

ISSN 2518-1491 (Online),
ISSN 2224-5286 (Print)

ҚАЗАҚСТАН РЕСПУБЛИКАСЫ
ҰЛТТЫҚ ҒЫЛЫМ АКАДЕМИЯСЫНЫҢ

Д.В. Сокольский атындағы «Жанармай,
катализ және электрохимия институты» АҚ

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ИЗВЕСТИЯ

НАЦИОНАЛЬНОЙ АКАДЕМИИ НАУК
РЕСПУБЛИКИ КАЗАХСТАН
АО «Институт топлива, катализа и
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NEWS

OF THE ACADEMY OF SCIENCES
OF THE REPUBLIC OF KAZAKHSTAN
JSC «D.V. Sokolsky institute of fuel, catalysis
and electrochemistry»

SERIES
CHEMISTRY AND TECHNOLOGY

3 (441)

MAY – JUNE 2020

PUBLISHED SINCE JANUARY 1947

PUBLISHED 6 TIMES A YEAR

ALMATY, NAS RK

NAS RK is pleased to announce that News of NAS RK. Series of chemistry and technologies scientific journal has been accepted for indexing in the Emerging Sources Citation Index, a new edition of Web of Science. Content in this index is under consideration by Clarivate Analytics to be accepted in the Science Citation Index Expanded, the Social Sciences Citation Index, and the Arts & Humanities Citation Index. The quality and depth of content Web of Science offers to researchers, authors, publishers, and institutions sets it apart from other research databases. The inclusion of News of NAS RK. Series of chemistry and technologies in the Emerging Sources Citation Index demonstrates our dedication to providing the most relevant and influential content of chemical sciences to our community.

Қазақстан Республикасы Ұлттық ғылым академиясы "ҚР ҰҒА Хабарлары. Химия және технология сериясы" ғылыми журналының Web of Science-тің жаңаланған нұсқасы Emerging Sources Citation Index-те индекстелуге қабылданғанын хабарлайды. Бұл индекстелу барысында Clarivate Analytics компаниясы журналды одан әрі the Science Citation Index Expanded, the Social Sciences Citation Index және the Arts & Humanities Citation Index-ке қабылдау мәселесін қарастыруда. Web of Science зерттеушілер, авторлар, баспашылар мен мекемелерге контент тереңдігі мен сапасын ұсынады. ҚР ҰҒА Хабарлары. Химия және технология сериясы Emerging Sources Citation Index-ке енуі біздің қоғамдастық үшін ең өзекті және беделді химиялық ғылымдар бойынша контентке адалдығымызды білдіреді.

НАН РК сообщает, что научный журнал «Известия НАН РК. Серия химии и технологий» был принят для индексирования в Emerging Sources Citation Index, обновленной версии Web of Science. Содержание в этом индексировании находится в стадии рассмотрения компанией Clarivate Analytics для дальнейшего принятия журнала в the Science Citation Index Expanded, the Social Sciences Citation Index и the Arts & Humanities Citation Index. Web of Science предлагает качество и глубину контента для исследователей, авторов, издателей и учреждений. Включение Известия НАН РК в Emerging Sources Citation Index демонстрирует нашу приверженность к наиболее актуальному и влиятельному контенту по химическим наукам для нашего сообщества.

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ISSN 2518-1491 (Online),

ISSN 2224-5286 (Print)

Меншіктенуші: «Қазақстан Республикасының Ұлттық ғылым академиясы» Республикалық қоғамдық бірлестігі (Алматы қ.).

Қазақстан республикасының Мәдениет пен ақпарат министрлігінің Ақпарат және мұрағат комитетінде 30.04.2010 ж. берілген №1089-Ж мерзімдік басылым тіркеуіне қойылу туралы куәлік.

Мерзімділігі: жылына 6 рет.

Тиражы: 300 дана.

Редакцияның мекенжайы: 050010, Алматы қ., Шевченко көш., 28; 219, 220 бөл.; тел.: 272-13-19; 272-13-18,
<http://chemistry-technology.kz/index.php/en/arhiv>

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Редакцияның мекенжайы: 050100, Алматы қ., Қонаев к-сі, 142, «Д. В. Сокольский атындағы отын, катализ және электрохимия институты» АҚ, каб. 310, тел. 291-62-80, факс 291-57-22, e-mail:orgcat@nursat.kz

Типографияның мекенжайы: «NurNaz GRACE», Алматы қ., Рысқұлов көш., 103.

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д.х.н., проф., академик НАН РК
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«Известия НАН РК. Серия химии и технологии».

ISSN 2518-1491 (Online),

ISSN 2224-5286 (Print)

Собственник: Республиканское общественное объединение «Национальная академия наук Республики Казахстан» (г. Алматы).

Свидетельство о постановке на учет периодического печатного издания в Комитете информации и архивов Министерства культуры и информации Республики Казахстан №10893-Ж, выданное 30.04.2010 г.

Периодичность: 6 раз в год.

Тираж: 300 экземпляров.

Адрес редакции: 050010, г. Алматы, ул. Шевченко, 28; ком. 219, 220; тел. 272-13-19; 272-13-18,

<http://chemistry-technology.kz/index.php/en/arhiv>

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Адрес редакции: 050100, г. Алматы, ул. Кунаева, 142, АО «Институт топлива, катализа и электрохимии им. Д.В. Сокольского», каб. 310, тел. 291-62-80, факс 291-57-22, e-mail:orgcat@nursat.kz

Адрес типографии: «NurNaz GRACE», г. Алматы, ул. Рыскулова, 103.

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News of the National Academy of Sciences of the Republic of Kazakhstan. Series of chemistry and technology.

ISSN 2518-1491 (Online),

ISSN 2224-5286 (Print)

Owner: RPA "National Academy of Sciences of the Republic of Kazakhstan" (Almaty).

The certificate of registration of a periodic printed publication in the Committee of Information and Archives of the Ministry of Culture and Information of the Republic of Kazakhstan N 10893-Ж, issued 30.04.2010.

Periodicity: 6 times a year.

Circulation: 300 copies.

Editorial address: 28, Shevchenko str., of. 219, 220, Almaty, 050010, tel. 272-13-19; 272-13-18,

<http://chemistry-technology.kz/index.php/en/arhiv>

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Editorial address: JSC «D.V. Sokolsky institute of fuel, catalysis and electrochemistry», 142, Kunayev str., of. 310, Almaty, 050100, tel. 291-62-80, fax 291-57-22, e-mail: orgcat@nursat.kz

Address of printing house: «NurNaz GRACE», 103, Ryskulov str, Almaty.

NEWS

OF THE NATIONAL ACADEMY OF SCIENCES OF THE REPUBLIC OF KAZAKHSTAN

SERIES CHEMISTRY AND TECHNOLOGY

ISSN 2224-5286

<https://doi.org/10.32014/2020.2518-1491.45>

Volume 3, Number 441 (2020), 66 – 72

UDC 637.333(479.2.5)

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**JUSTIFYING THE OPTIMALITY OF ESTABLISHED REGIMES
FOR SWISS CHEESE DOUBLE- SIDED PRESSING**

Abstract. The article discusses conditions when, under the established regime of double-sided pressing, which results in a more equally dimensioned distribution of moisture in Swiss cheese, the prerequisites for microbiological processes flowing are improved, as evidenced by the results of biochemical investigations. A new constructive solution is also proposed for double-sided cheese pressing molds with the possibility of fully automating the processes of molding and pressing, using mechanisms of step pressing of the cheese mass with a reduction in the number of pneumatic cylinders, with the automatic controlling valve of cheese grain filling and cheese removal by a telescopic pneumatic cylinder.

Keywords. Anisotropy, soluble and non-protein nitrogen, valve, ruler, tooth, shell, telescopic, perforated, corrugated, clamps.

Introduction. One of the most important problems of the dairy industry is to increase the efficiency of production and the quality of products, by using perfect high-productivity equipment and technology. In cheese making, the least perfect and rather labor - intensive technological processes are molding, wrapping the cheese mass in tissues, pressing and removing cheese from the mold. At the same time, the processes of cheese mass molding and pressing are the most important in cheese making, since they provide the cheese type features and the necessary quality of cheese. The imperfection of these technological processes leads to unequally dimensioned distribution of moisture and hardness in the cheese mass, and consequently to unequally dimensioned distribution and development of microflora, as well as the non-intensive flow of biochemical processes in the cheese mass, as a result of which the quality of the cheese reduces. The sources of flavoring and aromatic substances of cheese are all macronutrients: fats, proteins, carbohydrates. The hydrolysis of these macronutrients is carried out by microorganisms, which means that without microorganisms it is impossible to produce cheese [1], [2], [3]. Thus, it is extremely necessary to create conditions (moisture, temperature and PH) in order to produce cheese of the required quality. It is more important to distribute moisture in the cheese mass, which depends on the wrapping of the tissue, the repressing, the optimal regimes (pressure and duration), the pressing method and non- combining of technological processes (assembly of molds, filling of cheese, cheese shaping, pressing and removal of cheese from the mold), which lead to increased anisotropy of the cheese mass. In this area, a technological analysis of the review literature has been carried out to determine the influence of each of these technological processes, anisotropy change (unequally dimensioned distribution of moisture) in the cheese mass. Technological analysis shows that abroad, as well in CIS, two methods of cheese making have been used: self-pressing and single-sided pressing of cheese mass.

In case of self-pressing, the upper layers of the cheese mass press the lower ones. During single-sided pressing from top to bottom, in the direction of the being pressed side, the pressure, of course, drops. In both methods, repressing of the cheese mass is required for the equation of moisture distribution and density in the upper and lower layers of cheese mass. If the pressure on the cheese mass in the

technological regime is higher than the norm, then draining of tissue is more than pressing which leads to quick drying and hence to the closing of the capillaries holes and finally to the settling of whey in the capillaries. In addition, pressed cheese pieces can be cut off from pressed cheese during the removal from the mold. Unwanted microorganisms can enter these places, which later degrade the quality of the cheese. If the pressure is less, then the cheese is non-pressed up, i.e. again leads to settling of whey in the capillaries. These operations increase the cheese cost, reduce the productivity, interfere with the implementation of linear production, make difficult the integrated mechanization and automation of cheese making production [4].

Theory of anisotropy formation. When cheese grains are displaced by suppressing of the pressing force, capillaries are formed in the inter-granular space, through which whey leaks in different directions to the surface of the cheese mass. Wherein, the repressing and the tissue result in the correspondence of the holes of cheese press cloth with the pressing, as a result of which, the sizes of the pressed cheese are increased and the holes are quickly dried and closed, leading to the settling of the whey in the capillaries. Whey can exit through other capillaries if the pressure is higher than in neighboring capillaries, but the pressing duration is prolonged. And, if the whey remains in the capillaries, the humidity will be greater than in those capillaries which holes have not been closed. As a result, anisotropy, which is so undesirable in cheese making, is increased. In addition, with single-sided pressing, the pressure from the side being pressed towards the lower layers decreases, hence the density in the upper and lower canvas is not the same, for which they are exposed to repressing [4].

The above-mentioned factors negatively affect the intensity of the biochemical and microbiological processes. In this regard, the most important problem of cheese making production is the development and widespread industrial implementation of new progressive technologies and technical means, that is the non-tissue pressing of cheese.

Thus, the above-mentioned technological processes increase the anisotropy of the cheese mass, reducing the quality of the cheese.

Technical analysis. In the last decade, many processes of natural cheese making production are mechanized and automated. Several semi-industrial and industrial methods of continuous cheese mass making, its molding and pressing and various periodical and continuous operating apparatus are used. Molding - dosing devices, presses (lever, screw and pneumatic, horizontal, tunnel) are used to make high-quality cheese mass. Until now, ways, constructions of molds and devices, which are applied in cheese-making production, are mainly used for single-sided pressing of cheese. Among them, tunnel presses occupy a special place, in which two types of devices are used as power elements that develop the pressing force: [5], [6].

1. Pneumatic cylinders - a separate pneumatic cylinder presses on each cheese block. Wherein, the difference in height of each of the cheese block is not important, presses with pneumatic cylinders have a large working space height, which simplify loading. In addition, their construction provides parallelism of the upper and lower planes at any loading and any way of molding. This positive property makes such presses attractive to many cheese manufacturers. This press construction is very expensive and material-intensive, but it is considered the best and is used in the production of large mass cheese.

2. Flexible inflatable force elements. The disadvantage of such elements is the small size of the working stroke (with large differences in the height of the cheese blocks, the quality of the cheese can deteriorate), advantage - in high specific pressure, provided by the specificity of the press construction using of flexible power elements. At the same time, the main way to create a pressuring is the energy of compressed air and in most often a separate pneumatic cylinder presses on each cheese block in them. Wherein, the consolidation of the cheese mass in the direction from the pressed side to down anyway drops, and in order to get the same density of the upper and lower sides, the cheese is repressed. This is a very labor-intensive process, leading to unequally dimensioned distribution of moisture and hardness in the cheese mass, therefore, to unequally dimensioned distribution and development of microflora and to non-intensive flow of biochemical processes in the cheese mass, as a result of which the quality of the cheese decreases. Therefore, the current way of single-sided pressing of cheese with repressing and using tissues leads to anisotropy of cheese [5], [6].

Highly automated presses manufactured by the Press Pallet company are distinguished from existing types of tunnel presses. Press pallets are combined into blocks, having a common compressed air supply system, as well as a system of lifting and transporting devices for loading and unloading presses (press section equipped with Shalon Megar press pallets [7]).

Analysis of existing pressing systems allows us to conclude that they are constantly being improved, but the main way to create pressure is to use the energy of compressed air. Improvements relate to the automation of loading and unloading systems but not the constructions of molds, pressing molds and equipment [5], [6].

Thus, to produce high-quality cheese, it is necessary to get a cheese mass with a more equally dimensioned distribution of moisture and hardness during pressing. Consequently, the improvement and development of high-productive continuously operating technical means, techniques and technology for natural cheese production, especially the processes of getting the cheese mass, its molding and pressing, was and is an urgent task of science and practice.

Thus, until now, the ways and constructions of molds and devices used for the establishing of single-sided pressing are distinguished by a number of disadvantages (turning, wrapping the cheese mass in molding tissues, pressing, removing of pressed cheese, assembling and disassembling the molds, non-combining of these processes, manual labor, the large area occupied by the equipment), and the cheese produced by these ways are characterized by anisotropy [4]. The above-mentioned disadvantages interfere with the establishment of linear production, complicate the complex mechanization and automation of cheese making production. Therefore, in order to produce high-quality cheese, it is necessary to get cheese mass with increased homogeneity during pressing. To achieve this, it is necessary to develop new ways and technical means for cheese pressing and combining processes of cheese grain filling, molding and pressing of cheese mass and the removal of the pressed cheese from molds, which is still very actual and significant. The aim of the work is to develop a technology that combines the technological processes of cheese making (filling cheese grain, molding and pressing of cheese mass and removing pressed cheese from the molds), their automation with a reduction in the number pneumatic cylinders and replacing the energy of compressed air with electromagnetic forces, as well as the development of technical means for the implementation of pressing cheese without repressing and the use of tissues.

We offer three ways of double-sided pressing: double-sided, non-tissue pressing; double-sided, non-tissue step pressing (with less number of pneumatic cylinders) and double-sided, non-tissue pressing using electromagnetic forces (without pneumatic cylinders).

To solve this goal, we have formulated the following tasks:

1. To develop technological foundations and technical means for double-sided, non-tissue pressing of natural branded cheese and to improve the developed technical means.

a) to reconstruct the pressing mold of the French line of the company Pierre Cuerin for double-sided pressing of Swiss cheese.

b) to develop a device for determining the hardness of cheese.

2. To set the optimal regime (pressure and duration) of double-sided pressing for Swiss cheese depending on the height and mass [8].

3. To study the effect of double-sided pressing (the first method) on the quality of the Swiss cheese.

Materials and Methods. Based on the above, we offer 2 ways of double-sided pressing: double-sided non-tissue pressing; double-sided, step non-tissue pressing (with a less number of pneumatic cylinders).

The method of doing the research. Experimental studies were carried out according to standard and generally accepted methods based on the GOST. Determination of nitrogenous substances in Swiss cheese by Kjeldahl method GOST 23327 -1978 was made at the Gorelovsky cheese factory of the Bogdanovsky district in Georgian SSR. The moisture content in the cheese was made by express method (GOST 3625-75). The hardness of the cheese was determined by using the constructed and made device. The essence of the work is the fact that the necessary cone inclination of 20 degrees is achieved by penetrating the device into the cheese mass in a matter of seconds. (Fig. 1). In the control experiment, Swiss cheeses were exerted to double-sided pressing in reconstructed mold of the French line by Pierre Cuerin, which is intended for single-sided pressing of large cheese [9] [10].

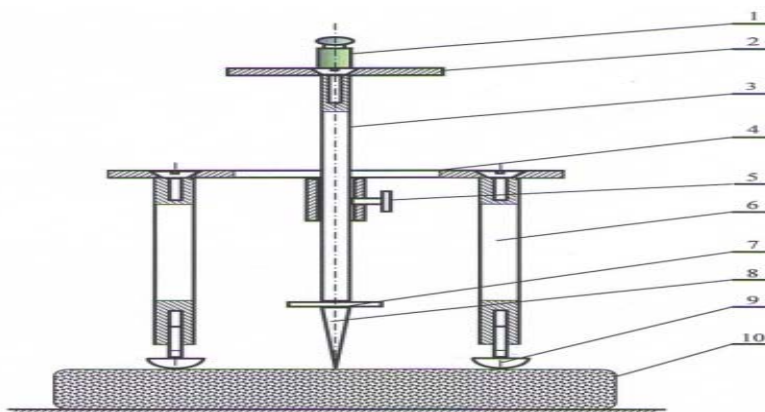


Figure 1 - Device for determining the cheese hardness:

1- weight, 2,4 –discs, 3 –rod, 5 – local screw, 6 –legs, 7 – ledge, 8 – cone, 9 – supports, 10 – cheese

The aim of the work was to study a new method of double-sided, non-tissue pressing to reduce the anisotropy of cheese by excluding its repressing and shortening the pressing duration, which should lead to an increase in the cheese quality, as well as the design of molds for its implementation. The study of the effect of double-sided pressing on the quality of Swiss cheese is determined by the establishment of the technological regime (pressure duration). To justify the optimality of the established regime, rheological and biochemical investigations were carried out.

Research Results. The results of rheological investigations have shown that cheese exerted to double-sided pressing differ in a more constant distribution of hardness and moisture, however according to the average data, the moisture content in both pressing methods slightly differs from each other (experimental 39.82% and control 39.47%), but in samples of control cheese taken from 5 different points, the fluctuation in moisture content in the cheese mass is slightly greater (1.9% versus 0.5% in experimental). The hardness of the cheese mass in the upper and lower canvases of the experimental fresh Swiss cheese is 12.7 and 11.5 sec, already then, as in the control cheese, it is correspondingly 61 and 60.6 sec, which is 5 times more than in the experimental cheese, due to the crust forming, which occurs due to repressing and the usage of tissue. In the latter, the layer becomes less consolidated, consequently, the edible portion of the cheese increases. The hardness fluctuation is more for control cheese. They are more constant in the cheese which is made by double-sided pressing. The hardness of the surface layer (30 mm deep) of fresh and mature cheese is determined by using a special device that we have constructed.

The effect of double-sided pressing on the content of nitrogenous substance in fresh and 5.5 months aged Swiss cheese. Nitrogen forms were determined in samples of the same cheese. The research results are presented on table.

From the data on Table 1, it can be seen that the soluble forms of nitrogenous substances in fresh Swiss experimental cheese during double-sided pressing, account to 11.604-12.319% of the total nitrogen, and non-protein - 9.544-9.802%, or correspondingly 0.572% (11,604-11,032) -1,03 (12,319-11,289) and 0,377% (9,802-9,425) -1,252 (9,544-8,292) more than in control cheese with repressing, and according to average data, the content of soluble forms of nitrogenous substances is more than 0.835% (12.018-11.183%), and the content of non-protein nitrogenous substances is more than 0.732% (9.666-8.934%).

Thus, the content of total and soluble nitrogen in experimental and control 5.5months aged cheese is almost at the same level, and from the aspect of non-protein nitrogen content, types of cheese differ from each other in favor of experimental cheese. So, the content of soluble nitrogen in 5.5 months aged experimental cheese was on average 22.42% of the total nitrogen, i.e. 0.68% more than in control cheese (21.74%). The content of non-protein nitrogen in experimental cheeses was on average of 14.21% of the total nitrogen, which is more, compared to control cheese with repressing (3.40%) by 0.81% (table 1).

With double-sided pressing, as a result of a more equally dimensioned distribution of moisture in the cheese, the conditions for microbiological processes are also improved. This is evidenced by data from biochemical studies, i.e. the established regime of double-sided pressing is optimal (rational).

The content of nitrogenous substance in fresh and 5.5 months aged Swiss cheese

Cheese	Total nitrogen, %	Nitrogen Type, %		In relation to the total nitrogen,%		
		soluble	non-protein	soluble	non-protein	
Fresh cheese						
Experimental	I	4,432	0,546	0,423	12,319	9,544
	II	4,438	0,515	0,435	11,604	9,802
	III	4,435	0,538	0,428	12,131	9,651
Average		4,435	0,533	0,429	12,018	9,666
Control	I	4,061	0,448	0,369	11,032	9,086
	II	4,004	0,452	0,332	11,289	8,292
	III	4,106	0,461	0,387	11,227	9,425
Average		4,057	0,454	0,363	11,183	8,934
5,5months aged cheese						
Experimental	I	4,49	1,011	0,648	22,52	14,43
	II	4,48	1,010	0,650	22,54	14,51
	III	4,46	0,990	0,610	22,20	13,68
Average		4,48	1,004	0,636	22,42	14,21
Control	I	4,30	0,912	0,580	22,21	13,49
	II	4,52	0,980	0,610	21,68	13,50
	III	4,53	0,966	0,598	21,32	13,20
Average		4,45	0,9531	0,596	21,74	13,40

Discussions. For the first time, double-sided, non-tissue pressing was proposed which excludes the repressing, with a decrease in the anisotropy of Swiss cheese and a reduction of pressing duration.

1. A pressing mold of the French company Pierre Cuerin was reconstructed for the experiment.
2. A device for measuring the density of cheese mass was designed and made.
3. The technological regime of double-sided, non- tissue pressing was determined, which excludes repressing and reduces the duration Swiss cheese pressing.
4. The optimality of proposed new regime for double-sided pressing of Swiss cheese was investigated.
5. Rheological and biochemical investigations were also carried out in order to justify the optimality of the proposed regime of double-sided pressing of Swiss cheese.
6. Schemes of mold for double-sided pressing of Swiss cheese, which have to be automated, were developed.

Conclusion. The results of the experiments and research fully justify the optimality of the proposed above regime for double-sided pressing of Swiss cheese.

According to the research results, we can conclude that the proposed technological regime of double-sided pressing of Swiss cheese is optimal.

Conclusion. Based on the above-mentioned research results, we can conclude that it is appropriate to continue further research of the effect of double-sided pressing on the quality of Swiss cheese with a justified technological regime.

According to the above-mentioned research results, it can be seen that this technological solution of the first method of double-sided pressing, positively affects the quality of Swiss cheese. It is appropriate to give a further technical solution for the implementation of the proposed double-sided pressing.

The purpose of the technical solution is to develop a technology that combines the technological processes of cheese making (mold assembly, cheese grain filling, molding and pressing of the cheese mass, disassembling the molds and removal of the pressed cheese from the molds, their automation with a reduction in the number of pneumatic cylinders, as well as the development of technical means for implementing cheese pressing without repressing and without using tissues.

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**ШВЕЙЦАРИЯ ІРІМШІГІН ЕКІЖАҚТЫ ПРЕСТЕУ ҮШІН
БЕЛГІЛЕНГЕН РЕЖИМДЕРДІҢ ОҢТАЙЛЫЛЫҒЫН НЕГІЗДЕУ**

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ОБОСНОВАНИЕ ОПТИМАЛЬНОСТИ УСТАНОВЛЕННЫХ РЕЖИМОВ ДЛЯ ДВУХСТОРОННЕГО ПРЕССОВАНИЯ ШВЕЙЦАРСКОГО СЫРА

Аннотация. В статье рассматривается впервые предложенный новый способ двухстороннего бессалфеточного, без перепрессовок прессования сыров. Его испытание проведено на швейцарских сырах, реконструированием нами прессформы фирмы *Pierre-Gurie* (Франция), предназначенной для одностороннего бессалфеточного, без перепрессовок на прессформу двухстороннего прессования. Ожидаемые результаты – значительное сокращение продолжительности прессования с уменьшением анизотропии и с исключением перепрессовки применением салфетки.

При испытании также впервые определен технологический оптимальный режим (давление продолжительности) двухстороннего прессования швейцарского сыра, который длился 8 часов 20 минут, отвесом головки 50-65 кг, высотой 12-15 см, диаметром 70 см, что позволит значительно сократить продолжительность почти в 2 раза по сравнению с существующим односторонним прессованием чехской линии (16-18 ч), не влияя на качество.

Прессующее усилие постепенно увеличивалось (4 этапа), от 0784-2,744 н/см² или 7980-31920 Пас.

После созревания эти сыры прошли дегустацию (высший сорт). Оказалось, что по данным органолептическим показателям, они ни чем не отличались от качества и анализов стандартных требований (оценка в баллах – опытные – 89, контрольные - 88 почти одинаковые).

Для обоснования оптимальности технологического режима двухстороннего прессования были проведены реологические биохимические исследования.

Результаты этих исследований показали, что пробы, взятые с 5 разных точек по содержанию влаги, по средним данным, составило в свежих опытных и контрольных швейцарских сырах 39,82% и 39,4%, т.е. почти одинаковые, а колебание содержания влаги составляют, соответственно, 0,5% и 1,9%. Низкое колебание (0,5%) у сыров выработанным двухсторонним прессованием является равномерное распределение влаги в сырной массе.

Твердость сырной массы свежих опытных швейцарских сыров составляет 12,7 верхних и 11,5 нижних полотнах, а у контрольных с применением салфеток с перепрессованием, из-за образующейся корки, соответственно, 60 и 60,6 сек, что в 5 раз больше опытных сыров. Колебание твердости намного выше контрольных сыров, в опытных – более постоянна. Твердость сыра определялось нами сконструированного и изготовленного устройства. Растворимый азот в свежих опытных швейцарских сырах, по средним данным, больше на 0,835%, а небелковых на 0,732%.

В 5,5 месячных опытных сырах содержание растворимого азота, по средним данным, 22,42% от общего азота, что на 0,68% больше, чем в контрольных сырах – 21,74%. Содержание небелкового азота в опытных, по средним данным, 14,21% от общего азота, что больше по сравнению с контрольными сырами 13,40% на 0,81%.

Исходя из вышеуказанных результатов исследований можно заключить, что предлагаемый способ технологического режима двухсторонним прессованием (давления продолжительности) швейцарского сыра является оптимальным. Вывод двухстороннего бессалфеточного без перепрессовок прессования обеспечивает более равномерный и стабильный сдвиг сырных зерен под давлением прессующего усилия с одновременным уплотнением с обеих сторон сырной массы. Вследствие этого влага распределяется по всем слоям сырной массы более равномерно. В результате этого уплотняющий слой получается более тонким, а это приводит к неотстаиванию сыворотки в капиллярах, образующих межзерновое пространство. Течка сыворотки осуществляется через капилляры по всему направлению наружной сырной массы, а также уменьшению анизотропии, т.е. к повышению однородности сырной массы. На основании этого равномерно развиваются и распределяются микроорганизмы и биохимические процессы протекают интенсивно. А это, т.е. оптимальность, обоснуют результаты исследования.

Совмещая вышеуказанные результаты можно заключить, что двухстороннее бессалфеточное без перепрессовок прессование положительно влияет на качество швейцарского сыра и дает возможность проводить дальнейшие исследования.

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ISSN 2518-1491 (Online), ISSN 2224-5286 (Print)

Редакторы: *М. С. Ахметова, Г. Б. Халидуллаева, Д. С. Аленов*
Верстка на компьютере *А.М. Кульгинбаевой*

Подписано в печать 08.06.2020.

Формат 60x88¹/₈. Бумага офсетная. Печать – ризограф.
10,8 п.л. Тираж 300. Заказ 3.