cellulose and pectin decreases. The amino-acid structure practically does not change; hollow fibers detain only 6 - 8% of proteins and amino acids. For obtaining high-quality citrus juices, ultrafiltration should be carried out at a pressure 0.2MPa, on hollow fiber, in a dynamic, circulating mode.

The juices obtained by ultrafiltration on hollow fibers (AP-2.0) are sterile, resistant to precipitation and turbidity, have significantly increased shelf lives, and they retain their organoleptic properties and nutritional values.

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Introduction

Georgia is an agricultural country cultivating great quantities of fruit. Therefore, it is essential for this country to have sufficient manufacturing capacities for the waste-free processing of fruit into high quality competitive products which are profitable and marketable both locally and abroad. A large amount of unutilized waste which is dumped, deteriorates the local ecological situation resulting in soil, water and air pollution (Bejanidze et al., 2019).

The juices produced through conventional technology (pressing, sterilization) are not stable because of pulp precipitation. Sterilization also affects the juice flavour and colour resulting in the population preferring imported produce, and hence the domestic produce is difficult to market at home or abroad.

Natural juices contain essential vitamins and nutrients for the human body. Therefore, they represent a good opportunity for the treatment and prevention of various diseases. With vitamins taken through the juice, the human body becomes more resistant to viruses and infections, stressful situations and intense physical stress, and the body's metabolism becomes normalized (Lamport et al., 2014; Yilmaz and Bagci, 2018). In addition to vitamins, fruit juices contain organic acids and mineral substances

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(potassium, calcium, iron, copper, magnesium, phosphorus, manganese, molybdenum, boron, iodine), and their salts, large amounts of fiber, pectin and enzymes - complex substances, that contribute to the food processing and absorption of nutritional elements. Beverages, prepared from juices improve intestinal motility and thus contribute to improving the allocation of toxic substances and slags from the organism (Bejanidze et al., 2006; Lichtenthäler and Marx, 2005; Castro-Muñoz et al., 2018). However, with high temperatures ($> 470\text{ }^{\circ}\text{C}$), enzymes become inert and break down, causing the juice to lose its healing power, and turning it into a thirst preventing drink (Kotsanopoulos and Arvanitoyannis, 2015; Bhardwaj and Pandey, 2011). The above-mentioned problems can be rationally solved through the baromembrane processes, in particular ultrafiltration.

Ultrafiltration belongs to the membrane equipment field and is a reticular filtration in the membrane field (Bykov et al., 2015). Open low-molecular compounds (acids, sugar, aromatic substances, etc.), that are part of unclarified juices, pass through the membrane. A certain quantity of macromolecular compounds (starch, proteins, pectin, etc.) and suspended particles are being held and concentrated while the juice passes through the membrane (Bejanidze et al., 2014; Khandpur and Gogate, 2015).

The purpose of this work is the development of technological parameters of the ultrafiltration process to obtain natural juices which are sterile, resistant to precipitation and turbidity, with have long shelf lives.

Materials and methods

The research was done on natural and clarified citrus juices: tangerine, lemon and orange juice, which were not filtered primarily. One of the substantial features that defines the possibility of filter material use, is the dependence of productivity process (W) on the membrane type and species; physical parameters (pore size, membrane selectivity, the filter flow direction), and also the nature of filtered juice, consistency and precipitate content (Lame and Satyavir, 2015). Ultrafiltration was carried out in static (FK-01 plant) and dynamic (UPL-06 plant) conditions. On the FK-01 plant, the filtration was done with the filtering material - flat filters "Khalipor1" ($d \approx 500\text{ }\mu\text{m}$); "Khalipor2" ($d \approx 200\text{ }\mu\text{m}$); UPM-P ($d \approx 500\text{ }\mu\text{m}$); UAM-300 ($d \approx 300\text{ }\mu\text{m}$), UAM-500 ($d \approx 500\text{ }\mu\text{m}$) perpendicularly to the surface; On the UPL-06 plant the filtration was done using tangential filtration in the dynamic mode and the hollow fibers VPU-15PA were used as a filtering material – separating plant AP-2.0 (Filtration area - 2.0 m^2). Filtration was also carried out in the dynamic mode on tubular membranes of BTU-0.5/2 (Filtration area - 0.5 m^2).

During the filtration on the FK-01 plant, a part of high-molecular compounds, was collected on the surface of the membrane and acts as a "secondary membrane", i.e. additional filtering was being conducted. This layer is removed during each cleaning and appears again as a new layer in the beginning of a new the filtration. The structure of hollow fibers, the ultrafiltration processes conducted in it and the mechanism are shown on the Fig.1-4. (Bejanidze and Kharebava, 2009; Bejanidze et al., 2017).

Figure 1: Hollow fibers VPU-15PA	Figure 2: Tubular membranes BTU - 0,5/2

Source: Authors	Source: Authors

We determined the content of juice composition before and after ultrafiltration: sugars (inverted, total, saccharose), vitamin C, the content of carotenoids and nitrogen through a spectrophotometric method,

dry solids through a refractometric method, pectin (total, soluble, protopectin) and acidity through a potentiometric method, cellulose through a chlorite method, ash through a gravimetric method, and viscosity with a viscometer. The productivity of the process was determined by the volume of clarified juice obtained in the process of ultrafiltration in liters per hour from 1 square meter of the membrane

Figure 3: The mechanism of the ultrafiltration	Figure 4: The scheme of ultrafiltration process

Source: Authors	Source: Authors

Results and discussion

It is established, that the productivity of the ultrafiltration process depends on the duration of the process and this dependence is determined by the nature of the process (Fig. 5 & 6) : membrane type in particular and filtration material: the highest productivity can be achieved by aromatic polyamide base during the filtration on the UPM-P membrane, and the lowest produced based on the N-vinil-2-pirolidone metilmetakrilate copolymer, done for the Khalipor-1 membrane.

According to the ultrafiltration process productivity decrease, membranes will stand in the following order:

UPM-P > UAM-500 > UAM-300 > Khalipor -2 > Khalipor -1 (for tangerine juice) (Fig.6)

Khalipor -1 > UAM-500 > UAM-300 > UPM-P > Khalipor -2 (for orange juice) (Fig.6)

Then according to the membrane porosity: with an increase in porosity, the productivity of the process, the volume of filtered juice, filtering speed and duration increases:

$W (UAM -500) > W (UAM -300) > W (Khalipor) -2 > W (Khalipor -1)$

Productivity of ultrafiltration process depends on the type of juice, in particular their acidity: It increases with an increase in juice acidity (Fig.7):

$W (\text{Lemon}) > W (\text{Tangerine}) > W (\text{Orange})$

With an increase in pressure, the productivity increases to a certain limit which is defined by the mechanical durability of the membranes (Fig.8).

The juice composition was studied before and after ultrafiltration (Fig.9-12).

It is established: the general acidity (1.17%), density (1.038 g/cm³), the content of dry substances (9.9%), sugars (7.8%), including invert (7.2%), ash (0.26%), and vitamin C (20mg/ 100gr.) do not change in the course of ultrafiltration of tangerine juice. Viscosity, the content of carotenoids, cellulose and pectin decrease.

The amino-acid structure practically does not change; hollow fibers detain only 6 - 8% of proteins and amino acids: Orange (6.1%) – Tangerine (6.96%) – Lemon (7.9%).

The juices obtained by ultrafiltration on hollow fibers (AP-2.0) are sterile, resistant to precipitation and turbidity, have significantly increased shelf lives, and they retain their organoleptic properties and nutritional values.

Figure 9: Influence of the type of membranes on physical and chemical indicators of tangerine juice

Source: Authors

Figure 10: Influence of the process of clarification of juice on their chemical composition (membrane – hollow fibers AP-2.0)

Source: Authors

Figure 11: Change of physical and chemical indicators of the juice in the process of ultrafiltration on hollow fibers AP-2.0

Source: Authors

Conclusion

It was established, that the productivity of the ultrafiltration process depends on: the duration of the process and this dependence is determined by the nature of the process: membrane type, in particular, filtration material; pressure: with an increase in pressure, the productivity increases.

It was established, that the ultrafiltration process productivity decreases for membranes in the following order: UPM-P > UAM-500 > UAM-300 > Khalipor -2 > Khalipor -1 (for tangerine juice); Khalipor -1 > UAM-500 > UAM-300 > UPM-P > Khalipor -2 (for orange juice).

Figure 12: The change of the vitamin C during the filtration of citrus juice on hollow fibers AP-2.0

Source: Authors

It was established: with an increase in the membrane porosity, the productivity of the process, the volume of filtered juice, filtering speed and duration increases;

It was established, that the productivity of the ultrafiltration process, during the filtration both in dynamic and static mode, depends on the type and consistency of the juice: it increases with increase in juice acidity : $W(\text{Lemon}) > W(\text{Tangerine}) > W(\text{Orange})$; When pressure is increased, the productivity increases to a certain limit which is defined by the mechanical durability of membranes.

It was established: the general acidity (1.17%), density (1.038 g/cm³), the content of dry substances (9.9%), sugars (7.8%), including invert (7.2%), ash (0.26%), and vitamin C (20mg/ 100gr.), do not change in the course of ultrafiltration of tangerine juice. Viscosity, the content of carotenoids, cellulose and pectin decrease. The amino-acid structure practically does not change; hollow fibers detain only 6 - 8% of proteins and amino acids.

For obtaining high-quality citrus juices, ultrafiltration should be carried out at a pressure of 0.2MPa, on a hollow fiber membrane, in a dynamic circulating mode.

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