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ANALYSIS OF MEMBRANE DEVICES CONSTRUCTIONS OF THE FOOD AND PROCESSING INDUSTRY

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An analysis of modern designs of membrane devices, which are used at enterprises of the food and processing industry, was carried out. The need for a wider use of membrane technologies for the processing of food liquids is substantiated. In particular, the processes of concentration and illumination. Characteristic shortcomings of baromembrane processes are identified. The conducted analytical studies made it possible to conclude that membranes with a larger pore diameter do not allow obtaining the required degree of illumination. Membranes with a smaller pore size are characterized by low permeability.

Keywords: *microfiltration, ultrafiltration, reverse osmosis, membrane treatment, baromembrane processes, membrane devices, food industry*

АНАЛІЗ КОНСТРУКЦІЙ МЕМБРАННИХ АПАРАТІВ ХАРЧОВОЇ ТА ПЕРЕРОБНОЇ ПРОМИСЛОВОСТІ

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Проведено аналіз сучасних конструкцій мембранних апаратів, які використовуються на підприємствах харчової та переробної галузі. Обґрунтовано необхідність більш широкого використання мембранних технологій для здійснення процесів переробки харчових рідин. Зокрема процесів концентрування та освітлення. Визначені характерні недоліки баромембранних процесів. Проведені аналітичні дослідження дозволили зробити висновок, що мембрани з більшим діаметром пор не дозволяють

отримувати потрібну ступінь освітлення. Мембрани з меншим розміром пор характеризуються низькою пропускною здатністю.

На даний час, ультрафільтрація є економічно ефективним процесом обробки харчових рідин. Цей процес має певні переваги перед традиційними процесами концентрування та освітлення харчових рідин.

Ультрафільтраційні апарати суттєво підвищують вихід готового продукту. При цьому, харчова та біологічна продуктів не зменшується. Якість кінцевого продукт покращується у, що дає змогу отримувати харчові продукти з високою харчовою цінністю і новими властивостями.

До апаратів, за допомогою яких реалізується процес ультрафільтрації, відносять апарати з тангенційною потоковою фільтрацією. Тангенціальна фільтрація може використовуватися як для мікрофільтрації, так і для ультрафільтрації вин та фруктово-ягідних соків. Застосування тангенціальних фільтрів забезпечує прозорість і мікробіологічну стійкість харчових рідин. Таку продуктивність мембран можна отримати без використання допоміжних речовин і добавок. Це виключає різні проблемні ситуації, пов'язані з утилізацією даної продукції. Мембрани, за умови правильного використання та своєчасного обслуговування фільтра, мають більший термін служби в порівнянні з традиційним тупиковим способом фільтрації. Використання тангенціальних фільтрів також сприяє збереженню структурних і органолептичних властивостей продукту. Тангенціальні фільтри є самоочисними і не вимагають дорогих витратних матеріалів.

Характерною особливістю тангенціальної фільтрації є більш тривалий термін експлуатації. При цьому немає необхідності застосовувати додаткові витратні матеріалів. Даний тип мембрани очищуються протитечією. Мембрани виготовлені з нейтрального харчового полімеру, або кераміки. Тангенціальна фільтрація забезпечує задану ступінь фільтрації за один прохід.

Ключові слова: *мікрофільтрація, ультрафільтрація, зворотній осмос, мембранна обробка, баромембранні процеси, мембранні апарати, харчова промисловість*

Statement of the problem. The fruit and vegetable industry performs one of the main tasks of providing the population with food products that have high biological and nutritional value, and also contain vitamins and biologically active substances that are indispensable for humans. Juices are one of the main products of the fruit and vegetable industry.

In the juice, unstable phenolic compounds can polymerize, forming tannins, which, interacting with proteins, contribute to the appearance of secondary turbidity. With traditional filtration methods, these compounds are usually removed by bentonite treatment. During ultrafiltration, this problem is solved by removing one of the components of the reaction - protein. Therefore, when choosing juice clarification membranes, it is necessary to ensure the removal of proteins. In addition to macromolecules dissolved and suspended in the solution, bacteria, yeast, molds and their spores are

completely removed during ultrafiltration. Therefore, the filtrate obtained during ultrafiltration is sterile. However, when bottling such juice, secondary infection of the juice is possible when passing through the bottling and capping equipment, so the pasteurization process cannot be excluded if aseptic bottling conditions are not ensured [1].

One of the main stages of the apple juice production process is the clarification stage. This process is carried out for the purpose of colloidal stabilization of the product during storage, as well as to improve the consumer appearance of the product and its organoleptic properties. In order for the product to meet international standards, it is necessary to use modern technologies and equipment based on advanced developments [2].

This type of equipment includes membrane technologies that provide a higher yield, improvement in taste, appearance and nutritional value of fruit and berry juices. At the same time, vitamins, amino acids and other biologically active components are preserved. This is possible due to the rejection of preservatives and the thermal sterilization stage. Membrane processes make it possible to create energy-efficient juice concentration technologies and expand the range of products [3]. Using microfiltration and ultrafiltration processes, you can get products with an adjustable mineral and carbohydrate composition [4].

The processes of separation of complex systems at the micro level are carried out with the help of membrane technology, which can be effectively used in the processes of filtration, purification and clarification of fruit and berry juices [5]. Separation of substances using membranes under pressure is carried out using reverse osmosis or ultrafiltration methods [6]. Reverse osmosis refers to forced filtration of solutions through semipermeable membranes that allow solvent molecules to pass through and retain molecules or ions of dissolved substances. Reverse osmosis processes occur at a pressure of 4...10 MPa [7].

Ultrafiltration is the process of separating high-molecular and low-molecular compounds in the liquid phase on selective membranes that pass molecules of low-molecular compounds and retain high-molecular compounds. If a solvent and a solution or two solutions of different concentrations are separated by a semipermeable membrane that can pass only the solvent, transfer of the solvent across the membrane is observed. This transfer is called osmotic, and the phenomenon is called osmosis [8].

If the pressure on the solution increases, osmosis slows down and at a certain pressure, called osmotic, it stops completely. When the pressure on the solution is further increased, the transfer of the solvent in the reverse direction from the concentrated solution is observed. This process is called reverse osmosis. Ultrafiltration is carried out at low pressures (0.3...1.0 MPa).

The main element of an ultrafiltration or reverse osmosis installation is a membrane device. Different modules of membrane installations are known. Tubular modules are used in the canning industry for clarification and concentration of fruit and berry juices [9].

The membranes are located on the inside of a dense porous tube through which the working solution is passed. One of the main areas of application of membranes in the production of juices is their clarification and concentration. Clarification of juices is carried out with the aim of destroying the colloidal system of the product, removing high-molecular protein, pectin and polyphenolic substances and microorganisms. At the same time, a necessary condition is the preservation of biologically active and valuable components - vitamins, sugars, acids, mineral and aromatic substances. Concentrated juice is obtained during the processing of direct-pressed juice. For this purpose, the direct-pressed juice can be concentrated in various ways. Among these methods, the membrane method of concentration has become widespread. As a rule, neither sugar nor other sweeteners are added to the composition of concentrated juices [10].

Review of the latest research and publications. Traditional juice production technologies involve filtration of freshly squeezed juice through porous partitions with the loss of some valuable substances, as well as the introduction of preservatives and the use of heat sterilization to ensure the necessary shelf life.

The use of these technologies does not guarantee complete removal of fruit pulp particles and obtaining a final product with a high level of organoleptic indicators and nutritional value. Some methods of brightening and stabilizing fruit juices are based on the addition of external additives to the product, namely brightening materials. Together with these materials, an excessive amount of mineral and other substances often enters the composition of the juice. The duration of juice processing according to traditional technology is from 24 to 30 hours [11].

As a result of such long-term contact of the product with air oxygen, part of the biological value of the juice components is lost. It is obvious that such a phenomenon negatively affects the quality of finished products [12].

Recently, membrane methods for separating mixtures have become widespread. These technologies are characterized by simplicity, economy and efficiency. Membrane filtration ensures the separation of various components in the stream according to the size and shape of microparticles. When filtration is improved, the quality of the finished product improves and its yield increases. In addition to improving the quality of products, the use of membrane units as part of technological lines for the production of juices provides the opportunity to improve the economic indicators of enterprises

due to the simplification of the composition of lines and the reduction of energy consumption of processes [13].

Based on the analysis of literature sources, the main problems preventing the widespread use of membrane technologies in the production of fruit and vegetable juices are the rather high cost of membrane installations due to the large filtration area, which compensates for the decrease in productivity due to the deposition of a sediment (gel layer) on the surface of the membranes.

The objective of the research. The purpose of the article is to carry out analytical studies of the constructions of membrane devices used at enterprises of the food and processing industry.

Presentation of the research material. Reverse osmosis, ultrafiltration, and electrodialysis processes are used to clarify, stabilize, and concentrate juices, soft drinks, and wines.

Membrane processes are especially appropriate to use in cases where the separated mixture contains labile substances that are easily destroyed. These are most often liquid food media, for example, juices, extracts, protein solutions, etc. The development of membrane processes for their separation makes it possible to create fundamentally new technological schemes and equipment for complex processing of plant raw materials, to reduce environmental pollution through the use of waste-free technologies, as well as to obtain food products with new functional properties and high nutritional value [14].

Membrane processes in fruit juice production technology are currently used mainly for their clarification and concentration. For the main filtration of juice in sugar factories, vacuum filters are used complete with settling tanks or disk thickeners, disk filters and filter presses. Cartridge and bag filters, filter presses and disk filters are used for control filtration of juice. Cartridge and disc filters, as well as filter presses, are used for the main filtration of juice [15].

Bag filters are used for control filtration. Sulfated juice is filtered on cartridge or muscle filters, sulfited syrup – on cartridge filters, filter presses or muscle filters. Filtration equipment must meet the following basic requirements: provide maximum filtration speed, maximum productivity, continuity of the process and its mechanization and automation to reduce manual labor costs and reduce production costs during operation [16].

Fabric, ceramics, and metal sieves are used as a filter partition during filtration. However, such a filter partition itself, without sediment, does not provide filtration, as it passes a significant number of small particles, and a cloudy filtrate is obtained. In the sediment, voids are formed between the

settled particles, which form thin winding passages that allow a transparent liquid to pass through [17].

The quality of the sediment is important during filtration: if it is large crystalline, filtration is fast; through fine sediment, the liquid passes more slowly, since the smaller sizes formed, the filter channels offer a lot of resistance. Filtration is even worse with heterogeneous sediment, when small particles fill the spaces between large ones. It is most difficult to filter gelatinous sediments (gels) that are formed during the purification of diffusion juice from proteins, calcium salts of pectin, pectic and humic acids, etc. Currently, CrossFlow tangential filters are widely used for baromembrane processes. These filters are also called cross-flow filters [18].

Tangential filters with a transverse (tangential) flow allow you to obtain the effect of ultrafiltration with the help of a tangential flow only when the raw material passes through the filter once. At the same time, the necessary transparency and microbiological stability of the finished product is ensured. Such characteristics are achieved without the use of auxiliary substances and additives. The main component of the tangential filter unit is filter membranes having a capillary structure with an open fiber. The diameter of the capillaries is 18 microns [19].

The membranes are placed in stainless steel housings, which are assembled in parallel in such a quantity as to achieve the desired filtering surface area. The liquid, which is filtered from the storage tank with the help of a pump, is fed into the body of the tangential filter and moves along the membranes at high speed. Part of the liquid passes through the pores into the membranes. All clean and filtered liquid is collected from all membranes and pumped out. The pump, which pumps out the filtered liquid, periodically switches for a few seconds in the reverse direction, creating a water hammer in the membrane. Due to this, the particles settled on the surface of the membrane fly off it and are captured by the flow of the contaminated liquid.

An example of the construction of a tangential membrane filter with tubular membranes is presented in Fig. 1.

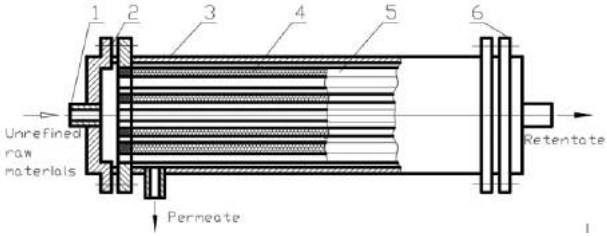

Fig. 1. Membrane module with tubular membranes

Tangential filters are self-cleaning filters and do not require expensive consumables. Basically, the average service life of membranes is about 5

years, but with proper use and timely maintenance of the tangential filter, this period can increase to 10 years [20].

Filtration of kvass or juice on a tangential filter will allow you to brighten the liquid as much as possible to the color you want. But the filter also has disadvantages - it always has the same filtration rating (depending on the membranes installed at the factory) and you will not be able to perform different degrees of filtration, as, say, with kieselguhr or press filters.

Conclusion. During the analysis, it was established that the output of the finished product increases significantly when using ultrafiltration devices. At the same time, the nutritional and biological value of clarified juices does not decrease. And the quality of the final product improves. This, in turn, makes it possible to obtain food products with high nutritional value.

Modern ultrafiltration processing using tangential crossflow filters can be used for processing beer, wine, and juices. This type of membrane processing allows you to preserve the organoleptic properties of the product as much as possible. In addition, the use of the modern Crossflow tangential filtration method allows you to completely replace such a complex of technological equipment as a separator, kieselguhr filter, filter press. In addition, this technology significantly extends the service life of the membrane module. A characteristic feature of tangential filtration is a longer service life. At the same time, there is no need to use additional consumables. This type of membrane is cleaned by countercurrent. Membranes are made of neutral food grade polymer or ceramics. Tangential filtering provides a given degree of filtering in one pass.

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