Innovative technologies in the production of curd

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Abstract. At the moment, the Russian Federation has mastered various methods of making dairy products. Cottage cheese is considered one of the most beloved goods of the population. This is explained not only by its taste, but also by its nutritional and bioavailability. Future progress in the production of cottage cheese must be achieved both through the introduction of comprehensive mechanization and automation of production processes, and through the use of investments for the technical reequipment of equipment and the installation of new lines. During the reconstruction and modernization of production facilities, mainly automated lines of manufacturing plants from Germany, Denmark, Poland, Bulgaria are installed. At some factories, work continues on the lines for the production of acid curd Ya9-OPT (Russia). In this regard, it is important to improve the existing and create new equipment for the production of curd and curd products. Along with the development of new methods for the production of curd and curd products, in order to increase their competitiveness, it is quite reasonable to use technologies with a closed method of conducting the process, i.e. it is necessary to exclude the influence of the human factor on a complex technological process. For the successful sale of products, it is necessary to expand the range of cottage cheese products, improve their quality and price competitiveness, develop production with a high proportion of prepackaged and packaged products with a design that meets consumer demand. It is necessary to increase the degree of factory readiness of products for direct consumption.

1. Introduction

In Russia, there is a constant increased demand for the production and consumption of cottage cheese, which is due to both the consumer's habit and the attractive taste of the product. In addition, cottage cheese and products made from it have a high nutritional value and are affordable [1,2,3].

Fatty cottage cheese is best used in its natural form, low-fat - for making curd products (cheesecakes, puddings, etc.). From a mixture of buttermilk and skim milk, table dietary cottage cheese (3% fat) is produced. Soft dietary cottage cheese, low-fat (5 or 11%), as well as sweet, has a delicate consistency. They produce dietary fresh low-fat cottage cheese, its acidity is 2-3 times less than that of other species.

Cottage cheese has a significant content of well-balanced protein (14-16%). Cottage cheese proteins are digested better than meat, fish and even milk proteins: 300 g of cottage cheese almost completely satisfies a person's daily protein requirement. It should be noted that during the production of cottage cheese, almost all the valuable components of milk pass into the finished product. Also, the high
nutritional value of cottage cheese is due to the increased content of amino acids important for the human body - methionine, lysine and choline. Methionine promotes the elimination of cholesterol from the body, choline is necessary for the normal functioning of the nervous system. Methionine and choline also normalize liver function, preventing obesity. Curd has a lipotropic effect and is widely used in diseases of the liver, cardiovascular system, obesity, diabetes, after burns and bone fractures, and many other diseases [4].

2. The results and discussion
Features of technological equipment for the production of cottage cheese are determined by the methods of its production. In one of the farms of the Irkutsk region, cottage cheese is produced in the traditional way, the scheme of which is shown in figure 1.

Figure 1. Scheme of the technological line for the production of curd in the traditional way:
1 – milk container; 2 – balancing tank; 3 – pump; 4 – separator-cleaner;
5 – plate pasteurization and cooling unit; 6 – curd bath; 7 – press cart; 8 – cooler for curd;
9 – automatic cheese filling machine; 10 – fermentor.

In the production of curd in the traditional way, for fermentation of normalized milk, special tanks are used to separate whey from the curd mass, presses and self-pressing baths. All equipment for the production of curd can be divided into several groups: equipment for obtaining and processing a curd, cooling and packaging of curd [5,6].

Milk normalization is the regulation of the composition of raw materials to obtain a finished product that meets the requirements of the standard. Milk standardization can be carried out by mixing the main milk constituents such as cream or skim milk. Mixing normalization is carried out in storage tanks and baths equipped with agitators. To reduce the mass fraction of fat in whole milk, it is mixed with skim milk, and to increase it – with cream. In the flow, milk is standardized in separators-cream separators equipped with special devices for standardizing [4,5,6].

At enterprises, normalization is carried out in three ways:

- in the presence of the required amount of cream and skim milk, they are added to whole milk, mixed and at the same time the mass fraction of fat is regulated in it;
- part of the whole milk supplied for processing is separated, cream and skim milk are obtained, and then the rest of the non-skimmed whole milk is mixed with skim milk and cream, while regulating the mass fraction of fat;
- all milk supplied for processing is normalized, and the part of the cream and skim milk remaining from the normalization is taken away for further processing.

Milk cleaning is carried out to remove mechanical impurities. Cleaning is carried out in a milk separator with centrifugal sludge discharge. The cleaning process is best done at temperatures between 40 and 45°C.
The normalized pasteurized mixture is fermented with a sourdough prepared on pure cultures of lactococci at a temperature of 30°C in the cold season and 28°C in the warm season. With the accelerated fermentation method, a symbiotic starter culture is used, prepared on the cultures of lactococci and thermophilic lactic acid streptococci. In this case, the mixture is fermented at a temperature of 32°C [7,8,9].

The dose of the starter culture, depending on its activity and the required duration of fermentation, is from 30 to 50 kg per 1000 kg of the fermented mixture; in order to accelerate the fermentation process, up to 100 kg of sourdough is added to the mixture per 1000 kg of the fermented mixture.

After adding the starter culture to the mixture, calcium chloride is added at the rate of 400 g of anhydrous calcium chloride per 1000 kg of the mixture to be fermented. Calcium chloride is introduced in the form of an aqueous solution with a mass fraction of calcium chloride from 30% to 40%. A solution of calcium chloride is prepared according to the instructions for techno chemical control at dairy enterprises, approved in accordance with the established procedure [8,10].

After adding a solution of calcium chloride, rennet powder, food pepsin or an enzyme preparation in the form of a solution with an enzyme mass fraction of not more than 1% are added to the mixture. The dose of the enzyme with the activity of 100,000 IU per 1000 kg of the fermented mixture is equal to 1 g.

Stirring the mixture after fermentation is continued from 10 to 15 minutes, then the mixture is left alone until a clot of the required acidity is formed: 60±2°T for cottage cheese with a mass fraction of fat 18.0; 9.0%; 73±2°T for cottage cheese with a fat mass fraction of 5.0; 4.0%; 75±5°T for fat-free cottage cheese (fat mass fraction 1.8%). The duration of fermentation of the mixture with an active bacterial starter culture at the temperatures indicated above is from 6 to 10 hours from the moment of adding the starter culture, with an accelerated method – from 4 to 6 hours [1].

To accelerate the separation of whey, the finished curd is heated for 30 to 60 minutes by introducing steam or hot water into the interstitial space of the bath. For uniform heating of the clot, the upper layers are gently mixed from one wall of the bath to the other, due to which the lower heated layers gradually rise up, and the upper layers go down. The curd, heated to the above temperature, is kept for 20 to 40 minutes, then cooled by at least 10°C by running cold or ice water into the interlink space [8,9,10].

The released whey is discharged from the bath and collected in a separate container. The duration of pressing the curd in the press cart lasts at least 1 hour. Then a metal plate is placed on the serpyanka, on which pressure from the press screw is transmitted through a special frame. Pressing continues until the curd reaches the mass fraction of moisture, due to the current technical documentation for this product, but no more than 4 hours. It is allowed to press cottage cheese in a cold chamber for no more than 10 hours.

For packing cottage cheese, parchment, cups, boxes made of polystyrene tape, from combined materials are used with the application of the appropriate requisites. Marking of consumer containers, cottage cheese must comply with STB 1100. Each packaging unit of the product must be coated with an indelible, odorless paint approved for use by the Ministry of Health of the Russian Federation and in other ways the following information: product name; name and location (legal address, including country) of the manufacturer; manufacturer's trademark (if any); net weight, g (kg); the composition of the product; the nutritional value; the number of lactic acid microorganisms; thermal state (for frozen product); storage conditions; date of manufacture; shelf life; designation of this standard; designation of a technological document in the presence of expiration dates other than those established by this standard; information on confirmation of conformity (if any); barcode identification.

The shelf life of frozen cottage cheese is calculated from the moment of their release from the manufacturer. In the absence of cold at the trading enterprise, the shelf life of cottage cheese is reduced to 12 hours, and the sale of other products is not allowed. Long-term storage of frozen cottage cheese is possible only in refrigerators or wholesalers [8,9,10].

At a dairy plant in the curd shop, work begins with a milk pasteurization tank, where milk has already arrived from the equipment shop. The tank for pasteurized milk has a volume of 9.500 tons, there are two of them in production. Milk is brought to a certain temperature in the warm season up to 30°C, in the cold up to 32°C.
Then the milk goes into curd baths of VTN-3.5P type. The bath has a working capacity of 3500 liters. The design of the bath for the production of curd is a stainless steel tank mounted on supports. The tank is equipped with a heat exchange jacket, in which a constant temperature is maintained by supplying water or steam. The device provides a branch pipe for supplying water of different temperatures, overflow and drainage systems. The curd bath is shown in figure 2.

![Curd bath](image)

**Figure 2.** Curd bath:
1 – water drain pipe; 2 – valve for draining whey and curd; 3 – overflow pipe; 4 – funnel;
5 – park shirt; 6 – steam pipe; 7 – inner perforated half-bath; 8 – external bath; 9 – supports

The bath is filled with milk mixture at the fermentation temperature. Then the water jacket is filled with water to the overflow level. Steam is supplied to the water and the boiling process begins.

At the end of the boiling process, ice water is fed into the space between the walls to the overflow level. The cooling process takes place. The bath is equipped with a coil for more efficient cooling. The coil allows you to supply ice water under a pressure of 0.15 MPa, which significantly improves the cooling process [8,9].

After the end of cooling, it is necessary to separate the whey from the curd grain. For this, a disc drain valve is provided in the unloading hatch. Part of the formed whey is drained through the tap. The main process of separating the whey is carried out using a perforated press. The press is driven by two pneumatic cylinders. When the press is lowered to the lower position, the curd is pressed against the walls of the bath, and the whey is separated through the openings of the press. In the lower position of the press, the whey is pumped out through the upper open part of the bath using a food hose and pump. To achieve the required consistency, it can be carried out several times.

Next, the curd is transported by trolleys to the screw bath for cooling. Cooler of curd with two screws, model OT-2. Designed for continuous cooling of the curd and obtaining a smearing consistency of curd at the exit. The curd is fed by trolleys to the cooler hopper. The augers, rotating towards each other, move the cottage cheese from the side walls of the hopper to the center, capturing it in turns and move it inside the cooling cylinders. Ice water circulates inside the cylinders and augers, with the help of which the curd is cooled. From the outlet covers of the cylinders, the curd goes into the curd cart.

The temperature of the curd at the inlet to the cooler is from 28 to 30°C. The temperature of the curd at the outlet from the cooler is from 8 to 10°C. After the curd has cooled, it is moved to a cart and transported to the filling machine [6,7].

Automatic filling machine for curd M6-AR2T manufactured in the city of Kirov at the Plant named after V.A. Degtyareva. It is intended for packing and packaging cottage cheese, sweet curd mass in briquettes of 125 g and 250 g. Products are packaged in parchment or aluminum foil with a pre-printed label. The technological cycle of the machine consists of the following operations: loading the bunker with the product; filing of packaging material and date stamping; pieces of tape of packaging material; transfer of the scan on the forming die; forming the box and placing it in the nest of the forming table; dosage of a certain portion of the product in the box; folds of the edges of the briquette; the end of pressing, ensuring the density and final embedding of the briquette; shooting of finished briquettes from
the forming table to the inverter, which overturns the briquettes by 180° and feeds them to the conveyor belt. All operations take place simultaneously in all slots of the forming table with its sequential periodic movement.

The production of a product on such equipment has a number of significant drawbacks: an open method, a large proportion of manual operations, and the inexpediency of automation in this hardware design. At the same time, cottage cheese can be obtained with a different mass fraction of fat by methods of both acidic and acid-rennet coagulation.

Taking into account the modern requirements for the production of cottage cheese and the features of traditional technology, a number of equipment has been developed and a complete automated line for the production of cottage cheese in a closed way A-TL-6 has been formed.

The open method of producing curd is not very hygienic. During the manufacturing process, it is possible that harmful microorganisms and foreign mechanical impurities can enter, so that this does not happen, an automated installation of a closed production line A-TL-6 is made. Basic automated operations of the A-TL-6 line:

1. Obtaining and processing of curd in a curd manufacturer;
2. Filling and dosing curd by means of a rotary pump;
3. Self-pressing, pressing and cooling of the curd in the installation;
4. Sanitization of basic equipment and pipelines.

Two people are required to service this installation, the daily output of finished products is 1800 kilograms. The advantage of A-TL over the existing equipment at the dairy is that it requires less human influence to produce curd. The basic configuration of this equipment includes: a curd manufacturer and a curd pressing machine. The A-TL-6 unit is shown in figure 3.

![Figure 3. Installation A-TL-6.](image-url)

The organization of the technological process is as follows:

- 1 – the curd from the manufacturer of curd is fed by a volumetric pump to the pressing installation and, with the help of a dispenser, is distributed over the filter elements (bags) in several cycles;
- 2 – the number of cycles is set by the program based on the quality and volume of the curd.
- 3 – after filling the filter elements with the entire volume, self-pressing of the curd takes place with spontaneous separation of whey;
- 4 – further bringing the moisture content of the product to the required parameters is carried out by cyclic pressing with a holding time set by the program;
- 5 – cooling is carried out simultaneously with the self-pressing and pressing processes.
- 6 – after determining the readiness of the curd, the filter elements with the finished product are automatically discarded;
• 7 – an operator servicing the pressing installation transfers the finished product from the filter elements into polymer boxes with a polyethylene liner, located on a euro pallet. Filled boxes are moved to the storage room or for packing;
• 8 – equipment sanitization is carried out by sequential mechanized supply of washing solutions along the circuits: cottage cheese manufacturer, UTS installation, process pipelines;
• 9 – sanitization is carried out in accordance with the instructions for sanitization of equipment, inventory and containers at dairy enterprises.

3. Conclusion
An innovative solution is a more convenient installation, since the closed type of curd production is protected from external influences. The compactness of the line allows you to significantly reduce the occupied production area, which ultimately is reflected in a decrease in production costs. Possibility of producing cottage cheese in cottage cheese makers using the acid-rennet method. A closed process, the design of each individual piece of equipment allows it to be washed in an automatic mode.

The entire line is controlled by a programmable controller. In the production of cottage cheese, one of the difficult tasks is also the creation of a product, the quality characteristics of which remain constant from batch to batch.

Manual production is the cause of the substandard end product. And most importantly, the traditional structure of the product has been preserved, which is important for the end consumer.

References
[1] Kozub Y A 2018 Development of the dairy industry in the Irkutsk region. In the collection: Problems in animal husbandry Materials of the international scientific and practical conference pp 30-6
[2] Kozub Y A 2013 Influence of carbohydrate-vitamin-mineral concentrate (UVMK) on milk quality Vestnik IrGSKhA 59 92-6
[3] Vlasov B, Karelina L and Kozub Yu 2012 Metabolic aspects of cows' productivity when feeding "Felucene" Dairy and beef cattle breeding 5 19-20
[4] Kozub Y A 2017 Improving the efficiency of milk production Bulletin of the Irkutsk State Agricultural Academy 81(2) 50-4
[5] Komlatsky V I, Podoinitsyna T A, Verkhoturov V V and Kozub Y A 2019 Automation technologies for fish processing and production of fish products J. Phys.: Conf. Ser. 1399 044050
[6] Kozub Y A, Komlatsky V I and Khoroshailo T A 2020 About some automated processes in the production of dairy products IOP Conf. Ser.: Mater. Sci. Eng. 862 032021
[7] Kozub Y A 2019 Improving the quality and improving the use of livestock products State and prospects for the development of animal husbandry and veterinary medicine in Siberia and the Far East (Federal State Budgetary Educational Institution of Higher Education "Buryat State Agricultural Academy VR Filippov", Ulan-Ude) pp 131-5
[8] Komlatsky V I, Takho-Godi A Z and Podoinitsyna T A 2017 To the problem of automation of technological processes of milk processing and production of dairy products Proceedings of the Kuban State Agrarian University 69 266-42
[9] Komlatsky V I et al. 2020 Technological process intensification trends in livestock J. Phys.: Conf. Ser. 1515 022009
[10] Khoroshailo T A and Kozub Y A 2020 Robotization in the production of dairy, meat and fish products J. Phys.: Conf. Ser. 1515 022007