Розроблено та обґрунтовано технологію виробництва оливки структурованої з внутрішнім умістом олії оливкової капсульованої. В основі технології лежать методи структурування із використанням іонотропних полісахаридів. Розроблена технологія відноситься до технологій екструзійного формування харчової продукції у середовищі альгінату натрію з одержанням структурованих форм оливок, тобто імітованої їх форми. У результаті реалізації даного способу передбачається комплексна переробка оливкової сировини з одержанням декількох видів нової продукції – олії оливкової капсульованої, оливки структурованої та їх комбіновані форми. Продукт представляє собою капсулу у оболонці гелеутворювача з внутрішнім умістом пюре оливки чи продуктів їх переробки (мезга, пульпа), з рівномірно розподіленими капсулами олії оливкової (наповнювач структурованої оливки). Структурована оливка може вироблятися різного діаметру (d=6…18 мм), різного кольору, за різного співвідношення «внутрішній уміст – оболонка». Регулювання структурно-механічних та органолептичних показників досягається шляхом використання змішаного гелеутворення споріднених структуроутворювачів (альгінат натрію і агар). Модифікована агаром альгінова оболонка оливки структурованої дозволяє забезпечити високу кислотостійкість та стабільність продукції упродовж тривалого терміну зберігання. На підставі комплексу досліджень встановлено основні показники якості та безпечності нової продукції, умови та терміни зберігання.

Науковий і практичний досвід під час реалізації технології може бути перенесений на різні види плодово-овочевої сировини. Це дозволяє одержувати харчову продукцію із різною фізичною формою. Залучення до технологічного процесу малоцінних частин плодово-овочевої сировини дозволяє комплексно переробляти цю сировину, збільшуючи рентабельність і ефективність технологічних процесів. Технологія структурування, як метод технологічного впливу, дозволяє розширити асортимент харчової продукції та ефективно контролювати хімічний склад та харчову цінність структурованої продукції

Ключові слова: оливка структурована, олія капсульована, альгінати, капсулоутворення, пюре на основі оливки

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DEVELOPMENT AND SUBSTANTIATION OF THE TECHNOLOGY FOR PRODUCING STRUCTURED OLIVES CONTAINING THE ENCAPSULATED OLIVE OIL

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1. Introduction

The world market of structured food products is growing rapidly, which is proved by the number of new ideas and technological solutions for the creation of innovative products taking into consideration the latest trends and the gained scientific experience [1]. Scientific and practical interest in the problems of structure formation of food systems is high enough [2, 3]. It is related not only to ensuring high quality and targeted nutritional values of prepared structured products. Highly effective waste-free technologies of processing raw materials of different origin with high economic potential and profitability indicators are implemented today.

The technological level of processing olive raw materials for many countries has been determining the economic status of the region in the country. The percentage of annual consumption of olives, as well as olive oil, is increasing every year. At the same time, the competition among firms-manufacturers of food products from olive raw materials also increases. This prompted the search for innovative approaches to its processing. It is planned to expand the sale markets, including those in the eastern countries, due to the implementation of modern innovative technologies.

At the same time, the analysis of the structure of food consumption indicates its insufficient coefficient of consumption of vegetable products regardless of age, income, kind of activity, etc. The main causes of this imbalance include dietary inertness of most consumers to traditional products of vegetable origin. This is the result of insufficient range of starch-free plant products, economically unaffordable imported vegetable raw materials. Therefore, the creation of structured products based of olive puree, including that with the internal contents of encapsulated olive oil with different taste characteristics, will create a new assortment range of products from olives. Ensuring a high export potential of the new product will make it possible to eliminate nutritional imbalances, create new semi-finished products of a high degree of readiness for the food industry.

The relevance of integrated processing of olive raw materials is related to the introduction of highly effective waste-free technologies. Creation of high-end olive products will enable the satisfaction of the constantly growing demand for this type of products in terms of "quality" and "value".

2. Literature review and problem statement

Today, innovative activity is the fundamental basis of theoretical and analytical studies of the development of the food industry. The interaction of organizational, economic, financial and social conditions results in the dynamics of the advance of scientific and technical progress in the field of nutrition. Introduction of technologies of processing fruit and vegetable raw materials, including the structuring methods is becoming increasingly important with regard to the growth of the agricultural and industrial sector. At the same time, the growth of the market demand of consumers for imported products, including olive, makes this area attractive in both economic and marketing aspects. Consumer interest in the use of canned olive has significantly increased in recent years. In paper [4], it was shown that olive is widely used both as an independent product, and in the composition of food and culinary products. The assortment is presented mainly with canned olives with a pit, without it, dried, sun cured, tapenade with different taste characteristics and fillers.

The integration of Ukraine into the European Union extends the possibility of introduction of scientific research in the interests of the world community. Therefore, the development of technologies of product structuring based on olive raw materials as the product of mass consumption is a scientifically relevant and attractive process.

Structuring food raw materials is the process of formation of the product structure with the features of a solid body under the influence of such external factors as the concentration of formulation components, temperature, pH of the medium, ion power of the solution, etc. [5]. The formation of the texture of structured products is based on a wide range of physical and chemical processes, caused by the method of technological influence on the original raw materials and formulation composition of the product. According to scientific research [6], such technologies are based on the implementation of functional and technological properties of the included ingredients capable of structuring. In most cases, this implies the necessity of involving cross-linking agents in the technological production cycle, the nature of origin of which determines the ways, mechanisms and methods of forming the texture of the product with assigned physical-chemical and structural-mechanical indicators [7]. At its core, in the known world technologies of the imitated, structured and restructured food products, structure-forming agents are biopolymeric carriers of the structure, shape and consistency. In scientific terms, the nature of a structure-forming agent determines the matrix, which identifies the created product by merchandising and technological features [8, 9]. The structured system (simulated product) is represented by a cross-linked polymeric mesh, which is capable of holding water and is limited to swelling. In this case, subpolymeric units of the structured system are cross-linked by the chemical covalent crosslink (protein substances), coordinated bonds, salt bridges (ionotropic polysaccharides), hydrophobic bonds (protein gels) that associate with each other in the water solution [7]. Covalently cross-linked structured systems based on ionotropic polysaccharides belong to the gels of the first kind. Such systems are characterized by irreversible chemical and thermal stability, high indicators of resilience and relatively low elasticity. The structured system obtained from neutral polysaccharides, proteins (collagen) due to mechanical interlocking of molecule chains, hydrogen bonds, ionic bonds are thermally reversible. These systems that are very sensitive to ionic power, pH, and temperature are called physically created and belong to structured systems of the second kind. While a structural system of the first kind appear as a result of the implementation of chemical potentials, structured systems of the second kind appear as a result of temperature influence, respectively [10, 11]. The mechanism of structure formation of food products depends on the type of raw material, its chemical composition, origin, etc.

However, the interest in structural formation is associated not only with the capability to create a product-analogue with the use of the technological principles. This is related to ensuring high quality and targeted nutritional value of finished structured products. A separate segment of the world market for the structured products is represented by structuring technologies "simulated soft centered fruits" [12]. Structured cherry, currant, blueberries, and mountain cranberries are obtained by dipping fruit and berry puree or pulp into the shell of the gel that is based on calcium alginate. The lack of a boundary separating the phases between the structured basis and the shell of the "imitated" product does not make it possible to reproduce the morphological structure of natural samples. The authors of [13] developed the technology of production of structured cherry. The mix that contains cherry puree with sugar and sodium alginate was extruded in a bath of calcium salt to create a shell on the surface of droplets. Despite high taste advantages, the structured product is characterized by low characteristics by the "appearance" indicator. The obtained cherry "capsule" is easy to damage, which limits the range of technological processes of its usage.

Given the complex morphological structure of olive raw materials (peel – pulp – pit), the existence of the characteristic spherical shape of the product–analogue, the use of the existing structure-formation methods is not possible. There is the known method of integrated processing of olive [14]. According to the method, pits are removed and pulp is crushed sequentially to obtain olive oil (phase 1). Then, floating oil is removed using the thermo-extractor (phase 2). In the next phases, the pulp and oil liquid (alpachines) are treated with vapor, the pulp is dried getting the feed, enriched with protein. At phase 4, pulp is granulated and olive is extracted from dried alpachines using the solvent. The disadvantage of the method is that it is complex and multi-staged, it uses vapor treatment, technological methods, and extractants. In addition, the edible part of olive – the pulp – is used for manufacturing feeds, and olive oil is only a semi-finished product of the usual product form. The disadvantages of the method include technological complexity and stage complexity, which requires expensive equipment of manufacturing special premises, and special qualification.

The above led to the search for the combined ways of forming the structure of the product with the maximum approximated characteristics to natural olives. These technologies include the technologies of encapsulating hydrophilic systems, as well as encapsulation of the systems of hydrophobic origin. Capsule formation is the ideal technology for forming the texture of the spherical or oval product with the assigned physical-chemical and structural-mechanical indicators [3, 7]. Introduction of the technology of extrusive formation based on principle [12] in the medium of ionotropic polysaccharide of sodium alginate and the external diffusive gel formation [15] of the system enables creation of a structured olive, which reproduces the organoleptic and rheological properties of canned olives.

The technological combination of these two principles can trigger new technological effects. This will enable the production of food products with fundamentally new organoleptic and technological properties, to develop and implement technological cycles with the pronounced export orientation.

The innovative design is also based on the development of the method for integrated processing olive raw materials. The method implies obtaining thermally stable alginic capsules, some of which retain the inner content based on olive oils, and the others are based on pomace, pulp or fiber after oil extraction.

It was determined that the dynamics of introduction of innovations regarding the influence on olive raw materials is low. Innovations in this market do not appear. That is why the technology of extrusive formation (structuring) will make it possible to recycle in an integrated way the fruit flesh (pulp) and pomace (fiber) after removing oil and oil into food products with the predictable content of these components. The result of it is a reduction of operating and transport costs due to the removal from the traffic flow of the fruit components – pits and the parts that are of little nutritional value.

Moreover, no effective methods for integrated processing non-standard raw materials and those with reduced market value – unripe, overripe, beaten and soft – into the products with high nutritional value were identified. The use of this method made it possible to increase significantly the efficiency of processing and to create new food products that have new properties and are standardized by the content.

3. The aim and objectives of the study

The aim of this study is to develop the technology of structured olives based on oil pomace and pulp containing the encapsulated olive oil.

To achieve the aim, the following tasks were set:

– to study the effect of formulation components on the stages of extrusive formation of the technological mixture based on olive raw materials;

– to substantiate the parameters of the technological process of formation of the structured olive containing the encapsulated olive oil;

– to explore the basic quality and safety indicators of the developed products in the technological flow and during the storage.

4. Materials and methods for studying the technological process and quality and safety indicators of the structured olive

The subjects of the study included: aqueous solutions of AlgNa, olive-based puree with different content of dry substances, mixed gels based on AlgNa and agar, aqueous solutions of modified starch. In addition, the characteristics of semi-finished products of structured olive, finished product "Structured olive containing the encapsulated olive oil" were studied.

Olive puree was received by mechanical crushing until a homogeneous mass (N=<3.000 r/min).

Structural and mechanical properties of the olive-based puree were estimated in the displacement mode at constantly applied shear stress. The research into the share of reverse deformation in the general one that characterizes plasticity of the samples of olive-based puree was carried out in the mode of flat parallel displacement. Viscosity of AlgNa solutions and mixed systems, which were subject to encapsulation, was studied using the viscometer of stable stresses [17].

Dynamic lamination of the olive-based puree under different technological conditions was determined on the photoelectric concentration colorimeter PCC-2 [18] by measuring the ratio of the total luminous flux F_0^γ and luminous flux, which passed through the medium $\left(F^\gamma\right)$.

The general chemical composition of structured olives was studied according to the standard procedures. The weight fraction of moisture was determined according to Regulation No. 2568/91 of the Commission (EU) [20], acidity – according to EN ISO 660:1999, EN ISO 10539:2002 [20, 21]. The weight fraction of carbohydrates was studied using the polarimetric method [22], and the weight fraction of mineral substances was studied by burning the batch with subsequent mineralization [23]. The weight fraction of dry substances was established in accordance with EN ISO 662:2000 [24].

The samples for microbiological research and determining the microbiological indicators were prepared in accordance with Regulations No. 2073/2005 of the Commission (EU) of 15.11.2005 and EN ISO 5555:2001 [25, 26].

Structured olives containing the encapsulated olive oil were obtained by drip extrusion of the formulation mixture with the content of aqueous solution of $CaCl_2$ in the forming solution AlgNa [27].

5. Development and substantiation of the technology for producing structured olive containing the encapsulated olive oil

5. 1. Development of the technological model of formation of structured olive containing the encapsulated olive oil

The development of the technological model of production of structured olive is based on the combination of two stages of the capsule formation of the technological mixture. The first phase is obtaining encapsulated olive oil, which is achieved by means of extrusive formation of the "olive oil – AlgNa solution" system based on the "pipe in a pipe" principle in the solution of cross-linking salt [28]. At this approach, encapsulated olive oil, which is the semi-finished product for internal filling of the structured olive, is formed. The second stage is the direct encapsulation of the technological mixture, which is represented by the semi-finished product of encapsulated olive oil, puree and olive brine, flavor formulation components. In addition, thermotropic polysaccharides and salts of calcium are supplied to AlgNa medium in order to obtain a semi-finished product of structured olive. Then the technological operations aimed at getting the finished product with assigned quality and safety indicators are carried out.

The technological and consumer advantages of the new structuring method using the encapsulation methods that affect the quality of new products in the technological stream and during the storage were studied and identified:

– the use of the semi-finished product of olive oil in the encapsulated form makes it possible to prevent its emulsification during the technological process. Emulsification in this case can act as a disturbing factor during the structural formation due to the complications of Ca^{2+} diffusion at the volume of the formulation mixture. Oil in the emulsion composition is able to laminate, which can destroy the integrity of the structure of the finished product;

– the intactness of olive due to the existence of the theremotropic-ionotropic shell of the capsule makes it possible to prevent the direct contact with acids and salts of the technological mixture that makes it possible to retain and regulate the nutritional value of finished products;

– the implementation of the innovative approach of structural formation of food systems with obtaining the “capsule in a capsule” system makes it possible to create a unique structure (texture) of an olive with the features of colloidal stability during the declared storage period;

– this approach makes it possible to influence the organaoleptic indicators of the notion of “appearance”, “flavor”, “dimensional characteristics and geometry” and correct the nutritional value for each instance, packaging unit and batch.

Within the scientific research, it was necessary to create a structured olive with the indicators of quality and chemical composition that are maximally approximated to the canned olive. By the texture characteristics, the product is a body of olive (internal content) – a capsule in the form of the structured basis, the film-like surface of the capsule, which imitates the olive “skin”. The encapsulated olive oil that is evenly distributed in the volume of the structured olive is used as filler. It became apparent that this is a very complex structure of the product, which may be obtained due to ensuring the laminar flows of technological mixtures. The controllable break of a jet at the outlet of the head of the encapsulation extruder makes it possible to carry out structural formation in the forming AlgNa solution. Under these conditions, the encapsulated technological system should comply with the assigned structural-mechanical and rheological characteristics to ensure its fluidity.

The main component of the formulation mixture for encapsulation is olive puree at the different content of dry substances. According to the classification, which evaluates the behavior of the technological system under the influence of external forces, olive puree belongs to solid-liquid systems. Therefore, the provision of fluidity of the paste-like mass will be determined by the ratio of liquid and solid phases. In this case, an increase in the share of solid phase will lead to an increase in elastic characteristics and a decrease in plasticity in the technological flow and during the storage. Table 1 shows the deformation change (pliability, I, m^2/N) of olive-based puree over time at varying shear stress.

Table 1 shows that the pliability of olive-based puree depends on the value of applied stress, which is typical of solid-liquid bodies. The regularity of an increase in the value of pliability at a decrease in the content of dry substances indicates a fall in the share of reverse deformation in the total one, i. e. the plasticity of the studied mixture increases. It is necessary to note that there is no self-causing flow in this case. This means that the dilution of olive-based puree with a liquid will lead to self-causing flow and, accordingly, to decomposition of the flow into drops. It was analytically calculated that dilution of olive-based puree by 1.5 times makes it possible to increase the plasticity of the system by 1.4 times, but under these conditions, the maximum shear stress increases. This results into the drop retaining its shape, the liquid does not flow, which makes extrusion impossible.

Table 1

Pliability of olive-based puree in the mode of layer-parallel displacement at different content of dry substances (t=18±2 °C)

Content of dry substances, %	Value of stress, m^2/N						
	0	50	100	150	200	250	300
24	0.20	0.35	0.42	0.48	0.51	0.54	0.62
21	0.25	0.47	0.52	0.61	0.64	0.69	0.71
17	0.27	0.52	0.64	0.87	1.00	1.06	1.12
13	0.40	1.00	1.36	1.50	1.68	–	–
9	0.49	1.17	1.50	1.69	–	–	–

It was experimentally determined that the content of dry substances in the range of 15.0...20.0 %, with an average radius of distributed fractions of solid particles of olive puree $R_{es.}$=(15...20)×10^{-5} m makes it possible to obtain a dispersion. Fluidity of the dispersion fully complies with the modes of coaxial extrusion with subsequent retaining the texture characteristics of structured olive.

Based on [29], the feasibility of the introduction of the liquid medium into the composition of olive-based puree was proved, but on condition of ensuring the mono-dispersed decomposition of the mixture, i.e. controlled viscosity characteristics. The viscosity of the technological system must be in the range of $0.20<\eta<0.35$ Pa×s.

Taking into consideration our own previous research [30], it was determined that aqueous solution of modified starch at the concentration of C=0.5 % makes it possible to ensure viscosity interval η=(0.20...0.35) Pa×s.

Fig. 1 shows the influence of olive-based puree on the formation of effective viscosity of aqueous solution of modified starch.

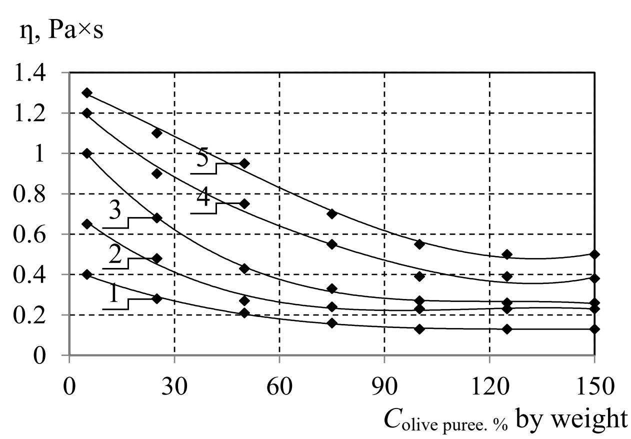

Fig. 1. Dependence of effective viscosity of aqueous solution of modified starch (C_{starch}=0.5 %) on concentration of olive-based puree, % by weight: 1 — 9; 2 — 13.0; 3 — 17.0; 4 — 21.0; 5 — 24.0, respectively

Analysis of Fig. 1 shows that an increase in the concentration of olive-based puree leads to a monotonous increase in the viscosity of the studied mixture. That is why we chose the interval of 23.0...25.0 % by weight as the rational concentration, which makes it possible to ensure viscosity of the mixture η=0.35 Pa×s, which is necessary to carry out the extrusion process.

It was established that the addition of agar (C_{agar}=0.8 %), cross-linking salts $CaCl_2$ and encapsulated olive oil does not affect the fluidity of the encapsulated mixture. That is why their concentration was selected taking into consideration the organoleptic indicators and the desired food value of structured olive.

For the purpose of determining sedimentation stability of modified starch, its behavior during the technological process was studied. Fig. 2 shows the dynamics of lamination of the technological system "olive-based puree – dispersed medium" on the concentration of modified starch.

Fig. 2 shows that the concentration of modified starch of 0.5 % makes it possible to ensure sedimentation stability during the time required for the organization and completion of the capsule formation process. Thus, we developed the formulation composition of the technological mixture based of olive raw material for extrusive formation with obtaining a spherical shape of the product.

The essence of the process is reduced to the fact that pits are removed from the flesh of olive raw material with obtaining pulp. Oil is extracted from the pulp by any known method, for example, by pressing or heating. This enables fractions to be separated and makes it possible to extract oil in the separated form and obtain the defatted fiber. The solutions of sodium alginate and calcium-containing salt are prepared simultaneously.

Pulp or fiber is mixed to produce their encapsulated form with the solution of calcium-containing salt. The obtained mixture is extruded in the solution of ionotropic polysaccharide of sodium alginate and, after curing, the encapsulated food form with the inner content of fruit pulp is obtained.

At the same time, the obtained oil and the solution of sodium alginate is subjected to coaxial extrusion in the drip top-down mode, according to the "pipe in a pipe" principle, where oil is fed along the inner tube and sodium alginate with the components is fed along the outer pipe. The mixture is fed to the aqueous solution of calcium-containing salt with obtaining encapsulated oil in the shell with the pulp.

The solution of sodium alginate can be prepared with the addition of defatted crushed pulp or crushed olive flesh, for example, obtained from the non-standard raw material or partially damaged mechanical raw material, or based on them, using them as a source of moisture for dissolving. After that, encapsulated oil, where the capsule shell includes crushed olive flesh or pomace.

The obtained data became the basis for the development of the technological circuit of manufacturing structured olive with inner content of encapsulated olive (Fig. 3). The sequence of the technological process is the formation of semi-finished products "Olive puree" – inner content, "Aqueous solution of gel-forming agents" – capsule shell, "Aqueous solution of modified starch with Ca^{2+}" – cross-linking agent, "Encapsulated olive oil" – filler, "Aqueous solution for coloring", "Brine".

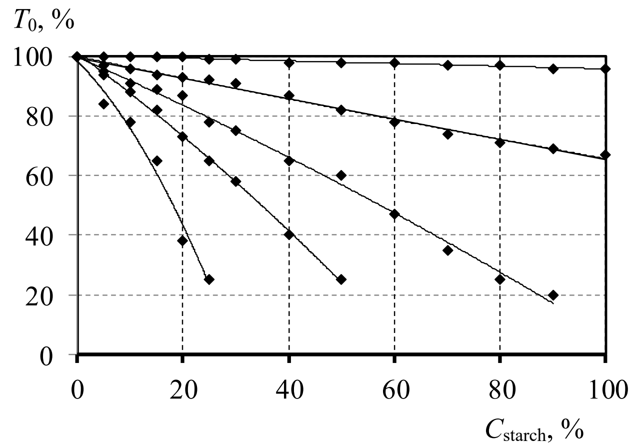

Fig. 2. Dynamics of lamination of "olive-based puree – dispersed medium" depending on concentration of modified starch, %: 1 – 0; 2 – 0.2; 3 – 0.3; 4 – 0.4; 5 – 0.5, respectively

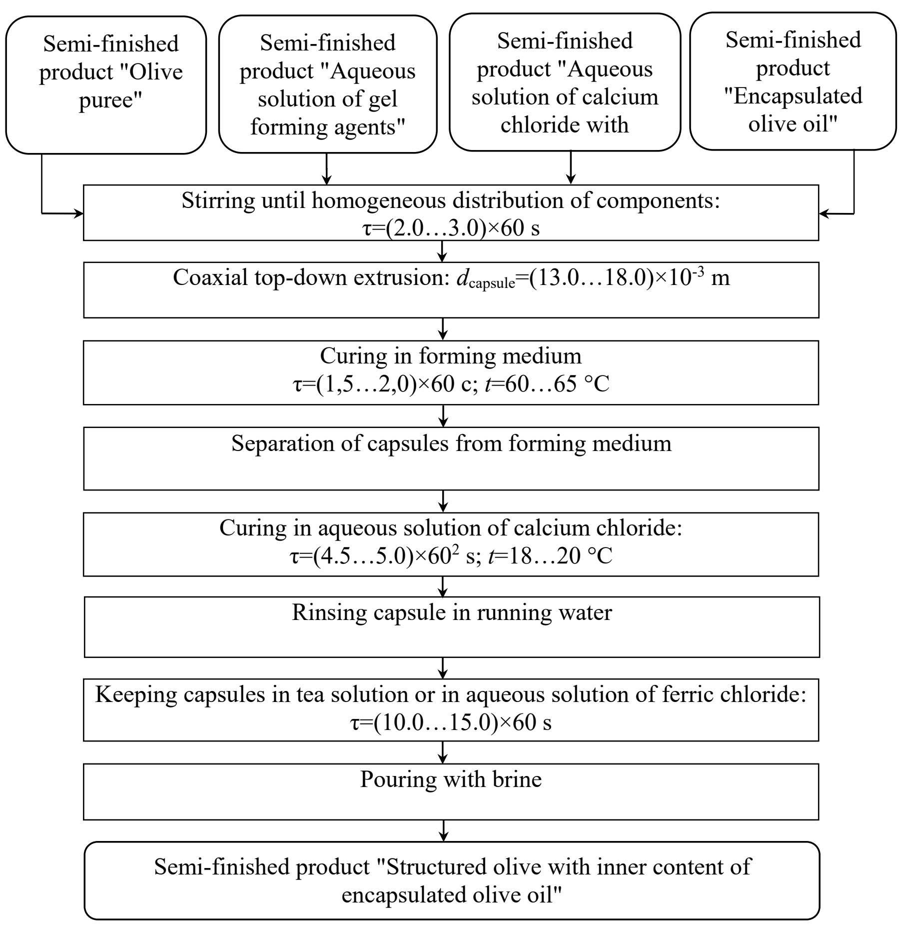

Fig. 3. Principal technological diagram of obtaining structured olive containing the encapsulated olive oil

Technological operations are performed in the following sequence: semi-finished product "Olive puree" is heated to the temperature of t=60...65 °C and stirred with semi-finished products "Aqueous solution of gel-forming agents" and "Encapsulated olive oil". The technological mixture is subjected to extrusion in the forming medium in a drip form (semi-finished product "Aqueous solution of Ca^{2+} and modified starch") with simultaneous formation of a spherical shape. The formed capsules can are kept in the forming medium for τ=(1.5...2.0)×60 s. Semi-finished product "Structured olive" is placed in aqueous solution of Ca^{2+} and kept for τ=(4.5... 5.0)×60^2 s until completion of the process of external gel formation. After this the semi-finished product of structured olive is subjected to painting in the tea solution or in $FeCl_3 \times 6H_2O$ until the moment of completion of ensuring the specified color and hue. Immersion of structured olives in the semi-finished product "Brine" is necessary to provide products with the desired taste and aroma.

The formation of the finished product is implemented by packaging in consumer package with subsequent pasteurization at the temperature t=80...85 °C for τ=(30...35)×60 s. Then the product is cooled to the temperature t=2...6 °C, labeled and placed in consumer package for subsequent transportation and sale.

5. 2. Studying the basic quality and safety indicators of the structured olives containing the encapsulated olive oil

In previous studies [17, 28], the aspects of mixed gel formation of the systems based on aqueous solutions of AlgNa and other polysaccharides, combined ways of structural formation (capsule formation) were studied. The example of the technology of production of the structured product of the spherical shape using the method of the extrusive formation of a technological mixture was developed on the example of the structured olive. The appearance of the structured olive with the internal content of encapsulated olive oil is shown in Fig. 4.

a *b*

Fig. 4. Physical appearance of the structured olive containing the encapsulated olive oil with a capsule diameter of, ×10^{-3} m: *a* – 18.0; *b* – 8.0, respectively

Structured olive containing the encapsulated olive oil is characterized by an elongated, ball-like shape and integrity of the structure without breaks. As far as the texture is concerned, the product is characterized by elasticity, plasticity and juiciness. Color, smell and taste of the structured olive were rated as natural, pure, without any outside smell or taste. The flavor balance and saturation correspond to natural canned green olives.

The chemical composition of the structured olive and its changes during storage were studied (Table 2). The content of dry substances increases by 2 % within 6 months of storage of structured olives. This is explained by insignificant syneresis of the structured system.

Table 2

Chemical composition of structured olive containing the encapsulated olive oil

Indicator	Term of storage, days		
	Freshly prepared	90	180
Weight fraction of dry substances, %	26.3±0.3	26.7±0.3	26.8±0.4
Weight fraction of protein, %	1.1±0.01	1.1±0.01	1.1±0.01
Weight fraction of fat, %	18.7±0.3	18.7±0.3	18.7±0.3
Weight fraction of carbohydrates, %	5.0±0.03	5.1±0.03	5.2±0.03
Food fibers, %	0.66±0.01	0.71±0.01	0.72±0.01
Weight fraction of ash, %	0.86±0.01	0.91±0.01	0.94±0.01
Caloricity (kcal)	192.3	193.1	193.5

An increase in titrated acidity by 1.16 times is observed, which is related to the destruction of the part of organic acids contained in the product (Table 3).

Table 3

Physical and chemical indicators of structured olives containing the encapsulated olive oil

Indicator	Term of storage, days		
	Freshly prepared	90	180
Weight fraction of dry substances, %	26.3±0.3	26.7±0.3	26.8±0.4
Weight fraction of sodium chloride, %	1.20±0.01	1.24±0.01	1.26±0.01
Titrated acidity, %	0.25	0.28	0.29
Mineral impurities, %	not found		
Outside impurities, %	not found		

Within 6 months of storage, it was found that there are no coli form bacteria, moulds and pathogenic microorganisms, the amount of aerobic and optionally-anaerobic microorganisms and yeasts is significantly lower than the indicators of the permissible content (Table 4).

Table 4

Results of research into microbiological indicators of structured olives containing the encapsulated olive oil

Indicator	Permissible levels, not more than	Term of storage, days		
		Freshly prepared	90	180
Number of aerobic and optionally-anaerobic microorganisms, CFU/g	1×10^4	2×10^2	1×10^3	3×10^3
Bacteria of e-coli group (coliforms), in 0.1 g	not permissible	not found		
S. aureus, in 1 g	not permissible	not found		
Pathogenic microorganisms, particularly bacteria of Salmonella genus in 25 g	not permissible	not found	not found	
Yeasts, CFU/g	25	not found	10	10
Moulds, CFU/g	1×10^2	not found		

According to the innovative idea, the technological parameters of the production of structured olives with the internal content of encapsulated olive oil were determined based on the obtained analytical and experimental data. The food, energy value and microbiological behavior were studied and their changes during storage within 6 months were explored.

6. Discussion of results of studying the technology of production of structured olive containing the encapsulated olive oil

The effective ways of integrated processing of non-standard raw materials and those with reduced market value – underripe, overripe, beaten and soft – into products with high nutritional value were proposed. The use of the structuring (encapsulation) method makes it possible to significantly increase the efficiency of processing and to create food products with new properties and standardized by the content of component. The technological principles of encapsulation of olive raw materials allow adjusting the size characteristics of an olive "capsule" with obtaining the diameters from 6 to 18 mm. The use of the effects of mixed gel formation makes it possible to ensure the specified textural parameters that are approximated to the indicators of a natural olive. In this case, the primary criterion for the choice of gel-forming agents was their relations, ability to form homogeneous gel structures and to resist synergistic effects during storage. Within the framework of scientific research, the expediency of using the mixed gel based on sodium alginate and agar was substantiated. It was established that the necessary condition of capsule formation is the provision of assigned viscosity characteristics of the capsulated formulation mixture. It was calculated that the dilution of olive-based puree by 1.5 times with ensuring the content of the dry substance of 15.0...20.0 % meets the criteria of extrusion. Appropriateness of the introduction of modified starch in the concentration of 0.5 % was proved. Under these conditions, the capsulated technological system acquires the assigned structural-mechanical properties, in addition to ensuring sedimentation stability. It was established that the use of different dyes of the film-like shell of the olive and corresponding olive puree makes it possible to extend the assortment and get the olives of pink and black color.

The implementation of a systematic approach allowed developing the fundamental technological circuit of production of structured olives with the internal content of encapsulated olive oil. The main organoleptic, physical-chemical and microbiological indicators of the new products were determined. It was established that structured olive has the stable quality and safety indicators within 6 months of storage at the temperature of 2...6 °C.

Integrated results of the study made the basis of the regulatory documentation TU 10.8-38128375-005:2018 "Structured semi-finished products based on canned olive raw materials" and TI to TU 10.8-38128375-005:2018 with the production of culinary production with the use of capsulated oil-fat semi-finished products.

7. Conclusions

1. Taking into consideration the tendencies in the development of food technologies and accumulated research experience in the field of ionotropic structuring of food systems and general demand of the society for the implementation of highly efficient technologies, the scientific-practical principles of the technology of structured olive were developed. The use of olive pomace, pulp and encapsulated olive oil, which ensures a high level of the waste-free technological process, makes it possible to get a fundamentally new structured product with high nutritional value.

2. Taking into consideration the structural-mechanical and physical-chemical indicators of the technological mixture and colloidal state of the components of the formulation mixture, the regularities of construction of the technological process of the production of structured olives were established. It was found that the use of olive-based puree at the concentration of dry substances of 15.0 ...20.0 %, modified starch of 0.5 % enables ensuring the viscosity of the formulation mixture η=(0.20...0.35) Pa×s. Such values of viscosity are an essential condition of the laminar flow of the formulation mixture and the formation of the target product with specific organoleptic indicators.

3. The basic physical and chemical indicators of structured olive, including the weight fraction of protein, fat, carbohydrates, and their change during storage were explored. It was proved that the storage of structured olive pasteurized in the airtight state at the temperature t=2...6 °C within 6 months does not lead to deviation from the standard physical-chemical and microbiological values.

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