

**TECHNOLOGY OF THERMOSTABLE
AND FROZEN
FILLINGS WITH USING DAIRY RAW
MATERIALS AND SESAME SEEDS
CONCENTRATE**

Monograph

Edited by Pertsevov F.V., Gurskyi P.V.

Sumi- Kharkiv -Saratov-Wroclaw – 2020

**TECHNOLOGY OF THERMOSTABLE AND FROZEN
FILLINGS WITH USING DAIRY RAW MATERIALS AND
SESAME SEEDS CONCENTRATE**

Monograph

Edited by Pertsevov F.V., Gurskyi P.V.

Sumi- Kharkiv -Saratov-Wroclaw – 2020

Authors: Pertsevov F.V., Doctor of Technical Sciences, Professor, Head of the Department of Nutrition Technology SNAU, Ukraine (introduction and main editing of sections; Gurskyi P.V., Candidate of technical sciences, Professor, Kharkiv Petro Vasylenko National Technical University of Agriculture, Ukraine (2.1,2.2,2.3,2.6); Ladyka V.I., Doctor of Agricultural Sciences, Professor, Sumy National Agrarian University, Ukraine (2.4,2.5,2.9,3.6,); Shilman L.Z., Ph.D, Professor, Department of Food Technology Sumy National Agrarian University, Ukraine (3.4,3.5); Simakova I.V., Doctor of Technical Sciences, professor, Vavilov Saratov State Agricultural University, Russia (2.7, 2.8, 3.7, 3,8); Yanchyk M.V. Candidate of technical sciences, National University of Food Technologies, Ukraine (1.1,1.2,2.10); Lubenko G.D., Candidate of technical sciences, (1.1, 1.2, 1.3, 1.4, 3.1, 3.7, 3.8, 3.9), Obozna M.V. Candidate of technical sciences, Associate professor, SNAU, Ukraine 2.9, 3.7, 3.8, 3.9); Garntsarek Z.E., Wroclaw University of Economics, Poland (3.2,3.3);

Technology of thermostable and frozen fillings with using dairy raw materials and sesame seeds concentrate: monograph / F.V. Pertsevov, P.V. Gurskyi, V.I. Ladyka, [etc.]–Saratov: 2020. – 111 p.

The monograph contains concentrated and systematic scientific information on the use of dairy raw materials and sesame seeds concentrate for the production of thermostable dairy-containing fillings in the restaurant industry, represented by text form, technological calculations, drawings, schemes, tables and is intended for teachers, postgraduate students, students engaged in scientific work.

jn 25.01. 2020

UDC 637.1

ISBN 978-5-6044617-9-2

© Pertsevov F.V., Gurskyi P.V., Ladyka V.I., etc, 2020
© Sumy National Agrarian University, (Ukraine), 2020
© Kharkiv Petro Vasylenko National Technical University of Agriculture (Ukraine), 2020
© National University of Food Technologies, (Ukraine), 2020
© Vavilov Saratov State Agricultural University, (Russia), 2020
© University of Economics (Wroclaw, Poland), 2020

CONTENT

Introduction	7
Chapter 1 Analysis of production technologies of thermostable dairy-containing fillings, features of application of plant protein products and prospects of freezing	9
1.1 Prospects of production, analysis of consumer, technological and physicochemical aspects of production of thermostable fillings	9
1.1.1 Features of assortment formation and substantiation of recipe components of thermostable fillings	9
1.1.2 Features of production technologies of thermostable dairy-containing fillings	13
1.2 Substantiation of using thickeners and structure-forming agents in the technology of thermostable dairy-containing fillings	15
1.2.1 Substantiation of the expediency of using starch	17
1.2.2 Relevance of pectins engaging	19
1.2.3 Mechanism of structure formation and gel properties of low-esterified pectin.....	21
1.3 Prospects of using plant protein products in technology of thermostable dairy-containing fillings	22
1.3.1 Features of production technologies of plant protein products	22
1.3.2 Prospects of plant protein concentrates production and substantiation of the expediency of using sesame seed concentrate in the technology of thermostable dairy-containing fillings	23
1.4 Expediency of freezing application and influence of the technological regimes on quality of thermostable dairy-containing fillings	24
Chapter 2 Scientific substantiation of the thermostable filling technology using dairy raw materials and sesame seed concentrate	27
2.1 Study of functional and technological properties of hydrocolloids	27
2.2 Investigation of rheological properties of hydrocolloids	29
2.2.1 Investigation of the effective viscosity of hydrocolloids	29
2.2.2 Determination of changes in the strength of hydrocolloids.....	32
2.3 Investigation of the thermostable properties of hydrocolloids	33
2.3.1 Melting temperature change of hydrocolloids	34
2.3.2 Change of thermal stability of hydrocolloids.....	35
2.4 Investigation of functional and technological properties of protein concentrates of oilseeds.....	38
2.5 Investigation of influence of high temperature on the technological properties of the research system of thermostable filling	39
2.5.1 Study of influence of recipe components on melting temperature of the research system of the thermostable filling	39
2.5.2 Study of influence of recipe components on thermal stability of the research system of the thermostable filling	40
2.6 Investigation of moisture connection forms in the research system of the thermostable filling.....	42

2.6.1 Study of influence of recipe components on the moisture-holding ability of the research system of the thermostable filling	42
2.6.2 Determination of the influence of recipe components on the moisture state of the research system of the thermostable filling	43
2.7 Study of influence of recipe components on duration of structure formation and strength of the research system of the thermostable filling	45
2.8 Investigation of the effective viscosity of thermostable filling	47
2.9 Investigation of IR spectroscopic parameters of the research system of the thermostable filling.....	49
2.10 Establishing a rational ratio of the recipe components of the research system of the thermostable filling and the principles of recipe development.....	51
Chapter 3 Development of technology of thermostable fillings with using dairy raw materials and sesame seeds concentrate and study of its quality indicators under traditional storage conditions and frozen	55
3.1 Development of recipe and technology of thermostable filling using dairy raw material and sesame seeds concentrate	55
3.2 Study of microbiological indicators of thermostable filling using dairy raw material and sesame seeds concentrate and justification of its storage life under traditional conditions and frozen.....	59
3.3 Study of the chemical composition of thermostable filling using dairy raw material and sesame seeds concentrate during storage under traditional conditions and frozen	60
3.4 Study of physicochemical properties of thermostable filling using dairy raw material and sesame seeds concentrate during storage under traditional conditions and frozen	67
3.4.1 Study of chemical changes	67
3.4.2 Study of changes in moisture connection forms.....	68
3.4.2.1 Study of moisture-holding ability	68
3.4.2.2 Determination of changes in product humidity relative to the time of high temperature action.....	69
3.4.2.3 Determination of moisture condition	70
3.4.2.4 Study of kinetic regimes of endothermic processes.....	71
3.4.2.5 Determination the amount of frozen moisture	76
3.5 Study of rheological properties of thermostable filling using dairy raw material and sesame seeds concentrate during storage under traditional conditions and frozen	77
3.5.1 Determination of strength	77
3.5.2 Determination of the shear stress	78
3.5.3 Study of structural and mechanical properties	78
3.6 Determination of the temperature influence on the technological properties of thermostable filling using dairy raw material and sesame seeds concentrate during storage under traditional conditions and frozen	81
3.6.1 Change of thermal resistance.....	82
3.6.2 Change of melting temperature	83

3.7 Microstructure research of thermostable filling using dairy raw material and sesame seeds concentrate during storage under traditional conditions and frozen..... 84

3.8 IR spectroscopic analysis of thermostable filling using dairy raw material and sesame seeds concentrate during storage under traditional conditions and frozen 87

3.9 Protein composition study of thermostable filling using dairy raw material and sesame seeds concentrate..... 88

References 91

List of abbreviations and symbols

MHA – moisture-holding ability

AHF – ability to hold fat

SMP – skimmed milk powder

SSC – sesame seeds concentrate

TI – technological instruction

TF – thermostable filling

TS U – Technical specifications of Ukraine

NMR – nuclear magnetic resonance

Introduction

In the modern food market more and more strong position is taken by the baked products with fillings. Producers are constantly updating their assortment, mainly due to use of various dough improvers, and fillings mostly leave traditional: jam, confiture and also fillings made on the basis of fruit puree and sugar, a dairy, fondant and fatty basis. Such fillings, on condition of their introduction in the crude dough, are negatively affected by temperature during baking and lose much of their primary organoleptic, nutritional and technological properties and become excessively fluid. Therefore, for preservation of quality indicators at the constant level, the fillings entered into the dough products must be heat-resistant, that is, do not lose shape during temperature about 200... 230°C during $(10... 15) \times 60$ s. Widespread got heat-resistant fillings based on fruit, vegetable, berry and fruit-berry raw materials. However, due to boiling, these fillings change the structural and mechanical properties. Milk and milk-containing fillings characteriz higher nutritional and biological value. By monitoring the current market of heat-resistant fillings, regardless of their basis, we can conclude that the conditions of storage of these products offered by manufacturers are very different. But most manufacturers offer the following storage conditions: at temperatures from 0 to 25°C and relative humidity not higher than 75%, heat-resistant fillings are stored for up to 6 months. Obviously, such a wide temperature range for a sufficiently long shelf life of the filling will lead to significant negative changes in their quality characteristics. In this regard, it is expedient to pay attention to such a perspective way oof storage of foodstuff as freezing.

Heat-resistant properties to the fillers can provide pectin. In spite of the fact that heat-resistant properties of products with pectin rather high, for receiving a product with steady physical and chemical properties, in particular with low content of free moisture, it is expediently to use starch, which begins to bind the free moisture when heated. Considering relevance of a problem of complex and waste-free use of agrosources and creation of a product with the combined animal-plant composition, it is expedient to use in the technology of heat-resistant fillings of plant protein concentrates of oil-bearing crops. The most perspective way of processing protein oil raw materials is cold pressing, which allows to obtain both products (oil and concentrate) with a high content of technologically unchanged nutrients. A special place among plant protein oil crops, owing to its high protein content (about 20%), fat (within 48%), calcium, magnesium, potassium, phosphorus, iron, a number of fat-soluble vitamins and antioxidants, is sesame. Thus, the processing of sesame into concentrate is a perspective scientific direction for obtaining a plant protein supplement with high nutritional and biological value.

The development of combined technologies dairy products, in particular emulsion, structured and pasty snacks, desserts, cheeses and cheese products with using of milk and plant components, is a subject of particular attention of domestic and foreign specialists. A significant contribution to the development of these technologies was made by R.Yu. Pavlyuk, V.V. Pogarskaya, N.P. Zakharova, F.V. Pertsevov, O.O. Grinchenko, G.B. Rudavska, S.S. Gulyaev-Zaitsev, V.A. Tutelyan

and other scientists. However, systematic studies aimed at obtaining the frozen thermostable filling using hydrocolloids, as well as dairy raw material in combination with plant protein concentrates of oilseeds, have not been found in the literature.

Given the above, a prespective direction for the development of filling technology for confectionery and culinary products is the development of new science-based technology and recipe of thermostable filling with combined composition, which is achieved by using dairy raw materials and concentrate of sesame seeds, the thermal resistance of which is due to the combined use of the properties of pectin and starch, high nutritional and biological value - the introduction into the recipe composition of sesame seeds concentrate, and the constancy of physical and chemical properties - the use of freezing.

In connection with the above, studying the technologies of dairy-containing foodstuffs with the combined compounding composition and development of a new generation of foodstuffs, taking into account the current trends and changes that are presently present, are relevant and timely.

The monograph contains materials which include characteristic and the review of the modern ways of receiving the combined dairy products and receiving with their use of new culinary products.

The first chapter provides an analysis of consumer, technological and physico-chemical aspects of production of a dairy-containing thermostable fillings; the use of thickeners, structure-forming agents and plant protein products in the technology of dairy-containing thermostable fillings is substantiated; the expediency of influence of the freezing process on the quality of dairy-containing thermostable fillings is shown.

The second chapter provides a scientific justification of the technology of milk-containing thermostable fillings using dairy raw materials and sesame seeds concentrate. Functional-technological properties of hydrocolloids, protein concentrates of oilseeds, rational ratio and influence of recipe components on the duration of structure formation, thermal resistance and strength of milk-containing fillings are considered in detail.

The third chapter presents materials that are devoted to the development of technology of dairy-containing thermostable filling with use in the recipe of dairy raw materials and sesame seeds concentrate; the prescription composition and technological process of the offered products have been developed; the chemical composition, microbiological and physico-chemical parameters, its rheological properties and quality quality were investigated.

The group of authors hopes that this work will be useful to engineers-technologists working in the food industry and institutions of restaurant economy, postgraduate students, teachers and students who want to deepen their knowledge of this scientific direction.

Chapter 1 Analysis of production technologies of thermostable dairy-containing fillings, features of application of plant protein products and prospects of freezing

1.1 Prospects of production, analysis of consumer, technological and physicochemical aspects of production of thermostable fillings

1.1.1 Features of assortment formation and substantiation of recipe components of thermostable fillings

Today, leading confectionery enterprises produce not only a wide range of finished products, but also are characterized by the production of semi-finished products, in particular fillings that have high consumer demand, as they are able to meet the various requirements of potential consumers. They found their use in the baking and dairy industries mainly in culinary and confectionery products. Depending on the components of the recipe composition, the fillings are able to give a variety of flavors, textural properties, nutritional and biological value, expanding the range of products.

Confectionery fillings, due to the combination of their properties, can be grouped and classified (Table 1.1). In the context of this classification, fillings are complex multi-component systems consisting of different types of raw materials. Their physicochemical properties are due to a certain ratio of the mass fraction of free and bound moisture, the absence of sucrose crystallization, and regulated rheological parameters. These indicators directly affect the shelf life of the fillings, which has a different duration (usually not less than three months).

The fillings of the first group are fillings, which include mono-, disaccharides and substances that act as anti-crystallizers. They include: treacle, various types of invert syrup, dextrans and other substances that contribute to the viscosity of the system.

The fillings of the second group belong to suspensions. They are based on: sucrose in the form of sugar, powdered sugar and other sugars (glucose, fructose, etc.), nuts (grit of different sizes and extent of thermal treatment), dry products - milk and cocoa, fat component, in the role of which is used not only milk and confectionery fats, but also oil of cocoa, coconut, palm, palm kernel and others.

Table 1.1

Classification of confectionery fillings

Group fillings	Name of filling	Basic processes of fillings technology		Characteristics of fillings		
		technological	physico-chemical	Sugar condition	Volume fraction of solids, %	Resistance to temperature influence*
First	Fruit and berry	Mixing and boiling	Homogenization and concentration	Amorphous in the form of solution	67,0–84,0	T, C
	Honey			The same	84,0– 86,0	T
	Liqueur			Amorphous in	69,0–86,0	NT

				the form of solution / amorphous crystalline		
	Dairy			The same	83,0–88,0	NT
	«Soft caramel»			Amorphous in the form of solution	78,0–82,0	C
Second	Marzipan	Grinding and rubbing	Increasing dispersion and homogenization	Crystalline, in suspension form	90,0–94,0	T, C
	Chocolate				97,1–99,1	NT, C
	Chocolate-nut				96,1–99,0	NT, C
	Butter and nut				93,4–98,9	T, C
	Butter and sugar				96,7–99,8	NT, C
Third	Jelly	Gelling and maturation	Structure formation	Amorphous in the form of solution	67,0–84,0	NT
Fourth	Fondant	Churning, cooling	Crystallization	Amorphous and crystalline at the same time	84,1–90,4	NT
	Cream	Churning-stabilization	Emulsification	Amorphous in the form of solution	88,0–99,2	NT, C
	Churned	Churning-maturation	Foaming	The same	76,0–88,0	NT

Note: T – thermostable, NT – non thermostable, C – cryostable.

The third group is jelly fillings. The peculiarity of their technology is the boiling of sucrose syrup containing sucrose in solution, with the addition of hydrocolloids (agar, agarid, pectin, furzelaran, modified starch, etc.) and fruit and berry raw materials. A necessary technological operation is a structure formation that depends on the amount of hydrocolloid, its type and technological parameters (temperature, time, acidity of the medium and nature of the components).

The fourth group includes fillings of fondant, cream and churned with a joint operation - churning. The fondant fillings are characterized by fine-crystalline mass, where sucrose is in the form of crystals and solution. Their quality depends on the technological parameters (churning speed, cooling temperature, etc.), the ratio of sucrose and anticrystallizer. Cream fillings are emulsions with soluble sucrose. Their quality is greatly influenced by the ratio of water and fat phases, as well as the properties of the emulsion.

The peculiarity of churned fillings is due to the presence of foaming agent. Foaming depends on the amount and type of foaming agent, as well as the technological conditions of production [15; 91; 100].

Modern confectionery production, to meet the complex of the above requirements made recently, requires the creation new or upgrading of traditional production technologies taking into account consumer demand. To the fillings which are most demanded are fillings with thermal resistant structure.

Thermostable filling is a product made on the basis of whole or ground to a puree state of raw materials, which has a jelly consistency due to the introduction of special structure-forming components (e.g., pectins), consistency stabilizers and other ingredients [58; 220]. It is considered thermostable filling if it is able to retain its functional-technological and physicochemical properties (shape, texture, volume fraction of solids, etc.) under normal baking conditions (convection method (200...230)°C, (10...15)×60 s) [59; 72; 133; 220].

In general, the fillings subject to high temperature influences are divided into three groups: thermostable filling; fillings with limited thermostable properties; fillings which have no thermostable properties [90; 210]. The melting temperature of the thermostable filling is above 200 °C with a distribution from 200 °C on the surface of the filling and up to 115 °C inside. Its shape should not boil and form bubbles on the surface of the so-called "craters" [125; 220]. The melting temperature of the filling with limited thermostable properties is in the range from 115 to 200 °C with a similar temperature distribution during thermal exposure. Its shape changes slightly, the surface melts and a shiny layer is formed. The melting point of the filling, which has no thermostable properties, is lower than 115 °C. Under conditions of temperature influence of about 200 °C, it melts and completely changes its shape [71]. Thermostable fillings are widely used in the confectionery industry, especially in flour products, which make up a large part of the confectionery production volume and have a wide range that satisfies the diverse range of consumer needs [39; 90; 161].

There are a number of enterprises in Ukraine today, which for many years have been representatives of domestic and foreign producers of raw materials for our country's confectionery industry. Their customers include pastry shops, retailers and hospitality industry representatives «HoReCa» (Hotel, Restaurant, Cafe/Catering): "Master Martini" (Italy), "Puratos" (Belgium), "Modacor" (Italy), "De Cecco" (Italy), "Alderman" (Germany) and others. However, the vast majority of such businesses and companies offer thermostable fillings made from fruit raw materials, rarely dairy [46; 64; 221].

Producers of thermostable confectionery fillings, which are nowadays widely represented in the food market of Ukraine, are distributor-production enterprises that not only produce their own products, but also represent well-known brands that are in high demand among consumers. Thus, the following has been identified through the monitoring of the food consumer market. Known manufacturers of thermostable fillings based on fruit raw materials are the following distributor-production enterprises: "Fruit Ex" (Kyiv region, Trebukhov village, Ukraine), "Nadiya-V PP" (Vinnytsia region, Luka-Meleshkovskaya village, Ukraine), "Zinto" (Cherkasy, Ukraine), "Petrikov Cannery" (Dnipropetrovsk region, Petrikovka village, Ukraine), "Nadiinyi partner" (Zaporizhzhia, Ukraine), "Compass Dessert" (Voronezh, Russia), "Bargus Trade" (St. Petersburg, Russian Federation), "Bery Style" (Korolev, Russian Federation), "Linii Vkusa" (Ufa, Republic of Bashkortostan), "Soyuzsnab" (Krasnodar, Russian Federation), "Pacific" (Vladivostok, Russian Federation), "Berta" (Stavropol, Russian Federation). Manufacturers of thermostable fillings made from dairy raw materials are: «"Nadiinyi

partner" (Zaporizhzhia, Ukraine), "Zinto" (Cherkasy, Ukraine), BMB Blend (Kyiv, Ukraine), "Compass Dessert" (Voronezh, Russia), "Bargus Trade" (St. Petersburg, Russian Federation), "Linii Vkusa" (Ufa, Republic of Bashkortostan), "Soyuzsnab" (Krasnodar, Russian Federation), "Berta" (Stavropol, Russian Federation), as well as a number of Italian companies that are limited to the Ukrainian market («Irca», «Italcanditi», «Salumificio Su Sirboni», «Novacart», «Ferrero SpA» etc.).

According to the carried-out monitoring of the recipe composition of traditional thermostable confectionery fillings, which are currently presented on the consumer market of Ukraine, revealed that the recipe ingredients are varied and have certain functional features, however it is difficult to make their accurate differentiation. Thus, the traditional recipe composition of thermostable confectionery fillings may include: fruit puree, jam, fruit slices, sugar (sugar substitutes and sweeteners), thickeners or system stabilizers (e.g., wheat flour, starch, pectin, etc.), flavorings, dyes, citric acid, and preservatives [42; 84; 86; 113; 121; 206; 227].

An important functional property of thermostable confectionery fillings is their ability to structure formation. And as the structure-forming act as their own pectins of fruit raw materials, and pectins added as a dietary supplement. A rather significant contribution to the study of the properties of hydrocolloids was made by the scientific school of Doctor of Technical Sciences, Professor, Academician of the International Cold Academy, Excellence in Education of Ukraine Pertsevyi F.V. - «Scientific substantiation and development of technologies of modified drag-forming agents» and Doctor of Technical Sciences, Professor, Academician of the International Cold Academy, Excellence in Education of Ukraine, laureate of the State Prize of Ukraine in the field of science and technology Pyvovarov P.P. "Scientific fundamentals of technology of the re-structured products received by monotropic gel formation".

The following scientists have made a significant contribution to the development of the confectionery industry in the context of thermostable fillings:

– Koretska I.L., Kiryanova G.A., who have developed a jelly thermostable filling. Its recipe includes sugar, pectin, citric acid, molasses and gum. The prepared recipe components are mixed and boiled, adding gum and pectin to the mass fraction of solids 67-69%, then added citric acid, stirred and poured in capacity. The resulting filling has a thermostable properties due to the adding of pectin and gum, which belongs to the group of heteropolysaccharides and is a natural thickener-stabilizer. Its use together with pectin leads to a significant reduction of syneresis and less intense color change of the finished product, as well as improvement of the structural and mechanical properties of the finished product [141; 142; 144; 145].

– Kropyvnytska I.O., Obolkina V.I., Yovbak U.S., Kambulova Yu. V., who developed thermostable filling for flour confectionery, which includes: hydrolysed carrot puree, white sugar, starch molasses, pectin apple with an esterification rate of 31-36%, citric acid and calcium citrate, which are used to form the gelatinous structure of low-esterified apple pectin. It is characterized by the highest activity and high efficiency for complexing with pectin among all calcium salts [146; 149].

– Cherevko O.I. and other scientists of Kharkiv State University of Food Technology and Trade developed thermostable fillings from vegetables and pumpkin

jam, enriched with heme iron, thermostable fillings from fruit and apple jam and dried fruits. The recipe composition of these fillings contains fruit base, diet supplement "Hemovital" and jerusalem artichoke powder . The technological process of production consists in the preparation of fruit and vegetable raw materials, the preparation of the recipe mixture by mixing pre-prepared raw materials with sugar and boiling. The filling has a sweet taste with a light acidity, a plastic and thick consistency with the color corresponding raw material used; it can be used in confectionery [135; 136; 138; 206; 227].

From stated above follows that the fillings acquire thermostable properties due to the presence in their composition of a rational concentration of one or more structure-forming agents, which improve their functional and technological properties due to the synergistic effect on each other. Of course, a number of thermostable fruit-based toppings do not contain protein. Therefore, another quite interesting by assortment and chemical composition, in particular the presence of protein, is a separate direction of development of the confectionery industry - the production of thermostable dairy-containing fillings.

1.1.2 Features of production technologies of thermostable dairy-containing fillings

The modern assortment of dairy-containing thermostable fillings include fillings for confectionery products, which are used as fillers and surface finishers of flour confectionery products with fillings and other food products. Such fillings are characterized by stable physicochemical and organoleptic properties at influence of high and low temperatures. These include: thermostable fillings "Souffle" made according to TS 9142-003-72446492-09, "Boiled condensed milk" thermo 3000 - according to TS 9129-002-87168165-11, fillings made according to TS 9129-023 -52176062-2009, which assortment number is as follows: "Boiled condensed milk"; "Butter cream"; "Cream cheese"; "Cottage cheese cream"; "Cream Brulee"; "Vanilla cream"; "Cream-chocolate".

An essential component of the formulation of these thermostable dairy-containing fillings is stabilizing systems, which are mainly pectins, caragines, alginates, starches and other hydrocolloids. The choice of hydrocolloids or a composition of them depends on their ability to impart the required consistency, certain physicochemical and structural-mechanical properties to the finished filling. In this case, the obligatory recipe component is dairy raw material of different production methods and physicochemical properties, which gives the finished product characteristic organoleptic properties [61, 73; 106; 122; 164; 169].

Considering given above, the characteristic of thermostable fillings of fruit and dairy-containing ones, we note that their main feature lies in the recipe composition and to some extent in the duration and expenses of raw materials during their production. Thus, thermostable fruit fillings are produced by boiling fruit raw materials in sugar syrup to a certain amount of solids. Thermostable dairy-containing fillings are made by mixing all of the recipe components with subsequent heat treatment, which continues until the filling reaches the necessary amount of solids, which characteristic of its certain type.

The technological processes of production of thermostable fruit and dairy-containing fillings are somewhat different. The technological process of production of thermostable fruit fillings is characterized by significant raw material costs and long-term influence of high-temperature modes [15; 43; 78; 98; 100; 121; 255]. It should be noted that during the long-term heat treatment of fruit raw materials there is a partial inversion of sucrose, hydrolysis of pectin substances and reducing of nutritional value, as well as loss of vitamins, flavors and formation of difficult-to-digest sugar aromatic complexes in products [98; 121; 223]. Thus, the considered traditional thermostable fillings do not have high functional and technological parameters that would meet the modern requirements of manufacturers who seek to reduce the technological process of production. That is why thermostable dairy-containing fillings have become quite widespread recently. However, a characteristic feature and at the same time a certain disadvantage of dairy-containing fillings is the impact on their main raw material base of seasonality, mainly due to the decrease in the number of dairy animals, which has led to a decrease in milk yields and its physical organization. Therefore, the relevance is acquired of using skimmed milk powder because it is a valuable raw material with a high protein content of 25...37%, fats 1...25%, carbohydrates 39...50%, as well as vitamins and minerals. Also, priority direction of regulation of improve prescription structure, properties and ensuring stability of chemical composition of a thermostable filling is a tendency to implication of components of a plant origin: hydrocolloids, protein-oil and cereals [7; 9; 41; 91; 206; 209].

Significant contribution to the development of combined dairy and plant products goes to the scientific school of Kharkiv State University of Food Technology and Trade - Doctor of Technical Sciences, Professor, laureate of the State Prize of Ukraine, Academician of the International Cold Academy Pavlyuk R. Yu. - "Fundamental and applied research in the development and introduction into production of high technologies, including nanotechnology of the first domestic natural vitamin and antioxidant additives from various kinds of plant raw materials in the form of fine powders, homogeneous pastes, extracts and functional products with their use», as well as the scientific school of the Odessa National Academy of Food Technologies - Doctor of Technical Sciences, Professor Vinnikova L.G. and Doctor of Technical Sciences, Professor Bezusov A.T. - "Theory and Practice of Creating New Food Technologies". Also, a considerable contribution to the creation and expansion of the range of dairy products was made at the National University of Food Technologies, in particular, Doctor of Technical Sciences, Associate Professor Polishchuk G.E. - "Development of innovative food technologies of combined composition on the basis of activated plant raw materials", as well as Candidate of Technical Sciences, Associate Professor Grek O.V. and others. The integrated use of dairy and plant raw materials has also been reflected in the meat industry. Staff of the North Caucasus State Technical University (Doctor of Technical Sciences, Professor Shipulin V.I., Candidate of Technical Sciences, Associate Professor Marchenko V.V., Candidate of Technical Sciences, Associate Professor Postnikov S.I. and Candidate of Technical Sciences, Associate Professor Statsenko O.M.) and the National University of Food Technologies (Doctor of Technical Sciences, Professor Pasichny V.M. and other

scientists) have made significant achievement in the development of the meat industry in application of dairy and plant concentrates for improvement and creation of new types of meat products.

Under the guidance of these domestic scientists, new scientific data on the joint combination of dairy and plant components were obtained for creation new or improvement of the existing types of products with predefined physical, chemical, structural, mechanical, functional, technological and rheological properties. The obtained data formed the basis for the creation of a number of products, in particular therapeutic and prophylactic character, enriched with vitamins B, A, C, with the increased content of calcium, iodine, protein and dietary fiber. These products include advanced dairy drinks, yoghurts, cheeses sour-milk, kefir, butter, sausage and other dairy and meat products.

It is worth emphasizing that cereals, beans, structure-forming agents have become widely used as plant raw materials. Protein-oil crops are less commonly used. However, due to the weighty direction of waste-free use of food raw materials, the relevance is acquired by protein-oil crops that enrich the product with plant protein and oil become, thereby contributing to a better balance of the chemical composition of the development. Protein-oil crops and products of their processing are widely used in bakery products, and much less - in the meat and dairy industries. The foreign scientists of the Siberian Research Institute of Cheesemaking of the Russian Agricultural Academy and the Kemerovo Technological Institute of the Food Industry make a great contribution to the development of this direction, in particular Candidate of Technical Sciences, Associate Professor Musynii O. and Candidate of Technical Sciences, Associate Professor Shulbaieva M. and domestic scientists of Kharkiv State University of Food Technology and Trade, Doctor of Technical Sciences, Professor Pavlyuk R. Yu., Doctor of Technical Sciences, Professor Pogarskaya V.V., Doctor of Technical Sciences, Professor Pertseyvi F.V. and National University of Food Technologies in the person of Doctor of Technical Sciences, Professor Rashevskaya T.O. and to other scientists who have worked in this field. On the basis of a number of new scientific data obtained, dairy products were developed with the involvement of protein-oil crops and products of their processing. [109; 217].

1.2 Substantiation of using thickeners and structure-forming agents in the technology of thermostable dairy-containing fillings

One of the main conditions for the effectiveness application of hydrocolloids is their complete dissolution, which depends on the chemical nature. Indicators of water solubility and features of the structure of some hydrocolloids are given in table. 1.2.

Features of structure formation depending on chemical nature are summarized in Table 1.3. The joint introduction of two different hydrocolloids given in table. 1.3, are accompanied by a synergistic effect, which can similarly be achieved by the ratio of individual thickeners with some biopolymers of protein nature [10; 12; 23; 83; 110; 124; 133; 165; 203; 232; 252; 255; 298].

Table 1.2

Features of structure and solubility of hydrocolloids

Additive	Features of the structure	Solubility of hydrocolloid
Guar gum	Highly substituted polysaccharide	Soluble at room temperature
Locust bean gum	Areas in polysaccharide chains are not substituted	Soluble only when heated
Pectins	Branched and methoxy groups in polysaccharide chains; acidic, ionized groups; electrostatic repulsion between chains	Soluble at room temperature
Alginates	Electrostatic repulsion between chains	Soluble at room temperature
Carrageenans	3-, 2-, 1- sulfide groups on two galactose	Soluble when heated at room temperature
Xanthan gum	A large number of side chains in polysaccharide molecules; electrostatic repulsion due to the presence of acid groups	Soluble at room temperature

Technological properties and perspective ways of their use in the food industry to provide the specified structural and mechanical properties are given in Table 1.4.

Table 1.3

Conditions of structure formation in polysaccharide solutions

Polysaccharide	Optimal pH range	Conditions of structure formation	Mechanism of structure formation
Pectin: – highly esterified	2,5–4,0	pH less than 4; Solids content = 55 – 80%	Sugar and acid
– low esterified	2,5–5,5	In the presence Ca^{2+}	Model of "egg packing"
Alginate	2,8–10,0	pH less or if present Ca^{2+}	Model of "egg packing"
Agar	2,5–10,0	At temperatures below 32...39° C	Model of double spirals

A lot of attention has recently been paid to confectionery products, which include hydrocolloids. The most common of the given above hydrocolloids are pectins and starch [10; 12; 23; 83; 124; 133; 158; 162; 190; 223; 262]. They are characterized by high functional and technological properties, low prime cost and simple technological use.

Table 1.4

Using of hydrocolloids in food industry

Technological function	Hydrocolloid	Field of application
Viscosity increase	Lambda-carrageenan, sodium alginate, xanthan gum, guar gum, locust bean gum, modified starches, modified cellulose	Sauces and various seasonings for salads, dairy desserts, soups, drinks, bakery products
Structure formation: - thermo-reversible gels	Kappa carrageenan, iota-carrageenan, low-esterified pectins, locust bean gum	Jams, thermostable fruit fillers, flavored milk gels, confectionery jams and confitures, pet food
- thermo-irreversible gels	Alginate of sodium, potassium or ammonium, high- and low-esterified pectins	Jams and confitures, pet food
Stabilization	Thickeners, low concentration of gels	Food emulsions, ice cream, fruit fillers, fermented milk products, chocolate milk

1.2.1 Substantiation of the expediency of using starch

A group of compounds – food hydrocolloids – the first time began to use in 1978 as a part of foodstuff to provide them with a predetermined consistency: viscous, plastic, or strong - and rheological properties [102; 104; 106]. Quite common hydrocolloids in the food industry that meet the modern requirements of manufacturers are agar, agarid, pectin, cellulose and its derivative starches, etc. [12; 21; 34; 45; 76; 126; 162; 187]. They are capable to perform the following functions: to protect the protein during thermal treatment, to stabilize the filler particles, preventing sedimentation, to improve the consistency of the finished product, to increase the viscosity of the system by binding of free moisture [23; 51; 56; 67; 102; 104; 220]. Depending on the final product, hydrocolloids are divided into two main groups: thickeners are substances used to give a product a viscous consistency; structure-forming agents - substances added to give a food product of a given consistency (jelly-like) [11; 54; 66; 211].

In the food industry, starch is often used as a thickener - native and modified for the preparation of kissels, puddings, sauces; it is also added to the dough (10%) during the production of biscuits, cakes and other products. It is used in the production of meat, pasta and sweets due to its ability to bind moisture, thereby preventing their sinerezis [48; 29; 126; 170; 254]. The main raw material for its production is potatoes, corn, wheat, rice, sorghum and others. Depending on the raw material starches have a number of features, namely: the size and a form of grain, viscosity and transparency of the formed paste, stability during storage, mixing and thermal influence [58; 120; 169; 213].

Starch is a natural polymer which contains in plants in the form of separate grains. It consists of amylose (10 - 20%) and amylopectin (80 - 90%), the monomer of which is α -glucose. It is little soluble in cold water, but in hot water swelling with the formation of starch paste. The degree of swelling of the starch depends on the

temperature, the amount of water and the type of raw material from which it is made [107; 126; 168; 155; 187; 213]. During swelling in the middle of the starch grain creates voids where water gets in, breaks and weakens some of the hydrogen bonds between the chains, which causes the starch grains to expand. At the same time a part of polymers dissolves and remains inside the starch grain, and the part diffuses outward, forming a dispersion system. In the process of heating, the grain structure changes. Initially, during slow heating, there is limited swelling of the grains and the viscosity changes, but with increasing temperature, starch grains increase in volume several times, absorbing water, which leads to the formation of starch paste. This process is called starch gelatinization [23; 29; 43; 49; 50; 102; 169], its temperature is for potato starch 59...64 °C, rye 50...55 °C, rice 65...73 °C, wheat 54...62 °C, corn 80 °C.

The main sign of formation of starch paste is system viscosity increase, which depends on the concentration of starch, surfactants, glycerides, speed of heating, temperature, mechanical influence, size of starch grains [29; 43; 49; 80; 87; 104; 168; 169; 174]. In the suspension forms a gel due to the aggregation to which amylose is capable, and the partial crystallization to which amylose and amylopectin molecules are capable, which is accompanied by the formation of hydrogen bonds between chains during cooling of the starch paste [118; 193; 170; 302]. During storage of starch gels, the phenomenon of syneresis and deterioration is observed due to retrogradation [29; 40; 210]. This process is characterized by the separation of bound moisture from the polysaccharide. It is displaced from the starch paste and the product becomes more rigid in consistency [83; 102; 118; 261; 300].

The use of native starch is quite wide. However, due to the inconvenience of its use and the difficulty of obtaining a product with the specified functional and technological properties, that is why the use of modified starches became popular [43; 50; 80; 86; 95; 118; 210; 254; 270]. It is worth noting that the major inconvenience of using native starches in food products, particularly during storage, is the ability of such starches to retrograde (aging), accompanied by syneresis. For elimination of this property, the starch is modified. For example, on OH-group of starch is acted by nitrogen, at the same time prevent the crosslinking of its molecules. Also, when starch is modified, the glycosidic bonds between the molecules are broken, accompanied by a decrease in viscosity, since the starch is crosslinked [43; 48; 86; 95; 103; 213; 277].

Due to the rather stringent technological conditions for the production of combined thermostable filling with the use of dairy raw materials and plant protein additives, its storage, especially in the frozen state, as well as during the implementation of the necessary technological qualities of development - thermal resistance under conditions of high temperature influence - it is appropriate in technology of such filling to use modified starch with the necessary technological properties.

The specified properties are fully consistent with corn starch modified E1442 - oxypropylene dichromalphosphate crosslinked. It is the most popular among manufacturers. Such modified starch rapidly swells and forms a starch paste, is resistant to high temperature processing and cycles of freezing / defrosting while maintaining high viscosity characteristics [10; 29; 32; 43; 47; 49; 80; 83; 86; 103; 277].

1.2.2 Relevance of pectins engaging

Pectin is widely used in the confectionery, dairy, meat, baking and canning industries due to its high technological characteristics, which are manifested in the ability to bind moisture, acting as a thickener, structure-forming agent, system stabilizer [10; 19; 20; 63; 133; 266; 269; 276]. Besides, pectin and pectin-containing substances are able to influence positively a human body, namely [110; 120; 170; 190; 226 Hours; 265; 280]: bind ions of heavy metals, radioactive substances; to show immunomodulatory properties; to reveal therapeutic and prophylactic properties in case of disruption of the gastrointestinal tract, for people suffering from diabetes and other diseases [6; 51; 63; 79; 87; 110; 117; 120; 157; 170; 216].

Pectin is characterized as a natural structure-forming substance which is contained in the cellular walls and intercellular space of all plants, and determines the regulation of water metabolism and the fulfillment of various physiological functions, both structural and binding components in plant tissues [10; 23; 76; 66; 83; 173; 247; 248; 265; 271; 290].

The most common raw materials for pectin production are citrus and apple pomace, sugar beet cake and sunflower core [21; 55; 68]. For the most part, pectin is contained in the peel, lamellae and cores of fruits and berries (Table 1.5).

Table 1.5

Concentration of pectic substances in fruits and vegetables

Fruits and vegetables	Concentration of pectic substances, %
Apricot	0,4–1,3
Quince	0,5–1,1
Cherry plum	0,6–1,1
Orange	0,6–0,9
Cherry	0,2–0,8
Wild strawberry	0,5–1,4
Cranberry	0,5–1,3
Gooseberry	0,2–1,4
Lemon	0,7–1,1
Raspberry	0,2–0,7
Tangerine	0,3–1,1
Peach	0,6–1,2
Plum	0,8–1,5
Black currant	0,6–2,7
Red currant	0,4–0,7
Sweet cherry	0,6–1,6
Apple	0,8–1,8
Carrot	1,0–1,4

There are two main types of pectic substances in plants: protopectin is characterized by a complex structure of the molecule, is insoluble in water, alcohol and ether; pectin, or soluble pectin, consists of water-soluble polygalacturonic acids, which are formed from protopectin by the action of acid, alkali or the enzyme of protopectinase [55; 158].

Pectic substances are plant polysaccharides, which by their chemical structure (Fig. 1.1) are macromolecular compounds which are the basis of a chain of 1-4 glycosidic bonds, residues of D-galacturonic acid and a certain amount of residues of 2-O-substituted L-rhamnopyranose that joins to the main chain. In the form of side chains in a small amount there are residues of neutral monosaccharides of L-arabinose, D-galactose, D-xylose, fructose, etc., this indicates that pectic substances are heteropolysaccharides [33; 46; 87; 173; 183; 190; 248; 264; 287; 289]. Much of the galacturonic acid residues are bonded to the metal groups.

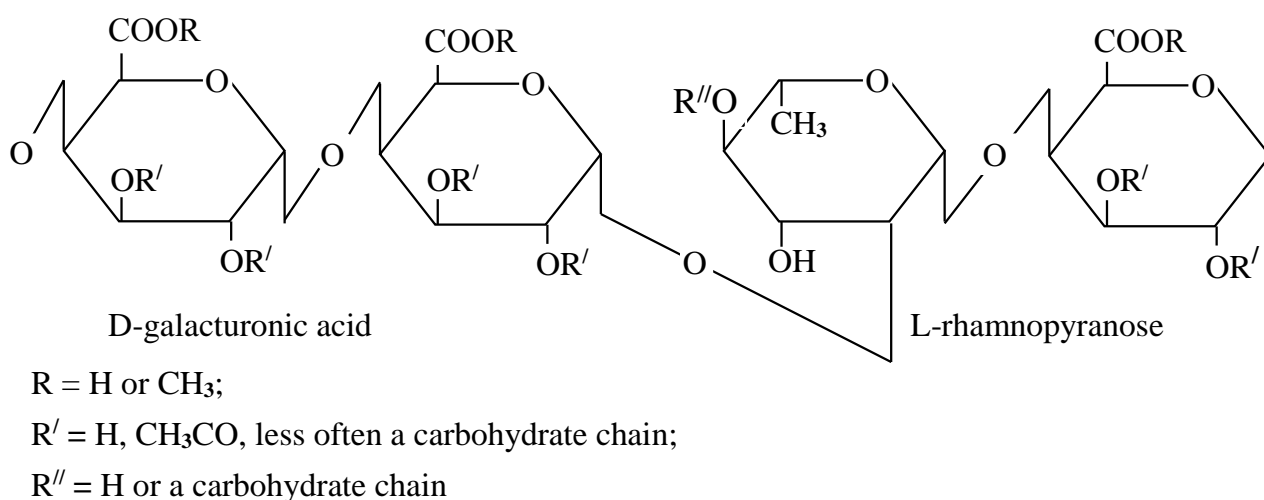


Fig. 1.1. Chemical structure of pectic substances

An important condition that determines the properties of pectin, its solubility and structure formation, is the degree of esterification, characterized by the ratio of esterified groups of galacturonic acid to its total amount [53; 259; 264]. Depending on the degree of esterification pectin is divided into: highly esterified (more than 50%); low-esterified (less than 50%).

The use of highly esterified pectin requires strict technological conditions: high temperature of formation and clear pH values. In this case, for formation of the gel it is necessary to adhere to certain conditions: the solids content of at least 55%, the pH value in the range of 2.8...3.5, which is achieved by the addition of lactic or citric acid [34; 133; 232; 259].

Instead, the conditions for using low-esterified pectin are much simpler. It is known that low-esterified pectin requires the presence of divalent metal ions (Ca^{2+}) in the system, but the realization of the functional and technological properties of such pectin does not depend on the pH value and the amount of solid [77; 128; 195; 220; 283]. First of all, the process of gel formation of low-esterified pectin is influenced by the gelation temperature and the amount of divalent metals in the system, namely: for insignificant their content rapprochement and orientation of molecules of pectin occurs,

with increasing gel is formed, and in case of overdose it precipitates, forming calcium pectinate with premature gelation [153]. Gels of high- and low-esterified pectins should be formed by reducing the polarity of the water and increasing the surface tension and viscosity by adding sugar. The formed dispersion system promotes the aggregation of hydrophilic pectin molecules, which partially dissociates into COO⁻ ions, owing to what they get a negative charge. When the pectin molecules converge to the distance of overlap of their diffusion layers, repulsive force arises between them. Its neutralization requires the introduction of an indifferent electrolyte (organic acid or divalent metal ions) into the system. In this case, the force of electrolytic repulsion is weakened and becomes equal to zero [29; 36; 111]. The mechanism of gels formation of high- and low-esterified pectin is to connect segments of spiral molecular chains due to crystallization, which leads to the formation of a three-dimensional network that holds water, sugar and other solvents. For the normal course of the gelation process, the molecular weight of the pectin should be at least 20 000 [83; 210].

1.2.3 Mechanism of structure formation and gel properties of low-esterified pectin

In confectionery thanks to simple technological application conditions began to use low-esterified pectin. The results of the market analysis indicate that the considerable share is made by citrus low-esterified pectin. As mentioned above, it is able to form a gel in the presence of divalent metals, preferably calcium ions, regardless of the solids content and pH values [111]. The process of gelation of low-esterified pectin is shown in Fig. 1.2.

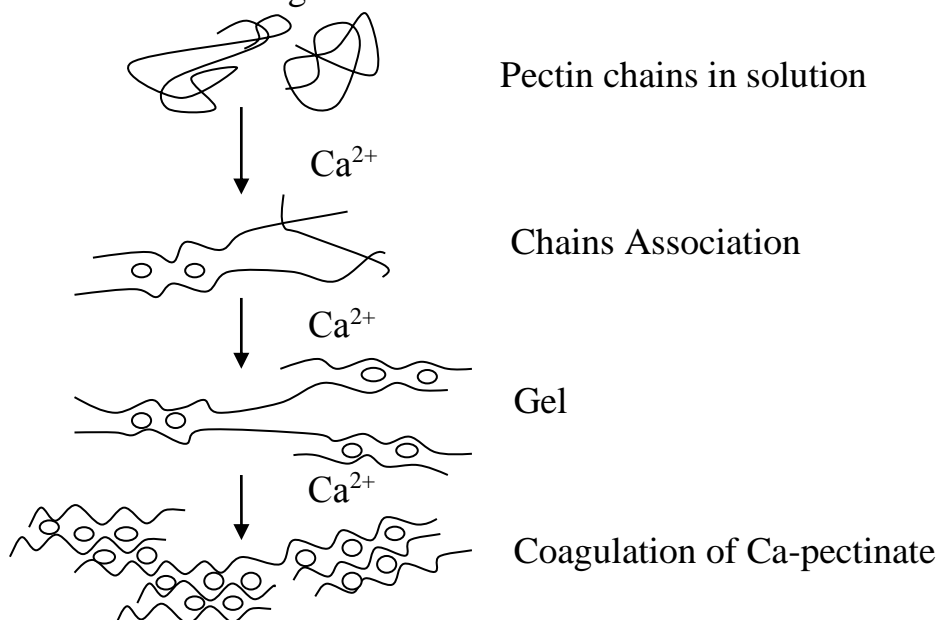


Fig. 1.2. The mechanism of gel formation of low-esterified pectin

In case of introduction of ions of calcium, the polymer chains begin to be grouped and bind at the expense of polyvalent cations (Ca^{2+}), forming calcium bridges. During rapprochement of pectinaceous molecules which have zigzag-like form, cavities are formed that contain carboxyl and hydroxyl groups. They promote the

association of pectin chains through the interaction and formation of complexes with calcium. The concentration of calcium ions plays an important role in revealing the properties of the gel: if their quantity is insufficient, the gel is not formed, and at excess, a gel is prone to syneresis and precipitation in the form of calcium pectinate salt, ie premature gelation occurs [47; 232 ; 275 ; 285].

The number of entering of calcium into a system is affected by the solids content, the type of sugar substitute and the buffer salt. At content about 60% it is not necessary to bring calcium ions, and at 20-30% it is necessary to add a significant amount, since no gelation will occur. It should be noted that the less solids in a product, the more calcium ions required. The formation of a gel of low-esterified pectin is to some extent influenced by the type of sugar or sugar substitute. Gel formation based on sugar substitute requires more calcium for optimum gel formation than when sugar is used.

On the dosage of calcium salts have no less influence the dosage and concentration of the buffer salt. Increasing its concentration, especially of the salt that is able to bind calcium, leads to increase in a dose of entering of calcium into a system. Such is preferably citric acid salt [47; 81; 111; 184; 286]. If the concentration of calcium ions is exceeded in the pectin solution, a brittle gel is formed with a tendency to syneresis and lumps are sometimes formed, indicating that calcium precipitates, that is, the occurrence of calcium pectinate. Thus, changing the amount of calcium input it is possible to influence not only the strength of the gel, but also its rheological and organoleptic properties.

In modern technology practical use was found by salts of calcium chloride and calcium citrate. Calcium chloride salt is characterized by a fairly strong ionic strength [127]. According to the normative document (Order No. 222 of 23.07.1996), it is used in a limited amount, since the excess quantity degrades the organoleptic properties of the pectin gel: it acquires a bitter taste. An unlimited amount of calcium citrate salt can be used. Although this salt has a lower reactivity, it contributes to the formation of a plastic, uniform consistency of the pectin gel. Also, on the properties of pectin gel the great influence is rendered by the recipe components that are added to the composition of the food product.

1.3 Prospects of using plant protein products in technology of thermostable dairy-containing fillings

1.3.1 Features of production technologies of plant protein products

Protein-oil crops are the most common food ingredient. For receiving in the technological purposes of raw materials from protein-oil crops it is obligatory their preliminary preparation during which the by-product is a hard shell - the husk and in some places the seed coat, and the main raw material – protein flour, groats, concentrates and isolates. For receiving groats and protein flour, the oilseeds are pre-degreased, cleaned and crushed. The resulting flour has a protein content of 40 to 50%. The protein concentrate has a slightly higher protein content of 65 to 70%. The peculiarity of its preparation is to remove simple and complex carbohydrates, mineral salts and other water-soluble substances from fat-free flour. The highest protein content

has the isolate – more than 90%. This amount of protein is caused primarily by its purification from non-protein substances [209; 235 ; 258]. Among these raw materials of protein-oil crops protein concentrates differ in inexpensive and not labor-consuming production process. Oil from seeds and kernels of oilseeds is removed without chemical treatment by two methods: cold and hot pressing. The method of cold pressing consists in the gentle temperature influence (about 50 °C) on the raw material during its pressing. The final product is characterized by almost unchanged composition of all nutrients, especially protein. During hot pressing, which is characterized by the influence of high temperatures – 100 ... 120 °C, the resulting final product can not only have a much lower content of nutrients and modified protein by the given temperature influence, but also can be burned slightly. Therefore, it is advisable to use the method of cold pressing for preservation of useful substances, during which the cake is 45%, and the amount of protein in it varies from 50 to 70%, fat - about 10%, i.e. approaching to concentrates by protein content [208; 223; 235].

1.3.2 Prospects of plant protein concentrates production and substantiation of the expediency of using sesame seed concentrate in the technology of thermostable dairy-containing fillings

In the food industry, a large interest in leading scientists is caused by such protein-oil crops as peanuts, sunflowers, sesame, rapeseed and soybeans. They have a high content of polysaccharides, unsaturated fatty acids, proteins and fats [224; 258; 291; 297]. Of these cultures, the most labor-intensive technological preparation process is characterized by soybeans [53; 231]. It also adversely affects the human body: causes various diseases, such as Alzheimer's disease, infertility, impairs physical development, and its content of trypsin and chymotrypsin inhibitors in the amount of about 6% prevents cleavage of proteins in a small intestine [82; 192]. Unlike soybeans, peanuts are the most promising raw material widely used in food. It is characterized by high functional and technological properties and balanced and complete protein composition [7; 53; 130; 192; 231 ; 297]. No less popular raw material is sesame, which is not inferior to peanuts in terms of functional and technological properties and chemical composition. Given the chemical composition of protein-oil crops (Table 1.6), it is likely that the resulting products of their processing will have a similar tendency to change the chemical composition, in particular in concentrate (Table 1.7).

Table 1.6

Comparative characteristics of the chemical composition of protein-oil crops

Name of crop	Fat, %	Protein, %	Carbohydrates,%	Ash,%	Energy value, kcal
Rapeseed seeds	43,6	30,8	7,2	4,5	544,4
Sesame seeds	48,7	19,4	12,2	5,1	562,9
Sunflower seeds	52,9	20,7	10,5	2,9	600,9
Peanut kernel	45,2	26,3	9,9	2,6	551,6

Table 1.7

Characteristics of the chemical composition of protein-oil concentrates

Product name	Fat, %	Protein, %	Carbohydrates, %	Energy value, kcal
Rapeseed concentrate	6	48	8	278
Sesame seed concentrate	6	52	6	286
Sunflower seed concentrate	10	46	8	306
Peanut kernel concentrate	7	56	8	319

Based on the above characteristics of the chemical composition, it should be noted that the most promising raw material by the amount of protein and fat is rapeseed, and energy value - sesame seeds, which is inferior to sunflower seeds. However, the concentrates of these protein-oil crops are characterized by a slightly different chemical composition (Table 1.7.). Thus, from the data table. 1.7 revealed that the highest protein values are characteristic of peanut kernel concentrates. Closer to it by the protein content, but somewhat lower in fat content, is a sesame seed concentrate. Therefore, in order to provide thermostable dairy-containing fillings of new organoleptic, technological, physicochemical and structural-mechanical properties, it is advisable to include in their prescription composition the product of processing protein-oil crops - sesame seed concentrate.

1.4 Expediency of freezing application and influence of the technological regimes on quality of thermostable dairy-containing fillings

Thermostable dairy-containing filling belongs to the category of products that cannot retain their quality for a long time, therefore apply freezing to extension of expiration dates, that represents one of ways of conservation. In turn, conservation prevents destruction, spoilage and keeps the product in an invariable look. Both domestic and foreign scientists have been engaged in maintaining the quality of food and studying the impact of low-temperature storage on the change and prolongation of food quality. Nowadays, a great contribution has been made by the scientific school of Kharkiv State University of Food Technology and Trade Doctor of Technical Sciences, Professor Potapov V.A. - "Research of heat and mass transfer processes and refinement of apparatus for heat and refrigeration processing of foodstuffs" and the scientific school of Odessa National Academy of Food Technologies Doctor of Technical Sciences, Professor Lagutina A.Yu. - "Heat exchangers of cooling systems and condenser units of refrigeration units". It is known that, under normal storage conditions, in the temperature range 0...4 °C, biochemical, physico-chemical, microbiological changes in food are slowed down. However, in the analysis of the works of domestic scientists, it was found that there is a group of bacteria - psychrophils, capable of continuing their activity at relatively low temperatures, namely from 10 to -10 °C [26; 119; 139; 229]. For this reason, it is advisable to use the freezing process to extend the shelf life of the filling.

Products subjected to freezing must retain their taste, nutritional and quality properties after defrosting and during storage at low temperatures. All foods contain water - bound and free. Freezing affects the speed of the flow of biochemical processes

and the intensity of microorganisms development, as well as causes a change in the thermophysical and mechanical properties of the product and leads to a change in the phase state of water, turning it into ice, accompanied by migration of moisture in the product [3; 5; 18; 74; 119; 139; 219]. The formation of ice crystals occurs in an intercellular substance, in which as the freezing of water begins to increase the amount of soluble substances. The emergence of a difference in osmotic pressure, that is, a change in concentrations between cells and in cells, leads to the formation of a flow of moisture from cells to crystals in the intermediate space [18; 35; 171; 219]. Such moisture migration results in significant changes in the structure of the product: cell deformation, partial rupture of cell membranes, and so forth.

The formation of ice crystals in food is due to a decrease in cryoscopic temperature, as opposed to isothermal crystallization of pure water [41; 151]. The decrease in cryoscopic temperature in a product depends on the amount of water and the substances that form solutions with it [24; 211; 212]. The decrease in temperature occurs with increasing concentration of the solution due to the freezing of water and lasts until the system reaches the eutectic point at which it freezes at a constant composition [3; 18; 24; 25]. The formation of crystalline germs, the rate of diffusion of water molecules and heat removal of crystallization all contribute to the rapid growth of crystals. In the case of lowering the temperature to about 0 °C, the growth rate of the crystals is insignificant, and the diffusion of water molecules is mainly affected. If to reduce temperature further, the heat transfer speed will begin to influence and the crystal growth rate will reach maximum and with achievement of speed of freezing that higher than the speed of diffusion it falls [24; 59; 65; 119; 139]. It is known that the filling structure depend on the size of the ice crystals. This indicates that the main criterion for freezing temperatures (Table 1.8), which affects the size and uniformity of the distribution of ice crystals, is the speed of crystallization. It is determined by the intensity of refrigerant supply and the rate of heat removal [3; 24; 26; 136; 179; 219].

Table 1.8

Characteristics of freezing modes

Freezing	Temperature condition	Moisture characteristics	Note
Slow	$t = -10 \dots -12 \text{ }^\circ\text{C}$, $v = 1 \text{ cm/g}$	Large ice crystals: $d = 0,5 \text{ mm}$, $L = 10 \text{ mm}$	The destruction of the structure
Fast	$t = -18 \dots -20 \text{ }^\circ\text{C}$, $v = 5-10 \text{ cm/g}$	Fine crystalline ice structure: $d = 5 \text{ microns}$, $L = 0,1 \text{ mm}$	Maintaining structure
Superfast	$t \text{ over } -40 \text{ }^\circ\text{C}$, $v \text{ over } 10 \text{ cm/g}$	Small ice crystals: $d = 20 \dots 230 \text{ nm}$, $L = 0,1 \text{ mm}$	The destruction of the structure

Storages of a product at low temperatures not only preserves its physicochemical properties, but also leads to a decrease in a significant number of microorganisms, which depends on the intensity and speed of the temperature

decrease. The highest number of microorganisms dies during fast freezing at temperatures of $-18...-20$ °C, and the smallest - during slow shallow freezing in the temperature range $-10...-12$ °C [112; 222; 244]. It should be noted that after defrosting the product, the microorganisms that have not died during freezing begin to develop, therefore during defrosting it is necessary to avoid additional moisture. If the defrosting is carried out at high temperatures ($20...25$ °C), there is an intensive reproduction of microorganisms, it less reproduce - during slow defrosting ($1...8$ °C) [38; 44; 59; 84; 119; 139]. It is widely recognized today the technology of rapid low-temperature freezing of the product, during which the movement of moisture decreases during ice formation, as well as defrosting with the use of air or liquid. Therefore, the rational freezing temperature is $-16...-20$ °C (fast freezing). During fast freezing, the largest number of microorganisms dies, slowing down the course of biochemical processes.

Chapter 2 Scientific substantiation of the thermostable filling technology using dairy raw materials and sesame seed concentrate

2.1 Study of functional and technological properties of hydrocolloids

During the research of modern production technologies of foodstuff the leading scientists pay great attention to hydrocolloids or their compositions. This attention is due to the fact that hydrocolloids have different origin, chemical composition, structural-mechanical and functional-technological properties; and thanks to this, it has wide functional action. As this paper deals with topical issues of creation of thermostable gel-like (condensed and structured) products, it is advisable to first pay attention to those recipe components that determine the thermostable and structural-mechanical properties of finished products - starch and pectin. The study of functional and technological properties of these hydrocolloids of different nature will allow to establish their suitability for further use in the composition of thermostable fillings.

The thermostable properties and specific structural framework of the filling depend mainly on the ability of the hydrocolloids to bind and hold moisture. Also, since the product under development has fat components, its properties depend on the ability to bind and hold fat. So, it is necessary to begin researches on studying the functional and technological properties of hydrocolloids - to study their moisture-holding ability and ability to hold fat (MHA, AHF) [2; 207; 238].

It is known that due to the formation of a negative charge on the surface of the hydrocolloid, the particle repels, encountering a charged particle, which characterizes the hydrophilic-hydrophobic properties [2; 17; 60; 207; 238; 241; 295]. In view of this assertion, fats and oils are used to impart certain properties to the fillings, which necessitates studies to examine the relationship between MHA and AHF. The MHA was determined at the following range of hydrocolloid swelling temperatures: $20\pm 2^{\circ}\text{C}$, $40\pm 2^{\circ}\text{C}$, $60\pm 2^{\circ}\text{C}$ and $80\pm 2^{\circ}\text{C}$. Table 2.1 shows the results of the study of MHA and AHF of widespread pectins and starches in Ukraine.

Table 2.1

Comparative characteristics of MHA and AHF of hydrocolloids

Raw materials	Indicator				
	MHA, %				AHF, %
	$20\pm 2^{\circ}\text{C}$	$40\pm 2^{\circ}\text{C}$	$60\pm 2^{\circ}\text{C}$	$80\pm 2^{\circ}\text{C}$	
Apple pectin highly esterified	$65\pm 3,0$	$84\pm 4,0$	$40\pm 2,0$	$38\pm 1,0$	$32\pm 1,5$
Citrus pectin highly esterified	$38\pm 1,5$	$80\pm 4,0$	$74\pm 3,5$	$63\pm 3,0$	$20\pm 1,0$
Apple pectin low-esterified	$145\pm 7,0$	$183\pm 9,0$	$101\pm 5,0$	$89\pm 4,0$	$28\pm 1,0$
Citrus pectin low-esterified	$165\pm 8,0$	$210\pm 10,5$	$125\pm 6,0$	$105\pm 5,0$	$65\pm 3,0$
Corn starch	$44\pm 2,0$	$62\pm 3,0$	$85,5\pm 4,0$	–	$42\pm 2,0$
Potato starch	$40,5\pm 2,0$	$60\pm 3,0$	$60\pm 3,0$	–	$46\pm 2,0$
Corn starch modified	$46,5\pm 2,0$	$72\pm 3,5$	$93\pm 4,5$	–	$61\pm 3,0$

From the table 2.1 shows that with increasing temperature up to 60 °C, the MHA of all studied starches increases, and at temperatures above 60 °C, the study is impossible. This tendency of change indicates the swelling of their starch grains due to the absorption and holding of moisture through chemical interaction. The intensity of increase MHA observed at temperatures above 40 °C indicates the beginning of the process of starch gelation, that is formation of colloidal systems with a certain spatial configuration [22; 150; 241].

On the other hand, for pectins the index of MHA changes quite unevenly. From the table 2.1 shows that the MHA of pectin increases rapidly with increasing temperature from 20±2 to 40±2 °C, and decreases in the temperature range from 40±2 to 80±2 °C. Such an uneven change MHA of the pectin is probably due to the fact that the hydrogen bonds between their molecules occur at temperatures from 20±2 to 40±2 °C, and with subsequent increase in temperature over 40±2 °C, they partially break down and release moisture [193; 205, 241].

Thus, in the conducted researches on the studying MHA of starches and pectins it was found that the highest rates of MHA have corn starch modified (93% at 60±2°C) and low-esterified citrus pectin (210% at 40±2 °C). In view of this, it can be concluded that it is expediency to use of corn starch modified and citrus low-esterified pectin as a prescription component of thermostable filling.

It is known that to give the fillings of high thermostable and structural-mechanical properties, a mixture of different hydrocolloids wich having a synergistic effect is introduced into their composition [216; 246]. Therefore, in order to study the possibility of joint use of corn starch modified and low-esterified citrus pectin, functional and technological properties of mixtures of these hydrocolloids were investigated (Table 2.2).

Table 2.2

Comparative characteristics of MHA and AHF of mixtures of “low-esterified pectin citrus:corn starch modified”

Low-esterified citrus pectin: corn starch modified, %	Indicator				
	MHA,%				AHF, %
	20±2° C	40±2° C	60±2° C	80±2° C	
0,8:1,0	126,5±5,0	132±6,5	174±8,5	192±9,5	82±4,0
0,8:2,0	155±7,5	176±8,5	191±9,0	238±11,5	91±4,5
1,0:0,8	150±7,0	195±9,5	142±7,0	95±4,5	72±3,5
2,0:0,8	194±9,5	220±11,0	164±8,0	103±55,0	79±3,5

From the data table 2.2 shows that in mixtures where corn starch modified predominates, there is a gradual increase in the indicators of MHA, and where low-esterified pectin citrus is dominated, on the contrary - a decrease of MHA with increasing temperature. Higher rates of MHA under conditions of temperature rise have a mixture with a concentration of modified corn starch 2.0% and low-esterified citrus pectin 0.8%. According to scientific data [193], such changes of MHA contribute to the aggregation of

hydrophilic molecules of pectin and starch. Components of starched paste which consisting of a branched chain of amylopectin and amylose molecules interact via hydrogen bonds with a spiral chain of pectin molecule, forming a common three-dimensional spatial grid [107; 193; 242; 249; 256; 261; 293]. This indicates a synergistic effect and the ability to further share corn starch modified and low-esterified citrus pectin in the production of thermostable filling. Therefore, high functional and technological parameters, prove the synergistic effect of the joint use of a mixture of pectin citrus low-esterified concentration of 0.8% and corn starch modified concentration of 2.0%.

Moving on to further research, it should be noted that one of the main conditions for the realization of a number of properties of low-esterified pectins is the presence of divalent metal ions - Ca^{2+} . In this case, the source of calcium ions was calcium citrate salt, insoluble in water. To convert calcium citrate from crystalline to soluble state, it is necessary to lower the pH of the water medium. The most common and readily available citric acid was used to reduce the pH.

Investigating the rheological and technological properties of systems with different ratios of components and concentrations of low-esterified pectins, it is worth paying attention to the content of calcium citrate concentration of 0.02, 0.04 and 0.06% - in accordance with established standards, which do not contradict sanitary and hygienic examination [47; 81; 111; 184; 286].

2.2 Investigation of rheological properties of hydrocolloids

2.2.1 Investigation of the effective viscosity of hydrocolloids

The main technological function of pectin and starch in the process is the adsorption and holding of moisture by various forms of communication, which helps to increase the viscosity due to the rapprochement of particles in the food system [116; 193]. The viscosity of hydrocolloid systems, in turn, depends on the location and number of hydrophilic groups along the chains and characterizes the consistency of the finished product; it also depends on the temperature and the components additionally introduced to the hydrocolloids.

It is known that starch, depending on the concentration in the system is capable of forming a viscous suspensions, and pectin - gels. It is also worth paying attention to the dehydration property of sugar: it is known that with the addition of sugar to the "water-starch" system (to a certain concentration) the viscosity, the speed of starch gelation and the strength of the starch paste begins to decrease. This is due to the interference of sugar in various interactions and connexion. It is able to exhibit its properties at 20 °C (to bind and hold about 8-12 water molecules), and starch - only with increasing temperature [116; 174; 185; 228; 243; 296].

Given the analytical data on low-esterified pectins, in particular their functional-technological and rheological properties, the proposed introduction of dry substances to the new thermostable filling is about 55% [36; 47; 107; 111; 185; 242; 249; 256; 261; 275; 285; 293]. The dependence of the effective viscosity of the "sugar-water-starch" system on various types of the most common starch and pectins on temperature is shown in Fig. 2.1 - 2.3.

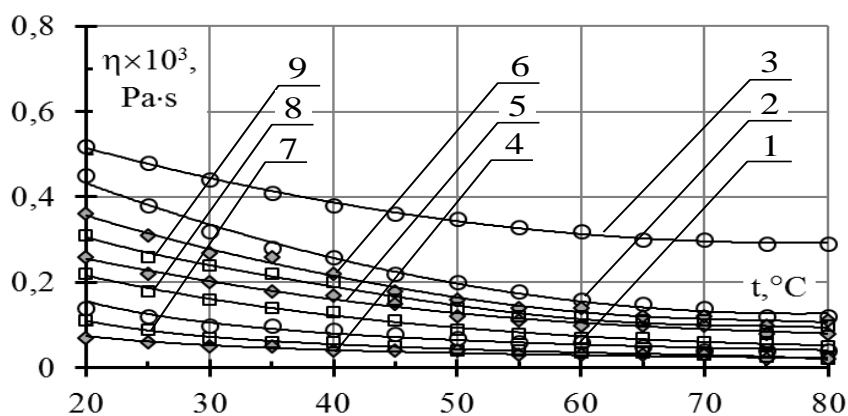


Fig. 2.1. Dependence of effective viscosity of starch paste on temperature at 55% sugar concentration and starch: 1, 2, 3 – potato starch 1,0, 2,0, 3,0% in accordance, 4, 5, 6 – corn starch 1,0, 2,0, 3,0% in accordance, 7, 8, 9 – corn modified starch 1,0, 2,0, 3,0% in accordance

In Fig. 2.1 there is a gradual decrease of effective viscosity with increasing temperature. This is due to the fact that the starch begins to absorb a large amount of moisture with increasing temperature, which causes the formation of a starch paste, and with a decrease in temperature becomes a viscous mass due to the fixation of intermolecular bonds. Possibly that the introduction of sugar into the "water-starch" system causes abnormal viscosity characteristics - a decrease of effective viscosity with increasing temperature. This indicates the ability of sugar to "intercept", "delay" moisture and thus increase the point (temperature) of the transition of starch grains to starch paste [174; 185; 228; 243; 296].

In Fig. 2.2 presents the research results of dependence of effective viscosity of apple and citrus low-esterified pectin on temperature influence

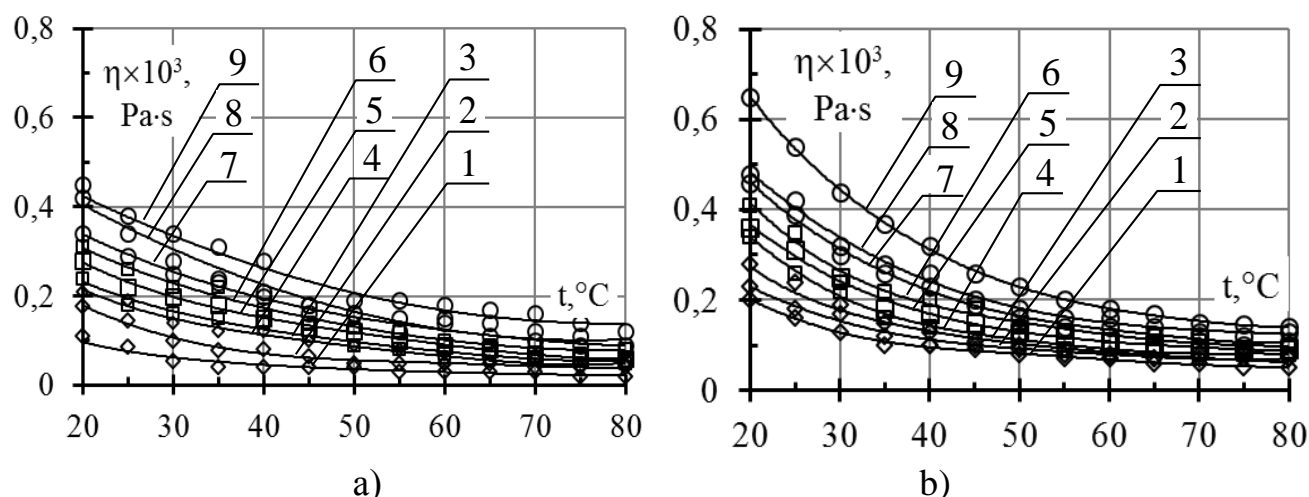


Fig. 2.2. Dependence of effective viscosity on temperature of the system "pectin low-esterified:calcium citrate" (%): 1 – 0,50:0,02; 2 – 0,80:0,02; 3 – 1,10:0,02; 4 – 0,50:0,04; 5 – 0,80:0,04; 6 – 1,10:0,04; 7 – 0,50:0,06; 8 – 0,80:0,06; 9 – 1,10:0,06 at a sugar concentration of 55% and a) apple pectin b) citrus pectin

According to the data (Fig. 2.2), the "sugar-water-pectin low-esterified-calcium citrate" system shows a slight decrease of the effective viscosity of citrus and apple pectin with increasing temperature. It is revealed that the effective viscosity increases with increasing in content of pectin and calcium citrate. Thus, the increase of the reactive groups leads to the formation of new groups, which further form a gel grid [36; 47; 111; 275; 285]. When comparing the effective viscosity of a pectin in the system sets minimum and maximum temperature limits of changing its values. The temperature difference of system of the citrus pectin is about 7 °C lower than the apple pectin . Therefore, lowering the temperature causes emergence of hydrogen communications and grouping of molecules, which leads to gel formation, growth of viscosity and strength. [107; 185; 242; 249; 256; 261; 293].

By comparing the effective viscosity curves (Fig. 2.2), it was determined that the highest effective viscosity had the apple low-esterified pectin. The lower viscosity at which the consistence of smaller density is formed characteristic of citrus low-esterified pectin. Therefore, in order to provide plastic consistency and stable physico-chemical and technological properties under the influence of the action of high temperature, pectin was combined with modified corn starch (Fig. 2.3).

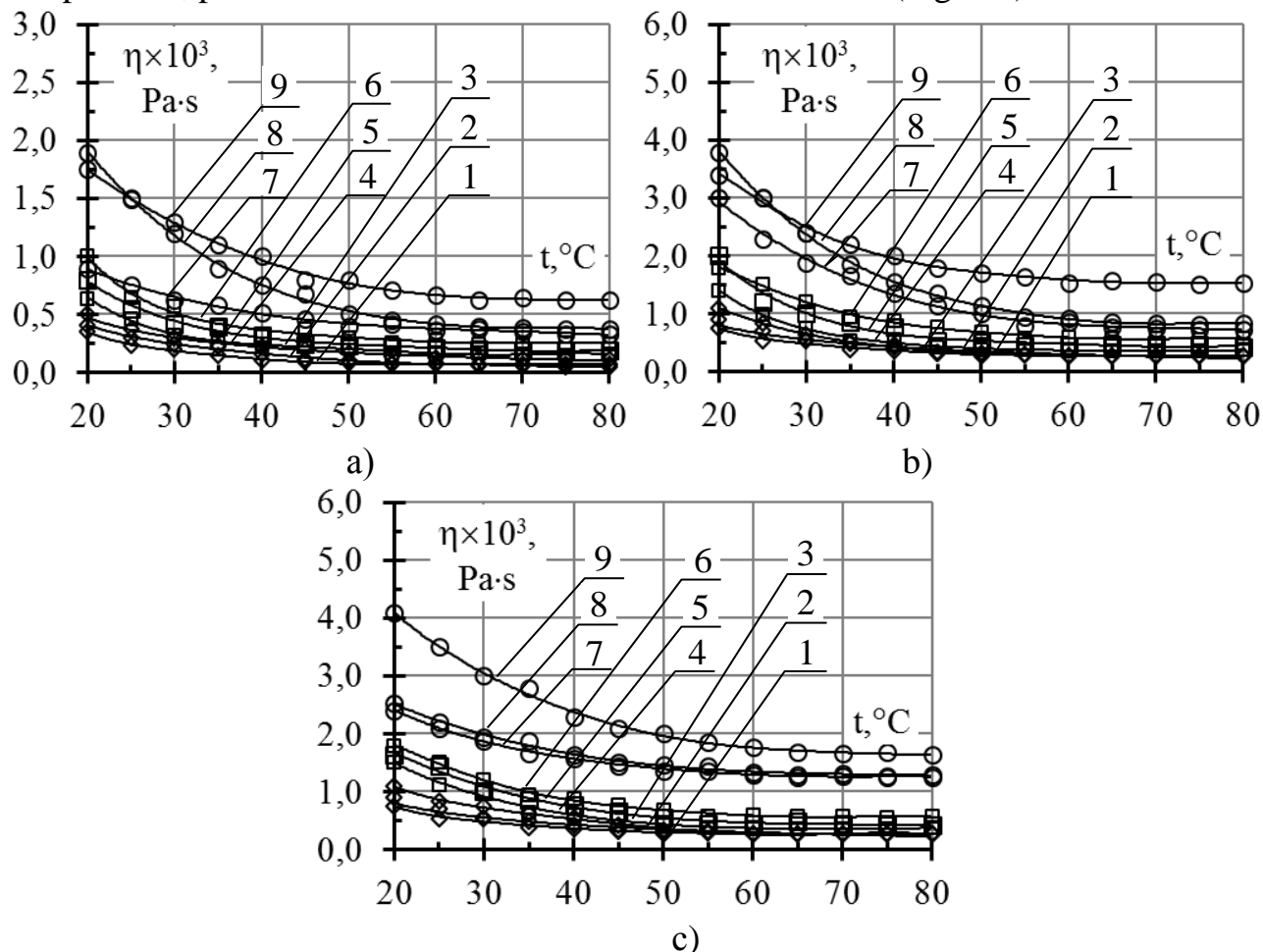


Fig. 2.3. Dependence of effective viscosity on temperature of the system "corn starch modified:calcium citrate", (%): 1 – 1,00:0,02; 2 – 2,00:0,02; 3 – 3,00:0,02; 4 – 1,00:0,04; 5 – 2,00:0,04; 6 – 3,00:0,04; 7 – 1,00:0,06; 8 – 2,00:0,06; 9 – 3,00:0,06 at a sugar concentration of 55% and citrus low-esterified pectin (%): a) 0,5, b) 0,8 and c) 1,1

As can be seen from the data of Fig. 2.1, corn modified starch is characterized by a not very high effective viscosity concerning a system with potato starch and not sufficiently low compared to the same corn starch system.

Data of Fig. 2.3 indicate an increase of effective viscosity in the "sugar-water-pectin-starch-calcium citrate" system with increasing pectin concentration, corn starch modified and calcium ions. With the increase in the content of corn starch modified, it becomes a more viscous, more plastic consistency.

From the results of the researches (Fig. 2.3) it can be concluded that the most expedient in the technological aspect indicators of effective viscosity varies from $1,68 \times 10^{-3}$ to $1,43 \times 10^{-3}$ Pa·s in the temperature range 18...25°C that is, the "sugar-water-pectin-starch-calcium citrate" system with citrus low-esterified pectin 0.80%, modified corn starch 3.00% and calcium citrate 0.04%.

2.2.2 Determination of changes in the strength of hydrocolloids

The peculiarity of the technological aspect of the use of hydrocolloids (pectin and starch) in food products, in particular in thermostable fillings, is based on their ability to form a characteristic strong structure. However, certain conditions and time are required to form the filling structure.

It has been found that, in process of cooling of the various types of pectin and starch to a temperature of 20 ± 2 °C, with endurance in a current 24×60^2 s systems of varying strength are formed for . The results of the study of the strength of the pectins structure and mixtures of pectin and starch are shown in Fig. 2.4 and 2.5. It is worth noting that strength studies for low-esterified pectin at concentrations of 0.5 and 0.8% are not possible due to the formation of a system of rather low strength. It is also difficult to determine the strength of starch paste due to the low concentration of starch in the suspension and the formation of very weak starch paste.

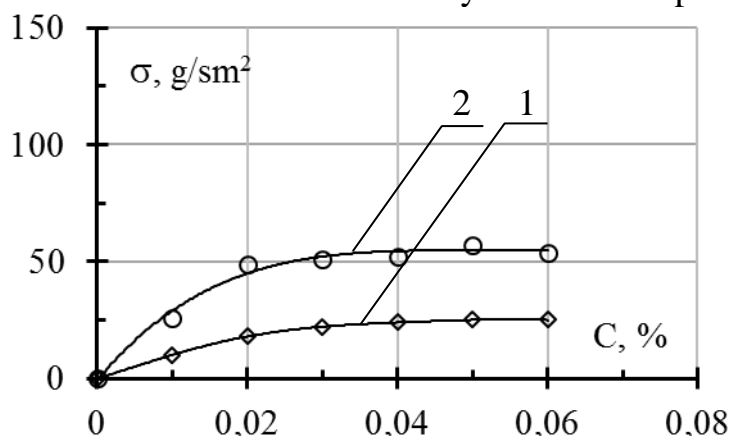


Fig. 2.4. Dependence of the strength of low-esterified pectins gels at concentrations of 1.1% with sugar content 55% from the concentration of calcium citrate: 1 - apple pectin; 2 - citrus pectin

In Fig. 2.4 shows the increase in the strength of low-esterified pectins gels , provided that the concentration of calcium citrate is increased. It has been found that apple pectin gels with the addition of divalent metals (calcium citrate) have too weak and dense structure compared to citrus pectin gel, which will further complicate the

formation of the filling. It is believed that in terms of general structural properties, in particular strength, the best indicators for further use in the filling production process are the gel of low-esterified pectin with a content of calcium citrate from 0.04 to 0.06%.

The dependence of the gel strength of the low-esterified pectins and modified corn starch mixture on the concentration of divalent metals is shown in Fig. 2.5. The strength indicators are given for low-esterified pectin of concentrations 0.8 and 1.1% and modified corn starch - 3.0%; at lower concentrations too weak gels are formed. The strength indicators of these gels has a similar tendency to change the strength of the above gels of low-esterified pectins (Fig. 2.4).

Thus, from the data of Fig. 2.5 shows that the gel strength of a mixture of pectin and starch increases with increasing concentration of ingredients, namely pectin (apple and citrus) low-esterified and calcium citrate.

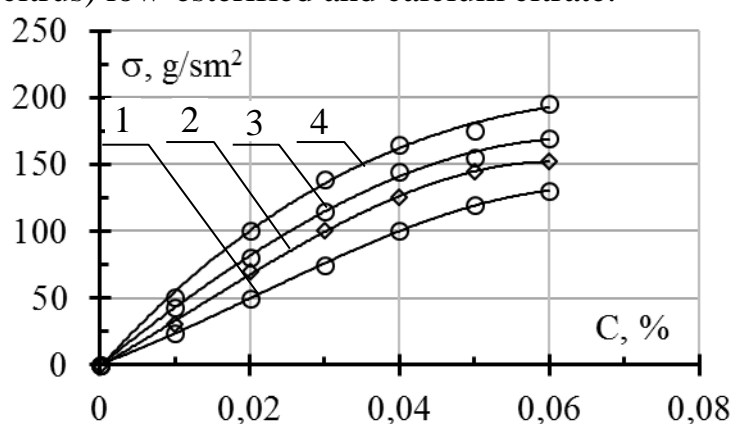


Fig. 2.5. Dependence of the gel strength of a mixture of low-esterified pectins and modified corn starch with sugar content of 55% on the concentration of calcium citrate in the ratio of "apple pectin:starch",%: 1 - 0,8: 3,0; 2 - 1,1: 3,0; "citrus pectin:starch",%: 3 - 0,8:3,0; 4 - 1,1:3,0

It is also seen that the gel strength of the mixture of citrus pectin low-esterified and modified corn starch higher with the content of apple pectin. It is proved that the addition of starch to pectin helps to increase the strength of the investigated gels, giving them a softer and gentler structure than those that do not contain its (Fig. 2.4). As a general conclusion from the results of the study of the hydrocolloids strength (Fig. 2.4 and 2.5) it should be noted that the highest strength values has a gel mixture of citrus low-esterified pectin and modified corn starch

2.3 Investigation of the thermostable properties of hydrocolloids

The above-mentioned results of the study of functional-technological and rheological properties of a number of hydrocolloids are the basis for further experimental studies in order to introduce them into the recipe composition of the thermostable filling that is being developed. Therefore, for the logical and complete justification of the use of hydrocolloids in the technology of thermostable product it is advisable to study the thermostable characteristics of these hydrocolloids.

2.3.1 Melting temperature change of hydrocolloids

It should be noted that due to the low concentration of modified corn starch and the presence of sugar in the slurry, it is not possible to measure the melting point since a rather low viscosity system is formed. Therefore, the change in melting point is given for low-esterified pectins with the addition of calcium citrate salt (Fig. 2.6).

In Fig. 2.6 shows an increase in melting temperature with increasing concentrations of apple and citrus low-esterified pectins. During the comparison of temperature data it is proved that apple low-esterified pectin is characterized by higher melting point relative to citrus low-esterified pectin. It should be noted that the formed gel of these pectins with the content of calcium citrate is characterized by insufficient plasticity, so in order to provide new and improve these characteristics was introduced modified corn starch .

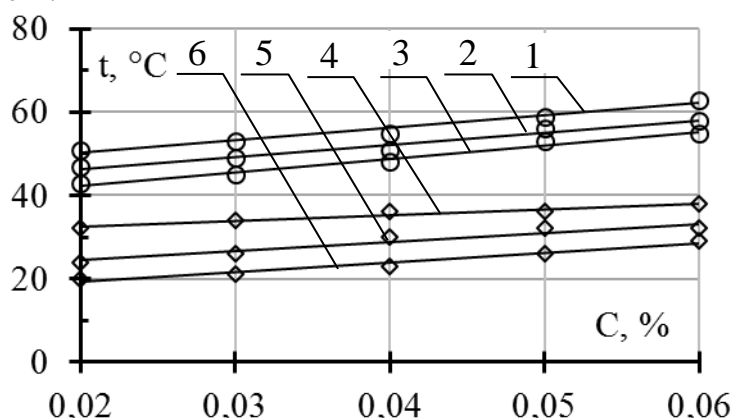


Fig. 2.6. Dependence of the melting point of gels of low-esterified pectins on the concentration of calcium citrate with a sugar content of 55%, low-esterified apple pectin (%): 1 – 0,5; 2 – 0,8; 3 – 1,1, and low-esterified citrus pectin (%): 4 – 0,5; 5 – 0,8; 6 – 1,1

In the case of the combination of apple and citrus low-esterified pectin concentration of 0.50% with modified corn starch of concentration of 1.00, 2.00 and 3.00% and the addition of calcium citrate of 0.02, 0.04 and 0.06%, a gel with high fluidity at room temperature (20 ± 2 °C) is formed, which is not appropriate for use in thermostable fillings. Thus, the study of the change in the melting point of the gels of a mixture of pectins and starch was carried out at concentrations of apple and citrus pectin 0.80 and 1.10% (Fig. 2.7).

Data of Fig. 2.7 indicate a slight change in the melting point of the pectin experimental gels. It was found that the melting point of the gels increases with the concentration of the components. This is probably due to the fact that as the concentration of these components increases, the number of free strong bonds between them increases - a spatial grid is formed, which more resistant to high temperature [36; 47; 111; 107; 242; 249; 256; 261; 275; 285; 293].

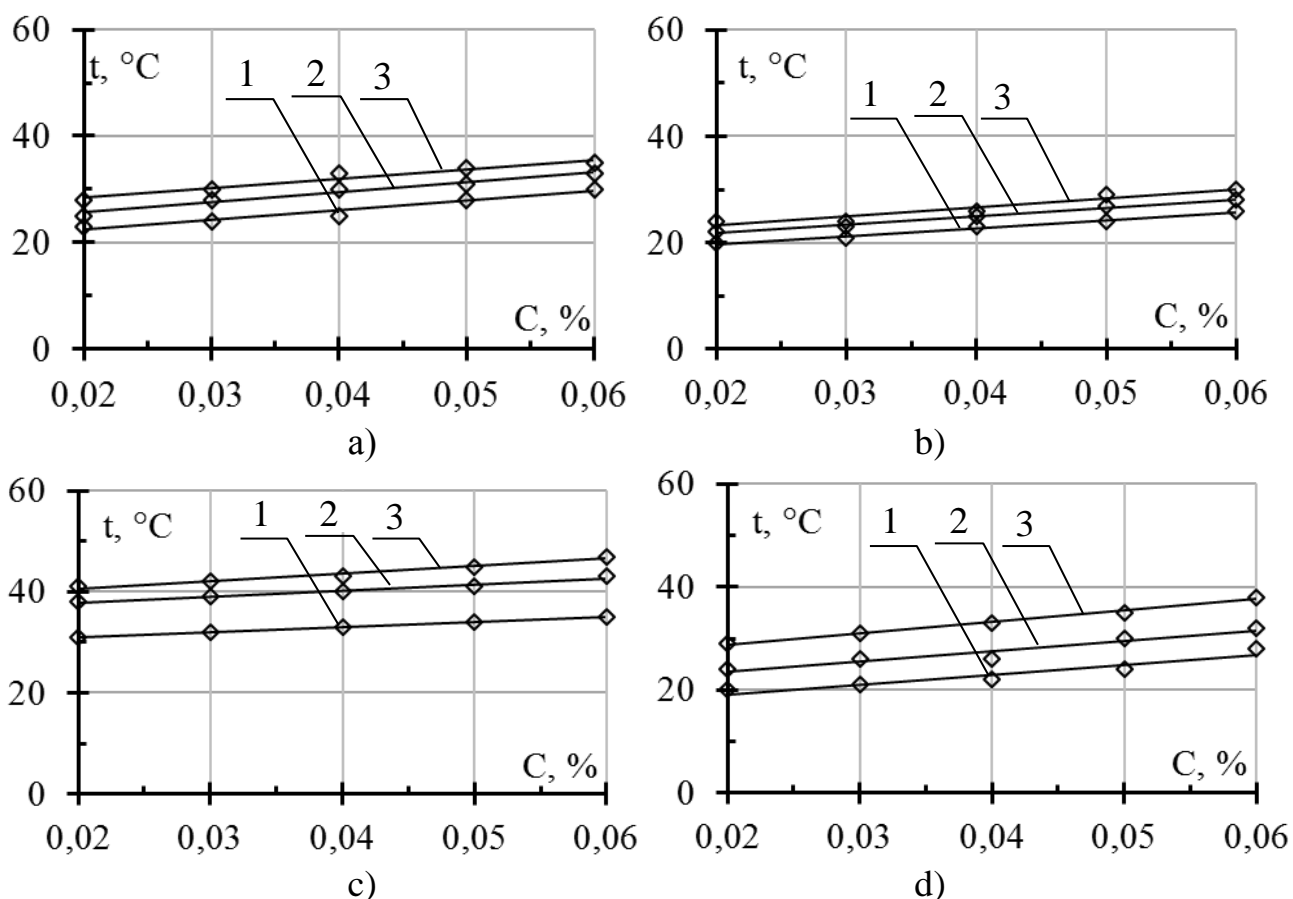


Fig. 2.7. Dependence of the melting point of gels of low-esterified pectins on the concentration of calcium citrate with a sugar content of 55% in the ratio: a) «apple pectin: modified corn starch» (%): 1 – 0,8:1,0; 2 – 0,8:2,0; 3 – 0,8:3,0; b) «citrus pectin: modified corn starch» (%): 1 – 0,8:1,0; 2 – 0,8:2,0; 3 – 0,8:3,0; c) «apple pectin: modified corn starch» (%): 1 – 1,1:1,0; 2 – 1,1:2,0; 3 – 1,1:3,0; d) «citrus pectin: modified corn starch» (%): 1 – 1,1:1,0; 2 – 1,1:2,0; 3 – 1,1:3,0

However, with the addition of starch, there was a slight decrease in the melting point of the gels of the pectin-starch mixture. This change is most likely due to the regrouping of the low-esterified pectin bonds formed in the gel and the emergence of new free ones, which require the additional involvement of calcium-containing raw materials to form a grid with high temperature properties. It should be noted that the formed gel of this mixture of pectin and starch is characterized by a softer and plastic consistency than the gel with only pectin.

Thus, based on the results of the data obtained from the study of the melting point, we can conclude that the combined organoleptic properties and melting point, it is rational to use a gel containing low-esterified citrus pectin 0.80%, modified corn starch 3.00% and calcium citrate 0.04% .

2.3.2 Change of thermal stability of hydrocolloids

The duration of thermal stability is characterized by the ability to maintain a stable form and general physicochemical properties throughout the period of temperature action. Indicator of thermal stability of pectins and a number of pectin and starch mixtures are given in Table. 2.3.

It is established that as a result of the addition of calcium citrate, the formation of too weak gels of apple and citrus pectin is observed, which with a temperature rise above 20 ± 2 °C quickly pass to the liquid state, and therefore difficult to determine their thermal stability. Starch suspensions are also quite difficult to determine, due to its low concentration and sugar content. This is due to the high ability of sugar to dissolve in water, which causes the dehydration of starch polymers and the formation of layers of concentrated solutions in the starch paste, which leads to a decrease in viscosity [174; 185; 228; 243; 296]. It is advisable to investigate the change in the duration of thermal stability of mixtures of pectins and modified corn starch. It should be noted that at concentrations of the studied low-esterified pectins 0.50%, modified corn starch 1.00, 2.00 and 3.00% and calcium citrate 0.02, 0.04 and 0.06% are formed gels of considerable fluidity at room temperature. Thus, the study of thermal stability began with a concentration of low-esterified pectins of 0.80% (Table 3.3).

The data analysis of the table. 2.3 indicates an increase in the thermal stability of the gel of apple low-esterified pectin relative to citrus low-esterified pectin. The tendency of increase of thermal stability is revealed due to interaction of molecules of pectin with calcium. In this pectin molecules are crosslinked by calcium ions to form a spatial grid of pectin, which holds all the ingredients together [36; 47; 111; 107; 242; 249; 256; 261; 275; 285; 293].

Thus, based on the results of thermostable properties studies, which do not contradict the findings of the studies on the functional-technological and rheological properties of hydrocolloids, it is proved that the concentration of low-esterified citrus pectin is 0.80% with a concentration of 0.04% citrate. It has also been found that the additional content of modified corn starch (1.00 and 3.00%) is a prerequisite, since a soft and plastic consistency gel is formed with its participation. The values close to effective have a gel at low-esterified citrus pectin concentrations of 0.80%, modified corn starch 3.00% and calcium citrate 0.04%.

Table 2.3

Comparative characteristics of the thermal stability of mixtures
"low-esterified pectin: modified corn starch"

Raw materials, %	Indicators											
	Thermal stability $\tau \times 60^{-1}$, s, at a temperature											
	40±2 °C			60±2 °C			80±2 °C			100±2 °C		
	C (calcium citrate), %											
	0,02	0,04	0,06	0,02	0,04	0,06	0,02	0,04	0,06	0,02	0,04	0,06
low-esterified apple pectin : modified corn starch												
0,8:1,0	0,51±0,03	1,33±0,07	2,37±0,10	0,47±0,02	1,19±0,06	1,58±0,08	0,41±0,02	0,30±0,02	1,11±0,06	0,14±0,01	0,17±0,01	0,30±0,02
0,8:2,0	0,53±0,03	2,31±0,10	3,41±0,20	0,52±0,03	2,12±0,10	2,58±0,10	0,37±0,02	1,30±0,07	1,52±0,08	0,36±0,02	0,41±0,02	1,08±0,05
0,8:3,0	0,57±0,03	3,48±0,20	5,37±0,30	0,58±0,03	2,42±0,10	3,08±0,20	0,50±0,03	1,50±0,08	2,14±0,10	0,42±0,02	0,45±0,02	1,27±0,06
1,1:1,0	1,54±0,08	2,00±0,10	2,50±0,10	1,10±0,06	1,50±0,08	2,50±0,10	0,47±0,02	0,50±0,03	1,30±0,07	0,17±0,01	0,29±0,01	0,43±0,02
1,1:2,0	11,50±0,60	21,00±1,00	30,0±1,00	1,50±0,08	2,20±0,10	3,00±0,20	0,50±0,03	1,45±0,07	2,15±0,10	0,41±0,02	1,20±0,06	1,30±0,07
1,1:3,0	21,00±1,00	30,0±1,50	30,0±1,00	2,25±0,10	2,55±0,10	3,10±0,20	1,40±0,07	2,10±0,10	2,40±0,10	0,55±0,03	1,30±0,07	2,08±0,10
low-esterified citrus pectin : modified corn starch												
0,8:1,0	0,23±0,01	0,58±0,03	1,36±0,07	0,14±0,01	0,30±0,02	1,15±0,06	0,10±0,01	0,18±0,01	0,50±0,03	0,05±0,01	0,11±0,01	0,27±0,01
0,8:2,0	0,35±0,02	1,15±0,06	2,25±0,10	0,24±0,01	0,36±0,02	1,52±0,08	0,18±0,01	0,29±0,01	1,31±0,07	0,08±0,01	0,15±0,01	0,42±0,01
0,8:3,0	0,41±0,02	2,13±0,10	3,15±0,20	0,36±0,02	0,43±0,02	2,38±0,20	0,26±0,01	0,38±0,02	2,02±0,10	0,12±0,01	0,28±0,01	1,10±0,06
1,1:1,0	1,24±0,06	1,52±0,08	2,20±0,10	0,18±0,01	0,49±0,02	1,26±0,06	0,16±0,01	0,35±0,02	1,10±0,06	0,08±0,01	0,13±0,01	0,36±0,02
1,1:2,0	9,45±0,50	15,0±0,80	29,0±1,50	1,19±0,06	1,55±0,08	2,32±0,10	0,25±0,01	1,28±0,06	2,02±0,10	0,12±0,01	0,29±0,01	0,51±0,03
1,1:3,0	19,16±1,00	30,0±1,50	30,0±1,50	2,06±0,10	2,13±0,10	2,50±0,10	0,38±0,02	1,56±0,08	2,20±0,10	0,32±0,02	1,05±0,05	1,50±0,08

2.4 Investigation of functional and technological properties of protein concentrates of oilseeds

Today, the role of functional and technological properties of powdered raw materials (particle size of about 50 microns) obtained during the technological processing of plant protein oil crops, and water as a solvent in the process of food production has not been sufficiently studied [4; 13; 41]. However, due to the ability to control the physicochemical, structural, mechanical and technological properties, these studies are indispensable for the production of high-quality thermostable filling. Therefore, it is advisable to study the functional and technological properties of the selected plant additive - sesame seed concentrate, comparing the results of studies with the data on the functional and technological characteristics of other protein concentrates of oilseeds (Table 2.4).

Table 2.4

Comparative characteristics of MHA and AHF of plant protein concentrates of oilseeds

Сировина	Indicator				
	MHA,%				AHF,%
	20±2° C	40±2° C	60 ±2° C	80 ±2° C	
Sesame seed concentrate	263±13,0	267±13,0	270±13,0	271±13,0	155±7,5
Sunflower seed concentrate	150±7,0	152±7,5	157±7,5	160±8,0	150±7,5
Flax seed concentrate	495±24,0	624±31,0	693±34,5	740±37,0	116±5,5
Peanut kernel concentrate	92±4,5	138±6,5	161±8,0	140±7,0	105±5,0
Walnut kernel concentrate	115±5,5	137±6,5	166±8,0	175±8,5	147±7,0

According to the table. 2.4 there was an increase in the indices of MHA of the investigation raw material in the temperature range from 20±2 to 80±2°C. Obviously, there is swelling of proteins and polysaccharides contained in the raw material; moisture is withheld mainly due to chemical interaction [4; 13; 34; 41; 61; 149; 208; 243; 297]. Due to the "protein-water" chemical interaction and a number of interactions of a non-chemical nature, a rather stable system is formed, MHA of which is almost independent of temperature.

Hydrophobic interactions of concentrates have a similar tendency to change properties. According to the data table. 2.2 it was found that the lowest values of AHF are characteristic for peanut kernel concentrate (105%) and the highest - for sesame seed concentrate (155%).

Considering the results of the conducted research, it can be concluded that sesame seed concentrate is functionally and technologically important component. It should be used as an ingredient that can bind and hold moisture and fat [61; 130; 174; 298].

2.5 Investigation of influence of high temperature on the technological properties of the research system of thermostable filling

2.5.1 Study of influence of recipe components on melting temperature of the research system of the thermostable filling

In order to prevent and correct changes of development, it is advisable to investigate its melting point with respect to the formulation composition. The dependence of the melting point of the experimental system of thermostable filling on the content of skimmed milk powder and the ratio "SMP: SSC" are shown (Fig. 2.8 and 2.9).

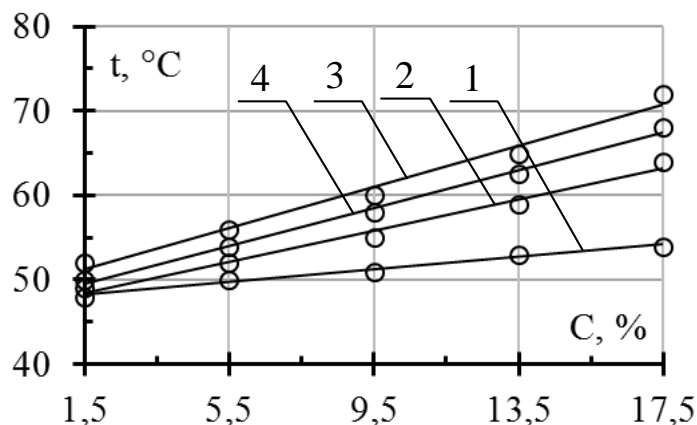


Fig. 2.8. Dependence of the melting point of the test system TF on the content of SMP at concentrations: 1 – low-esterified citrus pectin 0,8%; low-esterified citrus pectin and modified corn starch respectively: 2 – 0,8% i 1,0%; 3 – 0,8% i 3,0%; 4 – 1,1% i 1,0%

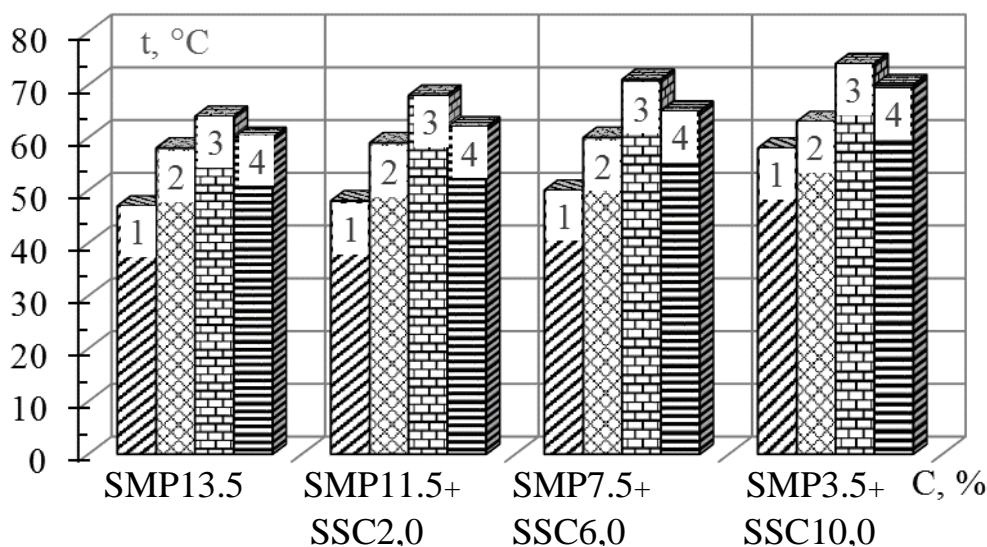


Fig. 2.9. Dependence of the melting point of the test system TF on the content of SMP and SSC at concentrations: 1 – low-esterified citrus pectin 0,8%; low-esterified citrus pectin and modified corn starch respectively: 2 – 0,8% i 1,0%; 3 – 0,8% i 3,0%; 4 – 1,1% i 1,0%

In Fig. 2.8 and 2.9 show an increase in the melting temperature with increasing content of prescription components of calcium-containing (skimmed milk powder)

and protein-polysaccharide nature (sesame seed concentrate) in the experimental system of TF. According to the above data, it was found that the lowest melting point (48.5 °C) to have an TF experimental system at low-esterified citrus pectin concentrations of 0.8% with a skimmed milk powder content of 1.5%. The highest value (71 °C) is characterized by the same pectin concentration of 0.8% and modified corn starch 3.0% with skimmed milk powder content of 17.5%, but this system is characterized by a rather dense structure. Less dense structure has a system with a given concentration of hydrocolloids and a dry skim milk content of 13.5%; the melting point is 65 °C. This phenomenon is due to the decrease in the number of free bonds of the carboxyl group of the pectin molecule [1; 236; 253; 278; 302].

Data Fig. 2.9 indicate the same above mentioned dependence of the melting point change. It has been found that in the experimental system of TF with increasing content of hydrocolloids and, in particular, plant protein additives - sesame seed concentrate - the melting point is increasing. From the obtained data it is determined that the rational concentrations of hydrocolloids and sesame seeds concentrate in the experimental system of TF are as follows: low-esterified citrus pectin - 0.8%, modified corn starch - 3.0%, skimmed milk powder - 7.5% and sesame seed concentrate - 6.0%.

2.5.2 Study of influence of recipe components on thermal stability of the research system of the thermostable filling

In order to further monitor changes in thermostable filling caused by the action of temperature, the dependence of the change of thermal stability of the TF experimental system on temperature with different contents of the recipe components is shown (Table 2.5).

Table 2.5

Comparative characteristics of thermal stability

C (modified corn starch), %	Thermal stability $\tau \times 60^{-1}$, s, at a temperature													
	100 \pm 2 °C		120 \pm 2 °C		140 \pm 2 °C		160 \pm 2 °C		180 \pm 2 °C		200 \pm 2 °C		220 \pm 2 °C	
	C (low-esterified citrus pectin), %													
	0,8	1,1	0,8	1,1	0,8	1,1	0,8	1,1	0,8	1,1	0,8	1,1	0,8	1,1
Skimmed milk powder 1,5%														
0	8,30 \pm 0,04	0	7,50 \pm 0,40	0	6,45 \pm 0,30	0	6,02 \pm 0,30	0	3,10 \pm 0,20	0	1,40 \pm 0,07	0	0,30 \pm 0,02	0
1,0	15,40 \pm 0,80	15,95 \pm 0,80	14,23 \pm 0,70	14,70 \pm 0,80	12,10 \pm 0,60	12,71 \pm 0,60	10,56 \pm 0,50	10,95 \pm 0,50	6,83 \pm 0,34	7,60 \pm 0,40	2,88 \pm 0,10	3,38 \pm 0,17	1,80 \pm 0,09	2,14 \pm 0,10
3,0	16,17 \pm 0,80	0	15,12 \pm 0,80	0	12,77 \pm 0,60	0	11,38 \pm 0,60	0	7,93 \pm 0,40	0	3,50 \pm 0,20	0	2,30 \pm 0,10	0
Skimmed milk powder 5,5%														
0	8,40 \pm 0,40	0	7,58 \pm 0,40	0	6,50 \pm 0,30	0	6,09 \pm 0,30	0	3,16 \pm 0,20	0	1,44 \pm 0,07	0	0,34 \pm 0,02	0
1,0	15,73 \pm 0,80	16,20 \pm 0,80	14,30 \pm 0,70	14,80 \pm 0,70	12,20 \pm 0,60	12,82 \pm 0,60	10,62 \pm 0,50	11,03 \pm 0,60	7,08 \pm 0,40	7,65 \pm 0,40	2,95 \pm 0,10	3,45 \pm 0,20	1,85 \pm 0,09	2,23 \pm 0,10
3,0	16,25 \pm 0,80	0	15,20 \pm 0,80	0	13,05 \pm 0,70	0	11,45 \pm 0,60	0	8,03 \pm 0,40	0	4,00 \pm 0,20	0	2,40 \pm 0,10	0
Skimmed milk powder 9,5%														
0	8,50 \pm 0,40	0	8,04 \pm 0,40	0	6,55 \pm 0,30	0	6,14 \pm 0,30	0	3,20 \pm 0,20	0	1,48 \pm 0,07	0	0,40 \pm 0,02	0
1,0	15,80 \pm 0,80	16,30 \pm 0,80	14,58 \pm 0,70	14,90 \pm 0,70	12,28 \pm 0,60	12,92 \pm 0,60	10,67 \pm 0,50	11,50 \pm 0,60	7,15 \pm 0,40	7,70 \pm 0,40	3,23 \pm 0,02	3,73 \pm 0,20	2,10 \pm 0,10	2,32 \pm 0,10
3,0	16,32 \pm 0,80	0	15,28 \pm 0,80	0	13,15 \pm 0,70	0	11,53 \pm 0,60	0	8,30 \pm 0,40	0	4,05 \pm 0,02	0	2,45 \pm 0,10	0
Skimmed milk powder 13,5%														
0	9,00 \pm 0,50	0	8,09 \pm 0,40	0	7,00 \pm 0,40	0	6,20 \pm 0,30	0	3,25 \pm 0,20	0	1,53 \pm 0,08	0	0,44 \pm 0,02	0
1,0	15,88 \pm 0,80	16,37 \pm 0,80	14,65 \pm 0,70	15,20 \pm 0,80	12,37 \pm 0,60	13,11 \pm 0,70	10,72 \pm 0,50	11,58 \pm 0,60	7,23 \pm 0,40	7,75 \pm 0,40	3,28 \pm 0,02	3,80 \pm 0,02	2,15 \pm 0,10	2,40 \pm 0,10
3,0	16,55 \pm 0,80	0	15,35 \pm 0,80	0	13,21 \pm 0,70	0	11,78 \pm 0,60	0	8,58 \pm 0,40	0	4,10 \pm 0,20	0	2,70 \pm 0,10	0
Skimmed milk powder 17,5%														
0	9,10 \pm 0,50	0	8,14 \pm 0,40	0	7,05 \pm 0,40	0	6,24 \pm 0,30	0	3,30 \pm 0,20	0	1,57 \pm 0,08	0	0,49 \pm 0,02	0
1,0	15,95 \pm 0,10	16,42 \pm 0,80	14,73 \pm 0,70	15,30 \pm 0,80	12,44 \pm 0,60	13,22 \pm 0,70	10,79 \pm 0,50	11,65 \pm 0,60	7,30 \pm 0,40	7,80 \pm 0,40	3,33 \pm 0,20	3,85 \pm 0,20	2,20 \pm 0,10	2,68 \pm 0,10
3,0	16,60 \pm 0,80	0	15,43 \pm 0,80	0	13,27 \pm 0,70	0	12,05 \pm 0,60	0	8,65 \pm 0,40	0	4,14 \pm 0,20	0	2,75 \pm 0,10	0
Ratio of "SMP:SSC" 11,5 : 2,0%														
0	9,5 \pm 0,50	0	8,12 \pm 0,40	0	7,05 \pm 0,40	0	6,60 \pm 0,30	0	3,50 \pm 0,20	0	2,00 \pm 0,10	0	0,55 \pm 0,03	0
1,0	16,0 \pm 0,80	16,70 \pm 0,80	15,00 \pm 0,80	15,85 \pm 0,80	12,50 \pm 0,60	13,65 \pm 0,70	11,00 \pm 0,60	11,85 \pm 0,60	7,70 \pm 0,40	8,50 \pm 0,40	3,50 \pm 0,20	4,00 \pm 0,20	2,50 \pm 0,10	2,70 \pm 0,10
3,0	17,0 \pm 0,90	0	16,05 \pm 0,80	0	13,89 \pm 0,70	0	12,15 \pm 0,60	0	9,25 \pm 0,50	0	4,50 \pm 0,20	0	3,10 \pm 0,20	0
Ratio of "SMP:SSC" 7,5 : 6,0%														
0	10,0 \pm 0,50	0	8,70 \pm 0,40	0	7,50 \pm 0,40	0	7,00 \pm 0,40	0	4,00 \pm 0,20	0	2,50 \pm 0,10	0	1,25 \pm 0,06	0
1,0	16,50 \pm 0,80	17,20 \pm 0,90	15,55 \pm 0,80	16,20 \pm 0,80	13,05 \pm 0,70	13,90 \pm 0,30	11,65 \pm 0,60	12,30 \pm 0,60	8,05 \pm 0,40	9,00 \pm 0,50	3,95 \pm 0,20	4,40 \pm 0,20	2,88 \pm 0,10	3,00 \pm 0,20
3,0	17,68 \pm 0,90	0	16,70 \pm 0,80	0	14,30 \pm 0,70	0	12,60 \pm 0,60	0	9,70 \pm 0,50	0	4,90 \pm 0,20	0	3,50 \pm 0,20	0
Ratio of "SMP:SSC" 3,5 : 10,0%														
0	10,40 \pm 0,60	0	9,10 \pm 0,50	0	7,95 \pm 0,40	0	7,20 \pm 0,40	0	4,50 \pm 0,20	0	3,20 \pm 0,20	0	1,55 \pm 0,08	0
1,0	17,20 \pm 0,90	17,80 \pm 0,90	15,90 \pm 0,80	16,70 \pm 0,80	13,80 \pm 0,70	14,40 \pm 0,30	12,40 \pm 0,60	12,70 \pm 0,60	8,70 \pm 0,40	9,50 \pm 0,50	4,45 \pm 0,20	4,70 \pm 0,20	3,30 \pm 0,50	3,85 \pm 0,20
3,0	18,10 \pm 0,90	0	17,50 \pm 0,09	0	14,90 \pm 0,70	0	13,20 \pm 0,70	0	10,40 \pm 0,50	0	5,20 \pm 0,30	0	3,65 \pm 0,20	0

According to the table. 2.5 there is a decrease in the thermal stability of the TF experimental system with increasing temperature. The thermal stability index of the TF system at a low-esterified citrus pectin of concentration 0.8% and a skimmed milk powder content of 1.5 to 17.5% at the lowest temperature effect (100 °C) varies from 8.3 to 9.1×60 s, respectively, at the highest (220 °C) - respectively from 0.3 to 0.49×60 s. The thermal stability index is slightly increased with the addition of modified corn starch, concentration of 1.0 and 3.0%. It follows that the indicator of thermal stability increases with the increase of modified corn starch and calcium-containing raw materials - skimmed milk powder in the system. A similar trend is observed in the case of partial replacement of skimmed milk powder with sesame seeds concentrate. It is revealed that the highest values of thermal stability are inherent in the TF experimental system at the concentration of low-esterified citrus pectin 0.8% and modified corn starch 3.0%.

Summarizing the data obtained for the partial replacement of skimmed milk powder with sesame seed concentrate, we note that the ratio of "SMP:SSC" as 7.5: 6.0% is rational in terms of organoleptic, consumer and technological qualities. In view of this, in the course of further experimental studies, attention should be paid to the revealed rational ratio of dairy raw material and plant protein supplement "SMP:SSC, as 7.5: 6.0%.

2.6 Investigation of moisture connection forms in the research system of the thermostable filling

2.6.1 Study of influence of recipe components on the moisture-holding ability of the research system of the thermostable filling

Moisture plays an important role in the production of thermostable fillings, because it determines the consistency, structure, duration of storage, etc. [13; 41; 149]. High MHA of thermostable fillings, in particular, contributes to the stability of organoleptic, physico-chemical, structural-mechanical and microbiological parameters during product storage. Of course, the recipe components of the filling, mainly hydrocolloids, have a great influence on the MHA. According to the results of studies of functional-technological, rheological and thermostable properties of hydrocolloids revealed that these properties are high in the case of a combination of low-esterified citrus pectin and modified corn starch. However, the change of MHA contributes to the introduction into the filling of other recipe components with hydrophilic properties, in particular skimmed milk powder and sesame seeds concentrate, which is a source of protein and calcium.

The features of the change of the MHA of the TF experimental system under the condition of partial replacement of skimmed milk powder with sesame seeds concentrate are shown in Fig. 2.10.

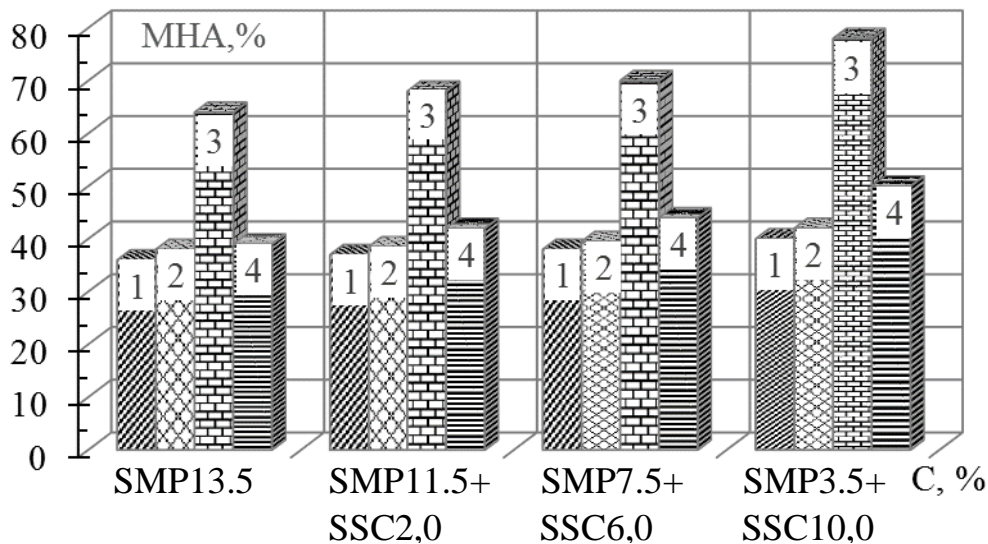


Fig. 2.10 Dependence of moisture-holding ability of the TF experimental system on the content of SMP and SSC and concentration: 1 – low-esterified citrus pectin 0,8%; low-esterified citrus pectin and modified corn starch respectively: 2 – 0,8% i 1,0%; 3 – 0,8% i 3,0%; 4 – 1,1% i 1,0%

From the above data of the TF research system (Fig. 2.10), taking into account the ratio of "SMP : SSC" and the concentration of pectin or composition with starch, there is a tendency to increase the MHA index with an increase in the system of components concentration (sesame seed concentrate, low esterified citrus pectin and mixture with pectin and modified corn starch). Taken together, these recipe components promote the entry into the research system of protein-polysaccharide nature substances, which in turn, are characterized by high adsorption and moisture-holding ability [4; 130; 149]. It is known that the hydrophilicity of individual proteins depends on their structure. Hydrophilic, amine and carboxyl groups present in the composition and located on the surface of the protein macromolecule attract the solvent molecules, strictly orienting them on the surface of the molecule [32; 160; 297; 300].

Summarizing the results of the MHA study of the TF research system, it is proved that the addition of sesame seeds concentrate contributes to the growth of MHA indicators. However, with an increase in the replacement of skimmed milk powder with concentrate ("SMP : SSC" ratio of 3.5: 10.0%), an organoleptically unacceptable herbaceous taste appears. In this regard, the rational ratio of "SMP : SSC" revealed by the MHA study is 7.5: 6.0%, which corresponds to the high quality characteristics of the product.

2.6.2 Determination of the influence of recipe components on the moisture state of the research system of the thermostable filling

Moisture type is known to be divided into free and bound by the type of bond. The ratio of free and bound moisture has a very large influence on food production, including TF. After all, knowing the prevailing moisture bond form, it is possible to prevent or correct the changes that the filling undergoes under the influence of certain

factors, while maintaining the stability of the TF properties during the action of technological factors (temperature, etc.) [41; 69; 71; 85; 144; 151; 152; 212; 214; 215; 237; 257; 261; 263; 272; 283].

The essence of the NMR method is that due to the creation of a local magnetic field, the water molecule is split into hydrogen and oxygen. In this case, the total molecular mobility of water in the experimental system of thermostable filling is determined by the degree of mobility of hydrogen protons, which determines the time of phase separation of magnetic moments, ie the duration of spin-spin relaxation (T_2) [212]. In Fig. 2.11 shows the duration of spin-spin relaxation of the dipole of water in the TF experimental system under the conditions of the ratio "skimmed milk powder: sesame seed concentrate".

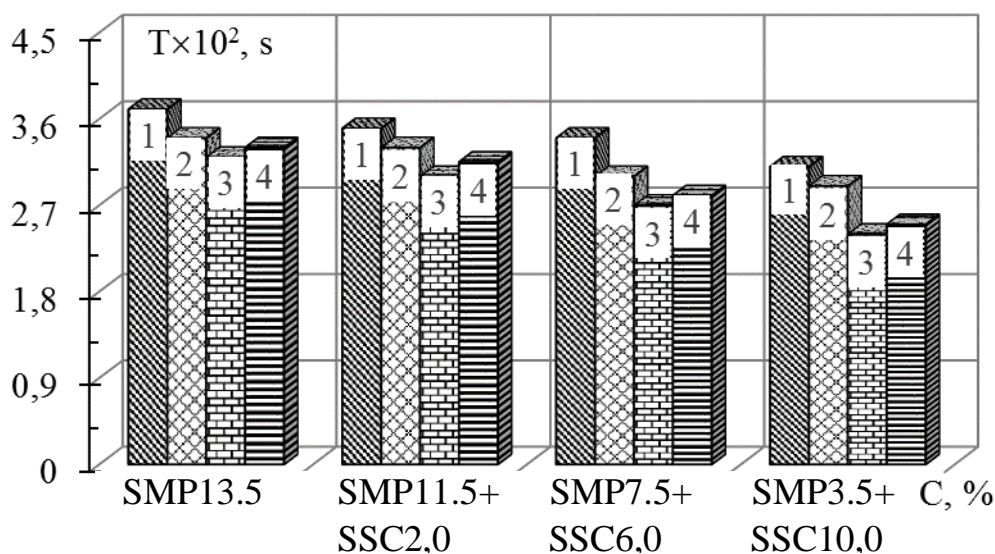


Fig. 2.11 Dependence of the spin-spin relaxation duration of the water dipole in the TF experimental system on the content of SMP and SSC at concentrations: 1 – low-esterified citrus pectin 0,8%; low-esterified citrus pectin and modified corn starch respectively: 2 – 0,8% i 1,0%; 3 – 0,8% i 3,0%; 4 – 1,1% i 1,0%

From fig. 2.11 shows that the duration of spin-spin relaxation (T_2) decreases as the experimental system TN content of hydrocolloids and sesame seed concentrate increases. This indicates the ability of the components of the TF experimental system to absorb and bind moisture with increasing content of hydrocolloids and sesame seeds concentrate.

A similar dependence of the T_2 decrease with the increase in the bound moisture content can be observed provided that the concentration of low-esterified citrus pectin in the TF experimental system is increased to 1.1% with the addition of 1.0% modified corn starch. Thus, during the NMR studies it was found that the duration of spin-spin relaxation of the TF experimental system decreases with increasing concentration of hydrophilic components of protein and polysaccharide nature and ionic polyvalent metals.

To sum up, it can be argued that the rational ratio of skimmed milk powder and sesame seeds concentrate in the experimental system of TF is also 7.5: 6.0%. Due to the increase of concentrate content to 10.0% and, accordingly, reduction of skimmed

milk powder to 3.5%, a system with a strong structure and deteriorated organoleptic characteristics is formed.

2.7 Study of influence of recipe components on duration of structure formation and strength of the research system of the thermostable filling

The formulation of the experimental system is combined due to the introduction of animal ingredients (skimmed milk powder) and plant origin ingredients (sesame seed concentrate, low-esterified citrus pectin and modified corn starch). Therefore, in order to form high-quality characteristics of the TF experimental system and taking into account the significant influence of prescription ingredients on the state of moisture in the system, it is necessary to determine the time when the filling will acquire a stable structure, that is, when strong intra- and intermolecular interactions will occur.

The duration of the structure formation of the samples of the TF experimental system under different ratios "SMP: SSC" is shown in Fig. 2.12 and 2.13.

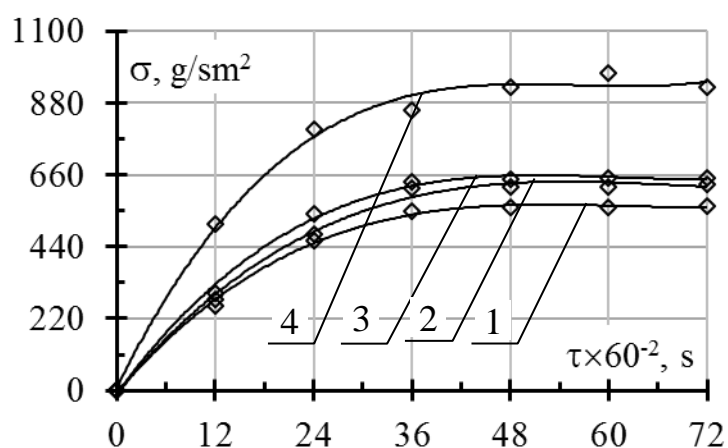


Fig. 2.12. Dependence the strength on the formation time of the TF experimental system with the content of skimmed milk powder 13.5% at concentrations: 1 – low-esterified citrus pectin 0,8%; low-esterified citrus pectin and modified corn starch respectively: 2 – 0,8% i 1,0%; 3 – 0,8% i 3,0%; 4 – 1,1% i 1,0%

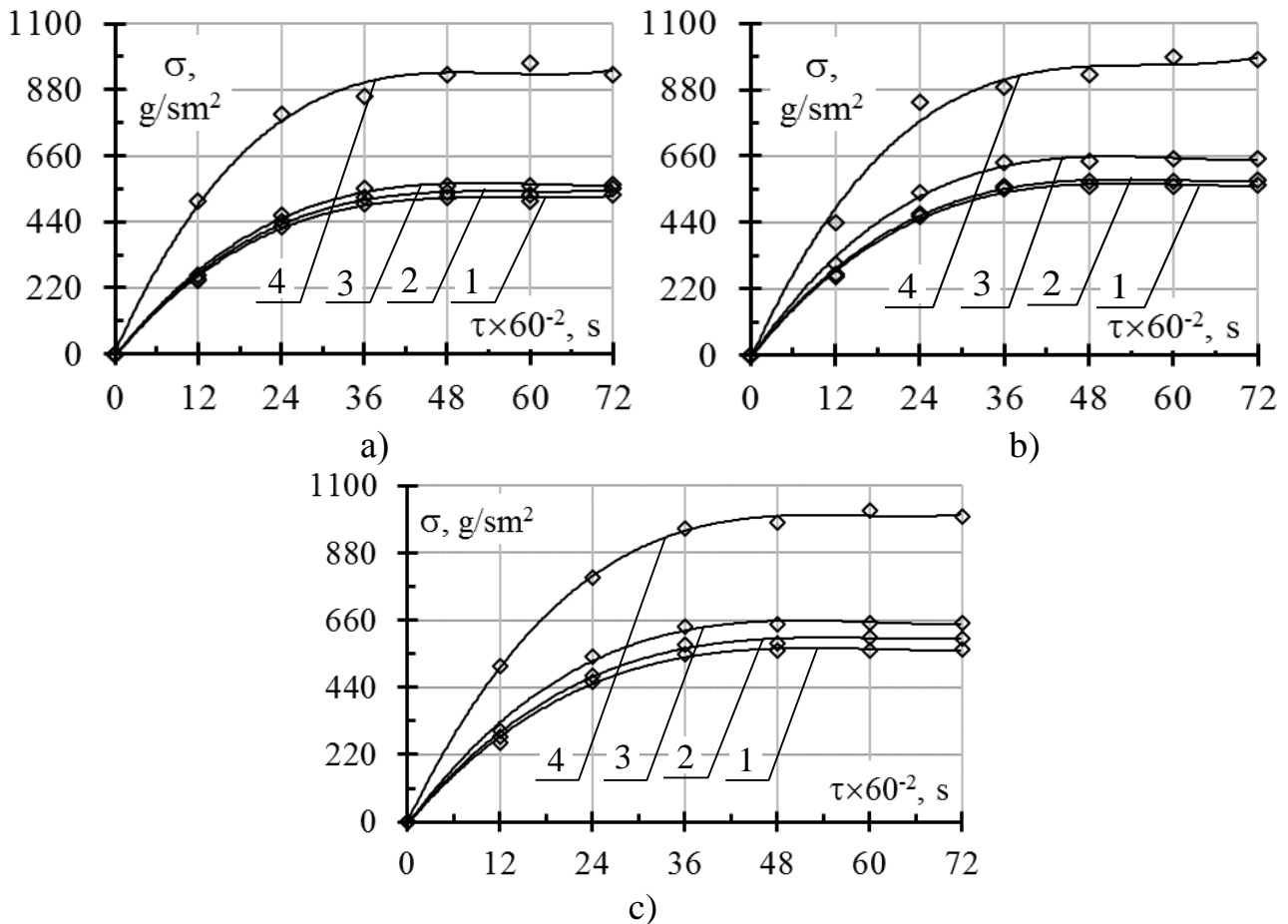


Fig. 2.13. Dependence the structure formation time on the TF experimental system on the ratio "SPM:SSC": a) 11,5:2,0%; b) 7,5:6,0% i c) 3,5:10,0%, at concentrations: 1 – low-esterified citrus pectin 0,8%; low-esterified citrus pectin and modified corn starch respectively: 2 – 0,8% i 1,0%; 3 – 0,8% i 3,0%; 4 – 1,1% i 1,0%

According to Fig. 2.12 and 2.13, it was found that the addition of sesame seed concentrate to the TF experimental system causes a decrease in the gel strength values. However, there is an increase in the strength of the gel samples of the TF experimental systems relative to each other with an increase in their recipe components, in particular hydrocolloids - low-esterified citrus pectin, modified corn starch and sesame seeds concentrate. It is established that the time of structure formation of combined systems lies in the interval $(48...72) \times 60^2$ s. It is in this period of time that the strength indicators of the gels of the research systems stabilize, and p to 48×60^2 s they increase, which indicates the formation of bonds of different nature between the recipe ingredients. Thus, the formed spatial grid contributes to the emergence of the characteristic structure of the TF experimental system at different concentrations of hydrocolloids and the ratio "SPM:SSC".

In general, the study results of the influence prescription components on the duration of the structure formation of the experimental system thermostable filling revealed that up to 48×60^2 s there is a significant increase in the strength of the gel

samples. In the interval $(48...72) \times 60^2$ s, the strength indicators stabilize, the system acquires a stable structure.

Summarizing the obtained results, it is established that according to the strength indicators of suitable for use is the system of TF with a ratio of "SPM:SSC" of 7.5: 6.0% and the content of the mixture of hydrocolloids - low-esterified citrus pectin 0.8% and modified corn starch 3.0 %.

2.8 Investigation of the effective viscosity of thermostable filling

In the technology of thermostable filling production using dairy raw material and sesame seeds concentrate, an important aspect is its viscosity. It determines the fluidity of the filling, that is, the resistance of its movement to the external forces, which characterizes its behavior during the technological operation "pouring into forms". Preliminary studies on the effective viscosity of hydrocolloids and mixtures thereof (low-esterified citrus pectin and modified corn starch) have shown that it is depend on temperature and chemical interactions between components. However, due to the presence in the formulation, in addition to hydrocolloids, components of a protein nature, the fluidity of the finished product is of great importance. Thus, in order to detect the fluidity of the TF experimental system, the dependence of the effective viscosity of the filling at different ratios of "SPM:SSC" on temperature was investigated (Fig. 2.14 and 2.15).

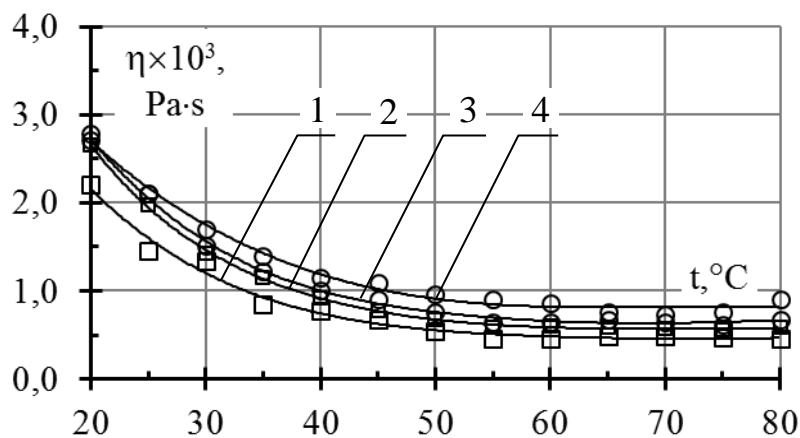


Fig. 2.14. The dependence of the effective viscosity of the TF research system on temperature with a skimmed milk powder content of 13.5% and with concentrations: 1 – low-esterified citrus pectin 0,8%; low-esterified citrus pectin and modified corn starch respectively: 2 – 0,8% i 1,0%; 3 – 0,8% i 3,0%; 4 – 1,1% i 1,0%

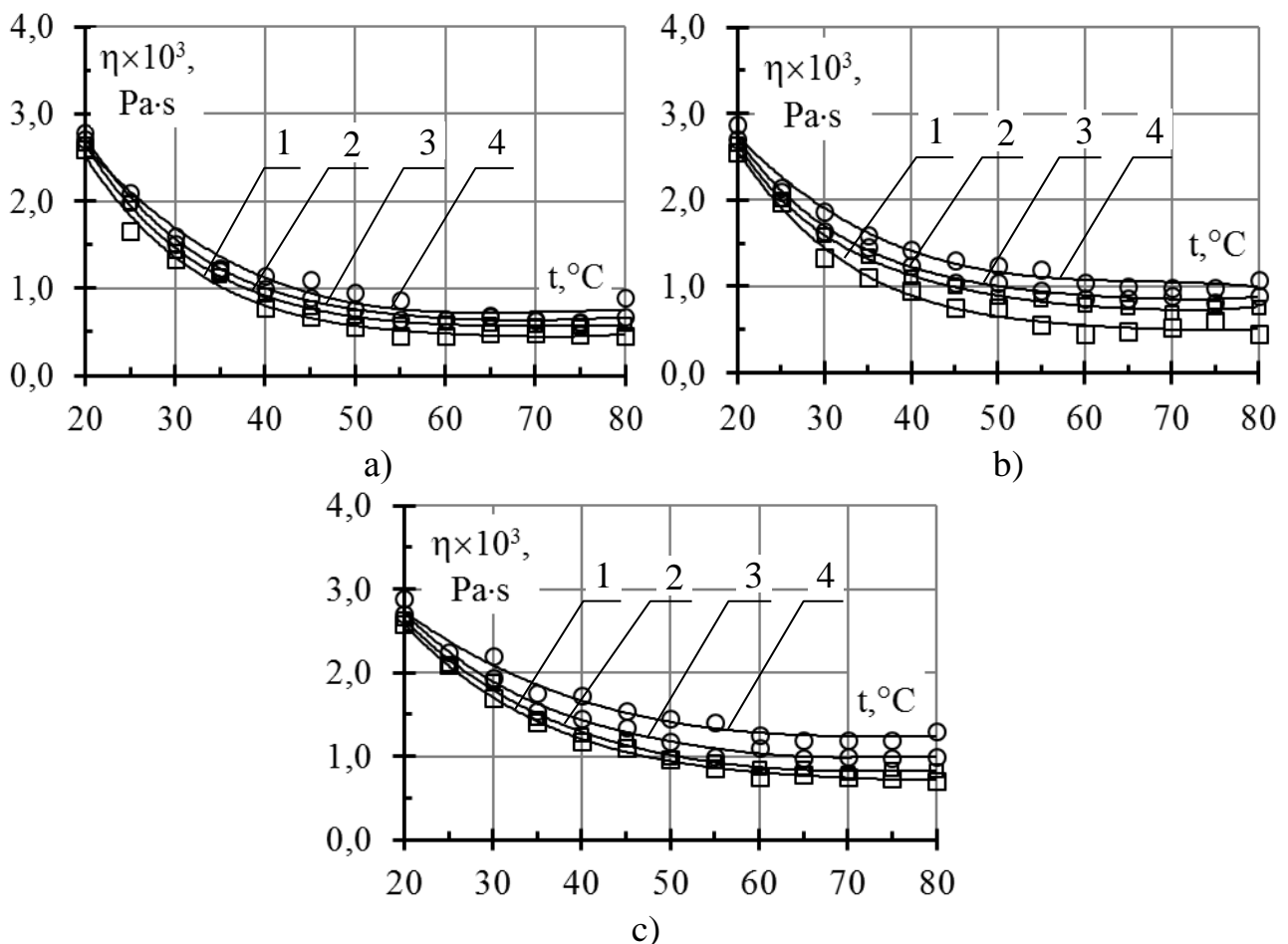


Fig. 2.15. The dependence of the effective viscosity of the TF research system on the temperature at the following ratios "SPM:SSC": a) 11,5:2,0%; b) 7,5:6,0% i c) 3,5:10,0% and at concentrations: 1 – low-esterified citrus pectin 0,8%; low-esterified citrus pectin and modified corn starch respectively: 2 – 0,8% i 1,0%; 3 – 0,8% i 3,0%; 4 – 1,1% i 1,0%

Comparing fig. 2.14 and 2.15, we note the increase in the effective viscosity of systems with partial replacement of skimmed milk powder with sesame seed concentrate. A decrease in the effective viscosity of the TF experimental system was also found, provided that the temperature influence on it was increased. It was found that the values of effective viscosity of the TF experimental system with ratios "SPM:SSC" 11,5: 2,0; 7,5: 6,0 and 3,5%: 10,0% and at different concentrations of hydrocolloids uniformly varies in the temperature range of 60...100 °C. Only the TF experimental system at low-esterified citrus pectin concentrations 0,8% and modified corn starch 3,0% with the same ratios "SPM:SSC" has a more intense and almost uniform increase in effective viscosity (approximately from 70 °C). In this system, more moisture is bound than at lower starch concentrations. It is established that this system with a ratio of "SPM:SSC" 3.5:10.0% is characterized by a rather high MHA and low molecular mobility (as revealed in the previous experimental studies), requires slightly more force to overcome the resistance, which indicates the formation of a strong structure.

Therefore, the results of studies of effective viscosity confirmed that a rational is TF research system at the concentration of low-esterified citrus pectin 0.8% and modified corn starch 3.0% at a ratio of "SPM:SSC" 7.5:6.0% (by conditions of temperature influence on the system up to 70 °C). By comparing the effective viscosity of the systems with the specified temperature, we prove that this indicator has the lowest values for the concentration of low-esterified citrus pectin 0.8%. Somewhat higher values are in the concentration of low-esterified citrus pectin 0.8 and 1.1% and modified corn starch 1.0%. And the system with a concentration of low-esterified citrus pectin 0.8% and a content of modified corn starch 3.0% has rational values of effective viscosity and is characterized by a plastic consistency within 0.63×10^{-3} Pa·s.

2.9 Investigation of IR spectroscopic parameters of the research system of the thermostable filling

Due to the combination and introduction of established concentrations of protein-polysaccharide components (skimmed milk powder, sesame seed concentrate, low-esterified citrus pectin and modified corn starch), the filling acquires thermostable properties. The IR spectroscopy method was used to confirm these necessary positive effects and to identify the linkages between the formulation components of the TF research system.

It is known that the radiation of the IR spectra depends on the general structure of the molecule and its environment, the group of atoms that make up it, and the individual bonds between them (electron polarization). The molecule can only be in certain energy relations. Each energy level corresponds to its total energy, which characterizes the transition of a molecule from one level to another. At the same time, only the radiation frequency is absorbed, the energy of which is equal to the energy difference of any two levels, that is, those wavelengths can be absorbed that can change their energy state. The release of energy that causes oscillations of atoms in a molecule is accompanied by absorption of the IR spectra by changing the dipole moment of the molecule [204; 242; 244; 251; 252]. The effect of infrared radiation with a constant variable frequency on the research system causes to absorb by molecule certain radiation links, which cause deformation of the corresponding bonds (Table 2.6), which are recorded as bands with a minimum and maximum oscillation frequency (Fig. 2.16).

Table 2.6

Characteristic bands of the valence vibrations of the TF experimental system

Sample number	Peaks area, cm^{-1}	Assignment of bands	Conclusion
1	2	3	4
1 – 8	3600...3100	Valence vibrations of the group OH	Characterized by the construction of intermolecular hydrogen bonds
4 – 8	3350...2850	Valence vibrations of the group CH	Characterized by the structure of alkanes
4 – 8	2440...2350	Valence vibrations of the group $\text{C}\equiv\text{C}$	Characterized by the structure of alkenes

Continuation of Table 2.6

1	2	3	4
1 – 8	2140...2100	Fluctuations of organophosphorus groups P-H	Conditioned by the construction of connections with a presence of dairy base
1 – 6	1680...1620	Vibrations of the group C=C	Characterized by the structure of alkenes
1 – 6	1470...1355	Symmetrically deformational vibrations of the group CH ₃	Characterized by the structure of alkanes
1 – 6	1350...1280	Valence vibrations of the group C-N	Characterizes peptide bonds
1 – 6	1280...1150	Fluctuations of the ether group C-O-C	Characterized by the structure of the ethereal bonds
1 – 8	1100...900	Valence vibrations of the group CH	Characterized by the structure of alkanes
1, 3 – 5, 7	550...450	Vibrations of the group S=S	Characterized by the structure of proteins

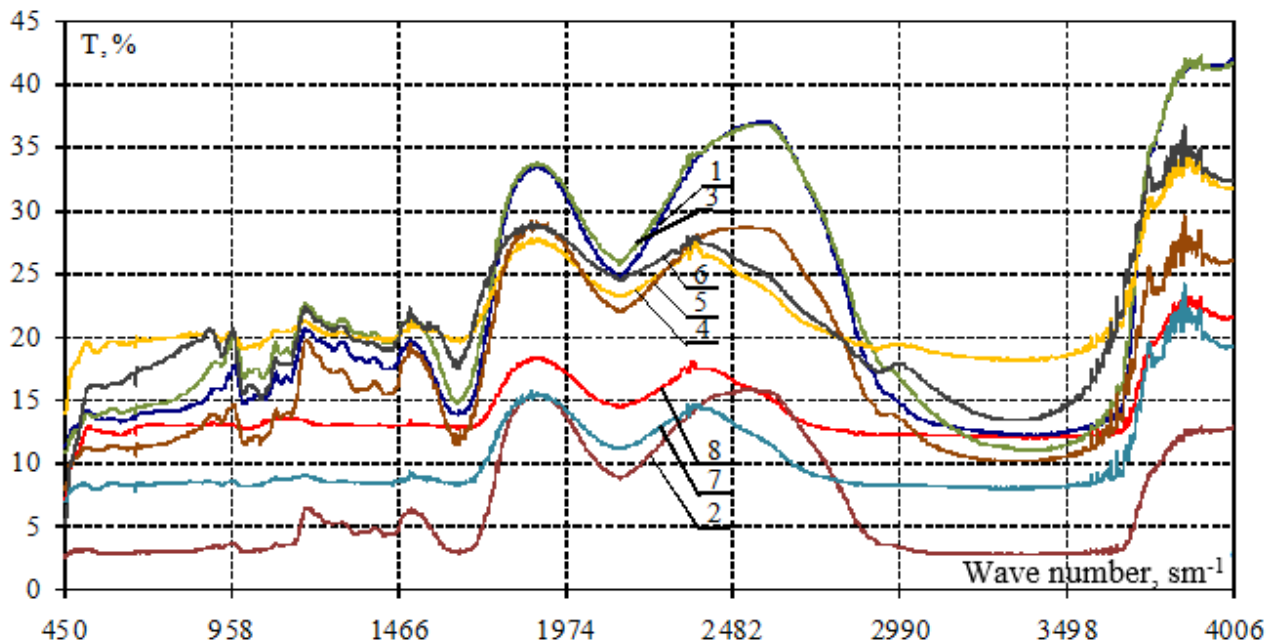


Fig. 2.16. IR spectra of samples of TF experimental systems:

- 1 – concentration of low-esterified citrus pectin 0,8%;
- 2 – ratio "pectin:starch"0,8:3,0%;
- 3 – ratio "pectin:calcium citrate"0,8:0,04%;
- 4 – ratio "pectin:skimmed milk powder"0,8:7,5%;
- 5 – ratio "pectin:starch:calcium citrate"0,8:3,0:0,04%;
- 6 – ratio "pectin:skimmed milk powder:calcium citrate" 0,8:7,5:0,04%;
- 7 – ratio "pectin:starch:skimmed milk powder" 0,8:3,0:7,5%;
- 8 – ratio «pectin:starch:skimmed milk powder:calcium citrate» 0,8:3,0:7,5:0,04%

From the above Fig. 2.16 shows that during the step-by-step introduction into the experimental system of thermostable filling with a concentration of low-esterified citrus pectin of 0.8% and recipe components (modified corn starch, sesame seed concentrate, skimmed milk powder and calcium citrate) identical strips of absorption

in the range of wave lengths $3600...3100\text{cm}^{-1}$, $2140...2100\text{cm}^{-1}$ and $1100...900\text{cm}^{-1}$ are observed, which characterizes the valence vibrations of the OH, C≡C and CH groups. OH - groups are involved in the construction of intermolecular hydrogen bonds, C≡C characterize the structure of alkenes and CH - alkanes. The absorption spectrum at $\nu = 3350... 2850 \text{ cm}^{-1}$ characterizes alkane compounds, and the bands in the range $2440... 2100$ characterize the organophosphorus P-H bonds that are available for the TF experimental systems (4–8) with the content of skimmed milk powder and calcium citrate which are the source of polyvalent metals, namely Ca^{2+} ions. They crosslink pectin molecules through the formation of calcium bridges.

Based on the above results, we trace the tendency for the absorption of the corresponding groups: OH, CH, PH, C≡C, CH and S=S, indicating the occurrence of molecular and intermolecular interactions between the prescription components. Thus, the influence of each formulation component on the experimental system is determined by detecting interactions with their sequential introduction.

Thus, during the researches the occurrence of physicochemical interactions between the prescription components of the experimental system of TF, which contribute to the formation of fillings with stable physicochemical parameters and high structural-mechanical and thermostable properties, was established.

2.10 Establishing a rational ratio of the recipe components of the research system of the thermostable filling and the principles of recipe development

The main recipe components of the protein-polysaccharide nature, which are part of TF composition (skimmed milk powder, sesame seed concentrate, low-esterified citrus pectin, starch and calcium citrate), play a significant role in the formation of its organoleptic characteristics and other properties (physical-chemical, structural, mechanical and technological). In the Table 2.7. the organoleptic characteristics of the TF experimental system with different ratios of prescription components are presented.

According to the above organoleptic characteristics of the TF experimental system, it was found that the softest, gel-like and dense consistency is characteristic of the system with the content of low-esterified citrus pectin 0.8%, modified corn starch 3.0% and skimmed milk powder 13.5%. The same is true for the skimmed milk powder content of 7.5% and the sesame seed concentrate of 6.0%. An TF experimental system with increasing the content of these prescription components acquires a strong, too dense consistency with a more saturated milky and sesame (herbaceous) taste.

It has been discovered that during the production of the filling, the raw material undergoes changes at the physicochemical level: there arise links between the animal (dairy component), plant and fat components, which leads to their rearrangement and formation of calcium bridges.

The production of thermostable filling using dairy raw materials and sesame seeds concentrate begins with the preparation of dry components to obtain a milk base (D_1) and a pectin-sugar mixture (D_2). The milk base is obtained by sequential mixing of the milk-starch mixture and the emulsion system.

Table 2.7

Organoleptic characteristics of the TF experimental system

Prescription components	Contents, %	Appearance, consistency	Color	Taste and smell
"pectin: skimmed milk powder"	0,8:1,5	Very weak gel, low density	From white with a grayish tint to light yellow	Pleasant, slightly dairy aroma. With a pure, sweet, slightly dairy (or milky) taste. No extraneous smacks (or with a slight sandiness)
	0,8:5,5			
	0,8:9,5	Very weak gel, slightly dense		
	0,8:13,5	Weak, dense gel		
	0,8:17,5			
"pectin:starch: skimmed milk powder"	0,8:1,0:1,5	From smear to gentle, in measure of low density	From pale white to light yellow	Pleasant, slightly dairy aroma. With a pure, sweet, viscous (gentle) slightly dairy (or milky) taste.No extraneous smacks (or with a slight sandiness)
	0,8:1,0:5,5			
	0,8:1,0:9,5			
	0,8:1,0:13,5			
	0,8:1,0:17,5			
	0,8:3,0:1,5	From smear, plastic, gentle to soft, gel-like, dense consistency		
	0,8:3,0:5,5			
	0,8:3,0:9,5			
	0,8:3,0:13,5			
0,8:3,0:17,5				
"pectin: sesame seeds concentrate: skimmed milk powder"	0,8:2,0:11,5	From gentle, flexible, soft, smooth to slightly dense consistency	From grayish to light yellow	Pleasant, slightly dairy aroma. With a pure, sweet, slightly dairy and slightly sesame (milky or herbaceous) taste
	0,8:6,0:7,5			
	0,8:10,0:3,5			
"pectin: sesame seeds concentrate: skimmed milk powder"	0,8:1,0:2,0:11,5	The consistency is elastic, in measure of dense, low strength	From grayish to light yellow	Pleasant, slightly dairy aroma. With pure, sweet, slightly dairy and in measure sesame (dairy or herbaceous) taste
	0,8:1,0:6,0:7,5			
	0,8:1,0:10,0:3,5	From soft, plastic, homogeneous consistency throughout the mass to dense		
	0,8:3,0:2,0:11,5			
	0,8:3,0:6,0:7,5	From plastic, soft, gentle, elastic, gel-like uniform throughout the mass to a dense consistency		
	0,8:3,0:10,0:3,5			
	1,1:1,0:2,0:11,5	Strong, slightly plastic, elastic, too dense consistency		
	1,1:1,0:6,0:7,5			
	1,1:1,0:10,0:3,5			

The milk-starch mixture is formed as a result of the interaction of recovered milk, which has been pre-heat-treated, that is, restored at temperatures of 30...35°C for (1...3)×60² s and pasteurized at 70...74 °C for 20...25 s, followed by the introduction of modified corn starch and concentrate of sesame seeds obtained by cold pressing, which causes the preservation of all nutrients.

While sustain skimmed milk powder, the particles are moistened and increased in volume. There arise a close interaction between the constituent parts, which causes their transition into solution: lactose - from the amorphous state to crystalline, the protein - into colloidal (particle size from 15 to 30 nm) and others, which are in the ion-molecular state (size about 1 nm and less).

Upon completion of the restoration, a complex polydisperse system is pasteurized and further cooled for the introduction of starch and sesame seed concentrate to neutralize extraneous microflora and inactivate the lipase enzyme. Starch swells. In the starch grain, due to the weakening and destruction of some hydrogen bonds during the heat treatment, creates a void where water enters. This leads to an increase in starch grain volume and the emergence of new hydrogen bonds [57; 248; 276; 293]. Sesame seed concentrate, which has a high protein content (about 45%) and low fat (about 8%), during the interaction with the solvent is characterized by swelling of protein molecules. Its particle size is from 50 to 150 microns, which is organoleptically not felt, thus indicating high moisture and fat-holding properties [4]. Formed in this way, hydrophilic centers, through interactions of different nature, are combined with other components of the system with the formation of a milk-starch mixture characterized by a complex polydispersed medium with a viscous consistency.

The emulsion system is formed as a result of the addition of refined deodorized sunflower oil at a temperature of 32...36 °C with emulsification for $(2...3) \times 60$ s into the milk-starch mixture.

It is known that the presence of fat in the composition of powdered milk worsens its swelling, the transition of protein into solution and the dispersion of fat [37], so to obtain reconstituted milk with the physico-chemical properties of natural, the oil is introduced after completion of swelling. During the emulsification of fatty milk components, there is a redistribution between the constituent particles, which are transformed into fatty protein complexes.

The main structural element of the protein is casein micelles, consisting of sub-micelles with a diameter of 10-15 nm, and they, in turn - from the subunits of the basic fractions of casein (α_1 , α_2 , β i γ), interconnected by hydrophobic, electrostatic, hydrogen bonds and calcium bridges [252; 260; 299 - 302]. The polypeptide chains of the casein fractions are folded in such a way in sub-micelles that its inner part form hydrophobic bonds, and in the outer part are hydrophilic ones, represented by the negatively charged acid groups.

Due to hydrophobic bonds around the fat molecule is distributed protein shell, which is connected by hydrophilic bonds with starch and aqueous medium, that is, due to the orientation of hydrophobic and hydrophilic sections of the protein, their ability to adsorb on the surface of phase distribution with the formation of a related medium is demonstrated. [250; 273; 300; 302]

Obtaining a pectin-sugar mixture (D2) consists of mixing sugar with pectin, adding water at a temperature of 40...45 °C, stirring for 1×60^2 s and further swelling within $(20...24) \times 60^2$ s. To prevent the formation of lumps, uniform and homogeneous distribution of pectin particles in the mixture, it is pre-mixed with

sugar and introduced into water. The pectin molecule has a spiral shape [236; 261; 263; 268; 279]. In the case of their convergence, voids arise, where form carboxylic and hydroxyl groups, which cause to form hydrogen bonds as a result of the interaction with the sugar oxy groups [242; 249; 268; 273; 279; 281; 285; 293].

The next step is subsystem C - mixing and heat treatment, characterized by the connection of the milk base (D_1) and the pectin-sugar mixture (D_2). By interacting with water, pectin molecules dissociate with the formation of COO^- ions, causing the molecules to acquire a negative charge and there is a repulsive force between them, which is suppressed by the addition of divalent metal ions (Ca^{2+}), i.e. by the addition of a milk base [242; 250; 253; 261; 287]. Due to heat treatment, starch grains absorb a large amount of water, increase in volume and form a starch paste, which is intertwined with the pectin chain to form a three-dimensional spatial grid. The formation of the gel occurs in several stages: with a small content of calcium ions, the pectin molecules approach and orient due to joining the carboxylic groups of two adjacent pectin molecules by calcium ions [242; 250; 268; 273; 279; 285; 294; 296].

Subsystem B - casting and structure formation. At this stage, the structural and mechanical properties of the product are formed due to the introduction of calcium citrate for $(48 \dots 72) \times 60^2$ s. Increasing the concentration of calcium ions in the system promotes the formation of complexes with calcium. Intermolecular interactions and the formation of calcium bridges occur, which crosslink pectin molecules, interact with their carboxyl groups, and form a spatial network that binds all the constituent components of the TF system together [94; 148; 242; 250; 256; 273; 281; 292; 293; 302].

The last stage is subsystem A - obtaining thermostable filling with the use of dairy raw material and sesame seeds concentrate - characterized by obtaining a structured product with certain physical, chemical and structural-mechanical properties. Its shelf life under normal storage conditions ($0 \dots 4^\circ\text{C}$) is 15 days. In order to prolong the shelf life up to 6 months, rapid freezing at $-18 \pm 2^\circ\text{C}$ was used, which facilitates the formation of a large number of crystallization centers [25; 94; 148; 281]. Thus, small crystals of ice arise, which preserve the textural, physicochemical and biochemical properties of the filling at the molecular level.

Chapter 3 Development of technology of thermostable fillings with using dairy raw materials and sesame seeds concentrate and study of its quality indicators under traditional storage conditions and frozen

3.1 Development of recipe and technology of thermostable filling using dairy raw material and sesame seeds concentrate

In previous studies, it was found that the main recipe components that give thermostable and structural-mechanical properties of TF are hydrocolloids - modified corn starch and low-esterified citrus pectin. These hydrocolloids, together with calcium ions (contained in dairy raw materials and calcium citrate), which "crosslink" pectin molecules to form calcium bridges, are constituent units of a strong spatial grid of filling. It was also found that the addition of sesame seeds concentrate to the filling, has a positive effect on a number of physico-chemical parameters of the product. Thus, the results of the research of analytical, organoleptic, structural-mechanical, a number of physicochemical and technological properties of the experimental system of thermostable filling became the reason for further scientific substantiation of the formulation (Tables 3.1 and 3.2) and technology of production of thermostable filling (Fig. 3.1).

In order to clearly demonstrate the positive effect of sesame seeds concentrate on the quality characteristics of the filling, the results of the experimental studies are further presented in the section with a comparison of the results obtained from studies of the control sample of thermostable filling made without adding the sesame seed concentrate according to the recipe in Table 3.1, and a sample of thermostable filling using dairy raw materials and sesame seeds concentrate (recipe is provided in Table 3.2).

Table 3.1

Consolidated recipe of thermostable filling per 100 kg

№	Raw materials	Mass fraction of solids, %	Calculation rate per 100 kg filling, kg	
			In reality	In solids
1.	White sugar	99,85	35,99	35,94
2.	Skimmed milk powder	96,00	14,19	13,63
3.	Starch treacle	78,00	5,07	3,65
4.	Modified corn starch	88,00	3,04	2,68
5.	Refined deodorized sunflower oil	99,90	2,53	2,53
6.	Low-esterified citrus pectin	90,00	0,81	0,73
7.	Calcium citrate	97,00	0,04	0,04
8.	Drinking water	–	41,4	–
Total		-	105,30	59,20
Product yield		56,22	100,00	56,22

Table 3.2

Consolidated recipe of thermostable filling using dairy raw material and sesame seeds concentrate per 100 kg

№	Raw materials	Mass fraction of solids, %	Calculation rate per 100 kg filling, kg	
			In reality	In solids
1.	White sugar	99,85	36,00	35,99
2.	Skimmed milk powder	96,00	7,90	7,59
3.	Sesame seed concentrate	92,00	6,30	5,80
4.	Starch treacle	78,00	5,00	3,60
5.	Modified corn starch	88,00	3,00	2,64
6.	Low-esterified citrus pectin	90,00	0,80	0,72
7.	Refined deodorized sunflower oil	99,90	2,10	2,10
8.	Calcium citrate	97,00	0,04	0,04
9.	Drinking water	–	44,30	–
Total		–	105,30	58,48
Product yield		55,54	100,00	55,54

The technological system of the TF production consists of four logically and functionally interconnected subsystems. In the first stage - preparation of prescription components (subsystem D) is mixed low-esterified pectin citrus with $\frac{1}{8}$ a part of sugar and $\frac{1}{3}$ a part of drinking water at a temperature of 40...45 °C, carefully mixed and stayed for swelling at $(20...24) \times 60^2$ s. The skimmed milk powder is mixed with drinking water at temperatures of 30...35 °C and sustained for $(1...3) \times 60^2$ s. The reconstituted milk is pasteurized at 70...74 °C for 15...20 s, cooled to 32...36 °C, added modified corn starch and remaining sugar. For receiving thermostable filling of milk-plant composition with these components is entered a pre-prepared sesame seed concentrate. Further mix is mixed for $(10...15) \times 60$ s. After that is added the refined deodorized sunflower oil and emulsify at a rotating speed of $25 \pm 1 \text{ s}^{-1}$ at 32...36 °C for $(2...3) \times 60$ s.

The second stage is mixing and heat treatment (subsystem C). The prepared pectin mixture is boiled at temperatures in the range of 55...85 °C to a solids content of $25 \pm 1.5\%$, the obtained combined base is added and continue to boil to a mass fraction of solids $46 \pm 1.5\%$, then added the starch treacle and boil to the contents solids $56.5 \pm 1.5\%$. At $(2...3) \times 60$ s before the end of the boiling process, a pre-prepared 1% solution of calcium citrate is introduced. A solution of calcium citrate is prepared with the addition of citric acid.

The third stage is spilling and structure formation (subsystem B). The resulting system is stirred and poured into a container for structure formation that occurs within $60 \pm 12 \times 60^2$ s. The resulting product is then packed.

The fourth stage is to obtain thermostable filling with the use of dairy raw materials and sesame seeds concentrate (subsystem A). Ready TF, regardless of the presence in its composition of sesame seeds concentrate, has the following organoleptic characteristics: appearance and consistency - homogeneous, gentle, in

measure of dense; filling color - from white to light yellow; smell - inherent in prescription components; the taste is sweet, inherent in the recipe components used. Storage and realization of TF is carried out in three directions. The first direction is the direct realization of the TF within 36 hours after packing at a temperature of 12 ± 2 °C and a relative humidity of $75\pm 2\%$. The second direction involves the storage of TF for 15 days at a temperature of 0 ... 4 °C and a relative humidity of $75\pm 2\%$. Third direction - freezing - storage of TF at temperatures -18 ± 2 °C for no more than 4 months with a relative humidity of $94\pm 2\%$. Thus, the connection sequence of the subsystems has a defined purpose and function (Table 3.3).

Table 3.3

Structure of technological system of TF production

Name of subsystem (stage)	Name of the subsystem and operations	Characteristics functioning of subsystems (stage)
D «Preparation of prescription components»	D ₁ «Obtaining a combined basis»: <ul style="list-style-type: none"> – mixing; – restoration and mixing; – pasteurization; – cooling; – mixing; – emulsification 	Quantity and quality control. Ensuring dissolution and swelling.
	D ₂ «Obtaining a pectin-sugar mixture»: <ul style="list-style-type: none"> – siftings; – compound; – mixing; – swelling; – filtering 	
C «Mixing and heat treatment»	Heat treatment (boiling)	Compound of prescription components, formation of structural-mechanical and physicochemical properties
	Filtering	
B «Spilling and structure formation»	Spill into molds	Providing the form, structure and necessary qualitative characteristics of TF
	Structure formation	
	Packing	
A «Obtain thermostable filling with the use of dairy raw materials and sesame seeds concentrate»	A ₁ «Realization»: <ul style="list-style-type: none"> – realization 	Obtaining TF with specified organoleptic, physicochemical, structural-mechanical and microbiological characteristics (with the possibility of storage in the frozen state)
	A ₂ «Short-term storage»: <ul style="list-style-type: none"> – storage 	
	A ₃ «Long-term storage»: <ul style="list-style-type: none"> – freezing; – storage 	

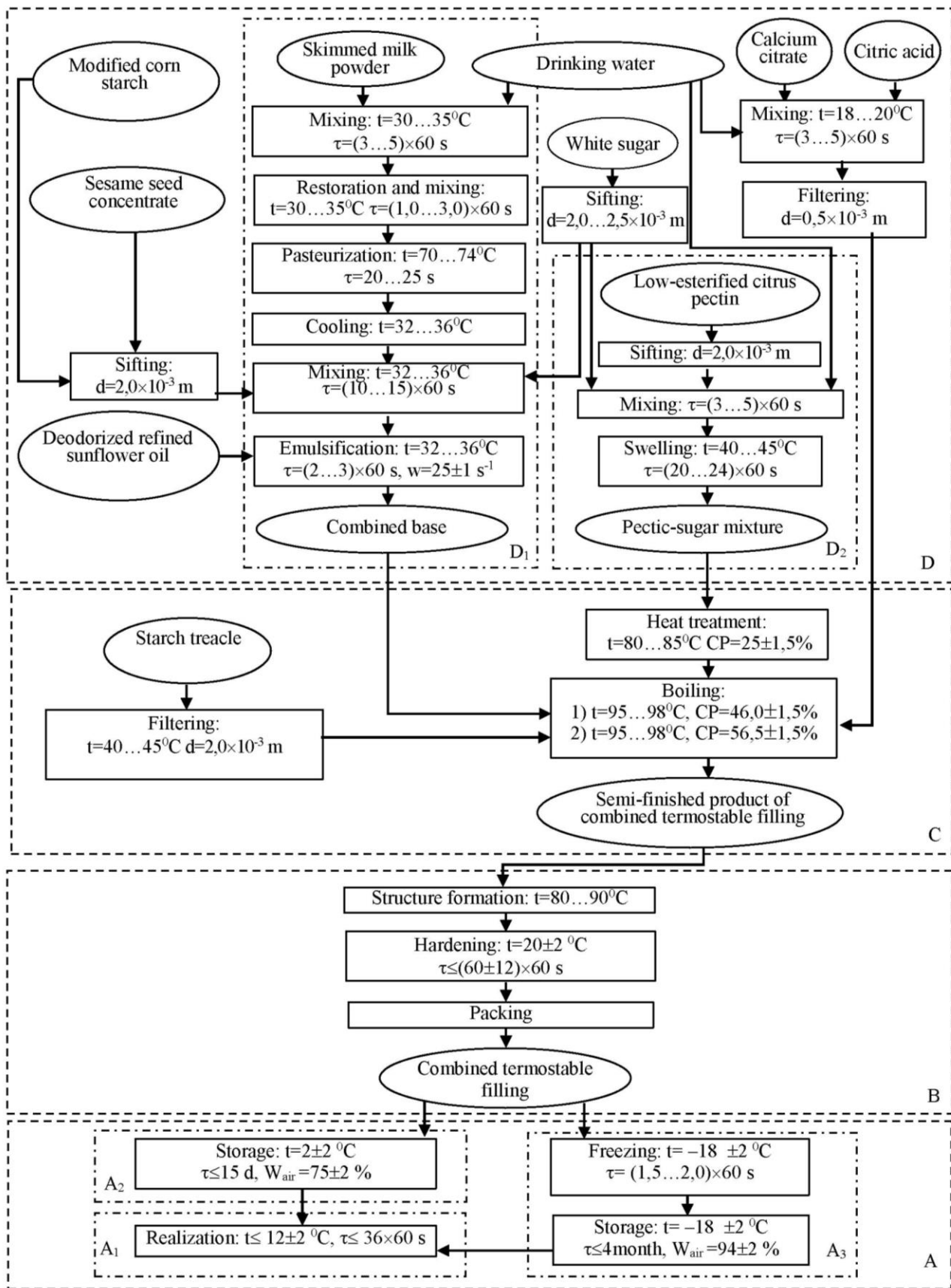


Fig. 3.1. Technological scheme of thermostable frozen filling using dairy raw materials and sesame seeds concentrate

3.2 Study of microbiological indicators of thermostable filling using dairy raw material and sesame seeds concentrate and justification of its storage life under traditional conditions and frozen

Microbiological indicators are important fundamental indicators of the quality of thermostable fillings, which determine their suitability for consumption. Given that the developed TF contains about 45% moisture, it is a receptive medium for the development of microorganisms. Due to the attraction to the TF formulation the components of protein-polysaccharide nature with high hydrophilic properties and moisture retention, some moisture becomes bound. However, there is a risk of introducing harmful microflora: molds and yeast, so there is a need to study the microbiological parameters of TF (Table 3.4).

Table 3.4

Microbiological indicators of TF

Indicator	TF control sample					Developed TF sample with sesame seed concentrate				
	Freshly made	Storage temperature, °C				Freshly made	Storage temperature, °C			
		2±2	-18±2		2±2		-18±2			
	after 15 days	after 28 days	after 4 months	after 6 months	after 15 days	after 28 days	after 4 months	after 6 months		
Quantity of Mesophilic Aerobic and Facultative Anaerobic Microorganisms (QMAFAM), number of conventional units (NCU) in 1 g not more $1,0 \times 10^3$	$0,5 \times 10^3$	$0,7 \times 10^3$	$1,0 \times 10^3$	$0,9 \times 10^3$	$1,0 \times 10^3$	$0,5 \times 10^3$	$0,75 \times 10^3$	$1,0 \times 10^3$	$0,85 \times 10^3$	$1,0 \times 10^3$
E. coli bacteria, in 0.001 g is not allowed	Not detected					Not detected				
Conditionally pathogenic microorganisms, including Staphylococcus aureus, in 0.1 g is not allowed NCU	Not detected					Not detected				
Pathogenic microorganisms, including Salmonella, in 25 g is not allowed	Not detected					Not detected				
Amount of yeast and mold, in 1 g not more 50 NCU	Not detected					Not detected				

It can be seen from Table 3.4 shows that the microbiological parameters of the samples of TF - freshly made and the samples stored at 2 ± 2 °C for 15 days - do not exceed the norms [106]. The final norm of QMAFAM $1,0 \times 10^3$ NCU in 1 g reaches the samples after 28 days of storage at the same temperature and after 6 months of storage at a temperature of -18 ± 2 °C. Therefore, it is advisable to use low

temperatures to prevent unwanted changes and preserve the quality characteristics of development.

Thus, according to the results of TF microbiological studies, the recommended shelf life at 2 ± 2 °C is 15 days, and at temperatures of -18 ± 2 °C - 4 months. Taking into account this results, it is advisable to submit the results of further experimental studies under the established rational storage conditions, under which the proposed thermostable fillings meets the microbiological norms of the current medical and biological requirements and sanitary quality standards. [106].

3.3 Study of the chemical composition of thermostable filling using dairy raw material and sesame seeds concentrate during storage under traditional conditions and frozen

The thermostable filling is a complex system consisting of a certain number of components of a particular nutritional and biological value. During the development of the TF formulation composition it was guided by the promising direction of creating a combined product of high biological value with specified thermostable, structural, mechanical and physico-chemical characteristics. This was achieved by the joint use of hydrocolloids of different nature and the introduction into the TF formulation of protein plant product - sesame seed concentrate [123; 159]. That is why, in order to understand the biological and nutritional value of TF, it is necessary to present a series of studies on the chemical composition of scientific development. General characteristics of the TF chemical composition are given in Table 3.5.

Table 3.5

Characterization of the TF chemical composition

Name of component	Contents, %					
	TF control sample			Developed TF sample with sesame seed concentrate		
	Freshly made	Storage temperature, °C		Freshly made	Storage temperature, °C	
		2 ± 2 after 15 days	-18 ± 2 after 4 months		2 ± 2 after 15 days	-18 ± 2 after 4 months
Proteins	5,00±0,25	5,00±0,25	5,08±0,25	5,10±0,26	5,10±0,26	5,16±0,26
Fats	2,53±0,13	2,55±0,13	2,62±0,13	2,48±0,10	2,50±0,10	2,58±0,10
Carbohydrates	45,63±2,30	45,63±2,30	45,63±2,30	41,35±2,10	41,35±2,10	41,35±2,10
Dietary fiber	0,95±0,03	0,95±0,03	0,95±0,03	0,95±0,03	0,95±0,03	0,95±0,03
Moisture	42,30±2,00	41,40±2,00	40,00±2,00	45,30±2,20	44,30±2,20	42,00±2,10

From the data Table 3.5 shows that the nutrients of both freshly made samples of TF remain at almost the same level after storage under traditional conditions for 15 days (slightly reduced moisture). The total amount of proteins, fats and carbohydrates at a storage temperature of 2 ± 2 °C of the TF control sample is 5.00, 2.55 and 45.63%, respectively, and the developed TF sample with the addition of sesame seeds concentrate, respectively 5.10, 2.50 and 41.35%. It was found that the total number of

dietary fiber under different regimes and the duration of storage of these samples remains unchanged - 0.95%.

Experimental studies have shown that a number of physico-chemical and biochemical processes undergo the filling of changes during storage. In particular, during freezing due to moisture crystallization, it is possible to damage protein and polysaccharide molecules by large ice crystals, accompanied by moisture loss. This is confirmed by the results of the moisture change (Table 3.5): according to the results of the chemical composition evaluation of the developed samples at a storage temperature of -18 ± 2 °C, the total amount of proteins and fats increases, and moisture - decreases relative to the samples stored at a temperature of 2 ± 2 °C 15 days. Therefore, due to the loss of moisture by the control and developed samples of TF with a plant protein supplement (respectively 3.4 and 5.2%) after their defrosting, the amount of protein substances is concentrated, which is accompanied by an increase of proteins by 1.6 and 1.2%, respectively. The total fat content in these samples increases respectively by 2.7 and 3.2%. It is likely that the increase in fat content after defrosting is due to oxidation and hydrolysis processes [31; 129; 131; 147]. Thus, freezing contributes to a slight loss of moisture with a parallel increase (concentration) of nutrients.

Since a certain amount of protein in the developed filling is caused by the use of plant protein-containing raw material - sesame seed concentrate, it is necessary to provide a comparative characteristic of the amino acid content of the sesame seeds and directly in its concentrate (Table 3.6).

Table 3.6

Comparative characteristics of the amino acid composition of the raw material

The name of the component	Contents, %	
	Sesame seeds	Sesame seed concentrate
Water	9,00	8,00
Protein	19,40	45,00
Essential amino acids		
Valine	1,20±0,06	2,78±0,1
Isoleucine	0,90±0,05	2,09±0,10
Leucine	1,60±0,08	3,71±0,20
Lysine	0,67±0,03	1,55±0,08
Methionine	0,70±0,04	1,62±0,08
Threonine	0,87±0,04	2,02±0,10
Tryptophan	0,47±0,02	1,09±0,05
Phenylalanine	1,10±0,06	2,55±0,20
Total	7,51±0,38	17,41±0,81
Non essential amino acids		
Alanine	1,10±0,06	2,55±0,10
Aspartic acid	1,90±0,1	4,41±0,22
Histidine	0,60±0,03	1,39±0,07
Glycine	1,20±0,06	2,78±0,10
Glutamic acid	4,70±0,24	10,90±0,5
Proline	0,97±0,05	2,25±0,10

The name of the component	Contents, %	
	Sesame seeds	Sesame seed concentrate
Serine	1,10±0,06	2,55±0,10
Tyrosine	0,87±0,04	2,02±0,10
Cysteine	0,44±0,02	1,02±0,05
Total	12,88±0,7	29,87±1,34

It was found (Table 3.6) that the total content of essential and non essential amino acids for sesame seeds is 7.51 and 12.88% respectively, and for sesame seeds concentrate - 17.41 and 29.87%. That is, a tendency to increase the content of amino acids by 131.82 and 131.91% respectively, relative to the content of sesame seeds.

For a more complete presentation of the biological value of seeds and sesame seeds concentrate, their amino acid score is presented. (Table 3.7). The most significant indicators of the biological value of the protein were established by the calculation method: by calculating the amino acid score, net protein utilization (NPU), protein quality index (I_{pq}) and biological value (BV).

Table 3.7

Characterization of biological value of sesame proteins

Name of amino acids	Scale of FAO/WHO, mg/g	Sesame seeds		Sesame seed concentrate	
		Content, mg/g	Score,%	Content, mg/g	Score,%
Isoleucine	40	46,39	115,98	46,44	116,11
Leucine	70	82,47	117,82	82,44	117,78
Lysine	55	34,54	62,79	34,44	62,63
Methionine	35	36,08	103,09	36,00	102,86
Phenylalanine	60	56,70	94,50	56,67	94,44
Threonine	40	44,85	112,11	44,89	112,22
Tryptophan	10	24,23	242,27	24,72	242,22
Valine	50	61,86	123,71	61,78	123,56
NPU	–	0,97		0,97	
BV,%	–	67,89		67,86	
I_{pq}	–	0,37		0,37	

From the given data in Table 3.7. it was found that the protein of seeds and sesame concentrate is not complete, because there are amino acids in which the value is less than 100%; such amino acids are methionine and phenylalanine. However, the net protein utilization and protein quality index for both samples are 0.97 and 0.37. The biological value for sesame seeds is 67.89% and for sesame seeds concentrate is 67.86%.

Solving the perspective task of creating a product of high biological value, it is advisable to present the characteristics of the amino acid composition of the proposed TF samples under the established TF storage conditions in three possible directions (Table 3.8).

Table 3.8

Characterization of the amino acid composition of TF

The name of the component	Contents, %					
	TF control sample			Developed TF sample with sesame seed concentrate		
	Freshly made	Storage temperature, °C		Freshly made	Storage temperature, °C	
		2±2	-18±2		2±2	-18±2
	after 15 days	after 4 months		after 15 days	after 4 months	
Protein	5,00±0,25	5,00±0,25	5,08±0,25	5,10±0,26	5,10±0,26	5,16±0,26
Essential amino acids						
Valine	0,29±0,01	0,29±0,01	0,27±0,01	0,31±0,02	0,31±0,02	0,30±0,02
Histidine	0,12±0,006	0,12±0,006	0,14±0,007	0,14±0,007	0,14±0,007	0,15±0,007
Isoleucine	0,26±0,01	0,26±0,01	0,25±0,01	0,26±0,08	0,26±0,08	0,24±0,07
Leucine	0,43±0,02	0,43±0,02	0,45±0,02	0,44±0,01	0,44±0,01	0,47±0,01
Lysine	0,34±0,01	0,34±0,01	0,29±0,01	0,28±0,01	0,28±0,01	0,23±0,01
Methionine	0,11±0,006	0,11±0,006	0,09±0,005	0,15±0,008	0,15±0,008	0,14±0,007
Threonine	0,19±0,009	0,19±0,009	0,24±0,01	0,22±0,01	0,22±0,01	0,26±0,01
Tryptophan	0,06±0,003	0,06±0,003	0,08±0,004	0,09±0,005	0,09±0,005	0,1±0,005
Phenylalanine	0,23±0,01	0,22±0,01	0,20±0,01	0,26±0,01	0,26±0,01	0,24±0,01
Total	2,02±0,08	2,02±0,08	2,01±0,09	2,15±0,16	2,15±0,16	2,13±0,15
Non essential amino acids						
Alanine	0,15±0,008	0,15±0,008	0,18±0,009	0,22±0,01	0,22±0,01	0,24±0,01
Asparagine	0,32±0,02	0,34±0,02	0,37±0,02	0,43±0,02	0,43±0,02	0,45±0,02
Glycine	0,09±0,005	0,09±0,005	0,12±0,006	0,20±0,01	0,20±0,01	0,22±0,01
Glutamic acid	0,95±0,05	0,9±0,05	1,04±0,05	1,09±0,05	1,09±0,05	1,15±0,06
Proline	0,42±0,02	0,42±0,02	0,45±0,02	0,35±0,02	0,35±0,02	0,40±0,02
Serine	0,26±0,01	0,24±0,01	0,26±0,01	0,27±0,02	0,27±0,02	0,31±0,02
Tyrosine	0,22±0,01	0,22±0,01	0,25±0,01	0,23±0,01	0,23±0,01	0,26±0,01
Cysteine	0,039±0,001	0,038±0,001	0,02±0,001	0,08±0,004	0,08±0,004	0,07±0,004
Total	2,40±0,12	2,39±0,12	2,69±0,13	2,87±0,14	2,87±0,14	3,10±0,15

It can be seen from Table 3.8 that the amino acid composition of the corresponding freshly made samples of TF and those samples that were stored for 15 days at 2±2 °C, has close values. However, these samples have differences in amino acid composition when stored at 2±2 °C for 15 days and -18±2 °C for 4 months. It should also be noted higher content of valine, histidine, leucine, threonine, phenylalanine, alanine, asparagine, glutamine and cystine in TF with sesame seed concentrate than in control TF.

Of course, the biological value of a protein depends not only on the number of essential amino acids, but also on their ratio to the reference protein: the greater their difference, the lower the balance and biological value [88; 137; 156]. The biological value is given for samples of TF, which were stored under the specified storage conditions in Table 3.9.

Table 3.9

Characterization of biological value of TF proteins

Name of amino acids	Scale of FAO/W HO, mg/g	TF control sample				Developed TF sample with sesame seed concentrate			
		Storage temperature, °C				Storage temperature, °C			
		2±2		-18±2		2±2		-18±2	
		after 15 days		after 4 months		after 15 days		after 4 months	
		Content mg/g	Score,%	Content mg/g	Score,%	Content mg/g	Score,%	Content mg/g	Score,%
1	2	3	4	5	6	7	8	9	10
Isoleucine	40	52,00	130,00	49,21	123,03	50,98	127,45	46,51	116,28
Leucine	70	86,00	122,86	88,58	126,55	86,27	123,25	91,09	130,12
Lysine	55	68,00	123,64	57,09	103,79	54,90	99,82	44,57	81,04
Methionine+cysteine	35	22,00	62,86	17,72	50,62	29,41	84,03	27,13	77,52
Phenylalanine+ tyrosine	60	88,00	146,67	88,58	147,64	96,08	160,13	96,90	161,50
Threonine	40	38,00	95,00	47,24	118,11	43,14	107,84	50,39	125,97
Tryptophan	10	12,00	120,00	15,75	157,48	17,65	176,47	19,38	193,80
Valine	50	58,00	116,00	53,15	106,30	60,78	121,57	58,14	116,28
NPU	–	0,56		0,46		0,82		0,76	
BV,%	–	62,86		61,33		65,50		64,69	
I _{pq}	–	0,39		0,39		0,36		0,36	

According to the Table 3.9 it is established that all the proposed samples of TF have the lowest value of amino acid score in the ratio of methionine + cystine amino acids. Net protein utilization, biological value and protein quality index of TF control samples, stored under traditional conditions and frozen are 0.56, 62.86%, 0.39 and 0.46, 61.33%, 0, 39, respectively. The same indicators under the same storage conditions of TF samples with sesame seed concentrate are as follows: 0.82, 65.50%, 0.36 and 0.76, 64.69%, 0.36.

The following studies are devoted to the determination of fatty acid composition of scientific development (Table 3.10).

Table 3.10

Comparative characteristics of fatty acid composition of raw materials

Name of fatty acid	Content,% per 100 g	
	Sesame seeds	Sesame seed concentrate
Saturated		
Myristic acid C _{14:0}	0,12±0,004	0,001±0,00003
Palmitic acid C _{16:0}	4,44±0,22	0,36±0,02
Stearic acid C _{18:0}	2,09±0,10	0,17±0,009
Total, %	6,65±0,32	0,53±0,03
Unsaturated		
Palmitoleic acid C _{16:1}	0,15±0,008	0,01±0,0003
Oleic acid C _{18:1}	18,50±0,93	1,48±0,07
Linoleic acid C _{18:2}	21,37±1,1	1,70±0,09
Linolenic acid C _{18:3}	0,38±0,02	0,03±0,002
Total, %	40,40 ±2,06	3,22±0,17

According to the Table 3.10 there is a decrease in the total amount of fatty acids in the sesame seed concentrate: the total amount of saturated and unsaturated fatty acids for sesame seeds is 6.65 and 40.40% respectively, and the sesame seed concentrate is 0.53 and 3.22%.

In view of the destructive processes, the results of the study of the TF fatty acid composition were determined under the established storage conditions of the filling in three possible directions (Table 3.11). Studies of the fatty acids content of the TF proposed samples indicate a predominantly increased their content in the samples of the fillings with a sesame seeds concentrate. Such an increase is likely due to the chemical composition of the plant protein supplement and the partial replacement of non-fat dairy raw materials with concentrate.

Table 3.11

Characteristics of fatty acid composition of TF

Name of fatty acid	Content, % per 100 g					
	TF control sample			Developed TF sample with sesame seed concentrate		
	Freshly made	Storage temperature, °C		Freshly made	Storage temperature, °C	
		2±2 after 15 days	-18±2 after 4 months		2±2 after 15 days	-18±2 after 4 months
Saturated						
Myristic acid C _{14:0}	0,0088±0,0004	0,009±0,0005	0,012±0,0006	0,009±0,0004	0,01±0,0005	0,015±0,0008
Palmitic acid C _{16:0}	0,02±0,001	0,02±0,001	0,03±0,001	0,22±0,01	0,25±0,01	0,30±0,02
Stearic acid C _{18:0}	0,01±0,0005	0,03±0,0001	0,1±0,005	0,10±0,005	0,12±0,006	0,22±0,01
Total, %	0,039±0,002	0,059±0,001	0,14±0,007	0,33±0,015	0,38±0,017	0,54±0,031
Unsaturated						
Palmitoleic acid C _{16:1}	0,004±0,0002	0,003±0,0001	0,001±0,00005	0,01±0,0005	0,007±0,0003	0,003±0,0001
Oleic acid C _{18:1}	0,02±0,001	0,02±0,001	0,015±0,0007	2,58±0,13	2,55±0,13	2,48±0,12
Linoleic acid C _{18:2}	0,003±0,0001	0,003±0,0001	0,002±0,0001	1,62±0,08	1,60±0,08	1,60±0,08
Linolenic acid C _{18:3}	0,1±0,005	0,1±0,005	0,05±0,002	0,03±0,002	0,02±0,001	0,02±0,001
Total, %	0,127±0,006	0,126±0,068	0,068±0,003	4,24±0,20	4,18±0,20	4,10±0,20

Table 3.12

Characteristics of the vitamin composition of TF

Name of vitamin	Content, mg/100 g	
	TF control sample	Developed TF sample with sesame seed concentrate
1	2	3
Water-soluble		
PP (nicotinic acid))	0,93±0,05	1,02±0,05
B ₁ (thiamine)	0,04 ±0,002	0,18 ±0,009
B ₂ (riboflavin)	0,22±0,01	0,17±0,009
B ₅ (pantothenic acid)	0,06 ±0,002	0,03±0,001
B ₆ (pyridoxine)	0,052±0,002	0,003±0,0001
B ₉ (folic acid)	(0,62±0,03)·10 ⁻³	(0,34±0,02)·10 ⁻³
B ₁₂ (cyanocobalamin)	(0,05±0,002)·10 ⁻³	(0,03±0,002)·10 ⁻³
C (ascorbic acid)	0,48±0,024	0,27±0,01

Name of vitamin	Content, mg/100 g	
	TF control sample	Developed TF sample with sesame seed concentrate
1	2	3
H (biotin)	$(0,40 \pm 0,02) \cdot 10^{-3}$	$(0,22 \pm 0,01) \cdot 10^{-3}$
Total	1,78±0,09	1,67±0,08
Fat-soluble		
D (calciferol)	$(0,0062 \pm 0,0003) \cdot 10^{-3}$	$(0,034 \pm 0,002) \cdot 10^{-3}$
E (tocopherol)	0,98±0,05	0,84±0,04
K (phyloquinone)	–	$(0,57 \pm 0,03) \cdot 10^{-3}$
Total	0,98±0,05	0,84±0,04

The results of determining the vitamin composition (Table 3.12) indicate that the use of sesame seeds concentrate in the technology of TF promotes the appearance of vitamin K, increase the content of vitamin D, but the total amount of fat-soluble vitamins is reduced and for the control sample is 0.98 mg / 100 g, and for sample with concentrate - 0,84 mg / 100 g. The content of water-soluble vitamins in TF with sesame seed concentrate is less than the control sample, and is respectively 1,67 and 1,78 mg / 100 g.

No less valuable for human health are minerals. They significantly affect the structural characteristics of the products, which is caused by their interaction with the polysaccharide molecules [138]. In order to identify and find out their quantity, the characteristics of the mineral composition of the scientific development are given (Table 3.13).

Table 3.13

Characteristics of the mineral composition of TF

The name of the element	Content, mg/100 g	
	TF control sample	Developed TF sample with sesame seed concentrate
1	2	3
Macroelements		
Calcium	150,90±7,54	263,45±13,20
Magnesium	19,58±0,98	86,25±2,50
Sodium	59,24±2,96	68,60±2,00
Potassium	145,98±7,29	207,96±10,40
Phosphorus	110,08±5,50	199,86±10,00
Chloride	12,81±0,64	12,81±0,40
Total	498,59±25,21	838,88±38,50
Microelements		
Iron	0,28±0,01	2,27±0,1
Zinc	0,05±0,002	0,05±0,002
Iodine	$(1,05 \pm 0,06) \cdot 10^{-3}$	$(0,1 \pm 0,003) \cdot 10^{-3}$
Copper	$(1,4 \pm 0,07) \cdot 10^{-3}$	$(1,4 \pm 0,07) \cdot 10^{-3}$
Manganese	$(0,7 \pm 0,02) \cdot 10^{-3}$	$(0,7 \pm 0,02) \cdot 10^{-3}$
Selenium	0,23±0,01	0,23±0,01
Fluorine	$(2,33 \pm 0,12) \cdot 10^{-3}$	$(2 \pm 0,08) \cdot 10^{-3}$
Total	0,56±0,02	2,55±0,11

Table 3.13 shows that the content of minerals in the TF sample with the addition of sesame seeds concentrate relative to the control sample is increased about twice, in particular, a significant increase in the content of calcium, magnesium, potassium, phosphorus and iron.

Drawing general conclusions about the chemical composition of TF, we can note the positive effect of sesame seed concentrate on the biological value of the developed products, vitamin and mineral composition.

3.4 Study of physicochemical properties of thermostable filling using dairy raw material and sesame seeds concentrate during storage under traditional conditions and frozen

3.4.1 Study of chemical changes

Chemical and biochemical processes play a major role in TF technology: they affect product readiness and shelf life. During storage, the filling undergoes a series of transformations that occur under the influence of oxidation processes. The product changes its acidity, which directly affects its organoleptic properties. In view of this, studies to determine the pH (active acidity) of TF are relevant (Fig. 3.2).

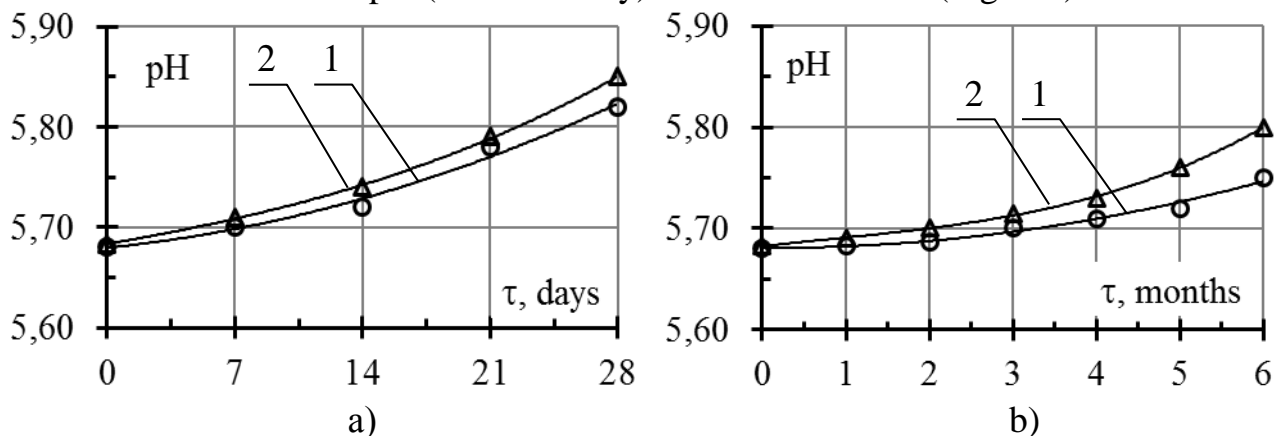


Fig. 3.2. Dependence of the TF active acidity on the storage duration at temperature: a) 2 ± 2 °C; b) -18 ± 2 °C; 1 - TF control sample; 2 - developed TF sample with sesame seed concentrate

In Fig. 3.2 shows that under different storage conditions there is an increase in the active acidity in the test samples of TF, and the presence of a sesame seed concentrate in the recipe composition of TF promotes an increase in the active acidity of the product. This is probably due to the tendency of the plant protein supplement itself to oxidize due to the presence of approximately 10% fat in the concentrate.

As shown in Fig. 3.2 (a), in TF samples, stored at 2 ± 2 °C, a steady increase in active acidity was observed during the first 14 days. Then the rate increased rapidly enough, which may indicate food unsuitability of a product. In Fig. 3.2 (b) it is seen that the active acidity of the TF control samples and the samples of the filling with sesame seed concentrate increased steadily during the first 4 months of low temperature storage. After 4 months, the active acidity of both fillings changed more intensively.

Considering the results of the active acidity study of the proposed TF samples under different storage conditions, the following rational storage periods can be recommended: at 2 ± 2 °C for 14 days and at -18 ± 2 °C for 4 months. It is worth noting that the recommended shelf life, taking into account changes in active acidity, does not contradict previous studies.

3.4.2 Study of changes in moisture connection forms

3.4.2.1 Study of moisture-holding ability

An important criterion for the quality of TF is the ability of the prescription components to retain moisture throughout the shelf life. This property helps to reduce technological costs and allows to obtain a filling with a gel-like gentle and plastic consistency [237; 257; 262; 272; 273; 284]. Therefore, there was a need to investigate the moisture-holding ability of TF. In Fig. 3.3. shows changes in the MHA index of TF under different storage conditions.

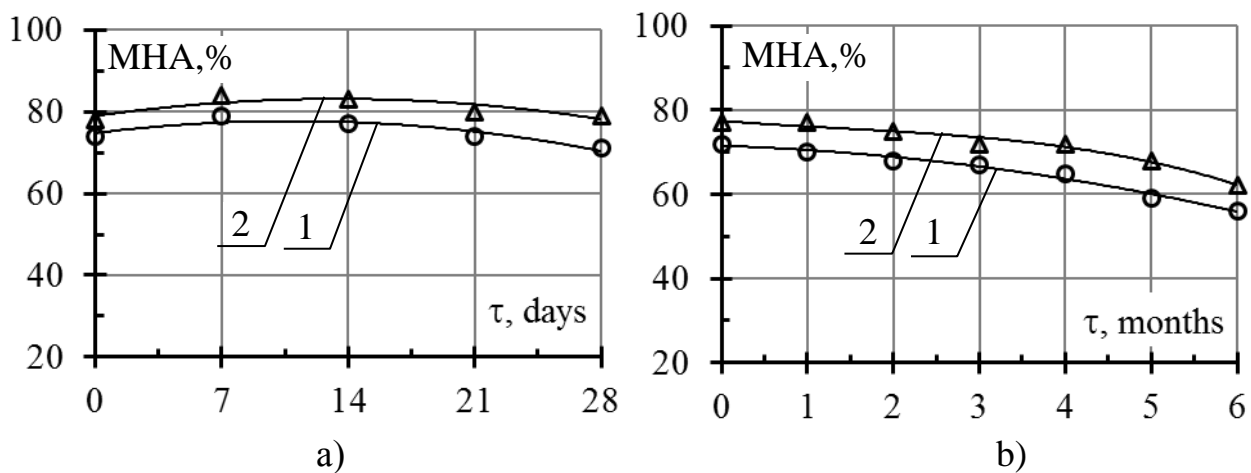


Fig. 3.3. Dependence of moisture-holding ability of TF on the storage duration at temperature: a) 2 ± 2 °C; b) -18 ± 2 °C; 1 - TF control sample; 2 - developed TF sample with sesame seed concentrate

In Fig. 3.3 it is shown that sesame seed concentrate as a prescription ingredient of TF promotes higher MHA of the development. The trends of MHA change in both samples are similar. It is probable that the increase of MHA in the presence of sesame seed concentrate in the system is due to the additional ability to hydration of plant proteins and polysaccharides, which was established by previous studies of the functional and technological properties of plant protein additives. A decrease of MHA indicates a decrease in the strength of the intermolecular interactions of the formulation components and the release of moisture, which is more relevant after defrosting of the samples when the product structure is "traumatized" by ice crystals [16; 31; 67; 135; 222].

3.4.2.2 Determination of changes in product humidity relative to the time of high temperature action

The different nature and chemical composition of the formulation ingredients of TF affect on the content and ratio of free and bound moisture. As it is found that MHA of TF decreases during storage, it becomes necessary to determine how much moisture is associated with the ingredients of filling. It is known that the weaker the bound moisture, the more intense the spoilage process in the product occur. Free moisture is easily removed by drying. It should also be noted that as the temperature rises, the water molecules move randomly, resulting in a break in hydrogen bond [267].

Moisture content was determined by thermogravimetric method with the help of scales-hydrometers at a constant temperature of 160 °C (Fig. 3.4 ra 3.5).

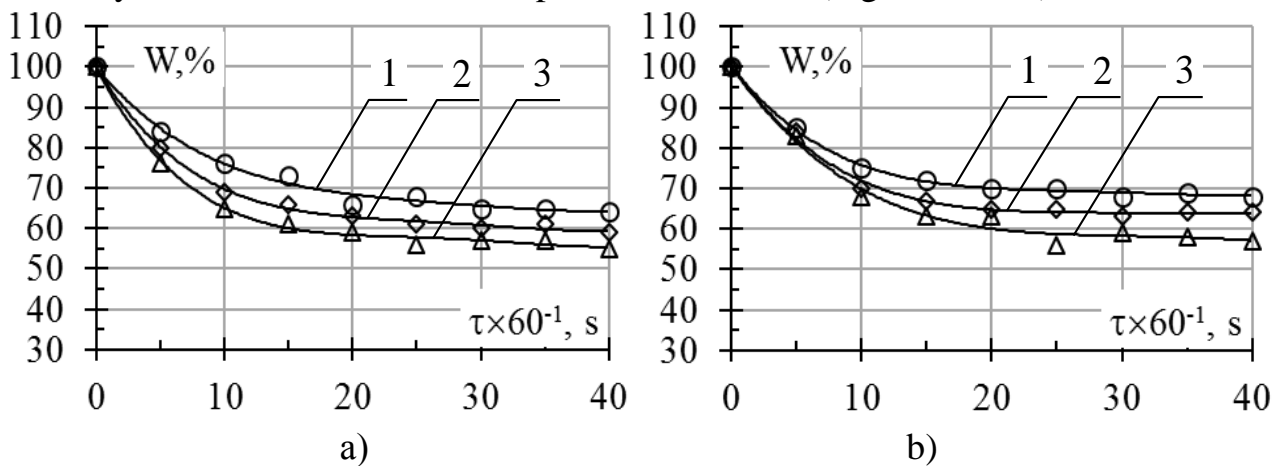


Fig. 3.4. Humidity dependence of a) TF control sample and b) developed TF sample with sesame seed concentrate at storage temperature 2 ± 2 °C on duration of high-temperature processing: 1 - freshly made sample; 2 - sample after 14 days of storage; 3 - sample after 28 days of storage

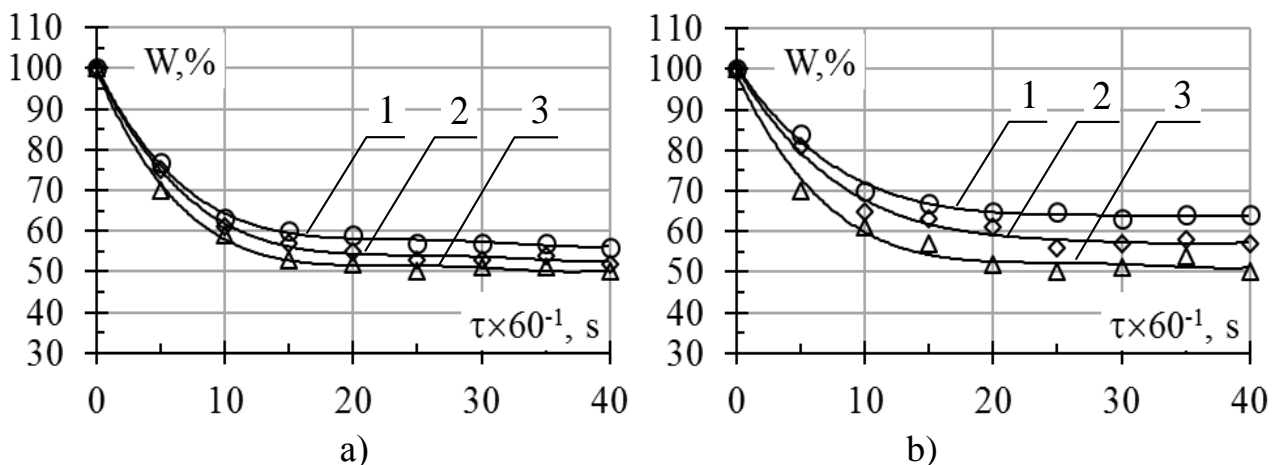


Fig. 3.5. Humidity dependence of a) TF control sample and b) developed TF sample with sesame seed concentrate at storage temperature -18 ± 2 °C on duration of high-temperature processing: 1 - freshly made sample; 2 - sample after 3 months of storage; 3 - sample after 6 months of storage

For TF is characteristic that its control samples are faster reaching constant humidity than those with sesame seeds concentrate, that is, they are dried more quickly. This tendency is true for TF samples which stored under traditional conditions and for the filling samples that have been frozen (Figs. 3.4 and 3.5). Thus, it has been found that plant protein supplement promotes moisture retention. With regard to freezing, it has a negative effect on the TF structure: TF samples after defrosting are dried faster than similar samples stored under traditional conditions.

It was also found that for TF, which stored under two different conditions, storage adversely affected the ability to hold moisture. With regard to changes in the humidity of TF, depending on the time of high temperature action, the following can be stated. First, it was found that the presence of sesame seeds concentrate slows the removal of free moisture. Secondly, it can be seen that the longer the product is stored under traditional conditions and at low temperatures, the more free moisture it has. And freezing leads to destruction of the structure [16; 31; 67; 135; 222]. Studies conducted to study the changes in humidity of TF depending on the time of high temperature action confirm the data obtained from the study of MHA.

3.4.2.3 Determination of moisture condition

A characteristic feature of free moisture is not only its ability to act as a solvent, but also its inherent high mobility, which can be determined by spin echo method - nuclear magnetic resonance [27; 30; 149; 173; 222; 245]. During the study, particular attention was paid to the chemical composition of TF samples, since the chemical composition affects the rate of energy redistribution in the spin-spin system and is characterized by spin-spin interaction and molecular mobility of water. It should be noted that the spin-spin relaxation time (T_2) depends on the mobility of the protons that make up the water molecule; the length T_2 increases with the mobility of protons.

Also, the temperature modes of storage have a great influence on the change in the moisture state. Thus, control TF and TF with sesame seed concentrate were stored under two temperature conditions studied: under traditional conditions (2 ± 2 °C) for 28 days and in a frozen state (-18 ± 2 °C) for 6 months. Figure 3.6 (b) shows the effect of freezing on the change in spin-spin relaxation which characterizing the molecular mobility of moisture, thereby indicating the free moisture in the TF samples with different content of dairy and plant components during low-temperature storage.

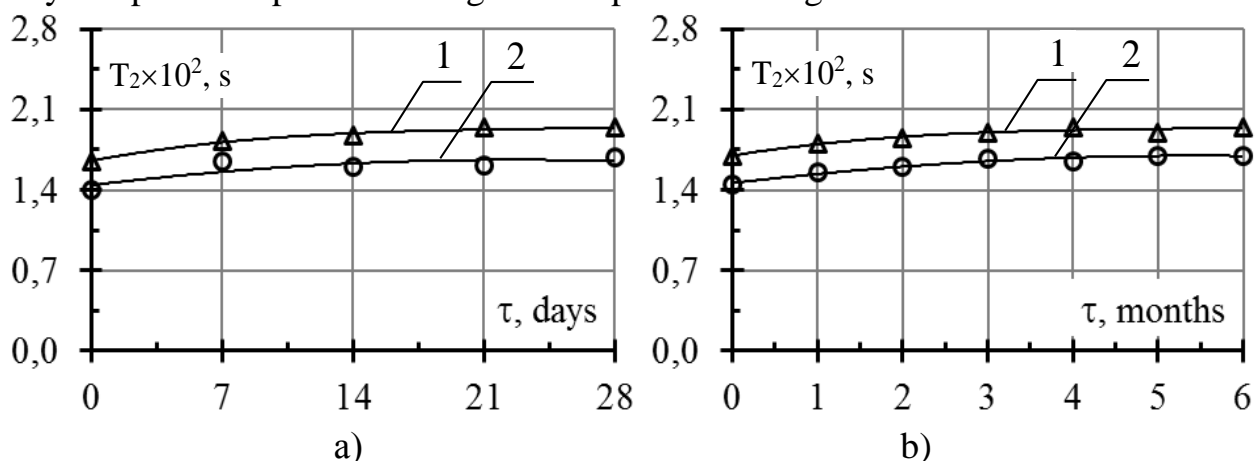


Fig. 3.6. Dependence of spin-spin relaxation time (T_2) of TF on the duration of storage at temperature a) 2 ± 2 °C and b) -18 ± 2 °C: 1 - TF control sample; 2 - developed TF sample with sesame seed concentrate

The results of the studies presented in Fig. 4.6, indicate that at storage temperatures of 2 ± 2 °C and -18 ± 2 °C of the TF samples, the spin-spin relaxation time (T_2) increases in the TF control relative to TF with the sesame seed concentrate. Thus, for a freshly made TF control sample (Fig. 3.6 a) and after 28 days of storage at a temperature of 2 ± 2 °C T_2 changes from 0.0171 to 0.0194 s, and for the developed TF sample with concentrate - from 0.0147 to 0.0170 s.

Freezing does not significantly affect the change in relaxation time. In the study of spin-spin relaxation of the dipoles of water of TF, it is found that the time of spin-spin relaxation of TF increases during storage, which indicates the loosening of the structure and the release of free moisture. Freezing does not significantly affect the time of spin-spin relaxation. The lowest values of T_2 are inherent in TF with sesame seed concentrate. This confirms the growth of MHA in the filling with sesame seeds concentrate, as noted above.

3.4.2.4 Study of kinetic regimes of endothermic processes

Previous research has shown that by using in the TF formulation of sesame seed concentrate, low-esterified citrus pectin and modified corn starch, bound moisture prevails. Bound moisture, unlike free moisture, is characterized by difficulty in removal, since it requires a high temperature, accompanied by absorption (endothermic conversion) or allocation of heat (exothermic conversion). Thus, physico-chemical changes in the TF occur, in particular changes of mass during the action of temperature.

The kinetic parameters of endothermic processes in TF were investigated using differential thermal analysis (DTA) on a derivatograph. The essence of the method is the assumption that at given the constant rate of heating, the value of the mass change degree or heat absorption by the system in the region of fixed onset and maximum process development is proportional to the conversion rate constant for each temperature value. Moisture bonding patterns were determined by analyzing the curves of change in mass (TG), differential thermogravimetry (DTG and DTA) and temperature (T) [152] (Figs. 3.7 and 3.8).

In Fig. 3.7 and 3.8 show different dynamics of moisture loss with increasing temperature influence on TF, which indicates about different forms of moisture connexion in it. Thus, according to the experimental DTG curves indicating the amount of moisture loss (TG) under a given temperature influence (T), three peaks of the endothermic process of mass removal of moisture from the TF were recorded. The maximums (peaks) of moisture mass loss at temperature in the TF, which determine the origin of the bond and characterize the moisture bond form are given in Table. 3.14.

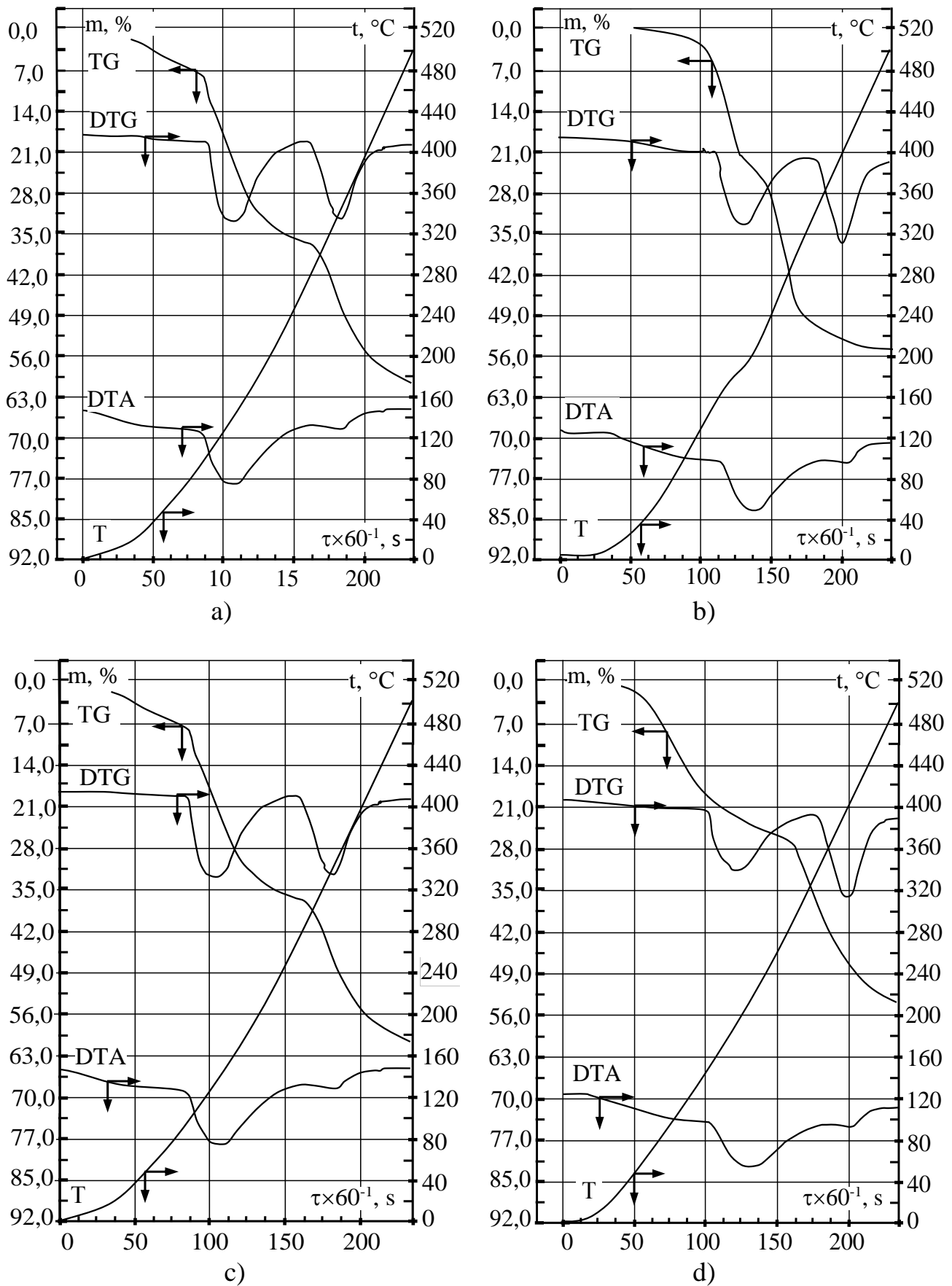


Fig. 3.7. Studying of endothermic processes kinetic parameters of TF control sample: a) freshly made; b) after 15 days of storage at 2 ± 2 °C; c) freshly made defrozen; d) after 4 months of storage at a temperature of -18 ± 2 °C

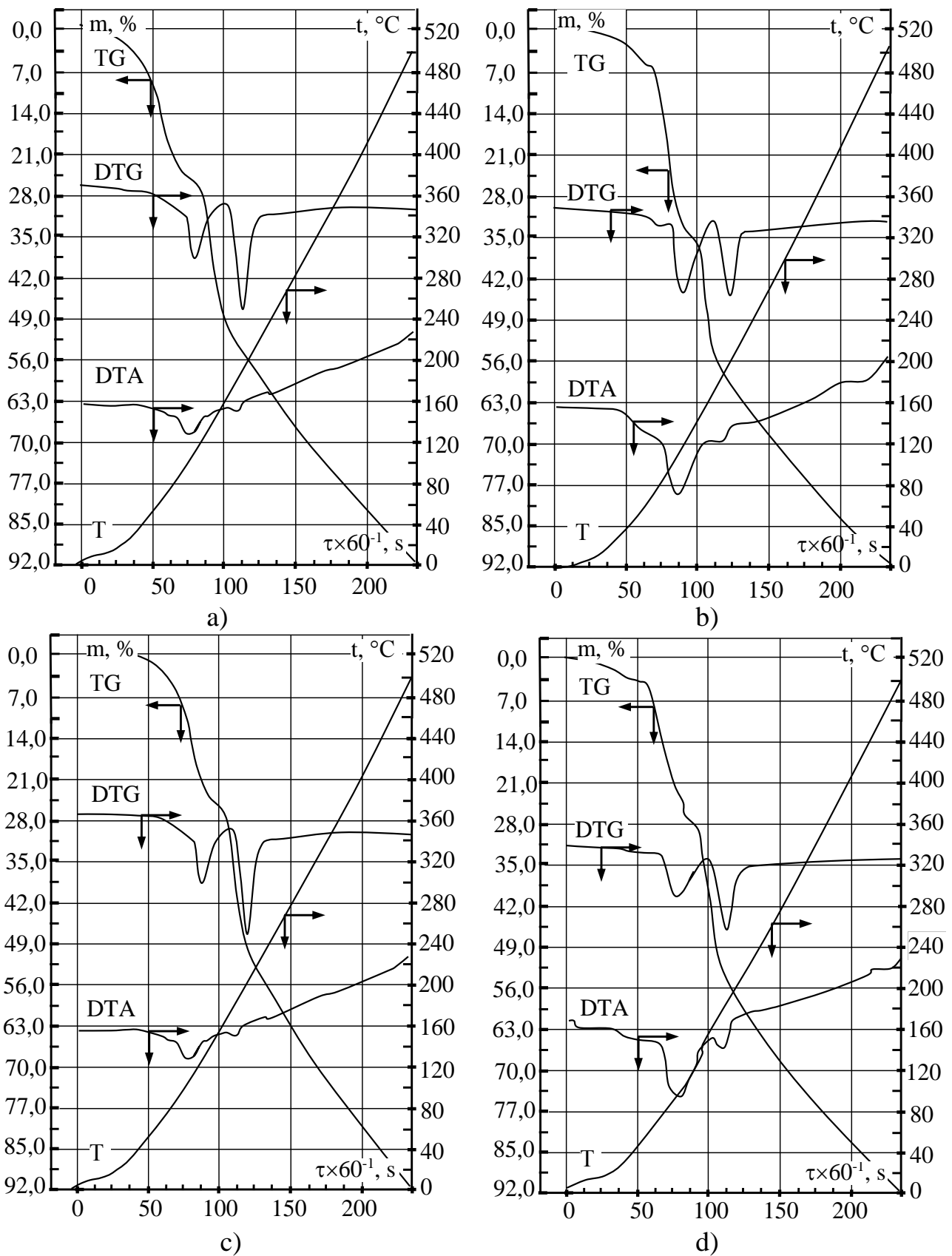


Fig. 3.8. Studying of endothermic processes kinetic parameters of TF with sesame seed concentrate: a) freshly made; b) after 15 days of storage at 2 ± 2 °C; c) freshly made defrozen; d) after 4 months storage at -18 ± 2 °C

Table 3.14

Characterization of maxima of TF mass loss

TF sample		Temperature maximum, °C	The amount of moisture released			
			Free		Bound	
			%	mg	%	mg
1	2	3	4	5	6	7
TF control	Freshly made	I stage				
		100±2	6,0±0,5	30,0±0,5	–	–
		II stage				
		120±2	–	–	16,0±0,5	80,0±0,5
		173±2	–	–	30,0±0,5	150,0±0,5
		206±2	–	–	41,0±0,5	205,0±0,5
		III stage				
		235±2	–	–	53,0±0,5	265,0±0,5
		Freshly made (defrozen)	I stage			
	100±2		6,5±0,5	32,5±0,5	–	–
	II stage					
	120±2		–	–	23,0±0,5	115,0±0,5
	173±2		–	–	33,0±0,5	165,0±0,5
	195±2		–	–	42,0±0,5	210,0±0,5
	III stage					
	234±2		–	–	55,0±0,5	275,0±0,5
	After 15 days of storage at 2±2 °C		I stage			
		89±2	6,0±0,5	30,0±0,5	–	–
		II stage				
		115±2	–	–	25,0±0,5	100,0±0,5
		167±2	–	–	35,0±0,5	175,0±0,5
		198±2	–	–	45,0±0,5	225,0±0,5
		III stage				
		225±2	–	–	56,0±0,5	280,0±0,5
After 4 months storage at –18±2 °C		I stage				
	86±2	8,0±0,5	40,0±0,5	–	–	
	II stage					
	110±2	–	–	25,0±0,5	100,0±0,5	
	164±2	–	–	40,0±0,5	200,0±0,5	
	195±2	–	–	47,0±0,5	235,0±0,5	

Continuation of Table 3.14

1	2	3	4	5	6	7	
Developed TF sample with sesame seed concentrate		III stage					
		223±2	–	–	58,0±0,5	290,0±0,5	
		I stage					
	Freshly made	105±2	–	–	8,0±0,5	40,0±0,5	
		II stage					
		177±2	–	–	24,0±0,5	120,0±0,5	
		205±2	–	–	35,0±0,5	175,0±0,5	
		III stage					
		245±2	–	–	48,0±0,5	240,0±0,5	
	Freshly made (defrozen)	I stage					
		103±2	–	–	10,0±0,5	50,0±0,5	
		II stage					
		170±2	–	–	24,0±0,5	120,0±0,5	
		200±2	–	–	36,0±0,5	180,0±0,5	
		III stage					
	After 15 days of storage at 2±2 °C	243±2	–	–	50,0±0,5	250,0±0,5	
		I stage					
		98±2	3,0±0,5	15,0±0,5	–	–	
		II stage					
		120±2	–	–	12,0±0,5	60,0±0,5	
		175±2	–	–	24,0±0,5	120,0±0,5	
203±2		–	–	36,0±0,5	180,0±0,5		
III stage							
240±2	–	–	48,0±0,5	240,0±0,5			
After 4 months storage at -18±2 °C	I stage						
	98±2	7,0±0,5	35,0±0,5	–	–		
	II stage						
	115±2	–	–	19,0±0,5	95,0±0,5		
	170±2	–	–	32,0±0,5	160,0±0,5		
	200±2	–	–	44,0±0,5	220,0±0,5		
	III stage						
240±2	–	–	55,0±0,5	275,0±0,5			

The first stage, which causes the beginning of moisture removal from the TF control for a freshly made sample and freshly made immediately after defrosting, occurs at a temperature of 100±2 °C, as after 15 days and as 4 months of storage. During the second stage of endo-effects in these TF samples removes the moisture inherent in the bound moisture, as are the maximums of the same samples in the third stage, which causes the final destruction of the structure due to significant moisture loss. Thus, it was found that the highest loss of moisture was experienced by the TF samples after storage under both regimes, which is probably due to the ability of the starch to retain moisture, but retrogradation (aging) occurs. In this case, the moisture during storage is bound by pectin and other prescription components with hydrophilic properties (the action of starch is weakened). This causes a decrease of temperature

influence for the destruction of certain chemical bonds between the TF prescription components during storage.

Summarizing the results of experimental studies to study the kinetic parameters of endothermic TF processes, the following conclusion can be drawn. Sesame seed concentrate contributes to the resistance of TF to high temperatures and reduces moisture mass loss. For both TF which stored under freezing, the peaks indicate a greater susceptibility to the removal of bound moisture in such samples. Moisture mass losses are more significant for TF samples (control) which were stored at low temperature.

3.4.2.5 Determination the amount of frozen moisture

An important role during the TF storage is played the mass fraction of moisture in the filling, which characterizes the consistency, determines the physical, chemical and structural-mechanical properties throughout the shelf life [99; 131; 142; 178].

Moisture bonding forms, including the amount of free and bound moisture, were investigated using a low-temperature calorimetric method. Its essence is to record the heat released during the phase transition of water to ice [27; 175; 178; 239; 256]. As is known, only free moisture is involved in the phase transition. It is in the free state of intercellular space and easily freezes, unlike bound moisture. With its freezing, the concentration of salts in the intercellular solution increases, which causes the cryoscopic temperature to shift to a lower one. The freezing of moisture occurs gradually, until a continuous solid mass is reached, called eutectic [39; 163; 178; 266]. The change in the amount of free moisture in TH during storage under traditional conditions is shown in Fig. 3.9. It is not advisable to carry out such studies for filling which has already been exposed to low temperatures (freezing and storage at -18 ± 2 °C).

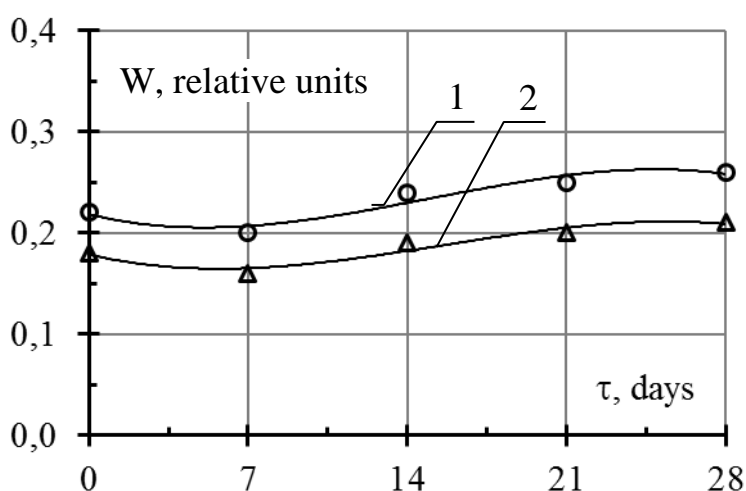


Fig. 3.9. Dependence of the content of frozen (free) moisture TF on storage time: 1 - TF control sample; 2 - developed TF sample with sesame seeds concentrate

In Fig. 3.9 shows that the amount of frozen (free) moisture in the TF during the whole storage period increases. Such an increase of the free moisture content in the TF indicates damage to the structure and the weakening of interactions between the recipe components that are activated over time. It is revealed that during storage in

TF with a plant additive less frozen moisture is released. Thus, it was found that the amount of frozen moisture depends on the formulation composition of TF: the presence in their recipe composition of the concentrate has a positive effect on the occurrence of intermolecular interactions between the ingredients, which is due to a decrease in frozen moisture.

Summarizing the above, the results of the study of the physicochemical properties of the proposed thermostable filling using dairy raw material and sesame seeds concentrate can be presented in two directions. The first area concerns the plant protein supplement and proves the feasibility of its use in TF technology. Thus, sesame seeds concentrate contributes to: increase of MHA, moisture retention, reduction of weight loss and amount of free moisture. The second direction - freezing - is manifested in a slight decrease of MHA and the destruction of the structure, a greater susceptibility to the removal of moisture.

3.5 Study of rheological properties of thermostable filling using dairy raw material and sesame seeds concentrate during storage under traditional conditions and frozen

3.5.1 Determination of strength

One of the important indicators that determines the changes in the properties of TF throughout the shelf life is the strength indicator. In particular, the influence of low temperature on the texture properties of the product leads to certain negative changes: as a result of the destructive action of ice crystals, the structure of TF after defrosting is disturbed and loosened, and moisture is lost. With the help of the Valent device, the strength of the proposed TF samples was determined (Fig. 3.10).

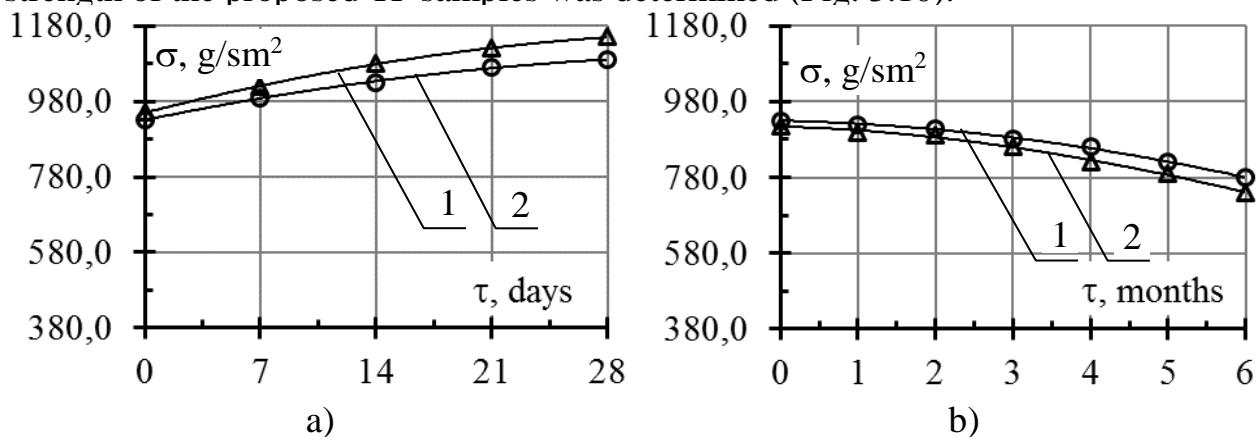


Fig. 3.10. Dependence of TF strength on the duration of storage at a temperature: a) 2 ± 2 °C; b) -18 ± 2 °C; 1 - TF control sample; 2 - developed TF sample with sesame seeds concentrate

The results of the strength study show that TF samples with the addition of sesame seed concentrate at storage temperatures of 2 ± 2 and -18 ± 2 °C have slightly lower values of strength than similar samples without concentrate. Also in the course of data analysis Fig. 3.11 it was proved the strength of the test samples with a shelf life of 28 days at 2 ± 2 °C was increased, and in the case of storage at -18 ± 2 °C for 6 months, the indicators decreased. In case of TF samples storage at -18 ± 2 °C for 6

months, there is a slight decrease in the strength indicator, mainly during the first 4 months: for the control and developed TF this indicator after 4 months is 862.5 and 855 g/cm², respectively, and after 6 months - 800 and 792.5 g/cm². The established change in the strength of TF indicates that the presence in the TF composition of sesame seeds concentrate helps to reduce the strength of the filling and gives a more plastic consistency; this is confirmed by subsequent studies.

3.5.2 Determination of the shear stress

The studies were performed on a penetrometer, which allows to measure the amount of the product deformation during the stress on it. According to the obtained values, the limiting shear stress of TF under different storage regimes was determined by the calculation method (Fig. 3.11).

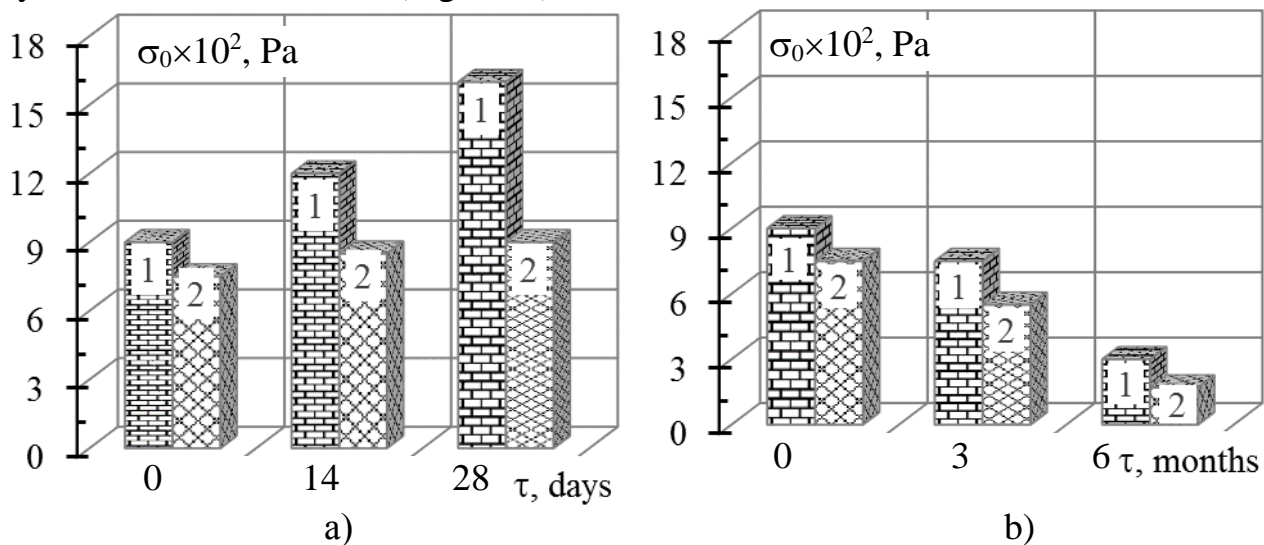


Рис. 3.11. Dependence of the maximum shear stress of TF on the duration of storage at temperatures: a) 2±2 °C; b) -18±2 °C; 1 - TF control sample; 2 - developed TF sample with sesame seeds concentrate

In Fig. 3.11 shows a decrease in the shear stress of the TF samples with the addition of a sesame seed concentrate, i.e. a decrease in their resistance. From the results of determining the shear stress, it can be stated that at low storage temperatures, the TF samples lose their resistance to deformation action; this indicates the destruction of the structure. TF with sesame seed concentrate has less resistance, which contributes to the formation of a softer structure. The trend identified is probably related to the structure, absorption and retention properties of moisture, the presence of a large number of hydrophilic and hydrophobic groups in the case of the combined use of dairy and plant components.

3.5.3 Study of structural and mechanical properties

Much of the rheological parameters of the proposed filling can be determined during mechanical loading. During loading, the TF samples are deformed and subjected to a certain stress, which is the integral beginning of the forces of internal interaction of the recipe components with each other. According to A.P. Rebinder's classification, dispersed, colloidal and high molecular systems are divided into liquid

and solid. In view of this, TF has the properties of a solid body. As you know, such bodies are characterized by certain indicators: elasticity, plasticity, strength and other characteristic properties, which are determined by the relative deformation of the product during the stress for a certain time. These changes in the structural and mechanical parameters of the TF during storage under different conditions are shown in Tables 3.15 and 3.16 and in the form of creep deformation curves of the prototypes (Figs. 3.12 and 3.13).

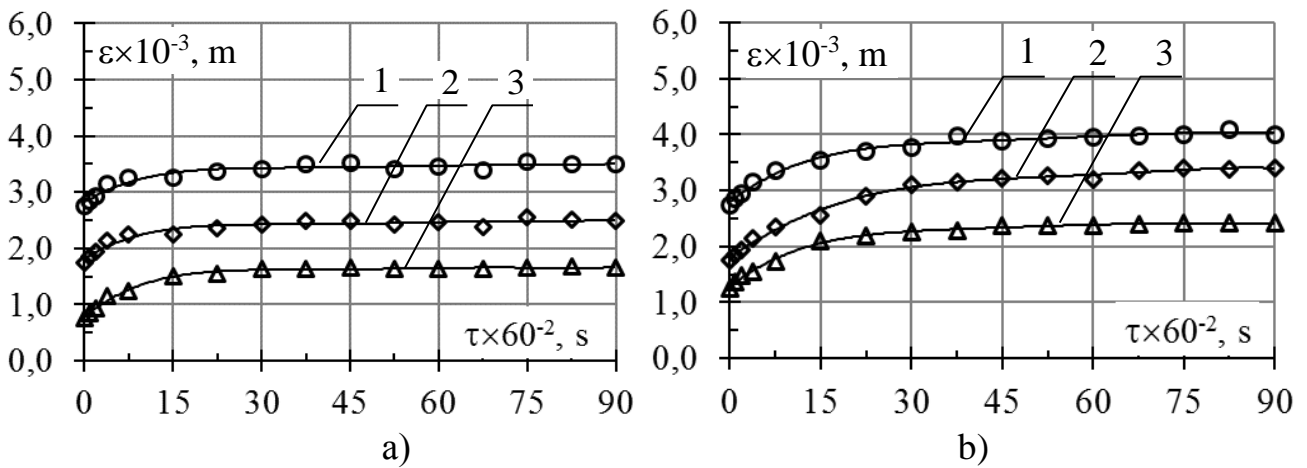


Fig. 3.12. Dependence of relative compression deformation of a) TF control sample and b) developed TF sample with sesame seed concentrate at storage temperature 2 ± 2 °C on the time of stress: 1 – freshly made sample; 2 – sample after 14 days of storage; 3 – sample after 28 days of storage

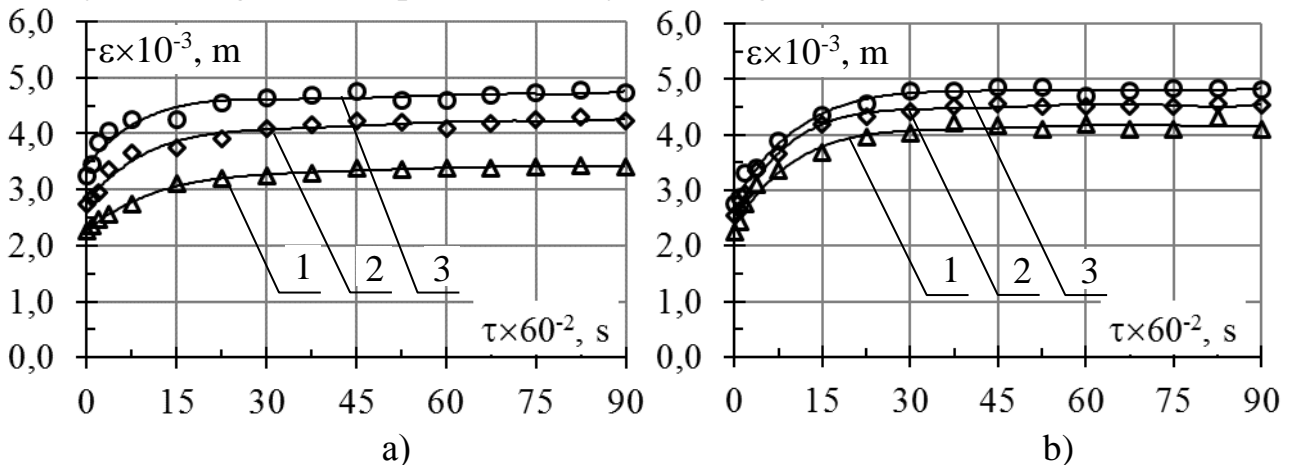


Fig. 3.13. Dependence of relative compression deformation of a) TF control sample and b) developed TF sample with sesame seed concentrate at storage temperature -18 ± 2 °C on the time of stress: 1 – freshly made sample; 2 – sample after 3 months of storage; 3 – sample after 6 months of storage

Table 3.15

Structural-mechanical characteristics of TF at storage temperature 2±2 °C

Name of indicator	TF control sample			Developed TF sample with sesame seed concentrate		
	Duration of storage at temperature 2±2 °C, days					
	0	14	28	0	14	28
Reverse deformation (γ_{rd}), $m \times 10^3$	3,37	2,24	1,66	3,84	3,20	2,32
Irreversible deformation (γ_{ird}), $m \times 10^3$	0,04	0,18	0,11	0,18	0,18	0,18
Total deformation (γ_{td}), $m \times 10^3$	3,40	2,42	1,77	4,02	3,38	2,50
Shear stress (τ), Pa	1498,86	1498,86	1498,86	1498,86	1498,86	1498,86
Pliability (I), $Pa^{-1} \times 10^6$	2,27	1,61	1,18	2,68	2,25	1,67
Conditionally instantaneous modulus of flexibility (G_f), $Pa \times 10^{-5}$	5,93	9,86	15,36	5,26	7,04	11,42
High elastic module (G_{el}), $Pa \times 10^{-5}$	17,84	20,93	21,91	15,17	14,03	14,92
Plastic viscosity (η^*_{o}), $(Pa \times s) \times 10^{-9}$	225,00	45,00	74,90	45,00	45,00	45,00
The ratio of deformation inverse to total (K)	0,99	0,93	0,94	0,96	0,95	0,93
Viscosity of elastic aftereffect (η_{el}), $(Pa \times s) \times 10^{-7}$	62,45	97,75	102,19	86,47	62,45	72,53
Relative flexibility (Fl), %	74,27	62,91	55,20	70,92	63,03	52,56
Relative plasticity (Pl), %	1,06	7,45	6,11	4,48	5,33	7,21
Relative elasticity (El), %	24,68	29,64	38,69	24,60	31,54	40,22
Relaxation period (Θ), $s \times 10^{-3}$	505,20	67,08	83,00	115,08	95,88	69,48

Table 3.16

Structural-mechanical characteristics of TF at storage temperature -18±2° C

Name of indicator	TF control sample			Developed TF sample with sesame seed concentrate		
	Duration of storage at temperature -18±2 °C, months					
	0	3	6	0	3	6
Reverse deformation (γ_{rd}), $m \times 10^3$	3,26	4,14	4,54	4,20	4,48	4,66
Irreversible deformation (γ_{ird}), $m \times 10^3$	0,11	0,07	0,07	0,18	0,18	0,11
Total deformation (γ_{td}), $m \times 10^3$	3,37	4,21	4,61	4,38	4,66	4,77
Shear stress (τ), Pa	1498,86	1498,86	1498,86	1498,86	1498,86	1498,86
Pliability (I), $Pa^{-1} \times 10^6$	2,25	2,81	3,07	2,92	3,11	3,18
Conditionally instantaneous modulus of flexibility (G_f), $Pa \times 10^{-5}$	7,77	4,85	4,20	4,79	4,53	4,29
High elastic module (G_{el}), $Pa \times 10^{-5}$	11,25	14,30	15,48	14,09	12,88	12,79
Plastic viscosity (η^*_{o}), $(Pa \times s) \times 10^{-9}$	74,90	112,00	112,00	45,00	45,00	74,90
The ratio of deformation inverse to total (K)	0,97	0,98	0,98	0,96	0,96	0,98
Viscosity of elastic aftereffect (η_{el}), $(Pa \times s) \times 10^{-7}$	37,47	49,96	72,53	41,25	48,88	40,87
Relative flexibility (Fl), %	57,24	73,38	77,43	71,57	71,13	73,15
Relative plasticity (Pl), %	3,21	1,71	1,56	4,11	3,87	2,27
Relative elasticity (El), %	39,55	24,90	21,01	24,31	25,00	24,58
Relaxation period (Θ), $s \times 10^{-3}$	163,00	310,20	340,20	125,88	134,28	233,00

In Fig. 3.12 it can be seen that during the storage of TF under the traditional conditions, the samples become less fluid, compacted, probably due to on the one hand, to the redistribution of moisture if the bonds are stabilized and, on the other due to syneresis. Instead, the fluidity for the corresponding samples (depending on the storage time) stored in the frozen state is increased (Fig. 3.13). This is due to the "loosening" of the structure by the negative influence of ice crystals. In general, it can be argued that freezing contributes to increased fluidity.

However, due to the analysis of changes in the structural and mechanical characteristics of the TF during deformation, the difference between them during storage at a temperature of -18 ± 2 °C was established. Thus, during the comparison of the TF sample freshly made (it was frozen and immediately unfreez) and after 6 months of storage the increase of the deformation curves is revealed. This trend is true only for samples stored in a frozen state. Such a change is likely to be caused by the effect of low temperature on the change in the moisture state, which in turn affects the structure of the filling.

Summarizing the data on the change in the rheological properties of TF with different formulations and the influence of freezing, we can state the following. TF samples during storage at a traditional temperature acquire a strong and dense structure, probably due to the physico-chemical changes in the interactions between the recipe components. It was found that a TF sample with a plant protein supplement had a more uniform change in storage curves and a softer structure, as evidenced by the deformation curves. Opposite changes have low-temperature TF samples for 6 months. As is known, during storage in a frozen state, moisture enters a crystalline state, and crystals of different sizes are formed, resulting in the possibility of damage to the structure. Therefore, after defrosting the filling, there is a softening of its structure, the so-called "loosening".

3.6 Determination of the temperature influence on the technological properties of thermostable filling using dairy raw material and sesame seeds concentrate during storage under traditional conditions and frozen

Of course, the thermal influence is a particular importance in the manufacture of thermostable filling. Temperature causes changes in heat exchange, physico-chemical, structural-mechanical and technological properties of the food system. Because of the temperature influence, strong chemical bonds can be broken. All of this leads to the rearrangement of the component molecules and the formation of new bonds. As you know, thermostable filling is characterized by a structure that does not change its physicochemical and, in particular, texture properties with a temperature action of about 200 °C for $(10...15)\times 60$ s [69; 70; 71; 93; 214; 215]. In the course of the experimental studies, in particular the establishment of moisture bound forms, the positive effect of sesame seed concentrate on a number of physicochemical properties of the filling was revealed. Thus, the concentrate promotes moisture retention and increases the moisture-holding ability of the product. Therefore, it is advisable to find out what effect the sesame seed concentrate has on the technological properties of the developed filling.

3.6.1 Change of thermal resistance

One of the main technological properties in the production of thermostable filling using dairy raw materials and sesame seeds concentrate is thermal stability, which means the temperature action that the product can withstand without changing its properties. To detect the thermostable properties, the duration of the action of temperature in the range of 100...220 °C for filling samples with different formulations, which were stored under different conditions was studied. The dependence of thermal stability on temperature ($\tau = f(t)$) has an inverse dependence. The thermal stability of the TF samples stored at 2 ± 2 °C was determined immediately after manufacture, on the 14th and 28th day of storage (Fig. 3.14). However, the thermal stability of TF samples stored at -18 ± 2 °C was investigated immediately after manufacture, on the 3rd and 6th month of storage (Fig. 3.15).

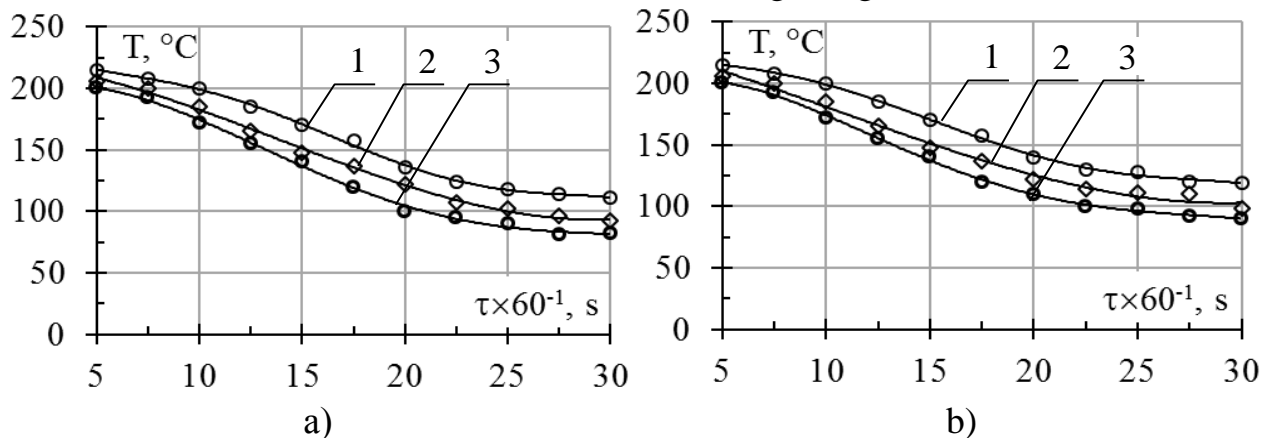


Fig. 3.14. The dependence of thermal stability a) TF control sample and b) the developed TF sample with sesame seeds concentrate at a storage temperature of 2 ± 2 °C on the influence of high-temperature processing: 1 – freshly made sample; 2 – sample after 14 days of storage; 3 – sample after 28 days of storage

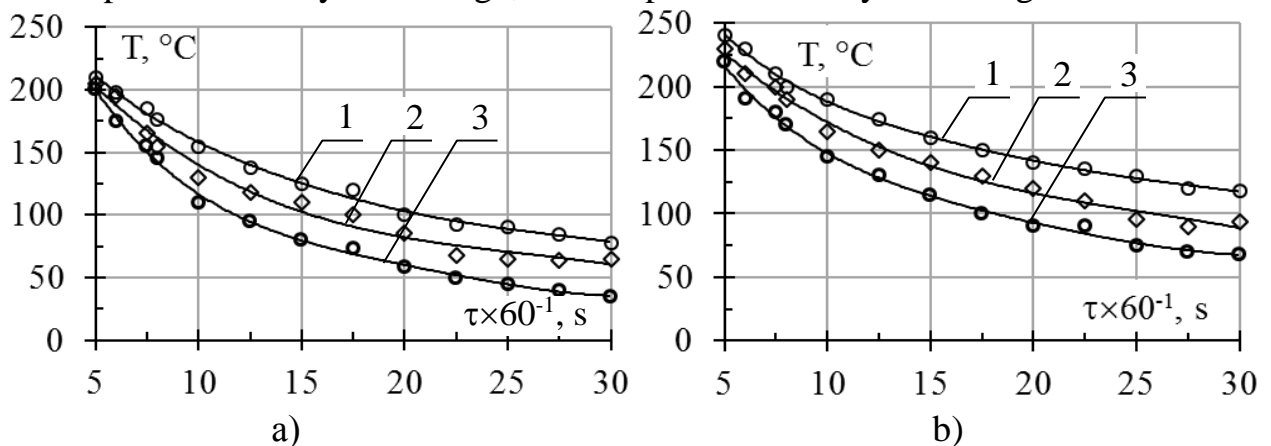


Fig. 3.15. The dependence of thermal stability a) TF control sample and b) the developed TF sample with sesame seeds concentrate at a storage temperature of -18 ± 2 °C on the influence of high-temperature processing: 1 – freshly made sample; 2 – sample after 3 months of storage; 3 – sample after 6 months of storage

According to Fig. 3.14 and 3.15, there is an intense decrease in the thermal stability of all TF samples during storage under both conditions, indicating syneresis.

Freezing has been shown to reduce the thermal stability of the filling. Probably, as a result of the transition of free moisture to the crystalline state during storage of TF at -18 ± 2 °C, ice crystals of various sizes are formed, which cause damage to the structure of the filling. This explains the slight decrease in thermal stability, since it reduces the connexion strength between the recipe components [16; 31; 67; 93 135; 220].

Comparing the data of Figures 3.14 and 3.15, the undeniable positive effect of sesame seed concentrate - a plant protein supplement increases the thermal stability of TF can be noted. This means that the developed filling, which contains in its recipe composition of sesame seeds concentrate, experiences less negative changes in its properties than the product without plant protein additives. This indicates the formation in the developed TF sample with sesame seed concentrate stronger interactions between the recipe components: high thermal stability is likely due to the action of intermolecular interaction forces, namely the increase of the interaction of surface layers and base phases [90; 233].

Therefore, it is established that the highest values of thermal stability have developed thermostable filling with sesame seeds concentrate. The results of the thermal stability study of the developed TF samples with concentrate after defrosting (freshly made, after storage for 3 and 6 months) are characterized by a similar trend of change of the indicator.

The above trend is also characteristic for filling control samples. Carrying out control samples of filling which stored under traditional conditions, then for a freshly made control sample of TF the thermal stability decreases from 28×60 to 11×60 s; for the sample examined for the 14th day, from 25×60 to 9×60 s; for the sample examined on the 28th day, from 20×60 to 7×60 s. Changes in the thermal stability of the control samples stored in the frozen state (fresh, after storage for 3 and 6 months) are as follows: from 28×60 to 11×60 s; from 15×60 to 7×60 s; from 10×60 to 3×60 s.

3.6.2 Change of melting temperature

Particular attention is paid in the production of thermostable fillings to the melting point, the temperature at which the product melts. It largely depends on the formulation components (together, the formulation components can both increase and decrease this temperature), in particular on their ability to form strong intermolecular interactions [93; 237; 274; 284; 288].

In Fig. 3.16 shows the change in the melting point of TF samples with different formulations, which were stored under different conditions.

The above data (Fig. 3.16) show that during storage under different conditions for both TF (samples of TF with and without sesame seed concentrate), a decrease in melting point is observed. And freezing helps to reduce the melting point (there is a "loosening" of the structure due to the breakdown of bonds of different nature).

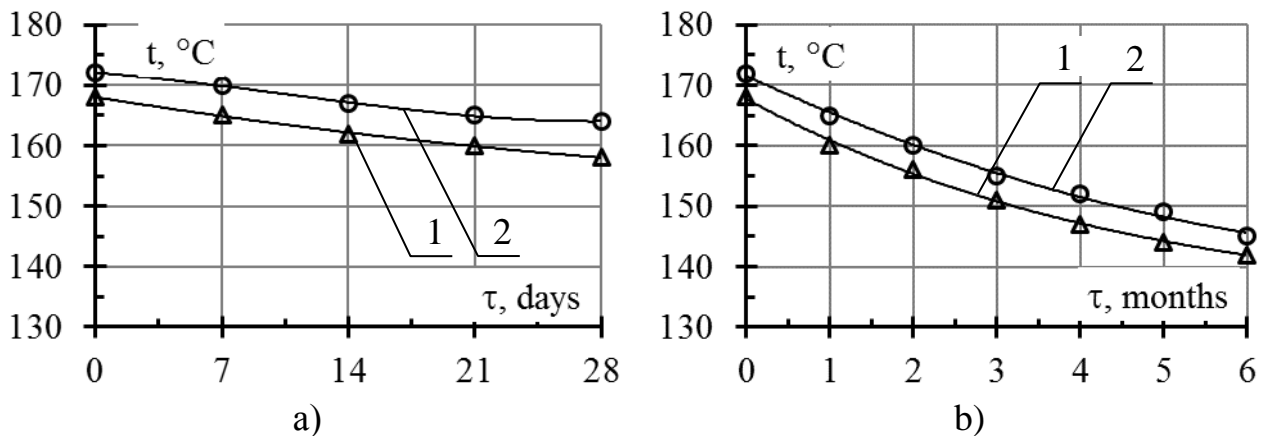


Fig. 3.16. Dependence of the TF melting point on the duration of storage at temperature: a) 2 ± 2 °C; b) -18 ± 2 °C; 1 – TF control sample; 2 – developed TF sample with sesame seeds concentrate

During the comparison of the melting point parameters of the studied samples, an increase in the melting point values in TF with a plant protein additive - a sesame seed concentrate, was recorded. This positive effect of sesame seeds concentrate on the melting point of the filling is due to the uniform distribution of moisture in the structure of the product, which during freezing causes slight damage to the structure [16; 31; 67; 135; 220].

After analyzing the results of both studies on changes in thermal stability and melting point, we can conclude. First, the long-term storage of the filling in two different conditions contributes to the reduction of thermal stability and melting point. This, as noted above, is mainly due to a decrease in moisture-holding ability and loss of moisture (syneresis). Secondly, the presence of sesame seed concentrate in the filling recipe composition has a positive effect on the technological properties of the product due to the formation of different forms of moisture bond: there is an increase in thermal resistance and melting point in products with the plant protein supplement. Thirdly, the freezing, due to the destruction of the skeleton filling with ice crystals, slightly reduces the technological characteristics of the product in accordance with the above trends.

3.7 Microstructure research of thermostable filling using dairy raw material and sesame seeds concentrate during storage under traditional conditions and frozen

It is found that in the process of production of thermostable filling the recipe components undergo physical and chemical transformations. They combine different connections in a common spatial grid of pectin and starch to form a homogeneous structure. These interactions are capable of breaking or forming new bonds, primarily during storage, which leads to a change in the microstructure of the finished product. In Fig. 4.17 in order to clearly demonstrate these changes, a comparative characteristic of the microstructure of the following control samples is shown: a freshly made control sample, a control sample for which a rational shelf life at 2 ± 2 °C (15 days) and a control sample after its storage in a frozen state for 4 months

(rational frozen storage conditions). In Fig. 3.18 shows the microstructures of samples of TF with sesame seed concentrate stored under the above conditions.

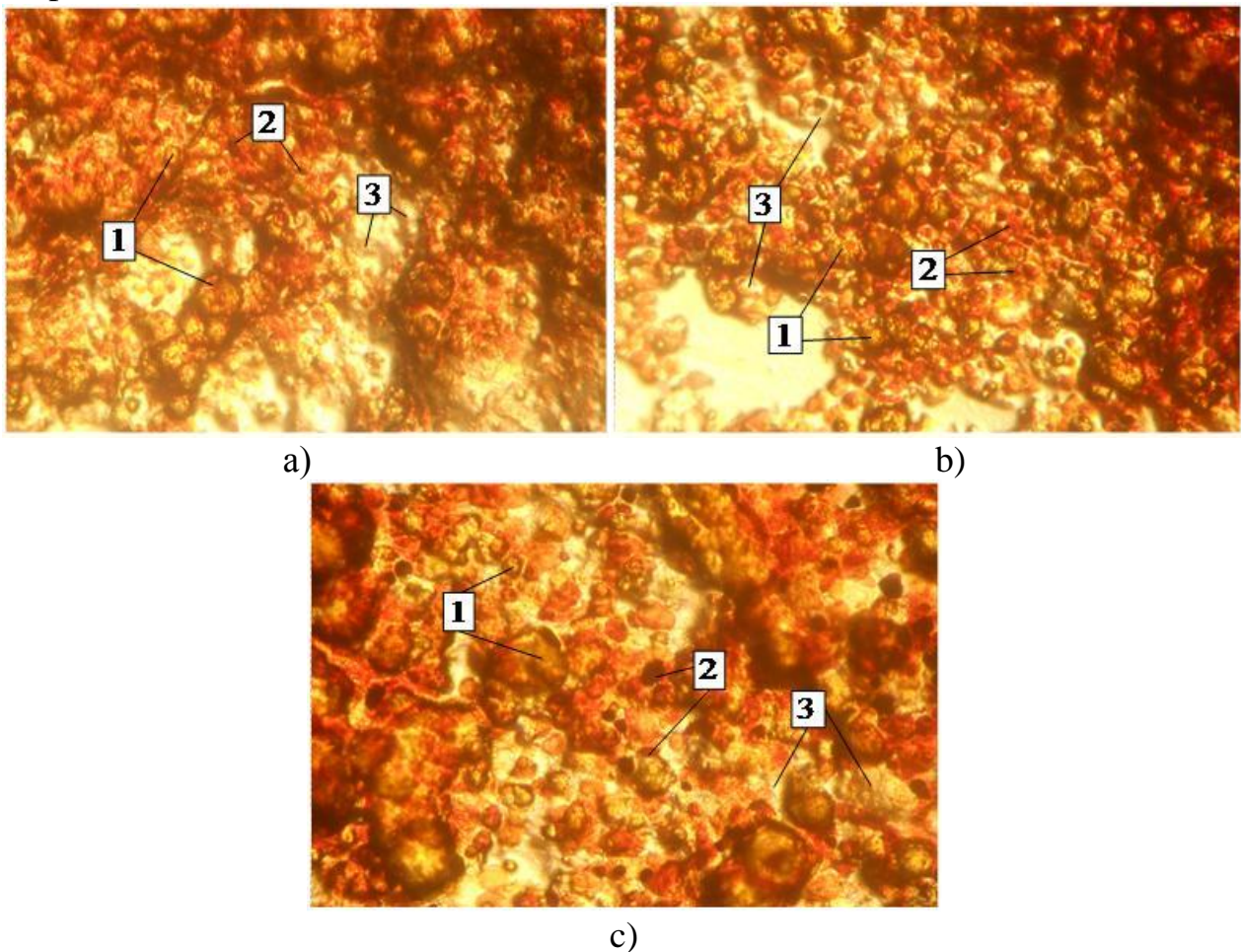


Fig. 3.17. Microstructure: a) control freshly made TF sample, b) control TF sample after 15 days of storage at 2 ± 2 °C, c) control TF sample after 4 months of storage at temperature -18 ± 2 °C with an increase of 120 times; 1 - fat globules; 2 - grains of modified corn starch; 3 - pectin-sugar-milk base

On the presented micrographs of fig. 3.17 and 3.18 show that the structure of the experimental samples looks like a spatial grid. The results of the study indicate the presence and uniformity of distribution of fat globules, which are an integral part of the sesame seeds concentrate and refined sunflower oil deodorized. The particle size of the sesame seed concentrate is about $50\ \mu\text{m}$, and the diameter of the fat globules is about $20\ \dots\ 60\ \mu\text{m}$

When comparing the micrographs, a slight difference in the microstructure of the test samples of TF and TF with the sesame seed concentrate was detected. In particular, due to the interaction of each composite component of the TF samples with the sesame seed concentrate, it is difficult to visually divide the boundaries of the structural elements, which indicates that they are ambiguity (Fig. 3.18).

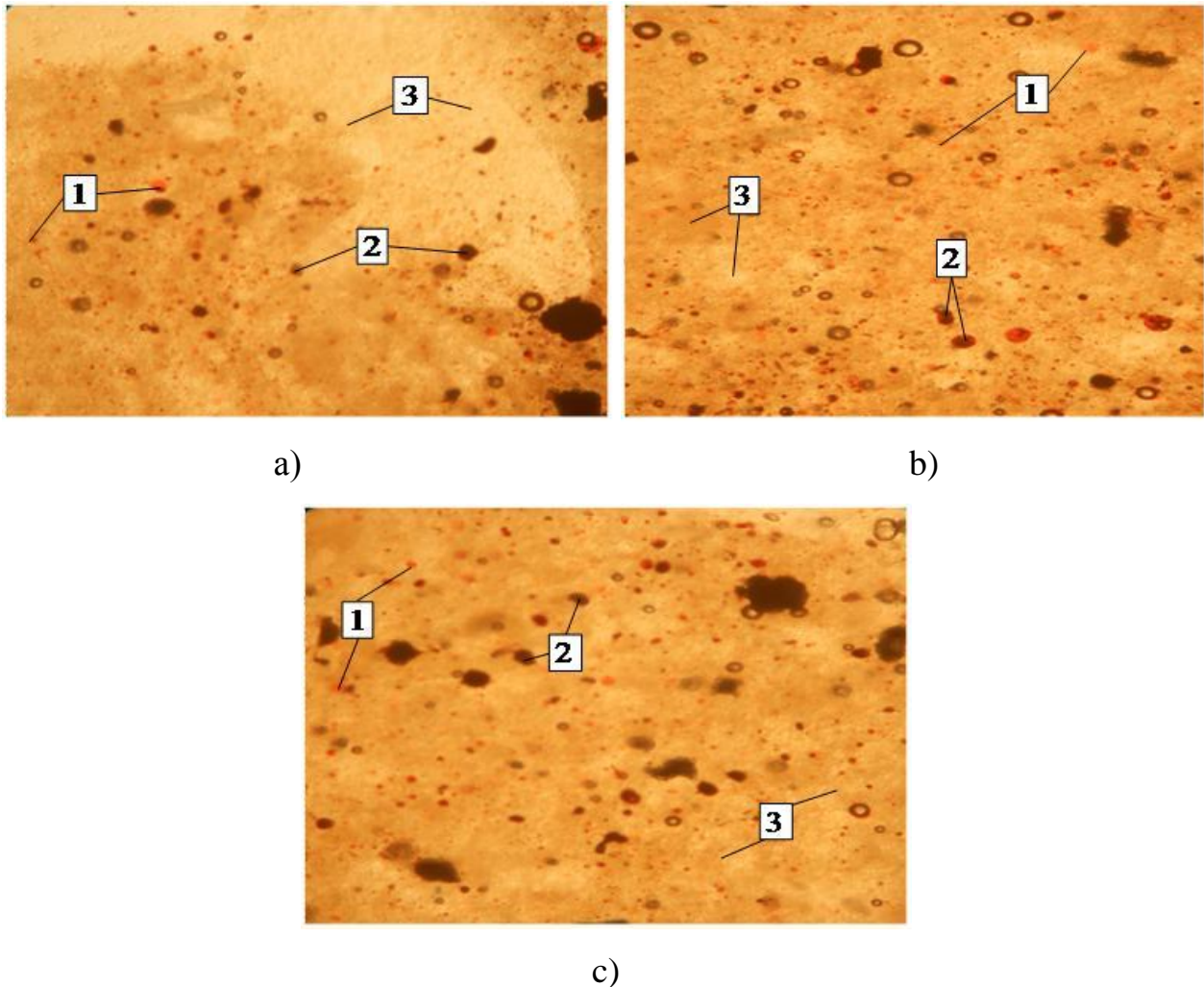


Fig. 3.18. Microstructure: a) control freshly made TF sample with SSC, b) control TF sample with SSC after 15 days of storage at 2 ± 2 °C, c) control TF sample with SSC after 4 months of storage at temperature -18 ± 2 °C with an increase of 120 times; 1 - fat globules; 2 - grains of modified corn starch; 3 - pectin-sugar-milk base

Both test TF samples after 15 days of storage are more pronounced in the visibility of the constituent particles, in particular, fat globules and grains of corn modified starch contained in the starch paste are clearly visible. After all, as it is known during storage in the starch paste, a process of retrogradation (aging) takes place, during which its physicochemical properties (MHA and AHF) decrease. Thus, during the storage for 15 days, the structure of the TF samples is slightly compacted, indicating a slight weakening and change of connections [16; 31; 67; 135; 220].

The most clearly expressed are the constituent recipe components, in particular fat globules and starch grains, in the control TF sample and TF with sesame seeds concentrate, which have undergone low temperature storage, compared with freshly made samples. In addition, changes in pectin-sugar-milk basis before and after low-temperature storage of TF are not observed. This is likely to indicate a loss of strength and partial destruction of the bonds of a different nature between the TF prescription components during defrosting.

Thus, the results of the research show that the combination in thermostable filling of plant and dairy components causes the formation of different bonds, concentrated in a common pectin-starch mesh, which determines the properties of the framework and the homogeneous structure of the filling.

3.8 IR spectroscopic analysis of thermostable filling using dairy raw material and sesame seeds concentrate during storage under traditional conditions and frozen

In order to detect influence of the recipe components of the protein-polysaccharide nature in the case of their joint use in TF technology, spectra of filling absorption revealed during IR spectroscopy were studied. With this analysis, you can detect the presence of certain bonds between the component molecules and identify the substances that participate in this. The characteristic absorption bands of TF control and TF with SSC are shown in Fig. 3.19, and their values and correspondence to certain functional groups are given in Table 3.17.

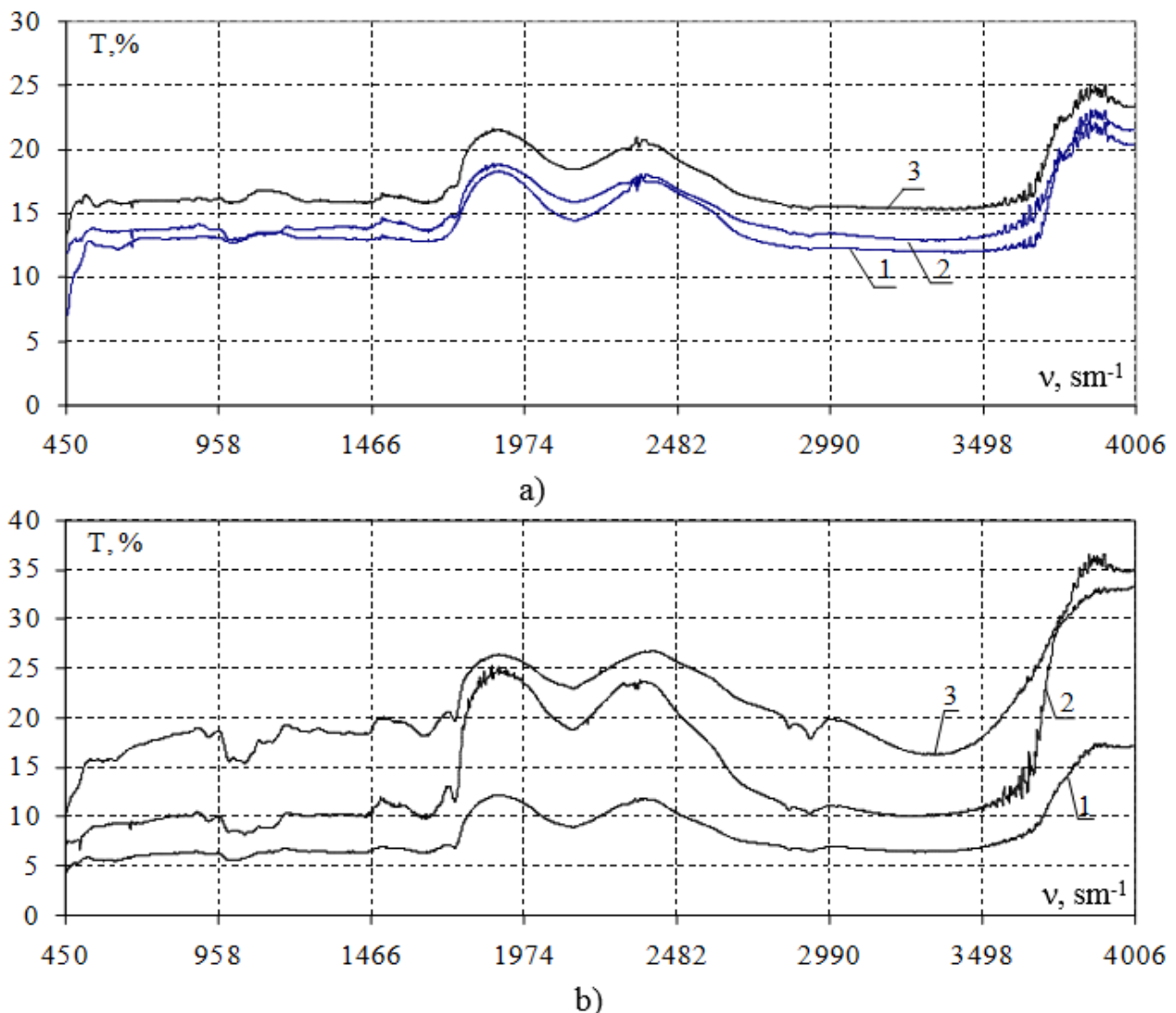


Fig. 3.19. IR spectra: a) control TF; b) TF with SSC; 1 - freshly made sample; 2 - sample after 15 days of storage at 2 ± 2 °C; 3 - sample after 4 months of storage at -18 ± 2 °C

Characterization of absorption bands of IR spectra TF

Spectrum range, cm ⁻¹					
3600...3100	3350...2850, 1100...900	2440...2350	2140...2100	1750...1720	550...450
OH-	CH-	C≡C	PH-	C=O	S=S

The spectra of all TF samples show wide absorption bands due to the valence vibrations of the bond of the functional group OH- ($\nu = 3600... 3100 \text{ cm}^{-1}$), which is involved in the construction of hydrogen bonds, that is, this group is characteristic of the recipe components of hydrophilic properties (sesame seed concentrate, skimmed milk powder, modified corn starch and low-esterified citrus pectin). These samples show absorption bands inherent in the deformation vibrations of the bond CH- group ($3350...2850$ and $1100...900 \text{ cm}^{-1}$), indicating the regrouping of intermolecular and intramolecular bonds, and the bands in the absorption region $2440...2350 \text{ cm}^{-1}$ are characteristic of the valence vibrations of the C≡C group involved in the construction of alkenes. Therefore, these bands in the areas of absorption contribute to the rearrangement and the emergence of new interactions of the recipe components. Thus, these areas characterize the formation of a spatial grid of pectin and starch.

The absorption of bands in the region $2140...2100 \text{ cm}^{-1}$, caused by the fluctuation of organophosphorus groups RN-, is characteristic of skimmed milk powder and sesame seed concentrate. Which, in turn, probably indicates the interaction calcium of skimmed milk powder and calcium citrate with pectin molecules to form calcium bridges. The absorption bands detected in the TF samples in the range $1750...1720$ and $550...450 \text{ cm}^{-1}$ are characteristic of vibrations of the C=O and S=S groups, respectively, indicating the presence of low-molecular substances (fats, proteins, etc.) involved in the construction of high-molecular substances. (polysaccharides, etc.).

Thus, according to the results of the IR spectra, it is found that the components introduced into the TF formulation form constituents of chemical bonds of different nature, characterized by certain absorption bands. The result TH is formed with a common spatial grid of pectin and starch, which holds all the constituent components together.

3.9 Protein composition study of thermostable filling using dairy raw material and sesame seeds concentrate

It is known that the biological value of TF depends primarily on the content and properties of the protein, so the protein composition of control TF and developed TF with sesame seed concentrate was investigated. The bands of protein intensities and the spectra of their presence in TF are shown in Fig. 3.20.

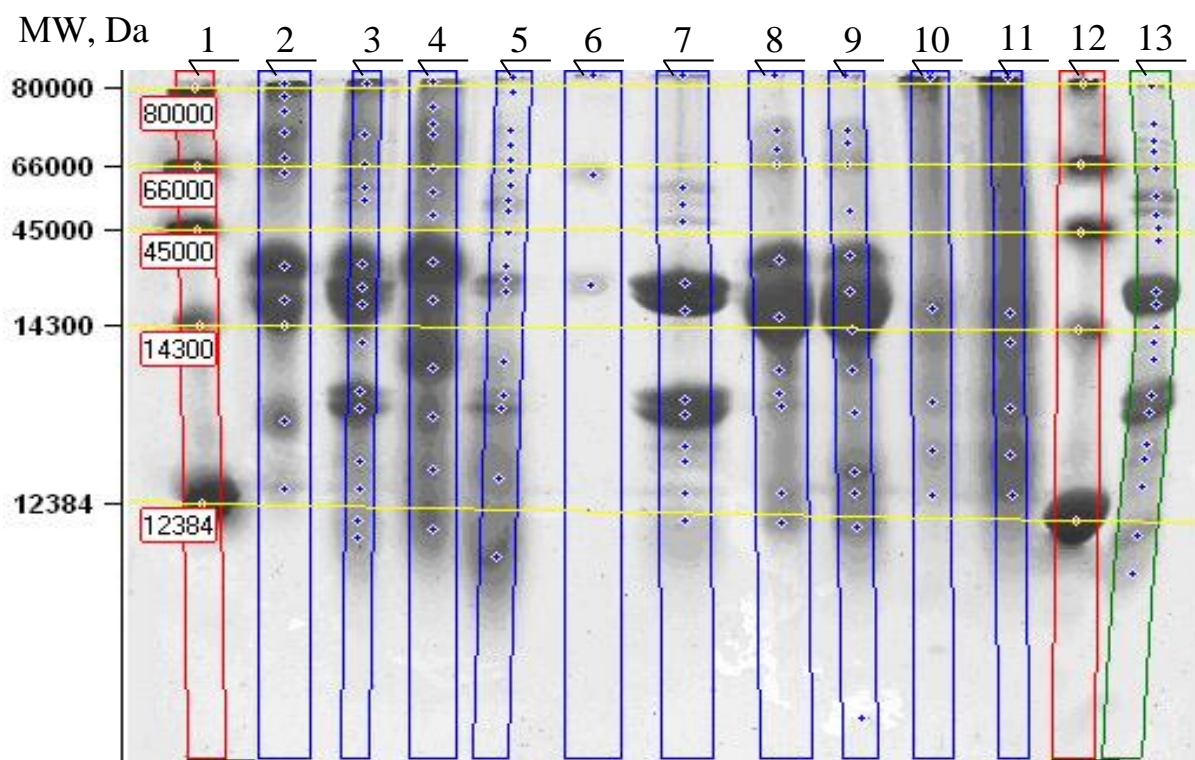


Fig. 3.20 Electrophoretic separation of proteins of control TF: 1, 12 - standards; 2 - total protein; 4 - water-soluble proteins; 6 - salt-soluble proteins; 8 - alcohol-soluble proteins; 10 - alkali-soluble proteins and developed TF with sesame seeds concentrate: 3 - total protein; 5 - water-soluble proteins; 7 - salt-soluble proteins; 9 - alcohol-soluble proteins; 11 - alkali-soluble proteins; 13 - the total protein of sesame seeds

From Fig. 3.20 found that the most significant peaks of the total protein of sesame seeds are peaks with a Molecular Weight (MW) of 26.4-22.6 and 13.48-13.8 kDa. These peaks correspond to proteins such as kaleosin and oleosin, which are characteristic of sesame seeds. However, some scientists claim that oleosin fractions are more diverse and may also have MW spectrum in the range of 12-20 kDa [240; 259].

From the presented data, it was found that the total protein of the control TF sample was divided into 11 bands, where the value of MW can identify the following proteins: 12.6 kDa - χ -casein; 14.2 kDa - lacto albumin; 20.6 kDa - λ -casein; 67.6 kDa - casein tetramer. In turn, the total protein of the developed sample with the sesame seed concentrate was divided into 15 strips; of these, 5 peaks coincide with the total protein of the control TF sample, and 7 have a close MW value to the sum of sesame protein. Also the MW peaks of 12.08 kDa, 14.08 kDa, 58.96 kDa, 66.27 kDa are unique. They are only fixed in the mixture, which may indicate the formation of strong covalent bonds between proteins in the developed TF sample and extract of sesame

In electrophoresis, water-soluble proteins have different separation spectra. The total amount of water-soluble proteins for the control and developed sample is 25.75 and 28.09 mg protein /1 g of product, respectively. In water-soluble proteins of

the developed TF sample revealed residual amounts of oleosin and kaleosin, which were introduced by the addition of sesame in the product. Also, fractions of 44.45 MW-54.4 kDa water-soluble proteins coincide in motility with bands of sesame protein in the same mass range. It should be noted that in this sample of proteins, bands with a molecular weight of 76.4, 73.29, 57.3, 21.2, 12.17 kDa are disappear, which were in the separation spectrum of the control TF sample. However, in this TF sample, the occurrence of new water-soluble proteins is recorded, in particular new bands appear with MW 79.09; 59.3; 28.67 kDa, which are probably the products of joint interaction of proteins of dairy and plant origin, since these bands are not detected in either the control or the total sesame protein.

From the analysis of the fractional composition it was found that the total amount of salt-soluble proteins of the control TF sample is 3.75 mg of protein/1 g of product, and developed - 29.26 mg of protein/1 g of product. Electrophoresis of the isolated salt-soluble proteins of the control sample showed that the starting material contained very little protein material. It was divided into only 3 strips. However, in the salt soluble proteins of the developed TF sample revealed bands of oleosin and kaleosin, which were introduced by the addition of sesame. It should also be noted that in the process of proteins separation of the salt-soluble fraction of the developed TF sample identified 12 strips. They also contain new protein strips with MW 59.09 and 12.31 kDa. In the proteins of this sample, bands with a molecular weight of 63.03, 26.11 kDa are disappear, which were in the separation spectrum of the control TF sample.

The total amount of alcohol-soluble proteins of the control and developed samples of TF are 12.29 and 7.61 mg of protein /1 g of product, respectively . These proteins were divided into 11 and 14 strips, respectively. In this case, alcohol-soluble proteins isolated from the developed TF sample do not have strips with MW 68.89, 17.19 and 13.62 kDa, which were detected in the protein separation spectrum of the control TF sample. As in the previous proteins, in these proteins in the developed TF sample there are new strips with MW 25,97; 10.32 kDa.

Alkaline extraction showed that the total amount for the control sample is 42.13 mg of protein /1 g of product, and for the developed TF sample - 40,96 mg of protein /1 g of product. Proteins isolated from both samples are found to be heterogeneous and consist of polypeptides with large variations of molecular weight spectrum values. Because of this, there is a significant peptide background. In the alkaline-soluble fraction of the control and developed sample of TF also allocated 6 and 7 strips of proteins, respectively. Significant background coloring is observed, which complicates the evaluation of the MW of the divided strips. From the received data it can be noted that in the developed TF sample compared with the control, proteins with MW 13,56 and 13,07 kDa were not detected.

References

1. Авраменко В. Н. Инфракрасные спектры пищевых продуктов / В. Н. Авраменко, М. П. Есельсон, А. А. Заика. – М., 1974. – 173 с.
2. Адамсон А. Физическая химия поверхностей : [пер. с англ.] / А. Адамсон. – М. : Мир, 1979. – 360 с.
3. Алмаши Э. Быстрое замораживание пищевых продуктов / Э. Алмаши, Л. Эрдели, Т. Шарой; под ред. Э. Алмаши, А. Ф. Наместникова; пер. с венг. О. А. Воронова. – М. : Легкая и пищевая пром-сть, 1981. – 408 с.
4. Альван Амин. Биохимическая характеристика запасных белков кунжута, используемых для обогащения пищевых продуктов : дис. ... канд. техн. наук / Альван Амин. – Краснодар, 2002. – 130 с.
5. Алямовский И. Г. Исследования в области технологии пищевых продуктов / И. Г. Алямовский, Н. А. Головкин, Г. Б. Чижов // Холодильная техника. – 1981. – № 5. – С. 53.
6. Анисимова Д.М. Пищевые волокна в рациональном питании человека / Д. М. Анасимова // Сб. науч. тр. – М., 1989. – С. 90 – 93.
7. Ардатская М. Д. Современные проблемы физиологии и патологии пищеварения / Д. М. Ардатская // Материалы XVI сессии Академической школы-семинара имени А.М. Уголева: Приложение № 14 к Рос. журн. гастроэнтеролог., гепатолог., колопроктолог. – 2001. – Т. XI, № 4 – С. 91–102.
8. Арет В. А. Физико-механические свойства сырья и готовой продукции / В. А. Арет, Б. Л. Николаев, Л. К. Николаев. – СПб. : ГИОРД, 2009. – 448 с.
9. Арсеньєва Л. Ю. Методологічні підходи до розроблення нових видів хлібобулочних виробів зі збалансованим хімічним складом / Л. Ю. Арсеньєва, В. Ф. Доценко // Нові технології та технічні рішення в харчовій та переробній промисловості: сьогодні і перспективи : IX міжнар. наук.-практ. конф. : матеріали. – К. : НУХТ, 2005. – С. 105–106.
10. Базарнова Ю. Г. Гидроколлоидные смеси с заданными свойствами / Ю. Г. Базарнова, Т. В. Шкотова, В. М. Зюкина // Кондитерское производство. – 2003. – № 3. – С. 38 – 40.
11. Базарнова Ю. Г. Применение натуральных гидроколлоидов для стабилизации пищевых продуктов / Ю. Г. Базарнова // Пищевые ингредиенты: сырье и добавки. – 2005. – № 2. – С. 84 – 87.
12. Бакулина О. Н. Галактоманнаны: аспекты использования / О.Н. Бакулина // Пищевые ингредиенты, сырье и добавки. – 2000. – № 1. – С. 20 – 21.
13. Баль-Прилипко Л. В. Значення води у формуванні якості харчових продуктів / Л. В. Баль-Прилипко, О. М. Ляшенко // Молочное дело. – 2010. – № 8. – С. 8–12.
14. Баранов Б. А. Теоретические и прикладные аспекты показателя «активность воды» в технологии продуктов питания : автореф. дис. на соискание уч. степени д-ра техн. наук : спец. 05.18.16 «Технология продуктов общественного питания» / Б. А. Баранов. – СПб., 2000. – 240 с.

15. Бархатова Т. В. Бифидогенные олигосахариды / Т. В. Бархатова, И. А. Евдокимов – Краснодар : Фирма Тамзи, 2003.
16. Белінська С. Особливості кристалоутворення під час заморожування суниць / С. Белінська, Н. Орлова, І. Китаєв // Товари і ринки. – 2008. – № 2. – С. 74 – 80.
17. Берлин А. А. Основы адгезии полимеров / А. А. Берлин, В. Е. Басин. – М. : Химия, 1974. – 320 с.
18. Большаков С. А. Холодильная техника и технология продуктов питания / С. А. Большаков. – М. : Академия, 2003. – 224 с.
19. Братан Л. Влияние ингредиентов растительного сырья на способность пектинов связывать кадмий / Л. Братан, Н. С. Краснова, П. И. Бульмага // Пищевые ингредиенты: сырье и добавки. – 2005. – № 1. – С. 60 – 61.
20. Братан Л. Новые типы пектина для лечебно-профилактического питания / Л. Братан, Н. С. Краснов // Пищевые ингредиенты: сырье и добавки. – 2002. – № 2. – С. 74 – 75.
21. Бредихина Н. А. Пектины – уникальные природные целители / Н. А. Бредихина // Пища, вкус, аромат. – 2001. – № 2. – С. 32.
22. Бровкин С. И. Хлебопекарные свойства кукурузной муки / С. И. Бровкин, Л. Я. Ауэрман. – М. : ЦИНТИПИЩЕПРОМ, 1961. – 28 с.
23. Булдаков А. С. Пищевые добавки: справочник / А. С. Булдаков. – С. Пб. : Vt, 1996.
24. Бурмакин А. Г. Справочник по производству замороженных продуктов / А. Г. Бурмакин. – М. : Пищевая пром-сть, 1970. – 464 с.
25. Буянова И. В. Замораживание и хранение крупных сыров: особенности поведения молочной кислоты / И. В. Буянова // Сыроделие и маслоделие. – 2004. – № 1. – С. 21 – 23.
26. Буянова И. В. Разработка и исследование технологии замораживания и низкотемпературного хранения твердых сыров : дис. ... доктора техн. наук : 05.18.04 / Буянова Ирина Владимировна. – Кемерово, 2006. – 326 с.
27. Вивчення молекулярної рухливості води в термостійкій молоковмісній начинці / Г. Д. Любенко, М. В. Обозна, Ф. В. Перцевой, Г. О. Дьяков // Прогресивні техніка та технології харчових виробництв ресторанного господарства і торгівлі: зб. наук. пр. – Харків : ХДУХТ, 2014. – Вип. 1 (19). – С. 25 – 32.
28. Витамины и каратиноиды фирмы «Хоффманн – Ла Рош» для пищевой промышленности: каталог.– М., 1998. – С. 27–32.
29. Влияние фруктозы на студнеобразование при производстве зефира на пектине / Г. О. Магомедов, А. К. Магомедова, Т. Н. Мирошникова, Л. А. Лобосова // Кондитерское производство. – 2007. – № 2. – С. 31 – 33.
30. Вода в пищевых продуктах / [пер. с англ. под ред. Р. Б. Дакуорта]. – М. : Пищевая пром-сть, 1980. – 376 с.

31. Воробьева Н. Н. Теплофизические процессы в холодильной технологии : учебн. пособие / Н. Н. Воробьева ; Кемеровский технол. Инс-т пищ. Пром-сти. – Кемерово, 2007. – 150 с.
32. Выродов И. П. Физико-химическая природа процессов набухания зерна / И. П. Выродов // Изв. вузов. Пищевая технология. – 2001. – № 1. – С. 9–11.
33. Голубев В. Н. Функциональные свойства пектинов и крахмалов / В. Н. Голубев, С. Ю. Беглов, А. В. Поджуев // Пищевые ингредиенты: сырье и добавки. – 2000. – № 1. – С. 14 – 18.
34. Голубев В. Н. Управление коллоидно-химическими свойствами пектина в ходе технологического процесса / В. Н. Голубев, Г. В. Михайлов, И. В. Волкова // Пищевая промышленность. – 1997. – № 8. – С. 25.
35. Голубева Л. В. Хранимоспособность молочных консервов / Л. В. Голубева, Л. В. Чекулаева, К. К. Полянский. – М. : ДеЛи принт, 2001. – 115 с.
36. Голубев В. Н. Пектины. Химия, технология, применение / В. Н. Голубев, Н. П. Щепухина – М. : Высшая школа, 1995. – 317 с.
37. Горбатова К. К. Химия и физика молока / К. К. Горбатова. СПб. : ГИОРД, – 2004.
38. Гришин М. А. Кривоцентрирование молочного сырья / М. А. Гришин, О. Т. Бурдо, Ф. Р. Алтлухов // Мясная и молочная промышленность. – 1990. – № 6. – С.21 – 43.
39. Гунько В. М. Вода на межфазной границе / В. М. Гунько, В. В. Туров, П. П. Горбик – К. : Наук. думка, 2009. – 694 с.
40. Гуськов К. Г. Реология пищевых масс / К. Г. Гуськов, Ю. А. Мачихин, Л. Н. Лунин. – М. : Легкая и пищевая пром-сть, 1970. – 208 с.
41. Дакуорта Р. Б. Вода в пищевых продуктах / Р. Б. Дакуорта. – М. : Пищевая пром-сть, 1980. – 376 с.
42. Дельмон Б. Кинетика гетерогенных реакций / Б. Дельмон – М. : Мир, 1972. – 554 с.
43. Джурик Н. Р. Аналіз розвитку борошняних кондитерських виробів в Україні / Н. Р. Джурик, І. Л. Тимчишин // Збірник наук.-техн. праць. – 2007. – Вип. 17.3. – С. 230 – 232.
44. Дибирасулаев М. А. Влияние холодильной обработки на питательную ценность пищевых продуктов / М. А. Дибирасулаев, Н. И. Соколова // Холодильная техника. – 1991. – № 10. – С. 17 – 20.
45. Долинян В. С. Начинки: свойства и применение / В. С. Долинян, З. Г. Скобельская // Кондитерское производство. – 2005. – № 2. – С. 16 – 18.
46. Донченко Л. В. Технология пектина и пектинопродуктов / Л. В. Донченко. – М. : ДеЛи принт, 2000. – 255 с.
47. Донченко Л. В., Фирсов Г. Г. Пектин: основные свойства, производство и применение / Л. В. Донченко, Г. Г. Фирсов. – М. : ДеЛи принт, 2007. – 276 с.
48. Драгилев А. И. Технология кондитерских изделий / А. И. Драгилев, И. С. Лурье – М. : ДеЛи принт, 2001. – 484 с.

49. Драгилев А. И. Основы кондитерского производства / А. И. Драгилев, Г. А. Маршалкин. – М. : Колос, 1999. – 448 с.
50. Дубцов Г. Г. Применение крахмала при производстве макаронных изделий быстрого приготовления / Г. Г. Дубцов, Т. Р. Любецкая, Н. Л. Андросова // Кондитерское и хлебопекарное производство. – 2007. – № 3. – С. 8 – 9.
51. Дудкин М. С. Пищевые волокна / М. С. Дудкин Н. К. Черно. – К. : Урожай, 1988. – 152 с.
52. Дьяков А. Г. Система управления спектрометром ЯМР / А. Г. Дьяков, А. Ф. Даниленко // Информатика и моделирование: сб. науч. трудов НТУ «ХПИ». – 2003. – № 26. – С. 119–123.
53. Дьяченко П. Ф. Атакуемость фракций казеина протеолитическими ферментами / П. Ф. Дьяченко, Е. А. Жданова // Прикладная, биохимия. и микробиология. – 1965. – Т. 1. – С. 49–51.
54. Эндерсс Х.-У. Применение классических яблочных пектинов в производстве термостабильных фруктовых начинок хлебопекарных изделий / Х.-У. Эндерсс, Р. Крац, А. Ю. Колеснов // Пищевая промышленность. – 1996. – № 1. – С. 13 – 14.
55. Ефремов А. А. Выделение пектина из нетрадиционного растительного сырья и применение его в кондитерском производстве / А. А. Ефремов, Т. А. Кондратюк // Химия растительного сырья. – 2008. – № 4. – С. 171 – 176.
56. Жушман А. И. Модифицированные крахмалы как эффективные пищевые добавки / А. И. Жушман, В. Г. Карлов, Н. Д. Лукин // Пищевая промышленность. – 1996. – № 6. – С. 18 – 19.
57. Жушман А. И. Применение нативных и модифицированных крахмалов в кондитерской промышленности / А. И. Жушман // Кондитерское и хлебопекарское производство. – 2004. – № 11. – С. 8 – 9.
58. Залевська Н. О. Удосконалення технології здобного печива з начинкою: автореф. дис. ... на здобуття наукю ступеня канд. техн. наук: спец. 05.18.01 / Н. О. Залевська – К., 2006. – 20 с.
59. Зилафф Х. Охлаждение и замораживание / Х. Зилафф, Х. Шлойзенер // Мясо и молоко. – 2002. – № 3.
60. Зимон А. Д. Адгезия пищевых масс / А. Д. Зимон, А. М. Евтушенко. – М. : ДеЛи принт, 2008. – 398 с.
61. Измайлова В. Н. Структурообразование в белковых системах / В. Н. Измайлова, П. А. Ребиндер. – М. : Наука, 1991.
62. Инихов Г. С. Методы анализа молока и молочных продуктов: справ. рук. / Г. С. Инихов, Н. П. Брио. – М. : Пищевая пром-сть, 1971. – 423 с.
63. Использование пектинов и пектинсодержащих продуктов при производстве кондитерских изделий с железной структурой / В. И. Оболкина, И. А. Крапивницкая, У. С. Йовбак, С. Г. Кияница // Продукты & Ингредиенты. – 2013. – № 2. – С. 21.

64. Исупов В. П. Пищевые добавки и пряности. История, состав и применение / В. П. Исупов. – СПб. ГИОРД, 2000. – 176 с.
65. Как влияет замораживание и низкотемпературное хранение на качество сыров / И. В. Буянова, О. В. Кригер, И. О. Ларина, В. О. Буянов // Сыроделие и маслоделие. – 2008. – № 4. – С. 22 – 23.
66. Квалиметрия: ее содержание, задачи, методы / [Гличев А. В., Шор Б. Я., Погожев И. Б. и др.] // Измерение качества продукции. – М. : Изд-во. стандартов, 1971. – 137 с.
67. Кварацхелия В. Н. Изменение аналитических характеристик пектиновых веществ яблок зимнего срока созревания при длительном влиянии низких температур / В. Н. Кварацхелия, Л. Я. Родионова // Научный журнал КубГАУ. – № 100 (06). – 2014. – С. 1 – 14.
68. Козлов С. Г. Физико-химические основы получения гелеобразных продуктов / С. Г. Козлов // Пищевые ингредиенты: сырье и добавки. – 2004. – № 2. – С. 88 – 91.
69. Колеснов А. Ю. Термостабильные свойства фруктовых начинок для мучных кондитерских изделий / А. Ю. Колеснов, Т. А. Духу, Х. У. Эндресс // Кондитерское производство. – 2004. – № 3. – С. 50 – 52.
70. Колеснов А. Ю. Пектиновые смеси для домашнего приготовления продуктов пищевого и лечебно-профилактического назначения / А. Ю. Колеснов, В. В. Письменный, Б. Н. Троицкий // Пища, вкус, аромат. – 1998. – № 5. – С. 2 – 3.
71. Колеснов А. Ю. Термостабильные начинки: производство, качественные свойства и их оценка / А. Ю. Колеснов // Кондитерское производство. – 2001. – № 1. – С. 32 – 37.
72. Колмакова Н. С. Пектин: новый подход к решению задач / Н. С. Колмакова // Пищевые ингредиенты: сырье и добавки. – 2002. – № 2. – С. 76 – 77.
73. «Кондитерская начинка «Вареная сгущенка» термо 300°»: ТУ 9129-002-87168165-11
74. Конц К. Исследование пригодности молока и молочных продуктов для замораживания / К. Конц, К. Фехер // Развитие теоретических основ и практики холодильной технологии пищевых продуктов : сб. науч. трудов. – Л., 1986. – С. 75 – 78.
75. Корецкая И. Л. Новый метод оценки пищевых продуктов / И. Л. Корецкая, Т. В. Зинченко // Продукты & Ингредиенты. – 2006. – № 2. – с. 16.
76. Копылова Л. Ф. Яблочные пектины rectowin для зефира / Л. Ф. Копылова // Кондитерское производство. – 2006. – № 6. – С. 12 – 13.
77. Кочеткова А. А. Пектин. О многих гранях одного ингредиента / А. А. Кочеткова, Л. Г. Ипатова // Пищевые ингредиенты: сырье и добавки. – 2009. – № 1. – С. 34.
78. Кочеткова А. А. Пищевые гидроколлоиды: теоретические заметки / А. А. Кочеткова // Пищевые ингредиенты сырье и добавки. – 2000. – № 1. – С. 10 – 11.

79. Крапович Н. С. Пектин: производство и применение / Н. С. Крапович, Л. В. Донченко, В. В. Нелина. – К. : Урожай, 1989. – 88с.
80. Крахмал и крохмалопродукты / под ред. Гулюка И. П. – М. : Агропромиздат, 1985. – 240 с.
81. Крац Р. Промышленное производство желейного мармелада / Р. Крац // Пищевая промышленность. – 1993. – № 3. – С. 19.
82. Кушманова О. Д. Руководство по практическим занятиям по биологической химии / О. Д. Кушманова, Г. М. Ивченко ; под ред. А. А. Покровского. – М. : Медицина, 1974. – 424 с.
83. Кушнир Ю. Гидроколлоиды / Ю. Кушнир // Продукты & Ингредиенты. – 2008. – № 5. – С. 106 – 107.
84. Лагони Х. Влияние хранения молока и сливок при низких температурах на стабильность коллоидов молока / Х. Лагони, К. Петере // 17-й Междунар. конгресс по молочному делу : материалы. – М. : Пищевая пром-сть, 1971. – 164 с.
85. Ларикова А. Секреты термостабильной начинки / А. Ларикова // Кондитерская сфера. – 2013. – № 2 (49).
86. Ластухін Ю. О. Органічна хімія: підручник / Ю. О. Ластухін, С. А. Воронов. – Львів : Центр Європи, 2001. – 864 с.
87. Лимарева Н. С. Разработка технологии пектиносодержащих функциональных напитков на основе томатного сока / Н. С. Лимарева, Л. В. Донченко // Научный журнал КубГАУ. – 2012. – № 82 (08). – С. 1 – 18.
88. Липатов Н. Н. Формализованный анализ аминокислотной сбалансированности сырья, перспективного для проектирования продуктов детского питания с задаваемой пищевой адекватностью / Н. Н. Липатов, Г. Ю. Сажинов, О. И. Башкиров // Хранение и переработка сельхозсырья. – 2001. – № 8. – С.11 – 14.
89. Литвин Б. Л. Фізичні методи дослідження будови органічних речовин: метод. Посібник / Б. Л. Литвин. – Івано-Франківськ: Прикарпатський нац. ун-т ім. В. Стефаника, 2009. – 134 с.
90. Лукин А. А. Технологические особенности и перспективы использования растительных и животных белков в производстве колбасных изделий / А. А. Лукин // Вестник ЮУрГУ. Сер. Пищевые и биотехнологии. – 2014. – Т. 2, № 1. – С. 52 – 59.
91. Лурье И. С. Технология кондитерского производства / И. С. Лурье. – М. : Агропромиздат, 1992. – 399 с.
92. Лыков А. В. Теория сушки / А. В. Лыков. – М. : Энергия, 1968. – 472 с.
93. Любенко Г. Д. Дослідження термічної стійкості та температури плавлення молокової начинки / Г. Д. Любенко, М. В. Обозна, Ф. В. Перцевой // Інноваційні технології в харчовій промисловості та ресторанному господарстві: Міжнар. наук.-практ. інтернет-конференція, 12 – 14 листопада 2014 р. : тези доп. – Харків: ХДУХТ, 2014. – С. 47 – 49.
94. Любенко Г. Д. Особливості технології та рецептури термостійкої молокової начинки з використанням пектину / Г. Д. Любенко // Прогресивні

техніка та технології харчових виробництв ресторанного господарства і торгівлі: зб. наук. пр. – Харків : ХДУХТ, 2013. – Вип. 2 (18). – С. 47 – 51.

95. Любецкая Т. Модифицированный крахмал в производстве макаронных изделий быстрого приготовления / Т. Любецкая, Г. Дубцов // Хлебопродукты. – 2010. – № 1. – С. 38 – 40.

96. МакКена Б. М. Структура и текстура пищевых продуктов. Продукты эмульсионной природы / Б. М. МакКена ; пер. с англ. под. науч. ред. канд. техн. наук, доц. Ю. Г. Базарновой. – СПб. : Профессия, 2008. – 480 с.

97. Малкин А. Я. Реология: концепции, методы, приложения : [пер. с англ.] / А. Я. Малкин, А. И. Исаев. – СПб. : Профессия, 2007. – 560 с.

98. Малышев С. Д. Технологические и физико-химические требования к фруктовым начинкам / С. Д. Малышев // Пищевая промышленность. – 2000. – № 2. – С. 22 – 23.

99. Манк В. В. Усовершенствование индикаторного метода определения количества связанной воды / В. В. Манк // Коллоидный журнал. – 2002. – Т. 64, № 3. – С. 432.

100. Маршалкин Г. А. Технологическое оборудование кондитерских фабрик Г. А. Маршалкин – М. : Легкая и пищевая пром-сть, 1984. – 448 с.

101. Маслов А. М. Инженерная реология в пищевой промышленности / А. М. Маслов. – Л. : ЛТИХП МВ и ССО РСФСР, 1977. – 88 с.

102. Маслова Г. М. К вопросу изучения процесса клейстеризации зерен крахмала картофеля, кукурузы, пшеницы и риса / Г. М. Маслова, Н. Н. Трегубов // Сахарная промышленность. – 1964. – №12. – С. 50 – 55.

103. Матвеева И. Модифицированные крахмалы для формирования качества хлебобулочных и макаронных изделий / И. Матвеев, В. Нестеренко // Хлебопродукты. – 2011. – № 3. – С. 43 – 45.

104. Матвеева И. Модифицированные крахмалы для формирования качества хлебобулочных и макаронных изделий / И. Матвеева, В. Нестеренко // Хлебопродукты. – 2011. – № 4. – С. 65 – 67.

105. Мачихин Ю. А. Инженерная реология пищевых материалов / Ю. А. Мачихин, С. А. Мачихин. – М. : Легкая и пищевая пром-сть, 1981. – 216 с.

106. Медико-биологические требования и санитарные нормы качества продовольственного сырья и пищевых продуктов: МБТ и СН № 5061-89 от 01.08.1989 г. – 16 с.

107. Мелвин-Хьюз Е. А. Равновесие и кинетика реакций в растворах / Е. А. Мелвин-Хьюз. – М. : Химия, 1975. – 472 с.

108. Методи контролю якості харчової продукції: [навч. посібник для студ. вищих навч. закл. технол. спец.] / [О. І. Черевко, Л. М. Крайнюк, Д. О. Касілова та ін.]. – Х. : ХДУХТ, 2005. – 230 с.

109. Методичні вказівки до лабораторних робіт з дисципліни «Колоїдна хімія». – К. : КТІХП, 1993. – 88 с.

110. Методические указания по использованию в лечебно-профилактических целях пектинов и пектиносодержащих продуктов:

№ 5049-89 / [Качалай Д.П. и др.] МЗ СССР; Разраб. НИИ микробиол. и вирусол. АН УССР. – К., 1990. – 14 с.

111. Минифай Б. У. Шоколад, конфеты, карамель и другие кондитерские изделия / Б. У. Минифай; пер. с англ. под ред. Т. В. Савенковой. – СПб. : Профессия, 2005. – 808 с.

112. Мишенина З. А. О возможности хранения замороженного творога при температуре минус 12°C / З. А. Мишенина, Н. Н. Фильчакова // Холодильная техника. – 1984. – № 4. – С. 31 – 34.

113. Модифицированный крахмал при производстве макаронных изделий быстрого приготовления / [Г. Г. Дубцов, Т. Р. Любецкая, Н. Л. Андросова и др.] // Кондитерское и хлебопекарное производство. – 2007. – № 3. – С. 8 – 9.

114. Моик И. Б. Термо- и влагометрия пищевых продуктов: справочник / И. Б. Моик, Н. А. Рогов, А. В. Горбунов. – М. : Агропромиздат, 1988. – 304 с.

115. Молоко и молочные продукты. Метод измерения массовой доли общего азота по Кьельдалю и определение массовой доли белка : ГОСТ 23327-98. – [Введ. 2000-01-01]. – Минск: Межгос. совет по стандартизации, метрологии и сертификации, 2009. – 8 с.

116. Муратова Е. И. Реология кондитерских мас: монография / Е. И. Муратова, П. М. Смолихина. – Тамбов: Изд-во ФГБОУ ВПО «ТГТУ», 2013. – 188 с.

117. Мыкоц Л. П. Определение кинетики сорбции катиона металла пектином из цитрусовых / Л. П. Мыкоц, Н. А. Туховская, С. Н. Бондарь // Успехи современного естествознания. – 2010. – № 6. – С. 55 – 57.

118. Набухание крахмалопродуктов для хлебопекарной промышленности / С. Быкова, Е. Коптелова, И. Истомина, И. Афанасьева // Хлебопродукты. – 2000. – № 6. – С. 18 – 19.

119. Нанотехнології заморожених кріопаст із плодів та овочів з унікальними характеристиками – добавок для функціональних молочних продуктів / [Р. Ю. Павлюк, В. В. Погарська, С. М. Лосева та ін.] // Молокопереробка. – К., 2010. – Вип. 1. – С. 24–29.

120. Нанохимия в разработке новых средств трансдермального введения лекарственных препаратов / [В. В. Туров, В. М. Гунько, В. Н. Барвинченко и др.] // Доклады Национальной академии наук Украины. – 2010. – № 7. – С. 180 – 187.

121. Научно-практические аспекты производства джемов / З. А. Троян, Л. В. Лычкина, Н. В. Юрченко, Н. Н. Корастилева // Пищевая промышленность. – 2009. – № 7. – С. 46.

122. «Начинка для кондитерских изделий термостабильная»: ТУ 9129-023-52176062-2009

123. Нестерина М. Ф. Химический состав пищевых продуктов / М. Ф. Нестерина, И. М. Скурихина. – М. : Пищевая пром-сть, 1979.

124. Нечаев А. П. Пищевые добавки: учеб.-метод. пособие / А. П. Нечаев, А. А. Кочеткова, А. Н. Зайцев. – М., 1999. – 70 с.

125. Нечаев А. П. Пищевые добавки / А. П. Нечаев, А. А. Кочеткова, А. Н. Зайцева. – М. : Колос, 2001. – 256 с.
126. Нечаев А. П. Характеристики и использование крахмалов / А. П. Нечаев, А. А. Кочеткова, А. Н. Зайцев // Пищевые ингредиенты: сырье и добавки. – 1999. – №2. – С. 31 – 32.
127. Никитчина Т. И. Влияние солей кальция на гелеобразование биохимически модифицированных пектиновых веществ / Т. И. Никитчина, А. Т. Безусов // Харчова наука і технологія. – 2014. – № 4 (29). – С. 18 – 22.
128. Новое направление в создании пектинсодержащих пищевых продуктов / Л. В. Донченко, Т. И. Костенко, Н. С. Карпович, В. В. Нелина // Электротехнология пектиновых веществ : тез. докл. 3-го науч.-техн. семинара.: –К., 1992. – С. 52 – 53.
129. Обозна М. В. Дослідження жирнокислотного складу термостійкої молокової начинки з концентратом насіння кунжуту / М. В. Обозна, Г. Д. Любенко, Ф. В. Перцевой // Прогресивні техніка та технології харчових виробництв ресторанного господарства і торгівлі: зб. наук. пр. – Харків : ХДУХТ, 2015. – Вип. 1 (21). – С. 429 – 441.
130. Обозна М. В. Технологія сирного продукту замороженого з рослинними добавками: дис. ... канд. техн. наук : 05.18.16 / Обозна Маргарита Василівна. – Харків, 2012. – 374 с.
131. Окисне псування харчових продуктів і методи контролю якісних показників тваринних жирів навч.-метод. посібник / Л. В. Баль-Прилипка, С. Д. Мельничук, В. Й. Лоханська, Н. М. Слободянюк та ін. – К., 2011. – 130 с.
132. Органолептический анализ. Методология. Общее руководство [Электронный ресурс]: ISO 6658:1985 – режим дрступа: www.ars_russia.com.
133. Осипов А. Лучшее для термостабильной начинки: пектин АРА 311 / А. Осипов // Бизнес кондитерской и хлебопекарной индустрии. – 2013. – С. 43.
134. Остриков А. Н. Исследование форм связи влаги в топинамбуре методом дифференциально-термического анализа / А. Н. Остриков, И. В. Кузнецова, И. А. Зуев // Хранение и переработка сельхозсырья. – 2004. – № 7. – С. 33–35.
135. Остроумов Л. А. Исследование процессов замораживания плодов и ягод [Электронный ресурс] / Л. А. Остроумов, О. Н. Буянов, И. А. Короткий – режим доступа: <http://cyberleninka.ru/article/n/issledovanie-protsessov-zamorazhivaniya-plodov-i-yagod>.
136. Остроумов Л. А. Холодное консервирование твердых сычужных сыров / Л. А. Остроумов, О. Н. Буянов, И. В. Буянова // Пищевая промышленность. – 1998. – № 4. – С.78 – 79.
137. Оценка аминокислотного состава рецептурной смеси пищевых продуктов / П. А. Лисин, Е. А. Молибога, Ю. А. Канушина, Н. А. Смирнова // Аграрный вестник Урала. – 2012. – № 3 (95). – С. 26 – 28.
138. Павлоцкая Л. Ф. Пищевая биологическая ценность и безопасность сырья и продуктов его переработки / Л. Ф. Павлоцкая, Н. В. Дуденко, В. В. Евлаш. – К. : ИНКОС, 2007. – 287 с.

139. Павлюк Р. Ю. Вплив різних швидкостей заморожування на збереження БАР ягід / Р. Ю. Павлюк, Т. В. Крячко, В. В. Яницький // Прогресивна техніка та технології харчових виробництв, ресторанного та готельного господарств і торгівлі. Економічна стратегія і перспективи розвитку сфери торгівлі та послуг: Міжн. наук.-практ. конф., 19 травня 2011 р.: тези у 4 ч.: Ч. 1. – Харків: ХДУХТ, 2011. – С. 93 – 94.

140. Пат. 38920 Україна, МПК А23G 3/00. Спосіб отримання термостабільних начинок з фруктового повидла / Черевко О. І., Євлаш В. В., Чуйко Л. О., Дуденко Н. В., Павлоцька Л. Ф., Акмен В. О., Старчаенко О. Т.; Харк. держ. ун-т харч. та торг. – № u200810260; заявл. 11. 08.2008 опубл. 26. 02. 2009, Бюл. № 2. – 2 с.

141. Пат. 38921 Україна, МПК А23G 3/00. Спосіб отримання термостабільних начинок з овочів та повидла з гарбуза, збагчених на гемове залізо / Черевко О. І., Євлаш В. В., Чуйко Л. О., Дуденко Н. В., Павлоцька Л. Ф., Акмен В. О., Старчаенко О. Т.; Харк. держ. ун-т харч. та торг. – № u200810264; заявл. 11. 08. 2008; опубл. 26. 01. 2009, Бюл. № 2. – 2 с.

142. Пат. 39326 Україна, МПК А23G 3/00. Спосіб отримання термостабільних начинок з яблучного повидла та сухофруктів / Черевко О. І., Євлаш В. В., Чуйко Л. О., Дуденко Н. В., Павлоцька Л. Ф., Акмен В. О., Старчаенко О. Т.; Харк. держ. ун-т харч. та торг. – № u200810257; заявл. 11.08.2008; опубл. 25. 02. 2009, Бюл. № 4. – 3 с.

143. Пат. 45798 А Україна, МПК G 01 N 24/00. Спосіб визначення кількості вологи у харчових продуктах /Торяник О. І., Дьяков О. Г.; Харк. держ. акад. техн. та орган. харч.– № 2001074759; заявл. 09.07.2001; опубл. 15.04.2002; Бюл. № 4.

144. Пат. 70553 Україна, МПК А23L1/06, А23L1/05, А23L1/0524, А23L1/0526, А23G3/34, А23G3/36. Склад желевної термостабільної начинки / Корецька І. Л., Кір'якова Г. А.; Нац. ун-т харч. техн. – № 20031211173; заявл. 08. 12. 2003; опубл. 15. 10.2004, Бюл. № 10 – 3с.

145. Пат. 70554 Україна, МПК А23G3/00, А23L1/0524, А23L1/0526. Спосіб виробництва желевної термостабільної начинки / Корецька І. Л., Кір'якова Г. А.; Нац. ун-т харч. техн. – № 20031211174; заявл. 08.12.2003; опубл. 15.10.2004, Бюл. № 10 – 3с.

146. Пат. 73798 Україна, МПК А23L1/00. Термостабільна начинка для борошняних кондитерських виробів / Оболкіна В.І., Йовбак У.С., Камбулова Ю.В., Крапивницька І.О.; Нац. ун-т харч. техн. – № u201203118; заявл. 10.03.2012; опубл. 10.10.2012, Бюл. № 19. – 5с.

147. Перцевий М. Ф. Технологія напівфабрикату сирного структурованого з використанням концентрату ядра соняшникового насіння: дис. ... канд. техн. наук: 05.18.16 / Перцевого Миколи Федоровича. – Харків, 2013 – 420с.

148. Перцевой Ф. В. Термостійка начинка для кондитерських та кулінарних виробів на основі пектину / Ф. В. Перцевой, Я. С. Маркович, Г. Д. Любенко // Актуальні проблеми розвитку харчових виробництв, ресторанного

та готельного господарств і торгівлі: Всеукр. наук.-практ. конф. молодих учених і студентів, 25 квітня 2013 р. : тези доп. – Харків: ХДУХТ, 2013. – С. 31.

149. Пивоваров П. П. Теоретична технологія продукції громадського харчування. Ч. 1. Білки в технології продукції громадського харчування / П. П. Пивоваров. – Х. : ХДАТОХ, 2000. – 116 с.

150. Пивоваров П. П. Теоретичні основи технології громадського харчування : навч. посібник в 4 ч. Ч. 2. Вуглеводи в технологічному процесі виробництва продукції громадського харчування / П. П. Пивоваров, О. О. Гринченко. – Х. : ХДАТОХ, 2001. – 162 с.

151. Пивоваров П. П. Теоретичні основи технології харчових виробництв: навч. посібник в 4 ч. Ч. 4. Вода та її значення у формуванні фізико-хімічних, органолептичних показників сировини та продуктів харчування / П. П. Пивоваров, Д. Ю. Прасол. – Х. : ХДАТОХ, 2003. – 48 с.

152. Пилюян Г. О. Введение в теорию термического анализа. / Г. О. Пилюян. – М. : Наука, 1964. – 284 с.

153. Письменный В. В. Новая технология производства жележных изделий на малых и средних предприятиях / В. В. Письменный, Б. Н. Троцкий, А. Ю. Колесков // Пищевая промышленность. – 1999. – № 3.

154. Пищевые волокна в клинической практике / [В. Г. Радченко, И. Г. Сафроненко, П. В. Селивестров и др.] // Клинические перспективы гастроэнтерологии, гепатологии. – 2010. – № 1. – С. 21 – 28.

155. Пищевые волокна как важнейший фактор полноценного питания / А. Н. Лилишенцева, Н. И. Иващенко, М. С. Исаченко, О. В. Шрамченко // Пищевая промышленность: наука и технологии. – 2008. – № 1 (1). – С. 35 – 39.

156. Покровский А. А. Атакуемость белков протеолитическими ферментами / А. А. Покровский, И. П. Ертанов // Вопросы питания. – 1965. – № 3. – С. 38–45.

157. Польза пектина. [Электронный ресурс]. – Режим доступа: <http://tvoezdorovie21vek.ru/pravilnoe-pitanie/polza-pektina>.

158. Потапов Г. А. Особенности использования пектина при производстве кондитерской жележной продукции / Г. А. Потапов, П. В. Даниленко // Кондитерская промышленность. – 1993. – № 5.

159. Практическое руководство по физико-химическим методам анализа / под ред. Алимарина И. П., Иванова В. М. – М. : Изд-во Моск. ун-та, 1987. – 208 с

160. Практическая химия белка : [пер. с англ.] / [под ред. А. Дарбре]. – М. : Мир, 1989. – 623 с.

161. Прикладная ИК-спектроскопия / пер. а англ. Б. Н. Тарасевича, А. А. Мальцева; под ред. А. Смит. – М. : Мир, 1982. – 328 с.

162. Проблемы и перспективы отечественного рынка пищевых добавок [Электронный ресурс]. – Режим доступа: <http://dspace.nuft.edu.ua/jspui/bitstream/123456789/11295/1/Problems.pdf>.

163. Продовольственная безопасность и холодильная технология / [В. С. Колодязная, Е. И. Кипрушкина, Д. А. Бараненко и др.] // Вестник.– 2013. – № 1. – С. 24 – 28.

164. «Продукт молокосодержащий. Начинка молочно-растительная с ароматом ванили (термостабильная)»: ТУ 9142-003-72446492-09
165. Продукты пищевые. Методы выявления и определения количества бактерий группы кишечных палочек (колиформных бактерий) : ГОСТ 30518-97. – [Введ. 2001-07-01]. – К. : Госстандарт Украины, 2001. – 10 с.
166. Продукты пищевые. Метод определения дрожжей и плесневых грибов : ГОСТ 10444.12-88. – [Введ. 1990-01-01]. – М. : Изд-во стандартов, 1988. – 8 с.
167. Продукты пищевые и вкусовые. Методы культивирования микробиологических анализов : ГОСТ 26670-85. – [Введ. 1985-01-01]. – М. : Изд-во стандартов, 1985. – 10 с.
168. Производство и применение набухающих крахмалопродуктов для пищевых целей / А. И. Жушман, Е. К. Коптелова, В. Г. Карпов, С. Т. Быкова // Продовольственная индустрия юга России. Экологически безопасные энергосберегающие технологии хранения и переработки сырья растительного и животного происхождения: междунар. науч.-практ. конф.: материалы. – Краснодар, 2000. – С. 49 – 50.
169. Путилов Н. Н. О набухании зерен кукурузного и рисового крахмалов в водных суспензиях при нагревании / Н. Н. Путилов, С. Е. Траубенберг // Изв. вузов СССР. Пищ. технол. – 1964. – № 5. – С.41 – 44.
170. Пучкова Л. И. Лабораторный практикум по технологии хлебопекарного производства / Л. И. Пучкова – М. : Легкая и пищевая пром-сть, 1982. – 231 с.
171. Радешпиль Э. Техника и технология заморозки / Э. Радешпиль, Х. Зилафф, Х. Шлойзенер // Мясо и молоко. – 2008. – № 9.
172. Разработать предложения по унификации методов определения функциональных свойств растительных белков : отчет о НИР № 01850019372 / Всесоюз. науч.-исслед. ин-т жиров. – Л., 1985. – 45 с.
173. Разработка оборудования для исследования количественных и качественных характеристик пектиновых концентратов / Г. В. Дейниченко, Н. А. Афукова, З. А. Мазняк // Технологический аудит и резервы производства. – 2014. – № 3/5 (17). – С. 11 – 14.
174. Ребиндер П. А. Вязкость дисперсных систем и структурообразование / П. А. Ребиндер // Тр. совещ. по вязкости жидкостей и коллоидных растворов. Изв. АН СССР. – М., 1941. – С. 361 – 390
175. Ребиндер П. А. О формах связи влаги с материалом в процессе сушки / П. А. Ребиндер // Тр. Всесоюз. совещ. по интенсификации процессов и улучшению качества материалов. – М. : Профиздат, 1958.
176. Реологічні методи дослідження сировини і харчових продуктів та автоматизація розрахунків реологічних характеристик : навч. посібник / [А. Б. Горальчук та ін.]. – Х. : ХДУХТ, 2006. – 63 с.
177. Реометрия пищевого сырья и продуктов : справочник [под ред. Ю. А. Мачихина]. – М. : Агропромиздат, 1990. – 271 с.
178. Рогов И. А. Химия пищи: [учебник для студ. вузов] / И. А. Рогов, Л. В. Антипова, Н. И. Дунченко. – М. : КолосС, 2007. – 853 с.

179. Рогов И. В. Электрофизические методы в холодильной технике и технологии / И. А. Рогов, Б. С. Бабакин, В. А. Выгодин. – М. : Колос, 1996. – 326 с.
180. Ромоданова В. О. Лабораторний практикум з технохімічного контролю підприємств молочної промисловості: навч. посіб. / В. О. Ромоданова, Т. П. Костенко. – К. : НУХТ, 2003. – 168 с.
181. Руцков А. В. Холодильная техника и технология / А. В. Руцков. – М. : ИНФРА-М, 2000. – 286 с.
182. Санина Т. В. Вопросы регулирования структурно-механических свойств теста / Т. В. Санина, Е. И. Пономарева. – Воронеж : Воронежская гос. технол. акад., 1998. – 72 с.
183. Сарафанов Л. А. Пищевые добавки : энциклопедия / Л. А. Сарафанов; под ред. А. П. Нечаева – СПб.: Пищевая химия, 2004.
184. Сарафанов Л. А. Применение пищевых добавок в кондитерской промышленности / Л. А. Сарафанов. – СПб. : Профессия, 2007. – 304 с.
185. Свойства крахмала. [Электронный ресурс]. – Режим доступа: <http://biofile.ru/bio/19903.html>.
186. Седюкин В. К. Методы оценки и управления качеством промышленной продукции / В. К. Седюкин, В. Д. Дурнев, В. Г. Лебедев. – М. : Филинь: Рилант, 2000. – 328 с.
187. Сирохман І. В. Товарознавство крохмалю, цукру, меду, кондитерських виробів / В. І. Сирохман. – К. : Смакота, 1993. – 237 с.
188. Системные исследования технологий переработки продуктов питания / [О. Н. Сафонова, Ф. В. Перцевой, А. Л. Фощан и др.] ; под ред. О. Н. Сафоновой. – Х. : ХГАТОП и ХГТУСХ, 2000. – 200 с.
189. Системи управління безпечністю харчових продуктів : ДСТУ 4161. – [Чинний від 2003-07-01]. – К. : Держспоживстандарт, 2003. – 18 с.
190. Скурихина И. М. Все о пище с точки зрения химика: справ. Издание / И. М. Скурихина, А. П. Нечаев. – М. : Высш. шк. 1991. – 288 с.
191. Скурихина И. М. О методах определения содержания минеральных веществ в продуктах / И. М. Скурихина // Вопросы питания. – 1981. – № 2. – С. 10–15.
192. Соя. Польза и вред сои. Соевые продукты. Кому показана соя. [Электронный ресурс]. – Режим доступа : <http://www.citydoctor.ru>.
193. Справочник по гидроколлоидам / [под ред. А. А. Кочетковой и Л. А. Сарафановой] – СПб. :ГИОРД, 2006. – 536 с.
194. Структурно-механические характеристики пищевых продуктов / [Горбатов А. В., Маслов А. М., Мачихин Ю. А. и др].; под ред. А. В. Горбатова. – М. : Легкая и пищевая пром-сть, 1982. – 296 с.
195. Сухих Т. Н. Низкоэтерифицированные пектины в начинках для кондитерских изделий / Т. Н. Сухих, М. Н. Зыбин // Кондитерское производство. – 2005. – №5. – С. 36 - 38.
196. Сырье и продукты пищевые. Атомно-абсорбционный метод определения токсичных элементов : ГОСТ 30178-96. – [Введ. 1996-01-01]. – К. : Госстандарт Украины, 1998. – 16 с.

197. Сырье и продукты пищевые. Методы определения кадмия : ГОСТ 26933-86. – [Введ. 1986-12-01]. – М. : Изд-во стандартов, 1986. – 10 с.
198. Сырье и продукты пищевые. Методы определения меди : ГОСТ 26931-86: сборник.– [Введ. 1986-12-01]. – М. : Изд-во стандартов, 1986. – С. 41–54.
199. Сырье и продукты пищевые. Методы определения мышьяка : ГОСТ 26930-86: сборник. – [Введ. 1987-01-01]. – М. : Изд-во стандартов, 1987. – С. 34–40.
200. Сырье и продукты пищевые. Методы определения ртути : ГОСТ 26927-86: сборник. – [Введ. 1986-01-01]. – М. : Изд-во стандартов, 1986. – С. 14–28.
201. Сырье и продукты пищевые. Метод определения свинца : ГОСТ 26932-86: сборник. – [Введ. 1986-12-01]. – М. : Изд-во стандартов, 1986. – С. 55–63.
202. Сырье и продукты пищевые. Метод определения цинка : ГОСТ 26934-86. – [Введ. 1986-12-01]. – М. : Изд-во стандартов, 1986. – 9 с.
203. Тамова М. Ю. Создание композиционных натуральных структурообразователей / М. Ю. Тамова // Пищевые ингредиенты: сырье и добавки. – 2002. – № 2. – С. 80 – 81.
204. Тарасевич Б. Н. ИК-спектры основных классов органических соединений. Справочные материалы / Б. Н. Тарасевич. – М., 2012. – 55 с.
205. Теймурова А. Т. Розробка технології желевної продукції з використанням концентратів тваринних білків: дис. ... канд. техн. наук: 05.18.16 / Теймурова А. Т. – Х., 2010. – 315 с.
206. Технология кондитерского производства / [Е. И. Журавлева, С. И. Кормаков и др.]. – М. : Пищевая пром-сть, 1968. – 400 с.
207. Технология молока и молочных продуктов / Г. Н. Крусь, А. Г. Храмцов, З. В. Волокитина, С. В. Карпычев. М.: КОЛОСС – 2003. – 316 с.
208. Технология получения растительных масел и пищевых продуктов, обогащенных каротиноидами: Монография / Ф. В. Перцевой, Ю. А. Савгира, Н. В. Камсулина и др. ; под ред. Ф.В. Перцевого. – Х.: ХГАТОП, 2002. – 229 с.
209. Технология производства функциональных продуктов питания : учеб. пособие / [Л. В. Донченко, Л. Я. Родионова, Н. В. Сокол и др.]. – Краснодар : КубГАУ, 2008. – С. 29 – 41.
210. Технология пищевых производств / [Ковальская Л. П., Шуб И. С., Мелькина Г. М. и др.]; под ред. Л. П. Ковальской. – М. : Колос, 1999. – 752 с.
211. Торяник А. И. Молекулярная подвижность и структура водных систем: дис. ... доктора хим. наук / Торяник А. И. – Донецк, 1978. – 368 с.
212. Торяник А. И. Определение влагосодержания в пищевых продуктах методом ЯМР: метод. пособие для асп. / А. И. Торяник, А. Г. Дьяков, Д. А. Торяник. – Х. : ХГУПТ, 2003. – 20 с.
213. Трегубов Н. Н. Технология крахмалов и крахмалопродуктов / Н. Н. Трегубов. – М. : Легкая и пищевая пром-сть, 1981. – 471 с.
214. Троцкий Б. Н. Желирующий порошок для термостабильной начинки на основе вареного сгущенного молока / Б. Н. Троцкий, В. В. Писменный // Кондитерское производство. – 2005. – № 3. – С. 28 .
215. Троцкий Б. Н. Начинки для мучных кондитерских изделий / Б. Н. Троцкий, В. В. Писменный // Кондитерское производство. – 2005. – № 2.

216. Тужилкин В. И. Теория и практика применения пектинов / В. И. Тужилкин, А. А. Качеткова, А. Ю. Колеснов // Известия вузов: Пищевая технология. – 1995. – № 1, 2. – С. 78 – 81.
217. Усов А. М. Сульфитированные полисахариды красных морских водорослей / А. М. Усов // Успехи биологии химии. – 1979. – Т. 20. – 169 с.
218. Фаррар Т. Импульсная и Фурье-спектроскопия ЯМР / Т. Фаррар, Э. Беккер. – М. : Мир, 1973. – 163 с.
219. Филимонова Е. Ю. Применение общих принципов предохранения сырья от порчи при консервировании плодов облепихи / Е. Ю. Филимонова // Ползуновский вестник. – 2013. – № 4-4. – С. 104 – 108.
220. Фокс Г. Свойства и применение яблочного и цитрусового пектинов / Г. Фокс, Х.-У. Эндресс, А. Ю. Колеснов // Пищевая промышленность. – 1993. – № 3.
221. Фридрихсберг Д. А. Курс коллоидной химии: [для хим. спец. ун-тов] / Д. А. Фридрихсберг. – Л. : Химия, Ленингр. отд-е, 1974. – 351 с.
222. Харчова хімія / [В. В. Євлаш та ін.]. – Х. : Світ книг, 2012. – 504 с.
223. Химия и биохимия бобовых растений / под ред. М. Н. Запрометова. – М. : Агропромиздат, 1986. – 336 с.
224. Химический состав пищевых продуктов. Справочные таблицы содержания основных пищевых веществ и энергетическая ценность пищевых продуктов / ред. А. А. Покровский. – М. : Пищевая пром-сть, 1977. – 227 с.
225. Химический состав пищевых продуктов: справочник в 2 кн. Кн. 2. Справочные таблицы содержания аминокислот, витаминов, макро- и микроэлементов, органических кислот и углеводов / [под ред. И. М. Скурихина и М. Н. Волгарева]. – 2-е изд., перераб. и доп. – М. : Агропромиздат, 1987. – 360 с.
226. Хлеб «Таловский с пектином» / Т. Тертычная, А. Лукин, В. Рымарь, Н. Гвоздев // Хлебопродукты. – 2006. – № 3. – С. 32 – 33.
227. Хотимченко Ю. С. Энтеросорбенты для больных и здоровых / Ю. С. Хотимченко, А. В. Кропотов // Медико-фармацевтический вестник Приморья. – 1998. – № 4. – С. 99-107.
228. Хоффстейн М. Модифицированные крахмалы в современной разработке продуктов / М. Хоффстейн // Пищевая промышленность. – 1998. – № 8. – С. 66 – 67.
229. Чекулаева Л. В. Технология продуктов консервирования молока и молочного сырья / Л. В. Чекулаева, К. К. Полянский, Л. В. Голубева. – М. : ДеЛи принт, 2002. – 249с.
230. Черников М. П. Протеолиз и биологическая ценность белков / М. П. Черников. – М. : Медицина, 1975. – 231 с.
231. Черников М. П. Скорость гидролиза α -, β и χ -казеина трипсином и химотрипсином и влияние денатурирующих факторов на ферментативный гидролиз χ -казеина / М. П. Черников, Е. Я. Стан // Биохимия. – 1970. – Т. 35, № 3. – С. 463–469.
232. Чумак И. Я. Получение и исследование комплексных студней желатина и пектина с целью использования в общественном питании: дис. ... канд. техн. наук. Чумак И. Я. – М. – 1976. – 172с.

233. Шелепина Н. В. Применение растительных белков в пищевой промышленности [Электронный ресурс] / Н. В. Шелепина, А. В. Каверочкина. – Режим доступа: <http://orelgiel.ru/docs/monah/93hn.pdf>.
234. Шталь Е. Х. Хроматография в тонких слоях / Е. Х. Шталь. – М. : Мир, 1985. – 508 с.
235. Щербаков В. Г. Химия и биохимия переработки масличных семян / В. Г. Щербаков. – М. : Пищевая пром-сть, 1977. – 164 с.
236. A new view of pectin structure revealed by acid hydrolysis and atomic force microscopy / A. N. Round, N. M. Rigby, A. J. MacDougal, V. J. Morris // *Carbohydr. Res.* – 2010. – Vol. 345. – P. 487 – 497.
237. Achayuthakan P. Pasting and rheological properties of waxy corn starch as affected by guar gum and xanthan gum / P. Achayuthakan, M. Suphantharika // *Carbohydrate Polymers.* – 2008. – № 71. – P. 9 – 17
238. Allen K. W. In *Aspects of Adhesion* / K. W. Allen, D. J. Alner. – London : Univ. of London Press, 1969. – 11 p.
239. Analysis of changes the stare of water in thermoduric milk-containing filling / G. Lyubenco, M. Pohogih, A. Pak, A. Dyakov, M. Obozna, F. Pertsevov // *French journal of Scientific and Educational Research.* – 2014. – № 2 (12). – P. 142 – 151.
240. Analysis of Major Constituents in Seed Cells of *Aquilaria sinensis* / Da-Huang Chen, Pei-Luen Jiang, Tzyu-Rong Jinn at all. // *Journal of Food and Nutrition Research.* – 2014. -- Vol. 2. – № 1. – P. 34 – 39.
241. Anderson N. S. Evidens for a common stryctural pattern in the polysaccharide sulphates / N. S. Anderson N. C. S. Dolan, D. A. Rees // *Rhodophyuae II Nature.* – London. 1965. – Vol. 205 – P. 1060 – 1062
242. Austarheim I. Chemical and biological characterization of pectin-like polysaccharides from the bark / I. Austarheim B. E. Christiensen, I.K. Hegna // *Malian medicinal tree Cola cordifolia, Carbohydrate polymers.* – 2012. – Vol. 89. – P. 259 – 268.
243. Baek M. H. Effects of sugars and sugar alcohols on thermal transition and cold stability of corn starch gel / M. H. Baek, B. Yoo, S. T. Lim // *Food Hydrocolloids.* – 2004. – № 18. – P. 133 – 142
244. Bligh E. J. A rapid method of total lipid extraction and purification / E. J. Bligh, W. I. Dyer // *Canadian journal of biochemistry and physiology*– 1959. – Vol. 37, – № 8. – P. 911 – 917.
245. Blumich B. NMR at lowmagnetic fields. / B. Blumich, F. Casanova, S. Appelt // *Chemical Physics Letters.* – 2009. – № 477. – P. 231–240.
246. *Carbohidrate Chemistry for Food Scientists* / ed. Roy L. Whistler and James N. BeMiller. –USA: Eagan Press, 1997.
247. Comparisons between conventional, microwave- and ultrasound-assisted methods for extraction of pectin from grapefruit / H. Bagherian, F. Ashtiani, A. Fouladitajar, M. Mohtashamy // *Chemical Engineering and Processing: Process Intensification.* – 2011. – № 50 (11-12). – P. 1237 – 1243.

248. Daud Z. Pectin show antibacterial activity against / Z. Daud, M. Sura, R. Abdel-Massih // *Advances in Bioscience and Biotechnology*. – 2013. – № 4. – P. 273 – 277.
249. Different action patterns for apple pectin methylesterase at pH 7.0 and 4.5 / [J.-M. Denes, A. Baron, C. M. Renard et al] // *Carbohydrate Research*. 2000. – Vol. 327. – 385 – 393.
250. Dickinson E. Hydrocolloids as emulsifiers and the influence on the properties of dispersed systems / E. Dickinson // *Food hydrocolloids*. – 2003. – Vol. 17. – P. 25 – 39.
251. Eddy C. V. Near-infrared spectroscopy for Measuring Urea in Hemodialysis Fluids / C. V. Eddy, M. A. Arnold. // *Clinical Chemistry*. – 2001. – № 47. – P. 1279 – 1286.
252. Edwards B. Products and applications for emulsifying and gelling agents / B. Edwards // *Confections*. – 1998. – P. 26 – 28.
253. Enzymatic modification of pectin in ca-pectic gels / [A. Slavov, E. Bonnin, C. Garnier et al.] // *Bulgaria scientific papers*. – 2008. – Vol. 36, № 5. – P. 75 – 82.
254. Erlander S. R. Starch biosynthesis. II. The statistical model for amylopectin and its precursor plant glycogen / S. R. Erlander // *Starch / Starker*. – 1998. – № 50. – P.62 – 67.
255. Food Additive User's Handbook. – Canada: Edited Professional 1996.
256. Fu J.-T. Rheology and structure development during gelation of low-methoxyl pectin gels: the effect of sucrose / J.-T. Fu // *Food Hydrocoll.*– 2001– Vol. 15. – P. 93 – 100.
257. Haghghi M. General analytical schemes for the characterization of pectin-based edible gelled systems / M. Haghghi, K. Rezaei // *The Scientific World Journal*. – 2012.
258. Hudson B. J. F. New and developing sources of food proteins / B. J. F. Hudson. – London : Springer, 1994. – 369 p.
259. Gordon A. Towle Otto Christensen. Industrial Guma. Polysaccharides and Their Derivatives / A. Gordon // New York and London: Academic Press. – 1973. – P. 146 – 152.
260. Guerra M. J. Extraction of sesame seed protein and determination of its molecular weight by sodium dodecylsulfate polyacrylamide gel electrophoresis/ M. J. Guerra, Y. K. Park // *Journal of the American Oil Chemists Society*. – 1975. -- Volume 52. – Issue 3. – P. 73-75.
261. Kastner H. Structure formation in sugar containing pectin gels – influence of Ca²⁺ on the gelation of low-methoxylated pectin at acidic pH / H. Kastner, U. Einhorn-Stoll, B. Senge // *Food Hydrocoll.* – 2012. – Vol. 27. – P. 42 – 49.
262. Kim C. Rheological properties of rice starch-xanthan gum mixtures / C. Kim, B. Yoo // *Journal of Food Engineering*.– 2006. – № 75. – P. 120 – 128
263. Kirby A. R. Atomic force microscopy of tomato and sugar beet pectin molecules / A. R. Kirby, A. J. MacDougal, V. J. Morris // *Carbohydr. Polym.* – 2008. – Vol. 71. – P. 640-647.

264. Koh P. C. Microwave-assisted extraction of pectin from jackfruit rinds using different power levels / P. C. Koh, C. M. Leong, M. A. Noranizan // *International Food Research Journal*. – 2014. – № 21 (5). – P. 2091 – 2097.
265. Kohn R. Ion binding on polyuronates-alginate-pectin / R. Kohn // *Pure and Appl. Chem.* – 1995. – Vol. 52.
266. Kohn R. Binding of lead cations to oligogalacturonic acids / R. Kohn // *Collect. Czech. Chem. Comm.* – 1982. – Vol. 47.
267. Laemmli U. K. Cleavage of structural proteins during the assembly of the head of bacteriophage T4 / U. K. Laemmli // *Nature*. – 1970. – Vol. 227. – P. 680–685.
268. Luzio G. A. Determination of galacturonic acid content of pectin using a microtiter plate assay / G.A. Luzio // *Proc. Fla. State Hort. Soc.* – 2004. – Vol. 117. – P. 416-421.
269. Malovikova A. Binding cadmium cations to pectin / A. Malovikova, R. Kohn // *Collect. Czech. Chem. Comm.* – 1982. – Vol. 47.
270. Matia-Merino L. Effects of low-methoxyl amidated pectin and ionic calcium on rheology and microstructure of acid-induced sodium caseinate gels. / L. Matia-Merino, K. Lau, E. Dickinson // *Food Hydrocolloids*. – 2004. – Vol. 18, № 2.– P. 271–281.
271. Michel C. Extraction of pectines from sugar beet pulp / C. Michel, C. Mercier // *J. Food Sci.* – 1995. – Vol. 145.
272. Mikus L. Usage of hydrocolloids in cereal technology/ L. Mikus, L. Valik, L. Dodok // *Acta univ. agric. et silvic. Mendel. Brun.* – 2011. – Vol. LIX., № 5.– P. 325-334.
273. Novel hydrocolloids: preparation & applications – a review. / [M. Kapoor, D. Khandal, G. Seshadri et al.] // *Novel hydrocolloids IJRRAS*. – 2013. – Vol 16 (3). – P. 432 – 482.
274. O'Brien A. B. Gelation of high-methoxy pectin by enzymic de-esterification in the presence of calcium ions: a preliminary evaluation / A. B. O'Brien, K. Philp, E. R. Morris // *Carbohydrate Research*. – 2009. – Vol. 344, № 14. – P. 1818 – 1823.
275. Pangler K. Texturing of gum and gel articles using classic apple pectin / K. Pangler // *Food Market and Technol.* – 1993. – № 4. – P. 22 – 28.
276. Parker R. Aspects of the Physical Chemistry of starch / R. Parker, S. Ring // *Journal of Cereal Science*. – 2001. – Vol. 34. – P. 1 – 17.
277. Partially esterified oligogalacturonides are the preferred substrates for pectin methylesterase of *aspergillus niger* / [Alebeek G.-J. W. M., van Scherpenzeel K., Beldman G. et al] // *Biochemistry Journal*. – 2003. – Vol. 372. – P. 211-218.
278. Paulsen B. S. Bioactive pectic polysaccharides / B. S. Paulsen, H. Barsett // *Adv. Polym. Sci.* – 2005. – № 186. – P. 69 – 101.
279. Pectin: cell biology and prospects for functional analysis / W. G. T. Willats, L. McCartney, W. Mackie, J. P. Knox // *Plant Mol Biol*. – 2001. – Vol. 47. – P. 9 – 27.
280. Pectins and pectinases / H. A. Shols, R. G. F. Visser, A. G. J. Voragen // *Wageningen: Wageningen Academic Publishers*. – 2009. – Pt. 5. – P. 293 – 325.

281. Pertsevoy F. Technology specifics of heat-resistant milk contain stuffing that was frozen / F. Pertsevoy, M. Obozna, G. Lyubenco // *Ukrainian Food Journal*. – 2014. – Vol. 3, Issue 4. – P. 550 – 559.
282. Ptaszek P. Viscoelastic properties of maize starch and guar gum gels / P. Ptaszek, M. Grzeslik // *Journal of Food Engineering*. – 2007. – № 82. – P. 227 – 237.
283. Raini A. P. Low methoxyl pectins from lime peel / A. P. Raini, S. Ranganna // *J. Food. Technol.* – 1979. – Vol. 14. – P. 332 – 342.
284. Rees D. A. Conformation analysis of polysaccharides / D. A. Rees // *V. I. Chem. Soc. B.* – 1970. – № 5. – 877p.
285. Rees D. A. Mechanism of the formation of polysaccharide gels and networks / D. A. Rees // *Adv. Carbohydr. Chem. and Biochem.* – 1969. – Vol. 24. – 267p.
286. Rees D. A. Structure conformation and mechanism in the formation of polysaccharide gels and networks / D. A. Rees // *Advances in Carbohydrate Chemistry and Biochemistry*. – New York, 1969. – Vol. 24. – P. 267 – 332.
287. Relation between Rheological Properties of Pectin Gels and Pectin Fine Structure / [A. Strom, L. Lundin, E. Morris et al.] // *Annual transactions of the nordic rheology society*. – 2012. – № 20 – P. 159 – 166.
288. Renard D. The gap between food gel structure, texture and perception / D. Renard, F. Van De Velde, R. W. Visschers // *Food Hydrocolloids*. – 2006. – Vol. 20, № 4. – P. 423 – 431.
289. Rheological and macromolecular quality of pectin extracted with nitric acid from passion fruit rind / [M. H. Canteri, A. P. Scheer, C. Ginies et al.] // *Journal of Food Process Engineering*. – 2012. – № 35 (5). – P. 800 – 809.
290. Ridley B. L. Pectins: Structure, biosynthesis, and oligogalacturonide-related signaling / B. L. Ridley, M. A. O'Neil, D. A. Mohnen // *Phytochemistry*. – 2001. – № 57 (6). – P. 929 – 967.
291. Rinzler C. A. The new complete book of food: a nutritional, medical, and culinary guide / C. A. Rinzler, M. Kroger, J. E. Brody. – New York : Infobase Publishing, 2009. – 474 p.
292. Rose D. Nomenclature of the proteins of cow's milk. 3 revision / D. Rose, J. R. Brunner, E. B. Kalan // *J. Dairy Sci.* – 1970. – Vol. 53. – P. 1.
293. Sajilata M. G. Resistant starch – a review / M. G. Sajilata R. S. Singhal, P.R. Kulkarni // *Comprehensive reviews in food science and food safety*. – 2006. – Vol. 5, Issue 1. – P. 1 – 17
294. Slade L. Review – water and glass transition – dependence of the glass transition on composition and chemical structure – Special implication for flour functionality in cookie baking / L. Slade, H. Lavine // *J. of Food Engineering*. – 1995. – № 24. – P.431 – 509.
295. Souheng W. Polymer Interface and Adhesion / W. Souheng. – New York and Bael : Marcel Dekker, Inc., 1982. – 337 p.
296. Srikaeo K. Effects of sugarcane, palm sugar, coconut sugar and sorbitol on starch digestibility and physicochemical properties of wheat based foods / K. Srikaeo, R. Thongta // *International Food Research Journal*. – 2015. – № 22 (3) – P. 923-929.

297. The relationship between thermodynamic and structural properties of low and high amylose maize starches / [Matveev Y. I., Nieman C., Wasserman L. A. Et al.] // Carbohydrate Polymers. – 2001. – № 44. – p.151 – 160.
298. Thickening and Gelling Agents for Food / Ed. by Alan Imeson // Blackie Academic & Professional, UK. – 1994.
299. Thompson M. P. Nomenclature of proteins of cow's milk. 2 revision / M. P. Thompson, N. P. Tarassuk, R. Jenness // J. Dairy Sci.– 1965. – Vol. 48. – P. 159.
300. Yada R. Y. Proteins in food processing / R. Y. Yada // Abington : Woodhead publishing. – 2004.
301. Walstra P. Dairy science and technology. / P. Walstra, J. T. M. Wouters, T. J. Geurts // Marcel: CRC, Taylor & Francis. – 2006.
302. Whitney R. M. Nomenclature of the proteins of cow's milk. 4 revision / R. M. Whitney, J. R. Brunner, K. E. Ebner // J. Dairy Sci. – 1976. – Vol. 59. – P. 795.

Scientific and practical publication

Pertsevoy F.V.,
Gurskyi P.V.,
Ladyka V.I.,
Shylman L.Z.,
Simakova I.V.,
Yanchyk M.V.,
Lubenko G.D.,
Obozna M.V.,
Garntsarek B.Ch.

**TECHNOLOGY OF THERMOSTABLE AND FROZEN
FILLINGS WITH USING DAIRY RAW MATERIALS AND SESAME SEEDS
CONCENTRATE**

Monograph

Edited by Pertsevoy F.V., Gursky P.V.

Author's editorial

Subsc. to print jn 25.01. 2020. Format 60x841/16 Offset paper. Offset printing.
Conditional printed sheets. 6,38. Regional publishing of sheets 6,22.
Circulation of 300 copies. Order #1/2020

Publishing house LLC «Center for Social Agroinnovation of SSAU»
Russia, 410012, Saratov, Teatralnaya square,1