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RESEARCH OF CHANGES IN THE STRUCTURAL AND MECHANICAL PROPERTIES OF SEMI-HARD CHEESE DURING DEFROSTING

Abstract: *The article presents the results of a study of the structural and mechanical properties of semi-hard cheese produced by coagulation of goat's milk with enzyme preparations of plant and animal origin. Data on the structural and mechanical properties of a freshly processed sample of cheese type halloumi and a sample subjected to low-temperature storage were obtained, and the relaxation coefficient characterizing the plastic-elastic properties of the cheese mass was calculated. The structural and mechanical properties of cheese produced using an animal-derived enzyme preparation had better indicators than those produced using a vegetable-derived enzyme preparation. Scientific research was carried out on the basis of Siberian Scientific Research Institute of Cheese Making (Barnaul, Russia). According to study, based on the experimental method, an objective indicator of the consistency of cheese was calculated-the relaxation coefficient, which fully reflects the most important rheological properties. Thus, it was found that the relaxation coefficient of defrosted cheese produced with the help of the SG-50 enzyme had better indicators and amounted to K_{relax}=93.709 N/s, while for cheese produced with the help of the Renin enzyme, the relaxation coefficient was K_{relax}=89.91 N/s. The results are of practical significance, as they allow to adjust the technological modes of cheese production and evaluate the influence of various factors on the formation of cheese consistency.*

Key words: *cheese, defrosting, relaxation coefficient, rheological properties, quality.*

Introduction

Consistency in many cases is one of the characteristics involved in assessing the quality and properties of raw materials and finished foods. Such an indicator, in addition to organoleptic properties such as hardness, viscosity, evaluated during tasting, in some cases characterizes resistance to mechanical influences during storage and transportation. Scientists from all over the world are interested in studying the qualitative characteristics of frozen cheese [1-4].

The key point in the development of cheese was the high quality of the finished product. When evaluating the quality of cheese, one of the main characteristics is the consistency, which is evaluated organoleptically, which is not always an objective assessment [5,6].

Previously, we developed the technology of semi-hard halloumi cheese of the European brand. Optimal doses of enzyme preparations of various nature and origin were determined experimentally using special experimental devices developed at the Siberian research Institute of cheese making. Since this type of cheese is subjected to low-temperature storage, the task was to investigate changes in structural and mechanical properties during its defrosting [7].

Based on the study of the rheological characteristics of the product, the initial requirements for the conditions of packaging, storage and transportation, for containers intended for these operations are formulated. Data on the structural and mechanical properties of the product are necessary when designing and selecting equipment for processing. In technological processes,

adhesion processes play an important role, characterizing the ability of the product to adhere to the working organs of the apparatus [4].

To evaluate this characteristics, various devices are used, the operation of which is based on the interaction of an indenter with a product. Various penetrometers, defometers, and adhesiometers are widely known to measure any characteristic [8].

The most common devices used in research are penetrometers and defometers. The work of the penetrometers is based on measuring the depth of penetration of the cone (indenter) deep into the product at constant load. Defometers measure the amount of deformation at a given load value. They are used to measure elasticity and plasticity.

Penetrometers are used to measure the consistency of products and materials. The penetration index (the depth of immersion of the cone into the product under study) characterizes the complex of product properties. Hardness is considered the main indicator of penetration, although it is influenced by a set of properties, including friction of the indenter surface on the product, plastic properties, connectivity and adhesion. Nevertheless, such a generalizing indicator is objective, reproducible and quite easily implemented in practice[9].

Research methods

To conduct research on the influence of various factors on the structural and mechanical characteristics of the product, a device was developed and constructed at the Siberian Research Institute of Cheese Making, the main purpose of which is to measure deformation under variable load. The design of the device is simple and consists of a support table on which the test sample of the product is installed (Figure 1).

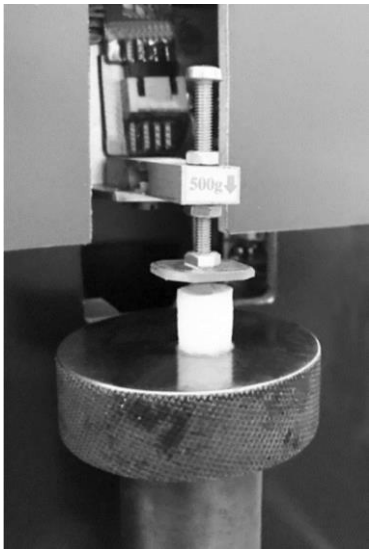


Figure 1 – Device for measuring the structural and mechanical characteristics of the product

To obtain an objective instrumental assessment of the consistency of the cheese mass, a method has been developed and a device has been manufactured that allows obtaining data on the hardness and plastic-elastic properties of the cheese mass. The rheological characteristics of cheese were determined using a device for measuring the relaxation of the cheese mass developed at the Siberian research Institute of cheese making. This device, unlike previously used ones, directly measures the change in the compression stress in the sample with a special strain gauge, while typical defometers measure the change in linear dimensions in the absence of load. In addition, the device displays data on the dynamics of the relaxation process, which allows to evaluate the elastic and relaxation properties of samples [10].

The method for determining the relaxation of the cheese mass is based on measuring the impact force of a pre-compressed cheese sample on the indenter. Preparation of samples for analysis was carried out as follows: a special sampler was used to cut out a blank with a diameter of 10 mm and a length of 15-20 mm. The samples were a fresh and frozen cheese type halloumi produced by coagulation with animal origin «SG-50» and microbial origin «Renin» enzymes.

The resulting sample is cut off from the ends using special calibers (conductors), first with a 12 mm caliber, and then with a 10 mm caliber. As a result, a prepared sample of cheese is obtained in the form of a cylinder with a height of 10 mm and a diameter of 10 mm. The resulting cheese sample, which is subject to relaxation measurement, is thermostated to a temperature of (20+0.5)°C. After temperature control, the cheese sample is placed on an adjustable table in its central part under the indenter and subjected to compression. The force generated by the movement of the indenter is recorded via an analog-to-digital converter and sent to the USB input of the computer, where it is recorded in the form of a graph or table. Data processing and control of the measurement process is carried out using a special program.

Research results

The results of relaxation of the cheese mass produced by coagulation of «SG-50» and «Renin» are shown in figure 2. It should be noted that, studies of structural and mechanical properties were carried out with fivefold repetition under the same conditions and the average value of the results was determined.

According to the deformation graph, during the indenter movement during compression of the cheese sample and its deformation, the load increases until it reaches the point (A) where the indenter position is fixed. After stopping the indenter, there is a smooth decrease in the force (point B) of the impact of the cheese mass on the indenter, which records the impact force and transmits data for processing and writing to the memory of the microprocessor.

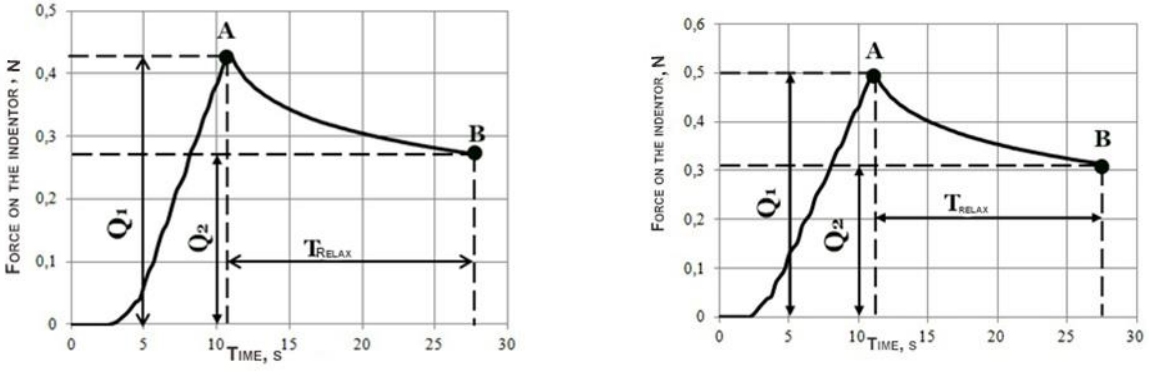
The stress relaxation process continues until 28 seconds have elapsed since the start of the indenter movement. Thus, the duration of relaxation was 16.91 s (27.6-10.69). The relaxation coefficient is calculated using the formula (1):

$$K_{relax} = T_{relax} / (Q_1 - Q_2) \quad (1)$$

where Q_1 – initial force on the indenter, N;
Q_2 – indenter force at the end of measurement, N;;
T_{relax} – time of relaxation;
K_{relax} – relaxation coefficient, N/s.

Thus, for cheese produced by coagulation with the «SG-50» enzyme, the relaxation coefficient is K_{relax}=16,91/(0,426-0,273)=110,552 N/s.

According to figure 2 b, for cheese produced from milk fermented by the «Renin» enzyme, the relaxation duration is 16.26 seconds (27.6-11.34), while the relaxation coefficient is equal to K_{relax} =16,26/(0,499-0,339)=101,625 N/s.



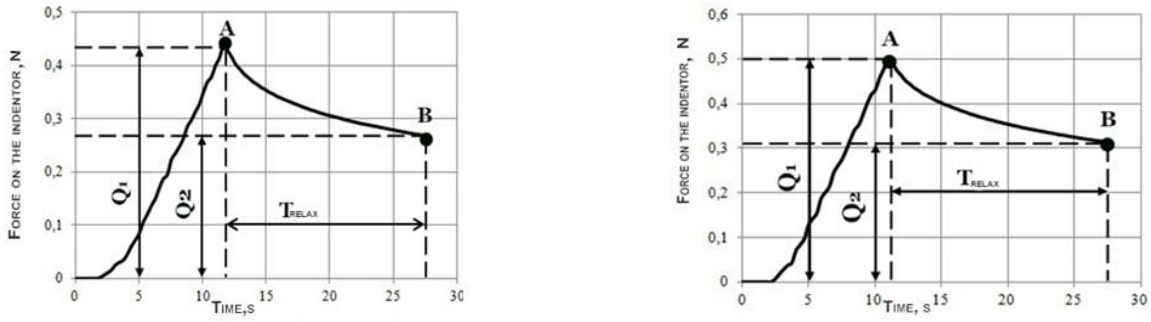
a –SG-50 b – Renin

Figure 2 – Diagram of deformation and relaxation of the cheese mass

The relaxation coefficient characterizes the plastic properties of cheese, which are a manifestation of internal friction that occurs as a result of moving the cheese under load. In physics, relaxation is the transition of a body from a non-equilibrium state to an equilibrium state. When a solid body is deformed at a certain speed, its thermodynamic equilibrium is disturbed and a relaxation process occurs, due to the desire of the cheese mass to return to the state of equilibrium.

Further, the study of plastic and elastic properties was performed on cheese samples stored at low temperature (-18 °C) for 6 months.

The results of deformation and relaxation of thawed samples are shown in figure 3.



a –SG-50 b – Renin

Figure 3 – Diagram of deformation and relaxation of cheese after defrosting

As shown in figure 3 a, the duration of relaxation was 15.94 s (27.6-11.66) s, with the relaxation coefficient equal to K_{relax} =15,94/(0,439-0,269)=93,709 N/s.

According to the results of the graph of figure 3 b, the duration of relaxation was 16.59 s (27.6-11.01) s, with the relaxation coefficient equal to K_{relax} =16,59/(0,498-0,314)=89,91 N/s.

Discussion of scientific results

The value of the relaxation coefficient depends on the quality of the rennet clot, as well as its structural and mechanical properties obtained as a result of coagulation of milk proteins. The higher the relaxation coefficient, the better the quality of the structural characteristics of the cheese and the more connected the structure of the cheese. The low relaxation coefficient indicates a hard, rubbery structure of the cheese. Note that, despite the freezing of cheese, all defrosted cheese samples had relaxing properties and withstood the load without losing the quality of the cheese consistency.

Analyzing the data obtained, it becomes clear that the most relaxing properties have a sample of cheese produced as a result of coagulation with the «SG-50» enzyme both in freshly processed cheese and subjected to low-temperature freezing.

Conclusion

Based on the research conducted on the development of cheese and the determination of structural and mechanical properties, it was decided to use the enzyme preparation of animal origin SG-50. This choice is justified by the fact that the enzyme of animal origin has an obvious priority over the microbial one, since its use increases the yield of the product and improves rheological characteristics, due to the uniform flow of the coagulation process due to adequate proteolytic activity.

In addition, from the point of view of food safety, the use of an enzyme of animal origin is more acceptable, since the enzyme of microbial origin is less studied and unpredictable.

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ИССЛЕДОВАНИЕ ИЗМЕНЕНИЯ СТРУКТУРНО-МЕХАНИЧЕСКИХ СВОЙСТВ ПОЛУТВЕРДОГО СЫРА В ПРОЦЕССЕ ДЕФРОСТАЦИИ

В статье представлены результаты исследования структурно-механических свойств полутвердого сыра, выработанный с помощью коагуляции козьего молока ферментными препаратами растительного и животного происхождения. Получены данные по структурно-механическим свойствам свежевыработанного образца сыра халлуми и образца подвергнувшийся низкотемпературному хранению и рассчитан коэффициент релаксации, характеризующий пластическо-эластических свойствах сырной массы. Структурно-механические свойства сыра, выработанного при использовании ферментного препарата животного происхождения имели лучшие показатели, чем показатели при выработке сыра ферментным препаратом растительного происхождения. Научные исследования проводились на базе Сибирского научно-исследовательского института сыроделия (Барнаул, Россия). В ходе проведенных исследований, основанных на опытно-экспериментальном методе, рассчитан объективный показатель консистенции сыра – коэффициент релаксации, который достаточно полно отражает важнейшие реологические свойства. Так, было установлено, что коэффициент релаксации дефростированного сыра, выработанного с помощью фермента СГ-50 имел лучшие показатели и составил K_{relax}=93,709 N/s, в то время как для сыра, выработанного с помощью фермента «Ренин» коэффициент релаксации составил K_{relax}=89,91 N/s.

Результаты имеют практическое значение, поскольку позволяют корректировать технологические режимы выработки сыров и оценивать влияние различных факторов воздействия на формирование консистенции сыров.

Ключевые слова: *сыр, дефростация, коэффициент релаксации, реологические свойства, качество.*

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ЕРІТУ ПРОЦЕСІНДЕ ЖАРТЫЛАЙ ҚАТТЫ ІРІМШІКТІҢ ҚҰРЫЛЫМДЫҚ-МЕХАНИКАЛЫҚ ҚАСИЕТТЕРІНІҢ ӨЗГЕРУІН ЗЕРТТЕУ

Мақалада ешкі сүтін өсімдік және жануар тектес ферменттік препараттармен коагуляциялау арқылы өндірілген жартылай қатты ірімшіктің құрылымдық-механикалық қасиеттерін зерттеу нәтижелері келтірілген. Халлуми ірімшігінің жаңа өңделген үлгісі мен төмен температурада сақталатын үлгінің құрылымдық-механикалық қасиеттері туралы мәліметтер алынды және ірімшік массасының пластикалық-серпімді қасиеттерін сипаттайтын релаксация коэффициенті есептелді. Жануарлардан алынатын ферменттік препаратты қолдану кезінде өндірілген ірімшіктің құрылымдық-механикалық қасиеттері өсімдік тектес ферменттік препаратпен ірімшік өндірудегі көрсеткіштерге қарағанда жақсы көрсеткіштерге ие болды. Ғылыми зерттеулер Сібір ірімшігі ғылыми-зерттеу институтының (Барнаул, Ресей) базасында жүргізілді. Тәжірибелік-эксперименттік әдіске негізделген зерттеулер барысында ірімшіктің консистенциясының объективті көрсеткіші – релаксация коэффициенті есептеледі, ол маңызды реологиялық қасиеттерді толық көрсетеді. Сонымен, СГ-50 ферментімен өндірілген дефростирленген ірімшіктің релаксация коэффициенті ең жақсы көрсеткіштерге ие болды және K_{relax}=93,709 N/s құрады, ал Ренин ферментімен өндірілген ірімшік үшін релаксация коэффициенті K_{relax}=89,91 N/s болды.

Нәтижелер практикалық мәнге ие, өйткені олар ірімшіктерді өндірудің технологиялық режимдерін түзетуге және ірімшіктердің консистенциясын қалыптастыруға әсер ететін әртүрлі факторлардың әсерін бағалауға мүмкіндік береді.

Түйін сөздер: *ірімшік, дефростация, релаксация коэффициенті, реологиялық қасиеттері, сапа.*

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