

УДОСКОНАЛЕННЯ ПРОЦЕСІВ І АПАРАТІВ ХАРЧОВИХ ВИРОБНИЦТВ

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Omelchenko O. V., PhD in Engineering sciences

Tsvirkun L. A., PhD in Pedagogical sciences

Goncharenko V. A., PhD in Engineering sciences

Shkilna Yu. S., a graduate of a master's degree

Pronkin Yu. V., a graduate of a bachelor degree

Donetsk National University of Economics and Trade named after Mykhailo Tugan-Baranovsky (Kryvyi Rig, Ukraine), e-mail: cvirkun@donnuet.edu.ua.

IMPROVEMENT OF A SPIRAL QUICK FREEZER FOR FREEZING SEMI-FINISHED DOUGH PRODUCTS ON THE BASIS OF AUTOMATION

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Омельченко О. В., канд. техн. наук

Цвіркун Л. О., канд. пед. наук

Гончаренко В. А., канд. техн. наук

Шкільна Ю. С., здобувач ОС магістра

Пронькін Ю. В., здобувач ОС бакалавра

Донецький національний університет економіки і торгівлі імені Михайла Туган-Барановського (м. Кривий Ріг, Україна), e-mail: cvirkun@donnuet.edu.ua.

УДОСКОНАЛЕННЯ СПІРАЛЬНОГО ШВИДКОМОРОЗИЛЬНОГО АПАРАТА ДЛЯ ЗАМОРОЖУВАННЯ НАПІВФАБРИКАТІВ ІЗ ТІСТА НА ОСНОВІ ЗАСОБІВ АВТОМАТИЗАЦІЇ

Objective. The purpose of the article is improvement of a spiral quick freezer for freezing semi-finished dough products on the basis of automation.

Methods. In this work, to improve the spiral quick freezer for freezing semi-finished dough products, methods and means of automating technological processes in food production were used.

Results. It is noted that the modern development of the global catering industry is characterized by the introduction of technology for freezing semi-finished dough products. The technology makes it possible to provide consumers with a wide range of products and expand the sales network by creating mini-bakeries with an unfinished technological cycle. To date, there are three main ways of freezing bakery and confectionery products: freezing a semi-finished product (raw materials are frozen), freezing a partially finished semi-finished product and freezing a finished product. The parametric scheme of the process of freezing semi-finished products from dough is considered. The main parameters influencing the process of freezing products are given. The main (input) parameters that affect the process of freezing semi-finished dough products include: dough humidity, dough temperature after kneading, dough fermentation time, flour quality, etc. The initial parameters are temperature, product weight, obtaining a stable product quality at the output. Disturbing influences

are the ambient temperature, relative air humidity, etc. Corrective actions include control of the temperature and speed of the cooling air at the surface of the product, the speed of the conveyor belt. An improved block diagram of the process of freezing semi-finished products from dough based on automation tools is proposed. The automated complex makes it possible to form optimal values of control actions to improve the quality of the initial product with minimal energy consumption. The system provides for the introduction of corrective actions, namely: the temperature and speed of the cooling air, the speed of the conveyor belt to maintain a stable temperature for freezing semi-finished dough products. Control and measuring tools provide prediction of potentially expected temperature deviations in three stages: the temperature of the object coming from the production line, the temperature in the quick freezer, the temperature of the object at the outlet of the quick freezer to form corrective actions. Proper freezing will ensure a stable quality of the finished product, exclude a small specific volume, a dense internal structure, and compaction of individual layers.

Key words: spiral freezer, freezing of semi-finished products, automation, fast freezing, technological line, control and measuring means, dough.

Formulation of the problem. Bread is one of the main goods that is in the consumer basket of every person. Bread products are essential goods that are in constant demand and have a diverse assortment. The production of bakery products, as one of the most important products in the daily human diet, is a complex hardware and technological process. Manufacturing technology is constantly being improved in order to improve the quality of the finished product, shelf life and sale [1, 2]. In the production process of dough products, one of the main operations is the cooling of bakery products or the freezing of dough pieces.

Today, technologies for freezing semi-finished products at different stages of readiness are used to expand the range and provide the consumer with always fresh bakery products. Small businesses are adopting intensive technologies that allow them to become more agile to ever-changing market conditions. Thanks to these technologies, such productions can compete on an equal footing with large manufacturers of bakery products.

The technology for the production of bakery products from frozen semi-finished products is relatively new. This technology allows to reduce the cost of delivery of finished products, due to the increased shelf life of the frozen product. Accordingly, the improvement of the process of freezing semi-finished dough products is relevant and timely.

Analysis of recent research and publications. To date, the leading manufacturer of bakery and confectionery products in Ukraine is the Kyivkhib enterprise. The enterprise produces more than 200 types of products that are in demand among residents of the city and regions. The organizational structure of management is aimed at creating conditions for the production and marketing of high-quality products, as well as the supply of new types of bakery products to the market.

In Ukraine, the largest cells of the baking industry are located in Kyiv – approximately 11-12%, Dnepropetrovsk region about 10%, Kharkov – 5-6%, Odessa – 5%, Zaporozhye – 4% [3]. The Ukrainian market of bread and bakery products can be divided into two segments: long-term storage products – products with low humidity and semi-finished products; short-term storage products are bread and pies made from wheat, rye and rye-wheat flour.

According to the information agency «AR-Group» [4], the assortment of bakery products on the Ukrainian market is distributed as follows: wheat bread – 39%, rye bread – 30%, rolls – 21%, fancy products – 5%, crackers – 2%, pies, donuts – 2%, other bakery products – 1% (fig. 1).

The modern development of the global catering industry is characterized by the introduction of technology for freezing semi-finished dough products. The technology makes it possible to provide consumers with a wide range of products and expand the sales network by creating mini-bakeries with an unfinished technological cycle [3, 4]. The use in the production of frozen dough blanks is promising:

- the possibility of using quick-frozen semi-finished products in the fast-food system;
- flexibility of the technological process;
- maintaining the freshness of finished products by the time of its sale;

- long shelf life of semi-finished dough products;
- a significant expansion of the range.

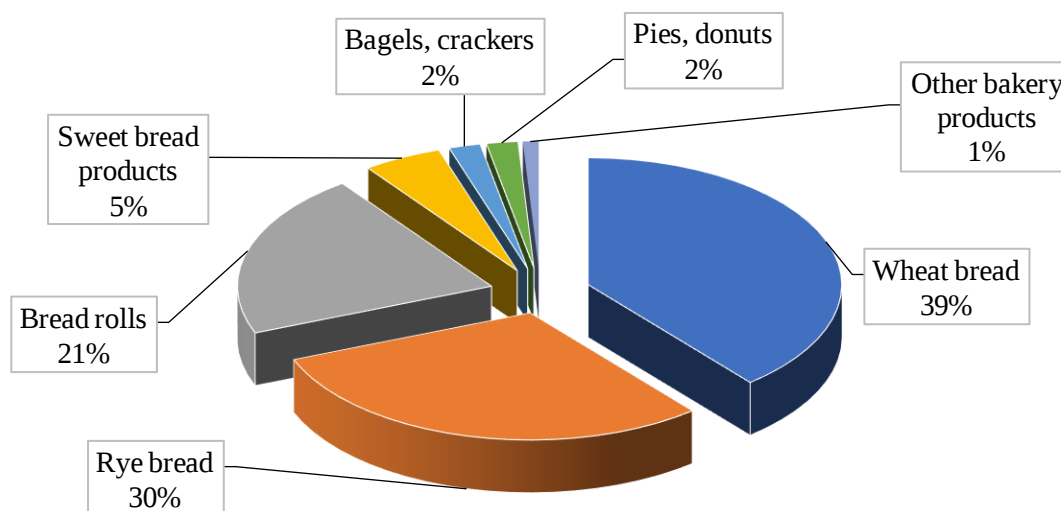


Figure 1 – Assortment of bakery products on the Ukrainian market

To date, there are three main methods for freezing bakery and confectionery products: freezing a semi-finished product (a raw product is frozen), freezing a partially finished semi-finished product, and freezing a finished product [5, 6]. When freezing a semi-finished product, the blanks are allowed to settle a little, then they are frozen and stored. With partial preparation, the product is usually baked until half cooked, then the dough pieces are frozen in a shock freezing chamber at a temperature of -30 to -40°C, packaged and sent for storage at a temperature of -18°C. With full baking, everything happens as with partial, but the product does not need to be cooked after defrosting, it is enough to reheat if necessary. For the freezing process, spiral quick-freezers are used. Spiral quick freezer ALCO food machines 500 is shown in figure 2, technical specifications in table 1.



Figure 2 – Spiral quick freezer for freezing semi-finished dough products

Table 1 – Characteristics of the quick freezer

ALCO food machines 500	Characteristics
Product entry height no more, mm	960
Product exit height, mm	1500 – 2100
Length of the input conveyor on the chamber, mm	540
Conveyor belt speed, m/min	2 – 18
Conveyor belt width, mm	400
Cooling capacity, kW	80
Refrigerant	Freon R404A, R507
Power, kWt	19
Overall dimensions, mm	6100x5332x3450
Temperature inside the chamber, °C	– 35
Air flow speed, m/s	2 – 4
Total capacity kg/h	200 – 500
Freezing time, min.	20 – 90
Performance for test and dough products, kg/h	300

Non-compliance with the technological parameters of the freezing process, such as temperature and air velocity in the quick freezer, can lead to a decrease in the quality of the freezing process. Accordingly, the improvement of the quick freezer and the process of freezing semi-finished products from dough based on automation is relevant.

Objective of the article – improvement of a quick freezer for freezing semi-finished dough products based on automation.

Presentation of the main study material. The process of freezing semi-finished products from dough is a complex multifactorial object. To improve this process, it is necessary to conduct a hardware-technological analysis. The set of equipment integrated into a flow-mechanized dough production line includes: a device for adding dough, an extruder for dough, a hopper for dough ripening, a conveyor for the top layer of dough, a belt conveyor, rolling and calibrating shafts, a conveyor belt, a transverse laminator, a longitudinal laminator, flour cleaning system, flour brush, etc. [7, 8].

Fast freezing is the main step in the technology of frozen semi-finished dough products. It is accompanied by the following undesirable effects: a decrease in the lifting force of yeast and a decrease in the rheological characteristics of the dough. To obtain the optimal quality of the finished product, it is necessary: the presence of air circulation (4-5 m/s) in the shock freezing chamber in combination with an optimally low temperature (-30-35 °C), which provides the necessary freezing of the dough piece (1°C/min). The duration of freezing of products should provide a freezing temperature in the center of -12-18°C.

On fig. 3 shows a parametric diagram of the process of freezing semi-finished products from dough. The main parameters that affect the process of freezing products, as well as disturbing and corrective actions are presented.

The main (input) parameters that affect the process of freezing semi-finished dough products include: dough humidity, dough temperature after kneading, dough fermentation time, flour quality, etc. The initial parameters are product temperature, weight, obtaining a stable product quality at the output [9, 10]. Disturbing influences – ambient temperature, relative air humidity, etc. Corrective actions include monitoring the temperature and speed of the cooling air near the surface of the product, the speed of the conveyor belt.

The difficulties of preparing croissants from frozen dough are associated with the requirements for the quality of finished raw materials, compliance with the sequence of stages and processing conditions, as well as obtaining a high-quality finished product. The main disadvantages arising in

the process of freezing semi-finished products include: low specific volume, dense internal structure of the croissant, compaction of individual layers.

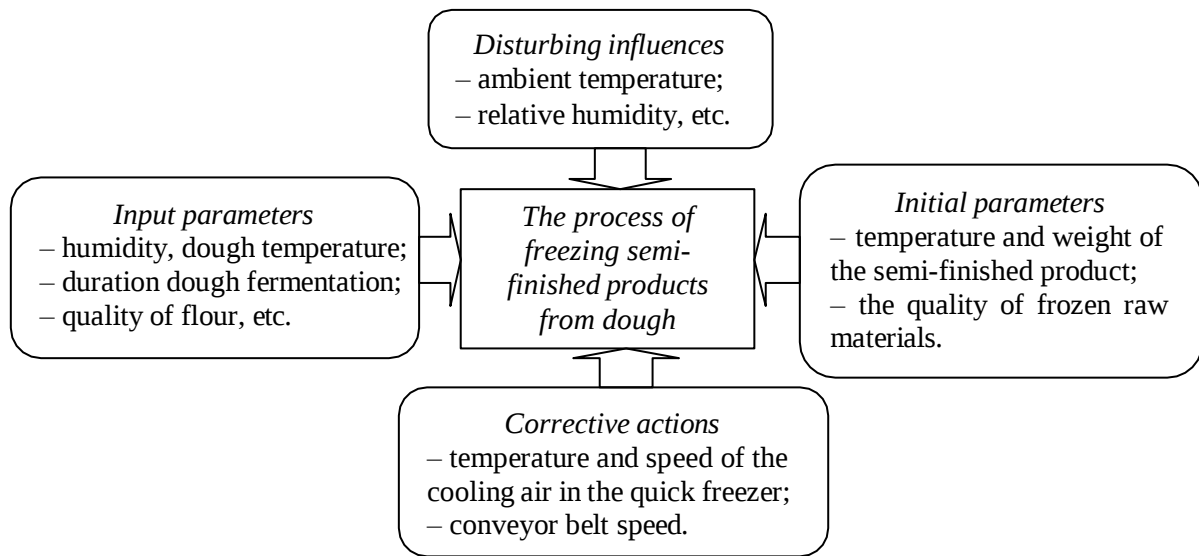


Figure 3 – Parametric diagram of the process of freezing semi-finished products from dough

Consider the technological scheme of freezing, which is based on a spiral conveyor. The block diagram shown in fig. 4 includes controls for predicting potentially expected temperature changes during freezing of semi-finished dough products.

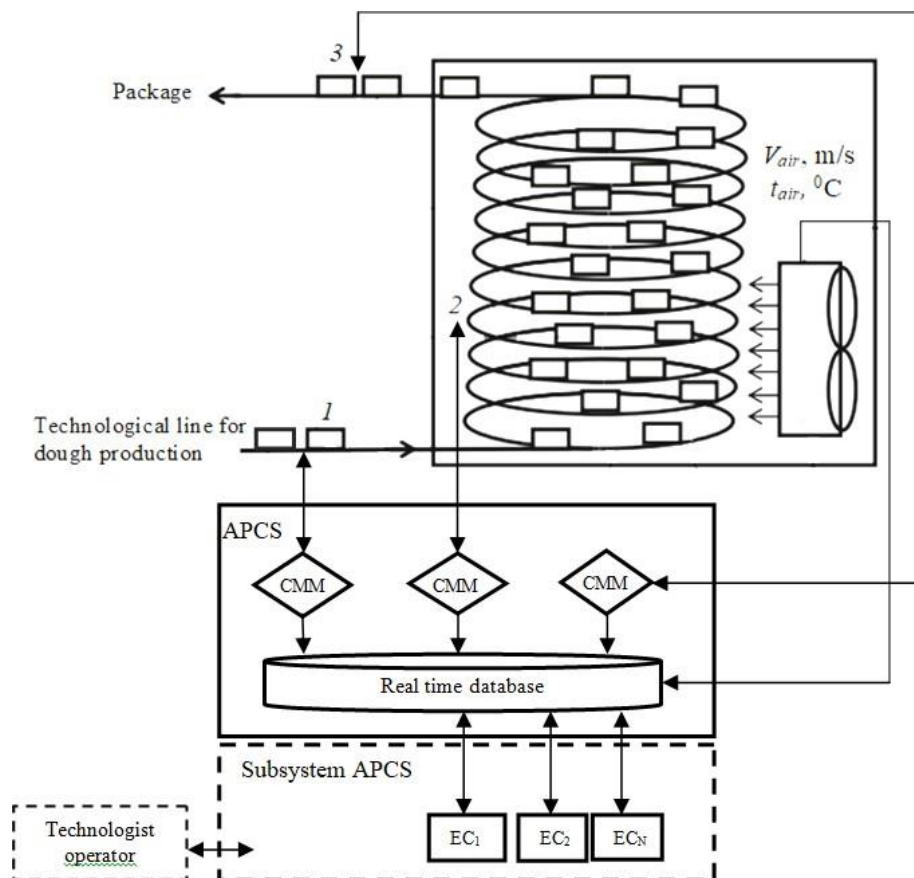


Figure 4 – Structural diagram of the dough freezing process in the technological process of its production

On fig. 4 presented: APCS – automated process control system; CMM – control and measuring means; EC – expert signal.

Control and measuring tools provide prediction of potentially expected temperature deviations at three stages: the temperature of the object coming from the production line (1), the temperature in the quick-freezing apparatus (2), the temperature of the object at the outlet of the quick-freezing apparatus (3) for the formation of corrective actions.

An improved block diagram of the process of freezing semi-finished products from dough based on automation tools is proposed. The automated complex makes it possible to form optimal values of control actions to improve the quality of the initial product with minimal energy consumption. The system provides for the introduction of corrective actions, namely: the temperature and speed of the cooling air, the speed of the conveyor belt to maintain a stable temperature for freezing semi-finished dough products. Proper freezing will ensure a stable quality of the finished product, exclude a small specific volume, a dense internal structure, and compaction of individual layers.

Conclusions. The modern development of the global catering industry is characterized by the introduction of technology for freezing semi-finished dough products. The technology makes it possible to provide consumers with a wide range of products and expand the sales network by creating mini-bakeries with an unfinished technological cycle. The use of frozen dough pieces in production is promising: the possibility of using quick-frozen semi-finished products in the fast-food system; process flexibility; preservation of the freshness of finished products by the time of its sale; long shelf life of semi-finished dough products; significant expansion of the range.

An improved block diagram of the process of freezing semi-finished products from dough based on automation tools is proposed. The automated complex makes it possible to form optimal values of control actions to improve the quality of the initial product with minimal energy consumption. The system provides for the introduction of corrective actions, namely: the temperature and speed of the cooling air, the speed of the conveyor belt to maintain a stable temperature for freezing semi-finished dough products. Proper freezing will ensure a stable quality of the finished product, exclude a small specific volume, a dense internal structure, and compaction of individual layers.

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Мета. Метою статті є удосконалення спірального швидкозаморозильного апарату для заморожування напівфабрикатів із тіста на основі засобів автоматизації.

Методи. У роботі для удосконалення спірального швидкозаморозильного апарату для заморожування напівфабрикатів із тіста, застосовано методи та засоби автоматизації технологічних процесів у харчовому виробництві.

Результати. Зазначено, що сучасний розвиток світової індустрії громадського харчування характеризується упровадженням нових технологій. Однією з таких технологій є швидке заморожування, яке дозволяє забезпечити споживачів більш широким асортиментом продукції та розширити мережу збуту за рахунок створення міні-пекарні з незавершеним циклом. На сьогоднішній день хлібобулочна промисловість виготовляє замороженні напівфабрикати (заморожена сировина), заморожені частково готові напівфабрикати і заморожені готові вироби. Розглянуто параметричну схему процесу заморожування напівфабрикатів із тіста, яка включає вхідні та вихідні параметри, що впливають на процес заморожування напівфабрикатів із тіста, а також обурювальні та керуючі впливи, необхідні для здійснення процесу автоматизації. На основі аналізу технологічного процесу з виготовлення тіста до основних (вхідних) параметрів було віднесено: вологість тіста, температура тіста після змішування, час бродіння тіста, якість борошна тощо. Вихідними параметрами є стабільна температура та маса продукту для отримання якісної сировини. Обурювальні впливи: температура навколишнього середовища, відносна вологість повітря тощо. Керуючі впливи включають моніторинг температури та швидкості охолоджуючого повітря, швидкість конвеєрної стрічки. Запропоновано структурну схему процесу заморожених напівфабрикатів з тіста на основі засобів автоматизації. Система передбачає введення коригувальних дій, необхідних для

підтримки основних показників стабільного замороження напівфабрикатів із тіста. Контрольно-вимірювальні засоби здійснюють вимірювання температури в три етапи: температура об'єкта, що надходить з технологічної лінії, температура в швидкоморозильному апараті, температура об'єкта на виході з виробничої лінії задля формування коригувальних дій. Правильна заморозка забезпечить споживача якісною готовою продукцією, виключаючи недостатній питомим об'ємом сировини, щільну внутрішню структуру і ущільнення деяких шарів.

Ключові слова: *спіральний морозильний апарат, заморожування напівфабрикатів, автоматизація, швидке заморожування, технологічна лінія, контрольно-вимірювальні засоби, тісто.*