In the article new low-waste energy saving ways of production of partite concentrates on the basis of fruit and vegetable raw materials are considered. The offered way of production of partite concentrates assumes the following basic technological processes: refinement of fruit and vegetable raw materials, equation in vacuo and vacuum drying. For the intensification of the drying process, residue vibration application is offered. Use of vibration in the course of drying, namely low-frequency fluctuations, allows to create a vibroboiling bed that intensifies the process of dispersible materials drying, solutions and suspensions due to the improvement of conditions of heat exchange between a heat carrier and a product. Namely it renders assistance to updating of a mass-exchanged surface of phases contact. Low-frequency processing of dispersible material sets it in an oscillating motion, at the same time forces of interaction between particles are considerably weakened: a sliding friction decreases, and the influence forces of the adhesion forces bond decreases. Depending on parameters of vibration and the nature of material vibration processing can render assistance to consolidation of particles, i.e. decrease porosity of a material. In the article the design of a vibration vacuum drier for drying vegetable raw materials is considered. The vibration Reynolds criterion of Rev, the analysis of which allowed to define rational modes of vibroprocessing of a residue was calculated. Experiments showed that application of vibration reduces drying process duration, and also promotes upgrade of a finished stock.

**Keywords:** concentrated products, fruit and vegetable raw materials, vibration, drying.
bacteria, etc.) and active enzymes is studied. The main objective of efficient mechanical stirring is aimed at permanent maintenance of optimal temperature and structure formation to ensure the flow of nutrients to the cells of bacteria, and the required moisture- and gas-exchange. Selection and substantiation of rational constructions of a new direction of mixing without vanes, and mechanism of working bodies influence on the components remains a hot topic for research.

Based on the analysis of recent research and publications on this effective direction of kneading, the technique of solving complex forecasting results of basic technological operations of kneading stages, where the value of work or relevant energy wastes will be determined based on the method of system evolution. It is revealed that this method depends on functional relationship of some kind of thermodynamic parameters of the system. An overall analysis of experimental researches on the effect of parameters and determination of their effectiveness as the evolution of a thermodynamic system to the equilibrium state, using classical method of thermodynamic potentials. The transition of thermodynamic system from its initial nonequilibrium state to final equilibrium state, which corresponds to the completion of the process of mixing the components and generally must include energy losses for mixing into dough with the predetermined characteristics is shown.

**Keywords:** system, thermodynamic potential, macromolecular structure, moisture content, temperature, interphase surface, interphase reciprocity.

**SYSTEM-DYNAMIC MODELING OF COMPLEX ASSESSMENT OF ARJM-0.07-1 APPARATUS**

V. Potapov, S. Kostenko

In this work the comprehensive assessment of the apparatus with a reflector for the infrared frying of meat semi-products ARJM-0.07-1 by system-dynamic modeling is carried out. Analysis of productivity, power intensity, steel intensity and specific expenses parameters proves that the using of radiation flux reflectors is productive and perspective.

**Keywords:** system dynamic, simulation model, infrared frying, reflector, steak, expenses.

**Statement of the problem.** The food production enterprises require the implementation and use of infrared equipment with high comprehensive characteristics. Simulation provides a system-dynamic foundation for intensification of the frying process and optimization of the infrared frying equipment.

**Review of the latest research and publications.** The infrared frying foods equipment is extremely energy-intensive and does not provide a uniform irradiation of convex receiver, reducing the quality of the product [1; 2]. The use of profiled heat flux reflector provides the uniform aggregate irradiation of the convex surface of product [3; 4]. Physical, analytical and system-dynamic modeling of meat semi-products infrared frying in
apparatus ARJM 0.07-1 became the basis of a comprehensive assessment of the effectiveness of the use of heat flux reflectors [5; 6].

The objective of the research is the comprehensive assessment of ARJM-0.07-1 apparatus with a reflector for the frying of meat semi-products and its comparison with the apparatus without reflector by the system-dynamic modeling at software complex Vensim.

Presentation of the research. Unit of measurement of model time is minute in accordance with the minimum delay in the process frying of steaks. Modeling term is 20 minutes. The simulation model is shown in Fig. 1.

Fig. 1. Simulation model

The assumptions in the model:
1) beef supply is a non-recurrent pulsing;
2) delays in operations comply with the recommendations in manuals;
3) thermal processing times correspond to types of equipment;
4) operating losses correspond to the experimental studies;
5) product no residue;
6) product quality is constantly.

The controlled exogenous variables:
1) mass components (sliced beef, mass of apparatus, mass of reflector);
2) energy components (reflector coefficient, preheating time, power of apparatus).

The controlled endogenous variables:
1) frying losses is 33%, multiplied by reflector coefficient;
2) frying time is 15 minutes, multiplied by reflector coefficient;
3) frying semi-finished is determined by delay fixed of sending semi-finished at the sum of preheating time and frying time, taking into account frying losses;

4) productivity is determined by the steak realization in an hour;

5) power intensity is the ratio of power of apparatus to the productivity;

6) steel intensity is the ratio of the sum of mass of apparatus and of reflector to the productivity;

7) specific expenses are determined by multiplying the power intensity to steel intensity.

The model reaction is specific expenses. All factors have a combined effect on the model reaction. The following levels of factors have been taken:

- sliced beef is of 2 pieces of 200 grams each;
- mass of apparatus is 3.5 kg;
- mass of reflector is 0.5 kg;
- reflector coefficient equals 0.6, i.e. the ratio of 9 minutes (frying with reflector) to 15 minutes (frying without reflector);
- pre-heating time is 2 minutes;
- power of apparatus is 1 kW.

The experiment was performed for apparatus with reflector (reflector coefficient 0.6, weight of the reflector 0.5 kg, Current 06), and for apparatus without reflector (reflector coefficient 1, weight of the reflector 0 kg, Current 1).

The steak realization is shown in Fig. 2.

![Graph showing steak realization](image)

**Fig. 2. Steak realization (kg): a – Current 06, b – Current 1**
The productivity is shown in Fig. 3.

![Figure 3: Productivity (kg / hour): a – Current 06, b – Current 1](image)

The power intensity is shown in Fig. 4.

![Figure 4: Power intensity (kW hour / kg): a – Current 06, b – Current 1](image)

The steel intensity is shown in Fig. 5.
Fig. 5. Steel intensity (kg hour / kg): \( a \) – Current 06, \( b \) – Current 1

The specific expenses are shown in Fig. 6.

Fig. 6. Specific expenses (kW kg hour / kg): \( a \) – Current 06, \( b \) – Current 1

Thus, the use of heat flow reflector provides the following advantages:

- increase in steak realization (Fig. 2) by \( 0.32 / 0.27 - 1 = -1.2 - 1 = 0.2 \), i.e. 20%;
- increase in productivity (Fig. 3) by \( 1.28 / 0.8 - 1 = 1.6 - 1 = 0.6 \), i.e. 60%;
- decrease in power intensity (Fig. 4) by \( 1.25 / 0.78 - 1 = 1.6 - 1 = 0.6 \), i.e. 60%;
– decrease in steel intensity (Fig. 5) by $4.38 \div 3.13 - 1 = 1.4 - 1 = 0.4$, i.e. 60%;
– decrease in specific expenses (Fig. 6) by $5.47 \div 2.44 - 1 = 2.24 - 1 = 1.24$, i.e. 124%.

**Conclusion.** Using the system-dynamic modeling to compare the complex quality characteristics of the apparatus with a reflector for the frying of meat semi-products ARJM-0.07-1 and of apparatus without reflector proves that the presence of the reflector causes an increase in productivity and decrease in power intensity and steel intensity. This fact significantly reduces the specific expenses with improving the quality of food products. Comprehensive assessment and system optimization of the infrared equipment for food production is impossible without the use of system dynamics simulation. It is necessary to expand the number of factors affecting the model reaction for a more complete assessment.

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INFLUENCE OF MULTIPLICITY OF MILK EMULSION TREATMENT IN PULSATION HOMOGENIZER

G. Deinychenko, K. Samoichuk, L. Levchenko

The article is a part of the cycle of articles, devoted to the efficiency increase of the pulsation homogenizer of milk emulsion. Dispersion of milk fat in the pulsation homogenizer is caused by impulsive shake action while the piston with openings vibrates. Prospective use of the impulsive homogenizer lies in the possibility to create high-rate flowing around fat globules of the surrounding plasma which is the principal reason for their destruction.

One of the indefinite influence factors of the emulsion homogenization process in the pulsation machine is treatment multiplicity, thus the aim of the research is analytical research of this factor’s influence on qualitative and power indexes of milk homogenization.

The influence of one of the key indexes of the pulsation homogenizer process – emulsions supply has been discovered. Specific energy consumption of the process decreases with the supply increase. Moreover, at once the amount of passageways of milk emulsion through the piston openings decreases – treatment multiplicity, which reduces milk homogenization degree.

The equation is found based on classic kinematic and hydrodynamic dependences to determine emulsion treatment multiplicity depending on the design-kinematic parameters of the pulsation homogenizer: emulsion supply to the machine, diameter of piston (process chamber), frequency and amplitude of piston oscillation. The analysis of this equation shows that to increase the homogenization degree (increase of treatment multiplicity) it is necessary to decrease emulsion supply to the machine and increase the piston diameter (process chamber), frequency and amplitude of piston oscillation.

The connection between homogenization degree and treatment multiplicity is shown. Based on the experimental data of the influence of milk treatment multiplicity in valve homogenizers, the assumption is made that for the pulsation machine there is such an optimal value of productivity, higher than the homogenization efficiency, which does not meet quality requirements. At the same time, decrease of supply (at unchanging amplitude and frequency of vibrations and diameter of piston) is inefficient because of the increase rates of specific energy consumption are higher than increase rates of homogenization efficiency.

The derived dependences supplement analytical model of fat emulsion homogenization in the pulsation homogenizer, and allow decrease substantially the volume of experimental researches of pulsation homogenization of milk.

Keywords: homogenization, pulsation homogenizer, energy consumption, theory.
DESIGN OF RECUPERATIVE HEAT EXCHANGE DEVICE FOR EXTRUDER FOR PROCESSING OF FOOD RAW MATERIALS

V. Potapov, D. Bilyi

Results of research and development of recuperative heat exchanger for upgrading of single-screw extruder, for processing food materials are presented. The process of heat exchange using heat of exhaust gases from the working chamber of the extruder for heating material in the bunker dryer are worked out. As a result, research has been developed continuously operating single-phase countercurrent heat exchanger, which is a chamber with insulation jacket in a cylinder, inside which is coil. Determined the average temperature of the heating of the coolant in the annular gap is \( T_{1\text{sr}} = 118^\circ C \). The temperature of water heated at the outlet of heat exchange tube is \( T_{2''} = 110^\circ C \). Determined the optimum temperature drying and heating the raw material is 90–110°C. Methodology of improve technological line of device-prototype was introduced into production. During development design of heat exchange device, thermal and structural layout calculations were conducted. The needed dimensions for modeling of heat transfer surfaces, the height of their location in the body of heat exchanger were obtained from the heat balance equation, previously has been calculated using ratios criterion for single-phase recuperative heat exchanger. Based on the these data were made economic and hydrodynamic calculations. Estimates shows that hydraulic losses in the countercurrent flow stream along the coils are smaller than the traditional using direct flow around the tube bundle which is transversely oriented. As result, heat power and main overall parameters of the heat exchanger were found. Structural and economic costs of production and operation of heat exchanger for the extruder has been estimated. Technical and economic indicators and the annual energy saving were identified for using the upgraded extruder with high energy-saving for processing food materials. Comparative calculations of the annual energy savings are presented.

*Keywords*: heat exchanger, extruder, research and development.

INTENSIFICATION OF MACHINES FOR PRODUCTION OF DRIED SEMIFINISHED PRODUCTS FROM FRUIT AND BERRY RAW MATERIALS

L. Kiptelaya, A. Zagorulko, A. Zagorulko

To improve processing of fruit and berry raw materials, it is supposed to implement technical re-equipment of the enterprises basing on their fitting out with efficient and reliable equipment which has high productivity, economicalefficiency and reliability, that will allow considerably excluding damage to and loss of
products by means of reducing duration of processing and low-temperature conditions of their heat treatment.

Heating of puree-like products, in which the heat is distributed mainly due to thermal conductivity, till boiling with further concentration and contact drying is a difficult technical task.

The purpose of the article is intensification of technological equipment for implementation of the processes of concentration and drying for production of semi-finished products from fruit and berry raw materials.

The author has improved the process of concentration of fruit puree in the rotary-film evaporator through creating turbulent regime in the heating shell of the device up to the content of 28...45% DI (dry ingredients) and further finishing drying of the resulting paste in the rotary drum IR-dryer up to the content of 85...92% of DI for production of high quality dried plant semi-finished products having considerable content of BAR.

Specific features of evaporation of the puree using apple, zizifus and blueberries from 10...15 to 28...45% DI in the RFE (rotary-film evaporator) have been experimentally investigated. Modes of the device operation during concentration of fruit-berry puree have been studied.

Kinetics of moisture retention during drying in the rotary drum IR-dryer of preliminary concentrated fruit-berry paste with the layer thickness of raw material 1 mm have been presented.

The advantages of the proposed equipment are as follows: improvement of efficiency of heat exchange by means of creating sustainable turbulent regime in the heating shell of the RFE (rotary-film evaporator) which transmits the heat; reduction of specific content of metal in the RFE and as a result of dimension-weight characteristics; improvement of efficiency of heat exchange in the rotary drum IR-dryer by replacing steam heating to infrared radiation; reduction of duration of the process of IR-drying by use of forced convection and enhancing the quality of the resulting dried semi-finished product through replacing the accumulation (blowing) zone by the direct blowing of fruit and berry paste onto the working surface of the corrugated drum.

**Keywords:** intensification, development, rotary-film evaporator, rotary drum IR-dryer, fruit and berry raw materials, dried cake mix.

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**EXPERIMENTAL RESEARCH OF PROCESSES**

**HOMOGENIZATION OF MILK IN THE ULTRASONIC FIELD**

G. Postnov, G. Shipko, V. Chervonyi, O. Postnova

The results of experimental studies on the use of ultrasonic treatment for the effective conduct of the process of milk homogenization are proposed. The authors studied the influence of ultrasonic treatment on the process effectiveness.
Regression dependences correlate with the experimental data with a correlation coefficient \( k = 0.95...0.99 \), which indicates a unique functional relationship between the variables under research.

Mathematical dependences allow to evaluate effectiveness of the process of ultrasonic milk homogenization at frequencies of 15, 22, 35 kHz, and to characterize the resulting product as a micro-heterogeneous.

According to the research, it is found that at the frequency 35 kHz, unsatisfactory results are obtained as compared with the frequencies 15 and 22 kHz. Thus, at frequency of 22 kHz in the range of fat globules' sizes to 3 microns, the obtained results were 18...20% higher than at 35 kHz under the same conditions. However, an important factor is that the frequency of 15 kHz is the upper limit frequency of oscillation, which a human ear is able to feel, so their use in food plants is improbable.

During the experiments, it was found that treatment of milk with 3.2% fat content by ultrasonic waves of 22 kHz frequency, allows to achieve greater fineness ratio within 27...64%.

At the next stages of research, it is planned to determine the influence of ultrasonic treatment on the change of microbiological indicators.

The results of the research will contribute to the formulation of basic technological, operational and environmental requirements for effective homogenization of milk, and to the proposal of the conceptual design of hardware for the appropriate process.

Keywords: ultrasound, homogenization, milk, frequency, size, dispersed phase.

MODERN TECHNICAL SOLUTIONS TO PROBLEM AREAS CLEANING AND MUCOUS COAT OFFAL

N. Afukova, D. Horielkov, D. Dmytrevskyi, O. Noskov

The article deals with topical issues of providing population with meat production in Ukraine, statistical results of raw meat production and its development perspectives. When covering the major issues affecting the rate of producing raw meat and products from it, based on market analysis and literary study, the authors suggested the ways for solving the shortage of raw materials, improving the quality of meat products, extension of the product range. The above literary analysis of the processes regarding the processing of raw meat demonstrated a perspective solution of the problem through the processing of by-products to culinary products, by developing new energy effective and resource saving processes using synergies. The authors have chosen such by-products as beef stomach with its compound parts (rumen, book) and such by-products as ears, beef lips, as a subject of the research. The developers propose to replace the centrifugation process for cleaning the products, with long-term scalding at a
transient process - steaming with mechanical action of the brush elements. The article shows a schematic diagram of a plant for cleaning wool and mucous offal, which allows processing by-products continuously without using the batch mode of action devices, which slows down the cleaning process, and in some cases, does not provide the required quality of raw materials purification and subsequent production of quality products. The article presents the pictures of the developed working bodies for the removal of the outer cover from mucous by-products, and some steps are proposed for carrying out the research to clarify the operating and design parameters of the equipment to clean the offal.

Keywords: cattle, slimy offal, combined treatment processes, energy efficiency, resource conservation.