Experimental studies have proven the effectiveness of the use of the herbal dietary supplement "Immunocort" in the technology of rennet cheese "Mozzarella Ukrainian". "Immunocort" is an herbal preparation that contains a balanced complex of immunoactive plants aimed at strengthening the immune system and eliminating immunodeficiency. The composition of the dietary supplement includes astragalus herb, echinacea root, Damascus blackberry seeds, currant leaf, string grass, Uncaria bark, and ant tree bark.

Based on organoleptic and physical-chemical studies, it was established that the best option in the manufacture of "Mozzarella Ukrainian" cheese is to add to the normalized mixture before its pasteurization of the "Immunocort" supplement in the amount of 3 % by weight of the normalized mixture.

A study was conducted on the effect of the coagulation temperature and pasteurization temperature on the synergistic properties of the cheese clot. These indicators confirmed the significant importance for the transition of solids into whey in the process of making rennet cheese "Mozzarella Ukrainian" with the bio additive "Immunocort". It was found that with an increase in temperature, there was a decrease in the syneretic ability of cheese clots. The efficiency of using solids increased with increasing pasteurization temperature. The relatively low content of dry substances in whey at high pasteurization temperatures can be explained by the denaturation of whey proteins and their transition to a cheese clot. The best results were achieved at the pasteurization temperature (86±2) °C and the coagulation temperature (32±2) °C.

The data obtained could make it possible to manage the process of making new types of cheeses with vegetable additives, depending on the specific conditions and requirements for the product

Keywords: rennet cheese, "Mozzarella Ukrainian", herbal supplement, "Immunocort" supplement, cheese clot

UDC 637.3
DOI: 10.15587/1729-4061.2023.272399

INFLUENCE OF THE BIOLOGICALLY ACTIVE SUPPLEMENT "IMMUNOCORT" ON THE PRODUCTION AND QUALITY OF THE "MOZZARELLA UKRAINIAN" CHEESE

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Received date 01.12.2022
Accepted date 03.02.2023
Published date 28.02.2023

***How to Cite**: Nagovska, V., Mykhaylytska, O., Slyvka, N., Bilyk, O., Hachak, Y. (2023). Influence of the biologically active supplement "immunocort" on the production and quality of the "Mozzarella Ukrainian" cheese. Eastern-European Journal of Enterprise Technologies, 1 (11 (121)), 31–40. doi: https://doi.org/10.15587/1729-4061.2023.272399*

1. Introduction

The world faces a deviation from a balanced diet these days [1]. Analyzing the set of foods that the population consumes, it is possible to identify a number of violations of nutritional status in adults and children. In particular, it is an increased caloric content of the diet due to the high content of animal fats and carbohydrates. Moreover, there is an insufficient amount of consumption of vegetable oils, proteins, vitamins, and dietary fiber [2]. The lack of quality food and the harmful effects of the polluted environment adversely affect the functioning of the human body [3]. That is why proper balanced nutrition should ensure full development, adaptation to the effects of toxic effects and cause high activity throughout a person's life [4].

Today, the development and manufacture of food products with specified properties – with a low content of animal fat, salt, and carbohydrates – is relevant. The range is also expanding and increasing the volume of production of products that are enriched with proteins, dietary fiber, minerals, and biologically active substances [5].

Among all food products, a special place is occupied by dairy products, in particular rennet cheeses. Cheese is a product of high biological and energy value, which contains essential and simple compounds of protein and non-protein nitrogen, which are absorbed easier and faster than milk proteins. In addition, cheeses contain a complex of fat, the mass fraction of which is in the range from 5–10 to 60 % in dry matter, water-soluble vitamins, and trace elements [6, 7].

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The main principles of creating new cheeses with a combined composition are to reduce calorie content and increase the content of biologically active substances. Such products must have a high taste and have a functional purpose [8].

The relevance of the research is to study the possibility of using dietary supplements of plant origin in the production of rennet cheese. This will not only expand the range of useful food products but also improve their organoleptic characteristics and chemical composition.

2. Literature review and problem statement

In works [9–17], a large number of research results are given on the use of various plant components in the production of cheeses to obtain products with specified characteristics. It is shown that cheeses are traditional food products in many countries of the world. Cheeses with herbal supplements continue to gain popularity among supporters of a healthy diet.

Analyzing the sources, it was found that considerable attention is paid to the manufacture and research of cheeses with the use of aqueous extracts of herbs or essential oils in their technology [9–13]. However, it should be noted that in most of the studies conducted, the addition of plant extracts was intended not only to increase the content of bioactive components and limit oxidation but also to increase the microbial stability of the product. In particular, studies are being conducted on the use of encapsulated extracts as cheese supplements. The extracts demonstrate excellent antioxidant and significant antimicrobial effects. But usually, they are not as powerful as essential oils. A number of experiments were carried out on the effect of encapsulated extracts from different plants on the physicochemical and microbiological profile of various cheeses. In order to extend the shelf life and maintain quality throughout the entire storage period, without adversely affecting the organoleptic characteristics, encapsulated essential oils and extracts have been included in various types of cheeses. The results of the study showed that due to encapsulation in various carriers, biologically active compounds are protected from oxidation, evaporation, and interaction with other components of the food matrix [9].

In [10], the use of nanoemulsions of coriander seed extract as a preservative for soft cheese is proposed. Coriander is a medicinal culinary plant. Its main value is in the seeds, which contain essential oil in the range from 0.3 to 1.1 %. It has been proven that extracts and essential oils derived from coriander exhibit antimicrobial, antioxidant, antidiabetic, anti-cancer, and antimutagenic effects. Coriander is the main source of flavonoids, phenols, and vitamins. Coriander can also be used as a flavoring in food. However, the authors have not investigated the possibility of using the coriander seed itself as a herbal supplement in the production of cheese.

The use of whey protein concentrate and aqueous extracts of rosemary and sage for the production of active food packaging materials for soft cheese was investigated. In samples of cottage cheese covered with edible films enriched with infusions, no spoilage and pathogenic bacteria were found until the end of storage. Rosemary and sage infusions were chosen for inclusion in the film because they had a high total content of phenols and flavonoids and showed good antioxidant properties. Their main phenolic compound was rosemary acid. Also, with the help of such packaging, you can control the taste and color of the cheese. In addition, consuming such cottage cheese with an edible film, you can avoid the formation of waste [11]. However, due to the hydrophilic nature of the films and the high water content in soft cheese (about 70 %), the films were absorbed by the surface a few minutes after coating. Thus, coated cheese should be considered as a new, probably functional food, as the films could not be separated from the cheese and they were not colorless and odorless.

In [12], studies have been carried out on the production of Cheddar-type cheeses enriched with extracts of marigold British flowers (*Inula Britannica*). It was found that higher concentrations of extracts resulted in a higher protein and ash content with a concomitant decrease in pH, total dry matter, and fat content compared to unsaturated control cheese. In addition, the use of flower extract gave the desired texture to the cheese and enhanced the smell and taste. The total phenol content also increased with the concentration of the plant extract but decreased over long storage periods. Overall, the marigold flower extract has demonstrated good potential as an antioxidant supplement for dairy products. However, it should be noted that the benefits of bioactive substances can be obtained using parts of plant material in the product. However, the study of the effect of crushed marigold flowers on cheese production was left out of the focus of this study.

Experimental studies were also conducted on the feasibility of using both extracts and oregano essential oil in the dairy industry. In nanoemulsions, oregano essential oil acted as a dispersed phase, and the corresponding aqueous extract acted as a continuous phase. Oil-in-water nanoemulsions have been prepared by sonication as a system for the delivery of oregano bioactive compounds. These systems were incorporated into traditional and Greek whey cheeses Mizitra and Antothyro. Sensory analysis has shown that oregano nanoemulsions affect the organoleptic profile of both types of whey cheeses [13]. However, most bioactive extraction protocols that are safe for human consumption (aqueous, ethanol extracts, and essential oils) do not allow the extraction of all bioactive compounds from plant materials. Therefore, to take advantage of the biologically active substances of many plants (such as sulfur compounds, polyphenols, etc.), it is best to include these plants directly in foods. This approach was used in work [14]. In the production of cream cheese, pink onion leaves (*Allium roseum*) were used in powder form and fresh leaf paste in quantities of 0.8 % and 6 %, respectively. The positive effect of these additives has been proven on the basis of sensory, physicochemical, and microbiological qualities. The results showed a significant extension in the shelf life of cream cheeses. However, determining the effect of powder and paste from pink onion leaves on technological processes in the production of cheese was left unattended.

Paper [15] describes the study of ultrafiltration soft cheese containing red radish root in the form of a nanopowder. Nanopowder was introduced in concentrations of 1, 2, and 3 %. The chemical, rheological, sensory, and antioxidant properties of cheese during storage for a month were investigated. It was found that it had an in-

creased amount of protein, minerals, fiber, and had good antioxidant activity. Adding red radish roots in the form of a nanopowder improves the quality of cheese products, as well as increases their nutritional value. But this study does not pay attention to the effect of the additive on the technological process of cheese production, which is also important.

The use of spinach powder as a functional ingredient in the production of ultrafiltration soft cheese is also described. Spinach nanopowder was applied in the amount of 0.5, 1, 1.5, and 2 %. Due to the addition of nanopowder with retentate, the content of fiber, minerals, phenols, as well as antioxidant activity was increased. In addition, the protein content and acidity of the product increased significantly with an increase in the percentage of added herbal supplement [16]. The processes that occur in the manufacture of ultrafiltration soft cheese from spinach powder have not been investigated.

The technology of functional soft rennet cheese "Mozzarella-manzar" with herbal additives has been developed. In the technological scheme of production of this cheese, they proposed the introduction of dill and parsley in a dry form in the amount of 1 % at the stage of readiness of the curd mass [17]. However, this paper did not study the issue of making a herbal supplement at other stages of cheese production.

The production of rennet cheeses with the bio additive "Immunocort" is a very promising area of research. The herbal preparation "Immunocort" contains a complex of plants aimed at strengthening the immune system and eliminating immunodeficiency. It increases antiviral, antibacterial, antitumor protection of the body, prevents the development of respiratory viral diseases, neutralizes the negative effects of aggressive environments, stress, bad habits. "Immunocort" has a tonic, anti-inflammatory, antioxidant effect, promotes the development of its own interferon, eliminates hypersecretion of adrenaline, norepinephrine, increases the activity of phagocytes, macrophages, and leukocytes, restores impaired functions. It promotes better recognition of cancer and precancerous cells and their destruction in the early stages, provides effective support of the immune system during a massive microbial attack, radiation, intoxication. "Immunocort" is recommended for people with weakened immunity, who often and for a long time get sick, with immunodeficiency states, allergies, frequent colds. The composition of the dietary supplement includes astragalus herb, echinacea root, Damascus blackberry seeds, currant leaf, string grass, cat's claw bark, and ant tree bark.

The literary sources [9–17] did not reveal data on the use of echinacea root, currant leaves, Damascus blackberry seeds, grass of the train and astragalus, cat claw bark, and ant tree, which have beneficial properties for the human body, in the technology of cheeses. All these immunoactive plants are contained in a balanced ratio in the composition of the drug "Immunocort". And because of this, it is necessary to conduct a comprehensive study to study the effect of the plant supplement "Immunocort" on the production and quality of rennet cheese.

3. The aim and objectives of the study

The aim of this work is to analyze the influence of the dietary supplement "Immunocort" on the production and quality of cheese "Mozzarella Ukrainian". This will expand the range of cheeses, as well as this cheese will be useful for consumers due to the natural ingredients that are part of the herbal supplement "Immunocort".

To accomplish the aim, the following tasks have been set:

– to establish the optimal amount of introduction of the "Immunocort" bio additive during the production of the cheese "Mozzarella Ukrainian";

– to study the syneretic properties of the cheese clot depending on the coagulation temperature and the pasteurization temperature of the normalized mixture;

– to study the dependence of the transition of solids into whey on the coagulation temperature and the pasteurization temperature of the normalized mixture;

– to determine the quality indicators of the finished product.

4. Materials and research methods

4. 1. The object and hypothesis of research

The object of our study is the cheese "Mozzarella Ukrainian" with the addition of the herbal dietary supplement "Immunocort". The main hypothesis of this study is that the introduction of the proper amount of dietary supplements will not lead to a decrease in the quality of "Mozzarella Ukrainian" cheese but will also increase the biological value, give it original organoleptic characteristics, and expand the product range.

4. 2. The study materials and methods

Experimental part of the work was carried out at the Lviv enterprise "Lemberg cheese" (Ukraine).

The main material for research was rennet cheese "Mozzarella Ukrainian" with the biologically active additive "Immunocort".

Two series of studies have been conducted. In the first series of studies, the dose of the "Immunocort" supplement was selected and the features of the "Mozzarella Ukrainian" cheese technology with a dietary supplement were studied.

The bio additive "Immunocort" (Fig. 1) was introduced in the amount of 1, 3, and 5 % by weight of the normalized mixture.

Rennet cheese "Mozzarella Ukrainian" with the bio additive "Immunocort" is made according to the technological scheme shown in Fig. 2.

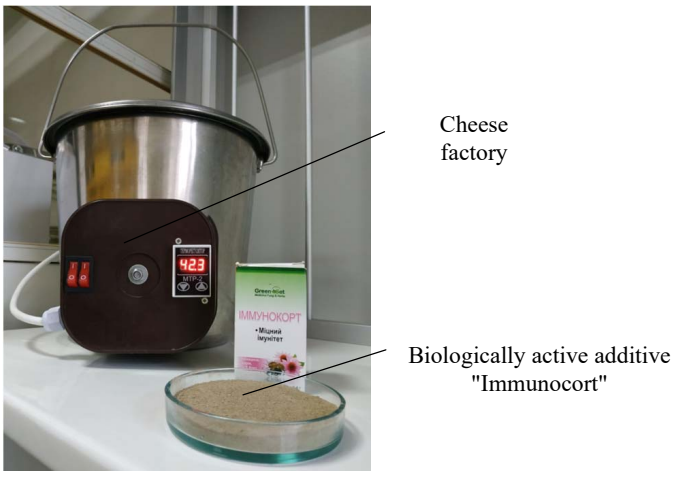

Fig. 1. Biologically active additive "Immunocort"

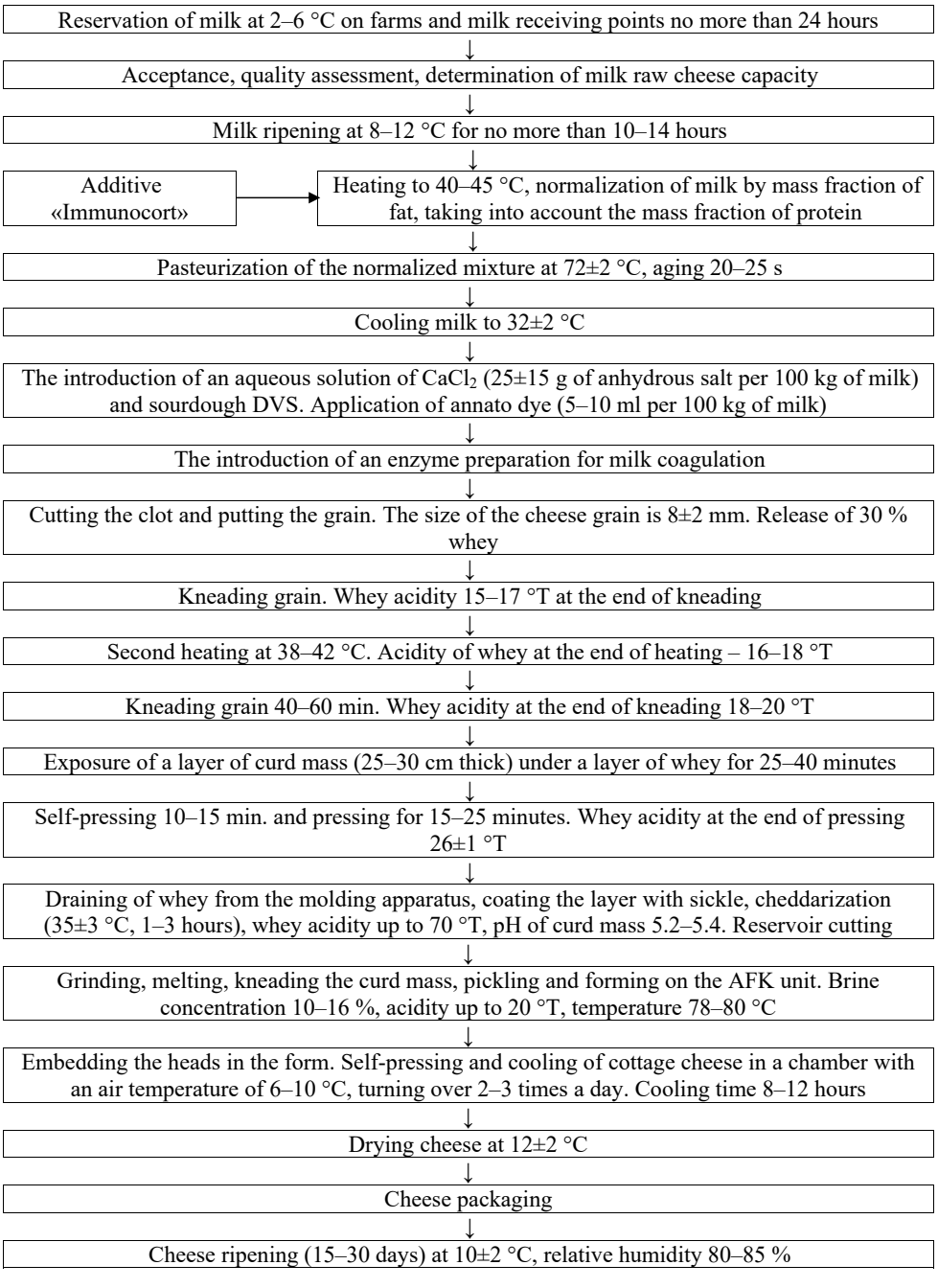

Fig. 2. Technological scheme of the rennet cheese "Mozzarella Ukrainian" with the biologically active additive "Immunocort"

Milk for the production of cottage cheese must meet the requirements of DSTU 3662:2018. Depending on the quality indicators, milk is sorted, its quantity is established, and suitability for cheese is determined. Then the milk is sent for aging at a temperature of 8–12 °C for 10–14 hours. Normalization of milk is carried out in a stream on separators-normalizers up to a mass fraction of fat of 3.1 % in a normalized mixture. Before separation, the milk is heated to a temperature of 40–45 °C in a plate pasteurization and cooling plant. In the tank with the normalized mixture, we add the bio additive "Immunocort" in quantities of 1, 3, and 5 % by weight of the normalized mixture. We pasteurize the mixture at a temperature of 72±2 °C with an aging of 20–25 s and cool it to a fermentation temperature of 32±2 °C. The cooled normalized mixture is fed into the cheese bath and an aqueous solution of $CaSl_2$, dry sourdough, and enzyme preparation for milk clotting are introduced. An aqueous solution of calcium chloride is applied at the rate of 25±15 g of anhydrous salt per 100 kg of milk. Next, the mixture is stirred for 3–5 minutes and left to form a homogeneous clot. Cheese clot should be of normal density and give an even fracture with sharp edges and highlight the whey of light green color. The cheese clot is processed in order to partially dehydrate the curd mass and regulate lactic fermentation. The processing of the clot consists of the following operations: cutting the clot and setting the grain, kneading the cheese grain, second heating, kneading after the second heating. Cutting the clot is carried out with liras for 10–15 minutes. The size of the cheese grain should be 8±2 mm. After cutting

the clot, when setting the grain from the bath, 30 % of the whey is eliminated from the total mass, the acidity of the whey before the second heating should be 15–17 °T. The temperature of the second heating is set in the range of 38–42 °C, the heating rate is 1 °C in 3±1 minutes. The whey acidity content after the second heating should be 16–18 °T. After the second heating, the cheese grain is kneaded for 40–60 minutes, the acidity of the whey at the end of grain processing should be 18–20 °T.

The peculiarity of "Mozzarella Ukrainian" cheese is its cheddarization, that is, keeping a layer of cheese under a layer of whey for 25–40 minutes. The thickness of the cheese layer should be 25–30 cm. During cheddarization, self-pressing of the cheese layer is carried out for 10–15 minutes and pressing for 15–25 minutes. The acidity of whey at the end of pressing is 26±1 °T.

Cheddarization of curd mass is a technological operation during which the necessary acidity and moisture of the curd mass is achieved. The curd mass acquires a layered-fibrous structure. To do this, the whey is removed from the molding apparatus, and the cheese layer is covered with lavsan and kept under a pressure of 1–2 kPa until the end of cheddarization. The readiness of the curd mass is set by melting breakdown, namely: pieces of curd mass with a thickness of 2–4 mm are cut out of the middle of the layer, dipped into hot water or brine at 71–72 °C. Curd mass, which is ripe, should stretch well into a long thread under its own weight.

Melting (heat treatment) of the curd mass is carried out in brine with an acidity of not more than 20 °T and a salt concentration of 10–16 %. The initial brine temperature is 78 °C, and during the melting process it is maintained at 74–80 °C. Warm-up temperature of the curd mass is 72–75 °C, the duration of the process is 5–8 minutes. Before warming up, the curd mass is crushed into pieces up to 6 mm in size. The temperature of the molten curd mass at the outlet of the unit must be at least 65–67 °C. Molten curd mass is separated from the brine and kneaded to a fibrous-elastic dough. Kneading takes place first in a drum with holes, which slowly spins, and then with the help of an auger, with which the curd mass is fed into the dispenser for packaging into the mold. Formed cheese heads weighing 1 kg in molds are fed into the chamber, where the air temperature is 6–10 °C, for self-pressing and cooling. For uniform cooling and obtaining a smooth surface, the cheese heads in the molds are turned over 2–3 times during the day. The cooling time is 8–12 hours, then the cheese is removed from the molds and sent to dry at a temperature of 12±2 °C. Dried cheese heads are packed on vacuum packaging machines into poviden bags. Cheese ripening is carried out at a temperature of 10±2 °C and a relative humidity of 80–85 % for 15–30 days. Packaging and labeling of cheese are carried out in accordance with the requirements of TUU 46.39.122-2001.

In the second series of studies, they studied the effect of pasteurization temperatures and coagulation temperatures of mixtures on the syneresis of cheese clots and the transition of solids into whey in the production of rennet cheese with the "Immunocort" supplement.

To establish the degree of syneresis in the production of rennet cheeses, the amount of whey was determined, which was released from the cheese clot for half an hour.

Samples of cheeses and whey were taken according to DSTU ISO 707:2002 Milk and dairy products. Sampling guidelines (ISO 707:1997, IDT), DSTU 4834:2007 Milk and dairy products. Rules for acceptance, sampling, and preparation of samples for control and DSTU ISO 5538:2004 Milk and dairy products. Sampling. Control over quality features (ISO 5538:1987, IDT).

Preparation of cheese samples for microbiological analyzes was carried out according to the methodology: DSTU IDF 122C:2003 Milk and dairy products. Preparation of samples and dilutions for microbiological research (IDF 122C:1996, IDT).

Evaluation of the quality of cheeses was carried out in accordance with generally accepted procedures. In cheese samples, we investigated the mass fraction of fat in cheese and dry matter of cheese in accordance with DSTU ISO 2446:2019 Milk. Determination of fat content (ISO 2446:2008, IDT). The mass fraction of sodium chloride in cheese was determined by the method of titration of the extract with silver nitrate (GOST 3627-81). The study of the mass fraction of moisture and solids in cheese and whey was carried out in accordance with DSTU 8552:2015 Milk and dairy products. Methods for determining moisture and dry matter. Organoleptic indicators of cheese samples were determined according to DSTU 6003:2008.

Bacteria of the E. coli group in 0.01 g of the product were determined in accordance with DSTU IDF 73A:2003 Milk and dairy products. Counting the number of coliforms. The method of counting colonies and the method for determining the most likely number at a temperature of 30 °C. The determination of *Staphylococcus aureus* was carried out in accordance with DSTU ISO 6888-1: 2003 Microbiology of food and animal feed. Horizontal method for calculating coagulase-positive staphylococci (*Staphylococcus aureus* and other species) (ISO 6888-1:1999, IDT). The presence of *Salmonella* was investigated in accordance with DSTU IDF 93 A:2003 Milk and dairy products. Definition of *Salmonella* (IDF 93A:1985, IDT).

5. The results of research on the effect of the dietary supplement "Immunocort" on the production and quality of cheese "Mozzarella Ukrainian"

5. 1. Study of the optimal amount of dietary supplement in the manufacture of cottage cheese

In the manufacture of dairy products, including rennet cheeses, their organoleptic characteristics are important. Therefore, first of all, they investigate their appearance, taste, smell, and color. Table 1 gives organoleptic indicators of all types of cottage cheese with different doses of biologically active additive of plant origin "Immunocort".

The introduction of a dietary supplement in different quantities revealed an impact on the formation of organoleptic indicators of "Mozzarella Ukrainian" cheese. From the data in Table 1, you can see that the most acceptable organoleptic characteristics is rennet cheese with a dietary supplement in the amount of 3 % by weight of the normalized mixture. Therefore, for further research, they chose this type of cheese.

Table 1

Organoleptic indicators of "Mozzarella Ukrainian" cheese with the "Immunocort" supplement

Indicator name	Characteristics for cottage cheese with a mass fraction of a supplement		
	1 %	3 %	5 %
Appearance	The surface is flat, covered with polymer film. Light delamination on the surface of the cheese is allowed		
Taste and smell	Lactic acid, moderately salted		
	There is a light taste and smell of currants and grass	Significantly more intense taste and smell of currants and grass, as well as a spicy taste of Uncaria and blackberry	The taste and smell of the grass and currants are clearly felt, the taste of Uncaria and blackberry becomes sharp
Consistency, pattern	There is no pattern, there are separate oval-shaped eyes. Plastic cheese, with light delamination		
	There are separate inclusions of plants included in the bio additive	The inclusion of powder supplements is clearly visible, evenly distributed over the entire head of the cheese	The inclusion of a dietary supplement is visible throughout the head of the cheese
Color	Barely cream with separate inclusions of dietary supplements	Cream, with clear inclusions of grayish-brown color	Cream, with a large number of grayish-brown inclusions

5. 2. Study of the syneretic properties of the cheese clot depending on the coagulation and pasteurization temperatures

From the literary data and studies [18, 19] conducted earlier, it was established that the formation of cheeses with vegetable and biologically active additives is greatly influenced by the number of herbal supplements made and the stage of their introduction. The content of the mass fraction of moisture in the finished product, organoleptic parameters, and the syneretic property of cheese clots depend on these factors.

At this stage, we studied the influence of individual technological parameters (pasteurization temperature, coagulation temperature of the mixture) on the formation of rennet cheese "Mozzarella Ukrainian" with the bio additive "Immunocort", which was added to the normalized mixture before its pasteurization.

The coagulation temperature was changed from 30 to 42 °C, the pasteurization temperature of the mixture was from 70 to 92 °C.

One of the most important indicators of a cheese clot is its syneretic ability. With the help of syneresis, you can control the process of formation of the structure of the protein gel, which contains the bio additive "Immunocort". This will affect the moisture content in the finished product, and also affect the yield of cottage cheese and its consistency.

The syneretic properties of the clot (the proportion of the released whey in 30 minutes) depend on the coagulation temperature and the pasteurization temperature of the normalized mixture.

The intensity of the isolation of whey from a cheese clot is influenced by each of the studied factors – this can be seen in the obtained graphs from Fig. 3, 4.

The process of separating the whey was influenced by the coagulation temperature. An increase in temperature (from 30 to 40 °C) led to an increase in the release of whey, contributing to the activation of processes occurring under the action of rennet enzyme, increasing the activity of the lactic acid process and reducing the viscosity of clots. At a coagulation temperature of 30 °C, the volume of whey released was 33 %. Of the clots coagulated at a temperature of 35 °C, the volume of whey released increased by 1 %. At a coagulation temperature of 40 °C, the whey volume was 34.7 %.

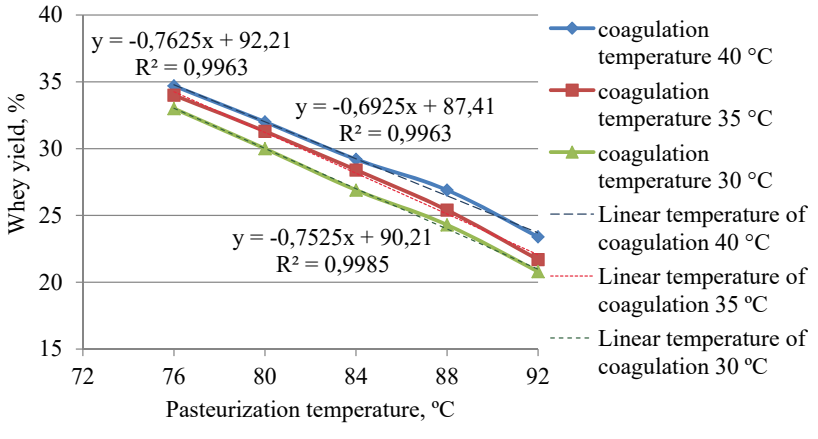

Fig. 3. The dependence of syneresis on pasteurization temperature

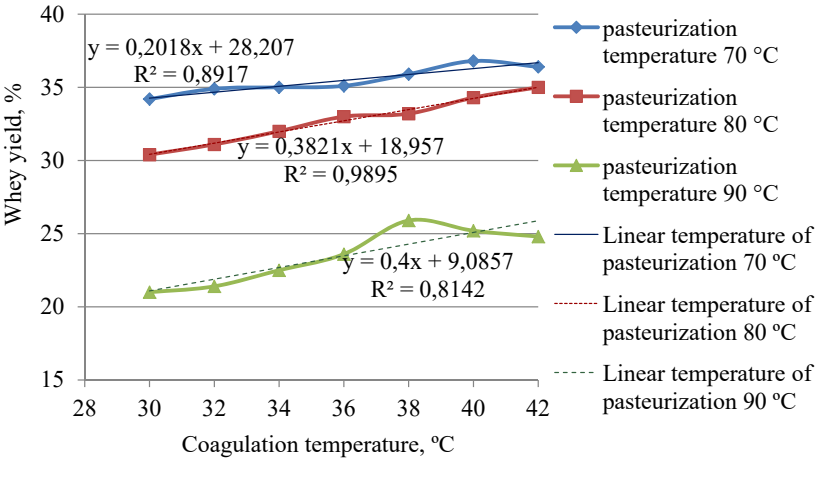

Fig. 4. The dependence of syneresis on coagulation temperature

Of the clots coagulated at a temperature of 30 °C, the minimum intensity of whey separation was 20.8 %; at a temperature of 35 °C – 21.7 %; at a temperature of 40 °C – 23.4 %.

An increase in the pasteurization regime has led to a decrease in the syneretic capacity of cheese clots. The amount of separated whey from pasteurized milk at 70 °C, coagulated at 40 °C, was 36.8 %. With an increase in the pasteurization temperature to 80 °C, a decrease in the syneretic ability of clots was observed. The amount of whey isolated is 34.3 %. With an increase in the pasteurization regime to 90 °C, the volume of separated whey decreased to 25.2 %. The syneretic capacity of cheese clots was significantly lower with all pasteurization regimes and a subsidence temperature of 30 °C. When pasteurized at a temperature of 70 °C, the amount of whey isolated is 34.2 %. Of the clots obtained using the pasteurization regime of 80 °C, the volume of the isolated whey was 30.4 %. When pasteurizing milk at 90 °C, clots isolated 21.0 % whey.

Thus, the intensity of the syneretic ability of cheese clots is influenced by pasteurization and coagulation temperatures. These factors are highly dependent on each other. The greatest influence on the whey separation process was exerted by the pasteurization temperature.

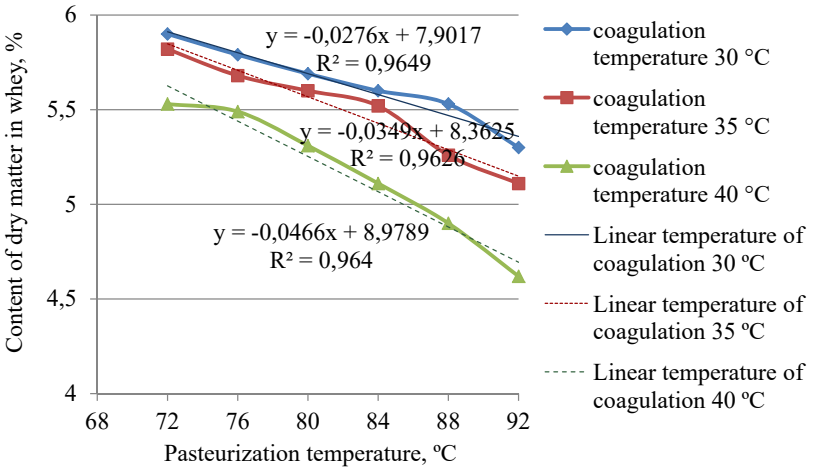

Fig. 5. The dependence of solids content in whey on pasteurization temperature

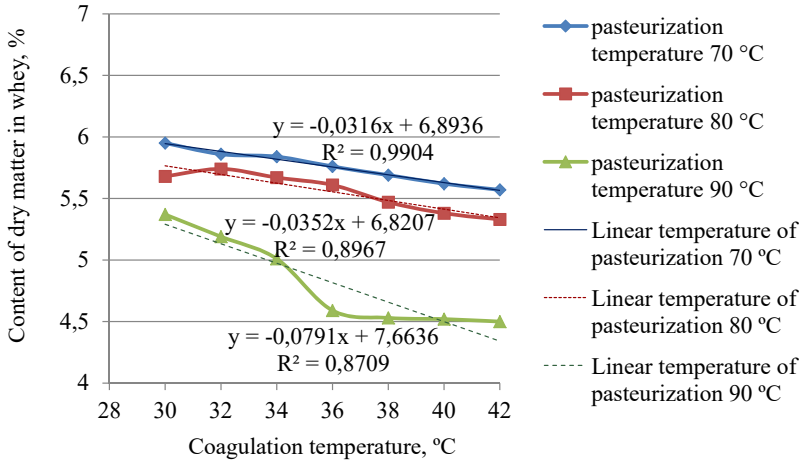

Fig. 6. The dependence of dry matter content in whey on coagulation temperature

5. 3. The results of studies of the dependence of the transition of solids into whey on the coagulation and pasteurization temperatures of the normalized mixture

The content of components such as fat and protein in milk has a significant impact on the yield of cottage cheese. How effectively these components of milk pass into the curd mass can be concluded by their content in whey.

In whey, which separated as a result of the treatment of clots coagulated at a temperature of 30 to 40 °C, a decrease in the dry matter content was observed (Fig. 5).

When processing clots obtained at a coagulation temperature of 30 °C, the maximum dry matter content was 5.9 %; minimum – 5.3 %.

Analyzing the graphic dependence shown in Fig. 6, note that with an increase in the temperature of pasteurization, the degree of transition of solids into the whey decreased.

The maximum solids content in whey separated during the processing of clots obtained from pasteurized milk at 70 °C and coagulated at 30 °C was 5.95 %. While maintaining the coagulation regime and increasing the pasteurization temperature to 80 °C, the degree of transition of solids into the whey decreased to 5.68 %. In the pasteurization mode of 90 °C, the dry matter content in the whey acquired the minimum value of 5.37 %.

When processing clots coagulated at 40 °C, a decrease in the content of solids in the whey was observed. Under pasteurization modes of 70, 80, and 90 °C, the degree of transition of solids into the whey was 5.62; 5.38; and 4.52 %, respectively.

5. 4. The results of examining indicators of the quality of the finished product

It is known that the physicochemical and microbiological parameters of dairy products are very important in assessing their quality and safety for consumption. Therefore, Tables 2, 3 give the corresponding characteristics of cottage cheese with a dietary supplement.

Studies of the mass fraction of fat in the dry matter of cottage cheese showed that the value of this indicator ranged from 50.36 to 50.58 %. It should also be noted there was a decrease in the mass fraction of moisture in cottage cheese with an increase in the dose of the introduced supplement. Regarding the content of salt, it is worth noting that the use of the dietary supplement "Immunocort" in the technology of cheese "Mozzarella Ukrainian" did not affect its level.

Bacteria of the E. coli group in 0.01 g of cottage cheese and salmonella in 25 g were not detected. The amount of *Str. aureus* in 1 g of the product was within the normal range.

So, our studies of "Mozzarella Ukrainian" cheese with the "Immunocort" supplement have shown that all types of cheese meet the requirements of regulatory documentation for all indicators.

Table 2

Physical and chemical indicators of cheese "Mozzarella Ukrainian" with the bio additive "Immunocort"

Indicator	The value of the indicator for cottage cheese with a mass fraction of dietary supplements		
	1 %	3 %	5 %
Mass fraction of fat in dry matter, %	50.45±0.43	50.58±0.64	50.36±0.58
Mass fraction of moisture, %	47.81±0.16	47.12±0.18	45.76±0.13
Mass fraction of salt, %	1.77±0.09	1.70±0.08	1.68±0.09

Table 3

Microbiological indicators of cheese "Mozzarella Ukrainian" with the bio additive "Immunocort"

Indicator name	Acceptable level		
	1 %	3 %	5 %
Bacteria of the E. coli group in 0.01 g of product	not detected	not detected	not detected
Pathogenic microorganisms, including salmonella, in 25 g of cottage cheese	not detected	not detected	not detected
Str. aureus per 1 g	231.03±38.65	154.20±27.09	193.69±40.75

6. Discussion of results of studying the effect of the additive "Immunocort" on the production and quality of cheese

One of the priorities of the dairy industry is the production of combined products. The essence of this direction is the directed regulation of the constituent components in order to improve the composition and properties of the finished products.

That is why the use of dietary supplements such as "Spirulex", "Blueberry Forte", "Rosehip, Rowan", "Rosehip, Echinacea, Mint", "Immunocort" opens up ample opportunities to create various combined products of a balanced composition [20]. Among all foods, a special place is occupied by dairy products, in particular rennet cheeses.

Cottage cheese is a high-protein and high-energy, biologically complete food product, which is obtained as a result of enzymatic coagulation of milk, the release of curd mass with its subsequent concentration and aging [6]. The inclusion of vegetable dietary supplements in the composition of rennet cheeses will make it possible to expand the range and increase the nutritional and biological value of combined dairy products.

It is important to note that the formation of cheeses with herbal supplements is greatly influenced by the stage of application and the number of herbal supplements introduced. Both organoleptic indicators and the mass fraction of moisture in the finished product, as well as the syneretic property of cheese clots, depend on it.

The results of studies of organoleptic parameters (Table 1) show that in the production of cheese "Mozzarella Ukrainian" it is optimal to introduce the supplement "Immunocort" in the amount of 3 % by weight of the normalized mixture before pasteurization. When adding this dose of supplements, the cheese was cream with clear inclusions of a grayish-brown color.

In the manufacture of combined cheeses, it is necessary to take into account not only the number of herbal supplements but also the influence of technological factors on the quality and formation of the resulting product [21].

Cheese production is essentially milk dehydration combined with other canning effects such as cultivation, acidification, pickling, packing, and cooling. In the production of cottage cheese, the main task is to obtain a strong clot that easily separates the whey. Syneresis is a phenomenon of spontaneous reduction in the size of the gel due to the release of a dispersion medium held in the structure. Syneresis is caused by an increase in the number and strength of contacts between particles and is accompanied by the appearance of crystallization bridges. An example of syneresis is the transition of the coagulation structure into a condensation-crystallization structure with the expulsion of fluid. The phenomenon of syneresis is prompted by factors contributing to coagulation. To obtain a product or clot with certain structural, mechanical and syneretic properties, it is necessary to be able to control the process of gelation. The structural-mechanical and syneretic properties of protein clots are viscosity, elasticity, strength, elasticity, ductility, brittleness, and the ability to separate the whey. These properties depend on the composition of milk, the modes of heat and machining, the method and duration of coagulation of milk proteins, and a number of other factors [22].

To establish the degree of syneresis in the production of rennet cheeses, the amount of whey that was released from the cheese clot for 30 minutes was determined.

Analyzing the different temperature regimes, it is worth noting that the syneretic properties of the clot depend on the coagulation temperature and the pasteurization temperature of the normalized mixture.

An increase in the coagulation temperature from 30 to 40 °C (Fig. 3) caused an increase in the release of whey, contributing to the activation of processes occurring under the action of rennet enzyme, increasing the activity of the lactic acid process.

The increase in pasteurization temperature in the production of "Mozzarella Ukrainian" cheese contributed to a decrease in the syneretic ability of cheese clots (Fig. 4). This can be explained by the fact that denatured whey proteins, having high hydrating properties, reduce the syneretic capacity of cheese clots.

Consequently, the intensity of the syneretic ability of cheese clots is influenced by both the pasteurization temperature and the coagulation temperature. These factors are dependent on each other. The pasteurization temperature most affects the separation of whey. This does coincide with the practical data obtained in work of other authors [23].

In whey, which is separated as a result of the treatment of clots coagulated at a temperature of 30 to 40 °C, a decrease in the dry matter content was observed (Fig. 5).

With an increase in the temperature of pasteurization, the degree of transition of solids into whey decreased (Fig. 6). The decrease in the content of solids in whey is explained by the denaturation of whey proteins, which precipitate, which allows them to be used in a clot.

Samples of cheeses, in the production of which the plant dietary supplement "Immunocort" was used, according to

physicochemical (Table 2) and microbiological (Table 3) indicators met the requirements of the current regulatory documentation. This indicates the possibility of using this supplement in the technology of rennet cheeses.

So, the goal has been achieved. On the basis of experimental studies, the optimal amount of application of the "Immunocort" supplement in the manufacture of "Mozzarella Ukrainian" cheese has been established. The dependence of the syneretic properties of the cheese clot on the coagulation and pasteurization temperatures of the normalized mixture has also been studied. The transition of solids into cheese whey depending on the coagulation temperature and pasteurization temperature of the normalized mixture was investigated. The quality indicators of the finished product are determined. The obtained data on the influence of coagulation and pasteurization temperatures on the degree of syneresis will make it possible to manage the process of making new types of cheeses with herbal supplements, depending on the specific conditions and requirements for the product.

The disadvantage of this study is that it focuses only on the effects of the proposed dietary supplement on the production and quality indicators of rennet cheese. No study has been conducted on the internal mechanism leading to these changes. Also, the detailed chemical composition of the finished product and the indicator of cheese yield have not been investigated. Therefore, in the next study, it is necessary to study the mechanism of qualitative changes, the chemical composition of cheese with a dietary supplement and the effect of the additive on the yield of cheese.

The limitations of this study are that it is only a study at the stage of a small laboratory experiment. So, in order for "Mozzarella Ukrainian" cheese with the "Immunocort" supplement to be used for commercial purposes, it is necessary to conduct further control experiments. In addition, the general acceptability of products is subjective since in this study the participants of the sensory group were only applicants for higher education and employees at the department of technology of milk and dairy products. Thus, a large number of sensory assessments must be carried out before commercial use in order to reduce the influence of individual preferences on the results of sensory evaluation.

7. Conclusions

1. The optimal amount of the introduced supplement "Immunocort" in the production of cottage cheese is 3 % by weight of the normalized mixture.

2. The greatest influence on the whey separation process is exerted by the pasteurization temperature and the coagulation temperature of the mixture. With an increase in pasteurization and coagulation temperatures, there is a decrease in the syneretic capacity of cheese clots. We recommend the most acceptable values of the studied criteria in the production of rennet cheeses with herbal supplements within the following limits:

– pasteurization temperature – 86±2 °C;

– coagulation temperature – 32±2 °C.

3. With an increase in the temperature of pasteurization of milk, the release of solids into the whey decreases and the efficiency of the use of solids increases.

4. The cheese "Mozzarella Ukrainian" with a dietary supplement had a mass fraction of fat in dry matter on average 50.58 %, mass fraction of moisture – 47.12 %. The experimental cheese was characterized by a more intense taste and smell due to the added herbal supplement and cream color with clear grayish-brown inclusions. According to microbiological indicators, the produced cheese met the requirements of the current documentation.

Conflicts of interest

The authors declare that they have no conflicts of interest in relation to the current study, including financial, personal, authorship, or any other, that could affect the study and the results reported in this paper.

Funding

The study was conducted without financial support.

Data availability

The data will be provided upon reasonable request.

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