

ABSTRACT

of the dissertations of Nazymbekova Aigerim Yerbolovna for the degree Doctor of Philosophy (PhD) in the specialty 6D072400- «Technological machines and equipment» on the topic «Development of equipment for the primary processing of watermelons»

The relevance of the dissertation research: is to increase the efficiency of the process of primary processing of watermelon fruits by creating devices and devices, means of mechanization of technological processes for cleaning fruits from the outer crust, cutting the peeled crust, separating and grinding the pulp.

Research objectives—

- analysis of existing structures and equipment for peeling, grinding and cutting the pulp of watermelon fruits;
- development of a design that allows to effectively separate the watermelon peel with simultaneous crushing of the pulp and calculation of the main parameters of the equipment;
- determination of the physical and mechanical properties of the fetal elements necessary to justify the parameters of the equipment;
- development of physical and mathematical models of the processes of separation from the peel, grinding, mixing of watermelon pulp;
- development of an engineering methodology for calculating equipment for separating from the peel, grinding, mixing the pulp of watermelon;
- production and testing of a prototype installation for the process of destruction of pulp in cramped conditions.

Research methods: theoretical (modeling, formalization, analysis and synthesis) and empirical (literature study, measurement, experiment) methods were used to study the regularities of the processes of separating the peel and seeds of watermelon with simultaneous crushing of the pulp and obtaining a homogeneous mass of juice with pulp in cramped conditions in order to develop equipment for the primary processing of watermelon fruits.

The main provisions submitted for protection:

- established regularities of the grinding process in the cramped conditions of the watermelon cavity;
- methodology for calculating the main parameters of equipment for separating the peel and crushing the pulp of watermelon fruits;
- a physical and mathematical model describing the process of separation from the peel and crushing of watermelon pulp;
- criteria equations for mixing and grinding watermelon pulp in cramped conditions;
- equipment for the primary processing of watermelon fruits in order to obtain a homogeneous pulp, intact seeds and separate the pulp from the crust.

The main results of the study:

- the regularities of the grinding process in the cramped conditions of the watermelon cavity have been established and equipment for the primary processing

of watermelon fruits has been created, allowing to obtain homogeneous pulp, intact seeds and pulp separated from the crust;

- based on theoretical analysis and experimental studies on the processing of watermelon fruits, namely, the process of peeling and grinding watermelon pulp, mixing pulp in the cavity of watermelon, the criterion equations of each process occurring in the cavity of watermelon during processing are obtained;

- physical and mathematical models of the process of grinding watermelon pulp in cramped conditions, without damaging the crust and separating from it, have been developed, allowing to calculate the optimal design parameters of the equipment;

- A method for calculating the power on the shaft of the mixing body using criterion equations has been developed.

Justification of novelty: A design of equipment for separating the peel and crushing the pulp of watermelon fruits has been developed, protected by patents of the Republic of Kazakhstan for a utility model (patent № 5621 "Device for cleaning watermelon fruits from the peel and extracting a homogeneous mass of pulp", patent № 6211 "Method for processing watermelon pulp and peel", patent № 6552 "Device for cutting watermelon fruits into juice"), which are recommended for use at domestic enterprises of small and medium capacity. An engineering technique has been developed to determine the main parameters of the equipment for grinding and mixing in cramped conditions: the shaft power and the speed of rotation of the agitator, depending on the mechanical properties and geometric dimensions of the fruits and their components.

Compliance with the directions of scientific development: The dissertation on the topic "Development of equipment for the primary processing of watermelons" (as of the date of its approval in 2018) corresponds to the priority directions of science "Sustainable development of the agro-industrial complex and safety of agricultural products".

Doctoral student's contribution: A device for processing watermelon fruits was created, protected by the Patent of the Republic of Kazakhstan for utility model patent № 5621 "Device for cleaning watermelon fruits from the peel and extracting a homogeneous mass of pulp", patent № 6211 "Method for processing watermelon pulp and peel", patent № 6552 "Device for cutting watermelon fruits into juice".

An industrial sample of a plant for the primary processing of watermelon fruits has been created, which provides a safe process for obtaining juice, pulp, seeds and peel of watermelon.

The methods of calculating the optimal design parameters of the device for the primary processing of watermelon fruits have been developed.

Industrial tests of a prototype plant for the primary processing of watermelon fruits were carried out in Yuzhny LLP and recommended for use in small enterprises of the food and processing industry.

7 articles have been published on the topic of the dissertation, including 3 articles in the materials of international conferences, 1 article in a journal with a non-zero impact factor (included in the Web of Science and Scopus database), 3

articles in journals recommended by the Committee for Quality Assurance in Education and Science of the Ministry of Education and Science of the Republic of Kazakhstan. The content of the articles covers the main content of the dissertation.

The introduction provides an analysis of the current state of the scientific problem being solved, the current situation of the problem in the Republic of Kazakhstan, the justification for the need for research work, the relevance and novelty of the topic, the connection of this work with other research works. The purpose, objectives, object and subject of research, methodological basis, provisions submitted for defense, practical value and approbation of practical results are described.

In the first section, the current state of production and processing of watermelon fruits is given. At the same time, a review of equipment for the primary processing of fruits, preparation for processing vegetable and melon crops, analysis of existing methods and technologies of cutting, grinding of food materials, analysis of the main patterns of cutting, destruction of pulp of materials of organic origin and the formulation of research tasks was carried out. The basic requirements for the designs of machines and apparatuses of food and canning production are given

The second section provides a justification for the shape of the working body, calculation of the geometric parameters of the equipment. The principle of operation of the proposed installation is described. A method of engineering calculation of the device for primary fruit processing has been developed. The results of the analysis of experimental studies of the interaction of watermelon pulp and the cutting organ in order to determine the sharpening angles, length and cutting force are presented. **The third section** describes the methodological part of the work. The GOST and regulatory documents on which they relied during the research are given. The developed method of calculating the device for processing watermelon fruits and the theoretical part of the study are presented. Methods for determining the rheological characteristics of watermelon pulp, physical and mechanical properties of watermelon peel are described. The methods of determining the physical and mechanical properties of individual components of watermelon fruits (peel, pulp), processes occurring during cutting and grinding of watermelon fruits using duly authorized devices of the research laboratory for assessing the quality and safety of food products of JSC "Almaty Technological University" are presented.

The developed and manufactured experimental plant for the primary processing of watermelon fruits is presented, where the processing process takes place in the cavity of the watermelon without destroying the fruit crust.

The description of the experimental setup and methods of its research are given. This chapter shows the results obtained during experimental studies of cutting and mixing processes.

The experimental setup allows you to destroy watermelon fruits into juice, pulp and seeds, through the use of impellers. The calculated dependences for determining the length of the impellers and their number are given.

The fourth section shows the calculation of the device for cutting the upper pole of the watermelon. The principle of operation of the knife feeding platform is described, the choice of the type of knife is justified. The knife feeding mechanism is calculated and selected, the electric motor is selected. In the calculation for the upper pole separation mechanism, two versions are considered, the choice is justified by the lowest costs.

The fifth section presents physical and mathematical models of the processes occurring in the device for the primary processing of watermelon fruits. The physical and mechanical characteristics of various parts of the watermelon are determined, which are taken into account when developing or selecting mechanical equipment for preparing fruits for processing. The process of separating the pulp from the crust is considered, a mathematical model of the process of cutting the pulp using a system of differential equations is proposed

$$\begin{cases} dT = v_p * F d\tau \\ dA = H_F * 2dF \end{cases} \quad (1)$$

The process of pulp grinding inside the watermelon cavity is considered, a mathematical model of the pulp destruction process in the form of a system of equations is presented

$$\begin{cases} v_p = \frac{dR}{F * d\tau} \\ dA_1 = \frac{\sigma^2 dV}{2E} \\ dA_2 = 2H_F * dF \end{cases} \quad (2)$$

A mathematical model of the mixing process is proposed in the form of the following system of equations:

$$\begin{cases} A_c = \oint \vec{R} * \vec{\delta r} \\ N = \oint \frac{dA}{\tau} \\ E = \frac{\rho * \omega_0 * h}{8} * (r_1^4 - r_2^4) \\ P = \frac{\varepsilon * F * \rho * (\omega * r_0)^2}{8} \\ N = K_N \rho n^3 d^5 \end{cases} \quad (3)$$

Criteria equations are derived that allow us to calculate the optimal parameters of watermelon processing equipment with different characteristics.

To describe the criterion equation of the process of destruction of watermelon pulp, the criterion of the deformation power of crumpling is used:

$$D_F = B \cdot R_D^x \quad (4)$$

The criterion of mechanical similarity characterizing the ratio of the active power of crumpling (destruction) to the power of the resistance forces.

$$D_F = \frac{N}{\rho \cdot F^{2.5} \cdot n^3} \quad (5)$$

Criterion equation of the relative rate of pulp mixing::

$$Sd^2 = \frac{1}{2\pi\xi} \cdot \Gamma_M \cdot \Gamma_r \quad (6)$$

The sixth section presents the results of testing the equipment and calculation of the economic effect of the introduction of this device at low-power enterprises. It is shown that the use of the installation will reduce the number of workers by a factor of 1.1, the conditional annual savings will amount to 111,144.9 tenge due to higher productivity compared to manual labor. Raw material waste will be reduced to a minimum. The annual economic effect from the use of the device for the primary processing of watermelon fruits will amount to 1280 thousand tenge.

In conclusion, an assessment of the completeness of solutions to the tasks set, brief conclusions based on the results of dissertation research, an assessment of the technical and economic efficiency of implementation and the scientific level of the work performed in comparison with the best achievements in this field is given.