Секція 2. **ОБЛАДНАННЯ ХАРЧОВИХ ВИРОБНИЦТВ ТА УДОСКОНАЛЕННЯ ПРОЦЕСІВ І АПАРАТІВ ХАРЧОВИХ ВИРОБНИЦТВ**

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DIRECTIONS OF IMPROVEMENT OF PROCESSES OF MEMBRANE SEPARATION OF JUICES FROM FRUIT AND BERRY RAW MATERIALS

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The article presents an analysis of modern methods of membrane processing of liquid food products. The main methods of juice processing are considered. The expediency of using membrane technologies for the processing of fruit and berry juices has been substantiated. The features of the use of microfiltration and ultrafiltration membrane treatment for the processes of concentration and clarification of juices from fruit and berry raw materials have been determined. The analysis of membrane processing in dead-end and tangential modes is carried out. The main advantages and disadvantages of their use in the processing of liquid food media are revealed. A solution is proposed that allows one to minimize the polarization layer on the working surface of the membranes.

Keywords: *fruit and berry raw materials, juice, membrane processing, ultrafiltration, microfiltration, clarification, concentration.*

НАПРЯМИ ВДОСКОНАЛЕННЯ ПРОЦЕСІВ МЕМБРАННОГО РОЗДІЛЕННЯ СОКІВ ІЗ ПЛОДОВО-ЯГІДНОЇ СИРОВИНИ

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Освітлення соку є одним із найбільш складних технологічних процесів. При цьому освітлення є важливою стадією процесу виробництва плодово-ягідного соку. Освітлення проводиться з метою колоїдної стабілізації продукту під час зберігання, а також для поліпшення органолептичних властивостей продукту і його споживчого вигляду. Для того щоб продукт відповідав міжнародним стандартам, необхідно застосовувати сучасні технології та обладнання, яке базується на передових науково-технічних розробках. Застосування мембранних технологій забезпечує більш високий *вихід, поліпшення смаку, товарного вигляду і харчової цінності плодово-ягідних соків. Також у разі мембранного способу обробки зберігаються вітаміни, амінокислоти та інші біологічно активні компоненти. Досягти цього можна завдяки відмові від теплової стерилізації і консервантів. Мембранні апарати дозволяють створювати сучасні ефективні технології концентрування соків та розширювати асортимент продукції. Використовуючи ультрафільтраційні й мікрофільтраційні апарати, можна отримати продукти з регульованим мінеральним і вуглеводним складом. Сьогодні основним напрямом застосування мембран у виробництві соків є їх освітлення та концентрування. Освітлення соків проводиться з метою руйнування колоїдної системи продукту, видалення високомолекулярних білкових, пектинових і поліфенольних речовин і мікроорганізмів. При цьому необхідною умовою є збереження біологічно активних і цінних компонентів – вітамінів, цукрів, кислот, мінеральних і ароматичних речовин.*

У статті подано результати аналізу сучасних методів мембранної обробки рідких харчових продуктів. Розглянуто основні способи обробки соків. Обґрунтовано доцільність застосування мембранних технологій для обробки плодово-ягідних соків. Визначено особливості застосування мікрофільтраційної й ультрафільтраційної мембранної обробки для процесів концентрації та освітлення соків із плодово-ягідної сировини. Проведено аналіз мембранної обробки в тупиковому і тангенціальному режимах. Виявлено основні переваги та недоліки їх застосування в процесах обробки рідких харчових середовищ. Запропоновано рішення, яке дозволяє мінімізувати поляризаційний шар на робочій поверхні мембран.

Ключові слова: *плодово-ягідна сировина, сік, мембранна обробка, ультрафільтрація, мікрофільтрація, освітлення, концентрація.*

Statement of the problem. The fruit and vegetable industry meets the needs of the population in food products of high nutritional and biological value. One of the main products of the fruit and vegetable industry is juices. Juices are an important food product because they provide the human body with a set of all necessary physiologically active substances such as vitamins, macro- and microelements and many other useful substances [1].

To date, the consumption of fruit and vegetable juices is constantly increasing. The main reasons for this are the nutritional value of juices, as well as the profitability of their production. The use of modern equipment, which is based on advanced scientific developments, allows to intensify the production process and provide rapid processing of large quantities of fruits and vegetables for the production of concentrated and natural juices [2].

Juices contain such important components as vitamins, minerals, phenolic compounds and other substances that have antioxidant properties. For example, freshly squeezed juice contains a large amount of pectin, insoluble biopolymers, lipids, polysaccharides and other substances. These substances can be sources of turbidity.

The presence of colloidal particles of dispersion in the juice is the main cause of turbidity of the juice during storage. As a result, there is a fusion of particles and their subsequent aggregation. At the beginning there is a slight turbidity, then gradually there is a precipitation. During the production of clarified juices, colloidal substances are removed. In the manufacture of unclarified juices, only purification is used, and colloidal substances are not subject to removal [3].

Juice clarification is the process of separating fruit juice into sediment and clear liquid. During clarification of the juice of its colloidal system is destroyed in full. The amount of colloids should be reduced by 20–30%. Juices after clarification are a liquid phase of the fruit with substances dissolved in it, squeezed from the fruit tissue.

Juice clarification is one of the most complex technological processes. The stage of clarification is one of the main stages of the process of apple juice production [4].

Review of the latest research and publications. Clarification process is carried out in order to colloid stabilize the product during storage, as well as to improve the organoleptic properties of the product and its consumer appearance. In order for the product to meet international standards, it is necessary to use modern technologies and equipment based on advanced scientific and technical developments. The use of membrane technologies provides a higher yield, improving the taste, appearance and nutritional value of fruit juices. Vitamins, amino acids and other biologically active components are also preserved during the membrane processing method. This can be achieved by avoiding heat sterilization and preservatives [5].

Membrane devices allow to create modern effective technologies of concentration of juices, and also to expand the range of production. Using ultrafiltration and microfiltration devices, you can get products with adjustable mineral and carbohydrate composition. Today, the main use of membranes in the production of juices is their clarification and concentration. The process of clarification of juices is carried out in order to destroy the colloidal system of the product, removal of high molecular weight protein, pectin and polyphenolic substances and microorganisms. The necessary condition is the preservation of biologically active and valuable components – vitamins, sugars, acids, minerals and aromatic substances [6].

The process of ultrafiltration is a type of membrane technology used in food production. Membrane technologies vary depending on the pore size of the membranes used. Ultrafiltration is the process of separating, fractionating and concentrating solutions using semipermeable membranes. The average pore diameter of the membranes is from 0.01 to 0.20 μm. The working pressure is in the range from 0.1 to 1.0 MPa. Using ultrafiltration devices from the source solution separate small bacteria and spherical viruses, as well as large protein molecules. During ultrafiltration, the initial solution is divided into two fundamentally new products: low molecular weight (filtrate) and high molecular weight. The filtrate passes through the membrane and is removed, and the macromolecular product is concentrated.

In contrast to microfiltration, the ultrafiltration process may be accompanied by the adsorption of solutes on the surface of the membrane pores and even intermolecular interaction. Ultrafiltration devices are used to separate systems in which the molecular weight of dissolved components is much greater than the molecular weight of the solvent [7].

The membrane used in ultrafiltration and microfiltration is a semipermeable barrier. This partition passes certain components of liquid mixtures.

Membranes must have a high resolution (selectivity); high specific productivity (permeability); chemical resistance to the environment of the separated system; mechanical strength [8].

The duration of the membranes, as well as their service life is significantly affected by the process of sediment formation. The sediment layer is usually salt-tight, clogs the surface pores of the membrane, creates additional resistance to flow and mass transfer in the boundary layer. As a result, the concentration polarization on the membranes increases and their productivity decreases. The phenomenon of concentration polarization is inherent in almost all baromembrane processes. This phenomenon is an increase in the concentration of solute near the surface of the membrane [9].

The objective of the research. The aim of the article is to study new areas of improvement of modern membrane devices for clarification and concentration of fruit juices.

Presentation of the research material. Concentration polarization has a negative effect on the performance of membranes. Due to the increase in the osmotic pressure of the solution, the driving force of the separation process decreases. It is also possible precipitation and deposition of insoluble salts on the membrane, gelation of macromolecular compounds. As a result, the permeability and selectivity of the membranes decreases, and the service life is significantly reduced.

Depending on the design of the membrane apparatus, the properties of the membrane, the cost of the finished product, the performance of the machine, it is possible to use different methods to reduce the concentration polarization. One such method is turbulence of the separated solution. There is an increase in the permeability and selectivity of the membrane due to the decrease in the concentration of solutes in the boundary layer. There is also a decrease in osmotic pressure and an increase in the driving force of the process. Creating a pulsating flow can, in turn, increase the speed of the near-wall fluid layers. This will reduce the likelihood of a layer of sediment on the surface of the membranes.

The phenomenon of concentration polarization is inherent in all membrane processes, including microfiltration and ultrafiltration. Polarization is that the concentration of solute on the surface of the membrane increases. The permeability and selectivity of the membranes are reduced, and the service life of the membranes is reduced. One solution to reduce the effect of concentration polarization is to create turbulence of the surface layer of the fluid adjacent to the membrane surface. This accelerates the transfer of solute to the center of the solution, which is separated. For this purpose, various magnetic stirrers and vibrating devices are added to the structure. It is also possible to increase the flow rate of the fluid along the membrane and the use of turbulizers.

One of the design solutions when creating equipment is the use of devices with narrow channels. This solution is aimed at creating a laminar mode of movement of the product, which allows to increase the productivity of the units while maintaining the small dimensions of the device [10].

Increasing the temperature of the liquid can reduce the viscosity of the solution to be separated, while increasing the diffusion coefficient of the solute. However, this method may not be acceptable for clarifying juices.

It is also possible to apply the effect of ultrasonic vibrations on the boundary layer of the membrane.

The main technological parameters of baromembrane processes are filtration rate, selectivity and permeability of membrane components.

The main factors influencing the processes of membrane separation are temperature, pressure, hydrodynamic conditions and the formation of sediment on the membranes. However, the main factor influencing the processes of microfiltration and ultrafiltration is the working pressure. The driving force of the process increases with increasing pressure and, therefore, increases the permeability of the membrane [11].

The operating pressure is set depending on the filtration process, the solution to be divided, the type of membrane, the design of the apparatus, the hydraulic resistance of the intermembrane channel and drainage.

The effect of solution temperature on the filtration process is complex. As the temperature increases, the viscosity and density of the solution decrease. At the same time there is an increase in osmotic pressure.

Decreased viscosity and density increase permeability. Increasing the osmotic pressure reduces the driving force of the process and reduces the permeability of the membranes.

During the increase of temperature in the processes of microfiltration and ultrafiltration there is an increase in the permeability and selectivity of the membrane. This is due to a decrease in the viscosity of the permeate, as well as a decrease in the effect of concentration polarization on the characteristics of the membranes. As the concentration of the solution increases, the driving force of the process decreases, the viscosity and density of the solution increase, and the permeability of the membranes decreases.

The concentration also affects the selectivity of the membranes. In solutions of low concentration, the selectivity of the membranes does not change significantly with changing concentration. Increasing the concentration of solutes in the solution degrades the performance of the membranes. The specific productivity and selectivity of the device decreases. Increasing the concentration increases the osmotic pressure of the solution. This reduces the effective driving force of the separation process. The viscosity also increases, resulting in a reduction in mass transfer. The consequence of this is a decrease in the specific productivity of the membranes to a minimum. In this case, the practical use of baromembrane processes becomes impractical [12].

Dead-end and tangential filtration is used in modern food industry enterprises.

Dead-end filtration is a highly efficient and economical way to clarify food environments. The equipment for its implementation is compact and easy to operate (Fig. 1).

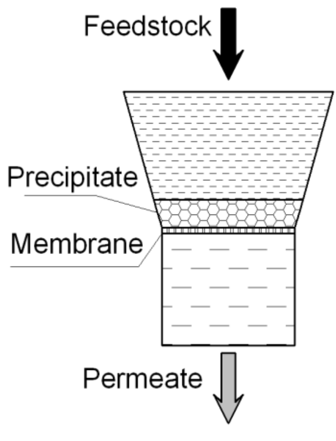

Fig. 1. Dead-end membrane filtration scheme

Tangential filtration is characterized by the passage of the product flow along the surface of the membrane (Fig. 2).

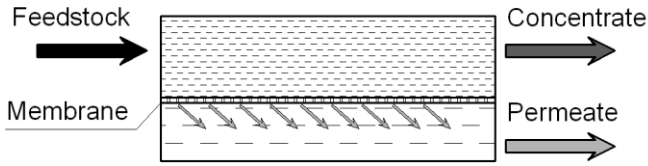

Fig. 2. Tangential membrane filtration scheme

Dead-end and tangential filtering are significantly different. In dead-end filtration, the fluid flow is directed perpendicular to the filter surface, and in tangential filtration, the flow moves in a direction parallel to the membrane surface.

Typically, in tangential filtration machines, the circulating pump creates a flow that moves along the surface of the membrane. Thus, this flow prevents the formation of sediment on the surface of the membrane. Unlike dead-end filtration, tangential filtration allows the process to be carried out in a continuous mode, while the pores of the membrane are not blocked.

In the process of tangential filtration, the liquid flows on the membrane not directly, but along it. This method creates a pressure difference across the membrane. As a result, a certain volume of liquid passes through the membrane in the form of a filtrate, and the rest continues to move along the membrane together with impurities, which in the stream clean the walls of the membrane.

Tangential flow filtration is characterized by the process of recirculation of the concentrate through the membrane surface. Weak cross-flow of fluid minimizes membrane contamination. This maintains a high filtration rate and provides a high product yield.

Conclusion. Tangential flow filtration can be used for both microfiltration and ultrafiltration of fruit and berry juices. The use of tangential filters provides transparency and microbiological stability of food liquids. Such performance of membranes can be obtained without the use of excipients and additives. This eliminates various problematic situations related to the disposal of these products. Membranes, provided proper use and timely maintenance of the filter, have a longer service life compared to the traditional dead-end method of filtration. The use of tangential filters also helps to preserve the structural and organoleptic properties of the product. The tangential filters are self-cleaning and do not require expensive consumables.

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УДОСКОНАЛЕННЯ АВТОМАТИЗОВАНОЇ СИСТЕМИ ВИРОБНИЦТВА ПЕТ-ТАРИ

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На основі інформаційної структури автоматизованої системи моніторингу якості розроблено систему аналізу інформації про якість формоутворення ПЕТ-тари з можливістю статистичного управління технологічним процесом. Удосконалено модель автоматизованої системи