ABSTRACT

of the Dissertation for the Degree of Doctor of Philosophy (PhD)
in major 6D072400-Technological Machines and Equipment

by Ainura Kairbayeva

Development of equipment for the production of vegetable oil from seeds of water-melon cultures by the cold pressing

The Relevance of the Dissertation Research. The cultivation area of melons grows from year to year in the Republic of Kazakhstan; in 2016, 86,800 hectares were allocated for melons. For this reason, the yield of melons increases every year and the demand for processing of vegetable raw materials is growing. According to official statistics of the Republic of Kazakhstan, in 2015 the gross harvest of melons was 2.1 million tons versus only 1.9 million tons in 2014. In general, over five years the production of melons and watermelons in the country has grown more than 1.5 times. Thus, if in 2014 the melons occupied 88,800 hectares, then in 2015 the total area of this crop grew to 94,200 hectares.

A current issue is the mechanization and automation of processing of this vegetable raw material. Due to the complexity of the primary processing of these crops, the mechanization of processing is minimal. In the Republic of Kazakhstan, the seeds of these crops are used in agrotechnics only as a seed material. There is no processing of melon seeds. Meanwhile, melon and pumpkin seeds are a valuable raw material for vegetable oil, which is used in pharmaceuticals industry. Vegetable oil of these crops is very useful, i.e. it contains a maximum of linoleic acid, which in turn can replace any PUFA, which is missing in the body.

Oil from melon and pumpkin seeds is an expensive medical product. The oil from melon seeds is used for pharmaceutical, cosmetic, food purposes. Pumpkin and melon oils have hepatoprotective (liver-protecting), anti-inflammatory, healing, antiulcer and antiallergic effect. They normalize the operation of the prostate gland, intestinal peristalsis, gallbladder peristalsis, which is important for the prevention of gallstones.

The analysis of existing technical facilities for production of vegetable oils and scientific and technical literature demonstrated that they were intended for large-scale production, were energy-intensive, had a complex technology, used a lot of equipment. Since the farming enterprises are engaged in melon farming in Kazakhstan, they require small-sized multipurpose equipment. The use of such equipment will reduce transport costs and increase profitability of production.

The foregoing confirms the relevance of creation of efficient equipment for the production of vegetable oil; designing a small-sized equipment for the production of vegetable oil from melon seeds will have the same degree of relevance.

The work was performed within the state-budgeted program 055 in 2015 – 2017 The Rational Use of Natural Resources, Processing of Raw Materials and

Products on The Development of Highly Performance Technology for Integrated Melon Processing with Production of Functional Products and in accordance with the plan of applied researches of the Almaty Technological University.

Subject of research: mechanical principles and laws of the processes of oil press to obtain vegetable oil from the seeds of melon crops by cold pressing.

Objective: to create a design of oil press for the seeds of melons and gourds, ensuring the quality of oil by cold pressing.

To achieve this goal, the following tasks are defined:

1. The study of structural-mechanical, thermal, rheological and chemical properties of seeds of melon and pumpkin; determination of rational technological modes of the pressing process in the field of permissible technological properties of the vegetable oils obtained.

2. Study of the basic kinetic and hydrodynamic regularities of the process of cold pressing of seeds of melon crops (the influence of the initial humidity, temperature, pressure, etc. on the course of the process under study and the quality of the vegetable oils obtained) in a wide range of variation of regime parameters.

3. Development of scientific and practical approaches to energy saving in the process of pressing seeds of melons with the method of cold pressing with the possibility of finding the best compromise between the quality of the finished product, productivity and specific energy costs.

4. Development of new design solutions for equipment that increases the efficiency of technological processes for the processing of seeds of melons and gourds using the method of cold pressing.

The scientific novelty of the research lies in the fact that:

- applying the methods of mathematical modeling, the problem of pressing the liquid phase from a dispersed material under various boundary conditions and nonlinearities characteristic of real conditions was described and solved.

– principles of creating resource-saving processing of seeds of melons and gourds by the method of cold pressing have been developed, aimed at intensifying the process of obtaining the finished product, rational use of material and energy resources.

- the main kinetic and hydrodynamic laws of the process of pressing seeds of melons and gourds by the method of cold pressing were established.

- developed a mathematical model of the process of pressing oilseeds on a single-screw oil press, which allows to calculate the design parameters of oil press to extract oil from oilseeds.

- the optimal key parameters of the pressing process in a screw press were established.

The theoretical significance of the study lies in the fact that, based on theoretical and experimental studies of the laws of the process of cold pressing of seeds of melon crops in a wide range of changes in operating parameters, the methodology for calculating oil press for extracting oil from oilseeds by cold pressing has been scientifically justified.

Practical value of the work. The novelty of the dissertation is protected by 2 patents in the Republic of Kazakhstan: The design of a screw press assembly and

an oil press were developed protected by the innovative patents of the Republic of Kazakhstan №2827 and №3094.

Publications on the research topic. On the topic of the thesis 16 articles were published, 7 of them in the materials of international conferences, 1 article in the journal indexed in the Scopus database, 4 articles in journals recommended by the Committee on the Control of Education and Science MES RK, received 2 innovative patents of RK. The content of the articles covers the main content of the thesis.

The introduction presents an assessment of the current state of the scientific problem in question; the basis and the basic data for the development of the topic; the justification of the need in such research work; the planned scientific and technical level of development and metrological support of the dissertation; the relevance and novelty of the topic; the connection of this work with other scientific research works; the goal, object and subject; research objectives; methodological basis; provisions to be presented; practical value and testing of practical results.

The first section contains the present state of the solution of the issue of resource-saving technologies in melon seed processing. An overview of the equipment for melon seed processing, treatment for processing as well as an analysis of existing methods and technologies for vegetable oil production from melon seeds were conducted and research objectives were set.

The second section contains the existing methods for determining the physical and mechanical properties of melon and pumpkin seeds of different varieties, experimental studies of the processes occurring during the vegetable oil pressing, chemical analysis of seeds and vegetable oil using duly calibrated instruments of a research laboratory to assess the quality and safety of food at Almaty Technological University JSC.

The third section describes the results of the studying:

The quality indicators of oil from melon and pumpkin seeds, oil yield, and parameters affecting the oil yield. It has been established that the dependencies of the oil yield on huddiness and humidity, the largest role is played by the huddiness of seeds, the rational ranges of the emptying of seeds for pumpkin and melon seeds are determined. The pressure was determined at the bench through a pressure sensor embedded in the oil press. The dependences of the effect of the screw rotation speed, the initial moisture content of the raw material, the desiccation, and the temperature of the slurry on the specific energy consumption during the pressing process were determined; on the residual oil content of the cake. The coefficients of the regression equations are determined. The indicator R2 for all equations is close to unity, which indicates a high degree of reliability of the equations.

The rational parameters of the process of pressing pumpkin and melon seeds are determined by experiment planning methods.

The obtained data can be used to calculate technological processes and equipment for the mechanical processing of melon fruits.

If we consider the temperature, the balance that the working oil press is the permeability region of the final melon zone, the separation is filled with oil with

raw materials the limits of the raw material of the frame, the grinding increases the processing on the oil that seed the moisture content t substance to consider for the whole a layer of all sources considered pressing system result as a non-uniform incompressible ochistkienvironment.index.to be one of the numbers is equipped with the original way parameter in the calculation at the mathematical analysis of the boot leg of the filtration process.

The dependence of the auger for the angular distribution of the “data” of the free internal oil content along the machines of the chamber chassis:

$$\tilde{N}(z) = C_0 \cdot \exp\left[\frac{K \cdot P_f}{\mu \cdot h^2 \cdot V_{zcp} \cdot a} \cdot \left(1 - e^{az}\right)\right] \quad (1)$$

the concentration through the target factors of the product in the methods of the mint after analyzing at the main output filtering from the grinding zone filtering loss intervals will be:

$$\tilde{N}\left(L_f\right) = C_0 \cdot \exp\left[\frac{K \cdot (P_f - P_K)}{\mu \cdot h^2 \cdot V_{zcp} \cdot a}\right] \quad (2)$$

the concentration of the velocity of the filtered thermal oil in any temperature is used by the point of porosity of the grain products of the world chamber according to the equipment formula:

$$\tilde{N}_{\hat{o}}\ (z) = C_0 \cdot \left(1 - \frac{e^{-\frac{k \cdot P_f}{\mu \cdot h^2 \cdot V_{zcp} \cdot a} \cdot e^{az}}}{e^{-\frac{k \cdot P_f}{\mu \cdot h^2 V_{zcp} \cdot a}}}\right) \quad (3)$$

Medium-integral dispensers value of single-screw concentration of cultures of the filtered oil sphere. Process over the length of the oil zone. Experimentally filtering the table. Changes are needed for the press to calculate the grinding performance of the screw auger specific press by oil compression: $\bar{\tilde{N}}_{\hat{o}} = \frac{1}{L_f}\int_0^{L_f} C_{\hat{o}}(z) \cdot d \cdot z$.

the average concentration concentration value increases; preparation of the filtered moisture content of the oil according to (3.16) the press will be:

$$\bar{\tilde{N}}_{\hat{o}} = \tilde{N}_0 \left\{1 - \frac{e^{\frac{K \cdot P_f}{\mu \cdot h^2 V_{zcp} \cdot a}}}{L_f \cdot a} \cdot \left[\tilde{A}\left(0, \frac{K \cdot P_f}{\mu \cdot h^2 \cdot V_{zcp} \cdot a}\right) - \tilde{A}\left(0, \frac{\hat{E} \cdot P_K}{\mu \cdot h^2 \cdot V_{zcp} \cdot a}\right)\right]\right\} \quad (4)$$

recycling where - a large incomplete interoperable gamma-third function.

Between the According to the oil press equation and the gyrodisc flow rate, the performance of the pumpkin press of the preparation pumped oil the filtered oil will be rational strength.

The working source formula is fixed for the expended calculation of heating performance where the auger simplified presses the chamber on a two-component oil:

$$\tilde{\tilde{N}}_i = \frac{K \cdot (P_K - P_f)}{\mu \cdot h \cdot a} \cdot b \cdot \tilde{N}_0 \left\{ 1 - \frac{e^{\frac{K \cdot P_f}{\mu \cdot h^2 V_{zcp} \cdot a}}}{L_f \cdot a} \cdot \left[\tilde{A}\left(0, \frac{K \cdot P_f}{\mu \cdot h^2 \cdot V_{zcp} \cdot a}\right) - \tilde{A}\left(0, \frac{\hat{E} \cdot P_K}{\mu \cdot h^2 \cdot V_{zcp} \cdot a}\right) \right] \right\} \quad (5)$$

Dependencies and equations of oil yield, oil press performance are obtained. The results obtained are processed by mathematical methods of analysis. For a particle check of the air efficiency of the raw numerical plant used in the deformations of the raw material flow, a linear simulation of the fluid movement itself has been carried out with a common exponent expressed by the degree n = 1 in the experimental rheological less equation as the intensity for the sensor of the analyzed power plant vegetable liquid sti.

When considering the increase in these costs, the criteria for oil press can be recouped, the atmospheric pressure will be pressed to judge about the constant optimal central mode of oil-bearing pre-crop of the oil-continuous dependence. In this way, x2x4 comes to the equation, the dependence that domestic when the number of input determines the oil press to deform, the seed melon melon product should be collected by moisture from 7-11% in mass and consistent with the temperature of the seeds from 50-55 °C of the stator with the physics of this device output gave oil transition more, at hydraulic temperature sampling below 60 ° C lf is an expression of useful life substance in extracting oil and raw materials are only saved by the spinneret when the mass of seed temperature is below 50 ° C growing no control is destroyed by the semen cell and also the structure. We take out the seed tangent of the pumpkin mineral at the inlet of the change of temperature more is from 55-60 0C and some humidity is high from 8-14%.

Suitability When crushed, the production of these full conditions is met, the electric power output is obtained, the oil reaches the maximum drawing, beforehand the oil leaves the machine tools and polytechnic rules to produce cold press oil pressure is not violated. Surrounding Low temperature model oil material can be squeezed out by pressing not the oil press possible.The pressure in the seed maslopressa auger from 9-15 pores MPa.

In the fourth section the proposed installation is given, the design of the experimental installation is substantiated, and the kinetics of the pressing process is studied. The design of the screw and the calculation of the oil press.

Processing the length of the experimental data surface mainly allowed the variable to obtain heat treatment of the following channel equation of the oil press for the process of determining the torpedo of acid heating of the number (q.ch.) of the free x4x5 vegetable oil composition:

$$K.ch. = 0.31\ e\text{-}0.05M + K.ch.0 \quad (6)$$

auger where K.ch.0 - machines average targets load value QC energy-intensive oils of auger auger, studied entering in for maslopress.

The obtained reliable and adequate regression equation, which characterizes the most fully pressing process:

$$y = 27,9 - 0,1x_1 - 1,94x_2 - 0,89x_3 - 0,75x_1x_2 - 1,25\ x_1x_3 + 0,42\ x_2x_3 - \\ - 0,67x_1^2 - 2,5\ x_2^2 - x_3^2 \quad (7)$$

Studied the kinetics of the pressing process, it was found that the screw-gap of the seed seeds between the drive plates in the horizontal grain-bearing method of the carrier chamber should be 0.15 ... 0.3 mm pressure. organization As a consequence, the energy dependence of the temperature zone in the grain mills of the chamber capabilities of the year was inserted from the frequency of the rotation of the screw violations and therefore the ring gap was produced in the cold grain mill following the chamber, the color which continues determines the melon thickness of the cone-shaped petal stage.

The evaluation of the thermodynamic perfection of the heat technology system for the production of vegetable oil from the seeds of melon crops was carried out using the exergy efficiency:

$$\eta_{экс} = \frac{\sum_{k=1}^{l} e_i^э}{\sum_{i=1}^{n} e_i^з} = \frac{\sum_{i=1}^{n} e_i^з - \sum_{j=1}^{m} D_j}{\sum_{i=1}^{n} e_i^з} \quad (8)$$

The specific exergy of the control surfaces into which the system under study, consisting of classical irreversible processes, was divided decreases with time, which is associated with energy dissipation: $\sum e_з = \sum e_э + \sum D$. The economic calculation of the effectiveness of the introduction of new technology and technology in production. Calculations show that the selected technology and equipment are cost-effective.

The calculation of economic efficiency has shown that the payback period is 1 month, the profit from technology improvement is 3,7 million tenge.

The conclusion provides brief conclusions on the results of dissertation research, an assessment of the completeness of the tasks, developed recommendations and baseline data on the specific use of the results, an assessment of the technical and economic effectiveness of the implementation and the scientific level of the work performed in comparison with the best achievements in this field.

Legend: K – air resistance coefficient, depending on the shape of the grain and the properties of its surface, kJ / kg; e – specific thermal exergy, a – specific work, kJ / kg; μ – Poisson's ratio; d – the screw shaft diameter, m; ξ – coefficient of resistance, determined by the ratio of the internal volume of the equipment, considered as a reference surface, to the cross section of the inlet. kJ / kg.