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

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DEVELOPMENT OF THE COMBINED MACHINE FOR APPLE PUREE PREPARATION

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In the article the existing technologies for making apple puree were analyzed. The necessity of improving the process of production applesauce and equipment for its implementation is proved. The relevance of experimental research to determine the rational parameters of the stage of heat treatment is substantiated. It was found that increasing steam pressure and the duration of the heat treatment process increase the depth of heat treatment of apples and reduce the penetration force of the product. The rational parameters of the process of heat treatment of fruit raw materials are determined. The design of a combined apparatus for producing applesauce has been developed, the main modes of its operation have been determined. This combined machine allows to reduce material costs due to the elimination of auxiliary operations.

Keywords: *apple puree, heat treatment, wiping, cutting force, grinding.*

РОЗРОБКА КОМБІНОВАНОГО АПАРАТА ДЛЯ ПРИГОТУВАННЯ ЯБЛУЧНОГО ПЮРЕ

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Удосконалення процесу переробки плодової сировини є актуальною науково-технічною задачею. Одним із найбільш перспективних напрямів інтенсифікації процесу виготовлення яблучного пюре є застосування апаратів комбінованої дії. У статті проаналізовано існуючі технології приготування яблучного пюре. Доведено необхідність удосконалення процесу виготовлення яблучного пюре та обладнання для його реалізації. Обґрунтовано актуальність проведення експериментальних досліджень для визначення раціональних параметрів стадії термічної обробки. Установлено, що підвищення тиску пари та подовження тривалості термічної обробки збільшують глибину термічної обробки яблук і зменшують зусилля

проникнення продукту. Визначено, що після термічної обробки яблук величина сили різання під тиском буде різною. Виявлено, що на силу різання впливають тиск пари, тривалість термічної обробки, термін зберігання і сорт яблук. Зі збільшенням терміну зберігання яблук зростає значення нарізання після термічної обробки.

Експериментально доведено, що за однакових параметрів термічної обробки глибина такої обробки буде однаковою для яблук, які відрізняються геометричними розмірами. Установлено, що глибина термічної обробки яблук суттєво не відрізняється залежно від геометричних розмірів та форми плода. Ці дані вказують на те, що різниця у впливі термічної обробки парою надлишкового тиску на яблука, що відрізняються геометричними розмірами, не є істотною і дозволяє проводити комбінований процес переробки. Це значно зменшує складність і енергоспоживання технологічного процесу. Визначено раціональні параметри термічної обробки фруктової сировини. Розроблено та обґрунтовано конструкцію комбінованого апарата, визначено основні режими його роботи. Апарат дозволяє зменшити матеріальні витрати внаслідок усунення допоміжних і перевантажувальних операцій, підвищити продуктивність за рахунок переходу на безперервний режим роботи. Установлено, що використання запропонованого пристрою, призначеного для харчової промисловості й ресторанного господарства, поліпшить якість переробки сировини під час виробництва пюре, заощадить матеріальні ресурси та зменшить споживання енергії.

Ключові слова: *яблучне пюре, термічна обробка, протирання, зусилля різання, подрібнення.*

РАЗРАБОТКА КОМБИНИРОВАННОГО АППАРАТА ДЛЯ ПРИГОТОВЛЕНИЯ ЯБЛОЧНОГО ПЮРЕ

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Проанализированы существующие технологии изготовления яблочного пюре. Доказана необходимость усовершенствования процесса производства яблочного пюре и оборудования для его реализации. Обоснована актуальность проведения экспериментальных исследований по определению рациональных параметров термической обработки. Выявлено, что увеличение давления пара и продолжительности термической обработки увеличивают глубину термической обработки яблок и уменьшают усилие пенетрации продукта. Определены рациональные параметры термической обработки плодового сырья. Разработана конструкция комбинированного аппарата для получения яблочного пюре, определены основные режимы его работы. Аппарат позволяет уменьшить материальные затраты вследствие устранения вспомогательных операций.

Ключевые слова: *яблочное пюре, термическая обработка, протирания, усилие резания, измельчение.*

Statement of the problem. Fruit and vegetable industry is an important sector of the agro-industrial complex of Ukraine. Today, special attention is paid to improving production technology, introducing more productive equipment, expanding the range of processed products. The production of various high-quality baby and diet food products, food concentrates, fresh-frozen fruits and vegetables, semi-finished products, canned food of high readiness is developing rapidly.

The production of food for children of different ages, as well as functional products is a separate sub-sector that differs from the production of conventional products with specific requirements for raw materials, technology, equipment, sanitary and anti-epidemic regime, environmental and chemical control. In recent years, in the field of hygiene and physiology of baby food created multicomponent formulations of products, balanced in chemical composition. Semi-finished products made from fresh fruits and berries used in the confectionery industry as raw materials. These semi-finished products are produced by confectionery or canning industries. The main fruit and berry semi-finished products include: fillings from various fruits, fruit and berry puree, etc. [1].

Fruit and berry puree is a grated fruit pulp. One of the most common in the confectionery industry is apple puree, which in most fruit and berry products is the main raw material, and purees of other types are introduced, as a rule, as flavorings [2].

Fruit processing is a rather laborious process, which requires storage and processing, the presence of special shops and staff. In order to preserve the vitamin composition and produce a quality product, there is a need to develop and improve equipment for processing fruit raw materials, which will be energy efficient and environmentally friendly. In order to intensify the development of new equipment and improve existing it is necessary to carry out a number of theoretical and experimental studies, which will determine the impact of varietal characteristics of apples and parameters of the blanching process on the efficiency of product processing.

Fruit and vegetable products are perishable goods, and therefore, their consumption in fresh form for a long time, as well as its delivery to the point of sale is a rather difficult problem. Therefore, fast and high-quality processing of fruits and vegetables is needed.

Review of the latest research and publications. During the production of food from apples, much of the raw material that is processed goes to waste and mostly during the wiping process. Based on this, the method of wiping plays a significant role in the economy of industrial production of apple food, as the cost of raw materials is 75% of the cost of products produced. You should also pay attention to the equipment used for the wiping process. Many fruits and vegetables are pre-cooked before canning [3].

To date, the effect of temperature and duration of heat treatment on the structuring ability of apple puree has been studied. It is established that the change of heat treatment modes leads to a significant change in its structuring ability. Prolonged exposure to temperature reduces the ability of apple puree to structure due to partial degradation of pectin macromolecules. Depending on the type of fruit and the degree of their maturity, the duration and temperature of heat treatment are selected individually so that the flesh of the fruit softens along the entire depth. Insufficient heat treatment generates significant waste during wiping [4].

At excessive heat treatment fruits strongly boil, there is a deep disintegration of pectin substances. As a result, the puree is liquid, its gelling properties are reduced. Inactivation of enzymes during heat treatment prevents the oxidation of tannins by air oxygen. Therefore, insufficient heat treatment can cause darkening of the puree during wiping. In addition, during the heat treatment of fruits and berries are the removal of air from the tissues and partial caramelization of sugars, which leads to a yellowish color in fruits with light flesh [5].

The developed combined method of processing consists of the process of thermal treatment of the fruit with steam and their mechanical grinding.

The primary task in conducting studies of the combined process of fruit processing was to determine the rational duration of heat treatment. Heat treatment of apples is one of the main stages in the process of obtaining apple puree. Raw materials are subjected to heat treatment, which is carried out in water vapor, in hot water, aqueous solutions of acid, alkali, salt, hot animal or vegetable fats, and by contact with the surface of heating, before cutting, grinding and wiping. To ensure the desired depth of heat treatment, it is necessary to set a rational duration for the treatment of apples with steam or water. During the research, the dependence of the depth of heat treatment of apples on the duration of treatment with water, steam, pressure was established. Apples blanching was carried out in boiling water for 70–90 min at atmospheric pressure and hot steam at 115…125 ºC for 30 min. Thus, there is a need to create equipment that minimizes the loss of raw materials and will improve the quality of finished product.

The objective of the research is to develop a device for implementing the combined process of obtaining applesauce, as well as substantiating the advantages of its use.

Presentation of the research material. The main task during the research of the combined process of making apple puree was to determine the rational duration of heat treatment, as heat treatment of apples is one of the main stages in the process of obtaining apple puree.

Based on literature data and patent research, it is established that the most promising area of production of apple puree is the use of a combined effect of the processes of pre-treatment with steam and mechanical wiping of the product. The presented combination of processes can be implemented using the proposed design of the apparatus for making apple puree. The developed combined method of making apple puree consists of the process of heat treatment of fruits with steam and their subsequent mechanical grinding.

The technical task of development is to improve the quality of the finished puree through the consistent use of combined mechanisms for grinding, rubbing, boiling, mixing, introduction of the necessary additional components and more uniform processing due to the use of rational designs of knives and perforated turns of the screw for fruit processing, reduction of material and energy resources, increase of productivity due to transition to a continuous mode of work. To implement the proposed method, a combined machine for the production of puree has been developed (Fig. 1).

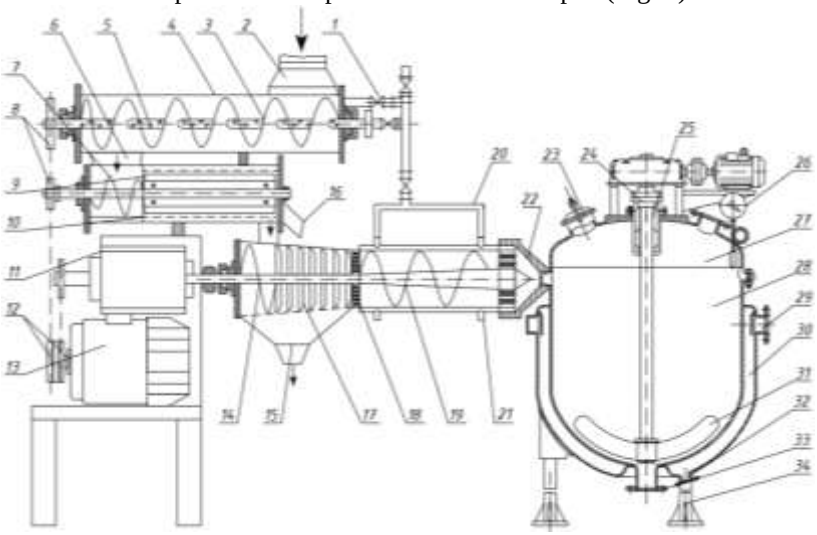

Fig. 1. The scheme of the combined machine for production of puree: 1 – the valve; 2 – the loading bunker; 3 – the screw; 4 – the case cylindrical; 5 – hollow shaft; 6 – the hatch for unloading; 7 – the screw for giving of raw materials; 8 – pulleys; 9 – shovels; 10 – perforated drum; 11 – reducer; 12 – belts; 13 – electric motor; 14 – feed auger; 15 – juice collector; 16 – hatch for waste; 17 – knives; 18 – grinding grate; 19 – auger with variable pitch; 20 – steam line; 21 – condensate pipe; 22 – extruder; 23 – hatch; 24 – friction transmission; 25 – rotating shaft; 26 – barometer; 27 – cover; 28 – working chamber; 29 – nozzle for supplying steam, 30 – steam bath; 31 – anchor stirrer; 32 – condensate receiver; 33 – gateway shutter; 34 – support rack

The combined device of continuous action for the production of puree includes a loading hopper 2 with placed in it the conveying auger 3, the housing 4, the valves 1, the hollow shaft 5.

The device contains four chambers, two of them are located in parallel and two chambers are located in series.

In the third chamber on the high-speed shaft is a coil of the auger 14 and vertically arranged knives 17. The knives 17 have a rotation angle that facilitates the movement of the product along the first chamber 26. The lower part of the third chamber is perforated and connected to the juice collector 15 of puree and includes an extruder 22 and a connected boiler 23. The extruder 22 consists of a loading hopper 2, three working cylinders with placed inside the motor 13 and a reducer 11, as well as four chambers: blanched wiping, squeezing the juice, boiling and squeezing.

The juice extraction chamber has the shape of a truncated cone, the body of this chamber is made perforated and equipped with an additional wall 25 to form a space for collecting juice and a nozzle 15 for draining juice. On the outer shaft 6 in this chamber are installed continuous turns 17 of the auger. At the end of the juice extraction chamber on the shaft is a knife and a second grinding grid 18 with holes of medium diameter.

In the fourth compression chamber on the inner shaft with a gradually increasing diameter made turns 19 of the auger with a decreasing step to exit the chamber. At the end of the chamber there is a third grinding grid with holes of smaller diameter. The forming head 22 of the extruder has a nozzle. A cooking boiler is attached to the forming head 22 of the extruder, inside which an anchor stirrer 30 with a drive is installed.

On the top cover of the boiler 27 there is also a pipe for the introduction of the necessary additional components (sugar syrup, flavors, structurants, stabilizers, etc.).

The vertical cylindrical and lower spherical parts of the boiler body are equipped on the outside with a housing, inside which steam is supplied through the pipe 29, and condensate is removed through the pipe 32.

In the lower part of the boiler 33 is a vacuum sluice gate to remove the finished puree.

The boiler is connected to an exhaust fan to support the discharge and ensure the removal of water vapor formed during the blasting of the extruded product at the outlet of the nozzle.

The combined device works as follows: pre-washed fruit is loaded through the hopper 2. On the surface of the apples act simultaneously working bodies, which is an auger 3 which is on a hollow shaft 5, which gets steam through the valve 1, also through this valve steam enters the working cylinder. The auger 3 is driven by a V-belt transmission, which

consists of a pulley 8 and a belt 12. The raw material moves along the cylinder while the sharp steam coats the entire surface of the apples, which leads to complete blanching of the apples. The apples are sent to the hatch for unloading 6. Then the apples fall into the wiping chamber. From the unloading hatch 6 apples enter the working cylinder, where there is a screw for feeding raw materials 7, this screw is needed to feed the raw materials to the perforated drum 10. When the raw material enters the perforated drum 10, the raw material is wiped. Inside the perforated drum 10 is a shaft on which are placed three blades 3 during the rotation of the blades, the raw material is captured by the blades and presses the raw material to the perforated drum, as a result of which the raw material is rubbed through a sieve. The perforated drum sieve can have different diameters, this is required for different types of raw materials (stone fruit). Waste, bones are sent along the drum to the hatch 16. The finished puree flows from the perforated drum to the next working cylinder.

Grated puree is fed into the receiving hopper of the loading hopper. The drive of the screw located in the loading bunker is included. The source product through the loading hopper enters the housing of the device. The puree is moved to vertically rotating knives with an auger 17.

In the squeezing chamber there is a separation of part of the juice contained in the product, due to the continuous turns 17 of the auger, made in the form of a cone with a decreasing pitch of the turns, and its discharge through the perforated housing. The juice formed during the crushing of the fruit, through the perforated body and the pipe 15 flows into the juice collector and is removed from it for further processing. The squeezed mass of the product is sent to the second grinding grid 18 with holes of medium diameter, where it is finally crushed with a knife.

Next, the crushed and squeezed mass is sent to the boiling chamber, where it is subjected to intense heating. At the same time through the nozzles 20 inside the body of the boiling chamber steam is supplied, which conductively heats the crushed fruit particles, making them more convenient for further processing. The steam condenses and is removed through the nozzles below the chamber.

In the compression chamber, the shaft 19 is made with a reduced pitch. Due to the fact that the speed of rotation of the low-speed shaft in the compression chamber is lower than the speed of rotation of the shaft 6 in the three previous chambers, it helps to provide the required pressure.

In the chamber there is an increase in the pressure of the puree-like mass of the product due to a sharp decrease in the size of the screw channel. The pressure of the puree in the compression chamber reaches the desired value, thus forming a puree, homogeneous in structure and temperature.

This allows you to have a given, uniform in cross section, the temperature of the product. After passing through the nozzle 22, the puree under excess pressure is discharged into the boiler equipped with an anchor stirrer 31. Simultaneously include the drive of the anchor stirrer 31 and the exhaust fan 10 to maintain discharge and ensure removal of water vapor formed during blasting the extrudate at the nozzle. After the compressed puree mass leaves the nozzle as a result of a sharp pressure drop, the moisture evaporates instantly. The water vapor formed during the heating of the puree-like mass is removed by means of an exhaust fan. Then through a branch pipe located on the top cover of a cooking copper, a mix of additional components which not only increase nutritional value of the crushed particles of fruits, but also promote essential change of their structure moves. Condensate is removed from the housing through the pipe. If the puree has a high humidity, it is subjected to additional evaporation. To do this, the puree-like mass is captured by the anchor stirrer 31 and pressed against the inner surface of the boiler. At the same time through the pipe in the body structure is supplied with steam, which further heats the puree and helps to complete the physico-chemical transformations required to obtain the finished puree.

Due to conductive heating, the temperature of the puree mass increases and due to the maintenance of the set value of the discharge in the cooking boiler, further evaporation of the formed water vapor occurs, which is removed by the fan. If the puree-like mass has a given final humidity, then the need for its heating is eliminated and steam is not supplied to the housing. The finished puree-like product is removed from the boiler 12 by means of a vacuum sluice gate, which is also rotated.

The use of the proposed design of the device intended for food and restaurant industry will improve the quality of raw materials processing for the production of puree, intensify technological processes, save material resources during the manufacture of the device, reduce its energy consumption and improve working conditions.

Conclusion. Thus, the use of the proposed combined device of continuous action for the production of puree allows to obtain puree-like concentrates of a given composition with the introduction of the necessary additional components for their further use in the production of confectionery and bakery products. The device also reduces the specific energy consumption for the production of puree concentrates through the consistent use of mechanisms for grinding, wiping, boiling, mixing, the introduction of the necessary additional components and more uniform processing due to the use of rational designs of knives and perforated turns of the auger.

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