

# TASHYBAYEVA MARZHAN MEIRAMBEKKYZY

## IMPROVEMENT OF THE FOOD ENCAPSULATION PLANT

### ANNOTATION

the dissertation work of PhD - doctoral student Tashybayeva M.M. for the degree of Doctor of Philosophy (PhD) in the specialty 8D07101 - Technological machines and equipment

**The relevance of the work.** The Message of the President of the Republic of Kazakhstan Kassym - Jomart Tokayev to the people of Kazakhstan «The economic course of a just Kazakhstan» says: «There are huge markets around Kazakhstan that need high - quality food products. The strategic goal of our country is to become one of the leading agricultural centers of the Eurasian continent. This is impossible without a step by step transition from primary production to the production of higher grade products. The task is to increase the share of processed products in the agro - industrial complex to 70% within three years. This is a real challenge. We need to encourage people to process products». The new paradigm of Kazakhstan's economic development will be based on the effective use of our competitive advantages, as well as the disclosure of the potential of all key factors of production – labor, capital, resources and technologies. We have another task ahead of us – to achieve a real breakthrough in the agro-industrial complex. We must make a real breakthrough in the agro-industrial complex. Currently, the basis for the sustainable development of the agro-industrial complex of the state is an increase in the volume of cultivation and production of agricultural products. As a result, our goal is to fully meet the demand in the domestic market, reduce the number of imports and increase exports. The priority of the national project will be the formation of 7 ecosystems around large investment projects, including the production and processing of meat, fruits, vegetables, sugar, cereals, oilseeds, and dairy products. This program was developed by the Government of the Republic of Kazakhstan in conjunction with the national program for the development of the agro-industrial complex, the main operator of which is the Ministry of Agriculture of the Republic of Kazakhstan. The beneficial effect of probiotics on the human body is determined by the positive properties of the microorganisms that make up probiotics. Probiotics can not only maintain the balance of bacterial microflora, but also improve the health of the whole body.

To preserve the necessary beneficial properties of fermented milk bacteria, including probiotics, it is necessary to place them in intestinal-soluble capsules. Putting probiotics in a capsule allows you to protect them from the acidic environment of the stomach, thereby opening the way to the latest technologies of functional products. At the same time, the acidic environment in the stomach should not destroy the capsules for more than 2 hours, but when the capsule enters the intestine, it should dissolve, not even 7 minutes. Collapsing, the capsule will release the necessary nutrients.

The issue of obtaining capsules of high quality, with the desired properties and characteristics, which dissolve in the necessary environment, retain their therapeutic

effect, and moreover, meet the requirements of the consumer (ease of use, efficiency, reasonable cost), still remains open. Taking into account the deterioration of the environmental situation, sedentary lifestyle, malnutrition, and malnutrition in many regions, the direction of creating encapsulated functional products is an urgent direction for the development of biotechnology worldwide.

In the developed capsule equipment, capsules obtained by the drip method using an injection die had a large diameter and low productivity. Therefore, the task has been set to improve the installation for obtaining capsules of a functional product that allows automating the process of obtaining capsules with probiotics. The optimal solution to this problem is to improve the installation for encapsulation by spraying using a gear pump and a centrifugal nozzle. The experiments have shown that it is optimal to improve the installation by applying pressure to a gear pump during encapsulation, using a centrifugal nozzle by spraying.

The solution of the tasks set in this work is based on the study of the fundamental works of N.E. Fedorov, A.V. Gorbatov, V.V. Kafarov. The scientific and methodological basis of this study was the works of scientists in the field of rheology of food masses, food production technology, food engineering, encapsulation, namely V.D. Solodovnik, P.F. Ovchinnikov, V.D. Kosogo, Y.A. Machikhin, S.A. Machikhin, E.V. Ilyushenko, A.K. Kakimov.

The topical issues of this dissertation work were promising directions for the development of many branches of the agro - industrial complex, including the improvement of the installation for encapsulating probiotics using a centrifugal nozzle and a gear pump.

**The purpose** of the dissertation work is to improve the installation for encapsulating food products, obtaining capsules by spraying through a centrifugal nozzle.

In accordance with the set goal, the following **tasks** are defined in the work:

- organization of research objects based on a literary review, determination of optimal ways to improve the encapsulation unit;
- development of rheological and mathematical models of the interaction of gel-forming mixtures with the working bodies of the installation;
- study of technical characteristics and selection of operating modes depending on the design parameters of the installation;
- development of an engineering methodology for calculating the working bodies of a food encapsulation unit;
- implementation of research results and conducting production tests.

**The objects of the study.** Centrifugal nozzles of the encapsulation unit; an aqueous solution of a gel forming mixture.

**The subject of the study.**

1. Determination of the viscosity of the aqueous solution of the gel-forming mixture;
2. Determination of the granulometric composition of capsules;

3. Preparation of capsule samples;
4. The method of measuring the diameter of the nozzles;
5. The method of issuing the energy characteristics of the installation;
6. Determining the performance of the pilot plant.

**Scientific novelty of the work:**

- rheological and mathematical models of the interaction of the gel forming mixture with the working bodies of the installation have been developed;
- installation for the production of encapsulated products received the patent of the Republic of Kazakhstan for utility model № 9093;
- technical characteristics have been studied and operating modes have been selected depending on the design parameters of the installation;
- an engineering method for calculating the working bodies of the food encapsulation unit has been developed;
- rational technological modes of capsule production have been determined using the proposed centrifugal nozzle, which make it possible to obtain stable structural and mechanical characteristics and technological parameters of the obtained capsules.

**The main points put forward for defense:**

- improved installation and schemes of centrifugal injectors for encapsulation and organization of object research methods;
- rheological and mathematical models of the interaction of the gel - forming mixture with the working bodies of the installation are proposed;
- technical characteristics and results of the operating modes of the installation, depending on its design parameters;
- equations of the methodology of engineering calculation of the working bodies of the food encapsulation unit.

**Scientific and practical significance of the work.** Based on a set of studies conducted in laboratory and production conditions, it is shown that capsules are obtained by spraying through a centrifugal nozzle at a food encapsulation plant. The technical solution is confirmed on the basis of the patent of the Republic of Kazakhstan № 9093 for a utility model. Industrial testing of equipment and production tests were conducted under the conditions of the Federal State Budget Scientific Institution «Federal Altai scientific center for agrobiotechnologies (department of the Siberian research institute of cheese making)» in Barnaul and in the Semey branch of «Kazakh research institute of processing and food industry» LLP.

**Personal contribution of the author.** Substantiation and selection of the installation design for encapsulation, mathematical modeling of fluid flow through holes, engineering methods for calculating working bodies, development of operator and technological schemes, verification of the adequacy of the mathematical model.

**Approbation of practical results.** The main provisions and results of the work were reported at international scientific and practical conferences: «Transformation of

the agro - industrial complex of Kazakhstan into a world food hub: prerequisites and prospects» (Semey, 2022); «Kazakhstan - Kholod 2022» (Almaty, 2022); «Kazakhstan – Kholod 2023» (Almaty, 2023); «Promising directions for the development of the agricultural and food industry» (Semey, 2023); «Collection of materials of the contest of poster reports among doctoral students of Shakarim University of Semey» «Shakarim Poster Event – 2024» (Semey, 2024).

**Publications.** 16 publications have been published on the topic of the dissertation: 7 articles in international conferences; 1 articles in journals of the near abroad, 4 articles in publications recommended by the Committee for Quality Assurance in Education and Science of the Ministry of Science and Higher Education of the Republic of Kazakhstan; 2 articles in scientific journals with a non-zero impact factor (Scopus and Web of Science databases); 1 analytical review, 1 patent for a utility model of the Republic of Kazakhstan.

**The structure and scope of the dissertation.** The dissertation work consists of an introduction, five chapters, a conclusion, a list of sources used and appendices. The main content of the work is presented on 114 pages of the text of the computer set, contains 68 figures, 9 tables, the list of references includes 95 sources and 5 appendices.

**Assessment of the completeness of solutions to the tasks.** According to the results of the dissertation work, it can be considered that the goals and objectives have been achieved:

1. Depending on the purpose of the dissertation, a mathematical, rheological model of the gel - forming mixture has been developed, the patterns of formation of the forces of interaction of a liquid with a centrifugal nozzle have been studied.

2. An engineering method for calculating the working bodies of the encapsulation unit has been developed.

3. When the viscosity of the gel-forming mixture depends on the concentration of the sodium alginate solution at different temperatures, at a temperature of 40 °C, the viscosity value changes slightly for the rotor speed, the optimal temperature of using the solution of 40 °C is obtained.

4. At a high speed of rotation of the gear pump 39,3 s<sup>-1</sup>, 47,6 s<sup>-1</sup>, the viscosity of the gel - forming mixture decreases, nozzle diameters 0,7×10<sup>-3</sup>m, 1,0×10<sup>-3</sup>m, 1,2×10<sup>-3</sup>m throughput increases.

5. When analyzing the capsules, the 3-rd sample with a diameter of the centrifugal nozzle opening d=1,2×10<sup>-3</sup>m was chosen as the optimal one, while the concentration of 1% sodium alginate was used as the encapsulation material, the average diameter of the resulting capsule was 1,4×10<sup>-3</sup>m.