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RESEARCH OF EFFECT OF CALCIUM URONIC COMPLEXES ON THE BASIC QUALITY INDICATORS OF THE CURD

Досліджена вологоутримуюча здатність (ВУЗ) харчових систем на основі сиру кисломолочного та гелю альгінату кальцію, утвореного між аніонами уронових кислот альгінату натрію та іонами кальцію з рідкої фракції сиру кисломолочного. Встановлено режими резервування харчових систем на основі сиру кисломолочного та уронатних комплексів. Доведено, що розроблені харчові системи покращують фізико-хімічні та органолептичні показники, які формують поняття «якість» сиру кисломолочного.

Ключові слова: *сир кисломолочний, іонотропне гелеутворення, якість, уронати, кальцій, вологоутримуюча здатність.*

1. Introduction

Today, all over the world dairy industry produces new ingredients and products with desired physical and functional characteristics. At the same proteins remain unchanged main component of building blocks of texture properties of the products, as well as human food.

Cottage cheese is caseinate-calcium phosphate complex (CCPC) with pronounced hydrophobic bonds formed mainly due to «the calcium bridges» of para-χ-casein. The hydrophobicity of these particles (micelles) is the cause of their location in a given volume. Protein aggregated by hydrophilic particles outward while ensuring maximum contact of proteins with water.

That's why CCPC has poor water-holding and water-binding capacity in the system «protein-water». The rate and stability of water binding depends mainly on the condition, properties and concentration of proteins and hydration conditions: pH of the medium, which characterizes the ionization level of amines; the degree of denaturation changes, the growth of which helps to reduce the water sorption by the protein due to the reduction of protein-protein interactions.

In this regard, current research is aimed at increasing the number of hydrophilic groups, and as a result, increase of protein water-holding capacity (WHC). It has been found that hydrophilicity can be increased by adjusting the pH by adding various reagents into the system, capable of making ion exchange with Ca^{2+} particles of protein substrate. Such is the solution of sodium alginate — polysaccharide with high content of guluronic anions in ionotropic gelation reaction.

2. The object of research and its technological audit

The object of this research is the physicochemical properties of the CCPC-based food system containing ionotropic gelation reaction products in the form of complex compounds of uronic acid anions with calcium.

Technological audit was conducted to identify the characteristics of the interaction in the protein product that allow to set the following process parameters:

— Polysaccharide (alginate) concentration in the solution.
— Polysaccharide solution concentration in the product system.
— Exposure time of polysaccharide solution.
— Temperature of polysaccharide solution.
— The parameters of polysaccharide solution addition in the product: rate and beating time.

Process scheme is shown in Fig. 1.

Observation of an object within a set time allows to establish a visible improvement of CCPC water-binding capacity indicators containing polysaccharide complex.

It is interesting to note that this system is not subject to change at reduced pH. Basic quality factors remain stable in the pH range of $4,6 \pm 0,2$. In practical terms this will prolong CCPC shelf life and products based on it.

3. The aim and objectives of research

The aim of research is improvement of CCPC basic quality indicators through the use of the chemical potential of uronic acids in the composition of sodium alginate polysaccharide gel and optimization of technological process of producing a protein-polysaccharide semi-finished product.

To achieve this aim it is necessary:

1. Determine the WHC dependence on the content of the polysaccharide solution.
2. Establish a parametric optimum of technological process of producing a protein-polysaccharide semi-finished product, in which the basic quality indicators and nutritional value are high.
3. Identify the impact of added polysaccharide in the system of protein-polysaccharide complex.

4. Literature review

Proteins are the source of energy for human and essential regulators and catalysts of biochemical reactions in metabolism.

The best way to solve the shortage of protein in the human diet is to increase consumption of dairy products, especially cottage cheese, where the concentration of amino acids is considered to be the maximum and easily digestible [1].

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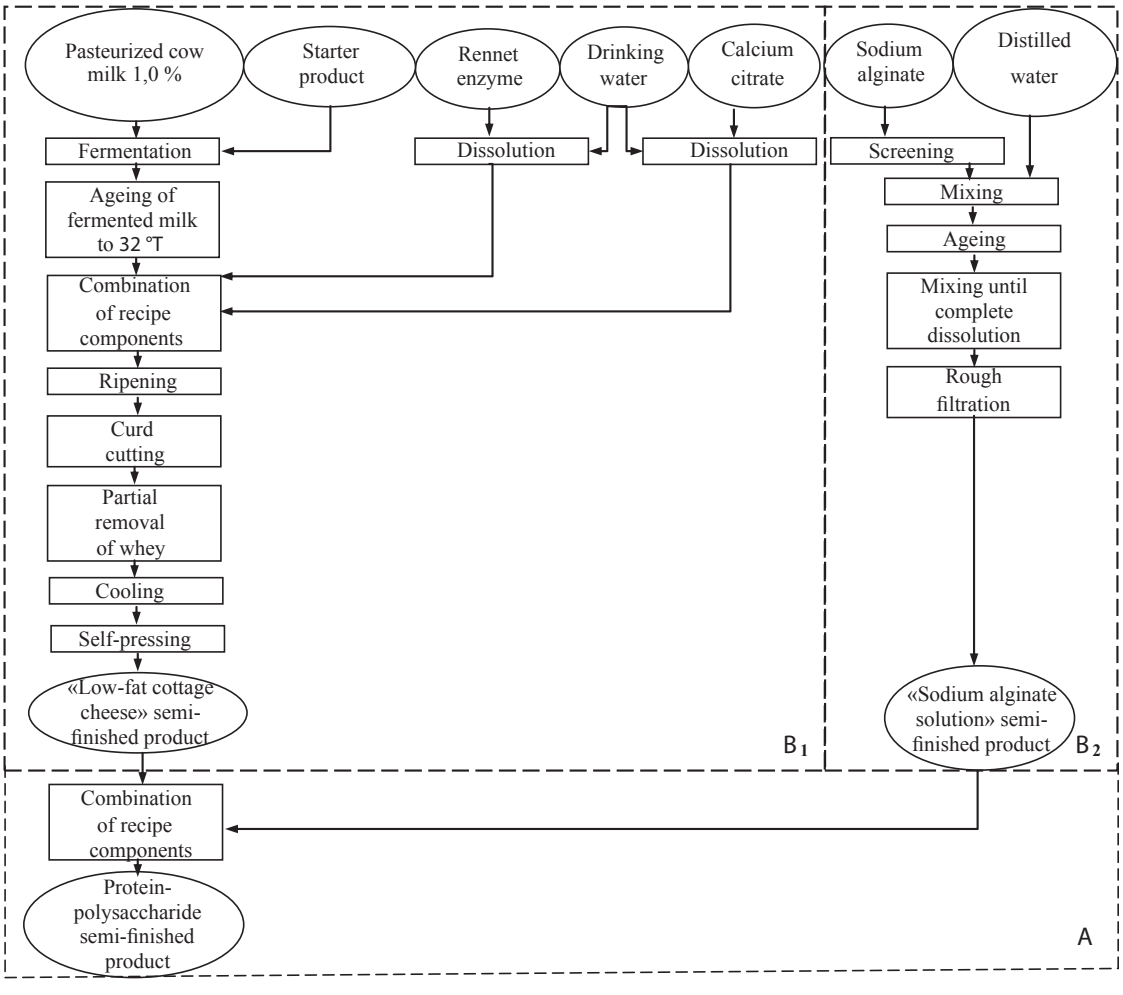

Fig. 1. Process scheme of the production of protein-polysaccharide semi-finished product

However, we should not forget that the cottage cheese is perishable dairy product because of the high content of free moisture in the milk protein concentrate [2, 3] favorable environment for the development of pathogenic and opportunistic microorganisms is formed. During long-term storage quality of the cheese is deteriorating: organoleptic properties are decreased (due to the microbiological processes), acidity is increased (due to chemical reactions under the influence of atmospheric oxygen), reduced moisture content is decreased (due to syneresis) and outflow of vitamins, minerals and peptides from the product composition is occurred [4, 5].

The short shelf life of cottage cheese (within 7 days) [6] complicates the turnover and the stability of supplies to the population, with the result that there is a need for conservation of cottage cheese in the off-season by freezing.

Analytical studies revealed that as a result of freezing, raw milk changes at the molecular level. Mass fraction of soluble proteins is reduced in these conditions. Irreversible bonds are occurred due to the formation of new structures with the formation of new structures, new complexes are formed. These complexes degrade digestibility of the products [7, 8].

Such chemicals as preservative are used to prevent the development of bacteria, fungi and yeasts in food [9–11]. Products made with preservatives retain the necessary properties for a longer time. The use of preservatives is cost-effective way of improving food storage stability as compared to physical methods of preservation, which require a significant investment for the purchase of special equipment, packaging and other activities, but their entry into the human body is necessary to limit.

Stabilizers (hydrocolloids) are food additives, which are used to improve the appearance, flavor characteristics, texture and longer shelf life of cottage cheese [12]. Stabilizers bind free moisture in the products and thereby create conditions to slow the growth of microflora [10], prevent whey sludge during storage of dairy products, allow to adjust their structure and consistency [12–14]. They can be used to produce high-quality low-fat cottage cheese with a solids content of 17,0–18,0 %, stable to syneresis and cottage cheese products having a flexible structure and cream-like consistency [15, 16].

It is necessary to consider that if such systems are subjected to further processing (mechanical, thermal, microwave heating), the quality of food products is will be low.

Thus, the use of sodium alginate ionotropic polysaccharide in the technology of cottage cheese-based semi-finished products will create a completely new product based on the principle of controlled ionotropic gelation [17], which is an innovative technological solution to the problem of water holding in CCPC system for extending the shelf life and regeneration of technological functions after conservation while maintaining the high quality

performance of cottage cheese and culinary products based on it. Thus, there are no changes in the physical state, structure, organoleptic properties and nutritional value.

5. Materials and methods of research

In order to implement the chemical potentials of the ionotropic gelling agents and free Ca^{2+} ions that are the part of milk-protein complex in the system of cottage cheese liquid phase, the content of free calcium is investigated. This technique is implemented by determining the mass fraction of cottage cheese moisture.

3...5 g of cottage cheese was added in the weighing bottle. Cottage cheese was weighed with an accuracy of less than 0,0001 g. After that weighting bottle was capped and weighed. Then the contents were thoroughly mixed with a glass rod and opened weighing bottle was heated on a steam bath with frequent mixing of the content until a crumbly mass. Then open weighted bottle and cap and were placed in an oven with a temperature of 102 ± 2 °C. After ageing for 2 hours the weighing bottle was removed from the oven, capped and cooled in a desiccator for 40 minutes and weighed.

The next weighing was carried out after drying for 1 hour as long as the difference between two serial weighing will be less than or equal to 0,001 g.

Mass fraction of solids was calculated by the formula:

$$S = \frac{m_1 - m_0 \times 100}{m - m_0},$$

where S — solids content in the cottage cheese, %; m_0 — mass of weighing bottle; m — mass of weighing bottle with the portion of the test sample before drying, g; m_1 — weight of weighing bottle with the portion of the test sample after drying, g; 100 — equivalent to bring the received value in percentage.

Mass fraction of moisture W, % in the cottage cheese was determined by the formula:

$$W = 100 - S.$$

Determination of the amount of free Ca^{2+} ions that are part of the milk-protein complex in the system of cottage cheese liquid phase was performed by measuring using ion-selective electrode.

Water-holding capacity of the protein-polysaccharide systems after low temperature storage was investigated to determine the optimum concentration of sodium alginate in the cottage cheese. These indicators were compared with the native cottage cheese.

WHC was determined by Grau-Hamm gravimetric method in A. Alexeev modification, based on the determination of water amount, extracted from the product under gentle pressing, which is absorbed with filter paper. The paper was used ashless slowly suction filters 9–11 mm (blue band), which for establishing a constant humidity are kept in a desiccator with calcium chloride.

The filter was placed on a glass plate with size $11 \times 11 \times 0,5$. 0,3 g of cottage cheese was weighed with accuracy of 0,5 mg and transferred to a polyethylene film of 40 mm in diameter. Film was covered by the glass plate of the same size, and weight of 0,5 kg was set on it. Content was pressed during 7 minutes. The filter with the sample was removed from the load and the plate. Cottage cheese with plastic wrap was removed from the filter paper and weighed. The difference in weight of the product with the film before and after pressing was point at whey weight, which was extracted. The amount of moisture that was retained by the sample was determined by the formula:

$$\text{WHC} = 100 \times (a - b)/a,$$

where WHC — water-holding capacity of cottage cheese, %; a — moisture amount in the test portion, g; b — whey amount, which was extracted from the cottage cheese, g:

$$a = 3,0 \times W/100,$$

where 3,0 — cottage cheese portion, g; W — mass moisture proportion in the cottage cheese, %.

6. Research results

Data on WHC definition is given in Fig. 2.

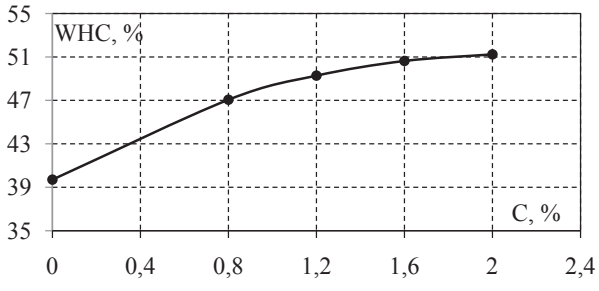

Fig. 2. WHC of cottage cheese with sodium alginate solution (1 %)

Considering the results shown in Fig. 2, as well as the previously obtained optimum concentration of sodium alginate (1...1,2 %) in a gel, it can be concluded that WHC is increases with increasing content of sodium alginate solution into a system of protein-polysaccharide complex. However, in systems with a high content of sodium alginate gel (over 2 %) there is marked reduction in the organoleptic characteristics of samples that can be adjusted an optimal gel content in CCPC in the range of 1...2 %.

7. SWOT-analysis of research results

Strengths. The strengths of this research can be called results of rational parameters of conservation process of food and biological value of cottage cheese by holding moisture in the product and adding an additional amount of liquid in the form of the polysaccharide solution. Support of this assertion is evidenced by the facts presented in the literature review confirmed that together with the moisture, extracting from the cottage cheese, vitamins, mineral components, lactic acid and soluble proteins are extracted too. In addition, the transition of moisture from the bound state to a free becomes a cause of formation and growth of pathogenic and opportunistic pathogenic microorganisms, and this situation goes to the rank of the problem. For this reason, the method of preserving the natural moisture and adding additional moisture, which is related as a polysaccharide solution that is able to continue hydration, can solve both problems.

Weaknesses. The weakness of this research lies in the fact that the method of addition of sodium alginate solution does not allow to save natural grainy consistency and texture of cottage cheese, and turns it into a viscous plastic mass. Therefore, it is the question of further ways of using this system as a part of culinary products.

Opportunities. Additional features that ensure demand for the results of this research lies in the fact that the weakness, namely the consistency, allows to work out the perspective of manufacturing of semi-finished product from this product with subsequent freezing. This information can be considered as a motivating factor for the development of the technology of frozen semi-finished products, quality and high nutritional value of which will guarantee by the participants of described system. Designated prospects may also be the basis for further development of described research.

Threats. The difficulties of implementation of research results are primarily related with the economic calculations of the cost of the finished product. Addition of additional ingredients will increase the value per 1 kg of product in the range of 10 ± 5 % in comparison with existing analogues. However, considering the increase in storage time (reducing the number of production cycles per month (year)), and the moisture holding in the product to 25 ± 5 %, the cost can even be reduced by 12 ± 2 % in comparison with existing analogues.

Thus, SWOT analysis of research results allows to determine the main ways of achieving aim of this research. Among them:

— Maximum moisture holding and preservation of high nutritional value of cheese.

— Increase in terms of product storage due to the fact that moisture is bound.

8. Conclusions

1. It was determined that the water holding capacity dependence on the concentration of added polysaccharide solution has an optimum of 50 ± 5 %, which is not only limited by the fact that syneresis occurs at the excess of sodium alginate gel in the system, but also the organoleptic evaluation, the results of which indicate that flavoring indicators are significantly deteriorated for gel content higher than 2 %.

2. It was found that rational process parameters are in the range:

— Polysaccharide (alginate) concentration in the solution — 1,1 ± 0,1 %.

— Polysaccharide solution concentration in the product system — 10 ± 2 %.

— Exposure time of polysaccharide solution — 25 ± 5 minutes.

— Temperature of polysaccharide solution — 20 ± 2 °C.

— The parameters of polysaccharide solution addition in the product — ν = 2500 rev/min; $\tau_{beating}$ = 200 ± 20 s.

3. It is known that the basis of developed technology is the complexing reaction between anions of sodium alginate uronic acid and free calcium ions contained in the liquid fraction of cottage cheese. Firstly, the chemical potential is realized by guluronic anions, interacting with calcium, and then mannuronate-guluronic anions enter into ion interaction reaction, and lastly, mannuronate-mannuronate blocks of alginic acid. Calcium is bound completely. Potentiometrically it has been proved the absence of calcium ions in the liquid phase of experimental samples with low water holding capacity.

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ИССЛЕДОВАНИЕ ВЛИЯНИЯ УРОНАТНЫХ КОМПЛЕКСОВ С КАЛЬЦИЕМ НА ОСНОВНЫЕ ПОКАЗАТЕЛИ КАЧЕСТВА ТВОРОГА

Исследована влагоудерживающая способность (ВУС) пищевых систем на основе творога и геля альгината кальция, образующегося между анионами уроновых кислот альгината натрия и ионами кальция, содержащимися в жидкой фракции творога. Установлены режимы резервирования пищевых систем на основе творога и уронатных комплексов. Доказано, что

разработанные пищевые системы улучшают физико-химические и органолептические показатели, формирующие понятие «качество творога».

Ключевые слова: творог, ионотропное гелеобразование, качество, уронаты, кальций, влагоудерживающая способность.

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ДОСЛІДЖЕННЯ ТЕХНОЛОГІЧНИХ ВЛАСТИВОСТЕЙ ПОРОШКУ ШКІРКИ ВИНОГРАДУ ЯК ФУНКЦІОНАЛЬНОГО ІНГРЕДІЄНТУ МАЙОНЕЗНОГО СОУСУ

Досліджено технологічні властивості порошку шкірки винограду, що пропонується як компонент майонезного соусу оздоровчого призначення. Визначені залежності технологічних показників суспензії порошку шкірки винограду від концентрації кислоти та температурних режимів попередньої обробки. Встановлено оптимальні діапазони значень концентрації кислоти та температури для технологічних показників суспензії досліджуваного порошку, а саме вологоутримуючої здатності, ефективної в'язкості та поверхневого натягу.

Ключові слова: *порошок шкірки винограду, технологічні властивості, майонезний соус, концентрація кислоти, температура.*

1. Вступ

Сучасні тенденції формування здорового раціону харчування диктують необхідність створення продуктів оздоровчого призначення зниженої калорійності, з низьким рівнем холестерину, збагачених спеціальними харчовими добавками натурального, переважно рослинного походження. З огляду на це, а також на популярність майонезної продукції на ринку України, перспективним є створення майонезних соусів, які мають збалансовану по поліненасиченим жирним кислотам ω-6 та ω-3 груп олійну основу, а також збагачених різними нутрієнтами, необхідними для організму [1].

Необхідно відзначити, що успішне створення майонезів необхідної харчової та фізіологічної цінності може бути здійснено тільки при комплексному вирішенні даного завдання з рядом технологічних завдань отримання майонезу у вигляді високоякісної, стійкої емульсії з високими органолептичними та заданими фізико-хімічними властивостями. Необхідність комплексного підходу у вирішенні зазначених завдань обумовлена низкою причин, однією з яких є те, що, на відміну від майонезів, майонезні соуси є емульсіями невисокої в'язкості, створення і стабілізація яких вимагає використання спеціальних нетрадиційних методів і засобів. Серед останніх одним з найбільш важливих є застосування стабілізаторів.

Сучасна харчова промисловість має у розпорядженні широкий вибір емульгаторів і стабілізаторів емульсій [2]. Однак необхідно враховувати, що при розробці рецептур майонезів і майонезних соусів оздоровчого призначення поряд з рішенням технологічного завдання — отримання стійкої емульсії — необхідно пам'ятати про основну мету — забезпечення високої фізіологічної та біологічної цінностей продукту. Останні будуть неминуче визначатися, виходячи з природи рецептурних компонентів [2, 3]. Тому при виробництві майонезних соусів оздоровчого призначення необхідно враховувати наявність певних технологічних властивостей функціональних інгредієнтів, що вводяться в рецептуру, це буде відігравати вирішальну роль у формуванні певних реологічних властивостей готового продукту.

2. Об'єкт дослідження та його технологічний аудит

Об'єктом дослідження є функціональний інгредієнт, що пропонується ввести у рецептуру майонезного соусу оздоровчого призначення — порошок шкірки винограду сорту Чорна перлина, що отримується з вторинних продуктів сокової промисловості та виноробства.

Предмет дослідження — технологічні властивості суспензії порошку шкірки винограду вищезазначеного сорту. Було визначено такі технологічні показники: вологоутримуюча здатність, ефективна в'язкість та поверхневий натяг в залежності від умов попередньої обробки.

Одним із важливих та проблемних питань при виробництві майонезної продукції є створення оптимальних фізико-хімічних показників (зокрема в'язкості готового продукту та стабільності емульсії). Проведення технологічного аудиту має за мету визначення таких основних задач:

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