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A prototype of a tray-type installation for milk starter drying

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Abstract. The development of methods for the conservation of living environments is an urgent task today. For the dairy industry, the key task is the preservation of the parent curd of lactic acid starters and its reproducibility after preservation, which will allow obtaining functional high-quality food products, having raw materials regardless of seasonality and being sovereign in the industry of lactic acid enzymes and starter cultures in the food and processing industry. The article is devoted to the development of a technological solution for the production of milk starters by cold infrared drying, which will allow maintaining the activity of the microbiome composition of the product at least 1.1×10^7 CFU/cm^3.

1 Introduction

Ensuring the country's food security is one of the most important issues. Due to the strong import dependence of dairy industry enterprises, there are currently problems with the supply of new foreign equipment, the closure of product sales channels, the lack of raw materials in the right volumes; all this leads to an increase in prices of dairy products on store shelves [1].

One of the points of technological sovereignty of our country in the field of agriculture is self-sufficiency in livestock products (meat processing and milk processing). To achieve sovereignty, there are three barriers that must be overcome to reduce import dependence:

The first one is sectoral, it includes the development of breeding cattle and feed stock; manufacture of veterinary medicines, enzymes, equipment; production of starters.

The second one is related one, it includes the production of agricultural machinery, fertilizers, seed breeding, etc.

The third one is indirect, this is something without which the first two barriers are difficult to implement: personnel, housing, roads, transport, energy, communications, etc.

Milk starter (the organization of its production belongs to the first barrier) represents viable cells of lactic acid, propionic acid, acetic acid, and bifidobacteria selected in a special way. Such ferments have found their application in almost all processes of the manufacture of fermented milk products. For example, the kefir production process shown in Figure 1 is accompanied by the introduction of biological starters.

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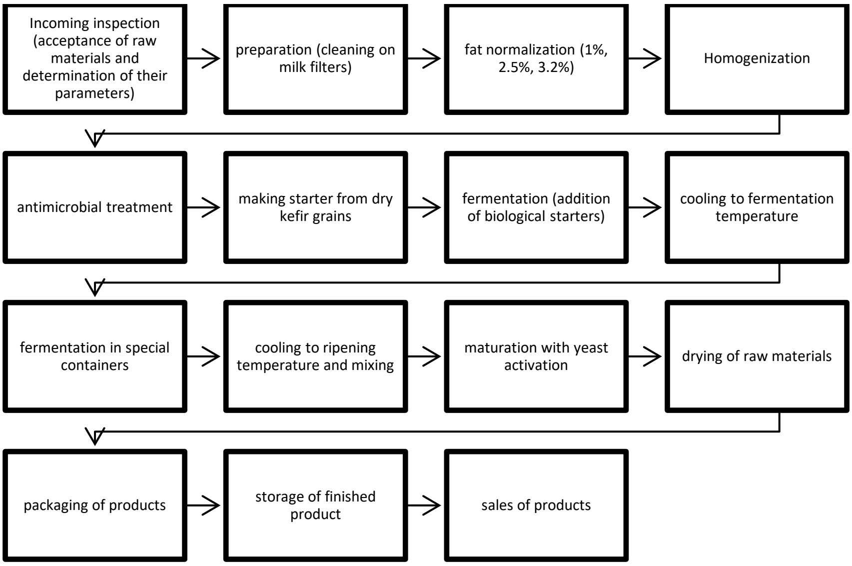


Fig. 1. Kefir production process.

Considering the biological activity of starters, their shelf life is limited, manufacturers cannot buy them for future use in liquid form, there is a high probability of loss of viable cells due to violation of transportation or storage conditions. One of the ways to preserve them is drying, which significantly reduces the cost of storing and transporting starters, while the shelf life of the dry product increases, with complete preservation of cell viability [1-4].

In world practice, spray installations have gained the greatest popularity for drying starters, but their significant disadvantage is the course of the process at high temperatures (up to 200°C), which implies high risks of producing low-quality products if the parameters set by the technology are not observed or rejected [5]. The second starter dryers in terms of polarity are sublimation plants, in which the output of products is always of high quality due to the fact that the drying process takes place at negative temperatures [6]. The disadvantage of freeze drying is the high cost of equipment and high energy consumption during the drying process.

One of the promising directions in the dehydration of living media is cold infrared drying, which takes place at temperatures no higher than 40°C, which allows for the preservation of a large amount of useful substances in the final product, while drying plants have simple design and low cost [2,3,7,8].

In previously published studies, we have proven the effectiveness of drying milk starters using infrared membranous electric heaters [2,3,7]. The purpose of this work will be the development and creation of a prototype drying plant based on membranous electric heaters for milk starters with subsequent testing.

2 Materials and Methods

The developed prototype of the drying unit (Fig. 2) is a housing 1, inside of which there are rigid membranous electric heaters 2. Non-stick coated pallets 4 are placed between the membranous electric heaters on special slides 3 fixed to the housing. The unit is equipped with a control panel 5, which allows to control the temperature of the membranous electric heater surfaces and the pallet surface.

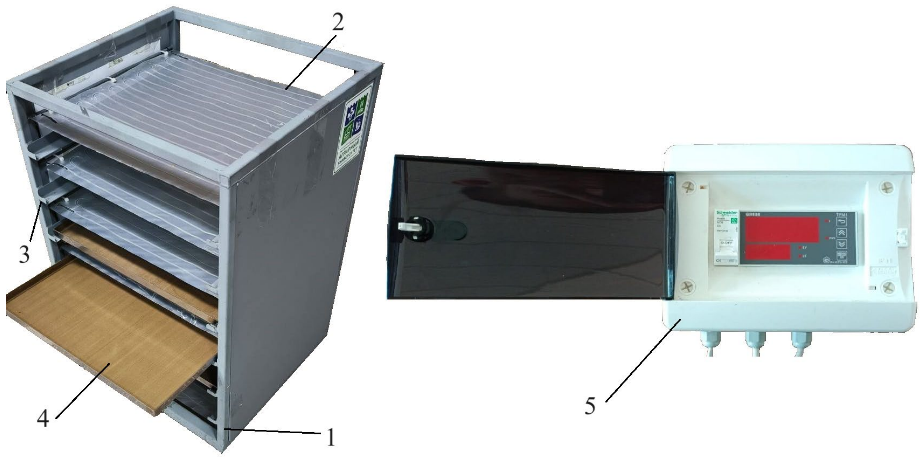


Fig. 2. The appearance of a prototype infrared lotus drying plant.

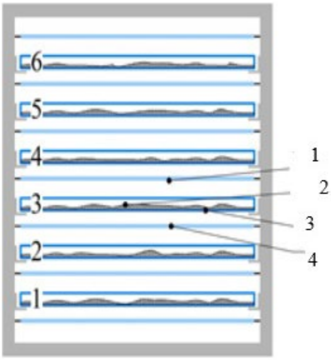
Table 1. Technical characteristics of the prototype infrared lotus drying plant.

No.	Parameter	Value
1	Overall dimensions of the unit, mm	470x510x730
2	Size of the membranous electric heater, mm	460x460
3	Number of membranous electric heaters, pcs.	7
4	Specific power of the membranous electric heater, W/m^2	360
5	Pallet size, mm	460x460
6	Number of pallets, pcs.	6
7	Supply voltage, V	220
8	Installed power of the unit, W	460
9	Distance between membranous electric heaters, mm	100
10	Distance from the upper membranous electric heater to the pallet, mm	70
11	Pallet loading volume, l	up to 3
12	Temperature range of drying process, °C	30-80

Studies of the drying process of milk starter in a prototype installation using membranous electric heaters [9,10] will be carried out at gentle temperatures (up to 50°C), which will prevent the appearance of a film on the spilled surface of the drying object and will preserve the largest number of beneficial bacteria, since it has been proven that they die when exceeding the specified temperature level.

During the experiment, milk starter (up to 3 kg) will be poured onto pallets, at a given mode, temperature and humidity drying curves will be obtained, for which the following tools are selected: moisture analyzer ELVIZ-2C – to obtain the dependence of humidity changes during the drying of milk starter culture; experimental data registration system, which includes products manufactured by LLC "ARIES Production Association" (TRM-138, AC-4M interface adapter, DTS014-50M temperature sensors, Owen Process Manager software) – to obtain the dependence of temperature changes in the process [11,12].

Samples to obtain the moisture curve will be taken out every hour. To obtain temperature curves, sensors will be installed according to the scheme in Figure 3.



1 - temperature of the upper membranous electric heater, 2 - product temperature, 3 - tray surface temperature (bottom), 4 – temperature of the lower membranous electric heater

Fig. 3. Location of temperature sensors in the pilot sample of the drying unit.

3 Results and Discussions

According to the proposed method, dependences of changes in humidity and temperature of the milk starter during the drying process in a prototype unit using membranous electric heaters (Figure 4, 5) were obtained, which fully correspond to the curves of the drying theory [13-15].

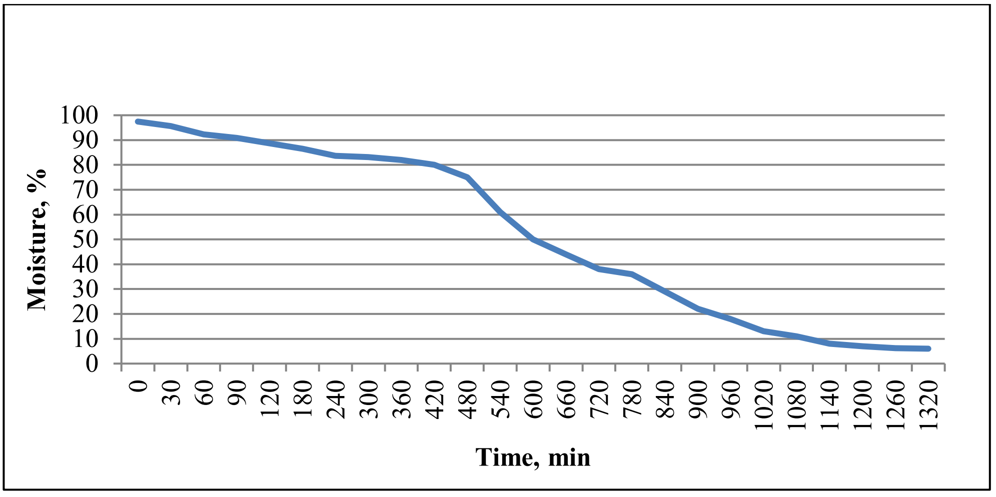


Fig. 4. Humidity characteristics of the milk starter drying process.

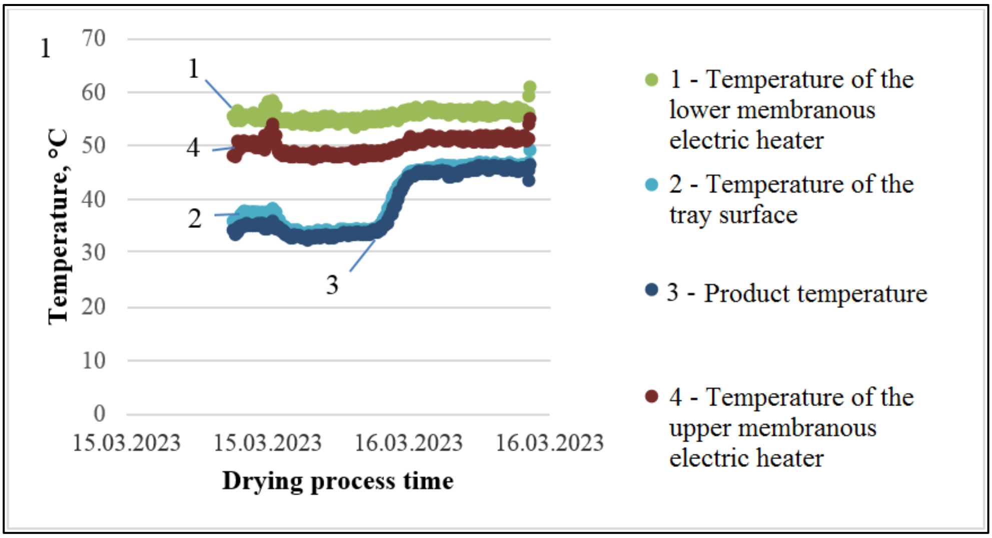


Fig. 5. Temperature characteristics of the milk starter drying process.

The initial moisture content of the milk starter was 97.5%, after drying 5.2%. The drying process lasted 22 hours, Figure 6 shows images at the beginning of the dehydration process of milk starters and at the end. The temperature of the product at the beginning of the drying process (the first 12 hours) it did not exceed 40°C, according to the humidity characteristic (Fig. 4) – this corresponded to a humidity level of ≈40%. Further, the product temperature curve has the character of a steep rise to the level of 44°C (duration 3 hours), according to the humidity characteristic (Fig. 4), no significant changes in product humidity were detected. For the remaining 7 hours, the product temperature was at 45°C, and humidity decreased linearly during this period. It should be noted that the nature of the curves "product temperature" and "tray surface temperature" are the same, which indicates the optional installation of a temperature sensor in the product – this is important from the point of view of food safety. The nature of the curves "temperature of the upper membranous electric heater" and "temperature of the lower membranous electric heater" is also the same, with a difference of ≈7°C, this can be explained by the measurement error of the sensors, or the convective component.

Fig. 6. The appearance of the milk starter loaded into the unit before and after drying.

The dehydrated dried product was transferred for laboratory testing to the Center for Hygiene and Epidemiology in the Chelyabinsk Region. The results showed that the dry product contains lactic acid microorganisms more than 1.1x10^8 CFU/cm^3, as well as bifidumbacteria more than 1.1x10^6. These indicators are normalized by GOST 33491-2015 and GOST 10444.11-2013, respectively. Both indicators in the dry product exceed the values of GOST standards, which indicates a high content of useful substances in the final product.

4 Conclusions

The test results of a prototype drying plant based on membranous electric heaters for drying milk starters should generally be considered successful, which has been proven by laboratory tests of the dried product. The prototype is suitable for identifying the patterns and relationships of the drying process of milk starters, which will form the basis for the creation of infrared drying technology for liquid and pasty media containing biologically active components.

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References

1. V.M. Popov, V.A. Afonkina, V.N. Levinsky, A.V. Medvedev, *A brief analytical review of the problems and prospects of the development of the domestic milk starter market*, Topical issues of agroengineering sciences in the field of technical service of machines and energy: theory and practice, Materials of the National (All-Russian) Scientific Conference of the Institute of Agroengineering, Chelyabinsk, December 06-09, 2022, Edited by N.S. Nizamutdinova (Chelyabinsk: South Ural State Agrarian University, 2022) 238-244.
2. V.M. Popov, V.A. Afonkina, V.N. Levinsky, A.V. Medvedev, News of the Orenburg State Agrarian University, **4(84),** 173-177 (2020).
3. V.M. Popov, V.A. Afonkina, V.N. Levinsky, A.V. Medvedev, *Study of the process of infrared drying of lactic starter cultures*, E3S Web of Conferences: International Scientific and Practical Conference “Ensuring the Technological Sovereignty of the Agro-Industrial Complex: Approaches, Problems, Solutions” (ETSAIC2023), Yekaterinburg City, Russian Federation, February 16-17, 2023 **395** (Yekaterinburg City, Russian Federation: EDP Sciences, 2023) 01004 DOI 10.1051/e3sconf/202339501004.
4. V.M. Popov, V.A. Afonkina, V.N. Levinskiy, A.V. Medvedev, *Research of substrate materials for drying liquid materials*, Digital Technologies in Agriculture of the Russian Federation and the World Community, Stavopol, September 27-30, 2021 **2661** (Stavopol: AIP PUBLISHING, 2022) 060008 DOI 10.1063/5.0107701.
5. H.S. El-Sayed, H.H. Salama, A.E. Edris, Journal of the Saudi Society of Agricultural Sciences, **19(7),** 461-467 (2020) DOI 10.1016/j.jssas.2020.08.003.
6. B. Abdizhapparova, V. Potapov, N. Khanzharov, Eastern-European Journal of Enterprise Technologies, **6(11(120)),** 6-15 (2022) DOI 10.15587/1729-4061.2022.268241.

7. V.A. Afonkina, V.M. Popov, V.N. Levinsky, A.V. Medvedev, Equipment and technologies in animal husbandry, **3(51),** 92-97 (2023) DOI 10.22314/27132064-2023-3-92.
8. V.M. Popov, V.A. Afonkina, V.N. Levinsky, Proceedings of the Orenburg State Agrarian University, **5(79),** 139-142 (2019).
9. V.N. Levinskiy, BIO Web of Conferences, **82,** 05025 (2024) DOI 10.1051/bioconf/20248205025.
10. V.N. Levinsky, News of the Orenburg State Agrarian University, **3(107),** 203-208 (2024) DOI 10.37670/2073-0853-2024-107-3-203-208.
11. V.N. Levinsky, International Scientific Research Journal, **4(142),** (2024) DOI 10.23670/IRJ.2024.142.131.
12. V.M. Popov, V.A. Afonkina, V.N. Levinsky, News of the Orenburg State Agrarian University, **1(99),** 136-143 (2023).
13. A.A. Kolobaeva, O.A. Kotik, E.V. Panina, K.D. Chernyshova, Technology and commodity science of agricultural products, **2(17),** 154-160 (2021).
14. S.P. Rudobashta, O.R. Dornyak, V.M. Dmitriev, Theoretical foundations of chemical technology, **55(5),** 612-617 (2021) DOI: 10.31857/S004035712104014X
15. S.K. Protasov, N.P. Matveiko, A.A. Borovik, Chemical industry, **96(2),** 87-94 (2019).