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THE POTENTIAL OF URONIDE HYDROCOLLOIDS FOR THE FORMATION OF SENSORY CHARACTERISTICS OF HEALTH PRODUCTS FROM HYDROBIONTS

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Introduction. Formulation of the problem

A current trend in the modern food industry is the development of fish products in which jelly filling of prolonged storage is used [1,2]. The rheological properties of fillings are largely influenced by the nature of polysaccharide hydrocolloids that not only

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Abstract. The article presents the theoretical basis and practical aspects of using binary compositions of uronide polysaccharides in the technology of culinary products made from aquatic organisms in jelly fillings. It has been shown how important it is today to use a composition of natural high-molecular-weight polysaccharides (such as sodium alginate and low-ester pectins) in order to improve the sensory characteristics of culinary products from aquatic organisms in the menus of fish restaurants. Dissolution of low-ester pectic substances is accompanied by the formation of different lumps. To ensure dispersion of hydrocolloid particles, a dry mixture was created. Sodium alginate and low-ester pectic substances were mixed with salt and sugar, which was followed by swelling in water at 18–20 °C for 15 minutes. The swelling process has three stages and is characterized by the swelling rate. Intense swelling of the mixture occurs in the first 10 minutes of hydration at the hydromodulus 1:10, with the swelling rate changing from 1.88 to 0.58 tg α /hour. The degree of swelling is as high as 5.8%. Further increase in time has almost no effect on the swelling process. The experiments have helped determine the most practical mass fraction of calcium ions that allows obtaining transparent gel with a stable, homogeneous, elastic consistency (0.3–0.4% of 10% solution of calcium chloride). The studies have shown that dispersions where the mass fraction of the mixture of alginate and low-ester pectic substances is 1.8% have a flowable consistency with the dynamic viscosity less than 0.94 Pa \cdot s. This is important for transportation and packaging of jelly fillings. The parameters studied include the conditions and rate of gelation. They are responsible for the high sensory characteristics of the finished products and for their elastic consistency due to the regulated melting temperature, which is provided by the composition of uronide hydrocolloids. Using a mixture of hydrocolloids with the mass fractions ranging 1.6 to 1.8% leads to the formation of gel with the strength over 140 g, which is evidence of high sensory characteristics.

Key words: jelly filling, uronide hydrocolloids, sensory characteristics.

form the structure of the jelly, but also add health-improving properties to the finished product.

The above shows how necessary it is to develop scientifically grounded technologies of fish-based culinary products using natural high-molecular-weight polysaccharide hydrocolloids, which add certain structural and functional properties and good sensory characteristics to food [1,3]. However, manufacture of

these products still faces a number of technological problems that include obtaining fillings with the required elastoplastic properties in the course of gelation and preventing syneresis during refrigerated storage [4].

Analysis of recent research and publications

Culinary products in jelly fillings are traditional mass-consumption dishes. The classic technology of culinary products from fish is based on fish broths with the use of gelatine. According to I. Parkhutova, to form jelly only based on fish broth, the dry solids should make up at least 12%. Such fish broths have a low melting point of 14 °C. The gel is very soft and loose. A combination of fish broth with gelatine allows increasing the melting point to 22–24 °C and getting soft, elastic gel [5]. For the formation of jelly like this, the mass fraction of gelatine must be at least 4%. The complexity of preparation of fish broth and the high consumption of gelatine are the main problems in the technology of fish culinary products. These fish products have a very short shelf life (72–96 hours) due to the protein nature of the gelling agent and the presence of free amino acids [6].

Another problem when using the classic broth-based filling is an extra technological operation, clarification. Clarifying the broth is necessary to obtain transparent, attractive-looking filling. Egg white is usually used for this purpose [6].

Quite a disadvantage of these jellylike fillings is a high content of extractives, which increases the stress on the liver and kidneys and thus limits the range of consumers of the products [7].

The above disadvantages of the classic technology make it necessary to look for new substances that have a structure-forming ability and give the finished product therapeutic or prophylactic properties. Natural high-molecular-weight polysaccharide hydrocolloids are used as components that help to improve the consumer properties of food products. One of the widely used hydrocolloids is sodium alginate obtained by alkaline extraction of brown algae. Sodium alginate has a wide range of therapeutic and prophylactic properties, that is why it is widely used in medicine, biotechnology, and various branches of the food industry [8,9].

In the formation of sensory characteristics, the rheological properties of the structure-forming agent play an important role.

The jellylike structure in solutions of alginates is formed with the participation of ions of bivalent metals by interaction of molecules with each other in the zones of ionotropic gelation [10]. In this formation, important factors are: the concentration of alginate, its chemical composition and molecular weight, and the ratio of the substances involved in the gelling process (calcium salts as a source of ions, complexing agents: phosphates, citrate, acids, etc.). The rapid course and irreversibility of the binding reaction between

polyvalent cations and alginates is a problem in the technology of alginate jellies.

Hydrocolloids of plant origin are primarily used in food technology to obtain a structure with certain rheological parameters. Gelation of low-ester pectin is carried out mainly due to the interaction between pectin and calcium ions [1].

Mixtures of uronide hydrocolloids can be used to obtain new and improved rheological properties of jelly fillings for culinary products from fish [11]. At low concentrations, sodium alginate makes the structure highly viscous, has a pronounced neutral taste, and the pH values of its solutions are close to neutral, which corresponds to the pH value of fish products. Gels formed by sodium alginate are heat-inverted and relatively resistant to acids, which is important in the production of fish culinary products with the addition of food acidity regulators.

The study of associative interactions in hydrocolloid systems was paid attention to in the works by many domestic and foreign researchers, whose purpose was to expand the functional and technological properties of hydrocolloids [12,13]. Traditionally, carob bean gum is added to kappa-carrageenan to obtain softer transparent gels, and carob bean gum is added to xanthan gum to initiate the gelation process [10].

This problem was also paid attention to when studying how the type and concentration of food ingredients of polysaccharide nature affected the nature of crystallisation and stability of systems during deep refrigeration [4].

There is great technological, physiological, and economic potential for food products made in jelly fillings from fish of inland waters and seafood, using uronide hydrocolloids with controlled gelation. So far, though, this potential has not been fully used.

The importance of the research consists in studying the rheological properties of jelly filling based on a composition of uronide hydrocolloids, namely pectins with a low degree of esterification and sodium alginate. Their combination will result in obtaining gels with structural and mechanical properties other than those of pure pectin or alginate gels. The data obtained allow recommending the complex use of these polysaccharides in the recipes of fish-based culinary products.

The purpose and objectives of the research.

The purpose of the research is to study the associative interactions of uronide hydrocolloids when making fish-based culinary products in jelly fillings.

The objectives of the research are:

1. Developing a structural scheme of obtaining jelly filling to determine the parameters of preliminary preparation of hydrocolloids.
2. Studying the effect of technological parameters on the rheological characteristics of the gel.

3. Obtaining a jelly filling of viscous consistency, with further formation of stable, elastic gel.

Research materials and methods

For the research, we used low-ester apple pectin in the form of fine powder (the degree of esterification 35%) obtained in the laboratory of the Odessa National Academy of Food Technologies from pomace of apples of winter varieties grown Odessa region. The biotechnological methods used in the research included processing an extract of high-ester pectic materials with pectin-methyl esterase Lucerne [14].

Formation of the gelling composition involved using sodium alginate of the brand Danisco FD 127 in the concentration 1.0–2.0%. The source of calcium ions was 10% solution of calcium chloride (PAT Galichpharm, 10% solution of calcium chloride for injection) in accordance with TU 21.2-25657043-069-2014.

The main technological stages of obtaining jelly filling with the required functional properties are shown in Fig. 1.

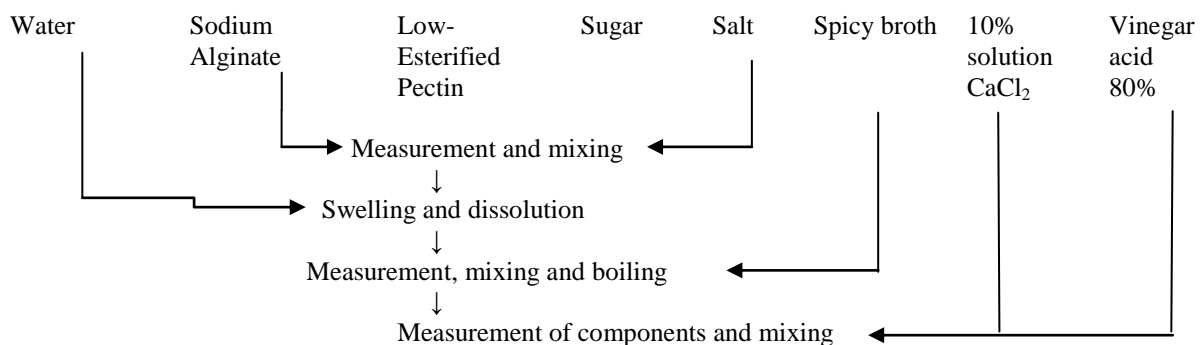


Fig. 1. Block diagram of obtaining jelly filling

Results of the research and their discussion

It has been found that to ensure stable structural and mechanical properties of the gel during refrigerated storage, it is rational to use a combination of low-methoxylated pectin and alginic acid in the ratio 1: 1 with the mass fraction 1.5%. In filling with these parameters, synearetic changes are not observed and gel with the strength 112 g is formed [1]. This strength of the gel indicates the high sensory properties of the finished product.

It is known that molecules of sodium alginate consist of residues of D-mannuronic and L-guluronic acids and have a polymeric structure. Molecules of sodium alginate in water are solvated and dissociated into sodium cations and multicharged highly elongated polymeric anions of alginic acid. This phenomenon explains the high viscosity of alginate solutions and their gelling ability [4,16-18].

The initial stage is the formation of a dry mixture of structurants with salt and sugar, for uniform swelling and dissolution of hydrocolloids.

Dynamic viscosity was determined on a rotary viscometer Brookfield LV DV-II + Pro. The principle of operation of the viscometer is based on the rotation of a special measuring spindle immersed in the test fluid, using a calibration coil spring. Each spindle is characterised by two constants that are used to calculate the viscosity [15].

The process of jelly formation was studied at 20 °C. The strength of the jelly was measured using a modified Valent device according to GOST (State Standard) 26185-84, which determines the mass of the sample required to destroy the jelly. The strength is determined by moving the work table at idle speed till the collision of the surface of the sample and the spherical nozzle. When the specified force of contact is reached, the load on the sample changes at a set speed till the sample is destroyed. After each successful completion of the mode, the indicator shows the average value.

The gel formation is significantly affected by the degree of hydration of hydrocolloids. Sodium alginate is highly hydrophilic, biocompatible, and provides high viscosity of the structure at low concentrations. L. Bolshakova *et al.* observed the maximum watering of sodium alginate at the water temperature 18–20 °C for 25 minutes. Increasing the water temperature to 95 °C does not affect the viscosity of the gel formed, but leads to an increase in the energy consumption of the technological process and the cost of production [16]. There are also data on the optimal hydromodulus of sodium alginate and water, which is 1:8, with the swelling time 40–60 minutes [19].

To prevent sticking and partial dissolution of pectic substances, it is important to ensure the dispersion of particles of dry pectin powder [20,21]. According to the scheme shown in Fig. 1, the process of swelling of a dry mixture of hydrocolloids with salt and sugar has been studied. To make the swelling

process effective, the hydromodulus was varied from 1:5 to 1:15. The findings are presented in Table 1.

Organoleptic evaluation of the swelling process was performed using the method of scores with the following weights: for appearance – $k = 0.3$; for texture – $k = 0.5$; for fluidity – $k = 0.2$, and a system of points: excellent – 4.1–5.0; good – 3.1–4.0, satisfactory – 2.1–3.0; unsatisfactory – 1.0–2.0.

Swelling of dry alginate, pectin, and their mixtures is accompanied by the formation of lumps, characterised by a dull appearance, inhomogeneous texture, and unflowable consistency. The highest organoleptic evaluation of 5 points was received by the mixture of low-ester pectin with sodium alginate, salt, and sugar, with the hydromodulus 1:10. Increasing the hydromodulus to more than 1:10 does not lead to

noticeable changes in the appearance, but the texture becomes too fluid and requires an increase in the mass fraction of the structurant. Factors that affect further dissolution and gelation are the extent and rate of swelling. The degree of swelling is the ratio of the volume (mass) of the swollen hydrocolloid to its initial volume (mass). The kinetics of swelling of hydrocolloids has been studied by weight.

The experimental data (Fig. 2) show that intense swelling of the mixture occurs in the first 10 minutes of hydration. After reaching the degree of swelling 5.8%, the rate of swelling decreases and there is a gradual slowdown in the degree of swelling over time. A further increase in time has almost no effect on the swelling process and the degree of swelling varies in the range $6.0 \pm 0.2\%$.

Table 1 – Organoleptic evaluation of the swelling process, points

Samples	Characteristics	Weight coefficient	Hydromodulus, structure-forming agent:water				
			1:5	1:7.5	1:10	1:12.5	1:15
Low-ester pectin	Appearance	0.3	0.60	0.90	0.90	0.60	0.60
	Texture	0.5	1.00	1.50	1.50	1.00	1.00
	Fluidity	0.2	0.40	0.60	0.60	0.40	0.40
	Overall rating		2.00	3.00	3.00	2.00	2.00
Sodium alginate	Appearance	0.3	0.60	0.90	0.90	0.60	0.60
	Texture	0.5	1.00	1.50	1.25	1.00	1.00
	Fluidity	0.2	0.40	0.60	0.50	0.40	0.40
	Overall rating		2.00	3.00	2.65	2.00	2.00
Low-ester pectin with sodium alginate	Appearance	0.3	0.60	0.90	0.90	0.60	0.60
	Texture	0.5	1.00	1.50	1.75	1.00	1.00
	Fluidity	0.2	0.40	0.60	0.60	0.40	0.40
	Overall rating		2.00	3.00	3.25	2.00	2.00
Mixture of low-ester pectin with sodium alginate, salt, and sugar	Appearance	0.3	0.60	0.90	1.50	1.50	1.50
	Texture	0.5	1.00	1.50	2.50	2.25	1.50
	Fluidity	0.2	0.40	0.60	1.00	0.80	0.40
	Overall rating		2.00	3.00	5.00	4.55	3.40

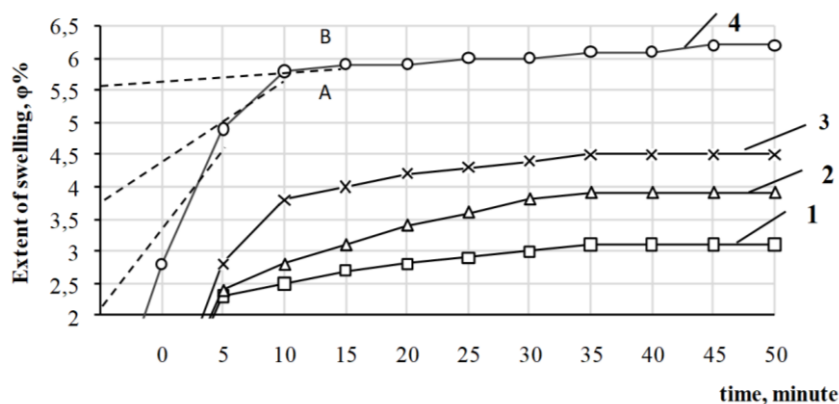


Fig. 2. Kinetic curve of swelling:

- 1 – low-esterified pectin with a extent of esterification of 35%;
- 2 – sodium alginate; 3 – low-esterified pectin with sodium alginate;
- 4 – A mixture of low-esterified pectin with sodium alginate, salt and sugar

The rate of swelling is characterised by the angle of the curve showing the ratio of the degree of swelling (α) to the time on the abscissa: the greater α , the higher the rate. As can be seen from the graph (Fig. 2), starting from the area at point A, the rate of swelling decreases and at point B becomes constant. The swelling kinetics of the hydrocolloid mixture was evaluated by determining the tg angle of inclination tangent to the curve describing the degree of swelling. The estimated data are given in Table 2.

Table 2 – The rate of swelling of the mixture of hydrocolloids (n = 5, p<0,05)

Swelling stage	Swelling rate, (tg α / h)
1st stage (up to 5 min)	1.88
2nd stage (from 5 minutes to 10 minutes)	0.58
1st stage (from 10 min to 15 min)	0.05

As can be seen from the data (Fig. 2, Table 2), at the third stage, the rate of swelling is almost zero. The degree of swelling, which corresponds to the appearance of a horizontal section on the curve, is the maximum or equilibrium. Thus, the swelling parameters of the hydrocolloid mixture are substantiated. Analysis of the results has shown that after 15 min, the test sample absorbs the liquid and the system receives a stable state that does not change over time.

The reaction of ionotropic gelation is an important process in the production of edible jelly fillings based on sodium alginate and low-ester pectin, so a special attention is paid to the choice of the component that promotes its course. In our studies, a 10% solution of calcium chloride was used as the source of calcium ions. It is known from the literature [10] that ionotropic gelation involving alginates, low-ester pectins, and calcium ions is characterised by a high reaction rate, so this process is subject to special control, as it is important to obtain gel with certain rheological properties. According to the process flow chart developed (Fig. 1), the next stage is mixing the prepared mixture of structurants with pre-prepared spicy broth [1] and heating the resulting solution. At high temperatures, gelation does not occur because the polymer chains are in thermal motion (have high thermal energy), which prevents their reaction with calcium. Gelation only occurs during cooling. That is why mixing was followed by adding 10% solution of calcium chloride, which was heated to 60 °C. It has been studied how adding the mass fraction of 10% calcium chloride solution (from 0.1 to 0.5%) affected the strength of gels formed by the composition of the hydrocolloids under study. The experimental data are presented in Fig. 3.

To implement a full gelation process, it is necessary to add at least 0.3–0.4% of 10% solution of calcium chloride, as gel formed at this ratio has a transparent, stable, homogeneous, plastic, and elastic

consistency. A lower dosage of 10% calcium chloride solution results in formation of gel with a soft, loose, inelastic consistency. With 0.5% of 10% solution of calcium chloride added, the gel has a dense and brittle consistency. According to the sensory and rheological studies, to obtain high-quality jelly, one should add 0.3–0.4% of 10% solution of calcium chloride.

In the technology of culinary products from aquatic organisms, important conditions are the viscous consistency of the jelly filling and the high strength of the jelly after solidification. Fig. 4 and 5 show the experimentally established dependencies of the viscosity of the dispersions and the strength of the gels on the mass fraction of the mixture of alginate and low-ester pectin in the ratio 1:1.

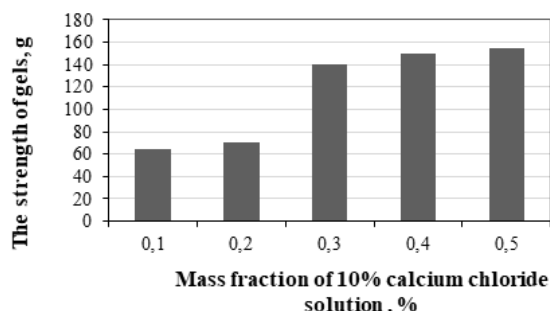


Fig. 3. The dependence of the gel strength of the mixture of hydrocolloids on the mass fraction of the 10% calcium chloride solution

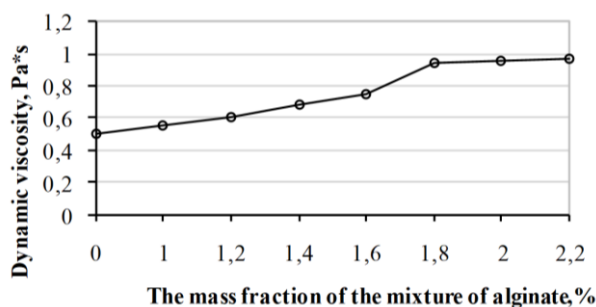


Fig. 4. Dependence of the viscosity on the mass fraction of the mixture of alginate and low-ester pectin in the ratio 1:1

It has been found that the dispersions studied, which have a dynamic viscosity of less than 0.94 Pa • s, are viscous fluids that meet the requirements of such technological operations as transportation and packaging of jelly fillings. From the graph (Fig. 4), it is seen that the required viscosity corresponds to the dispersion with the mass fraction of the mixture of alginate and low-ester pectin 1.8%.

It has been studied how the strength of the gels of the structure-forming mixture of hydrocolloids depends on the mass fraction. The experiments have shown that the strength of the gels formed does not increase linearly, therefore the data received are unique, and additional experiments are needed to research changes in compounding jelly filling (Fig. 5).

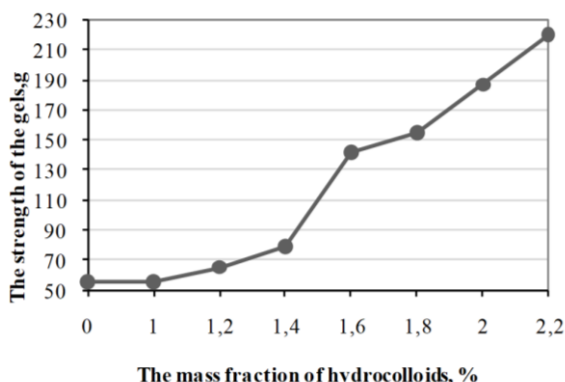


Fig. 5. The dependence of the strength of gels on the mass fraction of a mixture of alginate: low-esterified pectin in a ratio of 1: 1

Stable gels are characterised by a strength of more than 140 g. Analysis of the experimental data shows that the mass fraction of the structure-forming mixture of hydrocolloids, which is sufficient for the formation of stable jelly filling, can be considered 1.6 to 1.8%.

An important feature of the jelly fillings thus obtained is a rather high melting point (26°C), which is important in the technology of culinary products from aquatic organisms [11].

Thus, using mixtures of uronide hydrocolloids, you can regulate the texture of food systems to obtain new rheological and functional properties of finished products.

Conclusion

The associative interactions of uronid hydrocolloids in obtaining jelly fillings in the technology of culinary products from aquatic organisms are studied in the work. Technological stages of obtaining a jelly-filled viscous consistency have been developed, which provide for the need for preliminary preparation of finely-divided powders in order to prevent sticking and aggregation of particles. The extent and rate of swelling of the dry mixture of hydrocolloids was determined and the parameters were established: temperature 18–20 °C, swelling time 15 min, hydraulic module 1:10, while the degree of swelling is 5.8%.

The rational mass fraction of the 10% solution of calcium chloride for the formation of a transparent gel of stable, homogeneous, elastic consistency, which is 0.3–0.4%, was experimentally established.

It was investigated that dispersions with a mass fraction of alginate: low-esterified pectin – 1.8% have a viscous consistency with a dynamic viscosity of less than 0.94 Pa·s, which is important for the implementation of technological operations of transportation and packaging of jelly fillings. The conditions and rate of gelation, which provide finished culinary products with high consumer characteristics during certain storage life, were studied and it was found that the gel strength of more than 140 g forms a mixture of hydrocolloids with a mass fraction of 1.6 to 1.8%.

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ПОТЕНЦІАЛ УРОНІДНИХ ГІДРОКОЛОЇДІВ ДЛЯ ФОРМУВАННЯ СЕНСОРНИХ ХАРАКТЕРИСТИК ОЗДОРОВЧИХ ПРОДУКТІВ ІЗ ГІДРОБІОНТІВ

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Анотація. У статті представлено теоретичне обґрунтування та практичні аспекти використання бінарних композицій уронідних полісахаридів у технології кулінарних виробів з гідробіонтів у желейних заливках. Показано актуальність застосування композиції природних високомолекулярних полісахаридів, таких як альгінат натрію і низькоестерифіковані пектинові речовини, для сприяння покращенню сенсорних характеристик та біологічної цінності кулінарних виробів з гідробіонтів. До завдань дослідження входило отримання желейної заливки плинної консистенції з наступним утворенням стабільного, пружного гелю для застосування у технології продуктів з гідробіонтів. Отримання желейної заливки передбачає визначення параметрів попередньої підготовки гідролоїдів; дослідження впливу технологічних параметрів на сенсорні характеристики гелю. При розчиненні низькоестерифікованих пектинових речовин спостерігається злипання з утворенням грудочок. Для забезпечення диспергування частинок сухих порошоків гідролоїдів створювали суху суміш. Альгінат натрію і низькоестерифіковані пектинові речовини змішували з сіллю і цукром з наступним набуханням у воді за температури 18–20 °С протягом 15 хв. Процес набухання відбувається у три етапи і характеризується швидкістю набухання. Інтенсивне набухання суміші відбувається у перші 10 хвилин гідратації при гідромодулі 1:10 із зміною швидкості набухання від 1,88 до 0,58 tg α/год. При цьому досягається ступінь набухання 5,8 %; подальше збільшення часу практично не впливає на процес набухання. Експериментально встановлено раціональну масову частку іонів кальцію для утворення прозорого гелю стабільної, однорідної, пружної консистенції, яка складає 0,3–0,4 % 10-ого % розчину хлориду кальцію. Досліджено, що дисперсії з масовою часткою суміші альгінат : низькоестерифіковані пектинові речовини 1,8 % мають плинну консистенцію з динамічною в'язкістю менше 0,94 Па · с, що важливо для здійснення технологічних операцій транспортування і фасування желейних заливок. Суміш гідролоїдів з масовою часткою від 1,6 до 1,8 % забезпечує формування гелю міцність більше 140 г, що відповідає високим сенсорним характеристикам.

Ключові слова: желейна заливка, уронідні гідролоїди, сенсорні характеристики.

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