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Редакційна колегія

Contents

Food technologies

Intensifying drying process with creation of functional plant compositions

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Abstract

Introduction. The process of drying agricultural raw products is associated with loss of bioactive substances by the products exposed to heat, light, oxygen, or pH medium. It is reasonable to enhance the table beet processing technology in order to achieve maximum betanin conservation at lower energy consumption.

Materials and methods. Table beets, rhubarbs, lemons, and tomatoes were dried at temperature of 50 to 100 ºC, air speed of 1.5 to 3.5 m/s, heat carrier water content of 7 to 15 g/kg, and layer thickness of 2 to 20 mm. The betanin content was determined via absorption spectra, using the optical density value at 540 nm wavelength. A differential microcalorimeter was used for measuring evaporation heat consumption.

Results and discussion. The effect of raw product pre-drying preparation was studied. With no preliminary preparation, the loss of betanin after drying reaches 66 %. The preliminary preparation technology we have developed includes boiling whole root crops with optimal selection of acid medium and allows us to reduce the betanin loss down to 6 %. Regretfully, the process requires large energy consumption. Low energy consumption pre-drying preparation method was developed for antioxidant raw products with thermal processing replaced by blending. The betanin loss, in this case, does not exceed 5 %. Optimal drying temperature of betanin-containing raw stock, after its preliminary processing, is 60 °C. It allows to keep up to 95 % of betanin. Specific heat consumption for water evaporation out of the developed table beet based antioxidant plant compositions, with addition of rhubarb and lemon, is less by 4 to 5 % as compared to the initial components.

Conclusions. Dependence of betanin loss in plant raw stock on the material temperature and composition components, in the course of their pre-drying preparation, was found. It was also found that water evaporation heat, for some antioxidant plant compositions developed, is less as compared to the initial raw stock components. It is reasonable to use the results for development of industrial thermal processing technologies used for functional food powder production.

Introduction

Production of food keeping its nutrients requires additional processing operations not used, so far, in modern technologies. One of the drawbacks of current table beet treatment methods is considerable loss (20 to 80 %) of biologically active substances.

Betalains contained in table beet are water soluble pigments classified earlier as anthocyans. They are found in cell vacuoles. However, betalains differ, structurally and chemically, from anthocyans and were never found in the same plant with the latter [1]. For example, betalains contain nitrogen in their structures that can never be found in anthocyans. Currently, it is known that betalains are indole compounds synthesized from tyrosine. Chemically, they differ from anthocyans as well as from flavonoids [2]. All betalains are glycosides containing sugar and pigments. Their synthesis is stimulated by light [3].

Two type of betalains exist: betacyanins that include pigments from red to violet and betaxanthins that may be yellow or orange. The betalain studied in most details is betanin otherwise called beetroot red. Betanin is glycoside hydrolysed to glucose and bethanidine. Bethanidine is glycosidic food pigment extracted from table beets [4].

Thus, table beet is an important raw stock for production various vegetable tinned food including those aimed for dietary and medioprophylactic use. But the main problem of its treatment is still retaining its natural color, even after thermal processing. Retaining table beet natural color (betanin) is the main purpose when creating beet-based antioxidant products.

To make table beet pigments more stable and to retain its color, it is recommended to add ascorbic, sorbic, citric, acetic, and lactic acids till reaching pH level of 3 to 5. Otherwise, apple or black chokeberry juices may be added, or else sauerkraut, or mashed ashberry. Besides, caramel syrup, sodium phosphate, or sodium chloride may be used as stabilizing additives. Vine seed extract, tea, oak acorn broth, cherry or Cornelian cherry extract show considerable stabilizing effect, too [5].

The stabilizing methods proposed enhance betanin stability, but they could not take their due place in the food and food-canning industries. That is why the search for new, efficient pigment preservation methods for table beets under processing is still going on.

Since table beets, while being stored, may lose up to 70 % of pigments, while after drying with high temperature heat carrier the loss may reach 85 %, we have developed a method of whole root crop hygrothermal processing in acid medium aimed to stabilize betanin by creation of optimized pH medium. The method allows retaining almost 96 % of betanin over a rather long period of storage [Yu.F. Snezhkin, Zh.O Petrova. Patent of Ukraine No. 92843. Method of Receiving Powdery Pigment from Table Beet]. However, such hygrothermal processing is power-consuming and takes much time, so a new method was developed based on creation of optimal pH medium. It has been proposed to create, prior to drying, functional compositions of the raw stock based on table beets with addition of lemons, rhubarbs, or tomatoes. [Yu.F. Snezhkin, Zh.O. Petrova, V.M. Pazyuk, K.M. Getmanyuk, O.P. Samoylenko. Patent of Ukraine No. 102358. Method of Receiving Beet-Lemon Antioxidant Pigment].

The aim of the study set forth in the proposed paper is development of table beet processing technology using the proposed method of creating plant raw stock functional compositions right prior to drying in order to reach maximum preservation of betanin and essential reduce of power consumption.

Materials and methods

To perform the study, parenchymal table beet, rhubarb, lemon, and tomato tissues were used along with their functional mixtures. Since betanin stabilizes in media with pH in the range of 3.2 to 4.0, table beet/rhubarb, table beet/lemon, and table beet/tomato compositions were taken in such proportions as to get required pH.

For drying the raw stock, an experimental drying stand was used having wide ranges of working parameters, such as 50 to 100 ºC for temperature, 1.5 to 3.5 m/s for air speed, 7 to 15 g/kg of dry air for heat carrier water content, 2 to 20 mm for layer thickness. The stand is equipped with a system of automatic collection and processing of information, like mass and temperature changes, based on a software application we have developed [6].

Within the development of the proposed preliminary processing method, the effect of preliminary plant raw stock processing on conserving betanin in the finished product and dehydration heat consumption was studied.

The betanin content was determined via absorption spectra, using the optical density value at 540 nm wavelength on the SF-26 spectrometer [7].

For determination of specific heat consumptions for water evaporation out of the functional plant raw stock in the drying process, the DMKI-01 differential microcalorimeter was used developed in the Institute of Technical Thermal Physics, National Academy of Sciences of Ukraine [Yu.F. Snezhkin, L.V. Dekusha, N.S. Dubovikova, T.G. Grishchenko, L.Y. Vorobyov, L.A. Boryak. Patent of Ukraine No. 84075. Calorimetric Device for Determination of Specific Heat of Water and Organic Liquid Evaporation out of Materials]. The device functioning is based on the Synchronous Thermoanalysis Method, that is simultaneous use of thermogravimetry and differential calorimetry. In the course of isotermic drying inside the calorimeter heat unit, the amount of heat used for water evaporation out of the material and the respective loss of mass by the sample are measured simultaneously. Current evaporation heat values for water evaporation out of a sample are determined after termination of the experiment using the formula:

$$r_i = \frac{\int_{\tau_i}^{\tau_{i+1}} Q(\tau)d\tau}{m(\tau_i) - m(\tau_{i+1})} \qquad (1)$$

r_i are specific evaporation heat values for the drying period since τ_i till τ_{i+1}, *kJ/kg*;
τ_i and τ_{i+1} are current times of the drying process, *s*;
$Q(\tau)$ is the heat flow inside the working chamber of the DMKI-01 heat unit as function of time, *J/s*;
$m(\tau_i)$ and $m(\tau_{i+1})$ are masses of the sample at τ_i and τ_{i+1} time moments, *kg*.

Results and discussion

For identifying the betanin stabilization effect reached, the betanin loss was studied in the course of table beet drying, at t = 60 ºC, with no preliminary preparation, with preliminary hygrothermal processing of whole root crops in acidulous medium, and with table beet composition with rhubarbs, tomatoes, and lemons in respective proportions required for creation of optimal pH medium (Fig.1). As can be seen on the figure, the betanin loss in the course of table beet drying with no preliminary processing is 66 %. Boiling whole root crops in acidulous medium with pH of 3.2 to 4 reduces the loss down to

6 %. Preliminary creation of the proposed table beet-based functional compositions minimizes the betanin loss in the course of drying down to 5 %.

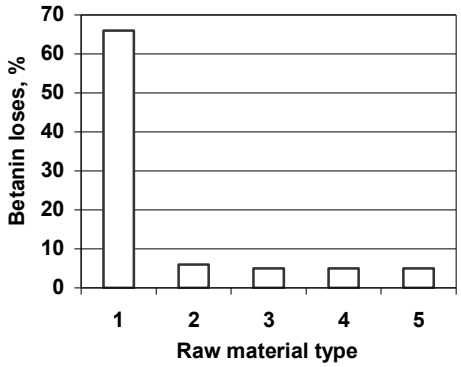


Fig. 1. Loss of betanin depending on raw stock and preliminary processing types:
1 – table beet with no hygrothermal processing;
2 – table beet after hygrothermal processing;
3 – table beet-rhubarb (blending);
4 – table beet-lemon (blending);
5 – table beet-tomato (blending).

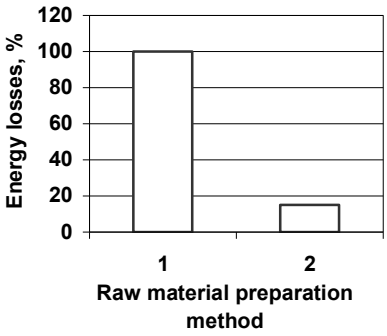


Fig. 2. Energy consumption for raw stock preparation prior to drying:
1 – hygrothermal raw stock processing;
2 – enhanced raw stock processing.

The process of the preliminary table beet hygrothermal processing (boiling whole root crops for 40 min.) requires a certain amount of energy. Taking this amount for 100 % (Fig. 2), we will have about 15 % of energy consumed for raw stock preparation via creation of respective pH medium by mixing minced table beets with minced tomatoes, lemons, or rhubarbs. Thus, the developed method of raw stock preparation for drying made it possible not only to minimize betanin loss in the course of drying down to 5 %, but also to reduce, by 85 %, the energy consumption for preliminary processing.

The study of dependence of betanin conservation in finished products of convective drying on heat carrier temperature has shown (Fig. 3) that maximum (94.0 to 96.5 %) conservation of betanin in table beet-based mixtures, as well as in table beets having passed hygrothermal processing in medium with pH of 3.2 to 4, takes place at heat carrier temperature of about 60 ºC. At temperatures of 40 to 50 ºC, the level of betanin conservation is in the range of 55 to 58 %. This is explained by the facts that table beets contain betalain oxidase enzyme, while the temperature of t = 40ºC and medium with pH = 2 to 3 are optimal conditions for detecting enzymatic activity of this enzyme. That is the cause of higher enzyme activity, essential betanin destruction and oxidation in minced table beets at temperatures of 40 to 50 ºC. At higher temperatures of 60 to 100 ºC, the percentage of retained betanin is gradually reduced returning to 50 % at the heat carrier temperature of 100 ºC. The level of betanin conservation in unprocessed table beets fluctuates around 30 % at the heat carrier temperature of 40 to 80 ºC, while in case of raising the temperature to 90 to 100 ºC, the percentage of betanin conservation drops down to 24 to 16 %.

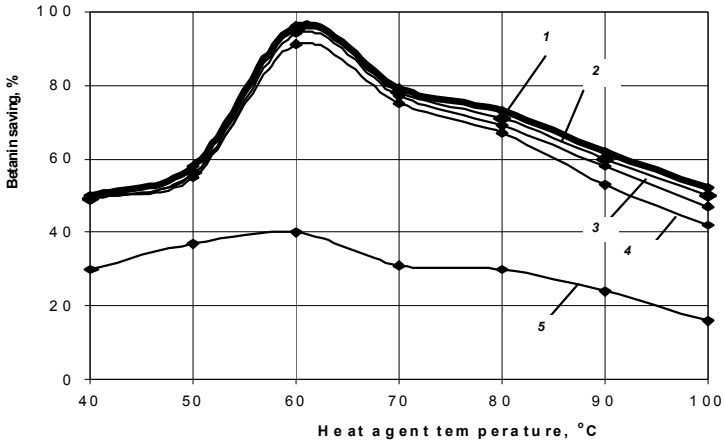


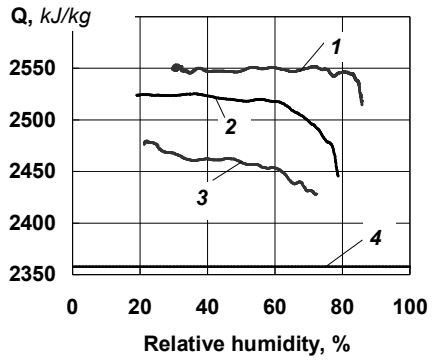
Fig. 3. Dependence of betanin conservation on drying temperature in various types of raw stock and with various preliminary processing.

1 – hygrothermal table beet; 2 –table beet-rhubarb (2:1); 3 – table beet- lemon (3:1); 4 – table beet-tomato (3:1); 5 – unprocessed table beet.

Thus, drying the mentioned table beet-based functional compositions, as well as table beets after hygrothermal processing, makes it possible to reach considerable rise of betanin conservation as compared to drying fresh table beets. Analysis of the betanin conservation results allows to come to the conclusion that the best betanin conservation is reached with convective drying at the heat carrier temperature of 60 ºC. I.e., drying compositions at 60 ºC is optimal according to qualitative indicators.

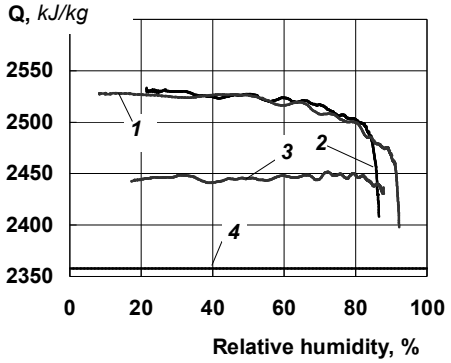
When calculating energy consumption for the drying process, it is necessary to know not only the process duration but also specific heat consumption for water evaporation. The practice of drying large number of complex plant materials shows an essential difference of actual heat consumption values required for water evaporation out of such materials as compared with the case of clean water evaporation [8]. Since energy consumption growth when drying plant materials is associated with difficult penetration of cell membranes by water and complicated remove of water interacting with soluble molecules of cellular fluid and material frame molecules, it would be important to study the effect of creating functional compositions of plant raw stock on the specific heat of its evaporation.

The drying process was taking place inside the DMKI-01 heat unit, at the temperature of 60 ºC which was optimal according to qualitative indicators. The results are shown on Fig. 4. The air (heat carrier) velocity and humidity values are shown in figure subscriptions.



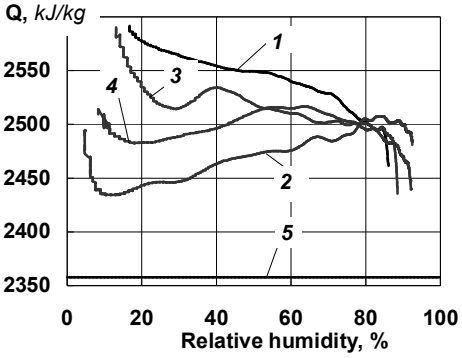
t = 60 ºC, v = 0.4 cm/s, d = 6.5 g/kg
1 – table beet; 2 – lemon; 3 – table beet-lemon (3:1); 4 – water

A



t = 60 ºC, v = 0.8 cm/s, d = 10 g/kg
1 – table beet; 2– rhubarb; 3 – table beet-rhubarb (2:1); 4 – water

B



t = 60 ºC, v = 0.8 cm/s, d = 5 g/kg
1 – table beet; 2 –tomato; 3 – table beet – tomato (3:1); 4 – table beet – tomato (1:3); 5 – water.

C

Fig. 4. Comparison of water evaporation heat values for table beet-based antioxidant raw stock with lemons (A), rhubarbs (B), and tomatoes (C).

Fig. 4 A shows that the heat of water evaporation out of table beet/lemon mixture exceeds by 4 to 5 % the clear water evaporation heat and is less, by the same value, as compared to the heat of water evaporation out of unmixed table beet and lemon. The same picture is observed for heat of water evaporation out of the table beet and rhubarb mixture (Fig. 4 B). We suppose that mixing pieces of minced table beet with tissues of rhubarbs and lemons, like the previous table beet hygrothermal processing, causes some changes in chemical content of the composition and destruction of cell membranes by organic acids. The changes, in this case, cause reduce of plant tissue water capture properties and reduce heat consumption for water evaporation out of these tissues by 4 to 5 %. That is, the effect of mixing different plant tissues was not just averaging heat consumption and water

evaporation out of individual components, as might be expected. Instead, a synergy effect was observed.

Fig. 4 C shows water evaporation heat values for tomatoes, table beets, and table beet/tomato compositions in comparison with one another and the clear water evaporation heat. As can be seen, the values of specific evaporation heat consumption for the table beet/tomato mixture (3:1 and 1:3) are between respective values for table beet and tomato individual tissues. That is, in this case, the mixture dehydration resulted in sum of the component dehydrations, according to the additive rule, instead of general reduce of evaporation heat consumption as in the cases of the table beet/rhubarb and table beet/lemon compositions. However, we managed to reach the effect of maximum retaining of both table beet and tomato colors in the final product. Moreover, their colors even became somewhat enhanced, more bright. We may suppose that the changes having occurred in the raw product after creation of the table beet/tomato composition were sufficient for conservation of table beet betanin and tomato licopin in the drying process but evidently are not sufficient for reducing water capturing.

Conclusions

Preliminary preparation of betamin-containing plant raw stock via creation of functional compositions with selected component proportions makes it possible not only to stabilize the native raw material components but also to reduce the drying period duration thanks to exclusion of rather long-time preliminary hygrothermal processing in acidulous medium.

The optimal drying temperature equal to 60 ºC was found experimentally for preliminarily processed betanin-containing raw stock (table beets) allowing to retain up to 95 % of betanin.

It was found that values of specific heat consumption required for evaporation of water out of the antioxidant plant compositions developed based on table beets with addition of rhubarbs and lemons are less by 4 to 5 % as compared to the initial components. The additive rule is not met for the specific heat of waster evaporation out of a mixture of various substances thanks to changes in the initial component plant tissues and creation, on the preliminary processing step, of an exactly new material to be dried.

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The potato chips and dry mashed as products of potato rational processing

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Abstract

Introduction. The percentage of potato processing for food products in the former Soviet Union decreased to 1%, at the same time in some countries of Europe and the USA the share of potato processing is 60-80%. Numerous works have shown the economic feasibility of potato processing for food products.

Materials and methods. In laboratory and industrial conditions of the open stock company «Mashpishcheprod» (Maryina Gorka, Minsk region, Belarus) researches have been conducted on increase of efficiency of technological processes potato processing. Sampling, preparation and conducting of tests were performed by standard and special methods of analysis.

Results and discussion. Potato varieties suitable for the production of dry mashed potatoes and potatocrisps have been determined, acclimatization before processing ensures minimumthe content of the reducing sugars, which provide high quality of the finished product. Studies have shown that the process of kneading potato at temperatures close to cooking temperature is optimal, in which the process of destruction cells is hardly taking place. Pneumatic dryers for drying boiled potato provide high product quality due to the low temperature of heating and short contact of a powdered product with a drying agent. However, the contents of damaged cells in the finished product do not exceed 1.3-2.6%. The optimum modes and parameters of potato crisps production have been defined, the processes of cutting, blanching, treatment with salt, drying and roasting have been scientifically grounded, that provide a finished product with fat content not more than 27.7%.

Conclusion. Economic expediency of processing the following varieties of potato Desire, Temp, Synthesis for dry mashed potato and potato crisps has been proved. The processes of kneading and drying potato are decisive stages of the processing, because they determine the number of destroyed cells in the finished product. Optimal parameters of production technology of potato crisps have been scientifically grounded.

Introduction

Condition of industrial potato processing in Eastern Europe is very deteriorated. Percentage of potato processing decreased to 1%. In Europe and the U.S. part of the potato processing is 60-80%, and the range of potato products increased from 10-15 to 28-30 titles. Common potato products are dried mashed as granules and chips from fresh potatoes. Scientific development of food production of potatoes showed the economic feasibility of potato processing primarily on chips and dried mashed potatoes.

The advantages of potato processing:

- Improving the nutritional value
- Elimination of losses during storage of potatoes
- Reducing containers for storage and transport
- Rational use of waste
- Improvement of working conditions

Materials and methods

In laboratory and industrial conditions of the open stock company «Mashpishcheprod» (Maryina Gorka, Minsk region, Belarus), where these products are produced, studies have been conducted to refine the scientific and practical fundamentals of technologies of dry mashed potato and potato crisps.

Sampling, preparation and conducting of tests were performed by standard and special organoleptic, physical and chemical and microbiological methods of estimation and the analysis of properties of raw materials and finished products. Starch content has been determined by Evers'method, maintenance of the common and reducing sugar byBertran'smethod; fatty acid composition of vegetable oils – by the method of gas chromatography. Mass fraction of fat in potato crisps has been determined by the chromatography method, the contents of protein – Kjeldahl's method.

The obtained results of the research have been described by the arithmetic mean value, which has been determined from the three parallel experiments under 3...5 times repetition of the measurements. The experimental data have been processed by the methods of mathematical statistics using standard computer programs.

Results and discussion

For the experiments widespread potato varieties of Belarusian and Ukrainian selection with the following physical and chemical parameters of quality [1] have been selected. They arepresented in table 1.

Table 1

Indicators of the quality of potato varieties

Potato varieties	The content of dry substances, %	Starchcontent, %	Reducing sugars content, %
Synthesis	23,8±0,1	21,2±0,5	0,10±0,02
Desiree	22,1±1,0	21,0±0,5	0,13±0,03
Temp	21,5±0,1	20,5±0,5	0,12±0,03

These varieties are the most suitable for the production of dry mashed potato and crispsdue to their orbicular-oval shape, shallow groundwater buds on the surface of the lower content of reducing sugars and high solids content.

It has been established that intensive assimilation of reducing sugars occurs during the storage, especially at low temperatures and the nature of assimilation of reducing sugars in the tubers at a temperature of 2...4°C has clearly expressed varietal peculiarity [2] (Fig. 1).

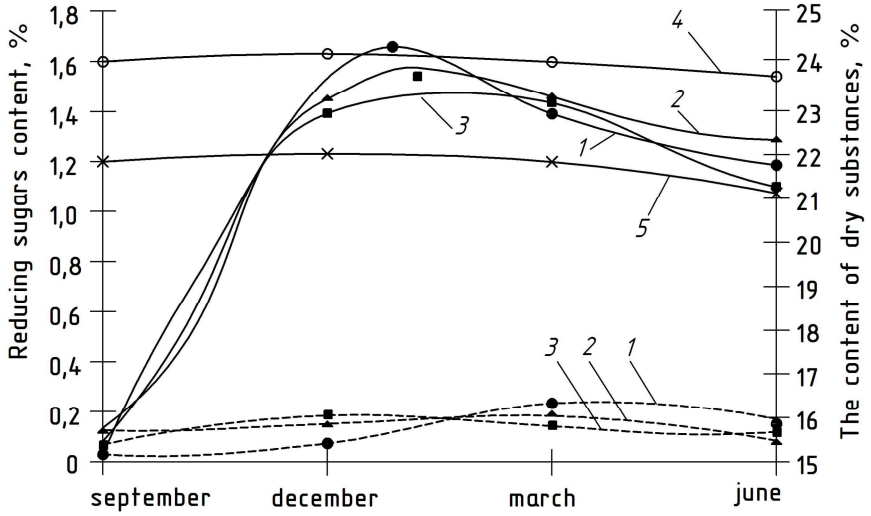

Fig. 1. The character of changes of dry substances and reducing sugars in the tubersduring storage:

Reducing sugar:
——— storage temperature 2...4 ºC
-------- storage temperature 6... 8 ºC
Varieties: 1 - Synthesis; 2 - Desire; 3 – Temp

Dry substance:
4 - Synthesis; 5 - Temp

The modification of the contents of reducing sugars in potatoafter acclimatization for 25 days after its cold storage has been investigated (table 2), while the content of reducing sugars in potato greatly reduces. Therefore acclimatization should be not less than for 20 days at a temperature of 15...20°C, regardless of potato varieties that provides the minimum content of the reducing sugars, the most acceptable for processing. After conducting acclimatization all subjects potato varieties provide good quality products (table 3). The quality of fried products has been determined on a scale.

Table 2

Changes of reducing sugars content in the tubers and the quality of potato crisps during acclimatization

Variety	Duration of acclimatization, 24 hours									
	0		10		15		20		25	
	%	mark	%	mark	%	mark	%	mark	%	mark
Synthesis	0,54	3,7	0,40	4,0	0,23	4,8	0,12	7,1	0,12	7,1
Temp	0,57	3,5	0,41	3,9	0,24	4,7	0,14	6,9	0,13	6,9
Desiree	0,48	4,0	0,38	4,1	0,21	5,0	0,17	6,5	0.17	6,5

Table 3

Impact of acclimatization on the content of reducing sugars in the tubers and the quality of potato crisps depending on the variety and period of storage

Variety	September		Storage temperature 2...4° C					
			After acclimatization					
			Reducing sugars content, %			Quality of potato crisps,mark		
	Reducing sugars content, %	Quality of potato crisps, mark	*December*	*March*	*June*	*December*	*March*	*June*
Temp	0,12±0,05	8,0	0,14±0,02	0,14±0,03	0,16±0,02	6,2	7,2	7,2
Desiree	0,13±0,04	7,9	0,17±0,02	0,17±0,01	0,16±0,02	6,0	6,5	8
Synthesis	0,10±0,02	8,7	0,12±0,02	0,14±0,02	0,15±0,01	6,7	7,3	6,7

It is seenfrom table 3 and figure 1 that the character of change in the tubers of reducing sugars when t = 2-4°Chas varietal characteristics, but the content of dry substance does not depend on the length of storage and depends on the source of their content in the tubers.
Increase in the content of dry substances in potato of 1% increases the profitability of processing of 10-20%. In addition, potato should have an insignificant quantity of reducing sugars (not more than 0.25) and a property not to collect them during prolonged storage of tubers. High content of sugars causes a decrease in the quality of the finished product as a result of leaking melanoid reactions between reducing sugars and amino acids. This forms dark-colored substances that cause darkening of the product, deterioration of its taste, being boiled soft, swelling. The researches concerning the determination of the number of destroyed cells potato tubers have been madeto clarify the scientific and practical basis for the technology of potato processing into dry mashed potato.
Received data are displayed in table 4.

Table 4

Cell destruction of mashed potato duringthe processing of tubersin different ways

Stages of the technological process	Number of destroyed cells, %
Blanching	0,1-0,2
Cooking	0,1-0,2
Kneading at different temperatures 80 ° C 40 ° C 20 ° C 10 °	2,1 11,8 32,5 37,8
Drying on contact monorolled dryers	4,5-5,0
Air conditioning of the product with the 2-stage pneumatic dryer	0-0,1

Microscopic examination of tissue boiled potatoes [3] and the data from table 4 have shown that large swelling of corn starch completely filled the cells and all the walls of the cells remained intact (whole) after cooking. Potato research, kneaded at temperatures close

to the temperature of boiling, suggests that the division of cells is easy and damage to cell walls is insignificant. However, withdecrease in temperatures during the kneading,the process of cell destruction increases. So, lowering the temperature of kneading with from 80° to 10°Chas caused 18 times increase of the percentage of destroyed cells from 2.1 to 37.8.

The most important for obtaining high-quality dry mashed potato plays drying, when it is unacceptable to change the color of the product and its natural organoleptic properties which may occur at the interaction of amino acids and sugars, and a drying agent should have a temperature at which caramelization and destruction of potato cells would not happen. Various methods are usedfor drying mashed potato, but in recent year two main methods of drying are used:drying on contact monorolled dryers and air conditioning with the pneumatic dryer. A great advantage of using pneumatic dryers is obtaining a high quality product, which is achieved due to the low temperature of product heating and short contact of the powdered product with a drying agent, the possibility to adjust the temperature and the duration of the process. The number of destroyed cells on monorolled dryers is 5.7-7.4 %, and pneumatic is only 0-0.1 %, which affects the quality of the finished product (table 5).

Table 5 shows that the use of pneumatic dryers with soft modes of drying and conducting air conditioning of the product provides the obtaining of a dry mashed potato in the form of granulate, which favourably differs from the flakes on the duration of the recovery, bulk density, the number of destroyed cells that express the stickiness of the product, as well as the amount of liquid that is added for the recovery.

Table 5

Comparative indicators of quality of dried mashed potato

Name of indicators	Product characteristics	
	Flakes	Granulate
Exteriorview	Dry bulk product in the form of plates	Dry bulk powder product
Consistency of reconstituted mashed	Homogeneous characteristic of mashed potatoes, expressed stickiness	Homogeneous characteristic of mashed potato, without the expressed stickiness
Durationofrecovery, min	2-3	1-2
Bulkdensity, g/dm3	200-300	700-800
Sizeofparticles, mm	0.8-10,0	Not more than1.0
The quantity of liquid in one part by weight of dry product, parts by weight	4,0-4,5	5,5-6,0
Number of destroyed cells,%	5,7-7,4	1,3-2,6

While studying the quality of potato crisps, the influence of water temperaturethat was supplied to the cutting process, has been studied. It has been established that with increase of water temperature the surface petals potato becomes smooth, oil absorbing abilitydecreases, they evenly absorb oil, and the resulting product has on the whole the surface of the same color and a pleasant taste. Oil absorbing ability decreases as largely retained the integrity of cells unlike petals with a rough surface. The optimum water temperature is 45... 50°C.

Petals were washed and blanchedto improve the quality of finished products. Blanching was a minute processing of petals potato with hot water. It should not give stickiness to theproduct, and it is necessary to reduce the content of reducing sugars and inactivation of enzymes that contributes to the quality of fried products. In our case a blancher does not perform technological functions as during the production of dry mashed potato, where the blanching process takes place within 10...20 minutes and is required for the hydration of starch grains. [4]

While studying the process of osmotic dehydration it has been shownthat with increasing concentration of salt solution there is an increase in the number of dry substances in the wings of a potato and reduction of fat in the potato crisps.

So, during the process of osmotic dehydration of aqueous solutions of salts from 3 to 12% of the amount of dry substances increased from 18.5 to 22.3% (potato variety - Temp, 10.8 cm). The fat content in the final product significantly reduced: from 35.8% to 31.2% (Fig. 2).

Studies have shown [5]that the salt concentration 3...5% and the content of dry substances in potatoes is not less than 21.5% a finished product had a taste satisfying the degree of salinity. For receiving high-quality potato crisps, it is necessary to apply petals of potatoes by successive processes of blanching at a temperature 78-80°Cfor 1...2 minutes and osmotic dehydration in the salt solution with the concentration of 5% for 10 minutes.

The influence of dry substances produced by the petals of the potatoes on the quality of potato crisps has been studied. Achieved in the process of drying the increase in the content of dry substances in the petals of potatoes ensures the reduction of fat in potato crisps (Figure 3). For example, the finished product made from potato variety Synthesis, fat content decreased from 35% to 24.2% with increase in the contents of dry substances from 25.9 to 62.3%, respectively.

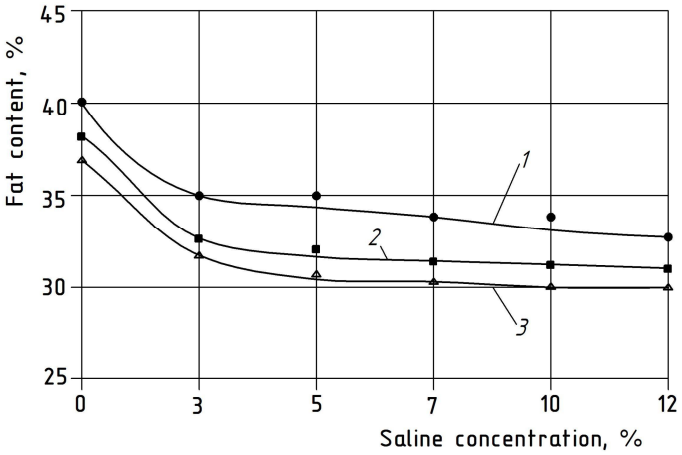

Fig. 2.The influence of the process of osmotic dehydration on the fat content in the petals of potato crisps with the specific surface10.8 cm:
1 – potatovariety - Synthesis; 2 - potato variety - Desire; 3 - potato variety –Temp

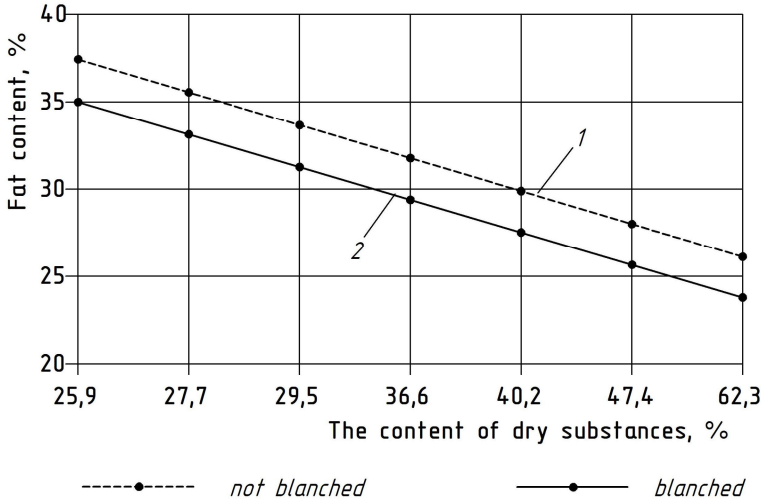

Fig. 3. The influence of the content of dry substances in the petals of potato crisps on the fat content (potato variety - Synthesis, the specific surface 14,1 см):
1 - not blanched; 2 - blanched

The optimum content of dry substances in the petals ofpotato while drying is from 37 to 40%, which provides high quality of the finished product. At the higher content of dry substances (not more than 40%) potato crisps get tough and burnt edges appearon the surface (Table 6).

Table 6

The impact of drying process of blanched petals of potato on the indicators of quality of the finished product

Specific surface area, cm^{-1}	**Drying time,** *min*	**Content of dry substances,** *%*	**Quality of potato crisps, mark**	
			Desire	Synthesis
14,1	0	22,0±1,4	8.3	8,4
	30	25,7±1,2	8.2	8,4
	60	29,7±1,2	8,2	8,3
	90	36,9±1,4	8,0	8,3
	105	40,2±0,9	8,0	8,3
	120	49,7±1,3	6,9	6.8
	150	62,0±1,3	5,6	5,5
10,8	0	22,2±1,4	8,3	8,2
	30	28,7±1,2	8,2	8,0
	60	32,1±0,8	8,0	8,0
	90	36,8±1,1	8,0	8,0
	120	40,0±1,4	8,0	8,0
	150	44,0±1,4	6,9	6,9
	180	61,0±1,3	5,8	5,7

It should be noted that the optimal content of dry substances during drying the petals of potato is guaranteed if the duration of this process is within 105…120 minutes. For intensification of the process of drying a consistently dryer was used in a vibro-boiling layer and then the belt conveyor dryer was used, reducing the time of drying up to 20..30 minutes.

As a result of mathematical processing of experimental data on the influence of specific surface and oil temperature on the fat content in potato crisps, cooked potato variety Desiree, the following equation has been received:

$$y_2 = -70,29 + 9,12 \cdot X_1 + 0,72 \cdot X_2 - 0,1 \cdot X_1^2 - 0,03 \cdot X_1 \cdot X_2 ,$$

Dependences for other varieties of potato have been received in the same way.

After organoleptic evaluation of the obtained samples of potato crisps by appearance, colour, smell, texture and taste, it has been established that high product quality is provided at frying pieces of potatoes, the specific surface of which is 10.8. ..14.1 cm. These petals have thickness of 1.5…2.0 mm and the straw has section of 3.0-4.0x4.0 mm. When the thickness of the petals is less than 1.5 mm – excessive accumulation of oilin the product takes place during frying because of the increase of the specific surface of slices of potato, and when the thickness is 2 mm –high quality of the finished product is not ensured (roasted product has burnt edges, soft middle).

A roasting oven was used for frying the product, where thermal oil was used to heat the vegetable oil as the heat carrier agent, which distinguishes it from the roasting oven, where the heat of vegetable oil is made directly with electric heaters.

Optimum temperature for roasting is 145-150 ± 1°C for 3-3.5 min.

Unlike traditional technology in the developed technology of production of potato crisps the processes of cutting, blanching, processing with salt, drying and roasting have been scientifically justified, that provided the finished product with high organoleptic and physical and chemical indicators (Table 7). So the colour of the product is evenly golden instead of uneven yellow, and the fat content of the product has decreased from 34.2% to 27.7%.

Table 7

Technological processes of potato crisps production

Traditional technology	Developed technology
• Cutting potatoes on the petalsthickness of • 1.5 mm with water supply t =10...20°C • Separation of little things • Rinsing • Air drying • Roasting at t = 140… 170°C for 4..7 min when vegetable oil is heated by electric heaters	• Cutting potatoes on the petalsthickness of 1.5.. 2 mm with water supply t =45...50°C • Separation of little things • Blanching in water t = 80°C for 1...2 min • Keeping in 5% salt solution, within 10 • Drying with hot air t=80°C • Roasting at t =145..150°C for 3..3.5 min when thermal oil is used as a heat carrier agent for heating vegetable oil

Conclusion

1. Economic expediency of processing the following varieties of potato Desire, Temp, Synthesis for dry mashed potato and potato crisps, which are most suitable according to the content of dry substances (20-24%) and reducing sugars (0.1-0.2%) has been proved. The character of changes in the tubers of reducing sugars when stored at 2-4°C, which has varietal characteristics, but the content of dry substances does not depend on the length of storage and depends on the source of their content in the tubers has been determined. For a high quality product all varieties of potato before processing should be necessary subject to acclimatization within twenty days at a temperature of 15-20°C.
2. It is established that the consistency of dry mashed potato depends on the changes faced the starch of potato in the technological process, and the process of kneading potato - the decisive stage of the processing, because it determines the degree of cell division of boiled potato and the number of destroyed cells. Lowering the temperature of the kneading process increases the destruction of the cells in 18 times that due to the strongstretching ofthe cell walls ofthe starchwith additionalmechanical loads in connection with cooling of the product. Air conditioning with pneumatic drying of mashed potato provides a high quality product by the number of damaged cells, recovery, stickiness, which makes the consistency of the product soft and crumbly.
3. Optimal parameters of production technology of potato crisps have beenscientifically grounded. Ithas been scientifically based that cutting potato on the petals of a specific surface 10.8... 14.1 cm with water supply at a temperature of 45...50°C, processing petals potato before frying, including blanching with water at 80°C for 1-2 minutes, osmotic dehydration in aqueous solution of sodium chloride concentration of 5% for 10 minutes and drying with hot air to the content of dry substances 37...40%, frying oil temperature of 145...150°C duration 3...3.5 minutes, that ensure the high quality of the finished product while reducingthe oil content in the product from 34.2% to 27.7%

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Sorption characteristics of pectin isolated from Jerusalem Artichoke tubers (*Helianthus tuberosus L.*)

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Abstract

Introduction. The aim of the present study is the isolation of pectin from Jerusalem artichoke tubers (*Helianthus tuberosus L.*) and the analysis of its sorption characteristics

Materials and methods. Research was carried out on the pectin content of the tubers of Jerusalem artichoke plants cultivated in Bulgaria. The polyuronide content (PUC) was determined via the McCready method. The static gravimetric method was used for analysis of the sorption characteristics of pectins.

Results and discussion. The polysaccharide was extracted. The isolated pectins were analyzed in physical terms: the equilibrium sorption isotherms, belonging to type II in Brunauer's classification, were obtained experimentally. The entire isotherm length demonstrated statistically significant hysteresis. The Henderson and Chung-Pfost models provided adequate isotherm description. The pectin content of the three Jerusalem artichoke samples is 14.8, 9.2 and 11.9 % a.d.m., respectively. The monomolecular moisture content of pectin was within the 7.42 – 7.92% dry basis range, its corresponding water activity value – within the 0.14 – 0.16 range.

Conclusion. The results of research are advisable for use in develop of functional food ingredient which is used pectin as a gelling agent and a stabilizer.

Introduction

Pectins are carbohydrates possessing complex composition and structure. They belong to the acidic branched heteropolysaccrahides. Their major chain is constructed by linearly joined with (1→4)-glycosidic bonds α-D-galactopyranosyluronic acid residues, partially esterified with methanol. α-L-rhamnose with (1→2)-bonds is found among them. Various neutral sugars – D-xylose, D-glucose, D-mannose, L-fructose, etc. – occur in the chain branches [10, 17].

Pectin is a common component of the cell walls of all land plants [18]. Among the basic raw materials used in the manufacture of commercial pectin is apple and citrus fruit peel [12].

Pectin extraction is a multi-stage physico-chemical process taking place under the influence of a number of factors, notably temperature, pH and duration [11]. It has been studied by many researchers. El-Nawawi and Shehata [8] have analyzed the factors bearing upon pectin production during its isolation from orange peel, the results showing that the highest yield is achieved with hydrochloric acid as extractant, at 90 °C, pH 1.7 and 120-minute duration of extraction.

Pagán and Ibarz [13] have studied the production and rheological properties of peach pomace pectin demonstrating that the maximum yield is achieved with 70%-nitric acid, 80°C, pH 1.2 and 60-minute duration. After isolating and analyzing waste apple peel pectins, Virk and Sogi [16] have found out that citric acid is a more efficient extractant than hydrochloric acid. Rehmann et al. [14] have extracted mango peel pectin with the help of sulphuric acid, their results testifying to a maximum yield at 80°C, pH 2.5 and 120-minute duration of extraction. Our previous research features a description of Jerusalem artichoke pectins *(Helianthus tuberosus L.)* [1]. Our results manifest that in tuber pectin extraction maximum yield and purity are achieved with ammonium oxalate as extractant, at 85°C and 45-minute extraction.

In food industry, pectin has a long-established application as a functional food ingredient which is used as a gelling agent and a stabilizer. Scientific literature provides data on the physical and physico-chemical properties of this polysaccharide accounting for its functional and technological characteristics [2, 3]. The equilibrium isotherms of food products show the correlation between equilibrium moisture content and water activity at a given temperature. The sorption isotherms of the product reveal the manner in which water is bound to the solid skeleton. Scientific literature suggests a multitude of empirical and theoretical models for sorption isotherm description [5, 7]. Chen and Morey [7] draw the conclusion that there is no universally applicable model. In general, several models are used, the most adequate of which is opted for on the basis of specific criteria. Model evaluation criteria are usually mean relative error (P, %) and standard deviation (SEM) [4]. Quite a few studies prove that the products whose moisture content corresponds to monomolecular moisture can be stored for long periods of time with no changes to their technological properties [6].

The aim of the present study is the isolation of pectin from Jerusalem artichoke tubers (*Helianthus tuberosus L.*) and the analysis of its sorption characteristics.

Materials and methods

1. Raw materials.

This study is based on the analysis of Jerusalem artichoke tubers collected during the technological maturity of the plant (November, 2012) in three Bulgarian regions: the

territory of the city of Stara Zagora, Stara Zagora District (sample №1), the town of Parvomai, Plovdiv District (sample №2) and the town of Vidin, Vidin District (sample №3).

All reagents used in the analysis are p.a.

2. Determination of pectins.

The polyuronide content (PUC) was determined via the McCready method which we used earlier [1], as follows:

2.1 Preparation and washing of the raw material.

10 g preliminarily ground plant matter is weighed, to which 100 cm^3 of a 5 %-solution of hydrochloric acid and 70 %-ethanol is added and the mixture is stirred for 1 h with the help of an electromagnetic stirrer. Afterwards, it is filtered in a Büchner funnel and rinsed with 70 %-ethanol first (until a neutral reaction) and then with 96 %-ethanol. The substance is dried at 50°C.

2.2 Polyuronide Content (PUC) determination.

Two 2-gram samples (with a precision of ± 0.0001 g) of the rinsed material are weighed, to each of which 2.00 g of NaCl and 150 cm^3 of distilled water is added. The samples are stirred with an electromagnetic stirrer for 2 h, after which 50 cm^3 of distilled water is added to each of them. Two check samples are prepared. 4-5 drops of Hinton reagent are added to each sample, which is followed by titration with 0.1 n NaOH. 40 cm^3 of 0.1 n NaOH are added to each sample, the samples are then left undisturbed for 2 h, after which 50 cm^3 of 0.1 n H_2SO_4 is added to each of them. The remainder of the acid is titrated with 0.1 n NaOH.

The PUC (%) of the rinsed plant matter is calculated by the following formula:

$$PUC = \frac{V_1 \cdot F \cdot 0.01761 + V_2 \cdot F \cdot 0.01901}{m} \cdot 100\%$$

V_1 is the volume of NaOH spent in the first titration, cm^3;

V_2 – the volume of NaOH spent in the second titration, cm^3;

F – NaOH factor;

0.01761 – the amount of the non-esterified galacturonic acid residue corresponding to 1 cm^3 of 0.1n NaOH in g;

0.01901 – the amount of the esterified galacturonic acid residue corresponding to 1 cm^3 of 0.1n NaOH in g;

m – sample mass, g.

In order to determine the degree of esterification (DE, %), the following formula is used:

$$DE = \frac{V_2 \cdot F}{V_1 \cdot F + V_2 \cdot F} \cdot 100\%$$

3. Extraction of pectins.

2000 cm^3 of 85-90°C distilled water containing 18.8 g (0.075 mol/l) of ammonium oxalate is poured on 100 g of the rinsed plant material. The extraction of the mixture continues for 45 min, at 85°C, with regular stirring. It is filtered while hot, the filtrate volume is measured and the filtrate is left to cool at room temperature. 20 cm^3 of concentrated hydrochloric acid and an equal volume of 96 %-ethanol are added. The

mixture is stirred well and left undisturbed at room temperature for 2 h. The resultant gel is filtered, rinsed a few times with 70 %-ethanol until the elimination of all chloride ions, then rinsed twice with 96 %-ethanol and dried at 40°C to get constant weight.

4.Analysis of the sorption characteristics of pectins.

We used the static gravimetric method recommended for food products [6]. One-gram samples (with a precision of ± 0.005 g) are weighed in weighing dishes. The latter are placed in hygrostats over saturated solutions of seven salts (LiCl, CH_3COOK, $MgCl_2$, K_2CO_3, NaBr, NaCl, KCl) keeping the water activity of the product in the 0.11 – 0.85 range [9]. The hygrostats undergo tempering in a thermostat at 20 ± 0.1°C. When equilibrium is reached (within 20 - 30 days), sample moisture is determined by weighing, the samples being dried for 24 h at 105°C. The experimentally obtained data are average values of the results achieved after triplicate tests.

In order to describe sorption isotherms, we resorted to the two-parameter Chung-Pfost, Halsey, Oswin, and Henderson models [5, 7]:

Chung-Pfost:

$$\ln(a_W) = -Ae^{-BM} \tag{1}$$

Halsey:

$$a_W = -\exp^{AM^B} \tag{2}$$

Oswin:

$$M = B\left(\frac{a_W}{1-a_W}\right)^C \tag{3}$$

Henderson:

$$\ln(1-a_W) = -AM^B, \tag{4}$$

M is equilibrium moisture content, % dry basis; a_W – water activity, decimal; *A*, *B, C* – constants.

To determine the monomolecular moisture content, the wide-known Brunauer-Emmett-Teller (BET) model was used [15], valid for $a_W < 0{,}5$ [6]:

$$M = \frac{M_m C a_W}{(1-a_W)(1-a_W+Ca_W)}, \tag{5}$$

M_m is the monomolecular moisture, % dry basis; C - constant.

Results and discussion

Table 1 presents the results related to the polyuronide content (PUC) and the degree of esterification (DE) of pectins contained in Jerusalem artichoke tubers (*Helianthus tuberosus L*).

Table 1

Polyuronide content and degree of esterification of pectins in Jerusalem artichoke tubers *(Helianthus tuberosus L).*

№ in turn	PUC, % a.d.m.	DE, %
Sample №1	14.8	60.7
Sample №2	9.2	63.4
Sample №3	11.9	59.8

a.d.m. – absolute dry matter

It is evident that sample №1 is the richest in pectins. Therefore, this sample was chosen to isolate the polysaccharide from in order to determine its sorption characteristics.

The experimentally obtained pectin sorption isotherms are illustrated in Figure 1. It demonstrates that with low water activity the character of the isotherms is typical of monomolecular adsorption whereas with high water activity it is typical of polymolecular adsorption, i.e. the isotherms possess the characteristic S-shape of Brunauer's II type [6]. Such sorption isotherms are common for many colloid capillary porous products and most foods are such products. The hysteresis effect is statistically significant (ά=0.05) along the entire length of the isotherm and the highest for higher water activity values (over 0.6), reaching 2.5% dry basis. With lower water activity, hysteresis values amount to about 1% dry basis on average.

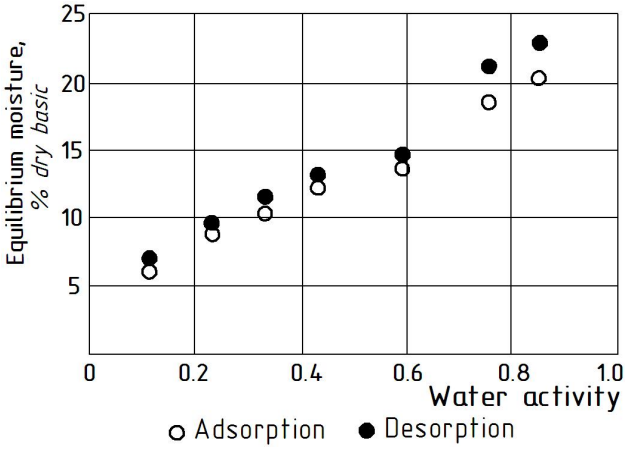

Fig. 1. Equilibrium isotherms of pectin

Table 2

Coefficients of the models (*A*, *B*), mean relative error (*P*,%) and standard deviation (*SEM*) for desorption

Model	*A*	*B*	*P*	*SEM*
Chung-Pfost	6,398093	0,1566	3,36	0,84
Oswin	0,3169	13,85852	4,45	0,94
Halsey	172,2075	-2,1395	7,55	1,66
Henderson	0,001587	2,2702	3,43	0,92

Table 3

Coefficients of the models (*A*, *B*), mean relative error (*P*, %) and standard deviation (*SEM*) for adsorption

Model	*A*	*B*	*P*	SEM
Chung-Pfost	6,86956	0,1793	3,79	0,61
Oswin	0,3155	12,5059	4,94	0,84
Halsey	134,5317	-2,1284	8,34	1,69
Henderson	0,001937	2,2838	2,56	0,58

The coefficients of the linear equations were determined on the basis of the Least Squares method. The coefficient values, mean relative error P and standard deviation SEM of the models from (1) to (4), for desorption and adsorption, respectively, are presented in Tables 2 and 3. The results obtained show that in adsorption the Henderson model is most suitable for sorption isotherm description (the lowest values of P and SEM) while in desorption the most adequate model is that of Chung-Pfost. However, since the differences in the P and SEM values for both models and both processes are minimal, both models can be recommended as equally adequate for the description of pectin sorption isotherms.

In order to calculate the monomolecular moisture content, equation (5) can be transformed into a linear form:

$$\frac{a_W}{M\left(1-a_W\right)}=\frac{1}{MmC}+\frac{\left(1-C\right)a_W}{MmC} \tag{6}$$

On the basis of the slope of the line, using the Least Squares method, one can determine the coefficients of the linear equation (6) and, hence, the monomolecular moisture M_m and the C coefficient. The linear dependence $a_W/\left[M\left(1-a_W\right)\right]=f\left(a_W\right)$, with the experimental data for desorption and adsorption for $a_W < 0.5$, is illustrated in Fig. 2. The monomolecular moisture values obtained and the correlation coefficients are given in Table 4.

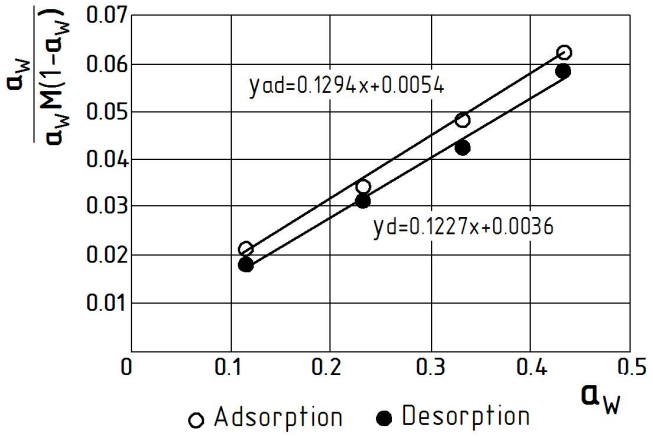

Fig 2. Dependence $a_W/\left[M\left(1-a_W\right)\right]=f\left(a_W\right)$ for pectin

Table 4

Monomolecular moisture values (M_m), correlation coefficients (R^2) and water activities corresponding to the monomolecular moisture content (a_{wm})

Pectin	M_m	R^2	a_{wm}
Desorption	7,92	0,9936	0,144
Adsorption	7,42	0,9958	0,16

The results demonstrate that the monomolecular moisture content of pectin is from 7.42 to 7.92 % dry basis, the hysteresis effect still occurring, while the value for desorption is higher.

The BET model makes it possible to determine the product's water activity at which it is to be stored in order to preserve its monomolecular moisture:

$$a_{wm} = \left(\sqrt{C} - 1\right) / \left(C - 1\right) \tag{7}$$

The results obtained for a_{wm} are given in Table 4. They show that if pectin is to have moisture content approximating monomolecular moisture, it should be stored at water activity within the 0.14 – 0.16 range.

Conclusion

The pectin content of the three Jerusalem artichoke samples is 14.8, 9.2 and 11.9 % a.d.m., respectively. The experimentally obtained equilibrium sorption isotherms of the pectin isolated from sample №1 belong to type II according to Brunauer's classification. The entire isotherm length manifests statistically significant hysteresis. The Henderson and Chung-Pfost models have been found to be adequate for isotherm description. The monomolecular moisture content of pectin is between 7.42 and 7.92 % dry basis, the corresponding water activity being between 0.14 and 0.16.

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Investigation of viscosity of whole hydrolyze sweetened condensed milk

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Abstract

Introduction. Paper is aimed at developing of low-lactose (hydrolyzed) sweetened condensed milk products technology for lactose intolerant people and for the whole population.

Materials and methods: Rheological characteristics were determined on a Reotest device by the 2nd method of viscometry

Results and discussion. Reasonability of ß-galactosidase use for milk lactose hydrolyze during the production of canned products with sugar was proved in the previous works. This technology gives possibility to increase the quality of condensed canned foods, to reduce sugar concentration till 50 %, to increase dietary properties. Due to the reducing of saccharose mass part till 22 and 31 % the products had a liquid consistency that's why was a necessity to increase the viscosity properties of condensed products.

One of method to increase the product viscosity is inoculation of stabilization systems. Reasonability of the usage of stabilization system Bivicioc 1L was proved. The researches of viscosity determination in whole hydrolyzed sweetened condensed milk were shown in the work. Relations of viscosity of whole hydrolyzed condensed milk to the deformation rate were presented.

Conclusions Viscosity indices of experimental samples in the fresh produced products and during storage are determined and justified.

Introduction

Due to the high biological value and good storage ability condensed milk products with sugar are widely used in human nutrition.

However, the defects of consistency as "mealy" and "grainy" that reduce the quality of products are often seen. Surplusage of sugar can be a risk factor for predisposition to diabetes and lead to excessive weight.

A part of the world population cannot consume milk, which is associated with insufficient or lack of ß-galactosidase enzyme in the human digestive tract, which leads to disruption of its work and discomfort.

Enzymatic hydrolysis of lactose makes it possible to develop a technology of dairy products with reduced lactose content [1-4]. Low-lactose products are considered as functional food products for people with lactose intolerance and it allows you to extend the range of dairy products, improve the organoleptic characteristics of the product, excluding the possibility of crystallization of lactose in the hydrolysed sweetened condensed milk during storage. During enzymatic hydrolysis, lactose is split into monosaccharides glucose and galactose, the organoleptic characteristics are changed and depending on the level of lactose hydrolysis the increase of sweetness of milk is took place that makes it possible to reduce the concentration of sucrose in the formulations of condensed milk products with sugar. New samples of hydrolyzed sweetened condensed milk products were proposed and developed in the production laboratory of Luhansk National Agrarian University and the technological properties were studied, Table 1.

Table 1

Characteristics of skim milk and whole hydrolyzed sweetened condensed

A title of the product	**Mass part of sucrose,** %	**Mass part of dry materials of milk,** %	**Mass part of dry materials of product,** %	**Effective viscosity,** *Pa·s*
Whole sweetened condensed milk (control)	43,5	28,5	72,0	3,6±0,2
Whole hydrolysed sweetened condensed milk	31,0	28,0	59,0	1,2±0,1
Whole hydrolysed sweetened condensed milk	22,0	37,0	59,0	1,6±0,1

With decreasing mass part of sucrose in the formulation of condensed sweetened canned products the consistency of the product with a mass part of 59% dry materials had a liquid consistency. To increase the viscosity properties of hydrolyzed sweetened condensed milk the stabilizer systems MAKGEL 11 and Bivicioc 1L have been recommended and used in many sectors of the food industry and, in particular, for condensed sweetened canned milk products.

At the same time, several functions perform: to provide the formation of uniform, stable fat emulsion, which is protected from destruction; the ability to reduce the mass part of fat in the product without deterioration of quality; the chemical bonding of water molecules are provided that help to extend the shelf life of products and reduce the migration of moisture from the product into the packaging etc. The mechanism of action of stabilizers is based on the ability to bind the moisture at coming into the food system, as a result of which the latter loses its mobility and thus altering the viscosity and consistency.

At first, theirs technological properties were studied in the laboratory conditions, in a production laboratory of Luhansk National Agrarian University and then samples worked out on JSC "Troitsky MDZ" Luhansk region. Determination of rheological properties of hydrolyzed condensed products were performed at a storage temperature of 6-10 ºC.

Materails and methods

Rheological characteristics were determined on a Reotest device by the 2nd method of viscometry [5].

Before the measurements, an appropriate index of measuring device was selected. The required amount (30 cm^3) of product charged into the measuring cylinder. The principle of measurement was as follows: under the action of the rotor one layer of product is shifted relative to another one. Measurements began to conduct at low rates of speed deformation increasing it gradually, by increasing the frequency of rotation of the measuring cylinder. The required frequency rotor speed was asked by the switching drive and by installing lever in position stage 1a to 12 a. The rheological characteristics of the product were determined according to the rotor speed (velocity gradient) and the resistance force of its rotation.

Shift stress τ (Pa) was determined by the formula:

$$\tau = Z \cdot \alpha, \quad (1)$$

Z - constant of cylinder, Pa / unit. scale of the instrument;
α – indexes of device.

Effective viscosity of experimental samples is determined by the formula:

$$\eta_{эф.} = \tau / D \cdot 100, \quad (2)$$

τ – shift stress, Pa;
D – shift rate, s^{-1}

Research task - increasing the viscous properties of hydrolyzed sweetened condensed milk products by using stabilization systems.

Results and discussion

Stabilization systems - Makgel K11 and BIVICIOC 1L are created on the base of polysaccharides of natural origin, which fulfill a useful role related to their molecular architecture, size and the presence of intermolecular interactions due to hydrogen ties. And moreover, they are important (such as food fibers) for the normal functioning of the human organism.

The results of experiments have showed that 11 MAKGEL is poorly soluble in milk, with the changes the color of the product, giving it a grayish hue, which adversely affects the organoleptic characteristics and the products did not meet the regulatory requirements. When using Bivicioc 1L the adverse effects were not revealed in the final product (almost 100% of solubility is achieved and the color of the product is not changed). Therefore it was decided to continue to use the stabilization system Bivicioc 1L. The series of experiments have been conducted with whole milk to determine the mass part of Bivicioc 1L, wherein into the raw material prepared in advance, respectively with technological scheme of production of hydrolyzed milk the stabilizing system was inoculated at an amount of 0.2, 0.4, 0.6, and 0.8 % of weight of the finished product. Enzymatic hydrolysis was conducted under the influence of GODO-YNL2 preparation at activity of 5000

NLE/sm^3. Hydrolysed milk was headed for inactivation of the enzyme at a temperature of 75... 80 ºC [6-8].

As evidenced by the data shown in Fig. 1, the dependence of the effective viscosity of the products is non-linear: an increase in the mass part of the stabilizer increases the effective viscosity products. Effective viscosity of whole fresh hydrolyzed condensed milk with mass part 31% is sucrose and stabilizer is 0,2% - 2,9 ± 0,1 Pa·s (the product had a liquid consistency, not peculiar to the skim sweetened condensed milk during storage can occur stratified fractions), a further increase of the mass part of the stabilizer cause even more substantial increase of viscosity up to 5,5 ± 0,3 Pa·s, which is not typical for whole sweetened condensed milk (a sharp increase of viscosity is possible during storage, the product may have a " thickening " defect).

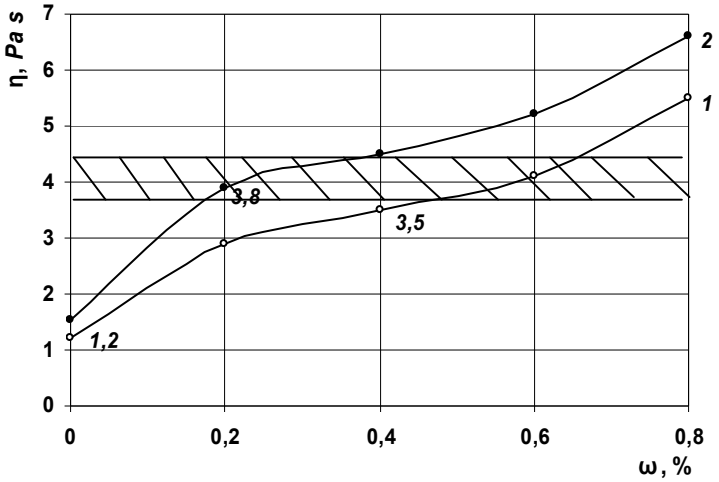

Fig. 1. Dependence of the effective viscosity of whole hydrolyzed sweetened condensed milk upon mass part of stabilizer:

1 - whole hydrolyzed sweetened condensed milk with mass part 59%, sucrose is 31%,

2 - whole hydrolyzed sweetened condensed milk with mass part of 59% dry materials, 22% is sucrose.

Dependence of the effective viscosity of the experimental samples of whole sweetened condensed milk and mass part of 59% dry materials of different amounts of the stabilizer on the deformation rate, Fig. 2 and 3.

As have been mentioned in the research, the recommended viscosity for the production - 3.5…4.1 Pa·s with a mass fraction of the stabilizer 0.4...0.6 % for whole hydrolyzed condenced milk with a mass part of sucrose 31% and 3.8...4.5 Pa·s and mass part of the stabilizer of 0.2...0.4 % by weight of the finished product to a whole hydrolyzed condensed milk with a mass part of 22% sucrose.

For further research the minimum mass part of stabilizer was selected.

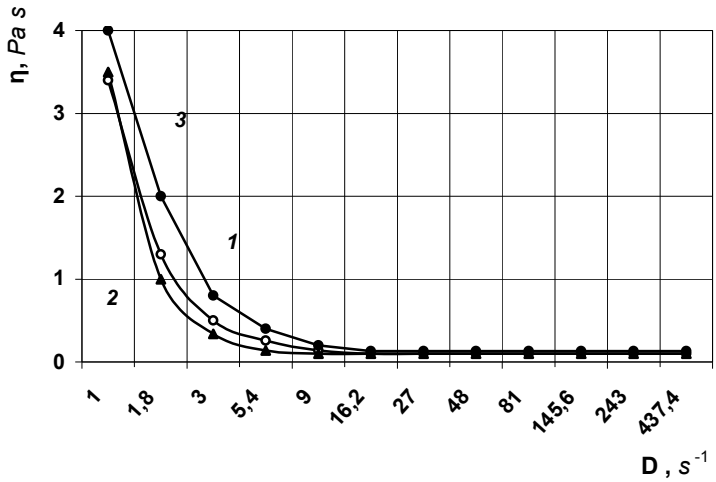

Fig. 2. Dependence of the effective viscosity of whole hydrolyzed sweetened condensed milk upon deformation rate:

1 – whole condensed sweetened milk (control);

2 - whole hydrolyzed sweetened condensed milk with mass part 59% of dry substances, 31% is sucrose, the mass fraction of the stabilizer is 0 4% by weight of the product;

3 - whole hydrolyzed sweetened condensed milk with mass part is 59% dry materials, 31% is sucrose, the mass part of the stabilizer is 0.6 % by weight of the product.

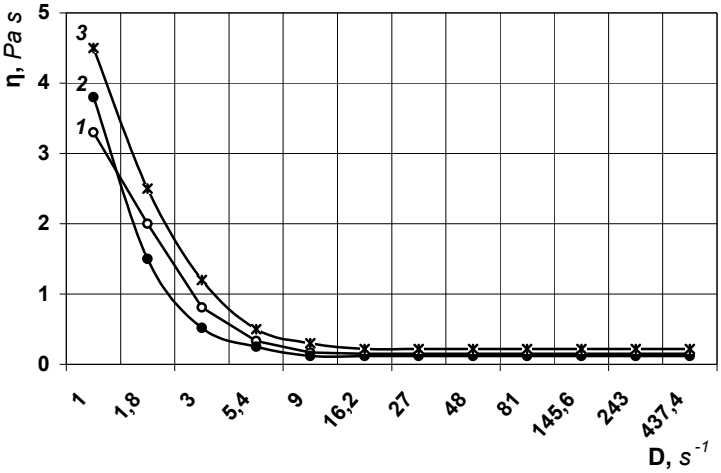

Fig. 3. Dependence of the effective viscosity of whole hydrolyzed sweetened condensed milk upon deformation rate:

1 – whole condensed sweetened milk (control);

2 - whole hydrolyzed sweetened condensed milk with mass part 59% of dry materials, 22% is sucrose, the mass part of the stabilizer is 0.2 % by weight of the product;

3 - whole hydrolyzed sweetened condensed milk with mass part 59% of dry materials, sucrose is 22 % mass part of stabilizer is 0.4% by weight of the product.

For all of experimental samples with increasing strain rate (from 1 to 16.2 s^{-1}) the effective viscosity decreases. And that particularly intensively the viscosity decreases in the range of low deformation rates up to 5.4 s^{-1}, while the structure of the product breaks down and shows the greatest strength. With increasing deformation rate the viscosity decreases sharply. At higher deformation rate of 5.4 s^{-1} a structure of the product is destroyed, the indexes of viscosity is lowering and changing inconsequently. According to the investigations which have been put into practice (Fig. 2 and 3) you can make specifications for hydrolyzed sweetened canned milk products, the results are presented in the Table 2.

Table 2

Characteristics of whole hydrolyzed sweetened condensed milk

A title of the product	**Mass part of sucrose,** %	**Mass part of dry milk material** %	**Mass of dry product materials,** %	**Mass part of stabilizer** %	**The effective viscosity of fresh condensed mixture,** *Pa·s*
Whole sweetened condensed milk (control)	43,5	28,5	72,0	–	3,6±0,2
Whole hydrolyzed sweetened condensed milk	31,0	28,0	59,0	0,4 0,6	3,5±0,2 4,1±0,2
Whole hydrolyzed sweetened condensed milk	22,0	37,0	59,0	0,2 0,4	3,8±0,2 4,5±0,2

It is known that during the storage the viscosity of sweetened condensed milk, is sharply increases [9,10].

They conducted investigations of structural and mechanical properties of hydrolyzed sweetened condensed products and stabilizer in fresh products and during storage. Results of the investigation of the effective viscosity of whole hydrolyzed condensed milk during storage are shown in Fig. 4

A series of experiments with whole hydrolyzed sweetened condensed milk were conducted, in the process to the beforehand prepared raw materials were added stabilizer Bivicioc 1L at the amount of 0.2, 0.4, 0.6 and 0.8 % by weight of the finished product [11]. For the whole hydrolyzed condensed milk mass part of dry materials of the product - 59 % including 31 sucrose and 22 %.

The facts of the studies (Fig. 5) testify that by increasing the mass part of the stabilizer from 0.4 to 0.6 % (for whole milk) during storage the indexes of effective viscosity and consistency of the products varies insignificantly. Further increase of the mass part of the stabilizer above 0.6 % (for whole milk) during storage causes more significant changes of indicators. For example, when adding a stabilizer at an amount of 0.8 % for the 8th month of storage the effective viscosity of the product increased to 10,2 ± 0,4 Pa·s with the product had a thick and dense texture.

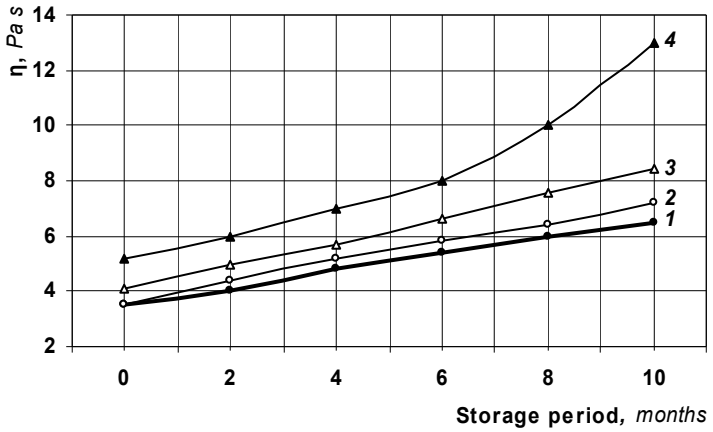

Fig. 4 . Change of the effective viscosity of whole hydrolyzed condensed milk during storage:
1 – whole condensed sweetened milk (control);
2 - whole hydrolyzed sweetened condensed milk mass part of 59% dry materials, 31% is sucrose, mass part of stabilizer is 0,4 % of the finished product;
3 - whole hydrolyzed sweetened condensed milk mass part of 59% dry materials, 31% is sucrose, the mass part of the stabilizer is 0.6 % of the finished product;
4 - whole hydrolyzed sweetened condensed milk mass part of dry materials 59 %, sucrose is 31%, the mass part of the stabilizer is 0.8 % by weight of the product.

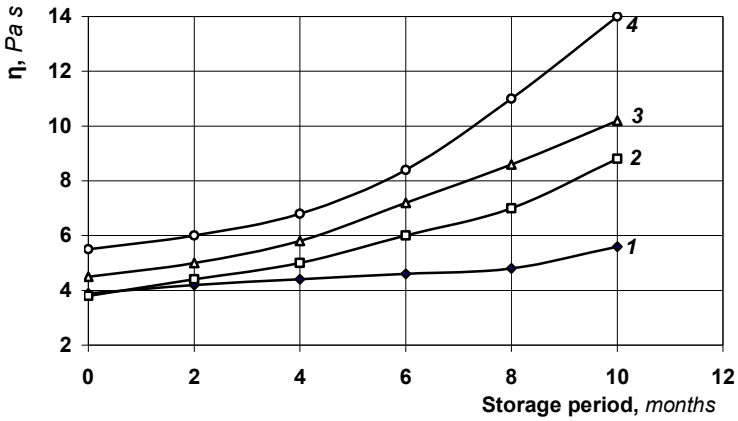

Fig. 5. Change of the effective viscosity of whole hydrolyzed condensed milk during storage:
1 - condensed milk with sugar (control);
2 - whole hydrolyzed sweetened condensed milk mass part of 59% dry materials, 22% is sucrose, mass part of the stabilizer is 0.2% of the finished product;
3 - whole hydrolyzed sweetened condensed milk mass part of 59% dry materials, 22% is sucrose, the mass part of the stabilizer is 0.4% of the finished product;
4 - whole hydrolyzed sweetened condensed milk mass part of 59% dry materials, 22% is sucrose, the mass part of the stabilizer is 0.6 % by weight of the product.

For whole hydrolyzed condensed milk with a mass part of 59 % dry materials, including 31% of sucrose, the optimum alternative of the mass part of the stabilizer became

samples with application of 0.4…0.6 % by weight of the product and the effective viscosity was 5.8 ± 0,3 to 6,6 ± 0,3 Pa·s, respectively (for 6 months storage).

For whole hydrolyzed condensed milk with a mass part of 59% dry materials, including 22% of sucrose (Fig. 4 b), the maximum amount of stabilizer became the samples with the introduction of 0.2…0.4% by weight of the product, and the effective viscosity was from 6,0 ± 0,3 to 7,2 ± 0,3 Pa·s (at the 6 months of storage period). At the mass fraction of 0.6 % stabilizer in 10 months the gelation process was seen, the effective viscosity have increased to 14,0±0,6 Pa·s, due to the peculiarity of the stabilizer (which is based on carrageenan), when the amount of stabilizer is overstated the consistency of the product become gelatinous (which is not typical for condensed sweetened milk products).

According to the obtained experimental facts (Fig. 4 and 5), the maximum mass part of stabilizer Bivicioc 1L for whole hydrolyzed condensed milk with a mass part of sucrose 31% and 22 is the quantity of 0.4...0.6% and 0.2...0.4 % by weight of the product, respectively [12].

Conclusions

1. Application of the stabilization system Bivicioc 1L for products with mass part of 59% dry materials is justified and the mass part of the stabilizer is determined:

- for whole milk with a mass part of dry materials (59% sucrose 31 % and 22) - 0.4...0.6 and 0.2 ... 0.4 % by weight of the product, respectively.

2 Viscosity of hydrolyzed condensed milk and sugar mixtures with the application of Bivicioc 1L stabilization system is established:

- for whole hydrolyzed condensed milk with mass part of dry materials (59% sucrose 31 % and 22) - 3.5…4.1 and 3.8…4.5 Pa·s.

3. Effective viscosity in the hydrolyzed sweetened condensed canned milk products with the application of Bivicioc 1L stabilization system in the process of storage is established:

- for whole hydrolyzed condensed milk with mass part of dry materials (59% sucrose, 31 and 22 %) - from 5,8 ± 0,3 to 6,6 ± 0,3 and from 6,0 ± 0,3 to 7,2 ± 0,3 Pa·s., respectively.

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Effect of starch as hydrocolloids for formation of a stable emulsion system in food

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Abstract

Introduction. It is necessary to determine the effect of the physicochemical properties of native and modified starches in their use in food.

Matherials and methods. Investigated two samples of food emulsions using starches of different nature of origin (native, modified starch). Using laboratory balances, volume of cylinders determined percentage of water separation during freezing and unfreezing emulsions; Brukfild viscometer measured the viscosity increase depending on the time, temperature and pH of food emulsions.

Results. When freezing / unfreezing emulsion of native starch in the first cycle of water has been separated by 8% in the second cycle of 38%, the third 50%, in contrast to the emulsion with modified starch water separation starts from the fourth cycle slightly, in the fifth cycle percentage of water separation is 1%, the sixth cycle of 3 %.

As a result, studies of viscosity versus time, temperature and pH of food emulsions proved that in an acidic medium at pH 6.5 viscosity emulsion with modified starch is stored and then increases over a longer time compared with the emulsion of native starch where the viscosity at the beginning of the storage period increases and then decreases.

Conclusions. Investigated the properties of native starch in the emulsion show that their use in industrial processes can lead to blockage of the heat exchanger, and the viscosity of the output of the production process is unpredictable and varies greatly depending on the combination of temperature and mechanical stress. It makes use in the manufacture of modified starches that combines a combination of two types of modifications: stabilization and crosslinking.

Introduction

Modern manufacturers merganser at their disposal are dozens or hundreds of titles and some special products combined title starch, where each product has its own specific characteristics and scope. Without claiming to be a complete analysis of starch produced special, try to capture the most significant features.

It all starts with the selection of raw materials. Having known iodine - starch reaction, it is easy to see that all starches except derived from waxy maize, iodine stained in dark blue. The next difference is seen iodine - starch complex under a microscope shows that starch is composed of numerous granules, and, depending on the raw granules have a different shape and size. Interestingly, potato starch is a mixture of both small and very large grains of which are several times larger than grains of corn or tapioca starch.

If you delve starch at the molecular level, it appears that the starch granules are composed of two types of natural polymer molecules - polysaccharides. Line polysaccharide called amylose and branched - amylopectin (Figure 1).

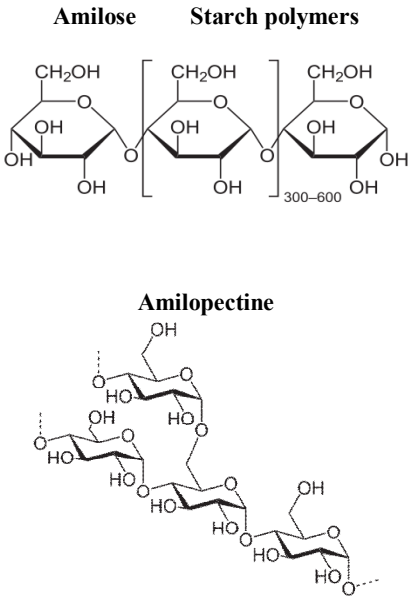

Fig. 1.

In most cases, the linear amylose content of about 20% and amylopectin - 80%. However, there are exceptions, such as waxy maize and highamiloze maize. In the first case, the content of amylose minimal (less than 1%) and the second - the maximum (90 %). Because of the lack of amylose starch from waxy corn gives blue color iodine - starch reaction, and texture brewed starch solution is pasty (sour cream) and does not turn into a gel during storage. In contrast, a high percentage of amylose leads to the fact that during cooling and storage starch paste turns into a gel.

As Table 1 shows the main characteristics of some species of native starches, on which most often produce modified starches for special and industrial processes.

As can be seen from the Table 1, another significant parameter by which to judge the properties of starch are gelation temperature. This - the temperature of water is typically 5% - solution of starch in which granules start to swell and bind water.

Thus, even when discussing the raw material for the manufacture of starch, there are certain criteria to choose a product: potato starch has a low gelation, corn and corn highamiloze has the ability to form gels, tapioca - clean neutral taste waxy corn - past consistency and the most stable texture. Why, despite the many variations of native starches, is a constant development and implementation of special starches or modified (not to be confused with genetic modification). Why, well working jelly "native starch is rarely used as a thickener in products with any significant shelf life?

Table 1

The origin of the starch	The diameter of the granules, mk	Temperature of gelation, °C	Amylose content,%
Corn	5-30	62-80	25
Wax corn	5-30	63-72	<1
Hyghamilozna corn	5-30	63-92	50-90
Potato	5-100	58-65	20
Topioka	4-35	52-65	17
Rice	1-3	68-78	19
Wheat	1-45	52-85	25

Matherials and methods

Investigated two samples of food emulsions using starches of different nature of origin (native, modified starch). Emulsions were prepared by following the recipes.

Emulsion for drinks
Recipe for 1000 kg of finished product

	Unit	Variations recipes	
Name of raw materials		**1**	**2**
Native starch (Wax corn)	kg	-	120
Modified starch	kg	120	-
Orange oil	kg	55	55
Rezynogum	kg	55	55
Colorant	kg	15,5	15,5
Citric acid	kg	5	5
Sodium benzoate	kg	2,5	2,5
Water	kg	747	747
Total	**kg**	1000	1000

Using laboratory balances, volume of cylinders determined percentage of water separation during freezing and unfreezing emulsions.

Brukfild viscometer measured the viscosity increase depending on the time, temperature and pH of food emulsions.

Results and discussion

There are several factors that hinder the wide industrial application of native starches as thickeners - stabilizers:

• Syneresis (water separation during storage and frozen);
• Uncontrolled change in viscosity when heated;
• A sharp decrease in viscosity in acidic medium, as well as overheating and homogenization ;
• Long sticky texture;
• Change in texture during storage.

In order to overcome these limit, developed a number of special modified starches.

As mentioned earlier, changes in texture during storage and display syneresis connect with presence in linear polymer amylose starch. One can imagine is schematically as line amylose obtained by brewing from the interior of the granules and distributed evenly throughout the volume of the solution.

However, the storage of linear amylose molecules can fit around each other and formed associates. This phenomenon is called retrogradation starch, as a result, there is a separation of the water and the texture of a product containing amylose, changes over time with the gradual formation of a gel.

Following the statement of facts in order to reduce and eliminate syneresis texture changes during storage is most suitable starch from waxy maize, which contains almost no amylose. However, despite the lack of amylose, one can imagine that the linear part of amylopectin is also able to associate. This can lead to syneresis during storage.

In order to avoid such associations in the molecular structure of starch introduce additional volume substitutes which interfere with the convergence of linear parts of amylopectin. From a chemical point of view volume substitutes are the esters of starch. This modification is called stabilization and provides a starch that holds water without a noticeable manifestation of syneresis for a long shelf life and modes of freeze/thaw. Figure 2 shows the diagram depending percent of separated water with starch paste, depending on the number of cycles a deep freeze (-27 ° C) and thawing.

Unlike native starches separating moisture after the first cycle, the standard modified starches stand at least 4-5 such cycles, and the most advanced modification much more such cycles without markedly water separation.

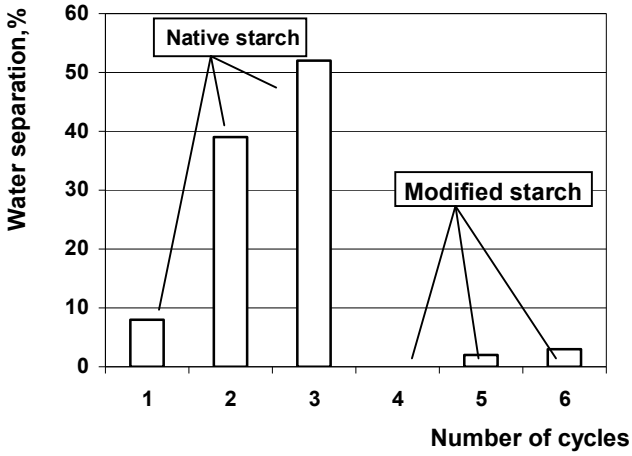

Fig. 2. The percentage of water separation during freezi and unfreezing of emulsions with native and modified starches

When freezing / unfreezing emulsion of native starch in the first cycle of water has been separated by 8% in the second cycle of 38%, the third 50%, in contrast to the emulsion with modified starch water separation starts from the fourth cycle slightly, in the fifth cycle percentage of water separation is 1%, the sixth cycle of 3 %.

Therefore, the stabilization modification eliminates syneresis and change the texture for long term storage and freeze thawing modes.

In order to describe how a change in the viscosity of native starch under the influence of temperature, acidic and homogenization, consider the so-called Brabender diagram (figure 3)

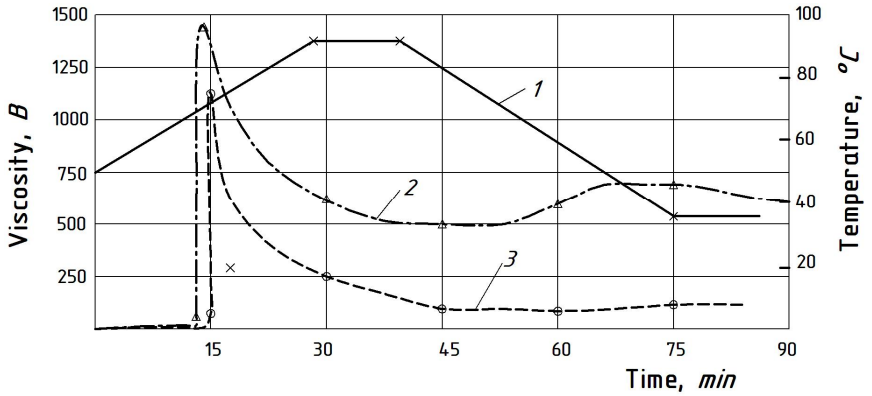

Fig. 3. The dynamics of the viscosity of native starch
1 - pH= 7,0
2 - pH= 6,5
3 - pH= 3,0

It shows a graph of the viscosity of the 5 % suspension of starch is heated in water at neutral and acidic environment in the absence of mechanical action. Direct the figure is a graph of temperature change (right axis) with time (bottom scale). Curve shows the change in viscosity (left scale) in the same time frame (lower scale)

As can be seen from the diagram, until the temperature gelation practically no starch water binding and viscosity not change. After reaching the temperature gelation seen a dramatic increase in viscosity. In this case, the starch granules begin to swell, form water and increase in size. Achieving peak viscosity means that most of the starch granules reached its maximum size and maximum water-retaining characteristics. When failure occurs subsequent recording of pellets, resulting in a decrease in viscosity and water - reducing ability. The same effect leads and mechanical action (homogenization) after brewing starch. As can be seen from the graph, in acidic medium viscosity decreases much faster. This is due to hydrolysis of starch polymer molecules.

The above properties of native starches leads to the fact that they use in manufacturing processes can lead to blockage of the heat exchanger (with high peak viscosity) , and the viscosity of the output of the production process varies greatly and often unpredictable depending on the combination of temperature and mechanical stress. In addition, the use of native starches in foods with acidic environment leads to a decrease in viscosity due to hydrolysis.

These shortcomings of native starches was overcome by strengthening the internal structure of the granules by means of so -called “cross- mating” (cross - linkage) or cross-linking.

Example diagram Brabendera modified starch is shown in figure 4. It can be clearly seen no peak viscosity or viscosity drop during heating.

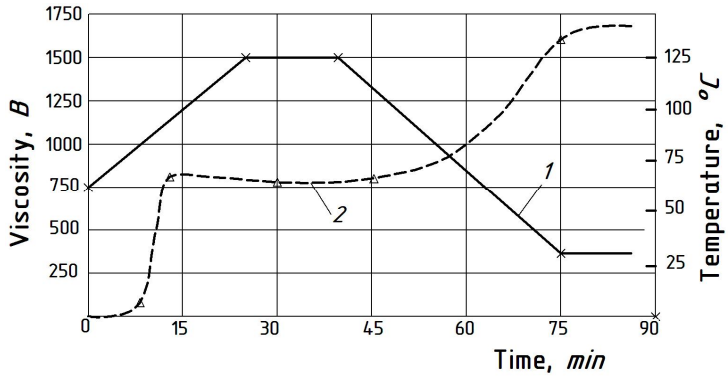

Fig. 4. The dynamics of the viscosity of modified starch
1 - pH=7
2 - pH<7

As a result, studies of viscosity versus time, temperature and pH of food emulsions proved that in an acidic medium at pH 6.5 viscosity emulsion with modified starch is stored and then increases over a longer time compared with the emulsion of native starch where the viscosity at the beginning of the storage period increases and then decreases.

Conclusions

The most common nowadays classical starch - thickener, which combine simultaneously two types of modifications: stabilization and crosslinking. Thus, it is important so-called «depth modification ", the number of modifying units, per molecule of starch. Thus, the deepening of stabilization - modification, except water- enhancing features, allows reducing point gelation starch. However, «overload ", especially acetyl fragments can cause unwanted interaction of the modified starch with milk proteins. Increased «cross- coupling» can get starches, which are characterized by high resistance to the conditions of the process (temperature, homogenization, exposure to an acidic environment). However, the more resistant to external influences starch, the lower viscosity makes it soft working conditions. Therefore, in each case, selecting the optimum starch, should take into account as much as possible the conditions of a particular process.

According to ISO 4380:2005 «Modified starch». General specific at the most common nowadays classical starch - thickener, which combine simultaneously two types of modifications: stabilization and crosslinking. Thus, it is important so-called «depth modification ", the number of modifying units, per molecule of starch. Thus, the deepening of stabilization - modification, except water- enhancing features, allows reducing point gelation starch. However, «overload", especially acetyl fragments can cause unwanted interaction of the modified starch with milk proteins. Increased «cross- coupling «can get starches, which are characterized by high resistance to the conditions of the process (temperature, homogenization, exposure to an acidic environment). However, the more resistant to external influences starch, the lower viscosity makes it soft working conditions. Therefore, in each case, selecting the optimum starch, should take into account as much as possible the conditions of a particular process.

The following (Table 2) are the special starch approved for use in the food industry , most of which modified method described above .ions " modified starch - a starch obtained due to physical , chemical, biochemical or combined processing of natural starch to change its properties. As you can see from the definition, modified starches not related to genetically modified foods. Starch modified without interfering with the structure of DNA, he acquires the required properties using very different transformations.

The following (Table 2) are the special starch approved for use in the food industry, most of which modified method described above.

Table 2

Code according to the index of food additives	Type of modification
E-1404	Oxidation
E-1410	Stabilization
E-1412	Stitching
E-1413	Stitching + Stabilization
E-1414	Stitching + Stabilization
E-1420	Stabilization
E-1422	Stitching + Stabilization
E-1440	Stabilization
E-1442	Stitching + Stabilization
E-1450	Stabilization

The most widely used in the food industry, thanks to a good combination of price / quality found from waxy maize (E1422). These are used as thickeners, stabilizers in the production of various types of yogurt and fruit flavours. The main advantage of these starches is stability against syneresis due to lack of amylose and shiny surface by small granules.

E1412 priori has lowered resistance to syneresis and less "work" mode freezing and thawing in what he is missing a stabilization type of modification, but the absence of amylose still allows the use of E1412 derived from waxy maize in dairy products as a thickener.

Modification E1414 is most often used for tapioca and potato starches. Despite the presence in this case, two types of modifications: "cross- coupling" and "stability" are usually (E1414) based on tapioca and potato amylose due to having less stable during storage and less resistant to syneresis.

The most functional today is the modification E1442. It distinguishes high storage stability, using the freeze-thaw and against syneresis. Low viscosity prevents hot block (brewing) pasteurizers, facilitates mass transfer and thermal conductivity.

Due to global market trends related to the concept of healthy eating, recently developed special starches - analogues modified in 1422, but chemically modified and are not a food additive. In foods in the U.S. and the EU are declared as ordinary natural starch.

Summary of the types of modifications should be noted that one and the same modification can be made using different materials and with different depth, which ultimately determines the specific properties of modified starch.

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Electrophoresis of oil-containing edible microcapsules with protein-polyuronic shells

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Abstract

Introduction. The aim of this work is to determine the sign of the charge of microcapsules shells, containing oil composition and to estimate stability of microcapsules with different diameters in the electric field.

Materials and methods. The microcapsules were prepared by complex coacervation method. Remains of electrolytes were removed by dialysis or electro-dialysis. Purified microcapsules were subjected to electrophoresis at 100-400 V/m. Polydispersity was determined by means of our own method.

Results and discussion. Small microcapsules with protein-poliuronate shells moves from the cathode (-) to the anode (+) during electrophoresis. Microcapsules with a diameter much than 35μm are most susceptible to degradation in the cathode space, while remaining stable at low pH values at the anode surface.

Conclusions. Gelatin-Alginat and Gelatin-Hyaluronat shells have a negative electric charge. Electrophoresis can be used to obtain required diameter of coacervate microcapsules. High stability of the microcapsules in the anode space (acid) confirms the validity of their introduction into fermented dairy products.

Introduction

Food fortification with biologically active substances in microencapsulated form is of interest to improve their sustainability, alimentary and biological value [1]. Microcapsules suitable for incorporation into food products must have a fully edible shells consisting of biopolymers. Such microcapsules can be prepared by complex coacervation of differently charged polyelectrolytes [2]. Polyelectrolytes are important components of many foods. So, the fermented dairy products contain the positively charged protonated forms of the proteins, but fruit nectars and juices include negatively charged pectin [3]. Therefore, knowledge of the surface charge of the microcapsules is important for predicting their

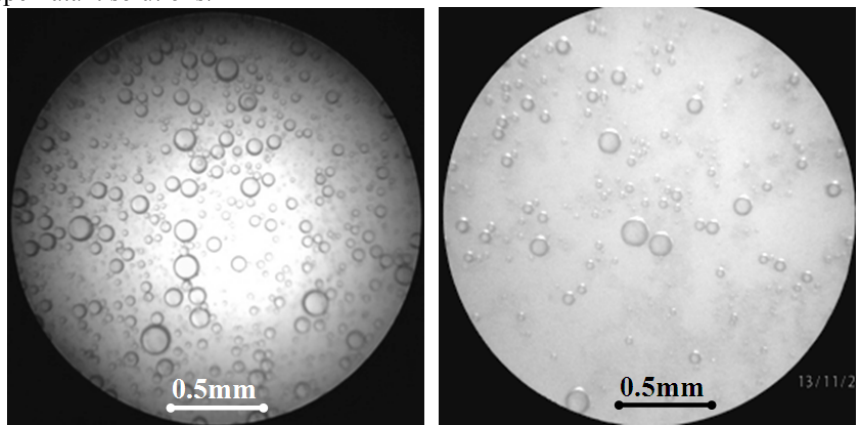
stability in different types of foods. Electrophoresis is a reliable method to determine the charge of macromolecules of biopolymers [4]. The aim of this work is the experimental determination of the shell charge of microcapsules containing oil composition and sustainability assessment of microcapsules in the electric field.

Materials and methods

Oil composition. Microencapsulated oil composition was formulated from *Juglans regia* nut oil, oil concentrate of carotenes and sunflower seed oil in the ratio of 2:1:1. The concentration of carotene in the final composition was determined by spectrophotometric method [5] and is amounted to 0.209 ± 0.001% (m). That provides good visibility of microcapsules during their microscopy and photography.

Microcapsules. Edible microcapsules (fig. 1.) were obtained by complex coacervation method (Patent MD-557, BOPI 11/2012, p. 31-32.). Initially, an aqueous gelatine solution and oil composition was stirred to form O/W emulsion. The emulsion was cooled and the rate of stirring was reduced to create conditions for coacervation process. The dehydration of gelatine shells with sodium sulphate and fixing of the shells by means of salts of alginic or hyaluronic acids was followed.

Dialysis and electro-dialysis. Suspensions of microcapsules in supernatant solutions were purified by dialysis through cellulose membranes for 1-2 days. Good results were obtained using electro-dialysis at 100V/m during 30-60min until the resistance of the 1cm of supernatant solution reached ≈ 100kΩ, which corresponds to the conductivity of approx. $1 \cdot 10^{-3}$S/m. This is only one order of magnitude more than conductivity of distilled water, approx. $5 \cdot 10^{-4}$S/m [6], that talks about almost complete removal of sodium sulphate from the supernatant solutions.



a *b*

Fig. 1. Microcapsules with Gelatine-Alginate (GelAlg) shells (*a*), and with Gelatine-Hialuronat shells (*b*) - "*in status nascendi*".

Electrophoresis. Microcapsules, purified by dialysis, were subjected to electrophoresis with graphite or stainless-steel electrodes, introduced in the U-shaped tubes. Parameters for graphite / steel electrodes: distance between cathode and anode surfaces: 10/25cm; Voltage: 10/100V; field intensity: $100/400 V \cdot m^{-1}$.

Polydispersity measurements. This was determined by our own method. Samples of microcapsules were photographed by the high resolution camera (3-12 megapixels) in the optical microscope in transmitted or lateral light (Figure 1). Real diameter of the observed field of view was 2.1mm. Microcapsules of certain sizes were manual counting in the images, zoomed to 15-20cm. Then, specific volume of the microcapsules with average diameter, the volume of fraction and the volume fraction of microcapsules of a certain size were calculated, using formulas:

$$V_{MC,i} = \frac{\pi < d_i >^3}{6}; V_i = N_{MC,i} \cdot V_{MC,i}; \varphi_i = \frac{V_i}{\sum V},$$

in which: $V_{MC,i}$ - volume of single MC with average diameter $< d_i >$; V_i - volume of fraction i, N_i - number of certain species of microcapsules; φ_i - volume fraction of microcapsules of certain diameter $< d_i >$; $\sum V$ - summary volume of all fractions.

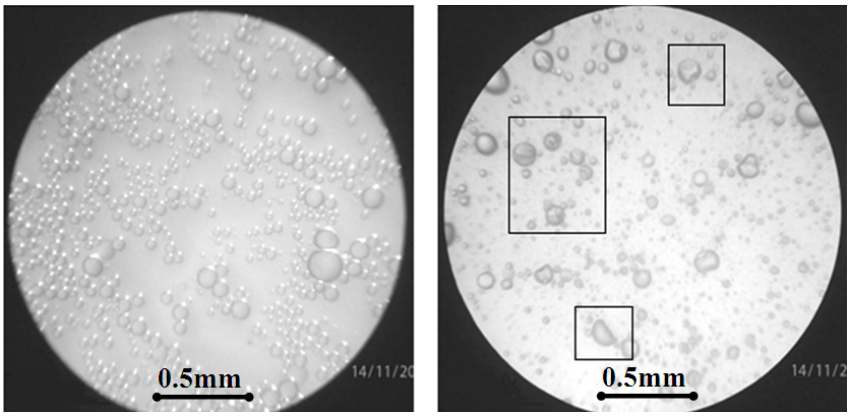
Table 1

Example: calculation of polydispersity for GelHur MC "in nascendi"

$d_{i,min.}$, μm	$d_{i,max.}$, μm	$<d_i>$, μm	$N_{MC,i}$	$V_{MC,i}$, μm^3	V_i, μm^3	φ_i, %
0	11.9	5.95	77	110	8493	0.16
11.9	23.8	17.80	20	2953	59060	1.09
23.8	35.7	29.65	37	13648	504980	9.35
35.7	47.6	41.55	25	37559	938970	17.4
47.6	59.5	53.40	14	79730	1116222	20.7
59.5	71.4	65.25	7	145459	1018212	18.8
71.4	83.3	77.15	2	240440	480880	8.90
83.3	95.2	89.00	2	369121	738242	13.7
95.2	107.1	100.95	1	538664	538664	9.90

Results and discussions

Nearly all known methods of obtaining a coacervate microcapsules with polyelectrolyte membranes involve the use of dehydrating agents, particularly sodium sulphate [1, 2]. It in turn causes vigorous electrolysis of water, which distorts the results of electrophoresis. Therefore there is a need of purification of the supernatant solution from the excess of sodium sulphate, maintaining microcapsules intact. We noticed that soaking in water causes destabilization of the microcapsules shells. This phenomenon may have at least two reasons. First, this is the removal of sodium sulphate from polyelectrolyte membranes. Second, slowly hydrolysis of polyelectrolyte complexes is possible. Filtration or centrifugation caused partial coalescence of the microcapsules in the irregular dodecahedrons and the further destruction of the microcapsules, similar to the destruction of foams [7]. The best results among all tested purification methods showed the dialysis of microcapsules suspensions through cellulose membranes. The dialyzed suspension was stirred, and the microcapsules were subjected to electrophoresis. A destruction of microcapsules at the anode wasn't observed even after 10-20min after the start of electrophoresis. But in the small time interval, the microcapsules were deformed and even broken at the cathode (fig. 2, right). In the cathode space appeared free oil, indicating extensive destruction of shells of the microcapsules.



a *b*

Fig. 2. The microcapsules coated with GelHur after electrophoresis: at the anode (*a*); at the cathode (*b*); broken MCs are contoured.

We explain the destruction of the microcapsules in the cathode space as follows. Electrolysis of water takes place rapidly in the presence of even small, trace amounts of electrolytes, such as sodium sulphate, and leads to a change pH near electrodes.

Cathode (−): $2H_2O \rightarrow H_2 + OH^- - 2e^-$; *water reduction*

Anode (+): $2H_2O \rightarrow O_2 + 4H^+ + 2e^-$; *water oxidation*

Electrolysis: $6H_2O + 2Na_2SO_4 \rightarrow (2H_2 + 4NaOH)_{cathode} + (O_2 + 2H_2SO_4)_{anode}$

It is known that the complexes of protein with polyuronic acids and their salts are particularly stable only in a narrow range of pH, namely, 2-5 [8]. It can be assumed that this interval is not respected on the cathode, whereby the microcapsules become unstable. We note that, despite apparent simplicity, is very difficult to measure the pH values in the immediate vicinity of the electrode, but it is possible to do in an indirect way, using electrochemical model. Thus, when experimentally determined current strength is 100μA, in 15 minutes of electrolysis must be formed approx. $1 \cdot 10^{-6}$ mol of ions, according to Faraday laws of electrolysis. Naturally, near the cathode and the anode are formed the equal number of OH^- and H^+ ions equivalents, respectively. Assuming that the volume of the near-electrode space is about 1ml or 0.001L, the molar concentrations of ions constitute approx. 0.001mol/l. Therefore:

$[H^+]_{anode} \approx 0.001 mol/L \Rightarrow \quad pH_{anode} = 3.$

$[OH^-]_{cathode} \approx 0.001 mol/L \Rightarrow \quad pOH_{cathode} = 3 \Rightarrow \quad pH_{cathode} = 14 - 3 = 11$

These estimations shows that microcapsules remain near the anode in the pH values, “friendly” to them. At the same time, at the cathode is very easily achieved the conditions for their destruction. It is quite obvious for us, that the reason is the local pH at the cathode, equal to 11, much greater, than that of the isoelectric point of the gelatin, equal to 4.8-5.0 [8]. From the above it follows that the destruction of gelatin-alginate membranes in the cathode space occurs by the following mechanism:

1.Neutralization of gelatine macromolecules at near its isoelectric point (pI ≈ 4.8):

$Gel^{+} + OH^{-} \rightarrow Gel^{0} + H_2O$;

2.Acquisition of negative charge by gelatine molecules at pH > pI:

$Gel^{0} + OH^{-} \rightarrow Gel^{-} + H_2O$;

3.Unbundling of polyelectrolyte shells because of repulsion of negatively charged macromolecules of gelatin and polyuronic salts :

$GelAlg \rightarrow Gel^{-} + Alg^{-}$; $GelHur \rightarrow Gel^{-} + Hur^{-}$.

As a matter of fact, the described process is not pure electrophoresis. Rather, this process can be called as “destruction of the microcapsules, caused by electrolysis”, but is not can be called as “electrolysis of microcapsules”.

High stability of the microcapsules in the anode space is further supported by statistical data for polydispersity of different samples (fig. 3.).

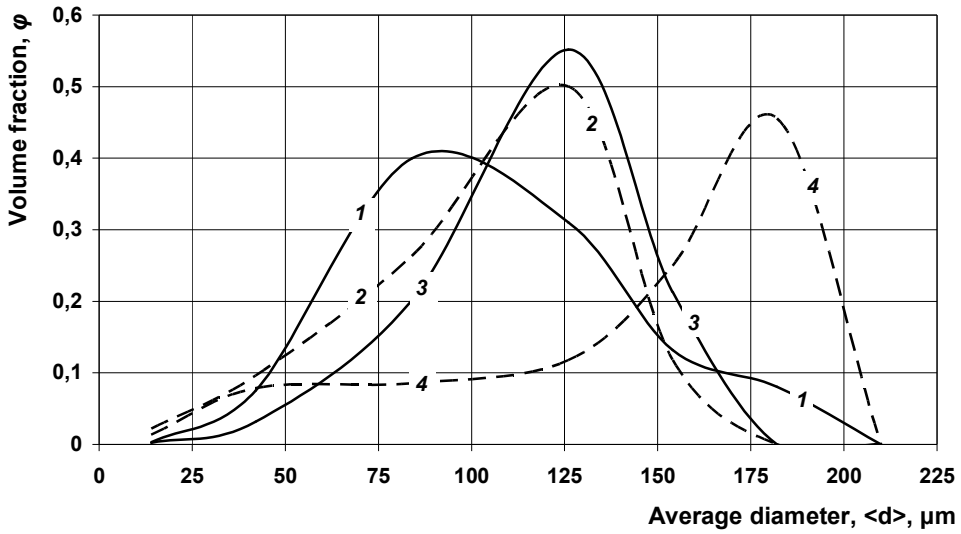


Fig.3. Statistical distributions of microcapsules coated with GelAlg:
1 – “in nascendi”
2 – on surface
3 – cathode (-)
4 – anode (+)

Maximum of the distribution curve of microcapsules with different diameter, taken directly from the reactor, “in (status) nascendi”, is located at 75-100μm. In comparison with the other curves, this curve is shifted towards the smaller microcapsules. At the same time, the polydispersity of the microcapsules in the anode space is practically identical to polydispersity of the microcapsules which were not subjected to electrophoresis, from the surface of the dialyzed suspension. In these cases, the maximum of the distribution curve is situated at <d> ≈ 125μm. Such shifts towards larger diameters can be explained due to different densities, which cause flotation of large microcapsules and deposition of the small ones [9]. At the beginning of the DC passing, a very intensive migration of the

microcapsules from the negative electrode (cathode) to the positive (anode) was observed. The process speed was 0.5-1.0mm/min. Movement of the microcapsules in the opposite direction, from the anode to the cathode, was much slower (near 0.1mm/min). Migratory MC-flows from both electrodes gradually slows down, forming incoherent suspensions in the U-shaped tube. These were separated from the near-electrode spaces, and always were displaced noticeably toward the anode (+).

The totality of all observed phenomena, demonstrates that the charge of microcapsule shells, which were not subjected to electrophoresis, is negative. Negative charge is also conserved in the initial stages of the electrophoresis. Some "runaway" of microcapsules from the anodic space suggests that recharging of MC-shells occurs at the anode surface, probably, because of two possible ways:

1.Neutralisation of polyuronic anions by H^+, liberated during the electrolysis:

$$Alg^- + H^+ \rightarrow HAlg \; ; Hur^- + H^+ \rightarrow HHur \; .$$

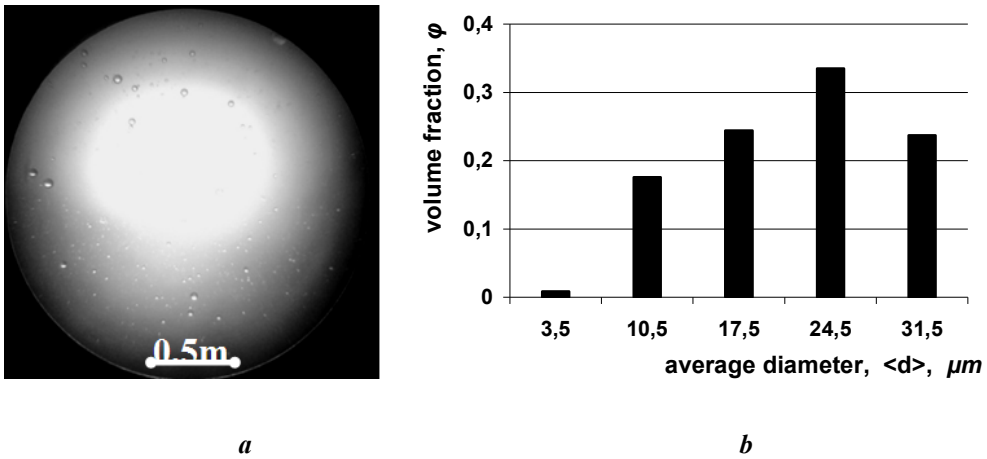
2.Further high-positive charging of gelatin molecules.

Interestingly, that the first presumed phenomenon should not lead to the destruction and destabilization of the microcapsule shell, and can even strengthen them thanks to the formation of insoluble polyuronic acids at the pH < 3 [10].

As for second phenomenon, the high positive charging of gelatin can cause the intra-molecular repulsion and critical straightening of macromolecules. This in turn should lead to the destruction of the shells. However, this straightening is possible only at very low pH values [11], which can not be achieved on the basis of electrochemical model, discussed above.

Insofar as the destruction of the microcapsules at the anode on the investigated electrophoresis conditions are not observed, the first process is most probable.

Statistical analysis shows that the mobile and stable fraction (fig. 4., left) consists of microcapsules having a diameter less than 35μm. A polydispersity of this fraction obeys the law of normal distribution (fig. 4., right).



a *b*

Fig. 4. Stable fraction with GelAlg shells (*a*); its statistical distribution (*b*).

The effect of migration of the microcapsules that do not suffer destruction in the electrode spaces is of interest for further practical applications. In particular, it will be possible to separate unstable large microcapsules and stable small ones, which are most valuable for food and cosmetic industries.

Conclusions

1. In an electric field the microcapsules with gelatine-polyuronic shells moves from the cathode (-) to the anode (+). This electrophoresis clearly confirms the negative charge of MC-shells, and further suggests the mechanism of their neutralization and recharge.
2. Microcapsules with diameter > 35μm undergo the electrochemical destruction at the cathode, constantly remaining in the cathode space because of their low density. At the same time, a fraction of the microcapsules with a diameter less than 35μm is practically not destroyed by the electric field, leaving the cathode space during electrophoresis. This effect can be used for separation of microcapsules of different diameters.
3. At the anode, the destruction of microcapsules at the investigated parameters of electrophoresis does not occur, because is not reached the critical level of pH, smaller than 2. High stability of the microcapsules in the anode space (containing H^+) confirms the validity of their introduction into dairy products.

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Investigation of the effect of water exposed to nonequilibrium contact plasma onto saccharomyces cerevisiae yeast

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Abstract

Introduction. Additional treatment of water by nonequilibrium contact plasma allows improving consumer characteristics of bakery goods considerably. Determination of the effect of plasma-chemically activated water on morphological, cultural and physiological properties of Saccharomyces cerevisiae yeast is important from the technological point of view.

Materials and Methods. Experimental investigations were carried out in the conditions of bacteriological laboratory by seeding the culture of yeasts of TM "Lvivski" and "Kryvorizki" on Sabouraud dense liquid nutrient media. The quantity of viable cells of microorganisms was determined by the method of Gould sector seeds. Morphology of the yeast was investigated by phase-contrast microscopy. Biotechnological properties of yeasts were determined on Giss media.

Results. The paper establishes the effect of water exposed to nonequilibrium contact plasma on the sensitivity of Saccharomyces cerevisiae and shows absence of suppressive action of treated water with regard to cultural properties of microorganisms. The experiments prove that with the use of plasma-chemically activated water morphological characteristics and biochemical properties of bakery yeasts produced by Lviv and Kryvyi Rig yeast plants are preserved. Culturing of Saccharomyces cerevisiae yeast on the nutrient media prepared with the use of water exposed to nonequilibrium contact plasm resulted in 6,5–15 times' increase in quantity of viable microorganisms compared with the control on the mains drinking water.

Conclusions. Physiological properties of Saccharomyces cerevisiae yeast improved owing to use water exposed to nonequilibrium contact plasma. Results of investigations are recommended for using in yeast production and bread making.

Introduction

Food and processing industry play a key role in the national economy of Ukraine, since the citizens' health directly depends on high-quality nutrition. According to global food pattern indices, share of cereals and bakery products amounts to 51 % of total foodstuffs consumed by population of the globe. In particular, the dominating role in present-day diet of Ukrainians is traditionally given to bakery products. As the most of foodstuffs, during the manufacture of which structural biopolymers undergo significant transformation of properties, substantial amount of breadstuffs cannot do without using additives of artificial origin. However, over recent years the number of consumers caring of their health is growing, so the market of environmentally safe production where the usage of improvers is limited features increasing opportunities for expansion in Ukraine.

The leading place in food industry is occupied by biotechnology where microorganisms are dominating initiators of transformations. Microbiological and biochemical processes occurring in the source raw materials throughout the technological process make a significant contribution into formation of organoleptic and physical-chemical properties of finished products. Microbiological processes running in heterogeneous food systems have a number of peculiar features connected with their component composition which may vary considerably.

Water is one of the basic raw materials in bread production. Most often, drinking water without any treatment is used in the process, but it is reported that in case of additional treatment thereof, for example, by plasma-chemical activation, it is possible to improve the technology of bakery products considerably [1]. It is found that owing to usage of plasma-chemically activated water instead of mains drinking water without additional treatment the dough maturation is accelerated by 20 % on average, compared with the control. Besides, technological characteristics of yeast, namely, fermentation property and osmo-sensitivity thereof, improve by 10–15 % and 40–45 % accordingly [2, 3]. However, the papers mentioned above do not deal with the action of water exposed to nonequilibrium contact plasma (NCP) on the bakery yeast beyond the heterogeneous food systems. Since the yeast is the main driving force of microbiological processes which occur during maturation in wheat semi-finished products, the purpose of this paper consists in investigation of the effect of plasma-chemically activated water on sensitivity, morphology and cultural properties of Saccharomyces cerevisiae.

Materials and methods

Pressed bakery yeast Saccharomyces cerevisiae is the main object of investigations. The work deals with the yeasts of trade marks (TM) "Lvivski" produced by Lviv yeast plant (Enzym PJSC) and "Kryvorizki" produced by Kryvyi Rig yeast plant ("Nadezhda" CJSC) as those being in good demand of Ukrainian bakery enterprises. It should be noted that each enterprise produces the yeasts following its own technical specifications stating the better quality indices and longer term of storage compared with the yeasts produced following national quality standard [4]. Strains of yeast used in production are not disclosed by the manufacturers for obvious reasons.

Investigators used mains water without additional treatment and water exposed to NCP, with the characteristics given in Table 1. Treatment of water with nonequilibrium contact plasma was carried out in the laboratory of plasma-chemical technologies of the Public higher education institution "Ukrainian State University of Chemical Technology" at the

discrete-type laboratory unit with the reactor volume of 0,1 dm3 (Fig. 1). For preparing control samples, drinking water of the Dnipropetrovsk city mains was used.

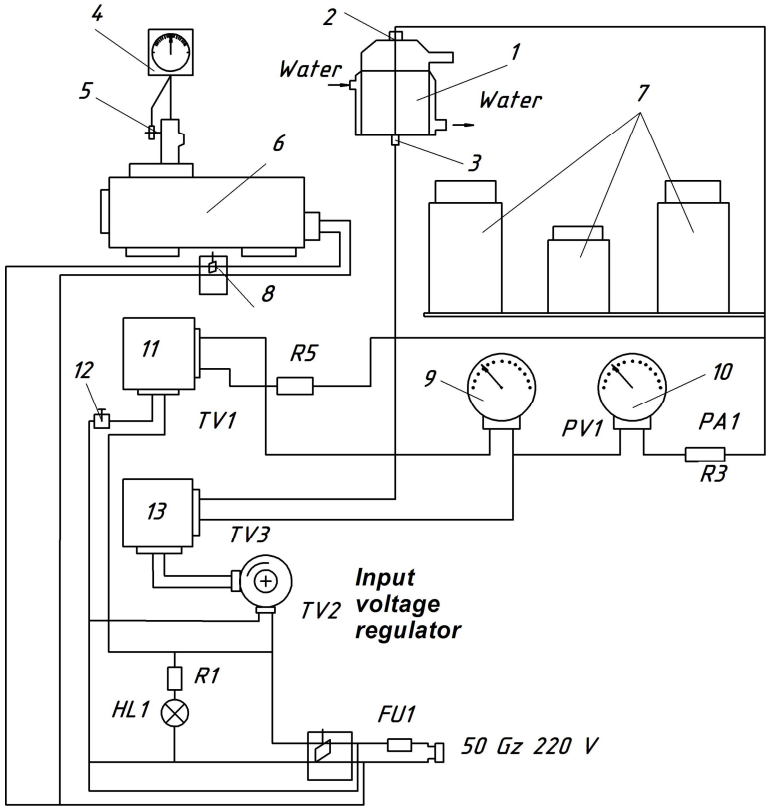

Fig. 1. Apparatus for plasma-chemical treatment of water:
1 – reactor; 2, 3 – electrodes; 4 – vacuum gage; 5 – cock; 6 – pump; 7 – filtering elements; 8 – switch; 9 – voltmeter; 10 – ammeter; 11 – ignition transformer; 12 – switch; 13 – voltage transformer

In order to determine sensitivity of yeast to water exposed to NCP, yeasts produced by Lviv and Kryvyi Rig yeast plants were cultured on Sabouraud medium for 24 hours at temperature of 28°C. After that 0,1 ml of the microbial suspension of 1 bln/ml dilution were seeded with a lawn on Sabouraud agar with 20 ml of agar per one Petri dish. Dishes with seeds were dried, and after that four wells of 5 mm in diameter were formed in agar. Obtained wells were filled with 0,1 ml of water exposed to NCP with various characteristics (Table 1). After incubation of seeds during 24 hours at 28 °C the degree of delay in growth of the culture in millimeters was determined.

Table 1

Characteristics of mains drinking water and plasma-chemically activated water

No. of sample		Duration of NCP action on water, *minutes*	Concentration of peroxide compounds, *mg/l*	pH of water	Oxidation-reduction potential, *mV*
1	Mains water without additional treatment	–	–	7,0	240
2	Plasma-chemically activated mains water	3	100	10,1	123
3	Plasma-chemically activated mains water	7	300	10,3	110
4	Plasma-chemically activated mains water	9	500	10,4	95
5	Plasma-chemically activated mains water	12	700	10,2	90

For investigating the effect of water on the yeast morphology, pure daily culture of Saccharomyces cerevisiae was seeded with inoculating loop on liquid Sabouraud agar prepared with the use of mains water without additional treatment (control) and plasma-chemically activated water with 500 mg/l concentration of peroxide compounds (sample 4). Cultural properties of microorganisms were determined after incubation of seeds during 24 hours at 28 °C. Morphological peculiarities of yeast microorganisms were additionally studied using the phase-contrast microscopy method. For that purpose, micro-chambers were prepared as follows: agar layer of 17×17×1 mm was placed onto preparation glass; 1 bln/ml suspension of Saccharomyces cerevisiae daily culture was applied onto its surface using the inoculating loop, with the cover glass put on top, and sealing of the sample with paraffin. Prepared micro-chambers were examined by the 100-power microscope.

Bakery yeasts cultured in the liquid medium were studied separately. Pure daily culture of yeasts was seeded in 5% Sabouraud broth prepared both on the mains water and plasma-chemically activated water. Seeds were incubated for 24 hours at temperature of 28°C; after that cultural properties of yeasts were determined. Quantitative content of viable cells of Saccharomyces cerevisiae in broth for experimental and control samples was determined by the method of Gould sector seeding on Sabouraud agar. Morphology of yeast cultured in Sabouraud broth prepared on the basis of mains water without additional treatment and plasma-chemically activated water was studied by means of phase-contrast microscopy. Biochemical properties of the grown Saccharomyces cerevisiae yeast were determined on Giss media. Bacteriological investigations were carried out following the standard practice (Klymniuk S.I., Sytnyk I.O., Tvorko M.S., Shyrobokov V.P. (2004), Praktychna mikrobiolohiia, Ukrmedknyha, Ternopil).

Results and discussion

Testing of microorganisms for sensitivity to components of chemical or biological origin is of top priority from the practical point of view. In bakery production, yeast promotes the alcoholic fermentation in dough semi-product with the generation of secondary metabolites which form organoleptic properties (taste, flavor, coloring of the crust) and physical-chemical characteristics (porosity, acidity) of the finished products. Running of microbiological processes depends on a number of factors of different origin, among which a special role is given to stress factors as those resulting in various damages of the cell constituents and, as a consequence, even the cell death. For example, occurrence of oxidative stress is conditioned by active oxygen forms (AOF). Increase in protons' concentration often leads to suppression of many metabolic processes. Accumulation of anions in the cell under aerobic conditions can increase the intensity of free radicals' generation, that is, cause the oxidative stress [5], i.e. a set of response reactions aimed at overcoming adverse changes in the environment under the action of stress. Because of NCP action in the liquid, owing to processes of ionization, dissociation and dissociative attachment of plasma electrons to water molecules, thermal dissociation and dissociation through excited vibrational levels of water molecules in collisions $H_2O - H_2O$ the ions, atoms and molecules like H_2O^+, OH^-, H^-, OH^-, H^+, H_2, are formed, which initiate many chemical ion-molecular reactions and cause the accumulation of molecules of H_2O_2, H_2O_3, H_2O_4 (1–3) and other peroxide-type compounds (up to H_2O_{10}) in water:

$$OH^{\bullet} + OH^{\bullet} \rightarrow H_2O_2 \quad (1)$$

$$HO_2^{\bullet} + OH^{\bullet} \rightarrow H_2O_3 \quad (2)$$

$$HO_2^{\bullet} + OH_2^{\bullet} \rightarrow H_2O_4 \quad (3)$$

After treatment with NCP, water acquires small-cluster structure, and its penetrating capacity increases which is shown by spectral and physical-chemical methods [6]. Therefore, it is important to ascertain whether the usage of plasma-chemically activated water would play the role of stress factor for Saccharomyces cerevisiae development. Regarding the other microbiological cultures, the paper [7] investigates the effect of plasma-chemically activated water and aqueous solutions on the pathogenic and opportunistic-pathogenic microorganisms, such as Staphylococcus aureus, Staphylococcus epidermidis, Staphylococcus saprophyticus, Escherichia coli, Pseudomonas aeruginosa, Candida ablicans, Streptococcus pyogenes, Proteus vulgaris, Klebsiella ozaenae. In particular, the action of chemical hydrogen peroxide on test cultures in concentrations approaching to the relevant values in plasma-chemically activated water was determined. Complete absence of antimicrobial action of hydrogen peroxide solutions of 10–100 mg/l concentration and poor sensitivity of microbiological cultures under study to the exciter of 500 mg/l concentration was shown. At the same time, test cultures demonstrated stable sensitivity to usage of plasma-chemically activated water with the concentration of peroxide compounds corresponding to similar hydrogen peroxide solutions (Table 2). It is found that the effect of water exposed to NCP on the microorganisms under study is similar to the effect of usage of known antiseptics such as Lyzoformin 3000 (Germany, Lyzoformin) and Sterillium (Germany, BODE Chemie Hamburg). There is well-known fact that the most of improvers of oxidizing action and preserving agents in bakery production suppress vital activity of yeasts which has a negative impact on biochemical, colloid and

physical-chemical processes during maturation of dough semi-products [8]. One of the reasons of delay in microbiological processes is the presence of AOFs capable of inhibiting the yeast metabolism in such food systems.

Table 2

Effect of plasma-chemically activated water and various antiseptics on growth of microorganisms [7]

Microbiological cultures	Delay in microorganisms growth, mm, when using:			
	plasma-chemically activated water with 500 mg/l concentration of peroxide compounds	hydrogen peroxide solution of 500 mg/l concentration	Sterillium	Lyzoformin 3000 of 1000 mg/l concentration
Staphylococcus aureus	20	13	13	20
Staphylococcus saprophyticus	10	N/A	8	13
Staphylococcus epidermidis	14	12	11	20
Escherichia coli	13	10	8	15
Pseudomonas aeruginosa	12	N/A	8	10
Candida ablicans	11	11	13	20
Streptococcus pyogenes	8	N/A	20	15
Proteus vulgaris	14	8	34	20

Investigation of the effect of water exposed to NCP on sensitivity of bakery yeasts produced by Lviv and Kryvyi Rig yeast plants showed no zones of delay in growth of Saccharomyces cerevisiae culture, that is, the usage of plasma-chemically activated water did not suppress the bakery yeast growth. During experimental investigations it was found that Saccharomyces cerevisiae yeast cultured on Sabouraud broth prepared with the use of plasma-chemically activated water and control samples where the mains drinking water was used for culturing had the same cultural properties, i.e. duration of growth, shape, color, and size of colonies. By way of studying the condition of microorganisms in micro-chambers it was determined that experimental and control samples of bakery yeasts had the same morphology inherent to yeast cells, and the young cells were observed as well.

Effect of specific components of nutrient media on microorganisms depends both on their concentration and duration of action on the objects under study. With the aim of determining the deep and more prolonged effect of water exposed to NCP on bakery yeasts after their culturing on Sabouraud broth for 24 hours with the subsequent three-time passaging the control of microorganisms' condition was carried out. Results of investigations have shown that micro-mycetes cultured in the liquid nutrient media with the

use of plasma-chemically activated water had cultural properties (gas production, turbidity of nutrient media) similar to control samples.

It is impossible to assess the action of impact factors on vital activity of the yeasts without determination of quantity of colony-forming microorganisms. For that purpose, bakery yeasts after their culturing on Sabouraud broth and three-time passaging were seeded on Sabouraud dense nutrient medium and incubated for 24 hours at temperature of 28 °C. Obtained data has shown that in the liquid nutrient media prepared with the use of water exposed to NCP quantity of microorganisms forming the colonies was growing 6,5–15 times compared with the control (Table 3) both for the bakery yeast of TM "Lvivski" and the yeast of TM "Kryvorizki".

Table 3

Effect of plasma-chemically activated water on physiological characteristics of Saccharomyces cerevisiae culture

No. of water sample used for yeast culturing	**Bakery yeast of TM**	
	Lvivski	Kryvorizki
1	10^5	10^5
2	$6,5\times10^5$	10^6
3	10^6	10^6
4	10^6	3×10^6
5	10^6	10^6

However, the prevailing effect was observed in case of culturing of the yeast produced by Kryvyi Rig yeast plant in the presence of water exposed to NCP, with the concentration of peroxide compounds of 500 mg/l (sample No. 4). It is evident that such difference is conditioned by peculiarities of fermentative complexes of yeasts typical for a certain strain of microorganisms used under conditions of their industrial production. Cultural properties of Saccharomyces cerevisiae of the above manufacturers for the experimental and control samples featured no difference.

Morphology of Saccharomyces cerevisiae yeast cultured on the liquid nutrient media with introduction of the mains drinking water and water exposed to NCP was studied with the use of phase-contrast microscopy. Fig. 2 shows the morphological state of Saccharomyces cerevisiae cells. Certain peculiar features of the Saccharomyces cerevisiae morphological structure depending on the yeast industrial origin were found: yeast of Lviv yeast plant had more rounded shape (Fig. 2.A, 2.B), while the yeast of Kryvyi Rig yeast plant were of somewhat elongated and oval shape (Fig. 2.C, 2.D). This difference is evidently caused by using of the yeast of various strains under conditions of production at specific company. At the same time, morphology of yeast cells was preserved with the use of water exposed to NCP – both experimental and control samples of microorganisms were characterized by typical appearance and shape (Fig. 2, pos. 1), and young budding cells were also in sight (Fig. 2, pos. 2). Biochemical properties of Saccharomyces cerevisiae yeast were determined on Giss media after their culturing in Sabouraud broth using plasma-chemically activated water and mains water without additional treatment. It is shown that both experimental and control samples fermented glucose, maltose and sucrose and had

similar biochemical properties. No suppression of metabolism of bakery yeast when using water exposed to NCP occurred.

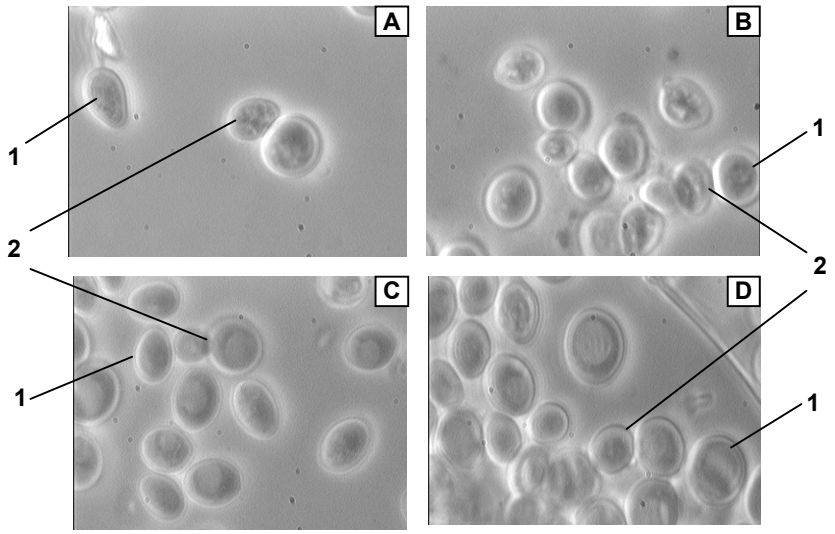

Fig. 2. Morphology of yeasts of TM "Lvivski" (A, B) and "Kryvorizki" (C, D) with the use of mains water (A, C) and plasma-chemically activated water (B, D): 1 – independent cell; 2 – budding cells.

Concerning the effect of hydrogen peroxide on the yeast, rather conflicting data is known. Results of investigations of the work [9] prove that with the use of hydrogen peroxide of 100-1000 mg/l concentration fermenting activity of bakery yeast is reduced. However, the paper [10] deals with the method of activation of must fermentation consisting in previous treatment of the yeast with the solution of hydrogen peroxide of 100 mM concentration and addition of the yeast ferment lysate to the initial must. Besides, the effect of parameters of treatment of brewing yeast with hydrogen peroxide which provides for the largest quantity of viable osmo-tolerant cells in suspension was determined. Proposed treatment of the yeast suspension with hydrogen peroxide allowed decreasing the negative impact of higher concentrations of ethyl alcohol on the fermentation process. As it was shown by results of investigations, growth of Saccharomyces cerevisiae produced by Lviv and Kryvyi Rig yeast plants was not restrained because of use of plasma-chemically activated water. On the contrary, increase in quantity of viable yeasts in suspension and stimulatory action of water exposed to NCP on the yeast vital activity was found. It is evident that AOFs, in particular, hydrogen peroxide, have essential influence on the effects obtained. Bailyak [11] has shown that *in vivo* hydrogen peroxide is capable of inactivating or activating antioxidant ferments depending on their concentration, peculiarities of the yeast strain and phase of the culture growth. The ability of baking yeasts to survive in the environment with presence of hydrogen peroxide depends on the capacity of antioxidant systems of cells. In the presence of catalase, with the action of oxidative stress induced by H_2O_2, activity of antioxidant systems and cell survival shall increase owing to restoration of intracellular homeostasis. Since water exposed to NCP contains peroxide and superoxide compounds, it should be noted that oxidative processes in Saccharomyces cerevisiae are enhancing, with the further adaptive response of cells. That

is, AOF content in plasma-chemically activated water results in mobilization of physiological and genetic reserves of a cell when the gradual increase in the organism resistance to stress action is displayed as metabolism stimulation and improvement of cultural properties of microorganisms. Besides, usage of plasma-chemically activated water may possibly increase the penetration of water molecules through membranes of Saccharomyces cerevisiae, that in turn speeds up metabolism between the cell and its environment and promotes higher resistance to stress, serving as an impulse to increased reproduction of microorganisms in the nutrient medium.

Results of experimental investigations are important for biotechnology and, in particular, for the theory and practice of bakery production based on microbiological processes traditionally initiated by Saccharomyces cerevisiae yeasts.

Conclusions

It was determined that plasma-chemically activated water had no suppressive action on Saccharomyces cerevisiae yeast in contrast to its impact on various pathogenic and opportunistic-pathogenic microorganisms.

The experiments prove that with the use of plasma-chemically activated water morphological characteristics and biochemical properties of bakery yeasts produced by Lviv and Kryvyi Rig yeast plants are preserved.

It is found that culturing of Saccharomyces cerevisiae yeast on the nutrient media prepared with the use of water exposed to NCP resulted in 6,5–15 times' increase in quantity of viable microorganisms compared with the control on the mains drinking water, and therefore it is promising for use in the yeast production, baking and fermenting branches of food industry.

Further investigations shall be aimed at determining the effect of plasma-chemically activated water on antioxidant ferments of Saccharomyces cerevisiae and peculiarities of transmembrane transfer of water exposed to NCP through hydrophilic channels of membranes of the bakery yeast.

Acknowledgments

Investigations of effect of plasma-chemically activated water on yeast microorganisms were carried out in five-fold repetition in the conditions of microbiological laboratory of the Department of microbiology, virology, immunology and epidemiology of the Public higher education institution "Dnipropetrovsk Medical Academy of the Ministry of Health of Ukraine".

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Technological foundations of processing tomato pomace in feed additives

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Abstract

Introduction. Search for new types of alternative raw material for the efficient development of poultry industry and problem of waste disposal of canning industry made it necessary to develop a method of processing tomato pomace in feed additives.

Materials and methods. Sampling, preparation and testing were carried out by general and specific organoleptic and physical-technological methods of assessment and analysis of the properties of raw materials and finished products.

Results. Incorporation of tomato pomace in the feed additive reduces the cost of raw materials and expenses associated with moistening of the mixture before extrusion and incorporation of chalk feed will solve the problem of calcium imbalance of laying hens. It was found that extrusion process has improved the physical properties of feed additive and showed the possibility of its use as a feed component: moisture content decreased by 34.5 %, the angle of repose increased by 11.4 %, flowability decreased by 39.7 % and bulk density decreased by 32.3 %.

Conclusions. The resulting feed additive will solve the problem of diversification of raw materials, waste, calcium imbalance of laying hens and reduce expenses on compound animal feedstuff production.

Introduction

At present stage of reform and development of the food complex of Eastern Europe countries there is a strategic issue to increase production of high-quality food for their own needs, while gaining international food market. One of the areas capable in the short term to solve the assigned problems is poultry breeding [2].

Poultry breeding is the most powerful branch of world agriculture which differs in extremely high dynamic development; is unbeatable on cost of feed and labor costs per production unit and provides the population with high-quality food [1-3].

However, despite the dynamic development poultry farming is facing a number of problems solution of which will enable industry to take new heights.

A necessary condition for the industry development is search for new types of non-traditional materials that can reduce the content of cereals in the poultry feeding and able to reduce the cost of compound animal feedstuff products.

At the same time, according to the data of the State Statistics Committee of Ukraine in recent years the production of fresh tomatoes in our country significantly increased. In 2000 Ukraine cultivated 1126.6 thousand of tons of tomatoes and in 2012 this number has already reached 2274.1 thousand of tons. Along with fresh vegetables production also production volume of tomato canning products and waste received in the process of their production has been increased [13, 14].

Therefore, canning industry faces the problem of herbal waste disposal of high humidity in the form of tomato pomace which contain a number of nutrient bioactive substances and can serve as an effective component of compound animal feedstuff production in nutrition diet of farm animals and poultry. However, insufficient attention is so far paid to the use of canning industry waste in our country. At most companies these valuable feed stuff are spoiled and destroyed in large quantities creating a significant threat to the environment [5, 6].

Limiting factor for use of tomato pomace in the process of compound animal feedstuff production is high humidity which is an excellent environment for the development of pathogenic organisms and significantly reduces the shelf life of waste. They are highly perishable and require immediate disposal. Existing disadvantages considerably complicate the processing and use of by-products of the canning industry in the compound animal feedstuff production of high humidity [6].

Literature data analysis shows various ways of processing tomato pomace both independently and in mixtures with other by-products of the canning industry. Tomato pomace can be fed to animals and poultry as green feed, silage and subjected to drying and granulation.

The most rational way of processing tomato pomace is drying to a final moisture content 8...14 % and use at the process of compound animal feedstuff production as feed flour [7]. However, this method was not widespread in the feedstuff industry due to high price – high electric power consumption makes it expensive.

Therefore, the most rational way to use them is the processing in feed additives for further use in the manufacture of compound poultry feedstuff.

Along with the problem of expanding the raw material base big problem for the poultry industry is the calcium imbalance including calcium deficiency of laying hens during ovulation period. This necessitates the development of feed additives that will expand the raw material base, solve the problem of the imbalance of calcium of poultry and reduce the production costs of compound animal feedstuff production.

Materials and methods

In the manufacture of feed additive fodder chalk and tomato pomace were used as raw material. Extrusion of additive has been carried out with grain extruder E3-150 (Fig. 1) at a temperature of 110...120°C and a pressure of 2...3 MPa.

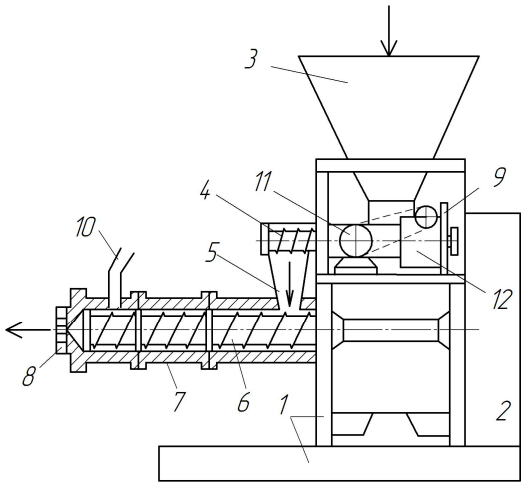

Fig. 1. Extruder E3-150 (Bronto, CherkasyElevatorMash)
1 – base (frame), 2 – main drive, 3 – bin, 4 – feed screw dispenser, 5 – receiving chamber, 6 – forcing screw, 7 – prefabricated housing, 8 – matrix, 9 – secondary drive, 10 – thermometer, 11 – DC motor, 12 – reducer.

Feed additives has been assessed by physical parameters such as moisture content, bulk density, modulus size, flowability, angle of repose, index of extrudate expansion.

Moisture content was determined by drying the sample of the product in the weighting cup in the drying oven at a temperature of 130°C for 40 min. and was calculated using the formula:

$$W = (q_1 - q_2) / (q_1 - q_0) \cdot 100, \%$$

where q_0 – mass of empty weighting cup, g; q_1 – mass of weighting cup with a lifting bar before drying, g; q_2 – mass of weighting cup with a lifting bar after drying, g.

Extrudate expansion ratio was determined by extrudate diameter to the diameter of the outlet of the extruder matrixes.

Bulk weight of additive has been determined with a half-liter grain-unit scale which consists of jack, filler, cylinder head, bailer, knive, puller and measurer. The cylinder was closed with funnel, put down on filler with bailer and after the product was poured in filler, the cylinder with bailer has been removed. The knife was removed faster from the crack and after the puller and the product fell in the measurer the knife was again gently inserted into the slot. Then the measurer with the filler has been removed from the jack, overthrown, holding the knife and the filler, and poured the excess remaining on the knife. Then the knife has been removed from the crack, the measurer with the product has been weighed and the nature of the product was set up accurate within ± 0.5 g.

Angle of natural repose was determined by the product pouring from the filler on a horizontal surface. The product has been poured through a metal funnel that has a cone angle of 60°, until the top reached the height of vertical walls of the device. There has been performed protractor angle measurement. For this the protractor has been applied to the cone generatrix and determined by screeching angle β. Then the angle of natural repose α was considered as: $\alpha = 90 - \beta$.

Flowability has been determined by the method of pouring the product through hole of a certain size (diameter 4 cm). The product was poured in a box with the outlet which was closed with the latch. To determine the product flowability the latch has been open and the time of pouring of the product through the outlet on a horizontal surface has been noted.

Volume of poured product was measured with the cylinder. Flowability was determined by the formula:

$$V_c = q / (S \cdot t),\ cm^3/sec.,$$

where q – volume of product that passed through the hopper outlet, cm^3; t – duration of pouring of the product, sec.; S – cross-section area of the outlet, cm^2.

Determining the size of the module was performed on a laboratory plansifter. Sample of the product on the top sieve placed laboratory plansifter, closed the lid and sieved for 5 minutes at 190...210 sieve oscillations per minute. After sifting weighed stairs on each sieve.

The size modulus was determined by the formula:

Size modulus determination has been carried out with the help of the laboratory diffuser. Sample of the product was placed on the top sieve of the laboratory diffuser, then it was closed with the lid and sieved for 5 minutes at 190...210 sieve oscillations per minute. After sifting remaining residue on each sieve were weighed.

$$M = (3,5 \cdot m_1 + 2,5 \cdot m_2 + 1,5 \cdot m_3 + 0,78 \cdot m_4 + 0,28 \cdot m_5) / 100,\ mm,$$

where m_1, m_2, m_3, m_4 – mass of remaining residue from the sieves with holes Ø 3, Ø 2, Ø1, Ø 0,56 mm, g;

m_5 – mass of passage with holes Ø 0,56 mm, g;

3,5; 2,5; 1,5; 0,78 – the average size of the particles remaining on sieves with holes Ø3, Ø1, Ø 0,56 mm, accordingly, mm;

0,28 – the average size of the particles which passed through a sieve with holes Ø 0,56 mm;

100 – mass of the sample taken for the analysis, g.

All tests were performed at 3-fold review of measurements and experimental results have been processed by software (Mathsoft, Inc., USA; Mathcad Professional).

Results and discussion

The feasibility of processing tomato pomace in feed additives demonstrates their physical properties. Therefore, at the first phase of work there has been investigated physical properties of tomato pomace indicators such as moisture content, bulk weight and density. Thus, weight ratio of moisty tomato pomace was 70 %, bulk weight comprised 399 kg/m^3 and accordingly density was 1.29 kg/m^3.

Analysis of studies of the physical properties of tomato pomace suggests that these residues are characterized by poor physical properties because of their high moisture content. Therefore, it is advisable to carry out their processing only as part of other grain ingredients of compound animal feedstaff for physical properties of the mixture to get satisfactory value and avoid demixing and clumping of products. In addition, high humidity of pomace may lead to corrosion of metal equipment.

A necessary condition for the development of feed additives using tomato pomace is the choice of the optimal additive components in terms of chemical composition, physical properties and cost. It is necessary to consider not only the cost of raw materials but also

the cost of electricity for its processing. Therefore, a further step in our research was the analysis of physical-chemical properties of grain components, costs related to their acquisition and processing.

Among cereals the most widespread in the poultry is corn as an energy source that exceeds all grain cereal feed that is 1,382 mJ of metabolizable energy but it has less protein (8...10 %). Corn contains 4...6 % of fat, about 60...70 % of starch and 2...3 % of fiber. In addition, the yellow pigment of corn make attractive broiler carcass and add to the egg yolks really yellow color [8-11]. In addition, the specific power consumption for extruding corn is lower by 10.2 % than wheat by 14.3 % lower compared to shelled oats and by 24.4 % compared with peeled barley [12].

The inclusion of the mineral feed additive will solve the problem of calcium deficiency of laying hens.

Fodder chalk is characterized by low cost and high contents of calcium what has made it widespread among other minerals. And due to its physical properties, chalk by sorbing moisture can increase the percentage of making tomato pomace, thereby reducing the cost of raw materials that is an important factor in calculating recipes of compound poultry feedstuff [4].

To determine the most optimal feed additive composition there has been determined moisture content of the components that can be included into its contents. Moisture content of corn comprised 12.9 %, fodder chalk – 0.5 %, tomato pomace – 70.0 %.

Extrusion process allows to save a number of nutrients and biologically active substances, to improve the taste and aromatic properties, increase the assimilation of food and increase shelf life of products [15-17].

Considering useful properties (advantages) of extruded products we have developed a way of processing tomato pomace in feed additives. As humidifier mixture before extrusion we were using tomato pomace. Since in the process of the extrusion up to 50% of moisture from the extrudate has been evaporated, we calculated the amount of tomato pomace which provided moisture content after extrusion in feed additive of not more than 12.5 % due to the inability to keep extrudate with higher moisture content for a long time. So dry mixture before extrusion shall be not more than 16...18 %.

Therefore, the estimated water content of the mixture before extrusion with the introduction of 73 % corn with a moisture content of 12.9 %, 12 % tomato pomace with a moisture content of 70 % and 15 % fodder chalk with a moisture content of 0.5 % comprises 17.89 %. If adding more tomato pomace of the mixture increases its moisture content and extrusion process fails completely while a smaller quantity the mixture have to be further moisten with water resulting in additional costs.

Addition of fewer quantity of fodder chalk is inefficient because it does not meet the needs of animals and poultry in calcium in full as well as increase of its addition negatively affects the physical and technological properties of the feed additive. Therefore, the introduction of such a large number of components of the additive is the best in terms of physical and technical characteristics and costs of their processing (table 1).

Table 1

Feed additive contents

Components content in feed additive, %	**Raw material**			**Total**
	Corn	Fodder chalk	Tomato pomace	
	73	15	12	100

Figure 2 demonstrates traditional and developed processing technology of tomato pomace. Traditional technology involves the processing of tomato pomace in feed flour by grinding it, drying, cooling, grinding and packaging. Processing of tomato pomace by traditional technology requires the use of external heat sources which requires additional investment in boiler construction, expenses on gas, liquid or solid fuel. At the same time as the extrusion process eliminates these costs, thereby reducing expenses on processing of tomato pomace in feed additives. Furthermore, in the process the structural and mechanical and chemical state of the mixture are changed and as result satisfactory sanitary conditions and better assimilation of nutrients are received.

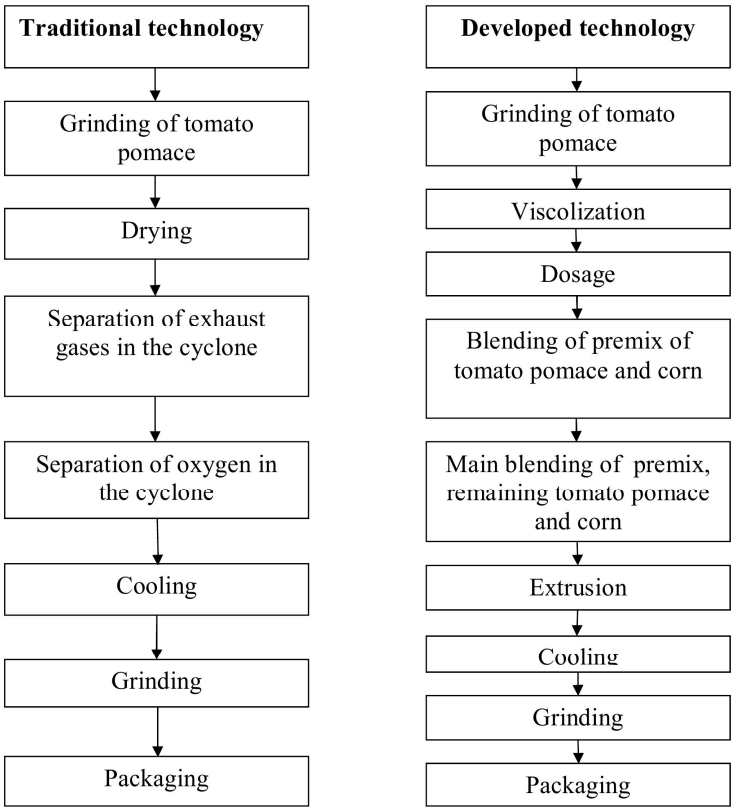

Fig. 2. Technological methods of processing tomato pomace

The developed technology provides cleaning of corn from impurities, grinding on hammer mill to a particle size of 3 mm and dosage. Separately there are prepared tomato pomace for processing including grinding with grinder to particle size of 2...3 mm, viscolize and dosage. Fodder chalk with humidity less than 10 % has been cleaned of impurities and dosaged. Then there is prepared premix for which tomato pomace and corn taken in proportion of 1:1 are mixed in grinder for 180 sec. to form a homogeneous mixture. Then the main blending of the premix with the remaining of corn and fodder chalk in blade-type mixer for 120...180 sec. The resulting mixture is extruded at a temperature of 110...120°C and pressure of 2...3 MPa. The resulting extrudate of moisture 11.6 % has been

cooled to a temperature that does not exceed the ambient temperature by more than 10°C, grind in a grinder to a particle size of 3 mm for storage, if necessary, extrudate is packaged.

Samples of feed additives was studied using indicators that mostly characterize the technological properties of the finished products such as angle of natural repose, flowability, bulk density, and efficiency of extrusion has been defined by specific power consumption, extrudate expansion index, starch dextrinizing degree and moisture content (table 2).

Table 2

Extrusion effect on the physical properties of the feed additive (n = 3, P≥0,95)

Index	Feed additive		
	Before processing	After processing	Alternations, %
Moisture content, %	17,7	11,6	-34,5
Angle of natural repose, *degrees*	35,0	39,0	+11,4
Bulk density, kg/m^3	665,0	450,0	-32,3
Flowability, *cm/sec*	13,6	8,2	-39,7
Size modulus, *mm*	1,8	1,2	-33,3
Starch dextrinizing degree,%	56,2		
Extrudate expansion index	2,1		
Specific power consumption, *kW·h/t*	16,0		

Analysis of the data presented in table 2 demonstrates that during feed additive extrusion moisture content is reduced by 34.5 %, the angle of natural repose is increased by 11.4 %, flowability is reduced by 39.7 %, bulk density is decreased by 32.3 %.

When extruding feed additive starch dextrinizing degree is 56.2 % while the recommended value is not less than 55 % , the specific power consumption is 16 kW·h/t and extrudate expansion index is 2,1. The low degree of starch dextrinizing degree and extrudate expansion index is explained by the formation during extrusion of protein-carbohydrate complexes.

Conclusions

1. Addition to the feed additive 12 % of tomato pomace reduces the cost of raw materials and expenses associated with moistening the mixture before extrusion.
2. Use of chalk feed in additives of a bound state will provide the organism of the poultry with calcium according to physiological needs.
3. Extrusion process has improved the physical properties of the feed additive including moisture content decreased by 34.5 %, the angle of natural repose increased by 11.4 %, flowability decreased by 39.7 % and the bulk density decreased by 32.3 %. Also as a result of extrusion there has increased nutrient uptake as that is demonstrated by starch dextrinizing degree (56.2 %).
4. Obtained feed additive allows to expand the raw material base in compound animal feedstuff production, recycle byproducts of canning industry of high humidity, solve the problem of calcium deficiency of poultry and reduce expenses on compound animal feedstuff production.

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Micro structural characteristics of minced meat products from use of protein-mineral additive

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Abstract

Introduction. Infringement of balance mineral substances is widely manifested in the meat products which is much wealthier in phosphorus than calcium. List of additives that containing calcium and technology meat products with their using are limited. Purpose of the work is studying and scientific substantiation of influence protein-mineral additive (PMA) on the technological micro-structural properties of minced meat products.

Matherials and methods. Studies water- and fat-holding ability (WHA, FHA) of samples carried out by gravimetric and refract metric methods. Histological sections were produced at microtome, followed by coloring with hematoxylin and eosin and by the method of Mallory.

Results and discussion. Created a technology of the minced meat products for health improvement using the PMA which is a carrier of Bioorganic calcium. Rational is the addition of PMA in powder form in amount of 7,5 % of the meat systems. Technological parameters of minced meat increase when making additions in particular WHA and FHA approx about 5 and 10 % respectively. Histological studies have shown that PMA promotes the preservation of meat juice and sarcoplasmic proteins in the meat systems during thermal processing.

Conclusions. PMA has a positive impact on the properties of water-holding properties of minced meat and output the finished product.

Introduction

The structure and quality of the nutrition the of modern person can described as those that do not provide to fully all physiological needs of the body of irreplaceable nutritional factors. Today expansion of assortment food products in particular meat, is mainly through by replacing the components of the product at more cheap, economically most advantageous raw materials. Among the essential elements of nutrition the most scarce are mineral compounds, in particular calcium in digestible by the human body form. An

imbalance of minerals commonly seen in meat products naturally much wealthier in phosphorus than calcium. The priority direction of the science of nutrition is the creation balanced chemical composition of food with health-improving properties.

The majority of well-known technology of meat enriched with calcium, a mineral component is represented as water-soluble inorganic salts of calcium or low organic forms, which does not provide this element deposition in body tissues [1-2].

Modern research has proved the importance of food bones as a source of bio-organic calcium compounds. However, for calcium-based food additives on bone and meat technology with their use is limited [3].

Therefore, additional food sources of digestible calcium compounds and their use in the meat processing of mass consumption is actually.

Matherials and methods

In order to study water- and fat-holding ability (WHA and FHA) the developed minced meat samples of natural mince and cutlet mass were researched made by traditional technology using protein-mineral supplements in powder form (PMA) in an amount of 2.5 ... 10 % by weight of raw meat, control samples - made without the use of PMA. WHA and FHA samples was determined by gravimetric and refractometric method.

For micro structural researches were chosen 4 samples

1. Control. Raw minced meat produced without the use of PMA.

2. Experimental model. Raw ground beef, made using 7.5% dry PMA relative to the mass of raw meat.

3. Control. Heat treated minced meat produced without the use of PMA.

4. Prototype. Heat treated ground beef, made using 7.5% dry PMA relative to the mass of raw meat.

In order to study histological characteristics samples of minced meat were fixed in 10% neutral formalin aqueous solution, followed by preparation and pouring in paraffinic blocks. Histological sections thickness of 5-7 microns produced at microtome, followed by coloring with hematoxylin and eosin and by the method of Mallory (differential coloring on the muscular and connective tissue).

For unbiased estimation of the obtained results was carried morphometric studies using the microscope "biolam" and eyepiece micrometer MOV - 1 - 15×. We determined the thickness of the muscular fibers in the control and experimental samples respectively raw and heat-treated. Calculated compacting factor of muscular fibers after samples minced meat heat treatment.

Obtained digital indicators treated variation-statistical methods [4].

Photographing was carried out using a microscope MBI-3 and photo tips MFN-10.

Results and discussion

For enrichment the diet with essential nutrients such as calcium bioorganic, and to correct the chemical composition of meat products we scientifically substantiated and the technology of minced meat products that are rich in digestible calcium by using of protein-mineral additive (PMA). PMA is a stable complex pig skin collagen and minerals (calcium, magnesium), which ensures their metabolic activity.

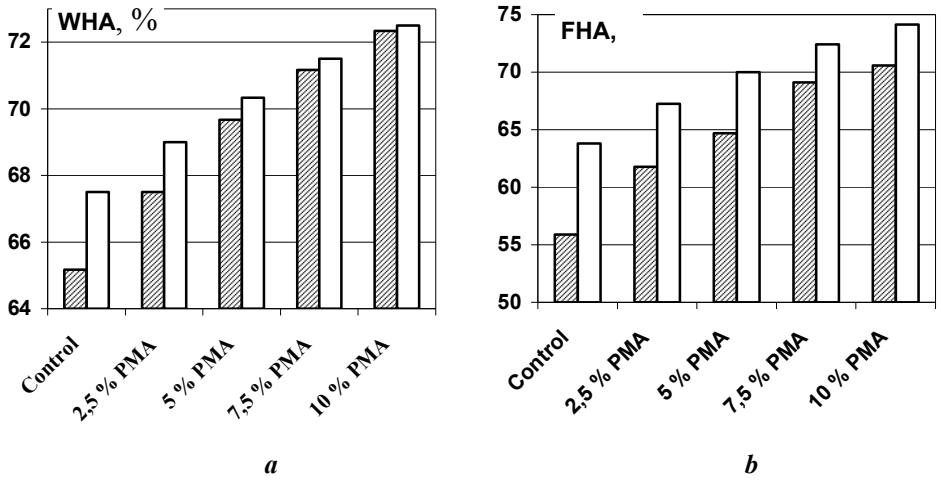
Investigations have established that the most appropriate is addition of PMA (in powder form) in the mince meat products in the quantities about 7.5% by weight of raw meat on stage of mixing prescription ingredients. It leads to an improvement of

technological, organoleptic characteristics, that fundamentally changes the traditional production process of the product, and provides about 50% of the daily physiological need for usable calcium [5].

Scientific interest and practical value is to study the effect of PMA in water- and fat-holding ability (WHA, FHA) developed samples of minced meat. From the data characteristics of the microstructure is strongly dependent samples technological properties minced meat systems, changes of protein components, yield and organoleptic properties of the finished product (texture) economic production efficiency.

On fig. 1 is shown the change in WHA (a) and FHA (b) minced meat by using PMA. The diagram shows that the WHA of ground meat at entering PMA in an amount of 2.5 ... 10% increases: for natural ground meat − on 2,33 ... 7,33% for cutlet mass − 1.5 ... 5%.

Results of the research of FHA minced meat show increasing the value of this parameter with increasing content of PMA. When used PMA in an amount of 2.5 ... 10% FHA value compared with control increased to 5.88 ... 14.71% for natural forcemeat and at 3.45 ... 10.35% for cutlet mass. Probably, this effect is achieved by the presence in PMA water soluble polypeptides that act as emulsifiers to form direct emulsion.



a *b*

Fig. 1. Changing WHA (a) and FHA (b) minced meat by using PMA

- natural mince *- kotlet mince*

It can be assumed that the increase in WHA minced meat by using PMA predefined the following:

− Through the use of PMA ensure absence of connective tissue basis and reducing the number of raw meat that can "squeeze" moisture during denaturation while heat treatment;

− A high degree of crushing PMA increases the active surface macromolecular substances - collagen for moisture absorption, increasing the number of proteins (of collagen) in the aqueous phase mince. Collagenic proteins composed of PMA able to swell, show hydration properties;

− It is possible interaction of calcium compounds PMA with myofibrils proteins of meat, in consequence is formation of complexes with high functional- technological properties;

− As a result of capillary-porous structure of PMA particles can to refrain moist by the surface tension in the pores of PMA.

In order to confirm the obtained highly functional and technological indicators, including WHA and FHA, minced of meat with PMA was researched micro structural characteristics of semi-finished and finished minced meat products using the PMA.

Minced meat semis without using PMA. On the histological sections of control samples raw minced meat are determined shredded muscle fibers plump and dense connective and adipose tissue. From Fig. 2 shows that the grinding mince uneven, a sign of what is the presence on the area of section fragments structurally framed muscular tissue with saved entries endomysium and peremizium and milled muscle fibers with loss of the beam and the violation of the integrity of the sarcolemma.

In these fibers occurs bundle of myofibrils formation micro-slit spaces resulting from loss of fiber sarcoplasm liquid fraction (Fig. 3). Liquid protein fraction of meat juice between fibers is not detected, indicating a free leaking it from the control sample of raw minced meat until the last fixation formalin.

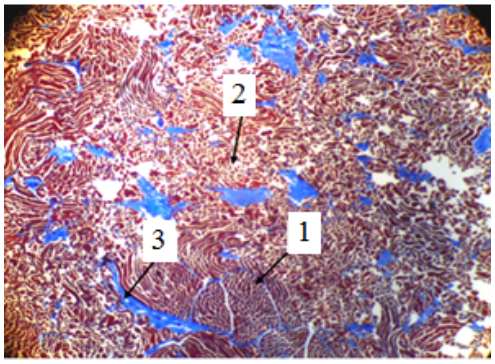


Fig. 2. A sample of raw minced meat with PMA (Mallori, × 3,2)
1 – fragments of muscular tissue structure decorated with saved entries endomysium and peremizium;
2 – finely milled muscular fibers with loss beam organization; 3 – fragments of connective tissue

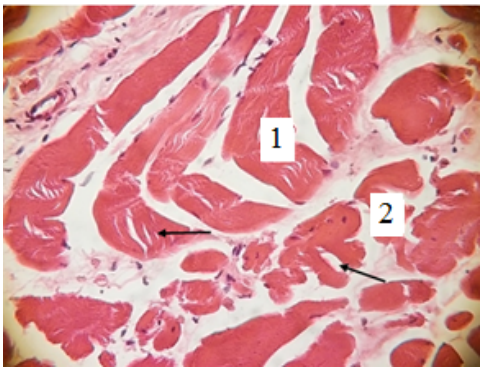


Fig. 3. A sample of raw minced meat with PMA (hematoxylin and eosin, × 40)
Micro cracks in musclar fibers shown by the arrows:
1 - longitudinal sections of muscle fibers;
2 – transverse sections of muscle fibers with violation the integrity of sarcolemma

Meat chopped semi-finished products using the PMA. In histological sections of test samples of raw minced meat (Fig. 4), as in control, defines all its components, as well as dispersed particles PMA. Latest at preparations colored with hematoxylin and eosin, have the form of basophilic particles that are show adhesive properties on structured components minced (Fig. 5).

Adding impurities to the minced meat had positively affect on the preservation of meat juice in semifinished from chopped meat (Fig. 5). Protein components of impurities, revealing hydrophilic properties, linking liquid component of meat juice. A characteristic feature of the test samples of raw minced meat is to keep the internal structure of the

muscle fibers without stratification of myofibrils, indicating a lower degree of loss by them liquid components of sarcoplasm.

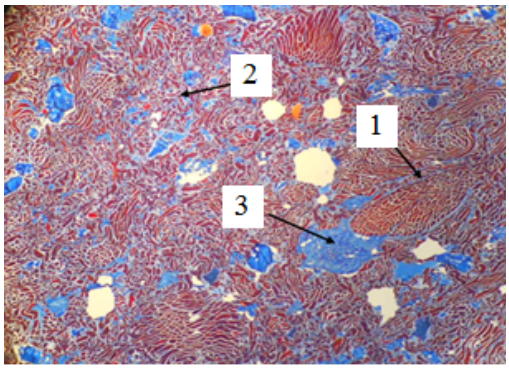


Fig. 4. Example of raw minced of PMA (Mallory, × 3,2)
1 – samples of muscle tissue structure executed with saved entries endomysium and peremizium;
2 – finely milled muscle fibers with loss beam organization;
3 – fragments of connective tissue

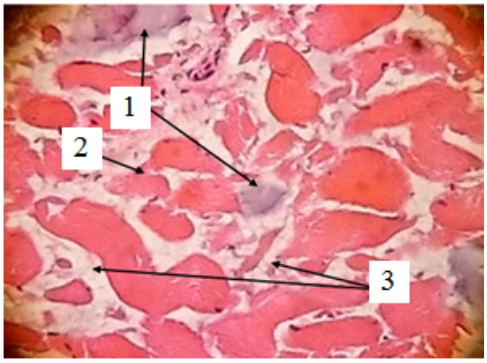


Fig. 5. Example of raw minced PMA (hematoxylin and eosin, × 40)
Micro cracks in the muscle fibers are almost absent.
1 – dispersed particles of impurities;
2 – transverse sections of muscle fibers in violation of the integrity of sarcolemma;
3 – meat juice between milled muscle fibers

Heat-treated minced meat products made by traditional technology without PMA. Heat treated control samples of mince characterized by irregular structuring (Fig. 6). On the histological preparations are defined areas of adhesion muscle fibers in large-sized conglomerates, which are formed between the large cavity.

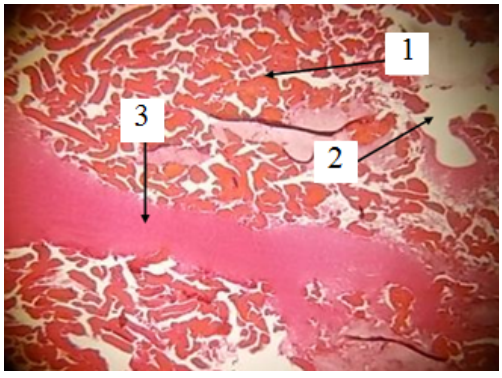


Fig. 6. sample of heat-treated mince without PMA (hematoxylin and eosin, × 10)
1 – adhesion of muscle fibers in large conglomerates;
2 – large cavity;
3 – coagulant of meat juice

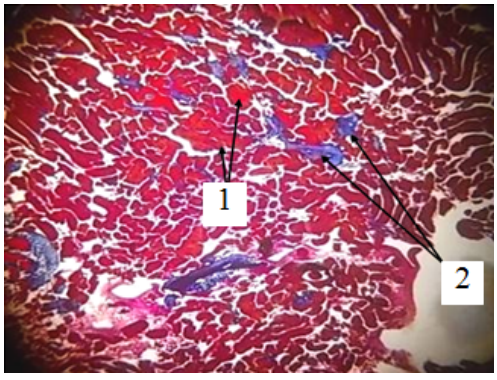


Fig. 7. A sample of heat-treated minced without PMA (Mallory, × 10)
1 – conglomerates of finely milled muscle fibers, colored in bright red;
2 – connective tissue

Empty slotted gaps formed between the individual muscle fibers. This structure leads to fragility of the finished mince meat product.

From Fig. 6 clearly shows that the voids between the compacted muscle fibers is determined by thermally coagulated juice of the meat in the form of large areas of oxyphilic granular mass.

In preparations painted by Mallory (Fig. 7) muscle fibers often become a mosaic view due to the prevalence of some of them bright red color, which results from excessive loss of protein fractions sarcoplasm when leak in meat juice.

Heat-treated minced meat products made of PMA. In heat-treated experimental samples of minced dense arrangement of muscle fibers occurs only in not chopped fragments where no impurity (Fig. 8). These fragments of minced when stained preparations revealed partially it turns coloring mosaic muscle fibers (Fig. 9).

On Fig. 8 shows that thermally coagulated meat juice mostly evenly distributed between the muscle fibers, which are also defining and dispersed particles of impurities.

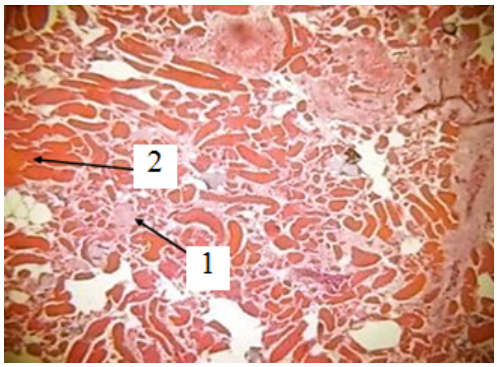


Fig. 8. A sample of heat-treated minced PMA (hematoxylin and eosin, × 10)
1 – meat juice between chopped muscle fibers;
2 – partial adhesion of muscle fiber Samples of mince in which was not included PMA

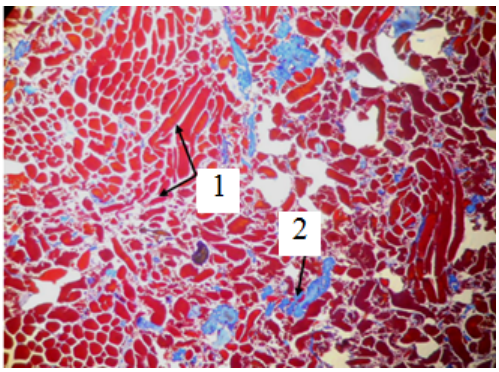


Fig. 9. A sample of heat-treated minced PMA (Mallory, × 10)
1 – muscle fibers and their fragments placed evenly;
2 – connective tissue

Thus, we can conclude that the control samples of minced because of mechanical integrity violations of sarcolemma muscle fibers lose in composition of meat juice soluble fraction of sarcoplasmic proteins. An introduction experimental impurity in PMA mince not only prevents the loss of meat juice that is evenly distributed between the fragments and of minced is kept in the finished product, but also significantly reduces the loss of muscle fibers sarcoplasmic proteins after heat treatment.

Conclusions

1. Created technology of the mince meat products using PMA. Exactly PMA is the carrier of bioorganic calcium metabolic activity which caused by the binding of calcium and collagen pigskin.

2. Established improve the organoleptic and technological parameters of mince meat products using PMA, by raising the value of WHA, FHA mincemeat. Probably, this indicates a positive effect PMA on output the finished product against the background of conservation of other functional-technological characteristics of the finished product, along with the fact that the use of recycled cheaper raw materials will reduce the cost of production.
3. Putting PMA in mince not only prevents the loss of meat juice that evenly placed between fragments of minced meat and preserving in the finished product, but also significantly reduces the loss of muscle fibers sarcoplasmic proteins. The obtained results of histological investigations meat products and ready-made products from PMA bring a positive impact of PMA on the water-holding properties of minced meat and output the finished product.

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Content iodine in sauces of type emulsion

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Abstract

Introduction. The scarcity of natural resources arouse a necessity to find additional sources of protein, fat, carbohydrates, and their complexes with scarce mineral compounds. Therefore, a relevant issue is to enrich the diets deficient iodine compounds through research and development of new food products.

Materials and methods. Investigation of iodine content in emulsion-type sauces at all stages was performed using X-ray-fluorescence analyzer «Elvax». X-ray-fluorescence method consists of the appearance characteristic X-radiation of atoms of a chemical element at infringement they the primary X-ray irradiation.

Results and discussion. Investigated for the determination of organic and inorganic forms of iodine in content of food items, and installed the total loss of iodine in sauces after cooking and storage at +5 ... +10 ° C for 30 days. Using iodine-proteinaceous additive from 0.5 ... 2.5% by mass of iodine 0.01% can be achieved from 15 to 50% of the human daily requirement by iodine.

The resulting product does not lose its organoleptic, physico - chemical, consumer characteristics and meets the requirements of normative documents.

As a result of our research, it was found that the addition of the supplements enriched protein-mineral (SEPM) in composition sauces does not adversely affect the physical - chemical characteristics of sauces, but due to the stabilizing effect of additives iodine-proteinaceous increased emulsion stability up to 98 - 100% without additional food additives (emulsifiers).

This additive has passed a series of tests that indicate on compliance with requirements normative and technical documentation.

Conclusions. Used methodical approach allowed us to estimate the level of organic and inorganic iodine, as well as describe in more detail and correctly interpret the chemical composition of foods fortified with iodine and predict their health properties.

Introduction

Of particular importance to maintaining the state of human health and longevity has a full and a regular supply of body all necessary micronutrients: essential amino acids, vitamins and mineral components. And the most suitable and physiologically reasonable route of these components in the body -is alimentary.

Insufficient intake of micronutrients from food - is a common problem of modern humanity. It arose as a result of reduction in the intensity of exercise on the body, as a consequence - lower energy costs and a corresponding decrease in the total amount of food consumed by people. Against such deficits arise metabolic disorders and so-called "diseases of metabolic origin." These diseases occur when deficiency of essential amino acids, fatty acids and minerals. Relative deficiency of minerals most often the cause of serious diseases is the lack of iron, iodine, calcium, selenium, etc.

The most feasible, effective, and economically accessible by the way of radical improvement of provision of the population micronutrients is a regular inclusion in the diet foods in health purposes, enriched with micronutrients.

Must take into account the fact that the level of uptake of micronutrients from food influenced by several factors: a person's age, gender, lack of pathological conditions of the digestive system, the ratio of individual components of the diet and the relationship between individual micronutrients.

Must take into account the fact that the level of uptake of micronutrients from food influenced by several factors: a person's age, gender, lack of pathological conditions of the digestive system, the ratio of individual components of the diet and the relationship between individual micronutrients.

Analysis of recent research shows that Ukraine is traditionally endemic region relative iodine deficiency. As a consequence, the structure of the metabolic pathology of origin accounts for a significant percentage of serious illnesses such as endemic goiter, short stature, deaf-mutism, disturbances of mental activity of children and adults.

Question iodine uptake by the human body is also associated with a number of problems. Iodine is absorbed by the body only in the state of a cation, in this form; it can form complexes with organic compounds, in particular with the proteins. However, in foods, it is basically in the state of the inorganic compounds in most cases, it corresponds to his anionic chemical form.

That is why one of the main functions of the thyroid gland of the human body is the conversion of iodine from anionic in a cationic state with subsequent formation iodine organic compounds necessary for normal biological processes of human.

Given the proliferation of thyroid disorders, a transformation of the population iodine may not always occur, which leads to the impossibility of assimilation by the body mineral iodine compounds.

Furthermore, it is known that iodine has radio protective properties, so adding it to the food will expand the range of products with radio protective properties, which is especially important for Ukraine, Belarus and Russia, as states the maximum affected by the Chernobyl NPP.

It is important to note the differences in the metabolism of organic and inorganic iodine associated with the regulatory function of the liver in this process. At the use of marine products (fish, non-fish marine hydrobionts, algae), which contains organic iodine, iodinated protein first under the action of proteolytic enzymes in the small intestine breaks down into amino acids, with one of them - tyrosine - iodine binds. Then iodinated amino acids via the portal vein enter to the liver cells - hepatocytes. The required amount of iodine

released into the blood and thyroid gland, and his excess through the biliary tract excreted from the body. The use of inorganic iodine that is absorbed in the stomach and does not pass the "filtration" in the liver may be the consequence of overdose of iodine and may cause iodine-inducing hyperthyroidism.

The aim of this work is to study the kinetics of iodine content in emulsion-type sauces made using additives iodine-proteinaceous during preparation and storage, as well as the application of a method for evaluating the content of organic and inorganic iodine in sauces emulsion type.

Materials and methods

For research were selected samples of emulsion type sauces with different content of additives mineral-enriched protein (AMEP) relative of egg powder, 0.5 ... 1.5% AMEP; Sauces emulsion type using AMEP (iodine-proteinaceous), which were submitted to the analysis, had the following characteristics:

- Appearance, consistency had uniform, creamy system, and was thick with single air bubbles.
- Taste and smell was neutral inherent in this type of mayonnaise, odors were not.
- The color was uniform throughout the mass had a creamy yellow color.

Organoleptic indicators are an important component in determining the quality of mayonnaise. On organoleptic indicators can determine the quality and freshness of mayonnaise.

In accordance with this have been developed formulations with content AMER 0.5 ... 1.5%. AMER added to the hydrated form in emulsifying basis to form a basis for a better distribution of the additive in the finished product. Other components were introduced by traditional technology.

For conducting research was used X-ray fluorescence analyzer «Elvax». X-ray-fluorescence method consists of the appearance characteristic X-radiation of atoms of a chemical element when excited by the primary by X-ray irradiation.

The fluorescence spectrum consists of a series of analytical lines. Each line corresponds to the energy of the fluorescent radiation characteristic for atoms of a given element. Since in the analyzer is used energy dispersive measurement method, then the resulting spectrum contains lines of all atomic elements located in the sample.

The energy range is from 1 to 40 KeV. This corresponds to a range of definitions the elements from Na to U. The intensity of spectral lines depends on the concentrations of elements determined. Pre-measured composition of pure filter paper and its spectrum is taken as a background. For calculation shall be taken the spectrum of the difference spectra taken a working sample and background.

Calculation of the mass fraction of the element produced according to the characteristics of the calibration of the analyzer. Calibration of the analyzer to determine the mass fraction of the element was performed using standard solutions of metal ions, which are used for calibration, certification and calibration of analytical instruments: photo colorimeter, spectrophotometers, atomic absorption spectrophotometers, etc.

Results and discussion

We created iodinated additive (iodine-proteinaceous) based on egg protein and mineral iodine compounds. Selecting objects due to expediency to ensure conditions of ion sorption İ-on protein molecules to form stable complexes.

Developed iodine-proteinaceous addition is a powdered system with can be used in a wide range of food health purposes, in particular in the technology of emulsion type sauces.

Based on knowledge about of the volatility and instability of inorganic iodine compounds, we carried out studies to determine the loss of iodine at the stage of preparation and storage of sauces emulsion type (Table 3). The iodine content in the emulsion sauce at all stages of determined using by X-ray fluorescence analyzer «Elvax».

Table 3

Kinetics of changes in the content of iodine in the emulsion-type sauces during cooking and storage

Indicator	iodine content mg/100 g	% loss from the beginning. content
The iodine content in the additive	207 ± 20	-
The iodine content in a freshly prepared gravy	146 ± 20	29,5
The iodine content after storage (t = +5 ... +10 ° C, τ = 30 days)	135 ± 20	7,2

Received data testify that the greatest loss of iodine occur during cooking. Probably this is due primarily to the fact that during the preparation of raw components to emulsify implemented pasteurization step (T = 70 ± 3°C, τ = 20 ... 25 ×60c) egg-mustard and milk mixture, in order to reduce the total bacterial contamination. Losses associated with iodine sublimation of inorganic iodine, which was in the system.

After preparation and storage at a temperature of +5 ... +10°C for 30 days the total loss of iodine in sauces is 37 ± 3%.

On the basis of the proposed method, we conducted a study to determine the relations of organic and inorganic forms of iodine in comprising of food. Based on literature data and on the volatility of inorganic iodine compounds, we carried out temperature control emulsion-type sauce using additives iodine-proteinaceous which applied a thin layer of less than 2 mm, the surface of the parchment paper. Mode of heat exposure was carried out at temperatures of 50 ... 60°C. (120) ×60 s. (Fig. 1).

Selection of temperature regime caused by need for process intensification on the background to avoid destruction of proteins and organic substances, which may lead to release of organic iodine and its loss. It was determined that after (110 ... 115) ×60 s. importance of iodine in food ceases to decrease and becomes stable. This is probably due to the complete sublimation of inorganic iodine compounds. The remaining amount of iodine is strongly linked to the protein, but not sublimate. According to the data this method, in test samples of the organic iodine content was 132 ± 3 mg per 100 g of product, i.e. decreased by 31 ± 2%.

Using additive iodine-proteinaceous from 0.5 ... 2.5% by mass of iodine about 0.01% can be achieved from 15 to 50% of the human daily requirement of iodine.

The resulting product does not lose its organoleptic, physicochemical, consumer characteristics and meets the requirements of normative documents

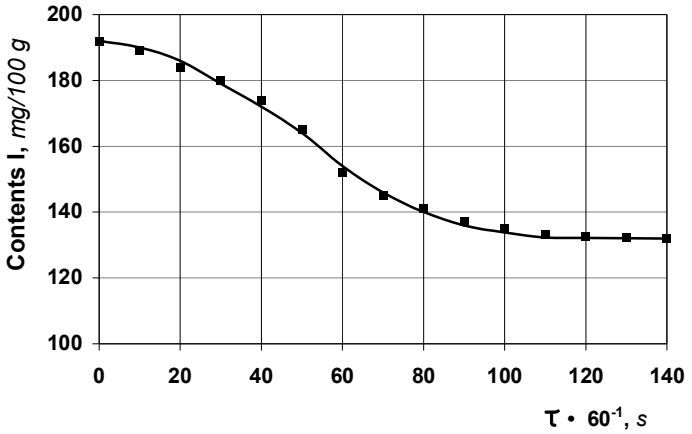

Fig. 1. Kinetics of changes in the content of iodine in the emulsion-type sauces during incubation (t = 50 ... 60°C)

As a result of our research, it was found that the addition to the composition of mayonnaise iodized food additive has no adverse effect on the physical and chemical characteristics of the sauces, but due to the stabilizing effect of additives iodine-proteinaceous increases resistance of the emulsion to 98 - 100% without additional food additives (emulsifiers).

This additive has passed a series of tests that demonstrate compliance with regulatory and technical documentation.

Conclusions

1. One of the key factors in improving the health of the population as a whole is to rationalize of nutrition since an unbalanced diet can cause quite serious violations in the body.
2. One way to solve the problem of unbalanced diet is the massive introduction of foods with health properties in the diets of consumers.
3. Topical issue is the enrichment diets of deficient iodine compounds through research and development of new food products fortified iodine-proteinaceous complexes
4. Given that the object of enrichment is advisable to use products of mass and daily food we have decided to choose as the object emulsion type sauces to enrich the bio-organic iodine compounds.
5. The carried out researches of physico-chemical parameters of the developed emulsion sauce evidencing of compliance regulations. These studies have identified the level of iodine and iodine resistance was studied at all stages of preparation and storage of the emulsion type in sauces manufactured using additives iodine-proteinaceous.
6. From the data obtained in test samples of organic iodine content compose 132 ± 3 mg per 100 g of product, i.e. decreased by 31 ± 2%. Although this level of iodine in the product sufficient to provide the daily requirement of iodine for human.
7. Used methodical approach allowed us to estimate the level of organic and inorganic iodine and as described in more detail and correctly interpret the chemical composition of foods fortified with iodine and predict their health properties.

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Determination of storage conditions for new biscuits using their sorption isotherms

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Abstract

Introduction For the formation of biscuits quality natural carrier of iodine and sweetener from stevia leaves were used. Desorption of moisture is the dominant process, which will determine the guaranteed shelf life of biscuits. The conditions for the developed biscuits storage was determined by investigating of sorption isotherms and kinetics of reaching the equilibrium moisture content.

Materials and Methods. The objects of study-are newly developed biscuits: "Health" (rich in iodine and with the replacement of 50 % sugar by stevioside), "Light" (with the replacement of 75% of sugar by stevioside and enriched with wheat bran), "Fortified" (contains elamine, which is a natural source of iodine). Control – the biscuit prepared according to traditional recipes. Tenzometric method was used to study the sorption equilibrium moisture content. Differential function of pore radius distribution was determined using sorption isotherms and then have been subjected to approximation.

Results. New biscuits samples are in the area of polymolecular and monomolecular sorption in the range of the relative air humidity (RAH) from 10 to 75 ... 80%. The control sample has less distinct plot of monomolecular sorption (10 to 20%) and short- moisture range wich is corresponding with polymolecular sorption (from 20 to 65 ... 70%). There is a moisture absorbtion of microcapillary and swelling of samples when RAH increases to 75 ... 80% for all the samples. The ratio of average pore radius to the most likely of the test samples are different that was shown by the investigation of differential function of pore distribution. So this ratio for biscuit "Health" is 5.73, for biscuit "Light" − 2.98, for biscuit "Fortified"− 4.91 and for the control − 3.88.

Conclusions. There's the sense to store developed biscuits in a cardboard packaging with polymeric covering, if RAH is not more than 75%, and vapor-proof if RAH is above that.

Introduction

There is a complicated ecological condition all over the world, which requires the improvement of quality and the creation of new fortified foods that have high biological, physiological and curative properties. Improving the quality and the range of pastry by providing them with dietary properties such as reducing sugar content, calories; enrichment by biologically active agents and inclusion to their composition dietary ingredients which are able to compensate iodine deficiency and promote excretion of toxic metabolic products compounds is the actual direction [1]. Traditionally, scientists all over the world use fructose to reduce the amount of sugar in pastry [2-4]. Also it is known methods for the replacement of sugar using Jerusalem artichoke, sorbitol, xylitol [5, 6]. We have proposed to enrich biscuits with product of processing of laminaria (elamin) and to decrease 50 ... 75% of sugar in their recipe through using natural sweetener − stevioside.

Changes in biscuit's recipe certainly lead to changes in the finished product. There are main processes taking place in biscuit during storage, which dominate and most of all effect on its safety. There're a lot of world scientists who are engaged in determining the storage conditions of enriched biscuits [7], they have found that the dominant process which will determine the guaranteed shelf life of these products is desorption of moisture. Moisture loss the most affects on sensory and microbiological quality parameters. Based on the above in order to determine the conditions of storage for new biscuits which is the aim of this work, it's worth doing a research of their sorption isotherms and kinetics of reaching the equilibrium moisture content.

Materials and methods

The study has been conducted with the help of determination of dependence between loss and gain of moisture by our samples as well as influence of processes associated with hygroscopic properties of biscuits, i.e. the ability to evaporate or absorb water vapor from the air. Product mass can exchange with the air when it is in an atmosphere of humid air. If the partial pressure of water vapor at the surface of the product is more than the partial pressure of vapor in the air, there is an evaporation (desorption), as a result weight and moisture content of the product are reduced but if the ratio of the partial pressures is inverse – there's a moistening of product (sorption) − weight and moisture content of the product increases. In this case, hereinafter, the product is characterized by equilibrium moisture content − a vapor pressure of water above the surface and in the atmosphere is aligned. We need explore sorption isotherms of new types of biscuits at different RAH and kinetics of achieving equilibrium moisture content to determine optimal conditions of their storage.

The objects of study-are: newly developed biscuits: "Health" (rich in iodine and with the 50 % replacement of sugar on stevioside), "Light" (with the replacement of 75% of sugar on stevioside and in addition is enriched with wheat bran), "Fortified" (contains elamin and satisfies the daily human need for iodine that enters the organically bound form of the protein). Control – the biscuit prepared according to traditional recipes.

Study of sorption and equilibrium moisture content. Tenzometric method was used to study the sorption equilibrium moisture content. Differential function of pore radius distribution was determined using sorption isotherms and then has been subjected to approximation. The test samples were placed in desiccators with a fixed RAH. All desiccators were maintained at a constant temperature for measuring (20 ... 23°C). Length of staying in desiccators was determined by the achievement of samples constant weight.

Construction of sorption isotherms and kinetics of reaching equilibrium moisture content for the samples at different ambient relative humidity were based on the experimental data.

Determination of differential distribution functions pore radii. Differential function of distribution of pore radii tested biscuits were determined using sorption isotherms, in order to explain the peculiarities of their character. They were calculated as follows [8-10]. Sorption isotherms of the samples were approximated according to the function [8]:

$$\phi = \frac{w^{A_3}}{A_1 + A_2 w^{A_3}} \tag{1}$$

ϕ – the relative humidity;

A_1, A_2, A_3 – approximation coefficients;

w – moisture content, kg/kg dry. peq.

Use of this approximation function allows us to receive such an important structural and physical characteristics as the differential function of distribution of pore radius $f_n\left(R^*\right)$. The differential function of distribution of pore radius is defined according to the formula:

$$f_n(R^*) = \frac{1}{\sqrt{2\pi}\sigma_R R^*} \exp\left(-\frac{\left(\ln(R^*) - m_R\right)^2}{2\sigma_R^2} \right) \tag{2}$$

m_R and σ_R – the parameters of the log normal distribution;

R^* – dimensionless pore radius $R^* = (R - d_0)/d_0$;

R – pore radius, m;

$d_0 = 0,3 \cdot 10^{-9}$ m – radius of a water molecule.

Lognormal distribution parameters are defined according to the formulas:

$$m_R = \left(\frac{A_2}{0,433} \right)^{1,247} \tag{3}$$

$$\sigma_R = -\frac{\ln(6,12A_1)}{0,625} \left(\frac{A_3 - 0,957}{0,223} \right)^{-0,6} \tag{4}$$

Using determined type of analytic functions of the pore size distribution it can be defined the average radius:

$$\overline{R} = d_0 \left[1 + \exp\left(m_R + {\sigma_R}^2 / 2 \right) \right] \tag{5}$$

and the most probable pore radius (the distribution center):

$$R_m = d_0 \left[1 + \exp\left(m_R - {\sigma_R}^2 \right) \right] \tag{6}$$

Results and discussion

Study of sorption and equilibrium moisture content. Sorption isotherms of tested biscuits are presented on Figure 1.

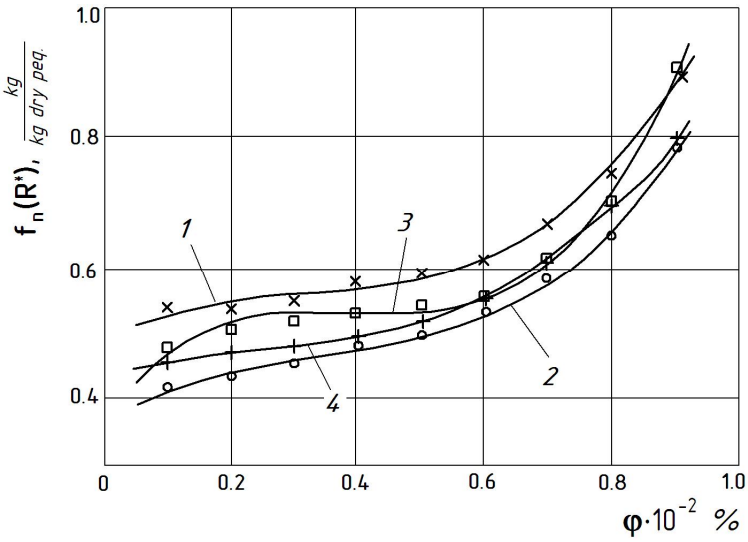

Fig.1 − Sorption isotherms of biscuits:
1 − "Health", 2 − "Light", 3 − "Fortified", 4 – control.

The figure shows that samples 1, 2 and 3 are in the area of polymolecular and monomolecular sorption in the range of the RAH from 10 to 75 ... 80%. The control sample (4) has less distinct plot of monomolecular sorption (10 to 20%) and short- moisture range wich is corresponding with polymolecular sorption (from 20 to 65 ... 70%). There is the moisture absorbtion of microcapillary and swelling of samples when RAH increases to 75 ... 80% for all the samples.

Continuation of hydration of the samples is possible only in case of direct contact with the liquid because of sorption isotherms have distinct asymptotes parallel to axis of the moisture content. Resulting indicates the possibility of long-term storage the test biscuits in cartons with a polymeric covering with RAH not over 75%. Storage at the relative humidity above this is possible only in vapor-proof packing materials.

If we construct the kinetics of reaching equilibrium moisture content by our testing biscuits at a different RAH (Fig. 2) it will allow to define the storage conditions for biscuit packaged in paperboard. This package is supposed by normative and technical documentation.

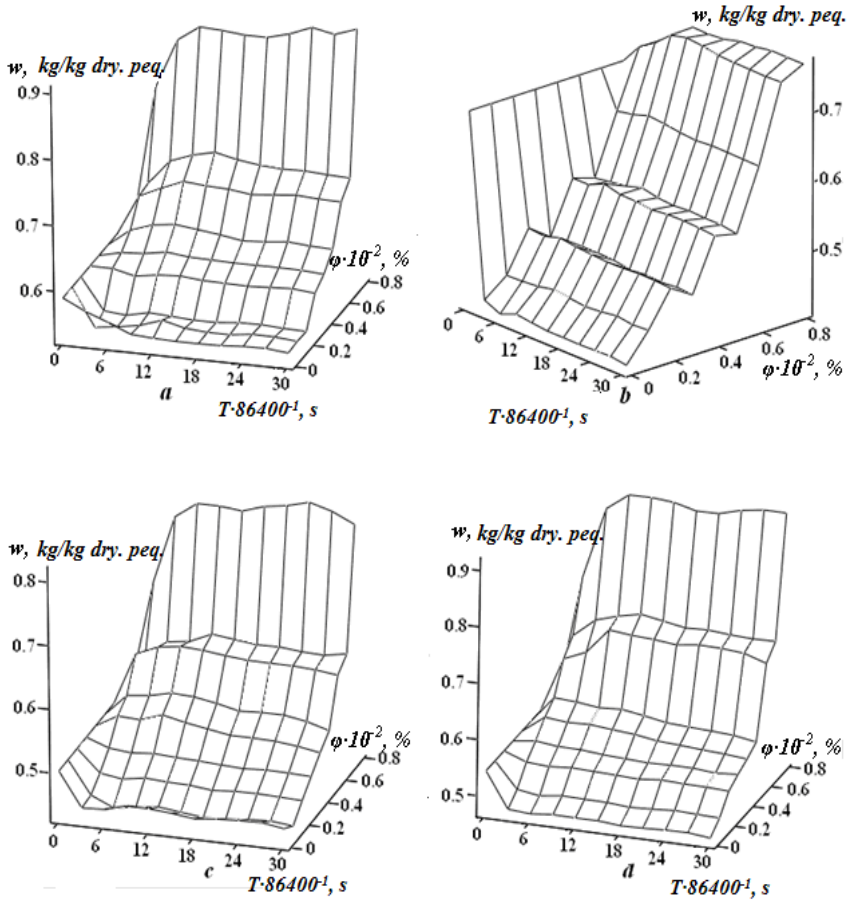

Fig. 2. Kinetics of moisture in biscuits at different RAH:
a – «Health»; b – «Light»; c – «Fortified»; d – control.

It can be found the water activity for the test biscuits samples using specified dependency. Water activity characterizes a condition of water in foods and its involvement in the chemical and biological changes. This is one of the criteria by which we can judge about the stability of food spoilage during the storage. It is important for food preservation extent to which water is associated with a non-aqueous component, i.e., solids in biscuits. It can be determine as follows. The relative humidity, at which the moisture content of the biscuit sample does not change during its storage in desiccators, is the water activity that holds the sample.

Figure 2 shows that the water activity in biscuits is: “Health” (a) − 0,40 RLU; "Light” (b) − 0,75 RLU; " Fortified” (c) − 0,45 RLU, the control (d) − 0,40 RLU. The water activity of the biscuit "Light" differs considerably to the other samples, because this sample contains wheat brans, which are highly hygroscopic material, and can absorb and hold large amount of water. For other biscuits meanings of water activity are similar.

Thus, based on these results, it can be conclude that, firstly, the lowest stability to spoilage during storage has biscuit "Light" due to his high water activity. Secondly, storage of tested biscuits without packaging and with minimal changes because of drying of their surface is possible at the relative humidity: biscuit "Health" − from 35 to 45% for biscuit "Light" − from 70 to 80%, biscuit "Fortified"− from 40 to 50% for the control − from 35 to 45%.

Determination of differential distribution functions pore radii. Study the distribution of pore radii for biscuits can explain the differences in the samples properties to absorb moisture from the air.

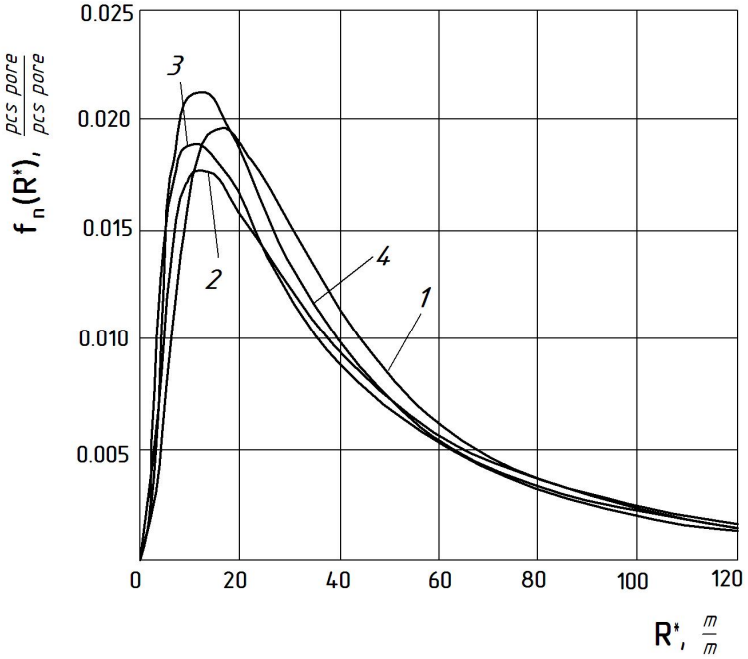

Fig. 3 - Distribution functions of pore radii for the biscuits:
1 − "Health", 2 − "Light", 3 − "Fortified" 4 − control.

Differential distribution function of pore radii for the test samples are shown on Figure 3, and calculated according to the formulas (5) and (6) the most probable and the average radii − in Table 1. Obtained distribution functions have similar character and similar positions of the maxima relative to the axis on which are the dimensionless pore radius.

Table 1

The average and the most probable pore radius

Sample	$\bar{R}\cdot10^9$, m ($\delta = 10\%$)	$R_m\cdot10^9$, m ($\delta = 10\%$)
Health	19,6	3,42
Light	15,2	5,10
Fortified	19,7	4,01
The control	15,2	3,92

However, it should be noted that the meanings of ratio of the average pore radius to the most probable of the samples are differ. So for biscuit "Health", this ratio is 5.73, biscuit "Light" − 2.98, biscuit "Fortified" − 4.91, for the control − 3.88.

It is known that the bigger is the result of the average pore radius ratio to the most probable material has, the more developed its porosity is, and the more moisture it can contain or absorb. Based on the presented results, the most developed porosity has biscuit "Health", and the lowest − biscuit "Light".

This result explains the different position about the axis of sorption isotherms of water content (Fig. 1): as biscuit "Health" has the most developed porosity compared to other samples, then its sorption isotherm is relatively higher than other samples sorption isotherms are, the sorption isotherm of biscuit "Light" is the lowest − because of its least developed porosity.

It should be noted that the pastry with a high content of air phase have several valuable functional and quality characteristics. For example due to the porous structure of the product it can easier wetted with saliva in the mouth and is easier to digest and has a more pleasant taste.

Conclusions

Samples can be stored for a long time in the carton with a polymeric covering if the relative humidity is not over 75%, storage if the relative humidity is above this cab be possible only in vapor proof containers.

The smallest stability of test samples has biscuit "Light" because of the high activity of water in it compared to other samples; storage of tested biscuits in cardboard packaging with minimal changes because of drying of the surface of products is possible at the relative humidity: biscuit "Health" − from 35 to 45% for biscuit "Light" − from 70 to 80%, biscuit "Fortified" − from 40 to 50% for the control sample − from 35 to 45%.

The most developed porosity compared to other samples has biscuit "Health", and the least − biscuit "Light" which makes biscuit "Health" more attractive from the viewpoint of organoleptic properties.

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Intensification of microbial exopolysaccharide ethapolan synthesis under Acinetobacter sp. IMV B-7005 cultivation on sunflower oil

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Abstract

Introduction. Microbial exopolysaccharides (EPS) by the ability of their solutions to change the rheological properties of aqueous systems are widely used in various industries. In recent years, research on the use of industrial waste (including oil-containing) to obtain practically valuable microbial metabolites intensified.

Materials and methods. Cultivation of *Acinetobacter* sp. IMV B-7005 strain was performed in liquid medium, containing as a carbon source sunflower oil (1−5 %, v/v), a source of nitrogen – ammonium nitrate (0.4−0.8 g/l), a source of pantothenate − multivitamin complex «Complevit» (0.00085 and 0.00095 %). EPS concentration was determined gravimetrically after precipitation with isopropanol, EPS-synthesizing ability − as a ratio of EPS concentration to biomass concentration, wich was expressed as g EPS / g biomass.

Results and discussions. It was established that increasing the concentration of sunflower oil in basic medium for *Acinetobacter* sp. IMV B-7005 cultivation to 4−5% was accompanied by decrease of ethapolan synthesis compared with those in the medium containing lower (2−3 %) substrate concentration. Increasing ammonium nitrate content to 0.6 g/l and/or pantothenate concentration to 0.00095% in a medium with 5% sunflower oil allowed to increase the amount of ethapolan synthesized up to 6.6−6.7 g/l, that is in 1.3−1.4 times higher than in the basic medium with the same concentration of the substrate but lower NH_4NO_3 (0.4 g/l) and pantothenate (0.00085 %).

Conclusion. The obtained results indicate the possibility of microbial polysaccharide ethapolan synthesis under *Acinetobacter* sp. IMV B-7005 cultivation in the medium with a high content of sunflower oil. These data are the basis for the development of ethapolan technology using as a substrate fried oil.

Introduction

Microbial exopolysaccharides (EPS) due to the ability of their solutions to gelation, emulsification, suspending and changing rheological properties of aqueous systems are widely used in various industries, agriculture and medicine [1, 2].

The vast majority of known microbial EPS are obtained from carbohydrate substrates. Usually, products derived from sugar beet: molasses, sugar syrup, sucrose or corn: starch, hydrolyzed starch, glucose syrup, glucose, maltose are used as substrates in the industrial production of EPS [3]. But studies conducted in the 70-80s of the twentieth century demonstrated the possibility of expanding the resource base of microbiological production of EPS by using of non-food substrates (methane, methanol, ethanol, ethylene glycol, hydrocarbons) [3]. However, the concentration of polysaccharides obtained on non-carbohydrate substrates remains low for today.

Our studies have shown that a wide range of mono- and mixed C_2-C_6-substrates (ethanol, acetate, propanol, pyruvate, C_4-dicarboxylic acids, carbohydrates − mono- and disaccharides, starch, molasses, etc.) can be used for the synthesis of ethapolan − complex exopolysaccharide preparation (producer is *Acinetobacter* sp. 12S, deposited in the Depositary of the Institute of Microbiology and Virology, National Academy of Sciences of Ukraine by the number of IMV B-7005) [3]. The ability of *Acinetobacter* sp. IMV B-7005 to form EPS on C_2-C_6 compounds allows to develop a flexible universal technology of polysaccharide production from a wide set of carbon substrates, or complex of different technologies, each of which can be realized depending on the economic feasibility, availability and accessibility of a substrate necessary to obtain the EPS with certain physical and chemical properties.

Last years the researches of using industrial waste have been activated to obtain a practically valuable microbial metabolites [4]. Replacing traditional substrates for microbial synthesis by industrial waste will allow to reduce the cost of technology in several times, and recycle unwanted waste, to solve the problem of storage or destruction of large masses of waste in food industry, agricultural sector and in companies that produce biodiesel, as it needs a lot of energy and money. Oil-containing waste are promising for using in microbial technologies [5, 6].

The world production of sunflower oil is about 2.5−3 million tons, 75 % of which is obtained mainly from plant raw materials [6]. Significant amount of waste produces on the enterprises which recycling such materials, and its getting into the environment is extremely dangerous [4, 5]. Oil-containing waste are cheap and available in necessary quantities for using in microbial technologies, but still there are only a few reports in the literature about the possibility of its using as substrate for the biosynthesis of microbial polysaccharides. Thus, there is information concerning of use of waste water from plants of processing oils for the synthesis of EPS [7]. In recent years *Cellulomonas flavigena* UNP3 was described as the strain, which is able to synthesize kurdlan-like EPS in the medium with vegetable oil or appropriate waste [8].

Previously, we have established the possibility to use sunflower oil as a source of carbon and energy for the synthesis of microbial polysaccharide ethapolan [9]. However, in earlier studies, the concentration of oil in the cultivation medium was low (only 1 % v/v). As for the synthesis of ethapolan we supposed to use fried oil as a substrate, volume of which is extremely large, so its content in the medium has to be more higher.

The purpose of this work − to research intensification of microbial polysaccharide ethapolan synthesis in medium with the maximum concentration of sunflower oil.

Matherials and methods

EPS-synthesized strain of bacteria *Acinetobacter* sp. 12S, which is deposited in the Depository of Institute of Microbiology and Virology, National Academy of Sciences of Ukraine by the number of IMV B-7005 was used as the object of research.

Cultivation of *Acinetobacter* sp. IMV B-7005 was carried out in a liquid mineral medium of such composition (g/l): KH_2PO_4 − 6.8; KOH − 0.9; $MgSO_4 \times 7H_2O$ – 0.4; $CaCl_2 \times 2H_2O$ – 0.1; NH_4NO_3 – 0.4; $FeSO_4 \times 7H_2O$ – 0.001. In one variant, the concentration of ammonium nitrate in the medium was increased to 0.6 and 0.8 g/l.

Sunflower oil (1−5 %, v/v) was used as a source of carbon and energy. In additionally yeast autolysate (0.5 %, v/v) and multivitamin complex "Complevit" (0.00085 and 0.00095 %) were added to the medium as growth promoter and source of pantothenate, respectively.

Culture from the exponential phase, grown in the medium with 0.5 % of sunflower oil was used as the inoculum. Quantity of inoculum was 10 % from the volume of the medium.

Cultivation of *Acinetobacter* sp. IMV B-7005 was carried out in flasks (750 ml) with 100 ml of medium in shacker (320 rpm) at 30 ºC for 120 hours.

Growth of the strain and EPS synthesis were evaluated by the following parameters.

Biomass concentration was determined by optical density of the cell suspension with the following recalculation on the absolutely dry biomass (ADB) according to the calibration curve. Quantity of synthesized ethapolan was determined gravimetrically. For this, 1.5−2 volumes of isopropanol were added to a certain amount of culture liquid (usually 10−15 ml), the precipitate of EPS was washed by clean isopropyl alcohol and dried at room temperature for 24 h. EPS-synthesizing ability was determined as the ratio of the EPS concentration to the concentration of ADB and was expressed in g EPS/g ADB.

The results of the experiment in accordance with the Student t-test were statistically significant at the 5 % significance level.

Results and discussions

Note, that the literature data about synthesis of microbial EPS on any industrial waste (not just oil-containing) is extremely limited. So, it is known that *Xanthomonas campestris* ATCC 13951 synthesized 28 g/l of xanthan under cultivation in reactor (2 l) during 96 h in the medium containing partially hydrolyzed molasses (the concentration of lactose, galactose, glucose was 4.7; 17.8; 17.8, respectively) as the carbon source [10]. It was determined that *Pseudomonas oleovorans* NRRLB-14682 synthesized EPS (12.18 g/l) on the medium with crude glycerol (by-product of biodiesel production) [11]. *Acinetobacter* sp. DR1 under cultivation in the medium with diesel oil (2 %) synthesized about 5 g EPS/g biomass [12]. It is known about synthesis of scleroglucan by fungi *Sclerotium rolfsii* from plant biomass [13]. Strain *C. flavigena* UNP3 synthesized 1 g/l of polysaccharide with high emulsifying properties in the medium containing 1 % of peanut oil after 192 h cultivation [8]. Parameters of EPS synthesis slightly decreased in case of replacement peanut oil with coconut, olive, castor, sesame, mustard and cotton oils. It should be noted, that until now in the available literature we couldn't find information about the synthesis of microbial EPS on sunflower oil.

Our previous data [9] have shown that during *Acinetobacter* sp. IMV B-7005 growth in medium with 1 % of sunflower oil, 5 g/l of EPS were synthesized. Further studies demonstrated that increasing sunflower oil content in the medium of IMV B-7005 strain to 2-3% was accompanied by increasing of synthesized ethapolan concentration to 5.8-6.3 g/l, but the EPS-synthesizing ability was slightly decreased (Table 1). Indices of EPS synthesis

decreased with the higher substrate concentration (4−5 %) and the highest EPS-synthesizing ability (5 g EPS/g ADB) was observed under *Acinetobacter* sp. IMV B-7005 cultivation in the medium with 1 % of sunflower oil (Table 1).

Table 1

Depending ethapolan synthesis on the concentration of sunflower oil in the cultivation medium of *Acinetobacter* sp. IMV B-7005

Concentration of sunflower oil in the medium, %	EPS, g/l	EPS-synthesizing ability, g EPS/g ADB
1	5.0±0.25	5.0±0.25
2	5.8±0.29	4.7±0.23
3	6.3±0.31	4.0±0.20
4	5.0±0.25	3.7±0.19
5	4.9±0.24	3.6±0.18

Note. The concentration of pantothenate in the medium was 0.00085 %, ammonium nitrate − 0.4 g/l.

As in case of increasing of carbon's concentration in the medium, C/N ratio changes, that significant impacts on synthesis of microbial polysaccharides [3], so on the next stage we increased concentration of nitrogen source simultaneously with enhancing of oil content (Table 2).

Table 2

The influence of the nitrogen source concentration on the synthesis of ethapolan under *Acinetobacter* sp. IMV B-7005 cultivation on sunflower oil

Concentration of ammonium nitrate, g/l	Concentration of sunflower oil in the medium, %	EPS, g/l	EPS-synthesizing ability, g EPS/g ADB
0.6	3	4.6±0.23	4.1±0.21
	4	5.6±0.28	4.2±0.21
	5	6.4±0.32	3.9±0.19
0.8	3	3.2±0.16	3.0±0.15
	4	3.4±0.17	2.9±0.14
	5	3.6±0.18	2.7±0.13

Note. The concentration of pantothenate in the medium was 0.00085 %.

Results presented in Table 2, show that increasing ammonium nitrate concentration to 0.8 g/l in a medium containing 3−5 % of sunflower oil promotes degrease of synthesized ethapolan concentration and EPS-synthesizing ability compared with those in the medium with lower (0.4 g/l) concentration of nitrogen sources (see Table 1 and 2). However, concentration of synthesized ethapolan in the medium with 4 and 5 % of sunflower oil and 0.6 g/l of NH_4NO_3 was 5.6 and 6.4 g/l, respectively. That is higher than in medium with 0.4 g/l of ammonium nitrate (5.0 and 4.9 g / l, see. Table. 1 and 2). EPS-synthesizing ability also increased under such cultivation conditions of IMV B-7005 strain. Thus, parameters of ethapolan synthesis were improved by increasing NH_4NO_3 concentration to 0.6 g/l with increase of oil content to 4−5 % in the medium.

The concentration of pantothenate in the medium is another factor that may affect on synthesis of ethapolan, as *Acinetobacter* sp. IMV B-7005 is auxotroph for calcium pantothenate [3]. Therefore, on the next stage concentration of pantothenate in the cultivation medium of IMV B-7005 strain was increased with enhancing sunflower oil and nitrogen source content (Table 3).

Thus, increasing of pantothenate content to 0.00095 % in medium with 0.4 g/l of ammonium nitrate and 5 % of sunflower oil allowed to enhance the concentration of EPS in 1.4 times, comparing with results in the medium with lower amount of pantothenate.

Table 3

Synthesis of ethapolan depending on the concentration of pantothenate in *Acinetobacter* sp. IMV B-7005 medium with sunflower oil

Concentration in the medium			EPS, g/l
of ammonium nitrate, g/l	**of pantothenate, %**	**of sunflower oil, %**	
0.4	0.00085	4	4.8±0.24
		5	4.9±0.24
	0.00095	4	5.6±0.28
		5	6.7±0.33
0.6	0.00085	4	5.6±0.28
		5	6.4±0.32
	0.00095	4	5.5±0.27
		5	6.6±0.33

However, no positive effect on the synthesis of ethapolan with higher concentrations of pantothenate and NH_4NO_3 (0.6 g/l) in the medium was observed (Table 3).

Conclusions

As a result of this work cultivation's conditions were established for producer of microbial exopolysaccharide ethapolan. They provide synthesis of 6.6−6.7 g/l of EPS in the medium with a high content of sunflower oil (4−5 %). These results were achieved in the case of both increasing of nitrogen sources content to 0.6 g/l and/or pantothenate − up to 0.00095 % with increasing of the substrate concentration for ethapolan synthesis. The experimental data are basic for the development of this polysaccharide technology in the medium with fried sunflower oil or other oil-containing industrial waste.

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Definition energy consumption for overclocking powered by mass with sinusoidal acceleration and synthesis drive mechanism

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Abstract

Introduction. Theoretical developments concerning the determination of the energy costs of the transition process dispersal devices driven mass food production based on the driving factors and factors of resistance.

Materials and methods. The mathematical description of these processes was carried out using Newton's laws, the principle of d'Alembert, general theorems of dynamics and power relations, as well as the independence of the forces .

Results and discussion. It is proved that the benefits of growth dynamic forces over the forces of resistance leads to a reduction in the time course of the transition process, but energy costs at the same time remain stabilized at the level of the kinetic energy of the mass.

Conclusions. Mathematical models have shown that the capacity of developing drivers with reduced time transients, increasing as the dynamic load of the system. This should be considered when designing and engineering calculations occasions devices for food industry.

Introduction

Concerning to food technology, mechanical power of action and interaction between the various components are widespread. They concerning to the processes that characterize the operation input reception commodity flows, transportation, processing, storage, overhaul, maintenance of internal flows, formation of gas and liquid flows, ensuring their interaction with the commodity flow, thermodynamic achieve this transformation of air or gases, special purpose and etc. Implementation of specified actions mean to have necessity to overcome the resistance factors, requiring introduction to the driving factors. Value of the driving factors (forces or moments of forces) and resistance factors determine the nature

of the process that accompanies their performance. Inequality of main factors and resistance factors means that their effect on individual lot will be accompanied by transients, result in the emergence of forces of inertia and (or) the moments of inertia forces [1].

This chapter includes following tasks:

- the choice of methods of estimation of parameters of mechanical systems;
- determination of energy expenditure in systems transporting cargo conveyors;
- determination of the energy costs of moving goods in the transition process;

Materials and methods

The mathematical description of these processes is using in Newton's laws and in the principle of D'Alembert. Using the latter allows it go from strength factors acting on a body or system of bodies (w) to describe their kinematics.

In subsequent studies, expected use of general theorems of dynamics and power relations, as well as the independence of the forces.

Results and discussion

Creating technological machines always linked to performance requirements set operations and also to minimize the energy, materials and economic costs of their operation. The most common in modern equipment operations include moving and handling specific cargoes or complexes of them (group of packages) that occur on the job of their surface areas of overcoming the friction forces [2, 3].

Giving some cargoes velocity and kinetic energy in the process of dispersal should to perform work against the forces of inertia.

These components of energy expenditure are required, but it is possible to significantly limit the total number of them through the full use of the kinetic energy of the body, accumulated during the dispersal of the latter [7]. Since established theoretical background processes of acceleration and coasting cargo is not in doubt, it is logical to make the transition to the problem of machine maintenance. Implementation of various laws of motion of the working bodies used in these operations can be carried out by various mechanical, pneumatic hydromechanical or electromechanical means.

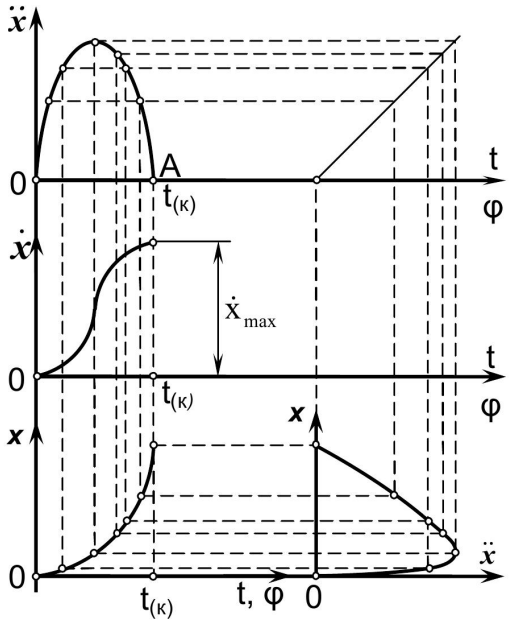

Fig. 1. Kinematic diagram displacement, velocity and acceleration of the pusher and chart x = x($\ddot{x}$)

Widespread use is a cam mechanism through which the cam profiles implemented various laws of motion outgoing links (pushers).

Let pusher and with it a load on the section 0 - A has a sinusoidal law of motion $\ddot{x} = \ddot{x}_{\max} \sin(\omega t)$ (Fig. 1).

Then the initial conditions

$$t_{(i)} = 0; \quad x_{(i)} = 0; \quad \dot{x}_{(i)} = 0; \quad \ddot{x}_{(i)} = 0 \tag{1}$$

we obtain

$$\dot{x} = \frac{\ddot{x}_{\max}}{\omega}\left(1 - \cos(\omega t)\right), \tag{2}$$

$$x = \frac{\ddot{x}_{\max}}{\omega} t - \frac{\ddot{x}_{\max}}{\omega^2} \sin(\omega t) \tag{3}$$

It is known that the energy costs associated with acceleration dynamic mass elementary displacement are determined dependence

$$dE = m\ddot{x}(x)dx \tag{4}$$

In our case, and the acceleration $\ddot{x}$ and displacement x are functions of time, except as a graphical parameter t (Fig. 1) we can get the chart $\ddot{x} = \ddot{x}(x)$. The area, which is bounded by the curve and the axis 0h determines wanted integral $\int_0^x \ddot{x}(x)dx$. At the same time accumulated at the end time $t_{(e)}$ defined as the kinetic energy

$$W_{kin} = \frac{m\left(\dot{x}_{(e)}\right)^2}{2} = \frac{m\left(\dot{x}_{\max}\right)^2}{2} \tag{5}$$

However, there is a possibility of an analytical evaluation of the kinetic energy via the displacement and acceleration. To get it out of the formula $\ddot{x} = \ddot{x}_{\max} \sin\left(\omega t\right)$, we determine

$$t = \frac{\arcsin \dfrac{\ddot{x}}{\ddot{x}_{\max}}}{\omega} \tag{6}$$

Then substituting (6) into equation (3) we obtain

$$x = \frac{\ddot{x}_{\max}}{\omega^2} \arcsin \frac{\ddot{x}}{\ddot{x}_{\max}} - \frac{\ddot{x}}{\omega^2} \sin \arcsin \frac{\ddot{x}}{\ddot{x}_{\max}} \tag{7}$$

As a result, look up and transformations we obtain the dependence for the determination of energy to overcome the forces of inertia

$$E = \frac{mx_{\max}^2}{2\omega^2} - \frac{mx_{\max}^2}{\omega^2}\cos(\omega t) + \frac{mx_{\max}^2}{2\omega^2}\cos^2(\omega t) \tag{8}$$

However, the kinetic energy of the body has determine as a function of time according to the formula

$$W_{kin} = \left(\frac{\ddot{x}_{\max}}{\omega}\right)^2 \left(1 - \cos^2(\omega t)\right)\frac{m}{2} \tag{9}$$

For further analysis we choose a finite displacement

$$t_{(e)} = \pi / \omega \tag{10}$$

and the resulting kinetic energy

$$W_{kin(e)} = \left(\frac{\ddot{x}_{\max}}{\omega}\right)^2 \left(1 - \cos\pi\right)\frac{m}{2} = m\left(\frac{\ddot{x}_{\max}}{\omega}\right)^2 \tag{11}$$

Moving cargo at $t = t_{(e)}$

$$x_{(e)} = \frac{\ddot{x}_{\max}}{\omega}\cdot\frac{\pi}{\omega} - \frac{\ddot{x}_{\max}}{\omega^2}\sin\pi = \frac{\ddot{x}_{\max}\pi}{\omega^2} \tag{12}$$

Energy costs associated with overcoming the friction forces at this stage

$$E_{F_m} = fmgx = fmg\frac{\ddot{x}_{\max}\pi}{\omega^2}. \tag{13}$$

Then the total energy at this stage

$$E_t = W_{kin(e)} + E_{F_m} = m\left(\frac{\ddot{x}_{\max}}{\omega}\right)^2 + fmg\frac{\ddot{x}_{\max}\pi}{\omega^2} \tag{14}$$

To minimize energy consumption at the stage of dispersal, then we note the need for further clarification of end conditions. Obviously, it is more reasonable to use the accumulated kinetic energy of the second phase, which is characterized as a stage freewheel. The initial level of the kinetic energy of the body at the second stage $W_{kin(i)}^{II}$ the final value of the first stage

$$W_{kin(i)}^{II} = W_{kin(e)}^{I} = m\left(\frac{\ddot{x}_{\max}}{\omega}\right)^2$$

Assuming that the kinetic energy is spent on performance against the forces of friction, we can write

$$m\left(\frac{\ddot{x}_{\max}}{\omega}\right)^2 = fmg\, x_{(\kappa)}^{II} \tag{15}$$

from

$$x_{(e)}^{II} = \frac{\ddot{x}_{\max}^2}{f\,\omega^2 g} \tag{16}$$

Then two general steps will be moving

$$x_g = \frac{\pi \ddot{x}_{\max}}{\omega^2} + \frac{\ddot{x}_{\max}^2}{f\,\omega^2 g} \tag{17}$$

From the last formula it shows that the parameters that can affect the outcome include the maximum value of acceleration $\ddot{x}_{\max}$ and angular velocity of the cam mechanism. The same values x_g can achieve different pairs of values $\ddot{x}_{\max}$ and ω. But let us return to the question of the choice of parameters in which energy minimization is achieved on the movement of goods and perform the differentiation dependence (14) for $\ddot{x}_{\max}$. Then

$$\frac{dE_g}{d\ddot{x}_{\max}} = \frac{2m}{\omega^2}\ddot{x}_{\max} + \frac{\pi fmg}{\omega^2} \tag{18}$$

Equating to zero right-hand side of this formula, we obtain the acceleration $\ddot{x}_{\max}$, which corresponds to the extreme function $E_g = E_{\max}\left(\ddot{x}_{\max}\right)$:

$$\ddot{x}_{\max} = \pi fg / 2 \tag{19}$$

Using the relation (19), we write the expressions for finite displacements on the stages and the angular velocity, wondering quantity $x_{(\kappa)}^{I}$:

$$x_{(e)}^{I} = \frac{\ddot{x}_{\max}\pi}{\omega^2} = \frac{\pi^2 fg}{2\omega^2}; \quad x_{(e)}^{II} = \frac{\ddot{x}_{\max}^2}{f\,\omega^2 g} = \frac{\pi fg}{4\omega^2} \tag{20}$$

$$\omega = \sqrt{\frac{\pi^2 fg}{2x_{(\kappa)}^{I}}} \tag{21}$$

If we take $x_{(e)}^{I} = 0{,}1$ m ; f = 0,3; g = 9,81 m/s^2, the

$$\omega = \sqrt{\frac{3{,}14^2 \cdot 0{,}3 \cdot 9{,}81}{2 \cdot 0{,}1}} = 12{,}045 \text{ s}^{-1}, \tag{22}$$

corresponding to the frequency of rotation of the cam $n = \frac{30\omega}{\pi} = \frac{30 \cdot 12,045}{3,14} = 115$ rev/min.

The table shows the correlation between parameters $x^{I}_{(e)}$, ω and n with f = 0,3, g = 9,81 m/s^2 and m = 10 kg. Determination of the angular velocity and acceleration $\ddot{x}_{\max}$ of the cam plunger movement are important components in the synthesis of cam mechanism. The next step should be to determine the values of the phase angles. If the selected value corresponds to the laws of motion and of the working of the cam, which is used to disperse the load. As the value $t^{I}_{(\kappa)}$ concerning $\ddot{x} = 0$, so the corner $\phi^{I}_{(\kappa)} = \omega t^{I}_{(\kappa)} = \pi$.

Table

Relationship between the geometric, energetic and kinematic parameters of "cam gear -load"

$x^{I}_{(e)}$, *m*	0,10	0,15	0,20	0,25	0,30	0,35
ω, s^{-1}	12,045	9,835	8,517	7,62	6,95	6,44
n, *rev/min*	115	94	81,4	72,8	66,4	61,5
$x^{II}_{(e)}$, *m*	0,2	0,3	0,4	0,5	0,6	0,7
E_g, *J*	4,4	6,62	8,79	11,03	13,24	15,44

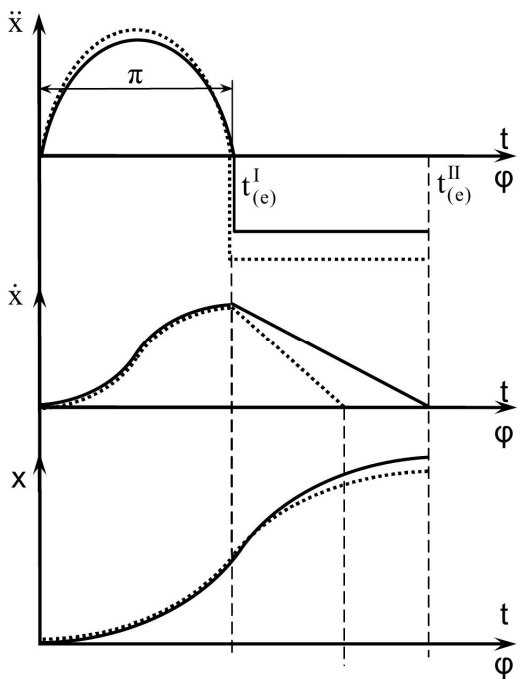

Fig. 2. Kinematic diagram of moving the pusher (·····), cargo (——)

The area from $\varphi^{I}_{(e)}$ to $\varphi^{II}_{(e)}$ important values to plug pusher acceleration was less than the negative acceleration module load (Fig. 2). At the corner of the phase reverse movement of the cam its laws of motion do not affect the goods, but because of their choice should be guided by the provisions of generally accepted theory of mechanisms and machines.

Conclusions

Growth of the benefits of dynamic forces over the forces of resistance leads to a reduction in the time course of the transition process, but energy costs at the same time remain stabilized at the level of the kinetic energy of the mass of the system. Nevertheless, capacity of developing dynamic with a reduction in the time transients, increasing as the dynamic forces of the system elements.

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Theoretical aspects of non-newtonian fluids flow simulation in food technologies

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Abstract

Introduction. The problems of simulating viscoplastic longitudinal and cross-sectional flow of non-Newtonian fluids are overviewed.

Materials and methods. For the first time the superposition method by expressing the components of the stress tensor for building flow fields with higher dimension from flow fields with lower dimension with various boundary conditions when rheological parameters change depending on pressure was used. The flows in the channel are categorized by velocity and pressure values in each point of the section.

Results. The theoretical methods for simulating flows of non-Newtonian fluids in channels of different geometry with moving bounds and pressure drop on channel edges with respect to functional connections between main process parameters are described using the superposition method. It is shown that longitudinal and cross-sectional are reduced to the collection of one-dimensional longitudinal flows of the same type which allow to describe three-dimensional isothermal in rectangular channel and two-dimensional flows in flat channels with different channel aspect ratio. The received theoretical two- and three-dimensional model of viscous flows in channels with basic geometry allow to research main regularities of the process and to establish optimal macro-kinetic and macro-dynamic flow characteristics of non-Newtonian materials which are aimed at reducing energy costs and material consumption of food processing equipment.

Conclusion. The developed and theoretically reasonable three-dimensional models flows of non-Newtonian fluids in channels allow to perform qualitatively new design of food processing equipment which allows to reduce energy costs and material consumption.

Introduction

The problems of viscous fluids flow simulation are overviewed. The method for building flow fields of higher dimension from flow fields of lower dimension with different boundary conditions and with changes in parameters of rheological state based on the pressure is suggested.

Materials and methods

The problems of viscous fluids flow simulation are overviewed. The method for building flow fields of higher dimension from flow fields of lower dimension with different boundary conditions and with changes in parameters of rheological state based on the pressure is suggested.

Theoretical analysis

All the variety of flows inside equipment can be divided into two major classes: flows with Reynolds numbers higher than 1 and flows with Reynolds numbers lower than 1. The flows of the first class are realized in practice for liquids with low viscosity. These flows allow easy sharing of heat and mass thus reallocating target substance [1]. Flows of the second class are realized for liquids with high viscosity. These flows allow developing high shear rates and internal friction powers as well as high pressure values. Pressure and internal friction allow affecting and changing internal structure of such fluids. While for the flows with Reynolds number higher than 1 the more important are the characteristics which provide effective interchange of heat and mass, and less important is the rheological state of the fluid; for the flows with Reynolds number lower than 1 the most important if the equation of substance state in rheological aspect. Therefore studying the fluid flow using only Newtonian model is not sufficient. The main difference between flows with high Reynolds number and flows with low Reynolds number lies in the fact that for the first type of liquids rheological parameters are fixed and constant during the flow while for the second type rheological parameters may change during the flow. This fact is especially true for chemical technology. The driving force for flows with Reynolds number higher than 1 is the pressure difference on both ends of the flow region. The driving force of the flows with Reynolds number lower than 1 is the movement of flow region bounds. Moving of liquids with high viscosity demands more energy. The pressure therein is the result of flow region bounds movement [2]. The typical regions of flows with high Reynolds number is tube segments with predefined pressure difference on their ends. Such flows appear in technological equipment of various constructions and also in conduits [3, 4]. Typical flow regions for high viscous fluids are segments of channels and their branches. These channels form working chambers for various screw machines in which high viscous fluids move and change their properties. When describing viscous fluids flow some principles which apply for both Newtonian and non-Newtonian fluids can be used.

Results and discussion

In this paper the methods for simulating viscoplastic longitudinal flow in flat and rectangular channels are discussed. The channel bounds are movable. This movement can occur both along and across the channel. The channel with rectangular cross-section is

considered standard. The flow in the channel is characterized by velocity and pressure values in each point of the flow region. Information about the flow may be condensed (pressure and consumption only) and full, or local (pressure and velocity) in each point. Movement of liquid in the channel can be straight and curved. The latter does not affect the results because inertia does not matter for the flows with Reynolds number lower than 1 [4].

The equations for stokes flows have the following general form:

$$\begin{gathered} -\widetilde{N}P + \widetilde{N}\hat{t} = 0\,,\vec{\upsilon} = \left(\upsilon_x, \upsilon_y, \upsilon_z\right), \\ \nabla\rho\vec{\upsilon} = 0\,,\hat{\tau} = \tau_{ik}\,, i,k = x,y,z\,, \\ \hat{\tau} = \hat{\tau}\left(\hat{\dot{\varepsilon}}, P, T\right), \hat{\dot{\varepsilon}} = \dot{\varepsilon}_{ik}\,, \rho = \rho\left(P\right), \end{gathered} \tag{1}$$

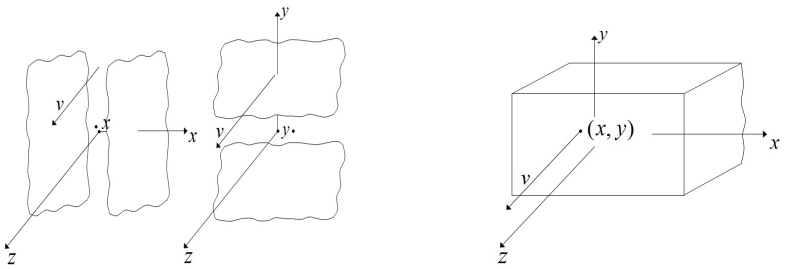
where P – pressure in the fluid, Pa; ρ – density of the fluid, kg/m^3; $\hat{\tau}$ – stress tensor, Pa; $\vec{\upsilon}$ – flow velocity vector, m/s; T – temperature, K; $\hat{\dot{e}}$ – strain rate tensor, 1/s; x, y, z – coordinates of point in the flow region, m.

All flows described by equations (1) can be divided into two groups. First group includes flows with velocity vector which has only one component. This component may depend on one or two coordinates but these coordinates should be transverse. If coordinate Z is chosen as the longitudinal coordinate (along OZ axis), then coordinates x and y will be transverse. Longitudinal flows have velocity component υ_z which can depend either on x or on y separately or on both these coordinates. Longitudinal flows have only one velocity component which depends only on transverse coordinates and can not contain any values which depend on pressure and temperature except for pressure gradient. In these longitudinal flows В таких продольных течениях картина the distribution of velocity is the same in all cross-sections. The second group contains flows with velocity vector which has two or three components each of which depends on two or three coordinates.

The flows of the second group can be ordered like this: two-dimensional longitudinal flows; two-dimensional transverse flows with zero longitudinal velocity, three-dimensional трехмерные twist-and-steer flows which contain all three velocity vector components each of which depends on all three coordinates.

The reasons for various types of flows are the boundary conditions and dependency (or independency) of rheological characteristics on pressure and temperature. Such dependency of reasons and consequences can be illustrated by the example of Newtonian or non-classical non-Newtonian fluid with properties that do not depend on strain rate tensor. If some flow depends only on longitudinal coordinate and has longitudinal component only than this is the flow in flat channel which has only one pair of bounds – and velocities of these bounds are also longitudinal. At the same time only pressure varies along the channel. If rheological parameters depend on pressure than component of stress tensor in equation (1) will also depend on pressure. In this case longitudinal velocity depends on longitudinal coordinate. Due to the equation of matter conservation (1) the second – transverse – velocity component appears, although boundary conditions are purely longitudinal. For Newtonian fluid the longitudinal flows with one velocity component which depends on two transverse coordinates are possible. These flows demand for one additional pair of bounds with longitudinal boundary conditions to be available. Complication of this problem and

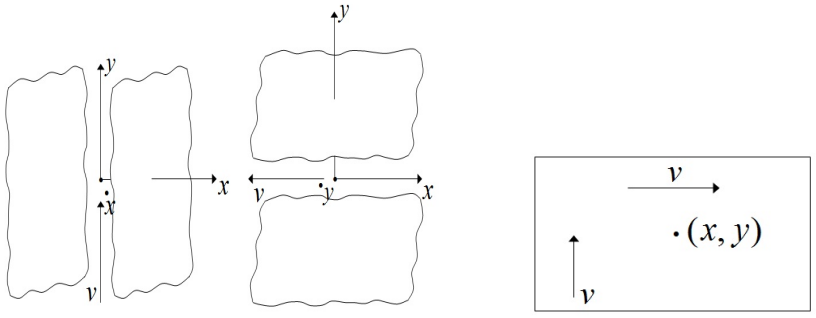
addition of dependency for rheological characteristics leads the solution of this problem beyond the two-component flow. The flow obtains additional component and yet another coordinate as an argument. Thus adding another pair of bounds adds new coordinate while adding dependency from the pressure adds both component and coordinate. This is illustrated on fig. 1.



a b

Fig. 1. Longitudinal fluid flow:
a – in channels with mutually perpendicular bounds;
b – in the rectangular channel

There are also purely transverse flows for Newtonian fluids. If the channel is flat and the velocities of its bounds are purely transverse then the flow will be purely transverse and will depend on one transverse coordinate only. In the practical aspect these flows are of interest to the small channels with large width. These channels may be approximately considered as flat. The flow consumption in wide closed channel has the value of zero. Hence in order for transverse flow in flat channel to adequately represent the transverse flow in rectangular channel, the purely longitudinal flow with zero consumption should be considered. If rheological characteristics of the flow depend on pressure then the transverse flow in flat channel obtains additional velocity component and additional coordinate as a variable. This is illustrated on fig. 2.



a **b**

Fig. 2. Transverse fluid flow:
a – in flat channels;
b – in the rectangular channel.

The flow in rectangular channel with bounds that move both longitudinally and transversally has three velocity components. If the fluid is Newtonian then all these components depend on two transverse coordinates only. If equation of rheological state includes pressure than the third – longitudinal – coordinate is added, and the flow itself has the highest complexity level.

When connection between bounds count, the type of boundary velocities and rheological characteristics is established, then the method of building velocity field of two- and three-dimensional flows on the velocity field of the flow with lower dimension can be suggested. This method involves representation of transverse flow in rectangular channel as the superposition of two transverse flows in two flat channels which are perpendicular to each other and have zero consumption. This method can be applied to both Newtonian and non-Newtonian fluids. This superposition is represented on fig. 3.

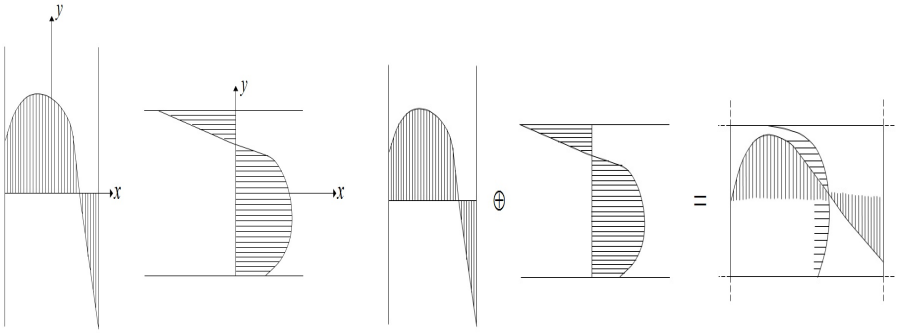


Fig. 3. Fluid flow in flat channels:
(a) – velocity profiles in transverse flows; (b) – superpositions of transverse flows

The superposition lies in the fact that for each flat channel with bound that are perpendicular to each other the longitudinal flow is considered. The equations of this flow contains terms related to another channel. The easiest way to see this is to consider the transverse flow of Newtonian fluid. Suppose there is a transverse flow on the oy axis direction which depends on x coordinate (see fig.4.).

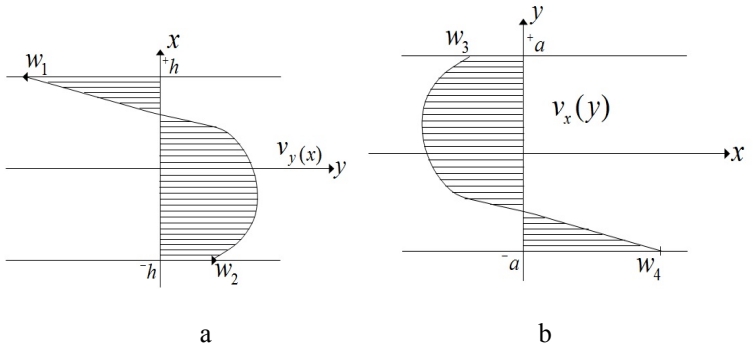


Fig. 4. Velocity profile and boundary velocities:
a – in longitudinal flow which depends on x coordinate;
b – in longitudinal flow which depends on y coordinate

In this case the equations for stress balance have the following form:

$$\frac{\partial P}{\partial y}=\frac{\partial \tau_{yx}}{\partial x}+\frac{\partial \tau_{yy}}{\partial y},\ v_{y(+h)}=W_1,$$
$$v_y=v_y(x),\ v_{y(-h)}=W_2\ v_y(-h)=W_2, \tag{2}$$

where h – if the half of flat channel width, W_1, W_2 – are the channel boundaries velocities.

In order to solve the problem (1) the connection between τ_{yx} and τ_{yy} should be specified. This can be done in several different ways, however the connection between stresses and velocities of deformations in the $\tau_{ik}=\mu\dot{\varepsilon}_{ik}$ form for Newtonian fluid should be known. Thus knowing the boundary conditions the derivatives with respect to x coordinate can always be expressed in terms of derivatives with respect to y coordinate. The derivatives with respect to x coordinate are related to the flow in channel with sides that are perpendicular to the channel from problem (2). This can be done as follows: $\frac{\partial v_y}{\partial x}\sim(W_1-W_2)/2h$; $\frac{\partial v_x}{\partial y}\sim(W_3-W_4)/2a$ in case when $W_1-W_2\neq 0$, $W_3-W_4\neq 0$. Otherwise the estimates of the following form should be used: $\frac{\partial v_y}{\partial x}\sim(v_m-W_1)/\Delta_x^+$; $(v_m-W_2)\Delta_x^-$; $\frac{\partial v_x}{\partial y}\sim(v_m-W_3)/\Delta_y^+$; $(v_m-W_4)\Delta_y^-$, where $\Delta_x^{\pm}$, $\Delta_y^{\pm}$ characterize the extremum position of velocity of the respective longitudinal flow: $\Delta_y^++\Delta_y^-=2h$; $\Delta_x^++\Delta_x^-=2a$. In the first case the estimates lead to $\frac{\partial \tau_{yy}}{\partial y}$ expressed in terms of $\frac{\partial \tau_{yx}}{\partial x}$. In the second case values v_m and $\Delta_x^{\pm}$, $\Delta_y^{\pm}$ act as unknown parameters which are determined after solution of the problem. In both cases the problem (2) is reduced to the longitudinal problem with one transverse coordinate. Then the same problem, but for the flat channel which is perpendicular to the first one is considered. This problem can be represented in the following form:

$$\frac{\partial P}{\partial x}=\frac{\partial \tau_{xy}}{\partial y}+\frac{\partial \tau_{xx}}{\partial x},\qquad v_x(+a)=W_3,$$
$$v_x=v_x(y),\qquad v_x(-a)=W_4. \tag{3}$$

The solution to this problem has the same form as the solution of problem (2). The estimates for velocity derivatives allow expressing $\frac{\partial \tau_{xx}}{\partial x}$ in terms of $\frac{\partial \tau_{xy}}{\partial y}$. The solution (2) and (3) should consider the zero-consumption condition. This condition leads to the

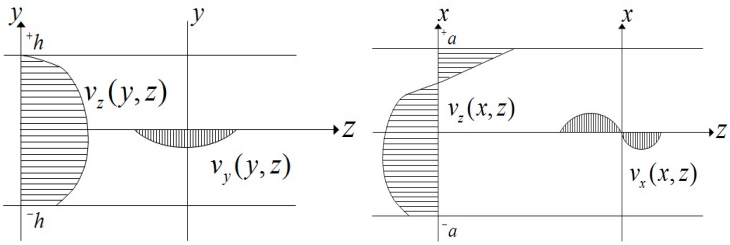
equations for $\frac{\partial P}{\partial y}$ and $\frac{\partial P}{\partial x}$ in a way that values of these pressure become dependant on $W_1 - W_2\pi$ and $W_3 - W_4$.

Applying the method described below to non-Newtonian fluid does not lead to any fundamental changes but make the solution for problems (2) and (3) core complicated. Here the following cases are possible: viscosity depends on the second invariant of the strain velocity tensor, or viscosity depends on pressure.

In the first case all terms of the second invariant should be expressed in terms of corresponding derivative of the longitudinal velocity: for problem (2) it is $\frac{\partial \upsilon_y}{\partial x}$; for problem (3) – it is $\frac{\partial \upsilon_x}{\partial y}$. In the second case the longitudinal flows $\upsilon_y(x)$ and $\upsilon_x(y)$ obtain additional component $\upsilon_x(x)$ – for problem (2), and $\upsilon_y(y)$ – for problem (3). Hence in this case the problem for longitudinal flow with one transverse component should be considered. This problem is based on the following equations:

$$\begin{gathered}\frac{\partial P}{\partial z} = \frac{\partial \tau_{zy}}{\partial y} + \frac{\partial \tau_{zz}}{\partial z}, \\ \upsilon_z = \upsilon_z(y,z), \upsilon_z(+h,z) = W_5, \\ \upsilon_x = \upsilon_x(y,z), \upsilon_z(-h,z) = W_6,\end{gathered} \tag{4}$$

where W_5, W_6 – values for longitudinal velocities of the bounds (see fig. 5).



a b

Fig. 5. Longitudinal flow with transverse component for the fluid, properties of which depend on pressure:
a – transverse component is directed along *ox* axis;
b – transverse component is directed along *oy* axis

The solution for this problem is based in reducing $\frac{\partial \tau_{zz}}{\partial z}$ to $\frac{\partial \tau_{zy}}{\partial y}$ with the aid of described estimates. The solution for problem (4) describes longitudinal flow along the channel axis with the following boundary conditions:

$$P(z=L)=P_L\,,\quad P(z=0)=P_0\,, \tag{5}$$

where L – channel length, m; P_0 and P_L – pressure values on the channel bounds, Pa.

If the zero-consumption condition is taken into account then the solution for the problem describes the transverse flows in channel which are perpendicular to each other and have two flat bound.

The problem for longitudinal flow for another pair of bounds looks similar to the problem (4):

$$\begin{gathered} -\frac{\partial P}{\partial z}=\frac{\partial \tau_{zx}}{\partial x}+\frac{\partial \tau_{zz}}{\partial z}=0\,, \\ \upsilon_z=\upsilon_z(x,z),\ \upsilon_z(+a,z)=W_7\,, \\ \upsilon_y=\upsilon_x(x,z),\ \upsilon_z(-a,z)=W_8\,, \end{gathered} \tag{6}$$

where W_7 and W_8 – longitudinal velocities, m (see fig. 5).

Problems (2), (3), (4), (5) lead to velocity fields which consist of two velocity fields in the intersection of flat channels. Thus the question of choosing one or another field arises. This can be done in two ways. The first method: the velocity fields obtained as the solutions for different problems are attributed to the bounds for which they are obtained. Herewith four fields are obtained for longitudinal velocity: two for each pair of bound. The condition for continuity of longitudinal velocity values, which are calculated based on two different expressions, leads to four equations for four lines which divide the rectangle of channel cross-section into sub-areas, each of which is described by its own expression for longitudinal velocity (fig. 6a).

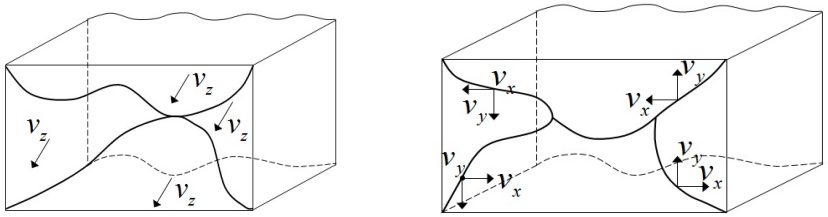


Fig. 6. Partition of cross-section of rectangular channel into sub-areas:
(а) – for longitudinal flow; (б) – for transverse flow

The same procedure is applied for transverse flow. In this case there are four sub-areas as well. However the condition for their fixation is not the condition for velocity continuity but the condition for continuity of the absolute velocity. Velocity vectors are tested on the lines which separate one area from another by rotating by the angle of $\frac{\pi}{2}$ (see fig. 6b). This method lies in the fact that for the rectangular channel with different sides a and h the main velocity field is the field which has longer bounds. This field is corrected

by the multipliers in order to match boundary conditions for the second pair of bounds. Also the experimentally tested statement about the fact that the influence of the pair of bounds extends inside the flow region for the distance approximately equal to the bounds length is used. Thus for large values of this length the influence of shorter pair of bounds weakens. In order to illustrate this statement the channel in which $a >> h$ can be considered. In this case the cross-section has two sub-areas which abut the sides with length h and extend deep for a distance of h, in which expression for velocity flow in flat channel with the width of $2h$ should be corrected in the abovementioned sense. Outside of these two regions the flow is the same as without these two bounds. Applying this method to the transverse flow leads to these two velocity fields, each obtained for its own pair of bounds, are attributed to the entire area of rectangular cross-section, but corrected by multipliers which consider the missing pair of bounds. The method described above is more precise but also more complicated. The complexity of its application is in the fact that bounds influence extends inside the flow region for a distance of bound area and is valid for Newtonian fluids only. This rule is also valid for non-Newtonian fluid but the bound length should be multiplied by some multiplier which depends on parameters of rheological state equation.

Conclusion

The method for reducing problems of flows with higher dimension to the problems of flows with lower dimension described in this paper can be applied to the wide variety of non-linear fluids with various boundary conditions which are based not only on adhesion. This method can be extended to the flows with slipping and to the non-isothermal flows. Herein one should consider the fact that the flow of fluids with high viscosity is accompanied by significant dissipative heat release which is described by distributed source. The presence of slipping apart from mentioned source indicates the necessity for accounting of surface source which is localized on the flow region bound. Sliding contact on the border is similar to the contact of two solid surfaces. Heat release in this contact depends both on pressure normal to the contact and on the magnitude of the slip. In the first case the heat release occurs on the Coulomb type, while in the second case – on the hydrodynamic type. The task for the future is to extend method of solving three-dimensional problems to the problems with surface heat sources.

Having the possibility of non-Newtonian fluid to slide at the region bounds allows dividing all flows into two groups. First group includes flows throughout which the first sliding conditions are complied. The second group includes flows which partially formed by adhesion conditions and partially – by sliding conditions. For the flows of the last group the number of velocity vector components and the number of coordinates are changed in the cross-section of the channel which has longitudinal coordinate that matches the coordinate along which the change of boundary condition form may occur. For such flows the problem of “bonding” several flows of two different types should be solved. Such “bonding” should be subordinated to the conditions of continuity of all velocity and pressure components. Here first derivatives of the velocity in the coordinates will experience a leap. Considering connections between the components of stress tensor and strain velocities the leap of velocity derivatives means the leap of components of stress tensors. Thus the imposition of velocity components continuity conditions is not fully consistent, because it leads to the leap of stress components and the continuity of pressure (fig. 7).

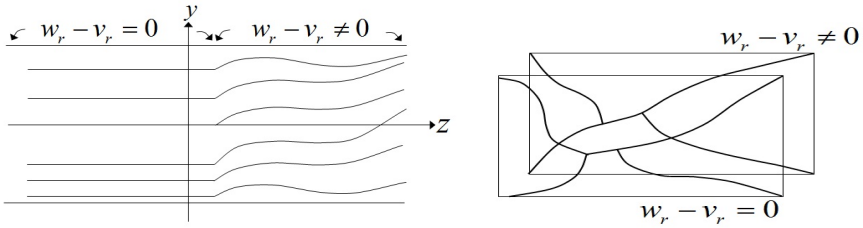


Fig. 7. Flow of the fluid with combined bounds:
a – "bonding" lines for the fluid with sliding and adhesion conditions at the part of the bounds
b – partition of channel; cross-section into sub-areas when one of the sections belongs to the area with sliding and the other section belongs to the area with adhesion

The more consistent is the extension of continuity conditions on the partial derivatives of velocity vector in cross-section, where flows with different dimensions are linked. Everything said above applies to the longitudinal components of the velocity field and to the transverse components providing that partition of channel cross-section rectangle into sub-areas from different sides of the cross-section of transition from one boundary conditions to another – is the same. In fact it is not so, thus the problem of "bonding" and partitioning arises. This problem requires additional study. Therefore the method for building three-dimensional velocity and pressure fields described in this paper has certain potential of development and extension on the flows which appear during the description of large amount of practical situations in food technological processes. The method described in this paper was applied to isothermal flows without sliding for the three-dimensional problems of the flow of Newtonian, power-law, generalized and Bingham fluids in the rectangular channel with arbitrary piecewise constant distribution of bound velocities [6]. Herein in some cases it was possible to consider fluid compressibility and the dependence of the parameters of rheological state equation of the pressure.

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Treatment of dairy effluent model solutions by nanofiltration and reverse osmosis

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Abstract

Introduction. Dairy industry generates a large amount of wastewaters that have high concentrations and contain milk components. Membrane processes have been shown to be convenient for wastewater treatment recovering milk components present in wastewaters and producing treated water.

Materials and methods. The experiments were carried out in an unstirred batch sell using nanofiltration membranes OPMN-P (ZAO STC "Vladipor", Russian Federation) and reverse osmosis membranes NanoRo, ZAO ("RM Nanotech", Russian Federation). The model solutions of dairy effluents – diluted skim and whole milk were used.

Results. The nanofiltration and reverse osmosis membranes showed the same permeate flux during the concentration of model solutions of dairy effluents. The reason of this was likely membrane fouling with feed components. The fouling indexes indicated the fouling factor that was higher for RO. The higher permeate quality was obtained with RO membranes. The NF permeate containing up to 0.4 g/L of lactose and 0.75 g/L of mineral salts can be discharged or after finishing treatment (e.g. RO or other) can be reused. The obtained NF and RO retentate corresponds to milk in composition and can be used for non-food applications or as feed supplement for animals.

Conclusions. The studied RO and NF membranes can be used for concentration of dairy effluents at low pressure. They showed better performance and separation characteristics comparing with data of other membranes available in the literature.

Introduction

Dairy industry generates a large amount of wastewaters, from 0.2 to 10 L of effluent per liter of processed milk [1] with an average value of about 2.5 liters of wastewaters per liter of the milk processed [2]. The effluents are produced in the starting, equilibrating, stopping and rinsing steps of the processing units [3] and during cleaning operations, especially between product changes. They are composed of milk components (lipid, protein and lactose) with cleaning chemicals (acids, alkalis and detergents). The dairy effluents are high loaded and have high concentrations. The first rinsing waters generated from the washing operations have the main contribution to the dairy effluents pollution load, since they content all components of milk. Because of its high chemical and biological oxygen demand and its high concentration the dairy wastewaters must be treated prior to discharge to the environment.

Dairy industry effluents are generally treated using biological and physico-chemical methods. Among these methods, membrane processes have been shown to be convenient for wastewater treatment [1, 4-8]. Membrane treatment of dairy wastewaters could simultaneously lower the total water consumption and the effluent production of the dairy plant by recovering milk components present in wastewaters (lactose, proteins) and producing treated water [3, 9, 10]. Several works dedicated to dairy wastewater treatment by membrane methods showed that one (UF, NF, RO) or two stage (NF+RO, RO+RO, UF+RO) operations allow recovering nutrients and producing reusable water [1, 3- 5, 11-13]. However, high transmembrane pressure (especially for RO) and membrane fouling weaken its application.

In this study, we investigated NF and RO concentration of dairy effluent model solutions (flushing waters, first rinse waters) by dead-end filtration at low pressure. The studied membranes were OPMN-P and NanoRo membranes (of Russian production) since they are cheaper and more available for Ukraine enterprises, and in addition their separation properties are poorly studied in this field.

Materials and methods

Dairy effluent model solutions. The dairy effluents are mainly generated in cleaning and washings steps of processing units. They are mixtures of water and milk without chemicals of various compositions (flushing waters, first rinse waters). Composition and concentration of these waters varies greatly and depend on the dairy plant main product and on the processing units used. That's why model solutions were used for the experiments to compare NF and RO. The solutions were prepared from skim and whole milk diluted with deionized water (dilution 1:4.5 and 1:5, respectively). The main characteristics of these model process waters are shown in Table 1.

Table 1

Main characteristics of dairy model effluent solutions

Characteristics	Skim milk	Whole milk
Fat, g/L	0.06-0.07	4.10-4.30
Proteins, g/L	4.40-4.60	4.45-4.70
Lactose, g/L	6.60-6.90	7.40-7.80
Mineral content, g/L	0.53-0.63	0.59-0.60
pH	6.45	6.7
Dry matter, g/L	17-18	18-20

Membranes. Two commercially available membranes were used in this study: one NF membrane OPMN-P (ZAO STC "Vladipor", Russian Federation) and one RO membrane NanoRo (ZAO "RM Nanotech", Russian Federation) with a NaCI rejection of 99.5%. Membranes are thin-film composite (NanoRo) with an active polyamide layer.

A new membrane was used for each experiment. New membranes were soaked in deionized water for at least 12 h prior to use. Once installed, each membrane was compacted at a high pressure (2.0 MPa for NF, 4.0 MPa for RO) until reached steady-state conditions. The membrane pure water permeability was measured with deionized water at 20 °C before each experiment. After the filtration, membranes were flushed with deionized water and then pure water permeability was measured again to calculate irreversible fouling for each membrane. Then membrane was cleaned with a 0.1% NaCl solution (pH=8) for 20 minutes at 20 °C. After cleaning membrane permeability was checked again.

Experimental set-up and procedure. The dead-end filtration was performed in a laboratory-constructed magnetically stirred cell in concentration mode. A detailed description of the cell used can be found in a previous paper [16]. The working volume of the cell was 200 mL. The working pressure in the cell, applied by a nitrogen tank, was 1.0 MPa for NF and RO membranes. The membrane sheet area was $1.38 \cdot 10^{-3}$ m^2. Stirring of the solution was provided with a two blades stirrer.

The filtration unit can concentrate the solutions up to VRR 2 due to dead volume. Thus, to reach a higher concentration of retentate, the filtration was performed in several steps. The experiments were carried out until permeate flux decreased to 5-6 $L \cdot h^{-1} \cdot m^{-2}$.

Analysis. During experiments, feed, retentate and permeate were sampled and assessed for fat, proteins, lactose and mineral salts content.

Dry matter content was measured by a refractometer URL-1. The protein concentration in solution was measured using AM-2 unit. Lactose concentration was determined using iodometric titration GOST 8764. Fat concentration was determined by Gerber method GOST 5867-90. The mineral salts content was measured by a conductivity meter (HANNA Instruments DIST 1) and pH was measured with a pH-meter (Ionomer 120M).

For the different components, the observed rejection of the membrane was obtained by the following equation:

$$R = \left(1 - \frac{C_P}{C_R}\right) \cdot 100\%, \tag{1}$$

C_P and C_R are the permeate and the retentate concentrations respectively.

Calculated parameters. Permeate flux J was calculated according to following equation

$$J = \frac{3600 \cdot V}{S \cdot t}, \tag{2}$$

V is permeate volume obtained at time t from the membrane area S.

Volume reduction ratio (VRR) vs. time

$$VRR = \frac{V_f(t)}{V_R(t)} = \frac{V_f(t)}{V_f(t) - V_P(t)} \tag{3}$$

$V_f(t)$, $V_R(t)$, $V_P(t)$ is the feed, retentate and permeate volume at time t, respectively.

The pure water permeability L_p was calculated as follows:

$$L_p = \frac{J}{\Delta P}, \tag{4}$$

where J is the permeate flux of deionized water, ΔP is applied pressure.

The irreversible fouling index (*IF*) can be expressed as a percentage of pure water permeability decrease after the experiment.

$$IF = \frac{L_{pi} - L_{pf}}{L_{pi}} \cdot 100\% \tag{5}$$

L_{pi} and L_{pf} are the initial and final pure water permeability, respectively.

Results and discussion

Permeate flux. The dead-end filtration of effluent model solutions was performed in the continuous concentration mode to about VRR 6. During filtration experiments permeate flux decreased continuously with increase of retentate concentration (Fig. 1). As it can be seen (Fig. 1) permeate flux from the NF membranes was not higher than from RO ones during concentration of model solutions of skim and whole milk in spite of different membrane characteristics, although it was expected that NF flux would be higher. It was likely due to membrane fouling by the feed components and their adsorption on to the membrane surface, especially proteins [3]. One should note here that permeate fluxes were slightly lower for NF and RO membranes during concentration of model solutions of skim milk. Comparing the obtained fluxes with those in papers [1, 3, 12] it can be seen that the fluxes of studied membranes (OPMN-P and NanoRo) at 1.0 MPa are the same as of membranes in [1, 3, 12] at higher pressure of 2.0-2.5 MPa. Obviously, these membranes have better performance and can be used for concentration of dairy effluents at lower pressures reducing energy consumption.

Although permeate fluxes were almost similar for NF and RO during concentration of model solutions the fouling indexes were different. The fouling indexes indicated the fouling factor of membranes with feed components. As it was expected the higher fouling index was observed for RO membranes (Fig. 2). It may be explained by the higher membrane fouling during RO experiments due to properties of RO membranes to retain all the components present in the wastewater in contrast to NF membranes. However, the fouling index of RO membrane was not much higher than of NF after concentration of effluent model solutions of skim milk (Fig. 2, a). Furthermore, it should be outlined that the fouling index was lower for OPMN-P membranes in 2-3 times at VRR 6 compared to the index that was obtained for NF-270 at VRR 3 [5]. The fouling was removed with an appropriate chemical cleaning, described in section 2, after which the initial membrane permeability was restored.

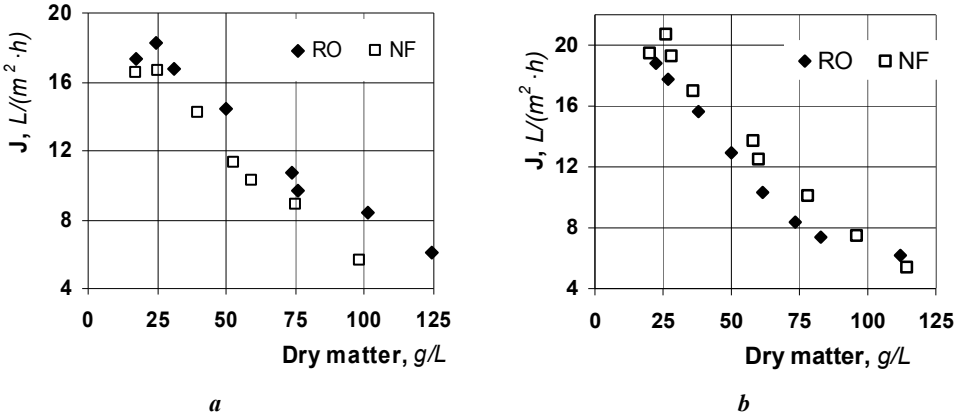

Fig. 1. Permeate flux vs. retentate dry matter during concentration of dairy model wastewaters of skim milk (a) and whole milk (b) by NF and RO

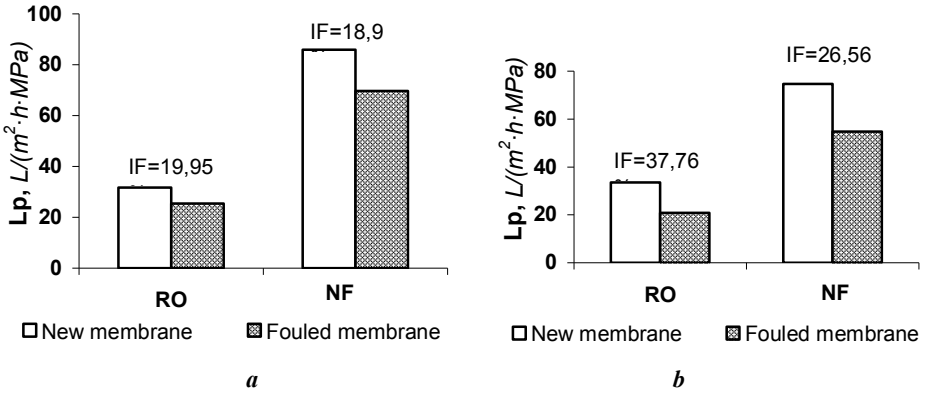

Fig. 2. Pure water permeability decline for RO and NF membranes after filtration of dairy effluent model solutions of skim milk (*a*) and whole milk (*b*)

Permeate and retentate characteristics. The main permeate characteristics are summarized in Table 2. As expected, concentrations in permeate were higher with NF membranes than with RO. NF and RO membranes totally retained fat and lipids. Lactose rejection was 97 and 95% for NF membrane for model effluent solutions of skim and whole milk respectively and 99.9% for RO membrane. Rejection of mineral salts was 62-63% for NF and 98-99% for RO. High mineral content of NF permeates (Table 2) and its low rejection is caused by permeability of NF membranes to monovalent ions Na^+, K^+, Cl^-. Multivalent ion concentrations were low (1 mg/L for Mg^{2+} and 3 mg/L for Ca^{2+}). Since lactose, which has an important contribution to COD, and mineral salt content are high in NF permeate, one single NF step is insufficient for producing water suitable for reuse, but these water can be discharged. Therefore a finishing step (e.g. RO or other) is needed for the production of reusable water. RO permeate of both model effluent solutions was low mineralized (50 mg/L). Thus it can be reused in dairy plants, e.g. for washing floors and the outside of plant vehicles [3]. Comparing the obtained results of permeate characteristics

with those in [12] it should be noted that the studied membranes in this study had better separation characteristics and showed better rejection of mineral salts and lactose at higher VRR.

Table 2

Main characteristics of permeate produced by NF and RO from dairy model process waters

Characteristics	NF		RO	
	Skim milk	Whole milk	Skim milk	Whole milk
Fat, g/L	-	-	-	-
Proteins, g/L	-	-	-	-
Lactose, g/L	0.230	0.370	0.02	0.02
Mineral content, g/L	0.670	0.75	0.05	0.03
Ca^{2+}, g/L	0.003	0.003	0.001	0.001
Mg^{2+}, g/L	0.001	0.001	0.001	0.001
Na^{+}, g/L	0.07	0.12	0.006	0.004
K^{+}, g/L	0.21	0.28	0.017	0.009
Cl^{-}, g/L	0.38	0.34	0.026	0.015

The retentate composition of model effluent solutions is shown in Table 3. There are also characteristics of skim and whole milk to make a comparison. As it can be seen NF retentate had lower content of the main components in the skim and whole milk, obviously due to penetration of some components (lactose, minerals) through the membrane into the permeate. For RO the concentration of components in the retenates of model solutions was higher and was almost the same as in the milk. The obtained NF and RO retentates can be used for non-food applications [17] or after the appropriate treatment (e.g. pasteurization) as feed supplement for animals [18].

Considering the obtained permeate and retentate characteristics it is recommended to use RO for concentration of dairy effluents. Such a treatment of dairy wastewaters allows achieving the set of targets:

-to recover valuable products (lactose, protein);

-to receive purified water suitable for reuse;

-to reduce the amount of wastewaters and its pollution load;

-to reduce the load of treatment plant.

Table 3

Comparison of main characteristics of retentate produced by NF and RO from dairy model effluents with skim and whole milk

Characteristics	NF		RO		Skim milk	Milk with fat content of 2.7%
	Solution of skim milk	Solution of whole milk	Solution of skim milk	Solution of whole milk		
Fat, g/L	0.4	23.5	0.5	25.8	0.5	26.0
Proteins, g/L	26.5	25.4	31.7	28.2	30.0	28.2
Lactose, g/L	40.8	41.6	47.5	46.8	45.0	47.2
Mineral content, g/L	5.8	7.0	6.9	8.8	7.0	9.0
Dry matter, g/L	98.0	114.0	124.0	112.0	96.0	112.0

Conclusions

1. The permeate flux of NF and RO membranes was the same during concentration of model effluent solutions in spite of different membrane characteristics. This was likely caused by severe membrane fouling with solution components (proteins).

2. The calculated fouling indexes showed that fouling with RO membranes was higher than with NF. The fouling layer formed on the membrane surface was removed with chemical cleaning, after which the initial membrane permeability was restored.

3. The higher permeate quality was obtained with RO membranes that showed better rejection of milk components. The low mineral content of RO permeate makes it possible to be reused in the dairy industry for washing floors and the outside of plant vehicles.

4. One single NF step is insufficient for producing water suitable for reuse, but allows the milk constituents to be concentrated in the retentate. These permeate can be discharged or reused in the dairy plant after finishing step (e.g. RO or other).

5. The NF and RO retentates corresponded in composition to skim and whole milk and could be used for non-food applications or after the appropriate treatment (e.g. pasteurization) as feed supplement for animals.

6. The studied NF and RO membranes showed better performance and separation characteristics at lower pressure comparing with data of membranes of foreign manufactures available in the literature. Considering the economic benefit it is better to use these membranes for concentration of dairy effluents.

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Planning of elimination of emergency consequences

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Abstract

Introduction. The volume of useful information in the planning of elimination of emergency consequences process is reasonable to assess with calculatory problems and mathematical models.

Materials and methods. The expert survey method is used to calculate quantitative values of probability and to determine the optimal solution before the information in condition is received.

Results. It is determined that the quality of the solution of elimination emergency consequences depends primarily on the number of factors that are taken into account in particular circumstances of the situation; on the level of information readiness of control bodies to take decision to eliminate emergency consequences as soon as possible and to consider several options for achieving reasonableness and concreteness of a particular decision.

The ratio between volume of useful information collected and processed during operation planning which is required for identifying optimal solution is calculated. This ratio allows to construct a graph of probability of identifying a solution in existing environment and probability value of identifying optimal solution before information in P*condition is obtained.

This graph also shows the ratio volume of useful information collected and processed during operation planning and necessary volume of information for identifying optimal solution.

Conclusion. The results of this research can be used for improving control bodies decisions to ensure safe working conditions for employees of food industry.

Introduction

The qualitative and operational work of control bodies during the planning of elimination of emergency consequences significantly depends on the completeness and usefulness of the information that will be used for management decisions. In order to control bodies could react timely and adequately to changes in environment and make reasonable decisions and develop plans, the process of obtaining necessary information during informational support must be continuous.

Completeness and usefulness of information is a the main objective of the phase of identifying the decision of planning of elimination of emergency consequences, this decision must fully meet the requirements of the existing situation and depend on completeness and usefulness of information collected and processed by the control bodies during its definition.

Some scientists in there works on planning of elimination of emergency consequences [1, 2, 3] paid enough attention to investigation of completeness and usefulness of information. But, proposed methods do not fully take into account wide introduction of new automation devices and this significantly affects the process of obtaining and processing of information.

In the article the method of assessing volume of useful information during the process of planning of elimination of emergency consequences, based on application of calculatory problems and mathematical models is proposed. From the functional point of view, the system of analytical data processing and mathematical modeling is closely connected with the subsystem of system analysis and making proposals. During the process of designing elements for decision making support in emergency situations the universal approach is used, that allows to bringing together both subsystems from viewpoint of the used software-tools and methodological support. In this connection we could claim that the system of analytical data processing and mathematical modeling, analysis and presentation of information and analytical materials fully solve all tasks during emergency situations.

Materials and methods

The developed method of assessing volume of useful information in the planning of elimination of emergency consequences, based on application of calculatory problems and mathematical models is used. During the process of designing elements for decision making support in emergency situations the universal approach is used, that allows to bringing together both subsystems from viewpoint of the used software-tools and methodological support. System of analytical data processing and mathematical modeling, analysis and presentation of information and analytical materials fully solve all tasks during emergency situations.

Currently to solution of similar problems, especially when analyzing large data volumes, it is impossible without the use of new information technologies, such as OLAP (online analytical processing) and Data Mining (data mining methods), which significantly increase the efficiency and effectiveness of the analytical information processing, that's why implementation of elements of support of control bodies decision in emergency situations is based on development of support data warehousing (Data Warehouse), and also on use of OLAP technology and Data Mining.

The method of survey experts was used to calculate the quantitative value of probability for identifying the optimal solution before information in (P*) condition is received. It is the practice to express [3] the probability of identifying optimal solution

before information is received during planning of elimination of emergency consequences as $P^* = 0,46$ according to experts. Certainly, the level of training of control bodies that make a decision, practical experience in performing duties of the position, psychological stability etc. influence greatly on this value.

Results and discussion

To make a decision of planning of elimination of emergency consequences is a creative and responsible task. The essence of this task from the perspective of cybernetics, can be defined as conversion of information in quantitative components, parameters of information control, and a creative side of identifying decision, can by defined as production of complete information cadastre and its assessment.

To solve this task control bodies need required volume of useful information, and the correctness of conclusions in assessment of a situation, timeliness and validity of the decision planning of elimination of emergency consequences will depend on this information. That is, the volume of useful information is a function of completeness and usefulness of information used by control bodies.

$$R_i = f(Q_i, C_i) \quad (1)$$

R_i - volume of useful information;
Q_i - completeness of information;
C_i - usefulness of information for control bodies during planning of elimination of emergency consequences.

According to equation 1 volume of useful information can be expressed in terms of increase in probability of achieving a goal. If before information is obtained this probability is (P^*), i.e., the decision could be defined as rational or irrational, and after information is obtained it has become – P, so volume of useful information can be defined as:

$$R_i = log_2(P/P^*), \text{ where } 0 < P^* < 0,5 \quad (2)$$

If before information is obtained the decision can be determined by one of two variants of $P^* = 0,5$, then after obtaining certain volume of useful information a variety of options appear, part of these options lead to a goal and others don't lead. Probability of achieving a goal after obtaining information can be equal P*, more or less than P* and it depends on relative fraction of one or other variants. In other words obtained information in some volume can be useful, neutral or harmful (misinformation).

We can state that the best solution in the existing environment must include information about all the factors which affect this solution.

It is important to know how to calculate the required volume of useful information for obtaining the optimal solution. To identify the optimal solution it is necessary to solve a certain number of calculatory problems and mathematical models, which take in account maximum number of factors (ideally all of them) that will influence performance of tasks of elimination of emergency consequences.

Based on the results of previous studies volume of useful information can be calculated as follows:

$$I = \frac{\sum_{i=1}^{N_1} N_i^{із} \cdot K_i^{із} + \sum_{i=1}^{N_2} N_i^{рз} \cdot K_i^{рз} + \sum_{i=1}^{N_3} N_i^{мм} \cdot K_i^{мм}}{\sum_{i=1}^{M_1} N_i^{із} \cdot K_i^{із} + \sum_{i=1}^{M_2} N_i^{рз} \cdot K_i^{рз} + \sum_{i=1}^{M_3} N_i^{мм} \cdot K_i^{мм}} \quad (3)$$

$N_i^{із}$ - information problems, which control bodies use in process of making decision;

$N_i^{рз}$ - calculatory tasks which the control bodies use in process of making decision;

$N_i^{мм}$ - mathematical models which use controls bodies use in process of making decision

N_1- number of information problems, which can be solved by control bodies in process of making decision depending on volume of useful information;

N_2- number of calculatory problems, which can be solved by control bodies in process of making decision depending on volume of useful information;

N_3- number of mathematical models, which can be solved by control bodies in process of making decision depending on volume of useful information;

M_1- number of information problems, which control bodies must solve in the process of making decision;

M_2- number of calculatory problems, which control bodies must solve in the process of making decision;

M_3- number of mathematical models, which control bodies must solve in the process of making decision;

$K_i^{із}$ - coefficient of comparative importance of information problems;

$K_i^{рз}$ - coefficient of comparative importance of calculatory problems;

$K_i^{мм}$ - coefficient of comparative importance of mathematical models.

But there is no sufficient statistics on control bodies activity in solving control at the stage of planning of elimination of emergency consequences. So, we propose to determine quantitative value P * by expert survey.

The proposed approach to assess the completeness of information supply is not unique, and from a logical point of view is the most suitable for assessing of information support of operation that meets requirements of completeness of information and its usefulness.

The method of experts survey is used to calculate quantitative value of probability of identifying the optimal solution before information*(P*)* is received. We can state [3], that the probability of identifying the optimal solution before information is received during elimination of emergency consequences, according to experts P * = 0,46. Certainly, such factors will have a significant impact on the value as: the level of training of control bodies that make a decision; practical experience in performing the duties of a position, psychological stability, etc.

The most appropriate ways to enhance the probability of identifying the optimal solution before information is received are:

- to increase the level of training of control bodies;
- to improve practical skills in duties of a position;
- improve regulatory framework of elimination of the consequences of emergency situations;

- create database and knowledge data base that would be used in identifying the optimal solution.

According to equation (3) calculated the ratio of volume of useful information, which is collected and processed during the planning of the operation required for making a solution is calculated. The ratio between volume of useful information collected and processed during operation planning which is required for identifying optimal solution is calculated. This ratio allows to construct a graph of probability of identifying a solution in existing environment (P) and probability value of identifying optimal solution before information in P*condition is obtained.

This graph also shows the ratio volume of useful information collected and processed during operation planning and necessary volume of information for identifying optimal solution *(I)* (fig. 1).

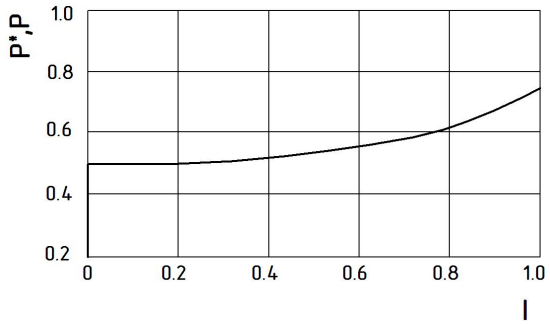

Fig. 1. The ratio of probability of identifying a solution that corresponds the situation to probability of determining the optimal solution before information is received and volume of useful information

The existing control system does not allow to collect centralized information. That is, the analysis shows that there is no possibility to connect informational support of planning of elimination of emergency consequences with the organization of the system of control, besides conditions for forming general principles of information choice and nature of information sources are created. This leads to the selection of the organizational and functional structures, which have the most favorable information characteristics. Currently it is possible to achieve this only in conditions of a rigid centralization of information gathering.

The study of causes and circumstances of elimination of emergency consequences at the food industry enterprises will allow to develop sustainable and effective ways of preventing and reducing occurrence of emergency situations in this field. Thanks to this study it will be possible to determine the directions and recommendations for prevention emergency situations. It is a topical scientific task, related, first of all, to solving industrial problems.

Conclusion

The quality of the solution of elimination emergency consequences depends primarily on the number of factors that are taken into account in particular circumstances of the situation; on the level of information readiness of control bodies to take decision to eliminate emergency consequences as soon as possible and to consider several options for achieving reasonableness and concreteness of a particular decision.

Thus proposed approach allows to establish the ratio between the volume of useful information and probability of identifying solution that corresponds to the situation in received information.

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Анотації

Харчові технології

Інтенсифікація процесу сушіння за допомогою функціональних рослинних композицій

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Вступ. При сушінні рослинної сировини у результаті теплової обробки, впливу світла, кисню, pH середовища відбуваються втрати біологічно активних речовин, тому доцільно удосконалити технологію переробки столового буряку з метою максимального збереження бетаніну та зменшення енерговитрат.

Матеріали і методи. Сушіння буряку, ревеню, лимона, помідора відбувалось при температурі 50…100ºС, швидкість повітря складала 1,5…3,5 м/с, вологовміст теплоносія - 7…15 г/кг, товщина шару - 2…20 мм. Вміст бетаніну визначали за спектрами поглинання, величиною оптичної густини при довжині хвилі 540 нм. Витрати теплоти на випаровування визначено на диференціальному мікрокалориметрі.

Результати і обговорення. Досліджено вплив попередньої підготовки на сировину, яка підлягає сушінню. Втрати бетаніну під час сушіння, без попередньої підготовки сировини, становлять 66%. Розроблена технологія попередньої підготовки, яка передбачає варку цілих коренеплодів з підібраним оптимальним кислотним середовищем, надає можливість зменшити втрати бетаніну до 6%, але це досить енергоємний процес. Розроблено енергоефективний спосіб підготовки антиоксидантної сировини перед сушінням з повною заміною теплової обробки купажуванням. При цьому відбувається втрата бетаніну до 5%. Оптимальна температура сушіння попередньо обробленої бетаніновмісної сировини становить 60 °С, при цьому зберігається до 95% бетаніну. Питомі витрати теплоти на випаровування води з розроблених антиоксидантних рослинних композицій на основі буряку з додаванням ревеню і лимона на 4…5% менші, ніж для вихідних компонентів.

Висновки. Знайдено залежність втрат бетаніну в рослинній сировині від температури матеріалу та композиційних складових під час її підготовки до сушіння. Встановлено, що теплота випаровування води в деяких розроблених антиоксидантних рослинних композиціях менша, ніж вихідних компонентів сировини. Результати доцільно застосовувати при розробці промислових теплотехнологій виробництва функціональних харчових порошків.

Ключові слова: *сушіння, буряк, бетанін, теплота, випаровування.*

Науково-практичні основи переробки картоплі на харчові продукти

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Вступ. Відсоток переробки картоплі на продовольчі товари на території колишнього Радянського Союзу знизився до 1%, тоді як у деяких країнах Європи та США частка переробки картоплі становить 60-80%. Сучасні наукові розробки довели економічну доцільність переробки картоплі на продукти харчування.

Матеріали та методи. Дослідження ефективності технологічних процесів переробки картоплі проведені у лабораторних і промислових умовах відкритого акціонерного товариства «Машпищепрод» (Мар'їна Горка, Мінська область, Білорусь). Відбір проб, підготовка і проведення випробувань виконані за допомогою стандартних і спеціальних методів аналізу.

Результати і обговорення. Визначені сорти картоплі, придатні для виробництва сухих пюре і чипсів. Їх акліматизація забезпечує мінімальний вміст цукрів, які позитивно впливають на якість готової продукції. Дослідження показали, що процес перемішування картоплі при температурах, близьких до температури варіння, є оптимальним. Руйнування клітин майже не відбувається. Пневматичні сушарки для сушіння вареної картоплі забезпечують високу якість продукції завдяки низькій температурі нагрівання і короткому контакту порошкоподібного продукту із сушильним агентом. Кількість пошкоджених клітин у готовому продукті не перевищує 1,3-2,6%. Визначені та науково обґрунтовані оптимальні режими і параметри виробництва чипсів, процесів їх різання, бланшування, зневоднення, сушіння й обсмажування, які забезпечують високу якість готової продукції та зниження олії в продукті до 27,7%.

Висновки. Доведено, що при виробництві чипсів і сухих пюре економічно вигідно використовувати сорти картоплі Дезіре, Темп, Синтез. Вирішальними процесами, що визначають кількість зруйнованих клітин в готовому продукті, є змішування і сушка.

Ключові слова: *картопля, чипси, пюре, сушіння.*

Сорбційні характеристики пектину, виділеного з бульб топінамбура (*Helianthus tuberosus L.*)

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Вступ. Мета дослідження - виділення пектину з бульб топінамбуру (*Helianthus tuberosus L.*) і аналіз його сорбційних характеристик.

Матеріали і методи. Дослідження проводилося за змістом пектину з бульб топінамбура, вирощеного в Болгарії. Вміст поліуронідів визначено за допомогою методу McCready. Для аналізу сорбційних характеристик пектинів використано статичний гравіметричний метод.

Результати та обговорення. Полісахариди були екстраговані. Виділені пектини були проаналізовані в натуральному вираженні: отримані експериментально рівноважні ізотерми сорбції, що належать до типу II в класифікації Brunauer. По всій

довжині ізотерми продемонстрували статистично визначений гістерезис. Адекватно описують ізотерми моделі Henderson і Chung-Pfost. Вміст пектину в трьох зразках топінамбура складає 14,8, 9,2 і 11,9% відповідно. Мономолекулярна вологість пектину складала 7,42 - 7,92%, відповідна їй активність води - в межах 0,14 - 0,16.

Висновки. Результати досліджень доцільно використовувати при розробці технологій виробництва функціональних харчових інгредієнтів, в яких використовуються гелеутворювачі та стабілізатори.

Ключові слова: *топінамбур, пектин, сорбція.*

Дослідження в'язкості гідролізованого молока незбираного згущеного з цукром

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Вступ. У статті розроблено технологію низьколактозних (гідролізованих) згущених консервів з цукром, призначених для людей, інтолерантних до лактози, а також для широких верств населення.

Матеріали і методи. Реологічні показники визначали на приладі Реотест - 2 методом віскозиметрії.

Результати і обговорення. В попередніх дослідженнях доведено доцільність застосування ферменту β-галактозидази для гідролізу лактози молока при виробництві гідролізованих молочних консервів з цукром. У зв'язку з тим, що в продукті знижено масову частку сахарози до 22 і 31 %, продукти мали рідку консистенцію, тому виникла необхідність підвищення в'язкісних властивостей. Технологія сприяє підвищенню якості згущених консервів з цукром, економії цукру до 50 % і покращенню дієтичних властивостей.

Один із способів підвищення в'язкості - це внесення стабілізаційних систем. Доведено доцільність застосування стабілізаційної системи Bivicioc 1L. Визначено в'язкість у молоці незбираному гідролізованому згущеному з цукром. Представлено залежності в'язкості гідролізованого молока незбираного згущеного від швидкості деформації.

Висновки. Визначено й обґрунтовано показники в'язкості експериментальних зразків у свіжовироблених продуктах і в процесі зберігання.

Ключові слова: *молоко, в'язкість, гідроліз, стабілізатор.*

Вплив крохмалю як гідроколоїду на формування стабільної емульсійної системи в харчових продуктах

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Вступ. Необхідно визначити вплив фізико-хімічних властивостей нативних і модифікованих крохмалів у процесі їх використання в харчових продуктах.

Методи досліджень. Досліджувались два зразки харчових емульсій з використанням крохмалів різної природи походження – нативний і модифікований. За допомогою лабораторних вагів, об'ємних циліндрів визначався процент відділення води при заморожуванні та розморожуванні емульсій; віскозиметром Брукфільда вимірювався приріст в'язкості залежно від часу, температури та pH розчину харчової емульсії.

Результати. При заморожуванні та розморожуванні емульсії з нативним крохмалем уже в першому циклі відділення води склало 8%, в другому циклі - 38%, в третьому - 50%, тоді як в емульсії з модифікованим крохмалем незначне відділення води починається з четвертого циклу, в п'ятому циклі відділення води становить 1%, в шостому - 3%.

У кислому середовищі при pH=6,5 в'язкість емульсії з модифікованим крохмалем зберігається, а згодом зростає протягом більшого часу порівняно з емульсією з нативним крохмалем, де в'язкість на початку терміну зберігання зростає, а потім знижується.

Висновки. Використання нативних крохмалів у виробничих процесах може призвести до блокування роботи теплообмінників. Це обумовлює використання в виробництві модифікованих крохмалів, які поєдують в собі одночасно два типи модифікації: стабілізаційну і зшивку.

Ключові слова: *крохмаль, нативний, модифікований, в'язкість.*

Електрофорез харчових олієвмісних мікрокапсул із желатин-поліуронатними оболонками

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Вступ. Метою дослідження є визначення знака заряду оболонок мікрокапсул (МК), що містять олійну композицію, оцінка стійкості мікрокапсул різного діаметра в електричному полі.

Матеріали і методи. Мікрокапсули отримували методом складної коацервації. Залишки електролітів видаляли діалізом або електродіалізом. Очищені мікрокапсули піддавали електрофорезу при 100-400 В/м. Полідисперсність визначали новим, розробленим нами методом.

Результати. Дрібні мікрокапсули з білково-поліуронатними оболонками переміщуються у процесі електрофорезу від катода (-) до анода (+). Мікрокапсули з діаметром > 35μм найбільш схильні до руйнування в навколокатодному просторі, залишаючись стабільними за підвищеної кислотності, що виникає на аноді.

Висновки. Оболонки GelAlg і GelHur мають негативний заряд. Електрофорез може бути використаний для цілеспрямованого отримання коацерватних мікрокапсул необхідного діаметра. Висока стабільність мікрокапсул у навколоанодному просторі (кисле середовище) підтверджує обґрунтованість їх введення в кисломолочні продукти.

Ключові слова: *мікрокапсули, желатин, альгінат, гіалуронат, електродіаліз, електрофорез.*

Вплив води, підданої дії контактної нерівноважної плазми, на дріжджі *Saccharomyces Cerevisiae*

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Вступ. Додаткова обробка води контактною нерівноважною низькотемпературною плазмою дає змогу суттєво покращити споживчі характеристики хлібопекарської продукції. Технологічно важливим є визначення впливу плазмохімічно активованої води на чутливість, морфологічні, культуральні та фізіологічні властивості дріжджів Saccharomyces cerevisiae.

Матеріали і методи. Експериментальні дослідження виконано в умовах бактеріологічної лабораторії шляхом проведення посівів культури дріжджів ТМ «Львівські» і «Криворізькі» на рідкі та щільні поживні середовища Сабуро. Кількість життєздатних клітин мікроорганізмів визначалась методом секторних посівів Gould. Морфологія дріжджів досліджена шляхом фазово-контрастної мікроскопії. Біохімічні властивості дріжджів встановлені на середовищах Гісса.

Результати. Визначено вплив води, підданої дії контактної нерівноважної плазми, на чутливість дріжджів Saccharomyces cerevisiae і доведено відсутність пригнічувальної дії підготовленої води стосовно культуральних властивостей мікроорганізмів. Експериментально підтверджено, що при застосуванні плазмохімічно активованої води зберігаються морфологічні ознаки й біохімічні властивості хлібопекарських дріжджів виробництва Львівського і Криворізького дріжджових заводів. Вирощування дріжджів Saccharomyces cerevisiae на поживних середовищах, приготованих з використанням води, підданої дії КНП, викликає збільшення кількості життєздатних мікроорганізмів у 6,5–15 разів порівняно з контролем на магістральній питній воді.

Висновки. Покращено фізіологічні властивості дріжджів Saccharomyces cerevisiae за рахунок застосування додаткової обробки води, підданої дії контактної нерівноважної плазми. Результати досліджень рекомендовані для застосування в дріжджовому та хлібопекарському виробництвах.

Ключові слова: *дріжджі, плазма, вода, морфологія.*

Технологічні основи переробки томатних вичавок у кормові добавки

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Вступ. Пошук нових видів нетрадиційної сировини для забезпечення ефективного розвитку галузі птахівництва та проблема утилізації відходів консервної промисловості обумовили необхідність розробки способу переробки томатних вичавок у кормові добавки.

Матеріали і методи. Відбір проб, підготовку й проведення випробувань проводили загальноприйнятими і спеціальними органолептичними та фізико-

технологічними методами оцінки й аналізу властивостей сировини і готової продукції.

Результати і обговорення. Введення томатних вичавок до складу кормової добавки зменшує витрати на закупку сировини та витрати, пов'язані зі зволоженням суміші перед екструдуванням, а введення крейди кормової дає змогу вирішити проблему кальцієвого дисбалансу в курей-несучок. Встановлено, що проведення процесу екструдування покращило фізичні властивості кормової добавки та довело можливість її використання як компонента комбікорму: масова частка вологи зменшилась на 34,5 %, кут природного укосу збільшився на 11,4 %, сипкість зменшилась на 39,7 %, а об'ємна маса зменшилась на 32,3 %.

Висновки. Отримана кормова добавка надає можливість вирішити проблему розширення асортименту сировини, утилізації відходів, кальцієвого дисбалансу у курей-несучок і зменшити витрати на виробництво комбікормів.

Ключові слова: *відходи, томат , переробка, екструдування, добавка.*

Мікроструктурні характеристики м'ясних посічених виробів із використанням білково-мінеральної добавки

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Вступ. Порушення балансу мінеральних речовин проявляється у м'ясопродуктах, що значно багатші за вмістом фосфору, ніж кальцію. Перелік кальцієвмісних добавок і технологій м'ясопродуктів з їх використанням є обмеженим. Метою дослідження є вивчення й наукове обгрунтування впливу добавки білково-мінеральної (ДБМ) на технологічні і мікроструктурні властивості м'ясних посічених виробів.

Методи досліджень. Дослідження волого- та жироутримуючої здатності (ВУЗ, ЖУЗ) зразків проведені гравіметричним і рефрактометричним методами. Гістозрізи виготовляли на санному мікротомі з подальшим фарбуванням гематоксиліном та еозином і за Маллорі.

Результати. Створено технологію м'ясних посічених виробів оздоровчого призначення з використанням ДБМ, що є носієм біоорганічного кальцію. Раціональним є додавання ДБМ у вигляді порошку у кількості 7,5 % до складу м'ясних систем. Підвищення технологічних показників м'ясних фаршів при внесенні добавки, зокрема ВУЗ та ЖУЗ, складає близько 5 та 10 % відповідно. Гістологічні дослідження показали, що ДБМ сприяє збереженню м'ясного соку та саркоплазматичних білків у м'ясних системах під час теплової обробки.

Висновки. ДБМ позитивно впливає на вологоутримуючі властивості м'ясних фаршів і вихід готового продукту.

Ключові слова: *кальцій, добавка, вологозв'язування, мікроструктура.*

Вміст йоду в соусах емульсійного типу

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Вступ. Брак природних ресурсів викликає необхідність пошуку додаткових джерел білків, жирів, вуглеводів та їх комплексів з дефіцитними мінеральними сполуками, тому актуальним питанням є збагачення раціонів харчування дефіцитними сполуками йоду шляхом розробки й дослідження нових продуктів харчування.

Матеріали і методи. Дослідження вмісту йоду в соусах емульсійного типу на всіх етапах проводили за допомогою рентгенофлуоресцентного аналізатора «Elvax». Метод рентгенофлуоресцентного аналізу полягає у виникненні характерного рентгенівського випромінювання атомів хімічного елемента при впливі на них первинного рентгенівського опромінення.

Результати. Визначено органічні й неорганічні форми йоду у складі продуктів харчування, загальні втрати йоду в соусах після приготування і зберігання при температурі +5 ... +10 ° С протягом 30 діб. Використовуючи добавку йодобілкову (від 0,5 ... 2,5 % , з масою йоду від 0,01 %), можна забезпечити від 15 до 50 % добової потреби йоду для людини. Отриманий продукт не втрачає своїх органолептичних, фізико-хімічних, споживчих характеристик і відповідає вимогам нормативних документів.

Виявлено, що додавання до складу майонезу йодованої харчової добавки не чинить негативного впливу на фізико-хімічні характеристики соусів, а за рахунок стабілізаційного ефекту добавки йодобілкової стійкість емульсії підвищується до 98 - 100 % без додаткових харчових добавок (емульгаторів).

Добавка пройшла ряд випробувань, які доводять її відповідність вимогам, визначеним у нормативно-технічній документації.

Висновки. Запропонований методичний підхід дає змогу оцінити рівень вмісту органічного й неорганічного йоду, більш детально описати і правильно трактувати особливості хімічного складу продуктів харчування, збагачених йодом, а також прогнозувати їхні оздоровчі властивості.

Ключові слова: *йод, білок, соус, емульсія.*

Визначення умов зберігання нових бісквітів за ізотермами сорбції

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Вступ. Для підвищення якості бісквітів використано природний носій йоду та підсолоджувач із стевії. Домінуючим процесом, що визначає термін зберігання бісквітів, є десорбція вологи. Визначено умови зберігання розроблених бісквітів дослідженням ізотерм їх сорбції й кінетики досягнення ними рівноважного вологовмісту.

Матеріали і методи. Об’єкти дослідження: нові розроблені бісквіти «Здоров’я» (збагачений йодом та із заміною 50% цукру стевіозидом), «Легкий» (із заміною 75% рецептурного цукру на стевіозид і додатково збагачений пшеничними висівками), «Збагачений» (містить еламін, який є природним джерелом йоду). Контроль – бісквіт,

отриманий за традиційною рецептурою. Для вивчення сорбції та рівноважного вологовмісту використовували тензометричний метод. За ізотермами сорбції визначені диференціальної функції розподілу пор за радіусами, які були піддані апроксимації.

Результати. Зразки розроблених бісквітів у діапазоні відносної вологості повітря (ВВП) від 10 до 75…80% перебувають в області моно- та полімолекулярної сорбції. Контрольний зразок має менш чітко виражену ділянку мономолекулярної сорбції (від 10 до 20%) та коротший діапазон вологості, який відповідає полімолекулярній сорбції (від 20 до 65…70%). При збільшенні ВВП для всіх зразків (75…80%) відбувається поглинання вологи мікрокапілярами та набухання. Дослідження диференціальної функції розподілу пор за радіусами показали, що відношення середнього радіуса пор до найбільш імовірного для бісквіта «Здоров'я» дорівнює 5,73; для бісквіта «Легкий» – 2,98; для бісквіта «Збагачений» – 4,91; для контролю – 3,88.

Висновки. Розроблені бісквіти доцільно зберігати в картонній тарі з полімерним покриттям, якщо ВВП не більше 75%, а також у паронепроникній тарі, якщо ВВП вища за вказану.

Ключові слова: *бісквіт, сорбція, пори, еламін, стевіозид.*

Біотехнологія, мікробіологія

Інтенсифікація синтезу мікробного екзополісахариду етаполану за умов росту *Acinetobacter* sp. IMB B-7005 на соняшниковій олії

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Вступ. Мікробні екзополісахариди (ЕПС) завдяки здатності їхніх розчинів до змінення реологічних характеристик водних систем широко застосовуються у різних галузях промисловості. Останніми роками активізувалися дослідження, пов'язані з використанням промислових відходів для одержання практично цінних мікробних метаболітів, в тому числі й олієвмісних.

Методи досліджень. Культивування *Acinetobacter* sp. IMB B-7005 здійснювали на рідкому середовищі, що містило як джерело вуглецю соняшникову олію (1−5 %, об'ємна частка), азоту – нітрат амонію (0,4−0,8 г/л), пантотенату − мультивітамінний комплекс «Комплевіт» (0,00085 і 0,00095 %). Концентрацію ЕПС визначали ваговим методом після осадження ізопропанолом, ЕПС-синтезувальну здатність – як відношення концентрації ЕПС до концентрації біомаси та виражали у г ЕПС/г біомаси.

Результати і обговорення. Встановлено, що збільшення концентрації соняшникової олії у базовому середовищі культивування *Acinetobacter* sp. IMB B-7005 до 4−5 % супроводжувалося зниженням показників синтезу етаполану порівняно з такими на середовищі з нижчою (2−3 %) концентрацією субстрату. Проте підвищення вмісту нітрату амонію до 0,6 г/л і/або концентрації пантотенату до 0,00095 % дало змогу збільшити кількість етаполану, синтезованого на середовищі з 5 % соняшникової олії, до 6,6−6,7 г/л, що в 1,3−1,4 раза вище, ніж на базовому

середовищі з такою ж концентрацією субстрату, але нижчою NH_4NO_3 (0,4 г/л) і пантотенату (0,00085 %).

Висновок. Одержані результати підтверджують можливість синтезу мікробного полісахариду етаполану за умов росту *Acinetobacter* sp. IMB B-7005 на середовищі з підвищеним вмістом соняшникової олії. Ці дані є основою для розробки технології етаполану з використанням як субстрату відпрацьованої (пересмаженої) олії.

Ключові слова: *екзополісахарид, біосинтез, соняшник, олія, культивування.*

Процеси і обладнання харчових виробництв

Визначення енерговитрат на розгін веденої маси із синусоїдальним прискоренням і синтез механізму приводу

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Вступ. Теоретичні розробки стосувалися визначення енергетичних витрат на перехідний процес розгону веденої маси пристроїв харчових виробництв з урахуванням рушійних факторів і факторів опору.

Матеріали і методи. Математичний опис таких процесів здійснювався з використанням законів Ньютона, принципу Д'Аламбера, загальних теорем динаміки і енергетичних співвідношень, а також принципу незалежності дії сил.

Результати. Доведено, що перевага рушійних сил над силами опору призводить до скорочення часу перебігу перехідних процесів, однак енергетичні витрати при цьому залишаються стабілізованими на рівні кінетичної енергії маси системи.

Висновки. Отримані математичні моделі показали, що потужності, які розвиваються рушійними силами зі скороченням часу перехідних процесів, зростають, як і динамічні навантаження елементів системи. Все це необхідно враховувати при інженерних розрахунках і конструюванні приводів пристроїв харчових виробництв.

Ключові слова: *сила, інерція, кінематика, рушійний фактор, енергія, енерговитрати.*

Теоретичні аспекти математичного моделювання течії неньютонівських рідин у харчових технологіях

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Вступ. Розглянуто питання математичного моделювання в'язкопластичної поздовжньої та поперечної течії неньютонівських матеріалів у пласкому й прямокутному каналах харчового обладнання.

Матеріали і методи. Вперше використано метод суперпозиції шляхом вираження компонентів тензора напруження через єдиний компонент, який дозволяє побудувати поля течії більшої розмірності з полів течії меншої розмірності з різними граничними умовами та зі зміною параметрів реологічного стану від тиску.

Результати. Наведено теоретичні методи моделювання течії неньютонівських рідин у каналах різної геометрії з рухомими границями та перепадом тиску на кінцях каналу з урахуванням функціональних зв'язків між основними параметрами процесу на підставі використання методу суперпозиції. Показано, що поздовжні й поперечні течії зводяться до сукупності однотипних одномірних поздовжніх течій, які дають змогу описувати тривимірні ізотермічні течії в прямокутному та двомірні в пласкому каналах з різним відношенням сторін каналу. Течії в каналах характеризуються величинами швидкості і тиску в кожній точці ділянки течії. Отримані теоретичні тривимірні й двомірні моделі в'язких течій у каналах базової геометрії дозволяють досліджувати основні закономірності процесу та встановити оптимальні макрокінетичні й макродинамічні характеристики течії неньтонівських матеріалів.

Висновки. Розроблені теоретично обґрунтовані тривимірні моделі течії неньютонівських рідин у каналах дають змогу проводити якісно нове проектування технологічного обладнання харчової промисловості у напрямку зниження енерговитрат і матеріалоємності.

Ключові слова: *течія, неньютонівська рідина, канал, реологія, моделювання.*

Очищення модельних розчинів стічних вод молочних підприємств нанофільтрацією і зворотним осмосом

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Вступ. На підприємствах молочної промисловості утворюється велика кількість стічних вод з високою концентрацією органічних забруднень. Перспективним для очищення стічних вод є застосування мембранних технологій, що дають змогу одночасно вилучити цінні компоненти молока зі стоків та отримати воду, придатну для повторного використання.

Матеріали і методи. Дослідження проводилися на установці непроточного типу з використанням нанофільтраційних ОПМН-П (ЗАТ «Владіпор», Росія) і зворотно осмотичних мембран НаноРо (ЗАТ «РМ Нанотех», Росія). Використовували модельні розчини стічних вод молокопереробних підприємств – розбавлене знежирене й цільне молоко.

Результати. В процесі концентрування модельних розчинів стічних вод питома продуктивність нанофільтраційних і зворотно осмотичних мембран була практично однаковою. Причиною цього могло бути забруднення поверхні мембран компонентами стічних вод. Отримані індекси забруднення показали ступінь забруднення мембран, який для зворотно осмотичних мембран був більший. За допомогою зворотного осмосу отримано пермеат кращої якості, що може повторно використовуватися для технічних цілей підприємства. Пермеат після нанофільтрації з вмістом лактози до 0,4 г/л і мінеральних речовин 0,75 г/л може скидатися в каналізацію або після доочищення (наприклад, зворотним осмосом тощо) використовуватися як технічна вода. Нанофільтраційний і зворотно осмотичний концентрат, який за хімічним складом відповідає молоку, може використовуватися для нехарчових цілей або відгодівлі тварин.

Висновки. Зворотно осмотичні та нанофільтраційні мембрани можуть використовуватися для концентрування стічних вод молокопереробних підприємств при низькому тиску. Порівняно з раніше досліджуваними мембранами зворотно осмотичні та нанофільтраційні мембрани мають кращу продуктивність і розділювальні властивості .

Ключові слова: *молоко, стічні води, розчин, нанофільтрація, осмос.*

Безпека життєдіяльності

Планування ліквідації наслідків надзвичайних ситуацій

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Вступ. Обсяг корисної інформації в процесі планування ліквідації наслідків надзвичайних ситуацій доцільно оцінювати із застосуванням інформаційних розрахункових задач і математичних моделей.

Матеріали і методи. Для розрахунку кількісного значення ймовірності визначення оптимального варіанта рішення до надходження інформації про становище використовувався метод опитування експертів.

Результати. Визначено, що якість рішення при ліквідації наслідків надзвичайних ситуацій залежить передусім від кількості факторів, що враховуються під час його визначення в конкретних умовах, рівня інформаційної готовності органів управління до прийняття рішення щодо ліквідації наслідків надзвичайних ситуацій у найкоротші терміни з необхідністю розгляду декількох варіантів для досягнення обґрунтованості і конкретності. Розраховане відношення обсягу корисної інформації про становище, що зібрана й оброблена під час планування операції, до необхідного для визначення рішення, що надало можливість побудувати графік залежності ймовірності визначення рішення, яке відповідає обстановці, від значення ймовірності визначення оптимального варіанта рішення до надходження інформації про становище та відношення обсягу корисної інформації про становище, що зібрана й оброблена під час планування операції, до необхідного для визначення оптимального варіанта рішення.

Висновки. Результати дослідження можуть бути використані при вдосконаленні проектів управлінських рішень щодо забезпечення безпечних умов праці працівників харчової промисловості.

Ключові слова: *надзвичайна ситуація, планування, оцінка, інформація.*

Аннотации

Пищевые технологии

Интенсификация процесса сушки с помощью функциональных растительных композиций

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Введение. При сушке растительного сырья в результате тепловой обработки, влияния света, кислорода, pH среды происходят потери биологически активных веществ, поэтому целесообразно усовершенствовать технологию переработки столовой свеклы с целью максимального сохранения бетанина и снижения энергозатрат.

Материалы и методы. Сушка свеклы, ревеня, лимона, помидора происходила при температуре 50...100 ºС, скорости воздуха 1,5…3,5 м/с, влагосодержании теплоносителя 7…15 г/кг, толщине слоя 2…20 мм. Содержание бетанина определяли по спектрам поглощения, величине оптической плотности при длине волны 540 нм. Расход теплоты на испарение определялся на дифференциальном микрокалориметре.

Результаты и обсуждения. Исследовано влияние предварительной подготовки на сырье, подлежащее сушке. Потери бетанина во время сушки, без предварительной подготовки сырья, составляют 66 %. Разработанная технология предварительной обработки, которая предусматривает варку целых корнеплодов з подобранной оптимальной кислотной средой, позволяет уменьшить потери бетанина до 6 %, но это достаточно энергоемкий процесс. Разработан энергоэффективный способ подготовки антиоксидантного сырья перед сушкой с полной заменой тепловой обработки купажированием. Потери бетанина при этом составляют до 5 %. Оптимальная температура сушки предварительно обработанного бетаниносодержащего сырья 60 °С, при этом сохраняется до 95 % бетанина. Удельные расходы теплоты на испарение воды из разработанных антиоксидантных растительных композиций на основе свеклы с добавлением ревеня и лимона на 4…5 % меньше, чем для исходных компонентов.

Выводы. Найдена зависимость потерь бетанина в растительном сырье от температуры материала и композиционных составляющих во время ее подготовки к сушке. Установлено, что теплота испарения воды в некоторых разработанных антиоксидантных растительных композициях меньше, чем исходных компонентов сырья. Результаты целесообразно применять в разработке промышленных теплотехнологий производства функциональных пищевых порошков.

Ключевые слова: *сушка, свекла, бетанин, теплота испарения.*

Научно-практические основы технологий переработки картофеля на продукты питания

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Введение. Процент переработки картофеля на пищевые продукты на территории бывшего Советского Союза снизился до 1%, тогда как в некоторых странах Европы и США доля переработки картофеля составляет 60-80%. Современные научные разработки показали экономическую целесообразность переработки картофеля на продукты питания.

Материалы и методы. Исследование эффективности технологических процессов переработки картофеля проведены в лабораторных и промышленных условиях открытого акционерного общества «Машпищепрод» (Марьина Горка, Минская область, Беларусь) Отбор проб, подготовка и проведение испытаний выполнены с помощью стандартных и специальных методов анализа.

Результаты и обсуждение. Определены сорта картофеля, пригодные для производства сухих пюре и чипсов. Их акклиматизация обеспечивает минимальное содержание сахаров, которые способствуют повышению качества готовой продукции. Исследования показали, что процесс перемешивания картофеля при температурах, близких к температуре варки, является оптимальным. Разрушение клеток почти не происходит. Пневматические сушилки для сушки вареного картофеля обеспечивают высокое качество продукции благодаря низкой температуре нагрева и короткому контакту порошкообразного продукта с сушильным агентом. Количество поврежденных клеток в готовом продукте не превышает 1,3-2,6%. Определены и научно обоснованы оптимальные режимы и параметры производства чипсов, процессов их резки, бланширования, обезвоживания, сушки и обжаривания, которые обеспечивают высокое качество готовой продукции и снижение масла в продукте до 27,7%.

Вывод. Доказано, что при производстве чипсов и сухих пюре экономически целесообразно использовать сорта картофеля Дезире, Темп, Синтез. Количество разрушенных клеток в готовом продукте определяют в основном процессы смешивание и сушки. Обоснованы оптимальные параметры технологии производства чипсов.

Ключевые слова: *картофель, чипсы, пюре, сушка.*

Сорбционные характеристики пектина, выделенного из клубней топинамбура (*Helianthus tuberosus L.*)

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Введение. Цель исследования - выделение пектина из клубней топинамбура *(Helianthus tuberosus L.)* и анализ его сорбционных характеристик.

Материалы и методы. Исследование проводилось по содержанию пектина из клубней топинамбура, выращенного в Болгарии. Содержание полиуронидов

определено с помощью метода McCready. Для анализа сорбционных характеристик пектинов использовано статический гравиметрический метод.

Результаты и обсуждение. Полисахариды были экстрагированы. Выделенные пектины проанализированы в натуральном выражении: получены экспериментально равновесные изотермы сорбции, принадлежащие к типу II в классификации Brunauer. По всей длине изотермы демонстрируют статистически определенный гистерезис. Адекватно описывают изотермы модели Henderson и Chung-Pfost. Содержание пектина в трех образцах топинамбура составляет 14,8, 9,2 и 11,9% соответственно. Мономолекулярная влажность пектина составила 7,42 - 7,92%, соответствующая ей активность воды - в пределах 0,14 - 0,16.

Выводы. Результаты исследований целесообразно использовать при разработке технологий производства функциональных пищевых ингредиентов, в которых используются гелеобразователи и стабилизаторы.

Ключевые слова: *топинамбур, пектин, сорбция.*

Исследование вязкости молока цельного гидролизованного сгущенного с сахаром

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Введение. В статье разработана технология низколактозных (гидролизованных) сгущенных консервов с сахаром, предназначенных для людей интолерантных к лактозе и для широкого круга населения.

Материалы и методы. Реологические показатели определяли на приборе Реотест - 2 методом вискозиметрии.

Результаты и обсуждение.

Доказана целесообразность применения фермента β-галактозидазы для гидролиза лактозы молока при производстве гидролизованных молочных консервов с сахаром. Технология способствует повышению качества сгущенных консервов с сахаром, экономии сахара до 50%, повышению диетических свойств. В связи с тем, что в продукте была снижена массовая доля сахарозы до 22 и 31 %, продукты имели жидкую консистенцию, поэтому возникла необходимость повышения вязкостных свойств.

Один из способов повышения вязкости продукта – это внесение стабилизационных систем. Доказана целесообразность применения стабилизационной системы Bivicioc 1L. Определена вязкость в молоке цельном гидролизованном сгущенном с сахаром. Представлены зависимости вязкости молока цельного гидролизованного сгущенного от скорости деформации.

Выводы. Определены и обоснованы показатели вязкости экспериментальных образцов в свежевыработанных продуктах и в процессе хранения.

Ключевые слова: *молоко, вязкость, гидролиз, стабилизатор.*

Влияние крахмала как гидроколлоида на формирование стабильной эмульсионной системы в пищевых продуктах

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Введение. Необходимо определить влияние физико-химических свойств нативных и модифицированных крахмалов в процессе их использования в пищевых продуктах.

Методы исследований. Исследовались два образца пищевых эмульсий с использованием крахмалов различной природы происхождения – нативный и модифицированный крахмал. С помощью лабораторных весов, объемных цилиндров определялся процент отделения воды при замораживании и размораживании эмульсий; вискозиметром Брукфильда измерялся прирост вязкости в зависимости от времени, температуры и pH раствора пищевой эмульсии.

Результаты. При замораживании и размораживании эмульсии с нативным крахмалом уже в первом цикле процент отделения воды составляет 8 %, во втором цикле - 38%, в третьем - 50%, тогда как в эмульсии с модифицированным крахмалом незначительное отделение воды начинается с четвертого цикла, в пятом цикле процент отделения воды составляет 1 %, в шестом цикле - 3 %.

В кислой среде при pH = 6,5 вязкость эмульсии с модифицированным крахмалом сохраняется, а затем возрастает в течение большего времени по сравнению с эмульсией с нативным крахмалом, где вязкость в начале срока хранения возрастает, а затем снижается.

Выводы. Использование нативных крахмалов в производственных процессах может привести к блокированию работы теплообменников. Это обусловливает использование в производстве модифицированных крахмалов, которые сочетают в себе одновременно два типа модификации: стабилизационную и сшивку.

Ключевые слова: *крахмал, нативный, модифицированный, вязкость.*

Электрофорез пищевых маслосодержащих микрокапсул с желатин-полиуронатными оболочками

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Введение. Целью работы является определение знака заряда оболочек микрокапсул (МК), содержащих масляную композицию, оценка устойчивости микрокапсул различного диаметра в электрическом поле.

Материалы и методы. Микрокапсулы получали методом сложной коацервации. Остатки электролитов удаляли диализом или электродиализом. Очищенные микрокапсулы подвергали электрофорезу при 100-400В/м. Полидисперсность определяли новым, разработанным нами методом.

Результаты. Мелкие микрокапсулы с белково-полиуронатными оболочками перемещаются при электрофорезе от катода (-) к аноду (+). Микрокапсулы с

диаметром > 35μм наиболее подвержены разрушению в прикатодном пространстве, оставаясь стабильными при повышенной кислотности, возникающей на аноде.

Выводы. Оболочки GelAlg и GelHur обладают отрицательным зарядом. Электрофорез может быть использован для целенаправленного получения коацерватных микрокапсул необходимого диаметра. Высокая стабильность микрокапсул в прианодном пространстве (кислая среда) подтверждает обоснованность их введения в кисломолочные продукты.

Ключевые слова: *микрокапсулы, желатин, альгинат, гиалуронат, электродиализ, электрофорез.*

Влияние воды, подвергнутой действию контактной неравновесной плазмы, на дрожжи *Saccharomyces Cerevisiae*

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Введение. Дополнительная обработка воды контактной неравновесной низкотемпературной плазмой позволяет существенно улучшить потребительские свойства хлебопекарной продукции. Технологически важным является определение влияния плазмохимически активированной воды на морфологические, культуральные и физиологические свойства дрожжей Saccharomyces cerevisiae.

Материалы и методы. Экспериментальные исследования проведены в условиях бактериологической лаборатории путем осуществления посевов культуры дрожжей ТМ «Львівські» и «Криворізькі» на жидкие и плотные питательные среды Сабуро. Количество жизнеспособных клеток микроорганизмов определялось методом секторных посевов Gould. Морфология дрожжей исследована путем фазово-контрастной микроскопии. Биохимические свойства дрожжей определены на средах Гисса.

Результаты и обсуждение. Определено влияние воды, подвергнутой действию контактной неравновесной плазмы, на чувствительность дрожжей Saccharomyces cerevisiae и показано отсутствие угнетающего действия подготовленной воды на культуральные свойства микроорганизмов. Экспериментально доказано, что в случае использования плазмохимически активированной воды сохраняются морфологические признаки и биохимические свойства хлебопекарных дрожжей производства Львовского и Криворожского дрожжевых заводов. Выращивание дрожжей Saccharomyces cerevisiae на питательных средах, приготовленных с использованием воды, подвергнутой действию контактной неравновесной плазмы, увеличивает количество жизнеспособных микроорганизмов в 6,5–15 раз по сравнению с использованием магистральной воды без дополнительной обработки.

Выводы. Улучшено физиологические свойства дрожжей Saccharomyces cerevisiae за счет использования воды, подвергнутой действию контактной неравновесной плазмы. Результаты исследований рекомендованы к использованию в дрожжевом и хлебопекарном производстве.

Ключевые слова: *дрожжи, плазма, вода, морфология.*

Технологические основы переработки томатных выжимок в кормовые добавки

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Введение. Поиск новых видов нетрадиционного сырья для обеспечения эффективного развития отрасли птицеводства и проблема утилизации отходов консервной промышленности обусловили необходимость разработки способа переработки томатных выжимок в кормовые добавки.

Материалы и методы. Отбор проб, подготовку и проведение испытаний проводили общепринятыми и специальными органолептическими и физико-технологическими методами оценки и анализа свойств сырья и готовой продукции.

Результаты и обсуждение. Введение томатных выжимок в состав кормовой добавки уменьшает расходы на закупку сырья и затраты, связанные с увлажнением смеси перед экструдированием, а введение мела кормового позволит решить проблему кальциевого дисбаланса у кур-несушек. Установлено, что процесс экструдирования улучшает физические свойства кормовой добавки, также доказана возможность ее использования в качестве компонента комбикорма: массовая доля влаги уменьшилась на 34,5 % , угол естественного откоса увеличился на 11,4 % , сыпучесть уменьшилась на 39,7 %, объемная масса уменьшилась на 32,3 %.

Выводы. Полученная кормовая добавка позволит решить проблему расширения ассортимента сырья, утилизации отходов, кальциевого дисбаланса у кур-несушек и снизить затраты на производство комбикормов.

Ключевые слова: *отходы, томаты, переработка, экструдирование, добавка.*

Микроструктурные характеристики мясных рубленых изделий с использованием белково-минеральной добавки

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Введение. Нарушение баланса минеральных веществ широко проявляется в мясопродуктах, которые значительно богаче фосфором, чем кальцием. Перечень кальцийсодержащих добавок и технологий мясопродуктов с их использованием ограничен. Целью работы является изучение и научное обоснование влияния добавки белково-минеральной (ДБМ) на технологические и микроструктурные свойства мясных рубленых изделий.

Методы исследований. Исследование влаго- и жироудерживающей способности (ВУЗ, ЖУЗ) образцов проведены гравиметрическим и рефрактометрическим методами. Гистосрезы изготавливали на санном микротоме с последующей покраской гематоксилином и эозином, а также по Маллори.

Результаты. Создана технология мясных рубленых изделий оздоровительного назначения с использованием ДБМ, что является носителем биоорганического кальция. Рациональным является добавление ДБМ в виде порошка в количестве 7,5% в состав мясных систем. Повышение технологических показателей мясных фаршей при внесении добавки, в частности ВУЗ и ЖУЗ, составляет около 5 и 10% соответственно. Гистологические исследования показали, что ДБМ способствует

сохранению мясного сока и саркоплазматических белков в мясных системах при тепловой обработке.

Выводы. ДБМ положительно влияет на влагоудерживающие свойства мясных фаршей и выход готового продукта.

Ключевые слова: *кальций, добавка, влагосвязывание, микроструктура.*

Содержания йода в соусах эмульсионного типа

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Введение. Нехватка природных ресурсов вызывает необходимость поиска дополнительных источников белков, жиров, углеводов и их комплексов с дефицитными минеральными соединениями, поэтому актуальным вопросом является обогащение рационов питания дефицитными соединениями йода путем разработки и исследования новых продуктов питания.

Материалы и методы. Исследование содержания йода в соусах эмульсионного типа на всех этапах проводили с помощью рентгенофлуоресцентного анализатора «Elvax». Метод рентгенофлуоресцентного анализа заключается в возникновении характеристического рентгеновского излучения атомов химического элемента при нарушении их первичным рентгеновским облучением.

Результаты. Проведено исследование для определения органических и неорганических форм йода в составе продуктов питания, а также установлены общие потери йода в соусах после приготовления и хранения при температуре +5...+10° С в течение 30 суток. Используя добавку йодобелковую (от 0,5...2,5%, по массе йода от 0,01%) можно обеспечить от 15 до 50% суточной потребности йода для человека.

Полученный продукт не теряет своих органолептических, физико - химических, потребительских характеристик и соответствует требованиям нормативных документов.

В результате проведенных нами исследований было обнаружено, что добавление в состав майонеза йодированной пищевой добавки не оказывает отрицательного влияния на физико - химические характеристики соусов, а за счет стабилизирующего эффекта добавки йодобелковой устойчивость эмульсии повышается до 98 - 100 % без дополнительных пищевых добавок (эмульгаторов).

Данная добавка прошла ряд испытаний, которые подтверждают ее соответствие требованиям, изложенным в нормативно - технической документации.

Выводы. Использованный методический подход позволяет оценить уровень содержания органического и неорганического йода, подробно описывать и правильно трактовать особенности химического состава продуктов питания, обогащенных йодом, и прогнозировать их оздоровительные свойства.

Ключевые слова: *йод, белок, соус, эмульсия.*

Определение условий хранения новых бисквитов по изотермам сорбции

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Введение. Для формирования качества бисквитов использовано природный носитель йода и подсластитель из стевии. Доминирующим процессом, определяющим срок хранения бисквитов, является десорбция влаги. Определены условия хранения разработанных бисквитов путем исследований изотерм их сорбции и кинетики достижения ими равновесного влагосодержания.

Материалы и методы. Объекты исследования: новые разработанные бисквиты «Здоровье» (обогащенный йодом и с заменой 50 % сахара стевиозидом), «Легкий» (с заменой 75 % рецептурного сахара на стевиозид и дополнительно обогащенный пшеничными отрубями), «Обогащенный» (содержит эламин, который является естественным источником йода). Контроль − бисквит полученный по традиционной рецептуре. Для изучения сорбции и равновесного влагосодержания использовали тензометрический метод. По изотермам сорбции определены дифференциальные функции распределения пор по радиусами, которые были подвергнуты аппроксимации.

Результаты. Образцы разработанных бисквитов в диапазоне относительной влажности воздуха (ОВВ) от 10 до 75...80 % находятся в области моно- и полимолекулярной сорбции. Контрольный образец имеет менее выраженный участок мономолекулярной сорбции (от 10 до 20%) и короткий диапазон влажности, соответствующий полимолекулярной сорбции (от 20 до 65...70%). При увеличении ОВВ для всех образцов относительно 75...80 % происходит поглощение влаги микрокапиллярами и набухание образцов. Исследование дифференциальной функции распределения пор по радиусам показало, что отношение среднего радиуса пор к наиболее вероятному для бисквита «Здоровье» равно 5,73, для бисквита «Легкий» − 2,98, для бисквита «Обогащенный» − 4,91, для контроля − 3,88.

Выводы. Разработанные бисквиты целесообразно хранить в картонной таре с полимерным покрытием, если ОВВ не более 75 %, и в паронепроницаемой, если ОВВ выше указанной.

Ключевые слова: *бисквит, сорбция, поры, эламин, стевиозид.*

Биотехнология, микробиология

Интенсификация синтеза микробного экзополисахарида этаполана при культивировании *Acinetobacter* sp. IMB B-7005 на подсолнечном масле

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Введение. Микробные экзополисахариды (ЭПС) благодаря способности к изменению реологических характеристик водных систем широко применяются в различных отраслях промышленности. В последние годы активизировались исследования по использованию промышленных отходов для получения практически ценных микробных метаболитов, в том числе и маслосодержащие.

Методы исследования. Культивирование *Acinetobacter* sp. IMB B-7005 осуществляли на жидкой среде, содержащей в качестве источника углерода подсолнечное масло (1−5 % по объему), азота – нитрат аммония (0,4−0,8 г/л), пантотената − мультивитаминный комплекс «Комплевит» (0,00085 и 0,00095 %). Концентрацию ЭПС определяли весовым методом после осаждения изопропанолом, ЭПС-синтезирующую способность – как отношение концентрации ЭПС к концентрации биомассы и выражали в г ЭПС/г биомассы.

Результаты и обсуждение. Установлено, что увеличение концентрации подсолнечного масла в базовой среде культивирования *Acinetobacter* sp. IMB B-7005 до 4−5 % сопровождалось снижением показателей синтеза этаполана по сравнению с таковыми на среде с более низкой (2−3 %) концентрацией субстрата. Однако повышение содержания нитрата аммония до 0,6 г/л и/или концентрации пантотената до 0,00095 % позволили увеличить количество этаполана, синтезированного на среде с 5 % подсолнечного масла, до 6,6−6,7 г/л, что в 1,3−1,4 раза выше, чем на базовой среде с такой же концентрацией субстрата, но более низкой NH_4NO_3 (0,4 г/л) и пантотената (0,00085 %).

Вывод. Полученные результаты свидетельствуют о возможности синтеза микробного полисахарида этаполана при культивировании *Acinetobacter* sp. IMB B-7005 на среде с повышенным содержанием подсолнечного масла. Эти данные являются основой для разработки технологии этаполана с использованием в качестве субстрата отработанного (пережаренного) масла.

Ключевые слова: *экзополисахарид, биосинтез, подсолнечнух, масло, культивирование.*

Процессы и оборудование пищевых производств

Определение энергетических затрат на разгон ведомой массы с синусоидальным ускорением и синтез механизма привода

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Введение. Теоретические разработки касались определения энергетических затрат на переходный процесс разгона ведомой массы устройств пищевых производств с учетом движущих факторов и факторов сопротивления.

Материалы и методы. Математическое описание таких процессов осуществлялось с использованием законов Ньютона, принципа Д'Аламбера, общих теорем динамики и энергетических соотношений, а также принципа независимости действия сил.

Результаты. Доказано, что рост движущих сил над силами сопротивления приводит к сокращению времени протекания переходных процессов, однако энергетические затраты при этом остаются стабилизированными на уровне кинетической энергии массы системы.

Выводы. Полученные математические модели показали, что мощности, развивающиеся движущими силами с сокращением времени переходных процессов, растут, как и динамические нагрузки элементов системы. Все это необходимо

учитывать при инженерных расчетах и конструировании приводов устройств пищевых производств.

Ключевые слова: *сила, инерция, кинематика, движущий фактор, энергия, энергозатраты.*

Теоретические аспекты математического моделирования течения неньютоновских жидкостей в пищевых технологиях

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Введение. Рассмотрены вопросы математического моделирования вязкопластического продольного и поперечного течения неньютоновских материалов в плоском и прямоугольном каналах пищевого оборудования.

Материалы и методы. Впервые использован метод суперпозиции путем выражения компонентов тензора напряжения через единый компонент, который позволяет построить поля течения большей размерности из полей течения меньшей размерности с различными граничными условиями и с изменением параметров реологического состояния от давления.

Результаты. Приведены теоретические методы моделирования течений неньютоновских жидкостей в каналах различной геометрии с подвижными границами и перепадом давления на концах канала с учетом функциональных связей между основными параметрами процесса на основании использования метода суперпозиции. Показано, что продольные и поперечные течения сводятся к совокупности однотипных одномерных продольных течений, которые позволяют описывать трехмерные изотермические течения в прямоугольном и двухмерные в плоском каналах с различным отношением сторон канала. Течения в каналах характеризуются значениями скорости и давления в каждой точке канала. Полученные теоретические трехмерные и двухмерные модели вязких течений в каналах базовой геометрии позволяют исследовать основные закономерности процесса и установить оптимальные макрокинетические и макродинамические характеристики течения неньютоновских материалов.

Выводы. Теоретически обоснованные трехмерные модели течения неньютоновських жидкостей в каналах дают возможность проводить качественно новое проектирование технологического оборудования пищевой промышленности в направлении снижения энергозатрат и материалоемкости.

Ключевые слова: *течение, неньютоновская жидкость, канал, реология, моделирование.*

Очистка модельных растворов сточных вод молочных предприятий нанофильтрацией и обратным осмосом

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Введение. На предприятиях молочной промышленности образуется большое количество сточных вод с высокой концентрацией органических загрязнений. Перспективным для очистки сточных вод является применение мембранных технологий, позволяющих одновременно изъять ценные компоненты молока из стоков и получить воду, пригодную для повторного использования.

Материалы и методы. Исследования проводились на установке непроточного типа с использованием нанофильтрационных ОПМН-П (ЗАО «Владипор», Россия) и обратно осмотических мембран НаноРо (ЗАО «РМ Нанотех», Россия). Использовали модельные растворы сточных вод молокоперерабатывающих предприятий – разбавленное обезжиренное и цельное молоко.

Результаты и обсуждение. В процессе концентрирования модельных растворов сточных вод удельная производительность нанофильтрационных и обратно осмотических мембран была практически одинаковой. Причиной этого могло быть загрязнение поверхности мембран компонентами сточных вод. Полученные индексы загрязнения показали степень загрязнения мембран, которые для возвратно осмотических мембран были больше. С помощью обратного осмоса был получен пермеат лучшего качества, который может повторно использоваться для технических целей предприятия. Пермеат после нанофильтрации с содержанием лактозы до 0,4 г/л и минеральных веществ 0,75 г/л может сбрасываться в канализацию или после доочистки (например, обратным осмосом или др.) использоваться как техническая вода. Нанофильтрационный и обратно осмотический концентрат, который по химическому составу соответствует молоку, может использоваться для непищевых целей или в качестве корма для животных.

Выводы. Исследуемые могут использоваться для концентрирования сточных вод молокоперерабатывающих предприятий при низком давлении. По сравнению с ранее исследуемыми мембранами обратно осмотические и нанофильтрационные мембраны показали лучшую производительность и разделительные свойства.

Ключевые слова: *молоко, сточные воды, раствор, нанофильтрация, осмос.*

Безопасность жизнедеятельности

Планирование ликвидации последствий чрезвычайных ситуаций

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Введение. Объем полезной информации в процессе планирования ликвидации последствий чрезвычайных ситуаций целесообразно оценивать с применением информационных расчетных задач и математических моделей.

Материалы и методы. Для расчета количественного значения вероятности определения оптимального варианта решения до поступления информации о состоянии использовался метод опроса экспертов.

Результаты. Определено, что качество решения на ликвидации последствий чрезвычайных ситуаций прежде всего зависит от количества факторов, которые учитываются при его определениии в конкретных условиях, уровня информационной готовности органов управления к принятию решения на ликвидации последствий чрезвычайных ситуаций в возможно короткие сроки с необходимостью рассмотрения нескольких вариантов для достижения обоснованности. Рассчитанное отношение объема полезной информации о состоянии, собранной и обработанной при планировании операции, до необходимого для определения решения позволило построить график зависимости вероятности определения решения, отвечающего обстановке, от значения вероятности определения оптимального варианта решения до поступления информации о состоянии и отношения объема полезной информации о состоянии, собранной и обработанной при планировании операции, до необходимого для определения оптимального варианта решения.

Выводы. Результаты исследования могут быть использованы при совершенствовании проектов управленческих решений по обеспечению безопасных условий труда работников пищевой промышленности.

Ключевые слова: *чрезвычайная ситуация, планирование, оценка, информация.*

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- Висновки
- Література.

За необхідності можна додавати інші розділи та розбивати їх на підрозділи.
8. Авторська довідка (Прізвище, ім'я та по батькові, вчений ступінь та звання, місце роботи, електронна адреса або телефон).
9. Контактні дані автора, до якого за необхідності буде звертатись редакція журналу.

Рисунки виконуються якісно. Скановані рисунки не приймаються. Розмір тексту на рисунках повинен бути **співрозмірним** (!) тексту статті. **Фотографії бажано не використовувати.**

Фон графіків, діаграм – лише білий. Колір елементів рисунку (лінії, сітка, текст) – чорний (не сірий).

Рисунки та графіки EXCEL з графіками додатково подаються в окремих файлах.

Скорочені назви фізичних величин в тексті та на графіках позначаються латинськими літерами відповідно до системи СІ.

В списку літератури повинні переважати статті та монографії іноземних авторів, які опубліковані після 2000 року.

Додаткова інформація та приклад оформлення статті – на сайті

www.ufj.ho.ua

Стаття надсилається за електронною адресою: ufj_nuft@meta.ua

Оформлення списку літератури

Наукометричні бази визначають рейтинг як журналу, так і окремих авторів за кількістю посилань на статті. Електронні системи опрацьовують кожен елемент списку – авторів, назву статті та видання, номер, рік та інші елементи.

Українські стандарти передбачають складні вимоги до оформлення посилань на літературу. Такі посилання не можуть опрацьовуватись наукометричними базами (Scopus, Index Copernicus, EBSCO, Google Scholar, Web of Science та ін.). Ці бази сприймають просте оформлення списку, без косих ліній та зайвих елементів.

В світі відсутні єдині правила оформлення посилань. Наукові видання розроблюють власні вимоги оформлення посилань, але зазвичай узгоджують їх із загальноприйнятими вимогами American Psychological Association, Council of Biology Editors, Citation-Sequence, Chicago 16th Edition, Harvard, Harvard - British Standard, NLM - National Library of Medicine та іншими.

Всі визнані світові стандарти передбачають оформлення списку літератури лише латинськими символами. При оформленні посилань на джерела, написані кирилицею, необхідно проводити транслітерацію. Користуючись програмами транслітерації, слід уважно вказувати, з якої мови проводиться транслітерація – української чи російської. Застосовуючи спеціальне програмне забезпечення для транслітерації з української мови використовуємо лише **Паспортний (КМУ 2010)** тип транслітерації, а з російської – тип **МВД,** в яких використовуються лише символи англійського алфавіту.

Для задоволення вимог як українських стандартів, так і визнаних в науковому середовищі наукометричих баз, редакційна колегія просить авторів оформлювати **два списки літератури** – згідно українського стандарту, та згідно вимог, описаних нижче.

1. Посилання на статтю.

Автори (рік видання), Назва статті, *Назва журналу (курсивом)*, том (номер), сторінки.

Всі елементи після року видання розділяються комами.

Приклад:

Український стандарт	**Стандарт Harvard**
Пирог Т.П. Використання мікробних поверхнево-активних речовин у біології та медицині / Т.П. Пирог, А.Д. Конон, А.Б. Скочко // Біотехнологія. – 2011. – Т. 4, № 2. – С. 24–38.	Pyroh T.P., Konon A.D., Skochko A.B. (2011), Vykorystannia mikrobnykh poverkhnevo-aktyvnykh rechovyn u biolohii ta medytsyni, *Biotekhnolohiia*, 4(2), pp. 24-38.

2. Посилання на книгу.

Автори (рік), *Назва книги (курсивом)*, Видавництво, Місто.

Всі елементи після року видання розділяються комами.

Український стандарт	**Стандарт Harvard**
Раєвнєва О.В. Управління розвитком підприємства: методологія, механізми, моделі: монографія / О.В. Раєвнєва. – Харків, 2006. – 496 с.	Raievnieva O.V. (2006), *Upravlinnia rozvytkom pidpryiemstva: metodolohiia, mekhanizmy, modeli,* Kharkiv.

3. Посилання на електронний ресурс.

Виконується аналогічно посиланню на книгу або статтю. Після оформлення даних про публікацію пишуться слова **available at:** та вказується електронна адреса.

Приклад посилання на статтю із електронного видання:
Barbara Chmielewska (2012), Differentiation of the standard of living of families in countries of the European Union, *Ukrainian Food Journal*, 2(2), pp. 230-241, available at: http://ufj.ho.ua/Archiv/UKRAINIAN%20FOOD%20JOURNAL%202013%20V.2%20Is.2.pdf

Приклад посилання на публікацію із електронного видання:
(2013), *Svitovi naukovometrychni bazy*, available at: http://www1.nas.gov.ua/publications/q_a/Pages/scopus.aspx

Приклад оформлення списку літератури:

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