

TECHNOLOGICAL SCHEME FOR PROCESSING MULBERRY FRUITS FOR JUICE AND CONCENTRATE. MATHEMATICAL MODELING OF THE PROCESS OF SEDIMENT DECANTATION IN JUICE

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The chemical composition of mulberry fruits was studied. A technological scheme for processing mulberry fruits into juices and concentrates has been developed. It is made in the form of decantation of solid particles - evaporation of clarified juice. Based on the analysis of all processes included in the technological scheme, a line was assembled, including pressing juice, cleaning freshly squeezed juice from mechanical impurities, fermenting and clarifying juice, filtering and obtaining clear juice, evaporating and obtaining juice concentrate.

Equations for the material balance of hydromechanical separation of sediments in mulberry juice in the field of centrifugal forces are obtained (sediment decantation). Thus, a mathematical model of the dynamics of the liquid separation process has been obtained. Using the SIMULINK part of the MATLAB program, a computer model for solving equations was compiled. The results of studies of the separation of solid particles of mulberry juice in the field of centrifugal forces were used as input parameters for studying the evaporation process on a five-pan vacuum evaporator. These are the following juice parameters a_1 , atr_1 , atn_1 , av_1 - respectively, the concentration of incoming juice, solid soluble, solid insoluble components and water in the incoming juice; atr_2 , atn_2 , av_2 - concentration of solids, including solid soluble, solid insoluble components and water in a thick mass; atr_3 , atn_3 , av_3 - concentration of solids, including solid soluble, solid insoluble components and water in clarified juice; G_1 , G_2 , G_3 - costs, respectively, of the original juice (input), thick mass (output), clarified juice (output).

Keywords: mulberry fruit juice, starch, pectin, fermentation, concentrate.

ШЫРЫН ЖӘНЕ КОНЦЕНТРАТ ҮШІН ТҮТ ЖЕМІСТЕРІН ӨНДЕУДІҢ ТЕХНОЛОГИЯЛЫҚ СҮЛБАСЫ. ШЫРЫНДАҒЫ ШӨГІМДЕРДІ ДЕКАНТАЦИЯЛАУ ПРОЦЕСІН МАТЕМАТИКАЛЫҚ МОДЕЛЬДЕУ

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Тұт жемістерінің химиялық құрамы зерттелді. Тұт жемістерін шырындар мен концентраттарға өндеудің технологиялық схемасы әзірленді. Қатты бөлшектерді декантациялау - мөлдірленген шырынды булану түрінде жасалады. Технологиялық сызбаға енгізілген барлық процестерді талдау негізінде шырынды пресеу, жаңа сығылған шырынды механикалық қоспалардан тазарту, шырынды ашыту және мөлдірлеу, сүзу және мөлдір шырын алу, шырын концентратын булау және алуды қамтитын желі құрастырылды.

Орталықтан тепкіш күштер аймағында тұт шырынындағы шөгінділерді гидромеханикалық бөлудің материалдық балансының теңдеулері алынды (жауын-шашынның декантациясы). Осылайша, сұйықтықты бөлу процесінің динамикасының математикалық моделі алынды. MATLAB бағдарламасының SIMULINK бөлігі арқылы теңдеулерді шешудің компьютерлік моделі құрастырылды. Тұт шырынының қатты бөлшектерін орталықтан тепкіш күштер аясында бөлуді зерттеу нәтижелері бес табаны вакуумды буландырғышта булану процесін зерттеу үшін кіріс параметрлері ретінде пайдаланылды. Бұл келесі шырын параметрлері a_1 , atr_1 , atn_1 , av_1 - тиісінше, түсетін шырынның, қатты еритін, қатты ерімейтін компоненттердің және түсетін шырындағы судың концентрациясы; atr_2 , atn_2 , av_2 - қатты еритін, қатты ерімейтін компоненттерді және қою

массадағы суды қоса алғанда, қатты заттардың концентрациясы; a_{r3} , a_{m3} , a_{v3} - қатты заттардың, оның ішінде қатты еритін, қатты ерімейтін компоненттердің және мөлдірленген шырындағы судың концентрациясы; G_1 , G_2 , G_3 - сәйкесінше бастапқы шырын (кіріс), қою масса (шығыс), тазартылған шырын (шығыс) шығындары.

Түйінді сөздер: тұт жеміс шырыны, крахмал, пектин, ашыту, концентрат.

ТЕХНОЛОГИЧЕСКАЯ СХЕМА ПЕРЕРАБОТКИ ПЛОДОВ ТУТОВНИКА НА СОК И КОНЦЕНТРАТ. МАТЕМАТИЧЕСКОЕ МОДЕЛИРОВАНИЕ ПРОЦЕССА ДЕКАНТАЦИИ ОСАДКОВ В СОКЕ

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Исследован химический состав плодов тутовника. Разработана технологическая схема переработки плодов тутовника на соки и концентраты. Она выполнена в виде декантация твёрдых частиц-выпаривание осветлённого сока. На основе анализа всех процессов, входящих в технологическую схему компонована линия, включающая прессование сока, очищение свежеежатого сока от механических примесей, ферментирование и осветление сока, фильтрацию и получение прозрачного сока, выпаривание и получение концентрата сока.

Получены уравнения материального баланса гидромеханического разделения осадков в соке тутовника (декантация осадков) в поле центробежных сил. Получена тем самым математическая модель динамики процесса разделения жидкости. Используя часть SIMULINK программы MATLAB составлена компьютерная модель решения уравнений. Результаты исследований разделения твёрдых частиц тутового сока в поле центробежных сил использованы в качестве входных параметров для исследования процесса выпаривания на пятикорпусной вакуум-выпарной установке. Это нижеследующие параметры сока: a_1 , a_{r1} , a_{m1} , a_{v1} - соответственно, концентрация поступающего сока, твердых растворимых, твердых нерастворимых компонентов и воды в поступающем соке; a_{r2} , a_{m2} , a_{v2} - концентрация сухих веществ, в том числе, твердых растворимых, твердых нерастворимых компонентов и воды в густой массе; a_{r3} , a_{m3} , a_{v3} - концентрация сухих веществ, в том числе, твердых растворимых, твердых нерастворимых компонентов и воды в осветленном соке; G_1 , G_2 , G_3 - расходы, соответственно исходного сока (вход), густой массы (выход), осветленного сока (выход).

Ключевые слова: сок плодов тутовника, крахмал, пектин, ферментация, концентрат.

Introduction. It is estimated that more than 150 t of mulberries are grown in Uzbekistan annually, mainly consumed in raw form by the population. Our research is focused on mulberry fruits as a source of production of natural sweet, at the same time useful products for the body: dried fruits, preserves and jams, juices and concentrates.

Mulberry (Morus) - a family of trees belonging to the mulberry family; fruit tree; In Uzbekistan, 5 species are grown. The fruits of white mulberry (M. alba, fig.1) and black mulberry (M. nigra, fig.2) are mainly used [1, 2].

In the food industry of the world, scientific research is being carried out on the processing of raw materials rich in carbohydrates, proteins, minerals, vitamins, organic acids, polyphenols, as well as on the production

of high-quality natural food products.

Modern medical research has proven that mulberry fruits have many properties, such as treating fever, protecting the liver, diuretic, lowering blood pressure, lowering blood sugar and lipids. Due to the high moisture content and short harvest period, mulberry fruits are not easily kept fresh and are prone to rotting, so obtaining juice and concentrate of mulberry fruits becomes an important processing method to increase shelf life and facilitate further use.

There are no such studies in the world on the processing of mulberry fruits, obtaining juice and concentrate. There are results of studies on the drying of mulberry leaves and fruits, and the study of the chemical composition of their extracts. There are



Fig.1. Morus alba



Fig.2. Morus nigra

technologies for the use of dried mulberry fruits in confectionery.

The purpose of the research is to obtain juice from mulberry fruits, develop technology and modes of juice clarification, obtain juice concentrate, study the chemical composition of juice and concentrate, and evaluate the indicators of the results obtained.

Methods and materials. We used standard and special physicochemical, microbiological, rheological and organoleptic (sensor) methods of raw materials, semi-finished products and finished products. Statistical processing of experimental data was carried out using correlation-regression analysis in Microsoft Excel 2013 and MathCad 15 environments [3].

The main methods have been developed and applied for the study of individual components of the juice and concentrate of mulberry fruits.

Flavonoids in the sample were determined using liquid chromatography. To do this, 5-10 g of a sample was taken on an analytical balance and placed in a flat flask with a capacity of 300 ml. 50 ml of 70% ethanol solution is added to it [4].

The mixture was heated at 70-80°C with vigorous stirring for 1 hour, stirred with a magnetic stirrer, reflux, and then stirred at room temperature for 2 hours. The mixture is cooled and filtered. 25 ml of 70% ethanol are added to the remainder and re-extracted 2 times. The filtrates were combined and made up to the mark with 70% ethanol in a 100 ml volumetric flask. The resulting solution is centrifuged at a speed of 6000-8000 rpm for 20-30 minutes. The resulting solution was taken from above for analysis. Phosphorus and acetate buffer systems and acetonitrile were used as eluents in the determination of flavonoids by HPLC. A phosphate buffer system and acetonitrile were used [4].

Isolation of free amino acids. Sedimentation of proteins and peptides from aqueous extract in centrifuge beakers. To do this, 1 ml (exact volume) of 20% trichloroacetic acid (TCA) was added to 1 ml of the test sample. After 10 minutes, the precipitate was separated by centrifugation at 8000 rpm for 15 minutes. After separating 0.1 ml over the sedimentary liquid, it was freeze-dried [5].

High performance liquid chromatography (HPLC) analysis of PTC-derivatives of amino acids. The synthesis of phenylthiocarbomayl (FTC) derivatives of free amino acids was carried out according to the method of Steven A., Cohen Daviel.

Identification of FTC-amino acids is carried out on an Agilent Technologies 1200 chromatograph on a 75x4.6 mm Discovery HS C18 column. Solution A: 0.14 M CH₃COONa + 0.05% TEA pH 6.4, B: CH₃CN. Flow rate 1.2 ml/min, absorbance 269 nm. Gradient % B/min: 1-6%/0-2.5 min; 6-30%/2.51-40 min; 30-60%/40.1-45 min; 60-60%/45.1-50 min; 60-0%/50.1-55 min.

The results of laboratory studies of the composition of amino acids in mulberry fruits are presented. Each dried sample was prepared for analysis separately in the following order:

We used standard and special physicochemical, microbiological, rheological and organoleptic (sensor) methods of raw materials, semi-finished products and finished products. Statistical processing of experimental data was carried out using correlation-regression analysis in Microsoft Excel 2013 and MathCad 15 environments [6].

Results and its discussion. Let us analyze the results obtained on the chemical composition of mulberry fruits presented in table 1.

Table 1 - The chemical composition of mulberry fruits

№	Nutrients	Mass fraction, g/100 g of fruit
1	Water	81,74
2	Protein	0,78
3	Sugar	12,60
4	Starch	0,65
5	Pectin	0,21
6	Fats	0,41
7	Organic acids	1,34
8	Alimentary fiber	1,75
9	Ash	0,23
10	Other substances	0,29
11	Degree of sweetness	high
12	Energy value, kcal	56,7

Vitamins: A-0.4%, β -carotenoids - 0.4%, B1 - 2.7%, B2 - 1.1%, choline - 2.5%, B5 - 1.6%, B6 - 2, 5%, B9 - 1.5%, B12 - not determined. , C-11.1%, D-not determined, E-5.8%, H-1.2%, K-6.5%, PP-4%, K-14%,

The total amount of macro- and microelements (in% of the total amount): K-14%; Ca-2.4%, Si-33.3%, Mg-12.8%, Na-1.2%, Ph-4.8%, Cl-0.1%, Fe-10.3%, I - 0.7%, Co-10. %, Mn-0.9%, Cu-6%, Mo-3.6%, Se-1.1%, R-0.3%, Cr-14%, Zn-1%.

Mulberry fruits are eaten whole, fresh or dried (mulberry raisins), they are also used to prepare sweets, jams, marmalades, jam and molasses.

The mulberry fruit is watery, it contains 81.7-86.2% water. The sugar content of fresh fruit is 10.9-12.7%, mulberry raisins 73.29-83.71%. Mulberry fruits are recommended for those who are weakened by diseases and often catch a cold. The seeds contain 24-33% oil and other useful substances. Since it contains a large amount of phosphorus, mulberry is very useful for people who are engaged in mental activity. For pregnant women, mulberry fruits are also a source of necessary preparations for good fetal development, strengthen the immune system, the body's defenses against infectious diseases, prevent premature skin wrinkles, improve vision, and protect retinal damage. Fresh (or canned) mulberry juice helps relieve chest pain and shortness of breath. With a therapeutic purpose, mulberry juice is consumed for three weeks, during this period of time the work of the heart is completely restored [4,5].

We are developing a technology for obtaining mulberry juice, in an organized workshop, the scheme of which is shown in Fig.3.

Mulberry fruits, despite the fact that they fell to the ground, are crushed and juice flows out of them, are collected in special containers and sent to a cannery for processing. The containers are unloaded into receiving tanks 1, then the fruits are fed to the belt press 3 by means of a screw pump 2, the juice is squeezed out of them, which accumulates in the collector 5. Particles related to dust, soil, tree leaves, as well as solid particles of fruits pass into the squeezed juice, they are previously separated from the juice using a separator 7, into which it is supplied by a pump 6.

In the technology for obtaining clear juice and concentrate, the starch and pectin contained in the juice are decomposed by fermentation in the 16 fermenter. heated to a temperature of 90°C and cooled to a temperature of 45-50°C in the "pipe in pipe" cooler 13. In this case, the starch binds water to itself and swells, which is favorable for its splitting. In the fermenter 16, the process of splitting starch with amylase supplied from tank 17 and pectin with pectinase supplied from tank 18 is carried out in parallel, processing is carried out with bentonite supplied from tank 19 and erbigel supplied from tank 20 to aggregate and precipitate the by-products of fermentation, then sediments are removed with a separator 23 is filtered on the device 25 and accumulated in the buffer tank 26 of the vacuum evaporator complex (VEC). Before evaporation, the juice is heated in a tubular apparatus 28 to avoid deformation of the tubular structure, accumulated in a container 29 and evaporated in a five-case vacuum evaporator complex, including buildings 31, 36, 41, 44 and 47, the resulting concentrate is sent to an aseptic storage tank 50 installed in the refrigerator compartment. Separators VEC 34, 39, 42, 45, 48 serve

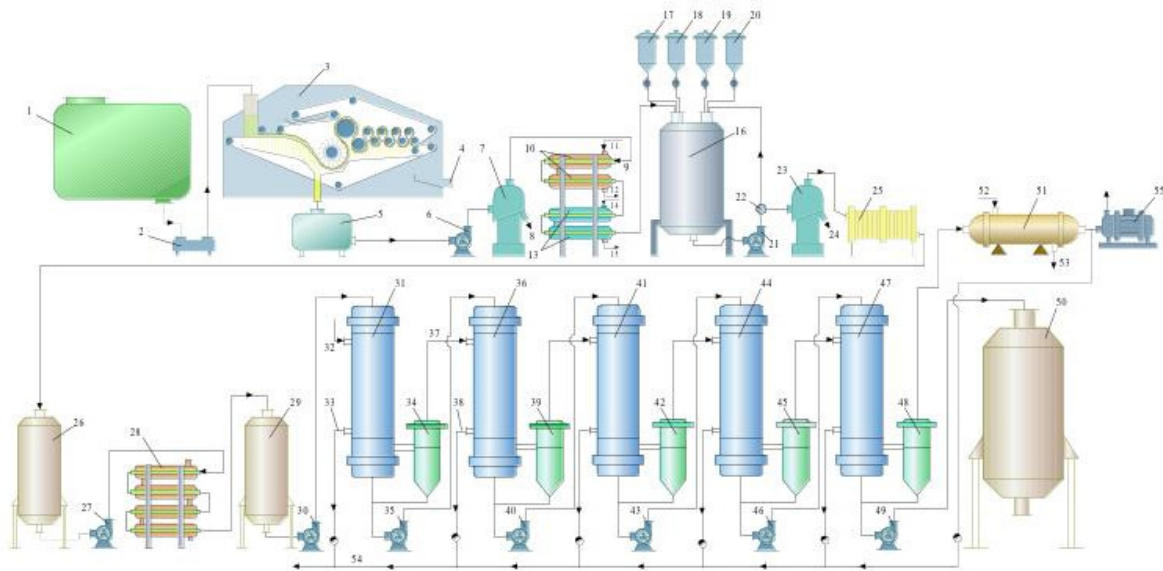


Fig.3. Technological line for the production of juice and concentrate from mulberries.

1 - buffer capacity for receiving mulberry fruits; 2-screw pump; 3-belt press; 4-node removal of pomace; 5-juice collector; 6, 21, 27, 30, 35, 40, 43, 46, 49 pumps; 7-separator for removing mechanical impurities; 8, 24-exit nodes of waste separators; 10-heater "pipe in pipe"; 11-inlet of heating steam; 12-heating steam condensate outlet; 13-cooler "pipe in pipe"; 14-cold water inlet; 15-cold water outlet; 16-fermenter; 17-enzyme dispenser for amylase; 18 - enzyme dispenser for pectinase; 19-bottle with erbigel; 20-tank with bentonite; 23-separator for removing sediments (decanter); 22-tee-guide juice; 25 filter; 26 - filtered juice collection tank; 29-tube heater; 31 - the first building of the 5-case vacuum evaporator complex (VEC), 32 - heating steam inlet pipe; 33-pipe condensate outlet; 34-separator of the 1st building; 36-2nd apparat of ; 37 - secondary steam inlet to the 2nd building of the ; 38-condensate outlet from the 2nd building of the ; 39 - separator of the 2nd building of the ; 41-third building of the ; 42-separator of the 3rd building of the ; 44th Corps of the ; 45-separator of the 4th building of the ; 47-5th building of the ; 48-separator of the 5th building; 50 - aseptic concentrate storage tank; 51 - secondary steam condenser; 52-cold water inlet; 53-cold water outlet; 54-vacuum-pump system.

to separate secondary vapors from juice [6, 7, 8, 9].

Mathematical modeling of the hydromechanical process of sediment decantation during the fermentation of raw juice. As stated above, deep processing of mulberries is proposed according to the scheme of fine grinding of silkworm pulp - separation into fractions (juice and thick mass) - juice clarification - juice concentration. When concentrating clarified juice, aromatic substances are recovered, for which one of the existing schemes of foreign companies is used.

We simulate the process of hydromechanical separation of sediment after fermentation of mulberry juice into fractions in the field of centrifugal forces. To this end, we denote the input and output parameters of the process as follows.

a_1 , atr_1 , atn_1 , av_1 - respectively, the concentration of the incoming juice, solid soluble, solid insoluble components and water in the incoming juice; atr_2 , atn_2 , av_2 - concentration of solids, including solid soluble, solid insoluble components and water in a thick mass; atr_3 , atn_3 , av_3 - concentration of solids, including solid soluble, solid insoluble components and water in clarified juice; G_1 , G_2 , G_3 - costs, respectively, of the original juice (input), thick mass (output), clarified juice (output).

For compiling a mathematical description and its study in the form of a model, it is favorable to use relative dimensionless quantities.

Let us compose the material balance equations for the juice components entering the centrifuge and releasing them together with the clarified juice and thick mass. The solids concentration of the solid component as a whole consists of the concentrations of solid soluble and insoluble components

$$a_{t1} = a_{t1} + a_{tn1} \quad (1)$$

Hence, the relative dimensionless value of water concentration is determined

$$a_{v1} = 1 - a_{t1} \quad (2)$$

The amount of solids entering the centrifuge is determined by the following expression

$$g_{v1} = G_1 \cdot a_{v1} \quad (3)$$

The amount of soluble component entering the centrifuge along with the juice

$$g_{r1} = G_1 \cdot a_{r1} \quad (4)$$

The amount of insoluble component entering the centrifuge along with the juice

$$g_{n1} = G_1 \cdot a_{n1} \quad (5)$$

The total amount of the solid component entering the centrifuge along with the juice

$$g_{t1} = G_1 \cdot a_{t1} \quad (6)$$

The total concentration of the solid component in the juice includes the solid soluble and insoluble components

$$a_{t3} = a_{r3} + a_{n3} \quad (7)$$

The concentration of water in the juice is determined by the following equation

$$a_{v3} = 1 - a_{t3} \quad (8)$$

The amount (consumption) of the insoluble component in the original juice and in the thick mass is assumed to be equal, i.e.

$$g_{n1} = g_{n2} \quad (9)$$

Juice consumption is determined as follows

$$G_3 = \frac{g_{n3}}{a_{n3}} \quad (10)$$

The proportion of water in the juice is determined by the following expression

$$g_{v3} = G_3 \cdot a_{v3} \quad (11)$$

The proportion of the solid soluble component in the clarified juice is determined by the following expression

$$g_{r3} = G_3 \cdot a_{r3} \quad (12)$$

The solid component in clarified juice consists of soluble and insoluble components (the proportion of insoluble component is zero $g_{n3} = 0$)

$$g_{t3} = g_{n3} + g_{r3} \quad (13)$$

The ratio of costs of clarified juice and thick mass with the original is as follows

$$G_3 = G_1 - G_2 \quad (14)$$

For moisture consumption in clarified and initial juices, as well as in a thick mass, the following expression can be written

$$g_{v3} = g_{v1} - g_{v2} \quad (15)$$

There is no insoluble component in the clarified juice

$$g_{n3} = 0 \quad (16)$$

Soluble dry matter in is distributed as follows

$$g_{r3} = g_{r1} - g_{r2} \quad (17)$$

The total amount of solids in the juice consists only of the solid soluble component

$$g_{t3} = g_{r3} \quad (18)$$

The concentration of water in the juice is determined by the following expression

$$a_{v3} = \frac{g_{v3}}{G_3} \quad (19)$$

The concentration of the insoluble component in the juice clarified by centrifugation is determined by the following expression

$$a_{n3} = \frac{g_{n3}}{G_3} \quad (20)$$

The concentration of the soluble component in the juice clarified by centrifugation is determined by the following expression

$$a_{r3} = \frac{g_{r3}}{G_3} \quad (21)$$

The total concentration of the solid component in juice clarified by centrifugation is determined by the expression

$$a_{t3} = \frac{g_{t3}}{G_3} \quad (22)$$

The system of equations (1-22) is a mathematical description of the silkworm juice centrifugation process. It is investigated for the range of changes in

the amount of dry substances in the mulberry pulp and the ratio of their water-soluble (S) and water-insoluble (IS) components in order to obtain a concentrate of a given concentration according to the proposed low-temperature technology [9, 10].

$$\left\{ \begin{array}{l} a_{t1} = a_{r1} + a_{n1}; \\ a_{v1} = 1 + a_{t1}; \\ g_{v1} = G_1 \cdot a_{v1}; \\ g_{r1} = G_1 \cdot a_{r1}; \\ g_{n1} = G_1 \cdot a_{n1}; \\ g_{t1} = G_1 \cdot a_{t1}; \\ a_{t3} = a_{r3} \cdot a_{n3}; \\ a_{v3} = 1 - a_{t3}; \\ g_{n1} = g_{n2}; \\ G_3 = \frac{g_{n3}}{a_{n3}}; \\ g_{v3} = G_3 \cdot a_{v3}; \\ g_{r3} = G_3 \cdot a_{r3}; \\ g_{t3} = g_{n3} \cdot g_{r3}; \\ G_3 = G_1 - G_2; \\ g_{v3} = g_{v1} \cdot g_{v2}; \\ g_{r3} = g_{r1} \cdot g_{r2}; \\ g_{t3} = g_{r3}; \\ a_{v3} = \frac{g_{v3}}{G_3}; \\ a_{n3} = \frac{g_{n3}}{G_3}; \\ a_{r3} = \frac{g_{r3}}{G_3}; \\ a_{t3} = \frac{g_{t3}}{G_3}; \end{array} \right. \quad (23)$$

For installations with processes that are fast and simple in terms of dynamics, the optimization procedure is carried out based on its cost and current costs - the consumption of electricity to rotate the centrifuge drum. Prof. K.O. Dodaev previously obtained an equation for determining the optimal flow rate when concentrating tomato juice [4].

Mathematical model of economic indicators of the process of hydromechanical separation of silkworm juice.

Given the known initial values of the suspension parameters, the water content in the suspension and the residual water content in the thick mass after centrifugation or the flow rate of pumped water, as well as the geometric and kinematic characteristics

of the centrifuge, it is possible to determine the energy consumption spent on centrifugation, which is mathematically expressed in the following form

$$N = f(G_1, X_0, X_1, \dots) \quad (24)$$

When determining the power of the electric motor N_{el} of the centrifuge, the expressions obtained for the individual components of the power consumption are used, which are given below [11, 12].

The power required to communicate the kinetic energy of the ejected liquid N_1 , the power required to overcome the frictional forces against the air N_2 , the power required to overcome the frictional forces in the support bearings N_3 , the power required to eject sediment through the discharge slots N_4 .

$$N_{эл} = \frac{N_1 + N_2 + N_3 + N_4}{\eta} \quad (25)$$

However, for practical calculations, a simplified formula for calculating the power of an electric motor is used

$$N_{обм} = 1000 \cdot M \cdot H_6 \cdot \frac{3}{6} n \cdot r^4 \quad (26)$$

where M is the coefficient ($M = 0.016 - 0.018$); H_b - height of the centrifuge drum, m; n - drum rotation frequency, s⁻¹; r - maximum radius of the drum, m.

Annual electricity costs in kW*h are determined by the expression

$$N_9 = N_{обм} \cdot \tau_{ces} \quad (27)$$

where τ_{sz} is the resource of working time in the season, hour.

The cost of electricity during centrifugation is one of the most significant current costs spent on the separation of mulberry juice into components in the field of centrifugal forces.

Production costs for pulp centrifugation are determined by the following expression

$$Z_c = \frac{A \cdot G_1}{G_r} + \frac{C_9 \cdot N_9}{3600 \cdot G_1 \cdot \tau_{ces}} \quad (28)$$

$$K = \frac{G_1}{G_m}$$

Here A is the depreciation of capital investments. They are defined by the following expression

$$A = \frac{C_c E_H}{G_1 \tau_{ces} 3600} \quad (29)$$

where C_c, C_e - respectively, the cost of the centrifuge and 1 kWh of electricity, soum; E_H - normative coefficient of depreciation; G_1 - current productivity of the centrifuge, kg/s; G_r - theoretical productivity of the centrifuge, kg/s; K - factor of centrifuge use, under normal conditions of operation of the workshop, K can be equal to one, the smaller K , the less the centrifuge is used in production, sometimes the value of K exceeds one, this goes without saying the optimal mode of using the centrifuge.

The resulting system of equations (30) is a mathematical description of the material balance of the suspension centrifugation process. Equations (28) and (29) are necessary to study the optimal parameters of the centrifugation process of mulberry pulp [10,11].

$$\begin{cases} n_{обм} = 1000 \cdot M \cdot H_6 \cdot n^3 \cdot r^4; \\ A = \frac{C E_H}{G_1 \tau_{ces} 3600}; \\ n_9 = N_{обм} \cdot \tau_{ces}; \end{cases} \quad (30)$$

Conclusions.

1. The method of hydromechanical decontamination of fermented juice sediments and further evaporation of the clarified juice of mulberry fruits was studied. A mathematical model of the centrifugation process was obtained, including the material balance equations for the concentrations of water-soluble P and insoluble HP of dry substances, a model for optimizing the economic indicators of centrifugation.

2. The study of a complex of processes occurring in complex technological lines, described by algebraic and differential equations, was implemented using the MATLAB complex program and its SIMULINK part, the MATHCAD program. The results of studies of the mathematical model in a wide range of variation of the input parameters of the process are presented. The analysis of the results obtained with respect to the weight of the parameters influencing the course of the sediment decontamination process is carried out.

An iterative algorithm for solving the system of transcendental balance equations is proposed. The results of the study turned out to be adequate to the results of calculating the evaporation of moisture from the phase interface in the separators of the evaporator complex by changing the interfacial equilibrium and partial pressures of steam and water. They are also

identical to the results of industrial experiments.

vacuum evaporator was also optimized.

3. The optimization of the juice centrifugation process at the stage of sediment decantation, obtained by fermentation of the original raw juice, was also optimized, the evaporation process in a multi-vessel

4. A number of parameters were obtained experimentally, the centrifugation of fermented mulberry juice was also investigated.

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