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Contents

The study of properties of a raw meat product during salting by brines

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Abstract

Introduction. The mechanism of forming of the coloured descriptions of the model meat systems is investigational with low maintenance of myoglobin on the stage of salting on the change of the coloured descriptions of meat raw material in the process of salting.

Materials and methods. Determination of relative content of myoglobin and its derivatives was performed by reflectivity spectroscopy spectrophotometer SF-18, the total content of pigments - pigments meat first extraction of water, acetone and hydrochloric acid, followed by extraction by photokolorimeter at a wavelength of 540 nm with respect to hydrochloric acid acetone; color intensity - the photoelectric KF-77 at a wavelength of 540 nm against distilled, the determination and colored integral characteristics - Cary 50 spectrophotometer.

Results and discussion. The expediency of using technology-based dyes of meat preparations hemoglobin slaughtered animals Vepro 70 Col R Red Apro and as components of multi brine for color correction ham products with high injection and with different levels of myoglobin in the meat raw. Rational drug concentrations of hemoglobin (Vepro 70 Col P and Apro Red) color for meat with a fat content of 10% was respectively 0.5% and 0.6%, while the use of 0.05% Sodium Erythorbate and 0.006% sodium nitrite.

Conclusions. The results recommended for modern production technologies ham products using intensification methods of salting.

Introduction

The development of new and improvement of existing technologies, improvement of manufactured products quality, namely, the exclusion of the using or minimizing various toxic substances is an urgent problem in a meat-processing industry.

Creation of cured-meat products with a high level of safety needs improving some core processes of production using some intensive cost-effective ways to influence the feedstock. In this regard, it is necessary to study the question of colour-correcting of whole muscle meat products of a high level injection, using some intensive methods of salting in combination with colour-correcting components of multicomponent brines. However, the analysis of the Ukrainian meat market shows that there are a lot of cured-meat products with the salt-brine level of 60% and 80% 'economy class' among them, in meat formula of which there are connective animal albumens and food hydrocolloids, i.e. the proportion of without myoglobine raw materials, contained in the finished product, exceeds 15 – 20%. During colour correcting of such products, as the results of research and practical experience have shown, staining power of sodium nitrite is not enough to produce the traditional red-pink colour. In this regard, it is appropriate to search for mixture with a more expressive red-pink variety, which would provide an opportunity to obtain the desired colour for products with a high level of the brine system injection in dependence to quantitative scope of hemoglobin.

There are almost always some contradictions as for the use of sodium nitrite salting process. Europe may introduce a ban on its use and we are, the Ukrainians, also can get rid of it. To do such step is easy, but what nitrite will be replaced is a rather complex issue. The list of colouring substances, that are allowed by the Ukrainian Government, for using them as food colouring additives, has more than 30 namings. But most of them can not be used in the manufacture of meat products for a number of reasons. Firstly, the colourant formation of model meat system is outlying for this type of sausage or meat products. Secondly, this is instability of colourant properties in the process of meat production.

The aim of the pilot experiment was to investigate the mechanism of formation of the coloured meat characteristics models with low myoglobin at the stage of curing with the inclusion to the feature-rich brine colloidal systems some nitrite salts instead of sodium nitrite and natural colourants (Apro Red and Vepro 70 Col P ('Viadi' company, the Netherlands), to change coloured characteristics of the raw meat products during salting.

In accordance with the objectives and tasks of the scientific paper, there has been studied the characteristics of the formation of the coloured raw meat products during salting using nitrite salts composed of multifunctional brine in an amount that is an equivalent to the content of sodium nitrite (20 g per 100 l), that in conversion is 3.5 % of nitrite salts to the mass of brine. Insufficient amount of salt was supplemented by vacuum, as it has a higher degree of sodium chloride (99.84%), while a small amount of insolubles, compared with unrefined type of food salt (rocksalt, deposited salt, solar salt).

Materials and methods

The object of the study was a longitudinal muscle of the back (L. Dorsi), which was obtained from the cooled lean beef of the 2nd category fatness with the autolysis period of 48 hours, pH 6.2 ± 0.01, weight pieces – 300 g. Drinking tap water (pH 7.8-8.0) was used for the brine preparation. The prepared raw product was injected by single-needle syringe by staggered scheme with a step 2.5×10-3m of different brines composition (Table 1).

Table 1

Brine composition for injection

Title	Components amount, a kilo for 100 l of brine		
	brine 1 (control)	brine 2	brine 3
Sodium nitrite	0.02	-	
Nitrite salt		3.5	3.5
Vacuum salt	7	3.5	3.5
Sodium tripoly phosphate	0.30	0.30	
Phosphates (E450iii, E 451i)			0.30
Water	92.68	92.70	92.70
Total brine	100	100	100

According to the traditional technology, sodium nitrite was brought in at the rate of 20 g per 100 l of the brine. In the process of 80% introduction of the brine into the mass of unsalted raw nitrite, the concentration will be 0.016 g per 1 kg of raw meat. According to the technological instructions for using nitrite salt of 'DANSK SALT A/S' company (Denmark), for producing the whole muscle chopped products, it is used as a part of the brine in an amount 5.4% (for the same amount of the brine). Taking into account, that 100 g of nitrite salts contains 0.57 g of $NaNO_2$, the amount of sodium nitrite is 30.78 g per 100 liters of the brine (0.12 g per 1 kg of raw products). With account of the presence of nitrites in the raw products, the entering of such a high number of them is a key problem due to toxicity and the possibility of carcinogenic nitrosamines formation.

In the process of the salted meat products a specail attention is paid to the temperature, as one of the main factor of the quality products. In the process of chopped meat products the temperature in raw muscle thickness was 4 ºC, the base brine temperature was in the range between 0 ... 2 ºC, which was achieved by the addition some ice in the brine. After the injection with the aim of substances perequation for salting the whole volume of a piece, the raw product was subjected to cyclic by the scheme that was proposed by A. A Borisenko and others [8]. Salted raw massaging was carried out in the following, selected by us, a reasonable program (15 min – rotation, 15 min – pause (6 rotations per minute), the depth of the vacuum massager at least 90%. The duration of the raw meat beef massaging process was 6 hours.

In order to explore the possibility of using colourants as the part of the multicomponet brines with the level more than 80%, and using as the part of the brines of connective tissue proteins and food hydrocolloids for amplification of the pink part of the spectrum, on the next phase of the research we studied the properties of the natural colourant on the base of animals' blood hemoglobin. As the objects we selected: natural, based on blood hemoglobin of slaughtered animals, colourant – Red Apro ('TEHRRO', Russia), Vepro 70 Col P ('Viadi' company, the Netherlands). The working range of concentrations for these substances has been selected in accordance with the recommendations of technological companies-manufacturers.

Based on the results of the study of the composition and main physical and chemical characteristics of hemoglobin preparations (Vepro 70 Col P, Apro Red), which showed the principal possibility of their use as components of multicomponent brines, there were carried out some simulations, the aim of which was to determine the environmental conditions that are optimal for the manifestation of the colouring effect of the selected colourants in the spectrum, which corresponds to a consumer's image about the colourant of the whole muscle meat products. Taking into account, that in the molecules of

hemoglobin or myoglobin as prostatic groups protoporphyrin IV is included, the formation of the red nitric oxide pigment is the same. Myoglobin goes into combination of red when interacting with the nitric oxide, and the rate of the reaction and the mass fraction of pigment formed depends on the amount of myoglobin content of metallic molds and oxidation-reduction potential of the system. In this regard, some analytical and experimental selections and justification of the required number of the nitrite salts and reducing substances were conducted.

It is known, that nitrous acid, which is formed during the hydrolysis of sodium nitrite, while absence in the environment and reducing agent and oxidizing agent, is decomposed into oxide and nitrogen dioxide, so along with the nitric oxide pigment appear metpihmenty [9]. Therefore, as a reducing reagent, we have used dietary supplements traditionally used to a more equal colourant of meat and maximum utilization of the nitrite in the process of the colour formation and colour stabilizing of the raw meat product – food acids and their salts (ascorbic acid, sodium askorbinat, sodium erythorbate, citric acid) and sugars (sucrose, glucose, maltose, dextrose, lactose), intermediate products of anaerobic decomposition of which are formed by the enzyme of bacteria, which have a significant reducing effect. Glucose has better regenerative properties than sucrose, but quickly involved in oxidative transformations, thus it should be used only at the short-term salting. At the high-temperature of processing glucose enters into Mayer's reaction with amino groups of protein, which negatively reflected on the nutritive value and the colour of the product [9].

As the maximum concentrations of these components some standarts of their layings using the nitrite salting were selected (sodium nitrite – $\leq$ 5 mg%, food acids – <5%, sugar – <1.5%), which were gradually decreased to determine the rational conditions for the formation of reaction of the nitric oxide pigments with maximum involvement of hemoglobin. During the studies the type and the value of the reductant were varied in the system. In assessing of the compositions effectiveness, which are created as the model systems, there were used gels and emulsions based on protein products of animal origin ProGel C-95. The colour assessment in the first stage was carried out visually.

The determination of relative content of myoglobin and its derivatives was performed by the method of reflectiving spectroscopy with the help of the SF-18 spectrophotometer.

The content of total pigments was determined by the common method that is based on the meat extraction, first by water and then by muriatic acetone, followed by photocolourimetry at a wavelength of 540 nm with regard to muriatic acetone.

The colorfastness was found out by determining the optical density of the nitric oxide pigment extracts before and after exposure of the product in the light.

The colour intensity of model systems was determined by KF-77 photoelectric spectrophotomete at a wavelength of 540 nm with respect to the distillate.

The definition of spectra and integral coloured characteristics was performed on a Cary 50 spectrophotometer.

The content of nitric oxide pigment was determined by nitric oxide pigment extraction with aqueous acetone followed by further determination of the optical density of the solution on a spectrophotometer at a wavelength of 540 nm with regard to 80% of aqueous acetone.

Results and discussion

Literature data analysis [1, 2, 3, 4, 5, 6, 7] and our own experimental studies revealed that the formation of the meat colouration begins during the process of salting. The reaction of nitric oxide pigment occurs intensely at pH 5.5-6.0. At more than pH 6.0 of the meat, the nitric oxide pigment reaction reaction (NOMb) runs at a slower speed. However, the lowering of the pH of the meat does not provide the maximum manifestation of functional and technological properties of muscle proteins and stability NOMb, which was formed – it is more stable at high pH values [2, 5, 9]. Significant influence on the meat colouration has the temperature. During the process of the traditional salting and cold smoking, 40 – 50% of the nitric oxide pigment NOMb is formed.

The experimental data analysis about the effect of multicomponent brines with high pH on the formation of coloured characteristics of the raw meat product during the salting (Table 2) indicates that the use of nitrite salts leads to more intense nitric oxide pigment formation and, consequently, to a smaller residual nitrite content in the product. After machine processing the content of nitric oxide pigment for the control sample corresponds 42.13% (Table 2).

Table 2

The influence of multicomponent brine composition on nitric formation in the beef after meat tumbling process

Sample title	General pigment, optical depth	Composition of NO-pigment, % to general pigment	Amount of remained nitrite
Brine 1 (control)	0.460	42.13	6.22
Brine 2	0.580	47.53	6.08
Brine 3	0.610	48.12	5.78
	mcp= ± 0.054	mcp= ± 0.20	mcp= ± 0.05

The introduction to the composition of ingredients for the nitrite salt pickling nitrite, upon obtaining of which the nitrite sprayed in crystals, promotes their more rapid enrichment in the test items (11.4 – 12.4%) compared with controls. However, the using as a part of selected phosphate of the brine mixture it was marked maximum amount – 48.12%. The studies confirm that the increase in the intensity and colour stability under the influence of the multicomponent brines with high pH is due to the creation of reducing conditions in the meat system, which prevent or delay the metmyoglobin formation. This is due to the ability of phosphate mixture to influence on reducing activity of oxidative enzymes. The described effect is confirmed by A. A. Borysenko's studies [1].

The raised level of the nitric oxide pigment improves the interaction of myoglobine with the nitrite, causing the reducing of its residual amount. With the same initial injection level of sodium nitrite in the all samples (10 mg % by weight of raw material meat product) its reducing proceeded at different rates: in the control to 6.22 mg/100g of the product, in the sample under investigation, which containied the nitrite salt, in equal conditions there was a rapid transformation of the nitrite: its residual amount after salting reached 6.08 mg/100g. However, using for the preparation of the brine along with the nitrite salt phosphate mixture (E450iii, E451li), the minimum rate is 5.78 mg/100 g in the test piece. Thus, using for salting in the brine composition of multicomponent nitrite salt instead of nitrite sodium linked with the mechanical processing of the raw meat product not only

speeds the process up of fixing a stable colour, but also can reduce the residual content of sodium nitrite in the product.

The obtained data, pH and 'general hemoglobin content' are shown in Table 3. All these indicate that the pH of experimental drugs for hemoglobin is: Apro Red – 5.84 and Vepro 70 Col – 6.0. Taking into account, that the pH level of the model meat systems, for colourant stabilizing of which is proposed to use these colourants, the last stage of the salting should make 6.2 ... 6.4, we can assume, that the use of colourant Apro Red and Vepro 70 Col P their colouring ability will not be fully reflected, because of the shift in pH of 0.6 units and 0.4 units, respectively.

Table 3

Key physical-chemical characteristics of the colourants on the blood pigment basis

Colourant title	**pH** (m±0,05)	**Deliquescence**, %, (m±3,5)	**Mass fraction 'general hemoglobine'**, %,
Apro Red	5.84	45.0	81.0
Vepro 70 Col P Brine 2	6.00	75.0	76.0

A high content of researched colourants (80%) of 'total hemoglobin', which is the second pigment, that corresponds along with the mioglobine for the colour formation process in the raw meat product, indicates about a potential opportunity of the efficient using of hemoglobin to provide the required red-pink colour for model meat systems with high levels of injection and changes in levels of myoglobin in the composition of model meat systems. Taking into account that the met-form of blood pigment that gives the finished product a brownish-gray colour, has low solubility, the presence of high levels of solubility in the experimental preparations suggests that the stock Vepro Col 70 contains a small number of metmyoglobin.

The discussion about data, presented above, shows a high potential of hemoglobin drugs (Vepro 70 Col P and Apro Red) with their possible use as colourants of red and pink range. However, for the manifestation of their colouring properties, it is necessary to make a purposeful choice of additional ingredients, their concentrations and ratios, which allow preventing the oxidation and destruction of the hemoglobin molecule, and can contribute to the formation of the nitric oxide pigment.

The results of initial studies indicate that the most suitable colour can be seen when making 0.3 – 0.4% of blood pigment colourants (Vepro 70 Col P) in the presence of the nitrite salt (0.001 – 0.006%).

For gels and protein-fat emulsions in a ratio of protein preparation:fat:water – 1:20:10 obtaining of the pink colour provides a composition containing pigment blood colourants (Vepro 70 Col P, Apro Red), sodium nitrite (nitrite salt) and isoascorbate Na (1:0,01:0,1; 1:0,01:0,12 respectively) when the number of input 0.5% and 0.6% by weight of the system. The correlation that facilitates effective manifestation of the properties of selected blood pigment colourants, there was successfully tested in the laboratory for modifying the colour of protein suspensions, gels and meat model systems.

At the final stage of the simulation there were performed some spectrophotometric analysis (Table 4) of aqueous solutions colourants Vepro 70 Col P and Apro Red and protein-fat emulsion-based animal protein ProGel C-95 + Vepro 75, which was painted with their help.

The spectral characteristics of solutions and emulsions showed that Vepro 70 Col P awards Red Apro for 'lightness', which at the background of low rate of 'redness' results to a light yellow-brown solution.

Table 4

Spectral characteristics of food coloured solvent and coloured model meat systems

№ п/п	Colourant title	Concentration, %	Colour coordinates CIELab		
			L (lightness)	a (redness)	b (yellowness)
Solutions					
1	Vepro 70 Col P	0.5	23.18	24.97	29.99
2	Apro Red	0.5	50.39	2.70	33.40
Emulsions					
3	Vepro 70 Col P	0.3	67.93	5.20	16.00
4	Apro red	0.3	77.99	2.32	16.80
5	Vepro 70 Col P	0.6	61.45	5.41	16.14
6	Apro Red	0.9	68.59	4.85	17.94

During the spectrophotometric estimation of the protein and fat emulsion, which was coloured with the help of the studied colourants, the analysis of the results showed that the dosage of colourants in the amount of 0.3% was the most appropriate colour system containing Vepro 70 Col P for which exactly this concentration was defined as the rational one during the sensory research. Using this concentration resulted to getting systems which are characterized by a very high rate of 'lightness' and 'yellowness' and a low value of 'redness'. Therefore, experiments were carried out with increasing content Vepro 70 Col P to 0.6%, and Apro Red to 0.9%, which made it possible to adjust the color emulsions.

Thus, the results of spectrophotometric studies allowed to conclude that the most significant colour correction effect in shaping the pink-red hue of the model emulsions has Vepro 70 Col P. Based on these data we can conclude that, although the blood pigment colourants are not significant in buffering capacity in the acidic conditions, they are able to make a stabilizing effect on the pH of alkaline systems, which includes multi brines for injection of the raw meat product.

Conclusions

- The results of the model studies allow to predict that for practical use in technology-based colourants of meat preparations on the base of drug blood hemoglobin of slaughtered animals Vepro 70 Col P and Apro Red by their physical and chemical characteristics, they can be recommended as a multifunctional brine for colour correction products of chopped products with high levels of injection and with different levels of myoglobin in the meat system that can be designed to provide the inherent colour for hams of an 'economy group', which include without myoglobine raw product.
- The using of nitrite salts instead of the traditional sodium nitrite leads to more nitric oxide pigment, which leads to obtain a finished product with a lower content of residual nitrite and better colour performance than in the equivalent administered sodium nitrite.

- Justified and defined the rational drug concentration of hemoglobin (Vepro 70 Col P and Apro Red) for colouring the meat of a fat content to 10%, which was respectively 0.5% and 0.6%, while the use of 0.05% isoascorbate Na and 0.006% of sodium nitrite, which are for colour correction of the salty products with different levels myoglobineless materials.

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Fatty acid composition of dairy fat products of vegetable origin

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Abstract

Introduction. For enrichment of polyunsaturated fatty acids and increasing biological and nutritional value of dietary fiber of spreads it is offered to add sweet brier processing products (SPP) - oil and meal. The expediency and the use of these products is proved for producing of emulsive type dairy fat products of vegetable origin with dietary fiber as "Citri-Fi".

Materials and methods. With the method of gas-liquid chromotography peak samples products of sweetbrier processing are identified. Found that received dairy fat products of vegetable origin of emulsive type contain more unsatured fatty acids than butter, which is included to the recipe of spreads.

Results and discussion. Found that in the investigated spread the amount of saturated and unsaturated fatty acids are reduced (capric (by 1,136 %), lauric (at 1.958 %), myristic (by 3.03 %), palmitic (at 6.454 %), stearic (at 1,016 %), arachidonic (by 0,229 %) also the amount of trans-isomers that during the consuming of the product can cause cardiovascular disease (by 1,305 % compared with butter). The main ω-3 fatty acid in dairy fat products of vegetable origin with dietary fiber is linolenic, compared with butter its content increases by 0,038 %. Among the ω- 6 acids in samples linoleic dominates which increases by 0,458 %, linoleic cis-9, cis-12 $C_{18:2}$ – 15,282 %. From monounsaturated fatty acids in the spread of PSP the lower amount of such fatty acids as: mirystooleinic, palmooleinic, heptadecenoic, elaidonic but more oleic (by 1,831 %). The results can be used in determining the biological value of the PCA spreads due to current principles of nutrition science.

Introduction

Development of combined food-based analytical evaluation of the quality and quantity of nutrients contained in them, led to the need of methodological approaches that are based on the principle of selection of key nutrients, modeling and optimization quality. This direction was developed in methods of calculating quality of protein and less lipid components of some foods, especially in many components of milk-based mixtures.

There is a shortage of polyunsaturated fatty acids (PUFA): linoleic, linolenic, arachidonic in the diet of modern people. These acids in their biological properties belong to the essential matters which are not synthesized in the human body, and therefore must come from food. Biological properties of oils and fats and fatty acids are provided by their fatty and acidtriglyceride content as well as the presence of biologically active compounds (tocopherols, sterols, phospholipids, carotenoids, etc). However, the basic criterion of the nutritional value of these products is their fatty acid composition. Therefore not accidently one of the stages in the transformation of traditional fat product in a product with high biological value is the change of the fat phase by selecting balance in number and ratio of polyunsaturated fatty acids of fatty bases.

Analysis of the literature

According to the principles of healthy eating physiologically full value food fat appointed for feeding healthy body should contain 30-40% saturated fatty acids (SFA), 50-60% mono-unsaturated fatty acids (MUFA) and 10-20% PUFA. A fractional ratio of fatty acid component of "standard" lipid is adopted (g/100 g fatty acids): SFA: PUFA: MUFA = 3: 1: 6. And if we analyze the class of fatty acids ω-3 and ω-6, we will have the same ratio, %:SFA:PUFA $_{ω-3}$:PUFA $_{ω-6}$: MUFA=23,0:1,6:6,4:69,0

Research of fatty acid composition of natural oils showed that there is no "ideal" body fat in nature with the composition that provides admission of essential fatty acids in the right amounts and proper proportions for human body.There are several ways to provide body with PUFA:

- creation of genetically modified sources of vegetable oils high in PUFA, including ω-3;
- increasing the share of oil in the diet with high content of ω-3 PUFA (linseed, false flax, canola oil);
- use of nutritional dietary supplements in the form of oil products and powders with a high (30 %) content of ω-3 PUFA;
- obtain and use of blended vegetable oils in food with essential content and the ratio of acids ω-6 and ω-3;
- use of blended vegetable oils in food (dairy, emulsive and baby products).

The most effective way of creating milk-fat foods with balanced composition and ratio of ω-6 and ω-3 PUFA is enriching with vegetable oils. In the late 1990s the concept of creating such products was established by scientists of Moscow National University of Food Industry, and jointly with the Center of Innovation and Development "Healthy Foods" the technology of their production was offered, including a system of calculating the optimal fatty acid composition.

Benefits of using vegetable oils to correct lack of PUFA to dietary supplements and medicine are as follows - oil is traditional food consumption of which does not cause complications and adverse reactions in the body and is much cheaper than dietary supplements.

Features of milk-fat products technology are following: spreads with fillers give the possibility to use ingredients of vegetable origin, mainly oils along with dairy ones. Through their presence spreads have several advantages over butter: plastic consistency at different temperatures from 0 to 10ºC, contain of more vitamins and biologically active substances and less cholesterol.

Biological efficiency as an indicator characterizes the balance of product with the content of polyunsaturated fatty acids, essential amino acids, phospholipids, minerals, polyphenols compounds and vitamins. Increased biological value of milk-fat product is achieved by the following:

- natural extracts and vitamins that reduce the rate of aging and neutralize the negative impact of the environment;
- polyunsaturated fatty acids that strengthen the cardiovascular system of a person, reduce bad cholesterol in the blood;
- prebiotics - polydextrose, natural dietary fiber.

For the production of milk-fat products using oils with alternative raw materials for the enrichment with physiologically important components is very actual nowadays. In particular, sweetbrier oil should get special attention, which is extracted from the crushed seeds of orange-red sweet brier - a perennial shrub of the Rosaceae family. Sweet brier is one of the main plant for the production of multivitamin and other medicine that are essential for health.

Composition of sweet brier oil is represented with a wide range of components such as fatty acids (polyunsaturated: linoleic, oleic, linoleic), saturated (myristic, palmitic, etc.), vitamins C and A, tocopherols, carotenoids, trace elements (Mn, Cu, Mb), macro elements (Fe, Mg, K, Ca, P). Sweet brier contains: vitamins (P, B_1, B_2, K, E), 0,01 to 0,06 % carotene, up to 8 % carbohydrate, up to 3,6% acids, flavonoids (astrahalin, hiperozyd, quercetin), catechins, lycopene, xanthophylls, arumin. After extraction of oil as a byproduct protein meal is produced, according to the concept of a balanced diet by A. Pokrovsky, the daily requirement for an adult in dietary fiber is 25 g. Due to this information it is appropriate to enrich milk fat emulsion products with such products of complex plant processing as oil and protein meal of sweet brier.

Purpose of the study is to study the influence of plant processing products on the fatty acid composition of foods high in fat - spreads with dietary fiber.

Materials and methods

Objects of the study are spreads with oil and protein meal of sweet brier. Investigation the fatty acid composition of spreads with sweet brier processing products prototypes of the technology, based on the separate preparation of milk-fat emulsion and mixing with cream has been elaborated. Vegetable-fat mixture is prepared using orange dietary fiber. Recipe model of spreads samples is presented in Table 1.

Table 1

The recipe of spread of SPP with 15-% replacement of milk fat with vegetable fat with mass fraction of total fat 72,5% excluding losses (kg to 1000 kg)

Raw material	Traditional	Elaborated
Sweet cream unsalted butter (fat 72,5 %, moisture 25,0 %, dry fat-free matter 2,5 %)	799,0	799,0
Sweet brier oil (fat 99,9 %)	-	141,27
Sunflowerseed oil (fat 99,7 %)	141,27	-
Dry fat-free milk (fat 1,5 %, dry matter 95 %)	4,00	3,26
Emulsion stabilizer (fat 100 %)	4,25	4,25
Sweet brier protein meal	-	1,25
Orange dietary fiber Citri-Fi (dry matter 95 %)	-	0,3
Flavoring matter	0,3	0,3
Water	51,18	51,62
Total yield	1000	1000

Table 2

Concentration of fatty acids, lipids of studied fat dairy products, % (of total fatty acids)

№	Fatty acids	Concentration, %	
		Sweet cream butter	Spread of SPP
1	Oleic ($C_{4:0}$)	4,308	3,338
2	Caproic ($C_{6:0}$)	2,624	1,854
3	Caprylic ($C_{8:0}$)	1,555	0,995
4	Capric ($C_{10:0}$)	3,011	1,875
5	Undecanoic ($C_{11:0}$)	0,328	0,191
6	Lauric ($C_{12:0}$)	3,983	2,025
12	Tridecanoic ($C_{13:0}$)	0,224	0,141
13	Myristic ($C_{14:0}$)	9,636	6,606
15	Myristeoleic ($C_{14:1}$)	0,512	0,434
17	Pendadecynic ($C_{15:0}$)	1,122	0,883
19	Palmitic ($C_{16:0}$)	26,255	19,801
21	Palmitooloic ($C_{16:1}$)	1,344	0,717
26	Heptadecoic ($C_{17:0}$)	0,046	0,032
27	Heptadecenoic ($C_{17:1}$)	0,240	0,216
28	Stearic ($C_{18:0}$)	10,038	9,022
29	Elaidic ($C_{18:1}$)	3,205	2,044
30	Oleic ($C_{18:1}$)	22,046	23,877
31	Linoleic ($C_{18:2}$) trans	0,446	0,302
32	Linoleic ($C_{18:2}$) cis	2,966	18,248
33	Arachidonic ($C_{19:0}$)	0,203	0,031
34	Linoleic ($C_{18:2}$) ω-6	0,206	0,244
35	Linolenic ($C_{18:3}$) ω-3	0,519	0,977

As a control, traditional butter was used, which is produced by classical technology.

Investigation of fatty acid composition of milk fat products peaks of spreads sample of sweet brier processing products were identified. The measurements were performed by comparing the retention time of the control mixture using a gas chromatograph "Kupol-55" of column length 30 m, internal diameter 32 mm, thickness 0,25mm, injector temperature 250°C, detector temperature 260°C. Thermostat of the column: initial temperature - 60°C with 15 min of aging, finish temperature - 220°C with 150 min of aging. As a standard sweet cream traditional butter was taken with a mass fracture of fat 72,3% produced by classical technology . The method is founded on the principle that the methyl esters of fatty acids are prepared by interesterification, and then are shared and determined by capillary gas-liquid chromatography.

Results and discussion

The concentration of fatty acids, lipids of studied fat dairy products, % (of total fatty acids) is presented in Table. 2 and chromatograms (Figure 1-2).

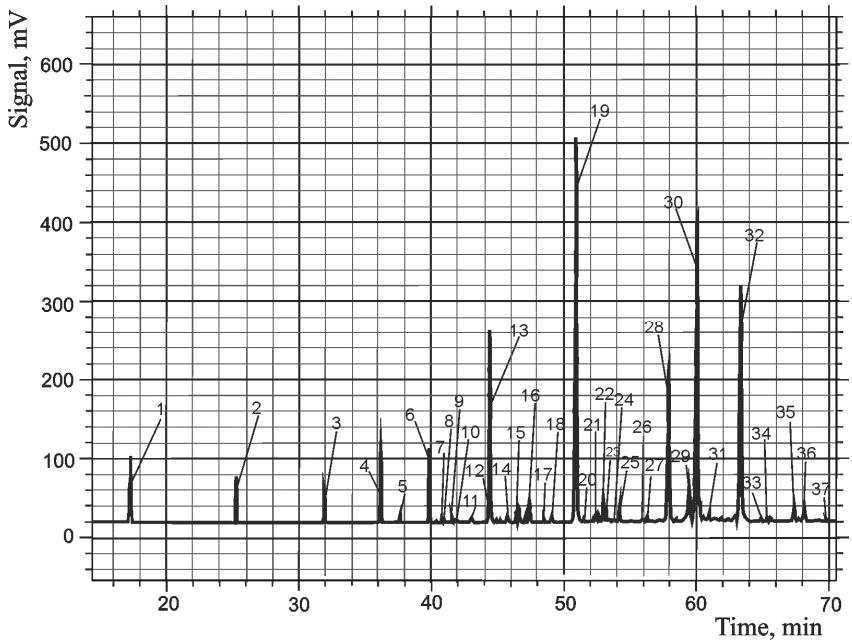

Fig 1. Chromatogram of sweet cream traditional butter

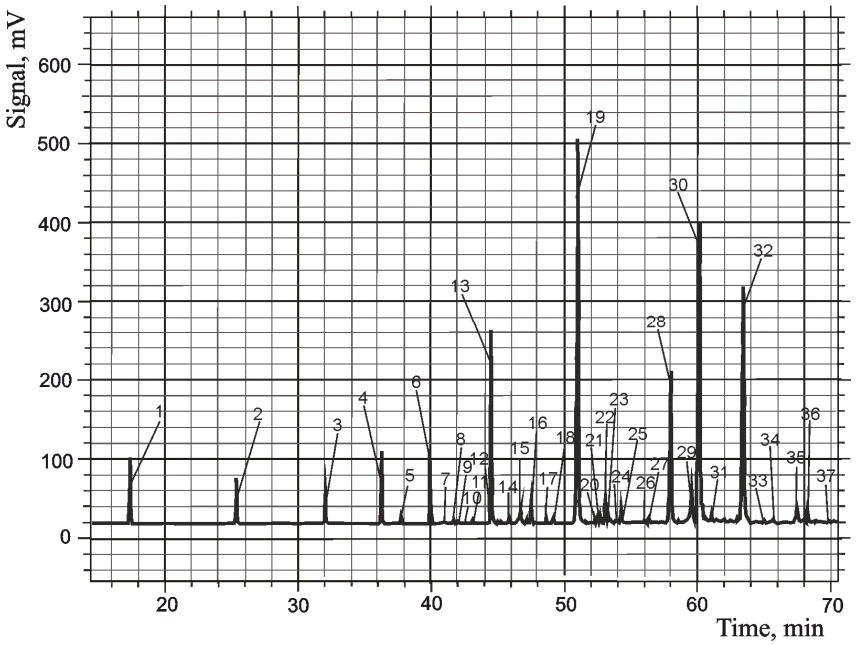

Fig 2. Chromatogram of spread of SPP

From the chromatogram presented in Fig. 1-2 is shown that elaborated spread with oil and sweet brier protein meal contains less saturated fatty acids compared with control. As you know , the most undesirable fatty acids of milk fat is medium- saturated fatty acids $C_{12:0}$, $C_{14:0}$ and $C_{16:0}$, as they increase the level of cholesterol and lipoprotein of low density in blood and, therefore, have atherogenic and thrombogenic properties. Instead, unsaturated acid analogues of this group do not have negative effects on human health. The biggest difference is in caproic (by 1,136 %), lauric (at 1.958 %), myristic (by 3.03 %), palmitic (at 6.454 %), stearic (by 1,016 %), arachidonic (by 0,229 %). In the spread of SPP from monounsaturated fatty acids there less: myristeoleic, palmitooloic, heptadecenoic, elaidic but more oleic (by 1,831 %).

Polyunsaturated fatty acids ω-3 and ω-6 series have antiatherogenic and antithrombogenic action, healthy diet strategy involves a rise in their contents in human diets. The main ω-3 fatty acid in milk fat foods is linolenic. Among the ω- 6 acids in samples linoleic dominates (cis-9, cis-12 $C_{18:2}$). These acids are essential, and therefore must come to the body with food. Spread contains more polyunsaturated fatty acids than sweet cream traditional butter: by 15,282 % linoleic, linolenic (ω-3) by 0,038 %, linoleic (ω-6) by 0,458 %. Number transisomers in the spread of dietary fiber compared with butter reduced by 1,305 %.

Conclusion

1. The study of fatty acid composition of SPP spread with oil and protein meal, it was found that received plant-derived milk fat emulsion type product contains more essential fatty acids than butter, which spread recipe includes.
2. The main ω-3 fatty acid in dairy fat products of vegetable origin with dietary fiber is linolenic, compared with butter its content increases by 0,038 %. Among the ω- 6 acids

in samples linoleic dominates which increases by 0,458 %, linoleic cis-9, cis-12 $C_{18:2}$ – 15,282 %.

3. Found that in the investigated spread the amount of saturated and unsaturated fatty acids are reduced (capric (by 1,136 %), lauric (at 1.958 %), myristic (by 3.03 %), palmitic (at 6.454 %), stearic (at 1,016 %), arachidonic (by 0,229 %) also the amount of trans-isomers that during the consuming of the product can cause cardiovascular disease (by 1,305 % compared with butter).
4. It is found that in the investigated spread saturated fatty acids and trans-isomers that can cause cardiovascular disease during the consumption reduces. The results can be used in determining the biological value of the SPP spreads under the current principles of nutritiology.

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Modeling composition of the mixed oils by blending

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Abstract

Introduction. In order to enrichment food ration essential fatty acids of the population investigated blending of vegetable oils which give a balanced composition of polyunsaturated fatty acids, and conventional flavor characteristics.

Materials and methods. Physico-chemical quality of oils were determined by standard methods; design of experiments and optimization of technological processes was performed experimental and statistical method based on the software package Pascal; fatty acid composition of oil determined by method of gas chromatography.

Results. Researched and updated the fatty acid composition of vegetable oils cold-pressed. Has been developed and scientifically based the composition of blendson the basis of sunflower oil with the addition of camelina oil, flax and walnuts, which ensure a rational ratio ω-6/ω-3 fatty acids with the recommendations of their consumption. Investigated autocatalytic oxidation and hydrolytic blends when stored at a temperature of 20 ± 2 ° C with free access of light and air. A substantial slowing of the accumulation of peroxides and free fatty acids by blending of 35% of the nut or 40% of camelina oil with corresponding amount of sunflower oil. Obtained data on a reduced stability of the blended oils with linseed oil. Identified the guaranteed storage life of blended oils based on sunflower oil.

Conclusions. Developed blended oils differ a balanced ratio of essential fatty acids, ω-6 / ω-3 from 10: 1 to 3:1, and can be used as a component of the fatty human diet and for the production of health-preventive purposes.

Introduction

Maintaining the health and increasing longevity of the individual - one of the most pressing problems of our time. One of the approaches to solving this problem is the creation of functional foods, which do not differ in taste and appearance of traditional, improve health, promote the reduction of disease and use of daily demand. [1]

Fat and oil products should be not only carrier of energy and a plastic material but also an important source of physiologically functional ingredients polyunsaturated fatty acids (PUFA), fat soluble vitamins, phospholipids, and other bioactive components. Of particular importance is presence in the products of essential polyunsaturated fatty acidsto which in the first place should include linoleic (C18: 2) and linolenic (C18: 3) acids. Linoleic acid is the main representative of the family of long chain fatty acids omega-6 (ω-6) and α-linolenic acid - equivalent of long chain fatty acids omega-3 family (ω-3). Polyunsaturated fatty acids perform two functions: they are components of the phospholipids of all cell membranes, on which depends the transfer of pulses and work the receptors and precursors for the synthesis of lipid mediators (eicosanoids), which are important in the regulation of many physiological processes [2, 3]. Omega-3 fatty acids improve the immune system, reduce blood coagulation, TAG level in the blood and the risk of coronary heart disease [4].

Remains debatable question regarding the optimal ratio of individual lipid classes of fatty acids food products, but most scholars are unanimous that the greatest biological effectiveness of lipids leads levels of omega-3 fatty acids. The ratio of ω-6 / ω-3 polyunsaturated fatty acids, it is recommended by the Institute of Nutrition in the diet of a healthy person should be 10: 1, and nutritional therapy - from 3: 1 to 5: 1 On the basis of clinical and experimental studies of scientists acid ratio ω-6 and ω-3, it is recommended is from 4: 1 to 2: 1 [5].

British Nutrition Foundation considers the ideal ratio between PUFA families ω-6 and ω-3 as a 6: 1 To achieve this, the ratio of the UK population is recommended to increase the intake of oily fish, containing a significant amount of PUFA ω-3 family. Din N. Jehangir contends that the consumption of oily fish once a week by 50% reduces the risk of stenocardia and atrial fibrillation in patients with cardiovascular disease, regardless of comorbidities [6].

To ω-6 fatty acids include linoleic (C18: 2), γ-linolenic (C18: 3n6), and arachidonic (C20: 4). Linoleic acid in the body can be elongated and desaturovana to arachidonicand the last is a precursor to the formation of eicosanoids. Linoleic acid-rich overwhelming amount of vegetable oils. Exception is olive oil, which is dominated oleic acid (ω-9), which contributes to lower of plasma cholesterol levels and necessary for the balance of polyunsaturated fatty acids.

The structure of ω-3 fats includes the three essential fatty acids: eicosapentaenoic acid (C20: 5) and docosahexaenoic acid (C22: 6) and α-linolenic acid (C18: 3n3). In the body of α-linolenic acid by the elongation and desaturation is converted into eicosapentaenoic acid - a precursor for the synthesis of eicosanoids, and docosahexaenoic acid - an important structural component of the phospholipids of cell membranes.

Research of scientists found that a living organism does not synthesize linoleic and linolenic acids, they can only come from food. Depending on the initial fatty acid eicosanoids are synthesized which have different structures and biological effects on the organism, often directly proportional. Eicosanoids formed from ω-3 fats, namely eicosapentaenoic acid, have anti-inflammatory, anti-allergic effect, blood thinners and prevent the thrombus formation, improve blood circulation, dilate blood vessels and reduce blood pressure. Conversely, eicosanoids synthesized from arachidonic acid (ω-6) contribute to the development of inflammation, allergy, platelet aggregation and thrombus formation,

blood vessels constrict. Exception is prostaglandin E1 which is derived from γ-linolenic acid (ω-6) and has anti-inflammatory effect and slows exemption of histamine, reducing allergic inflammatory component. Clinical research proves that deficiency in the cells of essential polyunsaturated fatty acids (especially ω-3) forms a high potential of inflammation [7].

Therefore it is very important is the introduction of the diets of these fat products that will provide the desired physiological needs of the body's balance of essential acids, ω-6 and ω-3.

An important argument in favor of vegetable oils is their safety as they contain α-linolenic acid which is a precursor necessary for the metabolism of the body and can accumulate in the body and consumed as needed.

However, the oil from sunflower seeds contains primarily family PUFA ω-6 (62.58% in our research), and the ratio of ω-6/ω-3 PUFA does not conform to the formula of balanced nutrition. Is why we calculated the fatty acid composition blends "sunflower × each of unconventional oils" in the following proportions: 50 × 50; 55 × 45; 60 × 40; 65 × 35; 70 × 30; 75 × 25; 80 × 20; 85 × 15; 90 × 10; 95 × 5. In further research elected blends, the fatty acid composition of which is within the range recommended by nutritionists: acid ratio of ω-6 to ω-3 10: 1 to 3: 1 is:

№ 1 - Sunflower oil 65% × walnut oil 35%

№ 2 - Sunflower oil 75% × 25% linseed oil,

№ 3 - Sunflower oil 60% × 40% camelina oil.

Materials and methods

As the research subjects was selected prevalence in the diet of the population of Ukraine vegetable oils obtained by cold pressing of the first technology spin - sunflower, soybean, rapeseed, linseed, mustard and unconventional oils – camelina hemp seed, maranth, sesame, cedar, pumpkin, walnut, wheat germ oil, fruits of sea buckthorn and grape seed. Also studied widely represented in the trading network olive oil varieties "Extra virgin".

Fatty acid and the isomer composition of vegetable oils was analyzed on a gas chromatograph Agilent 6890 (USA) with capillary column, programmed mode and ionization-flame detector Methods by preparation methyl esters according to ISO 5509-2002, analyzing the method of gas chromatography according ISO 5508-2001.

Method of preparation of the methyl esters according to ISO 5509: 2000 analyzing method of gas chromatography of methyl esters of fatty acids - ISO 5508: 1990 Sample preparation was as follows: the sample was dissolved in 2 ml of heptane was added by pipette 200 microliters of methanol solution of NaOH and shaken for 5 - 10 min. , then added to a solution 1 g of sodium hydrogen sulfate monohydrate and carefully agitated. After deposition of salts was separated upper layer containing the methyl esters of fatty acids. Detection of fatty acids was performed on a gas chromatograph: injector S/S with the allocation flows column Sp2380, length 100 m, internal diameter 0.25 mm, the coating thickness 0.2 micrometers. Chromatography conditions: temperature of injector - 280°C, discharge stream - 100: 1, the temperature detector - 290 °C. The column operates at a constant stream with speed of 1.2 ml/min, carrier gas helium. Temperature gradient column thermostat from 60 to 250°C. Research oxidative stability of blends was performed during storage at room temperature with free access of light and air. Samples of fat blends were stored in glass cups at 20 ± 2°C. As a control, use sunflower oil. During storage every 7 days selected samples to determine the peroxide (according to ISO 3960: 1998) and acid

(according to ISO 660: 1996, NEQ) numbers. Oxidation blends stopped when the number of peroxide value reached more than 10 mmol½O / kg. When exceeding this value vegetable oil is considered dangerous for health and becomes inedible product category. According kinetic curves defined oxidation induction period of oxidation, which is used for the prediction deadline storage oil.

Results and discussion

Biological and food respectively, the value of vegetable oils characterized by the composition and the ratio of fatty acids. Table. 1 shows the fatty acid composition of vegetable oils investigated oilseeds and fruit seeds.

Table 1

Fatty acid composition of vegetable oils

Vegetable oils	Fatty acids,%				Ratio ω-3/ω-6
	Saturated fatty acid	Monounsaturated	Polyunsaturated		
		ω-9 (oleic)	ω-6 (linoleic)	ω-3 (α- linolenic)	
Sunflower	11,34	24,61	62,58	0,09	1:695
Soy	15,64	21,36	55,60	5,73	1:10
Rape	6,86	58,99	18,68	9,13	1:2
Corn	11,31	43,1	44,90	0,65	1:69
Olive	15,53	72,06	7,12	0,59	1:12
Flaxseed	10,24	17,30	14,31	57,26	1:0,25
Camelina	9,96	15,99	19,26	33,85	1:0,6
Hempseed	10,74	13,53	55,40	15,32	1:3,6
Mustard	4,87	33,53	10,96	11,25	1:1
Amaranth	17,83	23,97	53,75	1,31	1:41
Sesame	11,31	38,0	40,71	0,34	1:130
Pumpkin	19,71	21,47	58,38	0,14	1:417
Walnut oil	8,21	16,56	61,35	13,58	1:4,5
Wheat germ oil	18,24	14,86	57,03	6,69	1:8,5
Sea buckthorn oil	29,32	5,82	16,84	4,94	1:3,4
Grapeseed oil	11,51	19,6	68,15	0,45	1:151

According to table. 1 sunflower and corn oils contain high amounts of ω-6 acids and small - ω-3 acids and therefore have no optimum fatty acid composition. Soybean oil is recommended for consumption ratio ω-3/ω-6 PUFA (1:10). For rapeseed and mustard oil are of relatively low levels of saturated fatty acids (7.4%), high oleic acid level (33-59%) and the average level of linolenic acid (9-11%) and thus is favorable balance of ω-3/ω-6 as 1:1-2. Olive oil characteristically high oleic acid and low levels of PUFA. In linseed and camelina oil content of irreplaceable α-linolenic acid is much higher than the recommended levels, which indicates their high physiological value and feasibility of using enrichment ω-3 acid foods. A distinctive feature of camelina oil is gondoinovoy content (14%) and erucic

(about 3%) acids. Walnut oil and hemp have a sufficiently high content of α-linolenic acid, but their use is limited to the high cost and nonproliferation. Other oils do not conform to the recommended dietary intake of PUFA ratio ω-3/ω-6.

We have developed blends based on sunflower oil with additives camelina oils, flax and walnuts with a fatty acid content families of ω-6: ω-3 from 10:1 to 3:1. This ratio corresponds to a nutritionist recommended "ideal" ratio of essential fatty acids diet. Basis for the blend elected sunflower oil. This is a traditional non-deficient product daily demand and consumption. Taste of Ukrainian sunflower oil consumer evaluates as "correct" neutral.

Having investigated blends and to determine them PN plotted changes PN of blended oils within 28 days (Fig. 1)

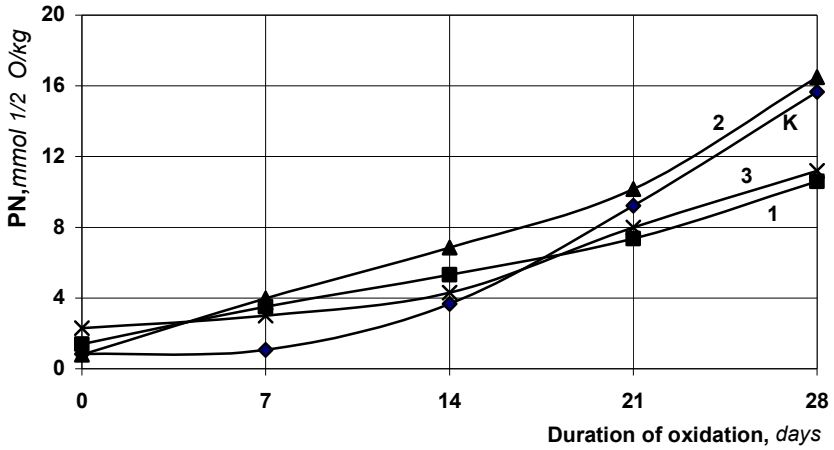

Fig 1. Changing the of peroxide number of blended oils during 28 days:
K - Sunflower oil
№1 - Sunflower oil 65% × walnut oil 35%
№2 - Sunflower oil 75% × 25% linseed oil
№3 - Sunflower oil 60% × 40% camelina oil

Time to reach PN = 10 mmol ½ O/kg is guaranteed shelf life of oils. It has been established that the addition of linseed oil in an amount of 25% negatively affects the stability of the vegetable oil, such oxidize faster than other blends. The longest period of storage - 27.5 days with free access to air and light - is number one with a blend containing 35% of walnut oil.

High resistance is noted as a sample number 3, which is period of storage 25.7 days. Thus, high resistance to oxidation processes are different blends of sunflower oil camelina and walnut oil.

Such blends appropriate to apply the treatment and prevention of atherosclerosis, to improve the effectiveness of diet therapy and correction of lipid metabolism in patients with type II diabetes, diseases of the cardiovascular system.

Investigation of autocatalytic oxidation and hydrolytic of blends at their storage at a temperature of 20 ± 2 ° C, with free access of light and air showed that blend with linseed oil oxidizes rapidly. Therefore, it was removed from further research. Obtained by oxidation curves calculated kinetic parameters of the oxidation process of blended oils (Table 2).

Table 2

Kinetic parameters of oxidation of blended oils

Sample	Kinetic parameters	
	kp2 /k7·10^{-5}	k7·10-4, $dm^3 \cdot mmol^{-1} \cdot c^{-1}$
1. Sunflower Oil 60% + 40% camelina oil	0,52	15,7
2. Sunflower oil 65% + walnut oil 35%	0,44	18,5

Kp2/k7 parameter value shows the ratio of rates of initiation and termination of the reaction rate of oxidation of the substrate. Parameter value greater than zero indicates the antioxidant properties of biologically active substances contained in blends. Thus, sunflower - camelina blend with parameter equals 0.52 kp2/k7 more stable during storage than sunflower - walnut blend with the value kp2/k7 - 0,44. The obtained values of the constants k7 indicate that the addition of camelina oil or walnut improve the inhibitory properties of the oxidation of the investigated blends.

Established antioxidant activity of additives camelina oils or walnut used for the prediction of the oxidative stability of oils blended.

Conclusion

Thus, we can say that the main indicator of biological and, accordingly, the nutritional value of oil is a fatty acid content. Their ratio in the diet affects the condition of the human organism, the problem of excessive weight and premature aging.

To get products increased biological value appropriate to use the principle of blending oilsthat allows to reach balance on the fatty acid composition and provides the functionality of the product. Economic efficiency and simplicity of the technology of blending oils recovered their production in the discharge actual and perspective.

Developed blends of sunflower oil with camelina and walnuts are stable to oxidation and can be recommended for the production of health-preventive foods.

Detected that blending traditional sunflower oil with other types of vegetable oils discloses an opportunity to solve two problems: improving the biological value of fat through the optimal balance of fatty acid composition and increases their resistance to oxidative damage. Therefore, this type of fatty foods is a priority for their nutritional value.

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Screening strains for fermentation of meet raw material

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Abstract

Introduction. Promising technology in fermented meat products is the use of bacterial products containing the same composition in lactic acid bacteria and microorganisms of other taxonomic groups.

Materials and methods. Microbiological analysis of 6 samples of meat brine was conducted to study the quantitative and qualitative composition of microflora. Isolates were tested for Gram reaction, cell morphology, catalase formation, CO_2 production from glucose, hydrolysis of arginine, nitrate reduction, catalase and aroma forming activities, ability to grow at 10 °C and 45 °C and at pH 3 and 9.2, and for their tolerance to 4 % and 15% salt. Proteolytic activity of the cultures was determined at IPA medium with 5% NaCl and with 10% hydrolyzed milk.

Results. The number of bacteria in cm^3 of brine, does not exceed millions of cells. The most common genus in meat brine is Lactobacillus, Micrococcus, Staphylococcus. The presence of reduction of nitrate, catalase and aroma forming activities were discovered in 52 % of the selected strains of bacteria. The number strains capable of growth in present salt was decreased with the increasing salinity of the medium. Almost all crops grown in the temperature range (10-40) ^{0}C. The vast majority of strains of staphylococci was able to hydrolysis of milk proteins. Two highly productive staphylococci and five strains of lactic acid bacteria were selected by both biological and technological characteristics.

Conclusions. Properties of the selected strains of bacteria allows to attract the best of them for the manufacture of fermented meat products.

Introduction

Recently, the use of new, functional starter cultures with an industrially or nutritionally important functionality is being explored. Functional starter cultures offer an additional functionality compared to classical starter cultures and represent a way of improving and optimising the meat fermentation process and achieving tastier, safer, and healthier products. Examples include microorganisms that generate aroma compounds, health-promoting molecules, bacteriocins or other antimicrobials, contribute to cured meat colour, possess probiotic qualities, or lack negative properties such as the production of biogenic amines and toxic compounds. The vast quantity of artisan fermented sausages from different origins represents a treasure chest of biodiversity that can be exploited to create such functional starter cultures.

In the production of cured meat products staphylococci and lactic acid bacteria (LAB) are the most important bacteria apply to the meat products.

Lactic acid bacteria play an essential role in the production of fermented meat products, *Lactobacillus* being the main species used in the European type of fermented products. In order to ensure sensory quality and good color formation, lactic acid bacteria are not sufficient and the contribution of *Staphylococcus carnosus* is needed. Some strains of meat lactobacilli exhibit important properties from a technological point of view, such as the production of antimicrobials. The application of bacteriocinogenic lactic strains as starter cultures in fermented products could provide an additional tool for preventing the outgrowth of food pathogens in sausages as well as enhancing the competitiveness of the starter organisms in favor of the fortuitous flora. However, further research is needed before the application in meat products of these bacteriocins can be put into practice. The spectrum of application of lactic acid bacteria is wide; lactobacilli are good candidates as probiotic strains, thanks to their GRAS status and their ability to adhere to epithelian cells. In the near future, lactobacilli probiotic cultures will be included in new foods; fermented meat products are likely to be one of these foods.

The production of organic acids - mainly lactic acid - from carbohydrates is the major role of LAB in sausage fermentation. This depends on several chemical, physical and microbiological reactions. While acidifying the batter, LAB participate in the coagulation of muscle proteins, resulting in the increased slice stability, firmness and cohesiveness of the final product They also enhance the spontaneous reduction of nitrites to nitric oxide, which reacts with the myoglobin to form nitritmyoglobin, the compound responsible for the typical pink color of cured sausage. Moreover, they contribute to the flavor of the final product through the formation of noticeable acidic and vinegary (acetic acid) tastes. Acidic conditions are also thought to increase the activity of cathepsin D, which is responsible for muscle proteolysis. The production of organic acids is undoubtedly the determining factor on which the shelf life and the safety of the final product depends. The inhibition of pathogenic and spoilage flora is also dependent on a rapid and adequate formation of these organic acids. Finally, it has been reported that a rapid decrease in pH caused by amine-negative starter cultures can largely prevent biogenic amine (BA) accumulation in sausages.

The critical features for selected staphylococci are pH tolerance and temperature tolerance enabling them to produce important enzymes under the relatively low temperature conditions present during fermentation. Staphylococci enhance color formation and color stability in addition to repressing hydrogen peroxide induced rancidity. The most commonly applied staphylococci are *Staphylococcus carnosus* and *Staphylococcus xylosus*, beneficially in a blend, as both strains produce different relevant functional components.

Together with proteolytic and lipolytic enzymes in the meat the enzymes produced by staphylococci contribute also to the aroma formation.

Besides, the most promising starter strains are those isolated from naturally fermented meat products once they are the dominant and the well adapted population.

The aim of this work the brine microflora, used in the manufacture of meat products was investigation and search for strains of different taxonomic groups with high levels of biochemical activity.

Materials and methods

6 brines samples were taken for microbiological examination. These brines within pH 6.4 to 6.6 was used for various raw meat. Samples of brine were selected for different duration of pickles. Brines for № 1-3 ham "special" was taken after 7 days of pickles, pickles № 4-5 for ham - 2 days.

One milliliter of each sample homogenate was diluted serially tenfold in saline solution (0.85% NaCl). Diluents (0.1 ml) were plated on appropriate agar medium for microbiological analysis.

A total of 57 isolates were identifed by comparing the morphological, physiological, and biochemical characteristics of the strains. Isolates were tested for Gram reaction, catalase formation, cell morphology, CO_2 production from glucose, hydrolysis of arginine, nitrate reduction, catalase and aroma forming activities.

They were also tested for their ability to grow at 10 °C and 45 °C and at pH 3 and 9.2, and for their tolerance to 4 % and 15% salt. Proteolytic activity of the cultures was determined at IPA medium with 5% NaCl and with 10% hydrolyzed milk.

Growth in high salt concentration was observed after 3 days of incubation at 37 °C on MRS agar (Merck, Darmstadt, Germany) plates added with 3.0 and 9.2% of NaCl (Merck, Darmstadt, Germany), respectively. Growth in the presence of commercial curing salt was observed after 3 days of incubation at 37 °C on MRS agar (Merck, Darmstadt, Germany) plates added with commercial curing salt (Cura 102 - Duas Rodas Industrial Ltda, Jaraguá do Sul, Brazil), with sodium nitrate and sodium nitrite in respective concentrations of 300 and 150 $mg.kg^{-1}$.

For the nitrate reductase test, a swab of each culture on selective agar (Merck, Darmstadt, Germany) plates (anaerobically incubated at 37 °C for 48 hours) and suspended in sterile peptone water 0.1% with turbidity equivalent to 0.5 McFarland. A 1.0 ml aliquot of homogenized bacterial suspension was added to a sterile tube containing nitrate broth (DIFCO, Lawrence, USA). All tubes were incubated anaerobically at 37 °C for 48 hours. After the incubation period, 1 drop of each reagent of the NIT test (NIT 1 + NIT 2 reagents bioMérieux®sa, Marcy l'Etoile, France) was added to each tube. After 10 minutes, the presence of red color indicated positive reaction to the reduction of nitrate to nitrite. A negative control with no substrate and a positive control with a culture of *S. xylosus* positive for nitrate redutase were used.

Belonging Gram positive cocci and catalase positive cocci to the genus Staphylococcus installed in the following diagnostic tests : fermentation of glucose to form acid under anaerobic conditions; capacity for oxidation of glycerol in the presence of erythromycin (0.4 mg/l); sensitivity furazolidon (disks 100 mg); resistance to lysozyme.

Analysis confirmed the purity of the culture of staphylococci and partitioned mixed culture if necessary.with rapid diagnostic system «Diastaf». Preparation: using a disc with an antibiotic batumin can reliably and quickly (within 18 hours). Differentiate Staphylococcus area for growth inhibition around the disc from other Gram-positive cocci

that are insensitive to the drug. Preparation " Diastaf " does not affect the growth of microorganisms other taxa and provides rapid diagnosis of staphylococci in mixed cultures The drug is intended for the detection of staphylococci in clinical , veterinary and research institutions.

The presence of coagulase define a preliminary assessment of the degree of safety of staphylococci was performed according to ISO IDF 138:2003. For positive and negative controls were reacted with typical collector strains of S. aureus HISK 049,065 and Kocuria varians ATCC 9341 , respectively.

Results and discussion

Lactic acid bacteria predominated particularly (35-43%) in brine for ham, whereas advantage on the side of coccoid forms - micrococci and staphylococci (33-36%) was in brine for balyk. A significant proportion were yeast (11-17%) and spore-forming bacteria - from 17 to 24% (Tab.1). Content of sanitary exponential mikrofalora didn't exceed 11%.

27 isolates catalase positive cocci was isolated from brine applying the diagnostic tests, and 20 of them (74.4%) assigned to the genus Staphylococcus.

In previous assessments of the safety 20 strains of staphylococci was isolated, of them the 3 strains (15.2%) was found that catalase positive cocci and potentially dangerous. They were removed from further work.

This isolated strains (82%) were able to reduction nitrate / nitrite and the rest strains didn't have this property.

Almost all crops grown in the temperature range (10-40) ^{0}C. The number strains capable of growth in present salt was decreased with the increasing salinity of the medium. Thus respectively for 100% and 96% of strains growth recorded if the concentration of sodium chloride 4.0% and 6.5%, whereas only 80% strains increased in content 10% of NaCl.

pH is a major factor limiting the growth of staphylococci, they was active in acidity pH of 4.5 units of the medium. In this acidity only 64% were viable of the investigated strains.

Taste and aroma of damp-dried products produced by lipolytic and proteolytic activity of microorganisms. Meat proteins are broken down into free amino acids under the action of the proteolytic activity of bacterial cultures that are directly involved in the formation of taste.

Thanks lipolytic activity of microorganisms volatile fatty acids was produced, which are further converted to carbonyl compounds contribute to the formation and flavor of the finished product. The consistency of meat products also depends on the muscle proteins (sarcoplasmic and miofibrylyarnyh). The stronger proteolysis occurs in meat, the more tender it becomes relevant role in this process is played by bacterial culture that affect consistency due to its proteolytic activity.

Research by strains of proteolytic activity showed that the vast majority of strains of staphylococci was able to hydrolysis of milk proteins. Thus, of the 17 strains studied 3 - formed enlightenment zone diameter of 10 cm, 6 - 13 cm to 15 cm, 2 - 20 cm for the remaining 6 proteolytic activity was not observed. The largest diameter of the zone of enlightenment characterized S. xylosus 5307 - 24 cm.

Table 1

Brine microflora

Sample	The total number of microorganisms,UFM/g	Value for groups of microorganisms, %				
		LAB	*MK+ST*	*YE*	*CF*	SIM
Brine 1 for ham,	$1,4 \cdot 10^6$	43	10	16	22	9
Brine 2 for ham,	$4,2 \cdot 10^6$	38	15	17	24	6
Brine 3 for ham,	$5,6 \cdot 10^6$	35	26	11	18	10
Brine 4 for balyk	$1,3 \cdot 10^6$	25	35	14	17	9
Brine 5 for balyk	$1,3 \cdot 10^6$	20	33	15	21	11

Footnotea. *LAB* - lactic acid bacteria; *MK+ST* - micrococci and staphylococci; *YE* - yeast, *CF* - spore-forming bacteria; *SIM* - sanitary indicative microflora.

Conclusions

The qualitative and quantitative composition of microflora meat brine was studed. Five samples of industrial brine microflora have been explored. It was determined that the number of bacteria in 1 cm^3 reaches 10^6 CFU, the main part is a genera Lactobacillus, Micrococcus, Staphylococcus. The most common genera in brine, used for preserving for meat Lactobacillus, Micrococcus and Staphylococcus. Two highly productive staphylococci and five strains of lactic acid bacteria were selected by both biological and technological characteristics. The presence of nitrate reducing, catalase and aroma forming activities were discovered in selected strains of bacteria, so they are promising for the manufacture of fermented meat products.

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Rational use of the collagen

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Abstract

Introduction. The topicality of the work is to justify the choice of low-grade meat raw material as a matrix for tying together calcium ions.

Materials and methods. A safe, effective and affordable enzyme preparation is chosen from literature sources in order to increase the number of functional groups in the raw material.

It was necessary to prove the amount of enzyme preparation for efficient proteolysis subject to technological processes and economic expediency.

Results. It was determined rational pH parameters (6,8 - 7,0), temperature (12±1°C), duration (3 hour), duty of water curve of environment (1:1) and amount of enzyme preparation for efficient proteolysis on model systems (0,1 %).

By means of complete factorial test, followed by mathematical modeling in problem-oriented package MathCad, mathematical model of dependence of length and temperature of proteolysis is developed the indicator of amino nitrogen content in the received of paunch of cattle was selected as the parameter of optimization. The study is conducted and the confirmation of the data in model environments during proteolysis of cow tripe is received.

The results are suggested to use in meat products industry of special food - gerodietetic. The development enables to reduce price of finished product, enrich it with micronutrients and improve it digestion by the human body.

Introduction

Nation health is a determining factor in the effectiveness and efficiency of both social and economic reforms. Today, state suffers from the combined effects of economic, environmental and demographic crisis, which reinforce each other and prevent the improving of the quality of life and socio-economic development of the state's population.

Disruption of the normal flow of processes of natural reproduction of population led to a decrease in the proportion of people whose age is under working age, to growth in working age and older than working age, which generally resulted in an increase in population pressure on the working age population. Overall mortality exceeds twice the corresponding rates of EU countries, the mortality rate of working age people exceeds in 2 - 3 times.

According to the Constitution of Ukraine, ensuring the health of the nation is a problem that should be solved in close conjunction with the public policy and activities of local governments, local communities and populations.

So, ensuring and strengthening of population health, extending the period of active longevity, prolonging life expectancy, focusing on health as a social value can provide citizen with competitiveness in the labor market, professional longevity, welfare and as a result - improvement of life quality, strengthening of human potential, preservation of the gene pool of the people, improvement of the demographic situation in the country. The economic business costs for employment potential recovery from disability will reduce. However it is important to form an understanding of individual responsibility for health.

Meat is the most important food product that provides human with essential, high-quality and full value animal protein. One of the most important tasks of providing humanity with food is to increase production of meat and meat products to satisfy the needs of population. It is important not only to increase the total production of meat products, but also provide their maximum production of each ton of raw materials, improve the quality, nutritional value and commodity indices extend the range. Solving this problem requires work to create precocious meat breeds of cattle, rational use of meat and products of animal slaughter, the intensification of technological processes, creating meat analogy and the use of plant and microbial proteins.

It is known that to achieve high economic efficiency of processing by-products it is necessary to strive to maximize their use in cost-effective high-quality manufactured meat products, such as sausages and smoked sausages that are most in demand and more stable to storage. One of the most promising ways to achieve maximum production efficiency, improve and stabilize the quality of sausages is the production with a minimum cost. This is achieved through the most rational use of raw materials, first of all, through the usage of muscle protein, the wide use of secondary raw materials (scrap, offal, protein components of plant and animal origin).

By-products of the second category have a full set of essential amino acids. As it is shown in Table 1, cattle rumen is the most significant source of collagen, which has more than half of connective tissue proteins (contains 61,3 % of collagen of the total protein). Collagens form insoluble filaments (fibrils), which are the part of extracellular matrix and connective tissues.

Table 1

Chemical composition of beef by-products of the second category

By-products	Protein content, %			
	total protein	collagen	salt-soluble	collagen of the protein
Lips	20,3±2,9	13,4±1,4	0,6±0,1	66,0
Abomasum	14,4±1,5	5,9±0,2	0,7±0,2	41,2
Cattle rumen	17,1±1,8	10,5±0,8	0,8±0,1	61,2
Gullet meat	16,3±1,4	5,7±0,7	1,9±0,1	34,7
Spleen	16,4±0,6	1,9±0,4	7,9±0,2	11,3
Lungs	16,1±1,0	4,3±0,5	4,4±0,1	26,3
Trachea	15,6±0,8	6,2±0,9	-	39,5
Head' meat	18,8±0,4	6,5±0,2	-	36,3
Ears	25,2±0,1	17,9±0,1	-	71,0

Materials and methods

Purpose of the study - the rumen of cattle, leaf mussels, semi-finished and ready-minced sausages.

Rumen of cattle receiving from healthy adult cattle from private farms. Leaf mussels were collected from private mussel farms in the Black Sea in the waters of Kerch. All parties were selected toxicological and radiological control center for evaluating the quality and safety of food materials. Semi-finished and ready-minced sausages produced in the scientific laboratory of the university.

It was determined rational pH parameters, temperature, duration, duty of water curve of environment and amount of enzyme preparation for efficient proteolysis on model systems.

Processing of the experimental data was carried out statistical modeling using Excel spreadsheet and problem-oriented mathematical calculations package Math Cad. A mathematical model of comprehensive quality index calculated by the method of numerical characteristics of the object, based on the law of additivity, which can be used to construct a model of food quality designation. The results of any measurements always contain some error. Therefore, the results of the studies were subjected to mathematical treatment in accordance with the recommendations set forth in by the formulas: arithmetic mean values of the chemical composition of prototypes:

$$\overline{X} = \frac{\sum X}{N}, \tag{1}$$

where X - the individual values of;

N - total number of studies.

Dispersion parameters determined by the formula:

$$S^2 = \frac{\sum (X - \overline{X})^2}{n-1}, \tag{2}$$

where n - sample size;

n - 1 - number of degrees of freedom.

Standard deviation values of parameters determined by the formula:

$$S = \sqrt{S^2} \tag{3}$$

Standard error:

$$S_{\overline{X}} = \frac{S}{\sqrt{n}} \tag{4}$$

The experimental results were treated by mathematical statistics, given the repetition of experiments, average values of the studied parameters, the rate of approximation.

The aim of the research is the usage of cattle rumen in the production of cooked sausages in raw condition. The expediency of using cattle rumen in raw condition in recipe of cooked sausages is due to the thermal properties of collagen. Depending on the nature of collagen, its temperature welding depends on the content of oxyproline. "Welding" temperature raises with the increase in the content of this amino acid residue in the peptide chain of protein. The content of oxyproline for cattle rumen is 7,6 % of the total protein. Accordingly, higher temperature and duration of heating is required to "weld" the rumen, which leads to a decrease in the nutritional value of the given by-product.

Previously, the rumen was deprived of fat, released of the contents, washed in limbo for dimethyl sulfoxide working [$(CH_3)_2S=O$]. After thorough brush cleaning of internal and external sides of the rumen on the umbrella table or on a centrifuge at water temperature of 35 °C for 3 - 4 min the raw materials were sent to the tub to scald at a temperature of 64 ... 68 °C for 5 - 8 min. Then it was transferred to a centrifuge (ISO-3C) for purification.

Results and discussion

Cleaned rumens were cooled in the tub with running water and kept for 20 - 30 min on frames with hooks. At the end of the process rumens were chopped in the meat mincer with a grating diameter of 2 - 3 mm. Salt was added at a rate of 3 kg per 100 kg of raw material (3 %) and dimethyl sulfoxide - 200 ml per 100 kg of rumen (0,25 %).

The ready substance is mixed thoroughly for 3 - 4 minutes and placed in a refrigerator (2 ... 4 °C). Filling was prepared after 24 hours of storage. Before cooking the filling we poured liquid that was released from the rumen softened in salt mixture.

Before salting, beef was chopped in the meat mincer with a grilles diameter of 16 - 22 mm, and for pork – 8 - 12 mm. Meat was` salted and kept at a temperature of 2 - 4 °C overnight. During this process the raw was stored in a container with a layer of 15 cm.

Enzymatic treatment leads to destructive changes of raw materials, increase of number of hydrophilic centers, increase of functional groups as a result of rupture of polypeptide chains, which further will be more accessible for reactions including calcium. However, our goal was not a complete hydrolyzate of protein molecules to amino acids, we tried to achieve only partial hydrolysis to increase the number of free functional groups, including those that are capable of binding calcium (figure 1).

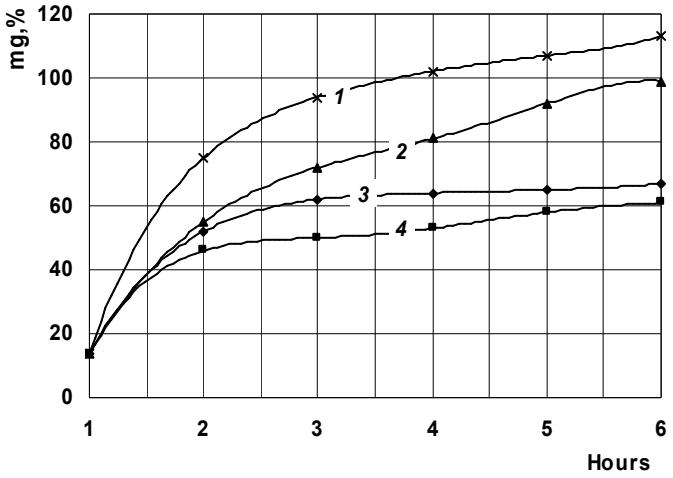

Figure 1. Diagram of accumulation of amino nitrogen in the processing of the rumen of cattle, depending on the ambient temperature:
1 - treatment at 2 °C; 2 - treatment at 12 °C; 3 - treatment at 37 °C; 4 - treatment at 50 °C (pH - 7,0).

Processing of cattle rumen was held by 0,05% solution of the enzyme by weight of raw materials (recommendations of Tolstobokov O. M.) at temperature regimes: 2 °C (cold chamber), 12 °C (in meat processing plants in the shops), 37 °C (norm of body temperature) and 50 ° C (thermostat) for 5 hours.

Proteolysis of protein of collagen containing tissue is observed in all modes, as evidenced by the accumulation of amino nitrogen. The highest rate of proteolysis of proteins is observed during the first time, as shown by angle curves from the second processing time it is reduced. The largest number of amino nitrogen was observed at 37 ° C in each period, minimum - at 2 ° C. So, after 2 hours of fermentation amount of amino nitrogen in samples that were treated at 37 ° C increased by 5.8 times at 12 ° C - 4.5 times, at 2 ° C - 3 times, further the rate of decay of proteins to peptides and amino acids gradually decreased. Thus, the most effective fermentation temperature is 37 ° C.

In conditions of production the support of 37 ° C entails additional costs for equipment and energy, which is undesirable in the development of new technologies. Also such temperature creates optimal conditions for microbial growth. Therefore, temperature 12 ° C is more suitable, which is chosen for further studies because it is constantly maintained at a meat processing enterprises in manufacturing plants, but also increased the concentration of enzyme to 0,1%.

Salted beef was minced in meat mincer with holes diameter of 2 – 3 mm before cooking. Preparation and processing of minced were performed in mixer. Minced meat and rumen were mixed with spices and auxiliary materials for 2 – 3 min. Six batches of minced meat were prepared under the first variant, one batch under the second variant to assess the influence of the composition of minced meat with rumen on the quality of sausages (Table 2).

Pork bellies were filled with minced meat of each batch, twisted like a long loaf of 20 - 25cm long. After ling loaf sinking at temperatures above 8 °C for 2 - 4 hours it was boiled at 80 ± 5°C for 60 min. to achieve the temperature inside the long loaf 75 ± 2 °C. After, the sausage was cooled at a temperature of 12 ± 2°C.

Spices and support materials are the following components (g/100kg, raw): sodium nitrite (solution) – 5; sugar sand - 100; ground black pepper – 100; allspice powder - 100; coriander - 150; fresh garlic – 200.

Table 3 and 4 show the results of the laboratory analysis.

Table 2

The composition of cooked sausages

Ingredients, %	Variant						
	1						2
	A	B	C	D	E	F	-
First class beef	60	60	60	60	60	60	60
Half-fat, veiny pork	35	33	30	28	22	20	30
Cattle rumen	3	5	7	8	9	11	7
Starch of flour	2	2	3	4	4	4	3

Samples of each batch were selected and analyzed under the established rules to (5-7) at the Department of Technology of meat and meat products of National University of Food Technologies determine the organoleptic and physico-chemical parameters and yield. Table 3 and 4 show that batches A, B, C and D meet the requires of cooked sausages. In terms of profitability of used raw and the possibility of using the optimal quantity of rumen batch formulation C and D can be used.

Formulations of the batches E and F do not meet the requirements for the 1st grade cooked sausages because of the smell, taste, color, texture as well as moisture content. The best sausage formulation is from variant 2, as it is shown in Table 3 and 4.

Table 3

Organoleptic evaluation of cooked sausages

Batch	Look	Taste and smell	Look in a cut
A	Loaf with a clean, dry surface without spots don't stick, without flow of minced meat	Taste and smell are specific to the type of product, with a particular aroma of spices, smoking and the smell of garlic, with a pleasant aftertaste, slightly spicy flavor, moderately salty	Stuffing is evenly mixed, has a pink color, without gray inclusions, voids and contains bits of rumen no more than 2-3 mm
B	The same	The same	The same
C	The same	The same	The same
D	The same	The same	The same
E	The same	Unusual to this type of product taste and smell begin to appear	Looseness of minced meat appears in cuts
F	The same	Unusual to this type of product taste and smell strengths	Looseness of minced meat increases
-	The same	Taste and smell are specific to the type of product, with a particular aroma of spices, smoking and the smell of garlic, with a pleasant aftertaste, slightly spicy flavor, moderately salty.	Stuffing is evenly mixed, has a pink color, without gray inclusions, voids and contains bits of rumen no more than 2 - 3mm

Studies showed that the shelf life of such a sausage is no more than 8 days at a temperature not higher than 12 °C and a relative humidity of 75 – 78 %. The moisture

content in the finished product 57 - 60 %, salt – 3 %. The output of finished products (sausages) to substance of unsalted raw is 115 - 128 %.

Depending on the species and varieties of sausages, meat is ground to varying degrees: in pieces weighing 100 g to 16 – 25 mm or 2 – 3 mm and to finely condition. Experiments have found that rumen grinding on the particle with a size of 2 – 3 mm is more profitable than others. It must be emphasized that it is not profitable to salt the by-products before grinding. In medium of the salt + dimethyl sulfoxide the diffusion transition of protein, extractives and minerals from rumen to brine enhances while grinding. It is therefore necessary to maintain rumen in brine after grinding.

It is necessary to mix crushed rumen for 3 - 5 minutes in order to obtain homogeneous medium of salt + dimethyl sulfoxide. Stirring of the rumen for 3 min. does not allow the complete dissolution of the salt in a medium of rumen + dimethyl sulfoxide and stirring over 5 min. leads to the already well-known transition from rumen to the brine of valuable substances. Compatible mixing of salt and dimethyl sulfoxide in the processing of rumen will reduce the complexity of the process.

Table 4

The chemical composition of cooked sausages

Variant	**Batch**	**Consistence**	**Moisture**, %	**Salt**, %	**$NaNO_3$,** 00г
1	A	Elastic	57,0	2,9	0,004
	B	»	57,9	3,0	»
	C	»	58,3	2,9	»
	D	»	59,6	»	»
	E	Slightly fragility	62,0	2,0	»
	F	Growing fragility	63,4	2,6	»
2	-	Elastic	59,5	2,9	»

These data suggest that the reduction of dimethyl sulfoxide in brine would result in undercooking of rumen and its increasing - in the loss of the substance. The timing of exposure in brine - 24 hours at a temperature of 2 ... 4 °C is connected with features of the native structure, composition and properties of by-products, and the inevitability of loss during salting of shredded rumen, that diffusion transition of protein, extractives and mineral substances and vitamins from meat to brine.

The concentration of dimethyl sulfoxide in proposed sausage is 0,015 % what is well below the sulfur compounds in garlic. Indicated content of dimethyl sulfoxide is achieved even when there were no losses during the various processes in the production of sausages.

We should emphasize that the sausage with such quantity of dimethyl sulfoxide cannot be harmful and this product can show the radioprotective properties, at normal temperature it is stored for a long time.

Conclusion

1. The use of the rumen in the production of cooked sausages is the best way to use rumen collagen and dimethyl sulfoxide + NaCl may serve as an inhibitory agent.

2. It is shown that the effective concentration of nutritive collagenase during proteolysis of the cattle rumen is - 0.1% by weight of raw material.

3. It is founded that the maximum proteolytic activity of enzyme preparation - nutritive collagenase at pH - 7,0; duty water curve - 1:1; temperature - 12 °C, proteolysis duration - 3 hours.

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The optimization of conditions for obtaining food supplement with the adaptogenic activity from *Agaricus bisporus*

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Abstract

Introduction. Adaptative and protective systems of the body cannot control homeostasis and respond to changes of the environment satisfactory. The development of supplements with the adaptogenic activity from regional raw materials will be reasonable.

Materials and methods. The studied preparations were the solid residue after treatment of mushrooms (*Agaricus bisporus*) with a number of extragent: boiling water, 3.7 % HCl solution at room temperature, 3.0 – 7.0 % NaOH solution at 98 °C for 1.5 – 4.5 hours. They were characterized by following attributes: the antioxidant activity (AOA), bifidogenic effect (BGE), sorption of cholic acid (SCA). AOA of samples was determined by thiocyanate method (after the initiation of lipid peroxidation). BGE were estimated by the number of *Bifidobacterium bifidum* cell grown in their presence. SCA was determined by spectrophotometrically.

Results. The linear regression equations are obtained. They adequately describe the correlation between AOA, BGE, SCA of isolated preparations and the analyzed factors: the concentration of alkaline agent and time of raw materials treatment. The two-factor interaction coefficients in equations for AOA and BGE are significant and have fairly large values. It is found that increasing treatment time brings about a considerable growth of AOA at low concentrations of the alkaline agent. The impact of treatment time on its level is less in the area of high values of C_{NaOH}. AOA increases significantly with the rise of an alkaline solution concentration when exposure time is minimal. The concentration of alkaline agent has a main influence on the BGE of preparations. Increasing C_{NaOH} from 3.0 to 7.0 % at minimum treatment time reduces the number of microorganisms by more than 3 times. A prolongation of the processing time in the area of minimum values of the alkaline concentration decreases this index. The opposite effect is observed at the maximum concentration. The intensity of SCA by preparations depends on both the concentration of sodium hydroxide solution and treatment time. The enlargement of the alkaline concentration increase SCA. The rise of the treatment time, vice versa, decreases this index. The optimum conditions for obtaining the food supplement with the adaptogenic activity from *Agaricus bisporus* is a raw materials treatment with boiling water, 3.7 % HCl solution at room temperature, 5.1 % NaOH solution at 98 °C for 4.2 hours. It has AOA being equal to 90.0 %, SCA – 22.4 mg/g of the supplement, BGE corresponding to $1.5 \cdot 10^{12}$ CFU/cm^3.

Conclusion. It can be recommended as the food supplement with the prevention activity if its adaptogenic properties were confirmed *in vivo* test. In Ukraine there are no preparations with such activity obtained from local raw materials.

Introduction

Most Ukrainians adhere to the deep-seated nutritional traditions developed by previous generations. However, according to medical researchers, our crusted habits may lead to a failure of the corresponding human integrating, adaptative and defence systems to control the homeostasis and react properly to any changes in the environment [1-3]. In this situation, a possible solution may be use of preparations with the adaptogenic activity [4, 5]. But raw materials required for their production include plants that do not grow in Ukraine [6, 7].

Nevertheless, cultivated mushrooms, in particular *Agaricus bisporus*, may become the promising regional raw materials for obtaining preparations with the adaptogenic effect. Earlier on we succeeded in isolating biopolymer complexes from *Agaricus bisporus*. β-glucan and aminopolysaccharide were predominating substances in their composition. A preliminary description of the properties of the said complexes showed that they are preparations with a multiple-vector effect. These complexes have marked antioxidant and antacid properties, water and fat binding capacities; besides, they can stimulate growth of bifidobacteria and bind xenobiotics and some metabolic products [8, 9].

An efficacious preparation with the adaptogenic activity is expected to have a high antioxidant effect, to recuperate a functional activity of the immune system and to have a positive influence on lipid metabolism [5].

It was found that samples of biopolymer complex showing these properties to different extents could be obtained by varying the mushroom treatment conditions. Thus, the range of AOA level in the preparations fluctuated from 33.1 to 99.8 %. The growth of bifidobacteria in their presence that set up the immune response and enhance nonspecific resistance of human organism was $0.74 \cdot 10^{12} – 2.53 \cdot 10^{12}$ CFU/cm^3. The sorption of cholic acid that had an indirect positive effect on lipid metabolism varied from 18.0 to 30.3 mg/g of the sample [8, 9].

In this regard, we deem it expedient to adopt the following values for the essential indexes of the food supplement with the adaptogenic effect: antioxidant activity (AOA) of more than 90.0 %, and bifidogenic effect (BGE) of $1.5 \cdot 10^{12}$ CFU/cm^3 and more, with the highest possible value of sorption of cholic acid (SCA).

The aim of this research was to determine the optimum conditions for obtaining the food supplement with the parameters aforementioned.

Materials and methods

The preparations were obtained by sequential treatment of raw materials with hot water and 3.7 % HC1 solution at room temperature. The solid residue was treated with 3.0 – 7.0 % NaOH solution at 98 °C, the time of treatment were varying in the range of 1.5 – 4.5 h.

AOA of preparations was determined according to [10] with modification. 5 cm^3 of 0.1 % solution of sunflower oil in ethanol was added to 50 mg of preparation. Oxidation was carried out at 90 °C for 90 min. After cooling, 0.5 cm^3 of 30 % $NH_4(CNS)$ solution and 0.5 cm^3 of 0.02 M $FeSO_4 \cdot 7H_2O$ solution were added to the reaction mixture. The colour intensity of the solution was measured at 500 nm. The control did not contain the sample. AOA was calculated by comparing the colour intensity of the test sample and control.

BGE of preparations was estimated by their ability to intensify the growth of *Bifidobacterium bifidum* cells. For this 5 % suspension of *Bifidobacterium bifidum* cells from Biopharma and 2 % of the preparation were added to the sterilized milk. Ripening was

carried out at 37 °C. The viable count of *Bifidobacterium bifidum* was determined by plating the appropriate dilutions into thioglycollate medium. All plates were incubated anaerobically at 37 °C for 72 hours. The results were expressed as CFU/cm^3.

For determination SCA 2.5 cm^3 of cholic acid solution in phosphate buffer, pH 8.0 (1 mg of acid per 1 cm^3) was added to preparation (0.1 g). The mixture was hold at 37 ºC for 2.5 hours. Then it was filtered. The cholic acid concentration in the filtrate was determined by spectrophotometrically. For this 0.4 cm^3 of 1 % fructose solution and 5 cm^3 of 67 % sulphuric acid solution were added to 1 cm^3 of filtrate. The mixture was being heated at 60 ºC for 15 minutes. Then it was rapidly cooled. The optical density of the solution was measured at 580 nm. A blank experiment was carried out in parallel. The cholic acid concentration in solution was determined using a calibration curve prepared for cholic acid (Sigma). SCA was evaluated by changing the cholic acid concentration in the solution before and after contact with preparation.

To trace the dependence of the properties of the preparations on the conditions for their obtaining, we used a method of a 2^2 factorial experiment. The test in the middle of experiment was conducted for the determination of the significance of quadratic effects.

The levels and intervals of factors variation that influenced the preparations' properties were selected on the basis of the results of a series of preliminary experiments. All the experiments were conducted in three simultaneous replications. Uniformity of the results obtained was verified by means of Cochran's test. In order to exclude the influence of any systematic errors caused by the external conditions, the experiments were randomized [11-13].

The design matrix of the experiments is given in Table 1.

Calculation of the regression constants, evaluation of their significance, and verification of the adequacy of equations were performed with the PLAN program, that realizes the least-square method and sequential regression analysis [14].

Response surfaces were plotted on the basis of these equations by means of Microsoft Office Excel 2003, a standard software package application (license № 74017-640-0000106-57490) [15, 16]. Further, we developed a program with the Turbo Pascal language which allowed drawing superposed contour lines of three regression equations [14].

Table 1

The design matrix of the experiments

Number of the experiment	Experimental conditions in dimension			
	natural values		encoded values	
	C_{NaOH}, %	τ, h	x_1	x_2
1	3,0	1,5	–1	–1
2	7,0	1,5	1	–1
3	3,0	4,5	–1	1
4	7,0	4,5	1	1
5	5,0	3,0	0	0

Results and discussion

The averaged results obtained for each index of the properties of the preparations as well as all relative errors in the replicate observations for $\overline{y}_1$, $\overline{y}_2$, and $\overline{y}_3$ are represented in Table 2.

As it is shown in the Table 2, the relative errors in the replicate observations do not exceed 5%, which evidences a high accuracy in determination of all the studied indexes of the properties $\overline{y}_1$, $\overline{y}_2$, and $\overline{y}_3$ of a preparations.

Table 2

The dependence of the properties of the preparations on the conditions for raw materials treatment

Number of the experiment	Experimental data			Relative errors, %		
	AOA $\overline{y}_1$, %	BGE $\overline{y}_2$, $\cdot 10^{-12}$ CFU/cm^3	SCA $\overline{y}_3$, mg/g	AOA	BGE	SCA
1	35,6	2,5	22,4	3,65	2,50	1,60
2	59,6	0,8	30,0	2,28	0,76	1,20
3	90,4	2,0	18,7	2,07	2,00	1,92
4	99,4	1,0	24,8	0,44	1,00	1,44
5	71,9	1,6	23,3	0,88	0,19	2,90

The least square method together with the sequential regression analysis in the PLAN program enabled us to obtain regression equations in the factors' encoded values that describe the experimental data of the correlation of AOA ($\overline{y}_1$), BGE ($\overline{y}_2$) and SCA ($\overline{y}_3$) of the preparations obtained with the factors studied:

$$y_1 = 71{,}267 + 8{,}250x_1 + 23{,}633x_2 - 3{,}750x_1x_2, \%; \quad (1)$$

$$y_2 = (1{,}567 - 0{,}685x_1 - 0{,}063x_2 + 0{,}185x_1x_2)\cdot 10^{12}, \text{ CFU/cm}^3; \quad (2)$$

$$y_3 = 23{,}975 + 3{,}425x_1 - 2{,}208x_2, \text{ mg/g}. \quad (3)$$

where x_1 and x_2 are encoded values of the factors determined by the ratio as follows:

$$x_1 = \frac{C_{\text{NaOH}} - 5}{2}; \qquad x_1 = \frac{\tau - 3}{1.5}.$$

The confidence intervals for equations (1), (2), and (3) are equal to 0.814, 0.046, and 0.712 respectively. A statistical assessment of significance of the regression coefficients showed that the regression coefficients are significant in equations (1) and (2) because they are bigger than the corresponding confidence intervals in absolute value ($\varepsilon_{b_i} = 0.814$ and $\varepsilon_{b_i} = 0.046$). Since the number of regression coefficients in these equations is the same as

the number of experiments (and in this case the estimated values of $\overline{y}_1$, $\overline{y}_2$, and $\overline{y}_3$ coincide exactly with the experimental data of $\overline{y}_1$, $\overline{y}_2$, and $\overline{y}_3$), then there is no need for verification of the adequacy of the equations obtained.

The coefficient b_{12} = –0,358 in equation (3) is not statistically significant because it is less than the corresponding confidence intervals in absolute value ε_{b_i} = 0.712. Therefore, it is excluded from the regression equation. Verification of the adequacy of equation (3) shows that the estimated value of Fisher's variance ratio is less than the critical one (F = 1.35 < F_{cr} = 5.35). It allows us to affirm that obtained equation (3) adequately describes the experimental data with reliability 95%.

Relying on the results of the experiments in test 5 and the values of coefficients b_0 for each of equations (1), (2) and (3), we tested the statistical significance of quadratic effects and found that for each index of the properties of a biopolymer complex following conditions are observed:

for AOA

$$|\overline{y}_{1,5} - b_{0,1}| = |71{,}900 - 71{,}267| = 0{,}633 < \varepsilon_{b_i} = 0{,}814;$$

for BGE

$$|\overline{y}_{2,5} - b_{0,2}| = |1{,}600 - 1{,}567| = 0{,}033 < \varepsilon_{b_i} = 0{,}046;$$

for SCA

$$|\overline{y}_{3,5} - b_{0,3}| = |23{,}300 - 23{,}975| = 0{,}675 < \varepsilon_{b_i} = 0{,}712.$$

This implies that for a mathematical representation of the properties of preparations in the full variation range of factors C_{NaOH} and τ it is enough to have linear regression equations (1, 2 and 3) adequately describing this process. The two-factor interaction coefficients in obtained equations (1) and (2) are significant and have fairly large values. Therefore, it is still difficult to make a definite conclusion as to the strength of the studied factors' influence on the preparations isolation process. This influence can be seen more clearly on the graphically represented response surfaces that were plotted on the basis of the equations.

The analysis of the response surface of dependence $y_1 = f(C_{NaOH}, \tau)$ (see Fig. 1) allows ascertaining that AOA increases significantly with the rise of treatment time when low concentrations of an alkaline agent are used. The impact of treatment time on its level is less in the area of high values of C_{NaOH}. At that an increase in concentration of an alkaline solution leads to a considerable growth of AOA only at the minimum values of τ.

As it is shown in Fig. 2, the main factor that affects the BGE of a preparations is concentration of sodium hydroxide solution. Thus, an increase of C_{NaOH} from 3.0 % to 7.0 % at τ = 1.5 h brings about a decrease in the number of microorganisms by more than 3 times (from $2.5 \cdot 10^{12}$ CFU/cm^3 to $0.8 \cdot 10^{12}$ CFU/cm^3). Influence of treatment time on the intensity of the BGE in preparations changes depending on the alkaline concentration used. A prolongation of the processing time within the range of minimum values of the alkaline concentration decreases this index. And vice versa, the BGE increases in the range of the alkaline maximum concentration.

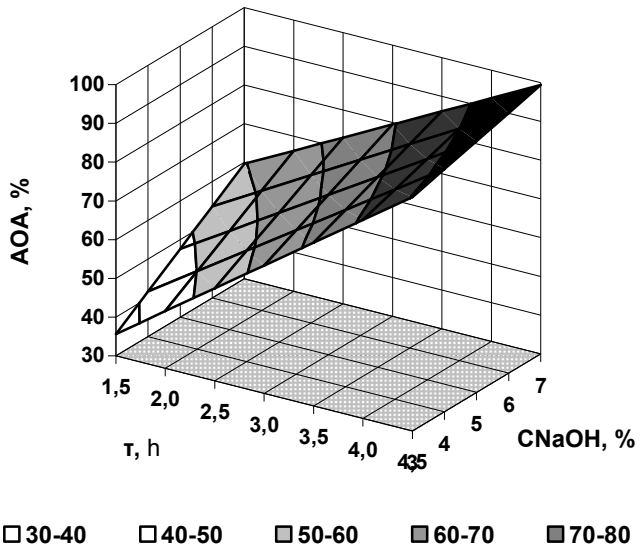

Fig. 1. Response-surface graph representing the correlation between AOA of isolated preparations and the concentration of alkaline agent C_{NaOH}, time of raw materials treatment τ

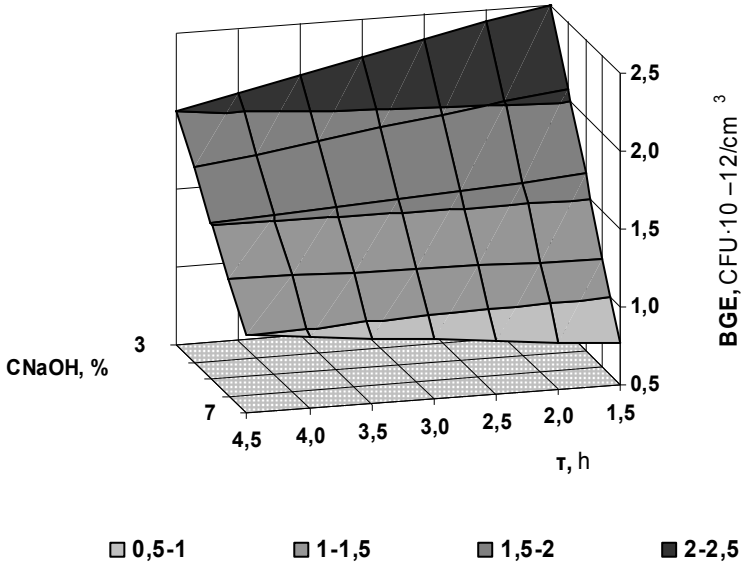

Fig. 2. Response-surface graph representing the correlation between BGE of isolated preparations and the concentration of alkaline agent C_{NaOH}, time of raw materials treatment τ

Since in equation 3 there are no two-factor interaction coefficient, therefore, based on the analysis of the equation obtained, we can make a conclusion that the intensity of SCA depends on both the concentration of C_{NaOH} and time of τ. However, the character of such dependence is different: SCA increases with the rise of the alkaline concentration. Enlargement of the treatment time, vice versa, decreases this index. It can be expressly observed on the response surfaces of dependence $y_3 = f(C_{NaOH}, \tau)$, that is shown in Fig. 3.

Thus, for obtaining a preparation with maximum value of BGE it is necessary to treat the raw material with a diluted sodium hydroxide solution for a minimum exposure time. A high intensity of SCA can be got by treating mushrooms with a concentrated alkaline solution for the same time. And vice versa, the maximum level of AOA may be achieved by a prolonged impact of the concentrated solution of an alkaline agent on the raw materials.

This can be explicitly seen in Fig. 4 where the contour lines of dependence of these properties' intensity on the treatment conditions are shown. The bounds of the area corresponding to the accepted values of optimization parameters (AOA being more than 90.0 % and BGE being more than $1.5 \cdot 10^{12}$ CFU/cm^3) are marked with the letters 'ABC'. The figure also shows that the maximum possible sorption activity within this area can be achieved at the point A.

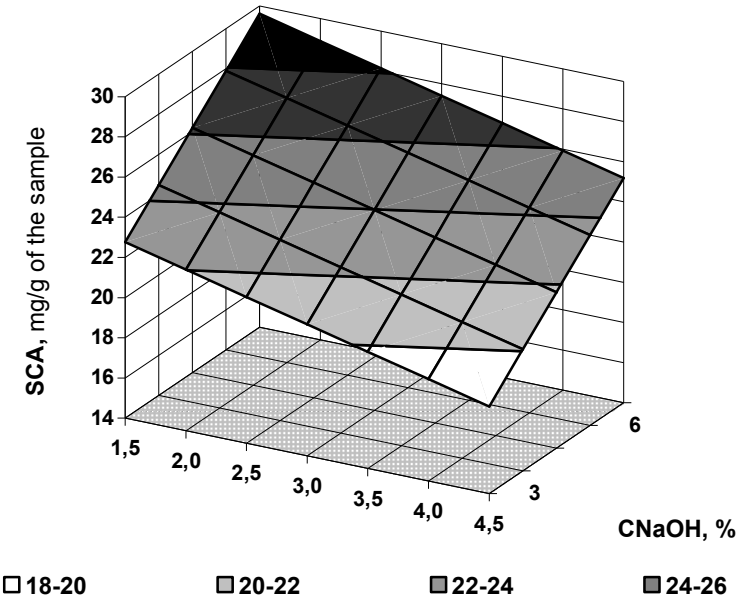

Fig. 3. Response-surface graph representing the correlation between SCA of isolated preparations and the concentration of alkaline agent C_{NaOH}, time of raw materials treatment τ

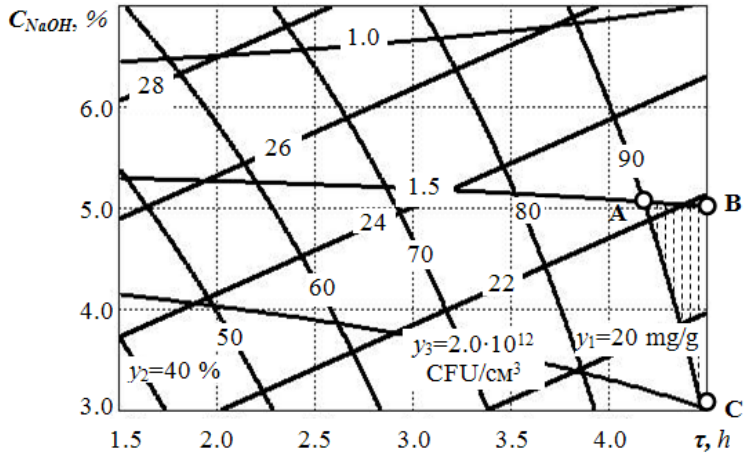

Fig. 4. The contour lines of dependence of AOA, BGE, SCA of isolated preparations on the concentration of alkaline agent C_{NaOH}, time of raw materials treatment τ

Calculation of maximum search of SCA, when AOA and BGE values are corresponded to the normalized levels, allows us to determine the optimum mode for raw materials treatment. In this case AOA is 90.0 %, SCA – 22.4 mg/g of the supplement, BGE corresponds to $1.5 \cdot 10^{12}$ CFU/cm^3.

Conclusion

It is determined the optimum conditions for obtaining the food supplement with the adaptogenic activity from *Agaricus bisporus*. It is a raw materials treatment with boiling water, 3.7 % HCl solution at room temperature, 5.1 % NaOH solution at 98 °C for 4.2 hours.

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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.

Materials 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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Extracting P - vitamin complex from green tea leaves

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Abstract

Introduction. P - vitamin complex from green tea has high antioxidant action of catechins, so it can be used to prevent and treat the most common diseases in the pathogenesis of which activation of free radical oxidation plays an important role.

Materials and methods. Packed big leaves green tea was researched. For extraction of vitamin P methods of simple and repeated extraction were used. Determination of extractives was carried out by evaporation and weighing.

Results and discussion. For the selection of optimal conditions of vitamin P extraction from green tea technological parameters of the extraction with ethanol were studied .

The most complete removal of target compounds is achieved by 60 minute extraction, further increase time of extraction does not increase the amount of extractives.

The best proportion of vitamin P extraction from green tea is the ratio of raw material - extractant 1:40 so as further increase of solvent volume does not increase the number of flavonoids in the extract.

Maximum extraction of target compounds was observed in extraction of raw materials with particles size less than 1 mm. Research of multiplicity extraction showed that it is feasible to use a double extraction.

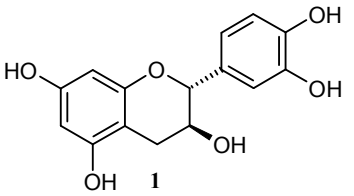
Conclusions. For vitamin P extraction from green tea leaves the following conditions of extraction are optimal: the process time - 60 min, the ratio of raw material - extractant 1: 40 during the grinding of raw materials to a particle size <1 mm, the double extraction of raw materials.

Introduction

For centuries, green tea *Camellia sinensis* and its extracts were used in medicine as a treatment for ailments [1]. The benefits of green tea was provened by modern research [1,2].

The healing properties of this drink due to its chemical composition - a high content of polyphenolic compounds that exhibit P - vitamin action. Catechins are bulk of all polyphenolic (flavan-3-ols). It is the most restored representatives of flavonoids. Green tea contains (+) - catechin 1, (-) - epicatechin 2, (+) - gallokatehin 3, (-) - epigallocatechin 4, (-) - epicatechin-3-gallate and 5 (-) - epigallocatechin -3-gallate (EGCG) 6 [1]. In addition, the composition of tea includes quercetin, kaempferol, and myricetin glycosides.

It is known that the antioxidant activity of plant extracts is caused mainly by the presence in them of natural phenolic compounds [1]. Interacting with free radicals, catechins, like other phenolic compounds neutralize them [1,3]. It should be noted that EGCG - the most powerful known antioxidants of plant origin [1].



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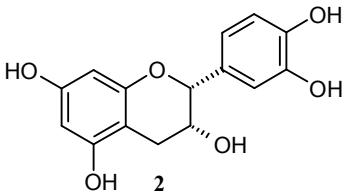

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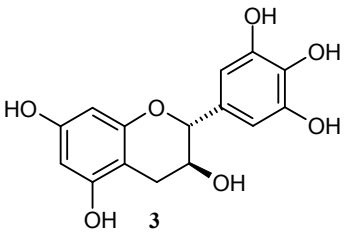

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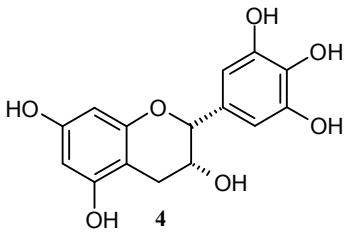

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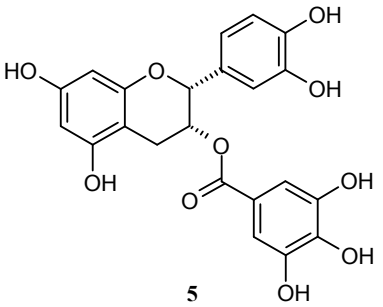

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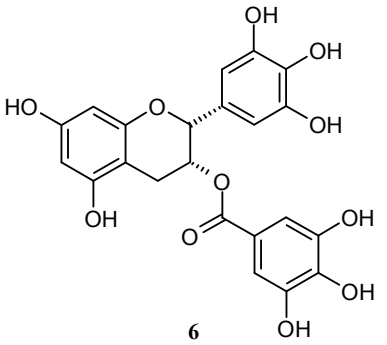

6

Due to its antioxidant action, catechins prevent and slow down atherosclerosis, coronary heart disease, hypertension and its consequences, diabetes, the development of Parkinson's and of Alzheimer's diseases. In addition, EGCG effectively reduse the level of cholesterol and triglycerides in plasma and blood pressure [1,2,3].

Scientists's particular attention is attracted to study antimutagenic and antitumor action of tea catechins, especially EGCG. It was found anticarcinogenic effect of tea catechins. For example, antiproliferative effect EGCG, which also induces and enhances apoptosis of tumor cells [1,2,3,4]. Toxicity tea catechins is minimal, practically they do not cause side effects.

It should be noted that the human's antitumor effect of EGCG is reduced due to low digestibility and its intense metabolism with loss of activity. For getting an effective dose in relation to cancer cells it is necessary to drink 1.5 liters of green tea per day [1]. However, undesirable effects of caffeine, which is found in green tea 1.8 - 2.8%, inevitably occur.

Materials and methods

Green tea is a rich source of flavonoids, its leaves contain 51-84 mg of catechins per gram of dry weight, that several times is more than in black tea [1]. Taking into consideration this, we chose packed chinese green tea as the raw material to produce vitamin P .

Tea leaves except polyphenols contain alkaloids caffeine, theophylline, theobromine, saponins, essential oils, amino acids, carbohydrates, vitamins and minerals. Taking into consideration physical and chemical properties of natural compounds that are included to tea composition for polyphenolic compounds extraction we used consistent processing of raw materials by organic solvents.

Packed big leaves green tea was studied. For vitamin P extraction methods of simple and repeated extraction were used . Determination of extractive substances was carried out by evaporation with the following weighing.

Taken into consideration approaches to extracting natural compounds for the extraction of alkaloids, resins, essential oils and pigments as a non-polar solvent we used dichloromethane. After plant material drying catechins and flavonols glycosides that exhibit P-vitamin activity were bereaved by extraction with the help of ethanol. P - vitamin complex is obtained after evaporation of the resulting extract.

The process of extraction depends on many factors: the duration of the extraction, the ratio of raw material - the extractant, the degree of milling of raw material, temperature, and so on. To ensure a high content of vitamin P in the extract of green tea is recommended to study the optimal conditions for its extraction.

Extraction of alkaloids, resins, essential oils and pigments from green tea leaves. 10 g of green tea is placed in a round bottom flask volume to 250 ml, add 100 ml of dichloromethane and heated in a water bath under reflux with stirring for 2 h. Plant material was filtered under vacuum through a Buchner funnel and dried and used for further extraction of vitamin P.

Extracting vitamin P.

1. The influence of extraction time on the amount of extractives

Samples of 2 g of treated CH_2Cl_2 green tea are placed in round-bottom flasks of 100 ml and 40 ml of ethanol is added. The flasks are heated under reflux in a boiling water bath for 15, 30, 60, 90, 120 min respectively. The extracts were filtered under vacuum.

2. The influence of the ratio of raw material - the number of extractant extractives.

Samples of 2 g of green tea are placed in a round-bottom flasks of 100 ml and ethanol was added at a ratio of 1:10; 1:20; 1:40; 1:50; 1: 100. The flasks are heated under reflux in a boiling water bath for 60 min. The extracts were filtered under vacuum.

3. The influence of particle size on the amount of extractives

Samples of 2 g of crushed green tea leaves with particle sizes respectively <1 1..2, 2..2,5,> 2.5 mm are placed in a round-bottom flasks of 100 ml and 80 ml of ethanol is added. The flasks are heated under reflux in a boiling water bath for 60 min. The extracts were filtered under vacuum.

4. The influence of the multiplicity of extraction on the amount of extractives

Samples of 2 g of crushed green tea leaves with particle size <1 mm is placed in a round-bottom flasks of 100 ml and 80 ml of ethanol is added. The flask was heated to reflux in a boiling water bath for 60 min. The extract was filtered under vacuum. Plant material is retreated with ethanol under the same conditions. Extraction is repeated 3 times. The extracts were combined and used for determination of extractive amount.

Determining the amount of extractives. 20 ml of the resulting alcohol extract of green tea is taken by pipette and it is placed in a predried at a temperature of 100-105 C accurately weighed porcelain cup with a diameter of 7-9 cm. A solution is evaporated to dryness in a water bath. Cup of residue is dried in an oven at a temperature 100-105C to constant matter, then it is cooled for half an hour in a desiccator over calcium chloride and is weighed. The amount of extractives X is calculated by the formula:

$$X = \frac{m_1 \cdot V}{m \cdot V_1},$$

where m - mass of sample, m_1 - mass of dry residue, V - volume of extractant, V_1 - volume of aliquot.

The efficiency of extraction was evaluated by the number of extractives in different technological parameters. To determine the amount of extractives the extraction of raw material exact sample was performed . The extract was transferred into a predried at a temperature 100-105º C accurately weighed porcelain cup with a diameter of 7-9 cm. A solution was evaporated to dryness in a water bath. Cup of dried residue in an oven at a temperature 100-105º C to constant weight, then it is cooled for 30 min in a desiccator over calcium chloride and is weighed.

Results and discussion

It was studied the dependence of the number of substances on the duration of the process, the ratio of raw material - the extractant, the degree of milling of raw material extraction and multiplicity.

The most complete removal of target compounds is achieved with extraction for 60 min, as shown in Figure 1, a further increase in extraction time did not lead to an increase in the number of extractives.

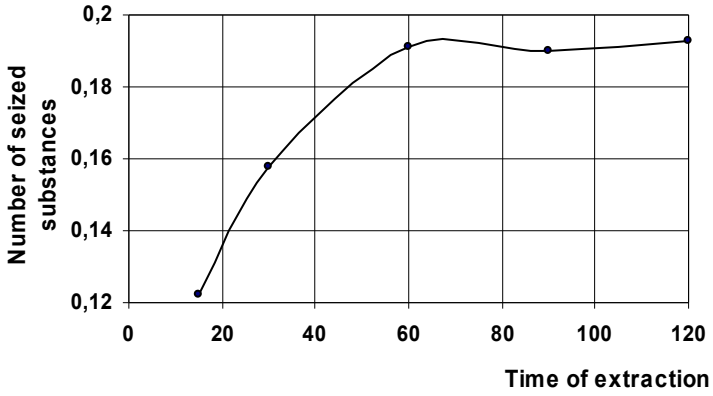

Fig. 1. Dependence of the number of seized substances on the duration of the process

It is established that the optimum ratio for the extraction of vitamin P from green tea (Figure 2) is raw - extractant 1: 40, so as to further increase the number of solvent does not increase the number of flavonoids in the extract.

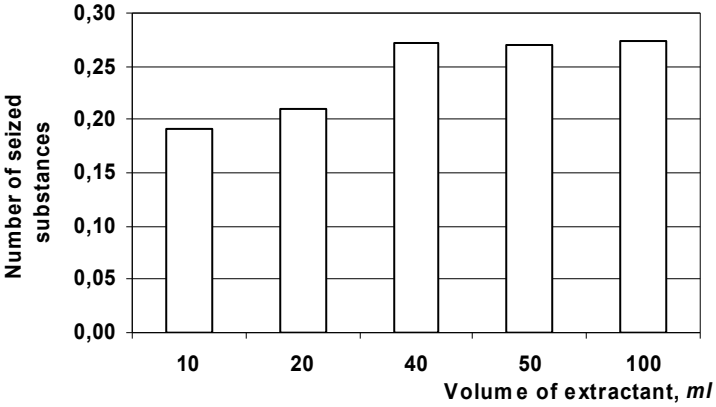

Fig.2. Raw-extractant ratio

On the basis of the calculations it was shown that the maximum extraction of target compounds is observed during the extraction of raw materials with particle size <1 mm (Figure 3).

Research of extraction multiplicity has shown (Table 1), that green tea leaves double extraction should be used.

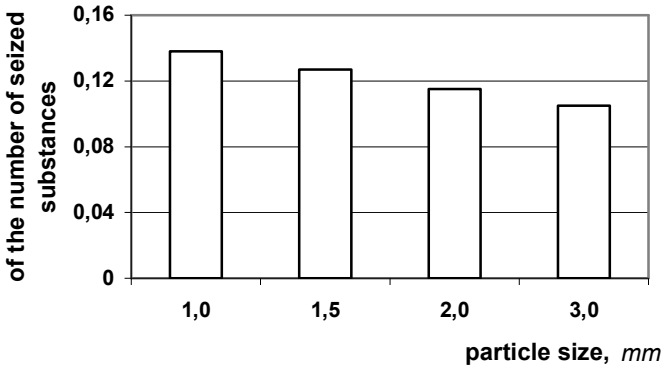

Fig.3. The degree of grinding material

Table 1

Extraction of flavonoids from green tea leaves according to multiplicity

Multiplicity extraction, number of times	**Number of extractives from 1 g of raw material**, g
1	0,272
2	0,052
3	0,019

Conclusions

For vitamin P extraction from green tea leaves the following conditions of extraction are optimal: the process time - 60 min, the ratio of raw material - extractant 1: 40 during the grinding of raw materials to a particle size <1 mm, the double extraction of raw materials.

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Determination of trace elements (Cr, Al, Pb) by atomic absorption in natural water of Kyiv

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Abstract

Introduction. The control of microelements in water is a one of the most important factor of the humans health in urbanized cities. ETAAS method with chemical modifiers has been used in drinking water analysis.

Materials and methods. All measurements of Al, Cr and Pb concentration in superficial and ground water samples were performed with atomic absorption spectrophotometer (model Saturn-3MP, Ukraine), equipped with graphite electrothermal atomizer (model Graphite 2).

Results and discussion. The significant differences between concentrations of lead in the two lakes can be explained by near location to highway of lake in Holosievo region and its contamination by some above mentioned gasoline additives. Unfortunately, the Al content in river Lybid is higher than acceptable level, which associated with continuous using of metal pipes, made from alloy with high aluminium content and uncontrolled emission of detergents and dyes as well. The presence of high content of chromium may be associated with both natural and anthropogenic sources. This may associated with lixivation of industrial solid wastes, which responsible for water contamination during intensive building. The high river water contamination by chromium also was observed

Conclusion. Health hazards related to the lead in drinking water are negligible. Most attention should be focused on Al and especially Cr content in natural water of Kyiv city because their high concentration in sources of drinking water. It is interesting, that consumption of water rich in chromium may have potential health benefit for some individuals such as diabetics, which is known have low chromium content in blood plasma.

Introduction

Chromium is an essential trace element for human health (Kabata-Pendias A. and Mukherjee A.B., 2007; Vincent J.B., 2010). This micronutrient is a cofactor for insulin function, it is reported to affect some of enzymes that control cholesterol level and beneficially impact on lipoproteides ratio (Evans G.V., 1989; Broadhurst C.L. and Domenico P., 2006; Sharma S. et. al., 2011). Chromium deficiency resulted in increased cholesterol and blood sugar level, coronary dysfunction, lipid abnormalities and an increased risk of atherosclerotic disease (Newman et al., 1978). However, excessive concentration of Cr compounds, especially when they are inhaled, may lead to a lung cancer among workers in certain industries (IARC Society, 1990), nasal and small intestine cancer in some species of test animals (Stout M.D. et.al., 2009). The sources of Cr in human diet are vegetables, beer and brewer`s yeasts, whole grains, nuts as well as cheese, liver and marine food (Kabata-Pendias A. and Mukherjee A.B., 2007). The Cr picolinate has been used as the main source of Cr both in medical practice and food fortification (Evans G.V., 1989; Broadhurst C.L. and Domenico P., 2006).

However, the role of aluminium and lead is doubtful. Both of these microelements are present in tissues of animal and human body, but there is no positive effect has been found so far. Aluminium is known to be a neurotoxicant effect which can cause motor neuron disease and brain cells damage due to the excess of this element (Meizi M. et. al., 1993). Industrial Al dust can play a role in aetiology and pathogenesis of Alzheimer disease (Polizzi et.al., 2002). It is known that Al can bind phosphate anions, decreasing availability of P compounds (Kabata-Pendias A. and Mukherjee A.B., 2007). Lead (Pb) is the one of the most dangerous contaminant. Human organism cannot distinguish Ca from Pb, which resulted in the accumulation of the last in the bones and teeth (Kabata-Pendias A. and Mukherjee A.B., 2007). The excessive exposure of Pb may cause several disorders of human health, such as damage of kidney and nervous system, hypertension, cardiovascular and cerebrovascular disease, cancer development, inhibition of heme formation, which further may lead to anemia and porphyria, may associated with erectile dysfunction and depression (Anis T.H. et. al., 2007). The children are the main group of risk because they retain more Pb than adults due to physiological and metabolical differences. If the diet is low in Fe, Ca and proteins, the absorption of Pb would be increased.

The main sources of Pb, Al, Cr and other microelements are the soil, air and ground water. Further they appear in tap water and finally in food. Canned bottles, which made from aluminium, may also play a role of contaminant of food and additional source of this microelement for humans. Aluminium compounds have been utilized as a coagulant on the most water supply plants, which resulted in the increased concentration of Al in drinking water. Lead compounds were used as an anti-knock additive in gasoline in the last century and still illegally used in several counties of Eastern Europe despite the strong restriction.

According to WHO acceptable levels of Pb, Cr, Al are 0.03, 0.05 and 0,2 mg/l respectively (WHO, 1995). These levels are equal to those of Ukrainian regulations of maximum permissible concentration in ground water.

Atomic absorption analysis with electrothermal atomization (ETAAS) is a most commonly used technique for determination of chemical elements at low concentration owing to its low time of analysis, availability, high sensitivity and specificity in different species, in particular in ground water (Acar O. et. al. 2000; Acar O., 2001; Correira P.R.M. et. al., 2003). However, the direct elements determination by ETAAS method is complicated due to the interference effects of salts in sample matrix. To overcome interferences in sample matrix during measurements, preconcentration and temperature

program correction (Gai R.A. et.al., 2006), chemical modification (Acar O., 2001; Acar O. et.al., 2000), coacervative extraction of trace elements prior to determination (Hagarova I. et. al., 2013) and other technique have been used. One of the most often employed approach is the addition of chemical modifiers to the sample. The main purposes of chemical modification are to reduce interference effects and stabilize volatile elements. Method of the direct determination of Pb, Al and Cr in natural water samples by atomic absorption with application of chemical modification technique was used in this work.

Materials and methods

All measurements of Al, Cr and Pb concentration in superficial and ground water samples were performed with atomic absorption spectrophotometer (model Saturn-3MP, Ukraine), equipped with graphite electrothermal atomizer (model Graphite 2). The analytical lamps with wavelengths 283.3 nm for Pb, 357.9 nm for Cr and 309.3 nm for Al have been used in this work. Hollow-cathode lamps of Cr and Al both were operated at 10 mA, whereas Pb lamp – at 5 mA. The slit width used 0,2 nm for Cr and Al measurements and 0,15 nm for Pb. The ramp time was within the range 0,2-0,5 s. Argon used as a carrier gas, the flow of which was equal to 0,25 $l \cdot min^{-1}$. The measurements were repeated twice. The optimized temperature program for Cr, Al and Pb determination is given in Table 1.

Table 1

Temperature program for the determination by ETAAC

Step	Temperature, °C	Hold time, s	Ar, flow rate ($ml \cdot min^{-1}$)
Dry-1	90	20	250
Dry-2	110	5	250
Pyrolysis	400 (Pb) 600 (Cr) 1200 (Al)	5 10 10	250
Atomization	1400 (Pb) 2500 (Cr) 2400 (Al)	5 4 3	0
Cleaning	2700	3	250

All the chemicals used were on analytical grade. Sulfuric, nitric and hydrochloric acids, Fe(III), Mg, Ca chloride, as well as potassium (chloride, sulfate, nitrate) and sodium (chloride, hydrocarbonate, hydrophosphate) salts and also chemical modifiers, including citric, sulfosalicylic, ascorbic, tartaric and oxalic acids, triethanolamine, complexon III were obtained from Sigma-Aldrich Chemical Co. Initial solutions of Pb, Cr and Al were prepared by solubilization of high purity metals in nitric (Pb), hydrochloric (Cr and Al) acids. The Certified Reference Materials (Ukrainian State Standard Samples of Metal Solutions) were used in order to obtain calibration solution of Pb, Cr and Al. Solutions with concentration lesser than 1μg/ml were prepared in the day of measurements by dilution of the initial solutions.

The natural water samples were preliminary treated by nitric acid just at place of the probe selection. All the samples were exposed to ultrasonic cleaning in order to remove some natural ligands, including fulvic and humic acids before microelements determination. The aqueous solutions were acidified to pH 2±0,1 by nitric acid. Statistical analysis was performed with Student`s t-test method (95% confidence level).

Results and discussion

The direct atomic absorption analysis of Pb, Cr and Al in natural waters is complicated due to interfering action of water macro components even at low salinity level. Utilization of the chemical modifiers (CM) is a method which allows direct measurements of these elements in the water samples. The chemical modifiers in ETAAC assays are the additives, which can transform certain element or matrix component into the suitable for atomization form. CM application has offered the opportunity for element analysis to increase the detection limit, which is 10-10^3 times higher than for a conventional method. It has been reported that utilization of organic chelating agents favoring relieve negative impact of matrix components, and therefore improve analytical signal. Several chemical modifiers including citric, sulfosalicylic, ascorbic, tartaric and oxalic acids, triethanolamine, complexon III were used for direct determination of Cr, Al and Pb in natural waters at the presence of macro components. These compounds are well known modifiers which able to form stable complexes with metal cations and resulted in the reducing of atomization temperature.

Chromium

It is well known that natural waters contain mainly ions of Na^+, K^+, Mg^{2+}, Ca^{2+}, Fe^{3+}, HCO_3^-, Cl^-, HPO_4^{2-}. These ions have been used in analytical procedure, particularly in sea and ground water analysis in water samples preparation, which mimic natural samples so-called synthetic water. Influence of above mentioned ions on analyte signal received much attention, since the may cause an undesirable action. The impact of the most important cations on chromium atomization was studied by preparing water samples with ions concentration similar to those of natural ground water of total low salinity up to 3 mg/ml with Cr concentration 0,08 mg/ml.

The investigations of influence of natural waters macro components on Cr analytical signal showed that either chlorides of Ca and Mg initially caused drastic rise of analytical signal, which further was stabilized (fig. 1).

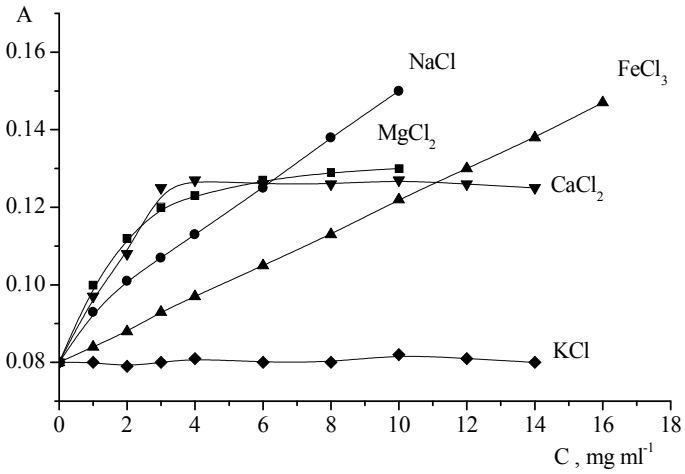

Figure 1. Chromium atomization in chloride aqueous solutions in presence of Cr^{3+} (C = 0,08 μg/ ml)

The rise of potassium content has almost no impact on Cr atomization process, which has offered the opportunity to use potassium salts as the components of the water samples matrix, which mimic natural waters. According to experimental data, the value of chromium analytical signal is constant in all the cases. Thus, it makes it possible to reduce undesirable effect of macro components of water samples at chromium determination by ETAAS. However, rise of sodium and ferric chloride (III) content in aqueous solution cause an increase of chromium signal absorbance. Therefore these cations can be used in synthetic solution only in presence of chemical modifiers. Subsequent experiments have shown that it is possible to determine Cr in natural waters using surrogate solutions, which imitates natural with potassium chloride addition.

Lead and Aluminium

The most effective chemical modifier was found by the follow procedure. All the solutions were acidified by nitric acid (1:1) in order to reach pH 2,0±0,1. The CM concentration being changed during measurements, the total salinity in one set of water samples was 0 g/l, in a second 10 μg/l with analyte concentration in all the samples 0,2 μg/ml.

It was found that the increase of natural water salinity in presence of triethanolamine and citric acid resulted in the little rise of Pb analytical signal in a beginning, whereas further increase of salinity lead to the signal drop. The negligible decrease of analytical signal in the presence of sulfosalicilc acid and complexon III has been observed. Application of tartaric acid was caused an increase of analytical signal with rise of macrocomponents concentration. Only in presence of ascorbic and oxalic acids the analytical signal has been stabilized with improving of the method sensitivity. It has been determined that the optimal concentration of these modifiers is 1 $\mu mol \cdot ml^{-1}$. Organic modifiers are favor to improve the method sensitivity and atomization conditions and minimize the disturbances, which caused by natural waters salinity. At the high level of salinity of natural waters, the presence of ascorbic acid favoring Pb determination, improve sensitivity and accuracy of measurements and give more linearity to the calibrating chart.

The better chemical modifiers for the Al determination in natural water are ascorbic acid and triethanolamine at different total level of salinity of water samples, that had changed up to 10 g/l. Further, ascorbic acid was used as a modifier owing to its high availability. The analytical signal of aluminium linearly related to its concentration at different salinity level. The data spread of the mean value of analytical signal not exceeded 20 %.

Kyiv is the one of the most populated city in Eastern Europe, which accounted more than 3 million people so that the quality of food and drinking water have received great attention due to their impact on health. The main sources of tap water in Kyiv are Dnipro river and underground Lybid river as well as lakes. However, consumption of tap water continuously decreased because of awareness of its strong pollution by hazardous metals. Therefore, the minor sources of drinking water, especially water from artesian well become more popular, so that quality control of these kinds of water is very important.

It is known, that Cr, Al and Pb are able to contaminate drinking water due to their presence in materials of water-pipes and contamination of soil as well. Therefore, we have determined concentrations of these microelements in several sources of natural water in the presence of 1 $\mu mol \cdot ml^{-1}$ ascorbic acid, which was used as a chemical modifier. The results are given in table 2.

Table 2

Results of Cr, Al and Pb determination in natural waters of Kyiv city

Analyte	Sample	Determined using calibration curve, $\mu g \cdot ml^{-1}$	Added, $\mu g \cdot l^{-1}$	Found, $\mu g \cdot l^{-1}$	Recovery, %
Pb	Lybid river	< 5	0	–	–
			20	18,8±1,2	94
			50	45,4±2,5	91
Cr		290±20	0	283±11	–
			20	301±12	91
			50	342±26	114
Al		291± 9	0	294±8	–
			20	303±11	93
			50	341±21	101
Pb	Lake water (Holosievo region)	27,6±1,6	0	28,1±0,8	–
			20	49,4±1,1	103
			50	76,2±1,8	98
Cr		83±2	0	82±11	–
			20	101±13	92
			50	134±16	104
Al		135±7	0	133±8	–
			20	150±11	92
			50	185±16	89
Pb	Lake water (Sovky)	5,1±4	0	6±3,1	–
			20	24±3,3	91
			50	53,5±3,2	97
Cr		110±20	0	112±18	–
			20	125±19	93
			50	161±23	91
Al		3,5±0,3	0	3,8±0,1	–
			20	22±1,2	88
			50	50,5±2,3	94
Pb	Artesian deep water	Less than detection limit	0	–	–
			20	16,8±1,2	94
			50	46,4±2,6	91
Cr		63±5	0	61±5	–
			20	83±6	95
			50	112±9	98
Al		78±7	0	74±6	–
			20	98±6	91
			50	126±11	94

The insight into Table 2 revealed that Pb content in all choosen sources of drinking water is lesser than maximum permissible level. The significant differences between concentrations of lead in the two lakes can be explained by near location to highway of lake in Holosievo region and its contamination by some above mentioned gasoline additives. We have suggested that the high amount of Pb collected in unsoluble forms in the bed slits of lakes and rivers. Unfortunately, the Al content in river Lybid is higher than acceptable level, which associated with continuous using of metal pipes, made from alloy with high aluminium content and uncontrolled emission of detergents and dyes as well. The presence of high content of chromium may be associated with both natural and anthropogenic sources. This may associated with lixivation of industrial solid wastes, which responsible for water contamination during intensive building. The high river water contamination by chromium also was observed (Nduka J.K.S. and Orisakwe O.E., 2007). Consumption of this kind of water over a long period of time may cause a nasal cancer. High content of chromium in river and lakes is a result of soil pollution by this metal in Kyiv, whereas relatively high Cr concentration in artesian water may be associated with some elements of water supply system, rich in chromium.

Calibration graphs for the direct determination of Pb, Al and Cr in drinking water sources were obtained by addition of microelements standard samples with 1 $\mu mol \cdot ml^{-1}$ ascorbic acid. In all cases calibration graphs were linear up to 1 mg/l of each of these microelements. The precision of the Al, Cr and Pb determination calculated on 6 replicate analysis of each sample was expressed as a rate of recovery of added standard solutions of these elements, that was not exceeded 90 %.

Conclusions

The approach of Al, Cr and Pb determination in natural water samples by ETAAS has been evaluated and demonstrated to be an effective for routine measurements of these trace elements. The methodology has shown adequate accuracy and selectivity. Surprisingly, in all water samples lead content was below WHO recommended limit of 0,03 mg/l and changed from 5,1 μg/l to 27,6 μg/l. Thus, health hazards related to the lead in drinking water are negligible. Most attention should be focused on Al and especially Cr content in natural water of Kyiv city because their high concentration in sources of drinking water. It is interesting, that consumption of water rich in chromium may have potential health benefit for some individuals such as diabetics, which is known have low chromium content in blood plasma.

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Analysis of the process of formation of n-nitrosodimethylamine in brewer's malt

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Abstract

Introduction. The article deals with the issues of carcinogenic substances formation in the manufacture of beer. It is shown that the basic technological process, that influences the N-NDMA accumulation in beer, is brewer's malt drying. The determining factor, influencing the N-NDMA content in malt, is the concentration of nitrogen dioxide at the entrance to malt layer.

Materials and methods. In the course of research, drying conditions typical for dryers of «Latvian Academy of Agriculture» type, one-deck dryers and apparatuses on malt manufacturing in combined way were secured. The measuring of nitric oxides was carried out by the means of gas- analyzer of 645 HL 20 type, the principle of operation of which is based on chemiluminescent method of determination of nitric oxide.

Results and discussion. More intensive absorption of nitrogen dioxide were observed during the first stage (constant speed) of drying due to the large number of free moisture presence in malt – a good nitrogen dioxide absorbent. The concentration of nitrogen dioxide in the drying agent has the greatest impact on intensification of N-NDMA formation processes in malt, that is recorded in all experiments.

That is why in order to achieve guaranteed quality of the product, one should establish the limit of concentration of NDMA in malt equaling 15 mcg/kg. Drying of malt with drying agent with concentration of nitric dioxide up to 0,4 mg/m^3 guarantees concentration of NDMA lower than this limit. This concentration should be limiting in the field of development of modern heating vent systems.

Introduction

Manufacturing method of many food substances involves adding various chemical substances to raw material and inters, as well as complicated heat treatment. At that, together with useful qualities, a relatively small concentration of reagents and additives remaining in products may have toxic and carcinogenic ones. Besides, harmful substances may be generated with the help of heat treatment.

Since carcinogenic substances, which products contain may cause formation of cancerous growth within an organism of a human; the topical task is extraction of carcinogenic substances from food [3]. Nowadays the problem of extraction of carcinogenic nitrosamines (NA) from food substances, which were discovered during the 1970-ies with the help of thermochemiluminescent method of NA determination in products, is of utmost importance [6].

Until now, the NA entry to human organism with various drinks is not taken into account [1]. For the first time NA was found in beer in 1979 in Germany. Researches ascertained that mostly N-nitrosodimethylamine (NDMA) was found in beer, in 70…75 % ale samples and in 80…100 % stout samples.

Analysis of numerous beer samples in 35 countries displayed that the product contained mostly NDMA, sometimes even high concentration of it (up to 68 mcg/l). Analysis of NDMA content during technological process of beer manufacturing showed that its accumulation in malt (up to 300 mcg/l) occurs at the drying stage with the use of gas-air bearer, containing nitric oxides [7, 8].

Analyzed material made it possible to determine the average consumption of NA with different products per person in various world regions (Fig.1.). E. g. in Germany an average citizen consumes 7, 0…10, 0 mcg NA per week [2].

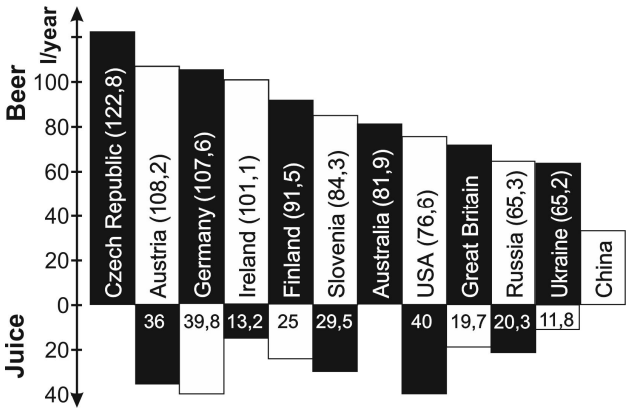

Fig.1. Average consumption of beer and juice in the world per person, l/year, 2011

In view of the fact that nitrosamines brought in with beer constitute a considerable part of the general consumption of NA by a person, in a range of countries limiting value of NDMA in malt and beer is recommended. This limiting value is not scientifically valid. It defines the possible limiting value of NA consumption with beer; specific part is quite high and totals 64% [4, 5].

Research of NA percentage in food substance has been carried out since 1969; the first beer samples were analyzed in 1979. Analysis of the samples elicited in them mainly NDMA. N-nitrosodimethylamine is a virulent carcinogenic substance, included together with some other nitroso-substances by International Agency for Research on Cancer (IARC) to the first category of substances, which are carcinogenic to humans. The impact of this carcinogenic substance on human organism is interrogated in scientific works [1, 3, 7, 8].

Materials and methods

In the course of research, drying conditions typical for dryers of «Latvian Academy of Agriculture» type, one-deck dryers and apparatuses on malt manufacturing in combined way were secured (vide table).

Table

Duration of the process of malt drying

Number of variant	**Duration of drying with the temperature of drying agent**, h			**Total duration of drying**, h
	55 °C	65 °C	85 °C	
1	5,0	3,0	2,5+1,5*	12,0
2	10,0	6,0	4,0	20,0
3	18,0	8,0	4,0	30,0

* – transition from 65 to 85°C.

Concentration of nitric oxides in drying agent totaled: 0,1; 0,3; 0,6 mg/m^3. In course of carrying out an experiment, the following parameters were measured and controlled:

– expenditure of drying agent;
– temperature of drying agent under the malt layer and out of it;
– humidity of lower and upper malt layer;
– the quantity of damp and dry malt, the thickness of a layer;
– percentage of nitrites, nitrates and NDMA in lower and upper layers.

The measuring of nitric oxides was carried out by the means of gas- analyzer of 645 HL 20 type, the principle of operation of which is based on chemiluminescent method of determination of nitric oxide. The main point of it lies in the fact that reaction between nitric oxide (NO) and ozone (O_3) results in receiving an excited molecule of nitrogen dioxide, because of which luminescence takes place:

$$NO + O_3 \rightarrow NO_2^{(hv)} + O_2, \quad (1)$$

$$NO_2^{(hv)} \rightarrow NO + hv, \quad (2)$$

where by (hv) photon of light, got during luminescence, is conventionally denoted.

Detected radiation is registered by photomultiplier tube and by the value of output current the concentration of NO in an analyzed sample is calculated. To calculate the nitrogen dioxide NO_2 concentration, which together with NO is present in drying agent, NO_2 should be transformed into NO. Reduction of nitrogen dioxide is realized in converter with the help of catalyst, heated to the temperature of +200 °C. Since in this condition radiation from the total concentration of nitrogen oxides is detected, concentration of NO_2 is estimated through difference between the value of electric signal proportional to concentration of sum of oxides NO_2 and, correspondingly, NO.

Percentage of nitrites in samples was estimated with the help of the method in accordance with state standards of Ukraine 4948:2008 "Fruits, vegetables and products of their processing. Methods of estimating the percentage of nitrates". To estimate the percentage of N-nitrosamines methodics instructions on methods of inspection MUK 4.4.1.011-93 "Estimating of volatile N-nitrosamines in food raw material and foodstuff" were used (Ratified by Federal Service for Supervision of Consumer Rights Protection and Human Welfare in 22.12.1993). Quantitative estimation of NDMA percentage in a sample was carried out with the standard solution of NDMA.

Sampling was carried out in upper and lower layers. A concentration of nitrites, nitrates and NDMA was estimated separately in every sample. At the end of drying all the malt was mixed in order to estimate the average indexes.

To value air pollution with nitric oxides concentration of oxides in air was estimated, which equaled 0, 02…0, 08 mg/m^3. During rush hours because of heavy traffic NO_x concentrations rose up to 0,1…0,12 mg/m^3, while nitric dioxide concentration did not exceed 0,05 mg/m^3. Samples, selected during intermediate stages of drying, were completely dried by the air, heated in electric heating coil, in which concentration of NO_x did not exceed 0,02 mg/m^3.

Because of fluctuation of NO_x concentration in environment, while drying correction of nitric oxide in drying agent has been carried out. With prescribed expenditure of drying agent V (m^3/h), nitric dioxide concentration in drying agent at the input to layer $C^{in}_{NO_2}$ and at the output of layer $C^{out}_{NO_2}$ the following parameters were estimated:

– amount of nitric dioxide (mg), put into layer per time unit on the basis of 1 kg of malt:

$$C_{NO_2} = \frac{1}{G_c} C^{in}_{NO_2} V \text{ , mg/h;} \quad (3)$$

– amount of nitric dioxide, absorbed by 1 kg of malt per time unit:

$$G^{abs}_{NO_2} = \left(C^{in}_{NO_2} - C^{out}_{NO_2} \right) V \text{ , mg/h;} \quad (4)$$

– amount of nitric dioxide, put into the layer during all drying period per 1 kg of malt:

$$\overline{C}_{NO_2} = \frac{1}{G_c} \int_0^{\tau_n} C^{in}_{NO_2} V \tau d\tau \text{ , mg;} \quad (5)$$

– amount of nitric dioxide absorbed by 1 kg of malt during the whole drying period:

$$\overline{G}^{abs}_{NO_2} = \frac{1}{G_c} \int_0^{\tau_n} \left(C^{in}_{NO_2} - C^{out}_{NO_2} \right) V \tau d\tau \text{ , mg.} \quad (6)$$

Since nitric dioxide is present in the air, concentration of nitric oxide in drying agent was recorded in order to ascertain its influence upon NDMA formation in malt.

Results and discussion

Results of experiments are displayed in table 2, which presents parameters of malt drying of 20 h duration with feeding of nitric oxides in drying agent and without it.

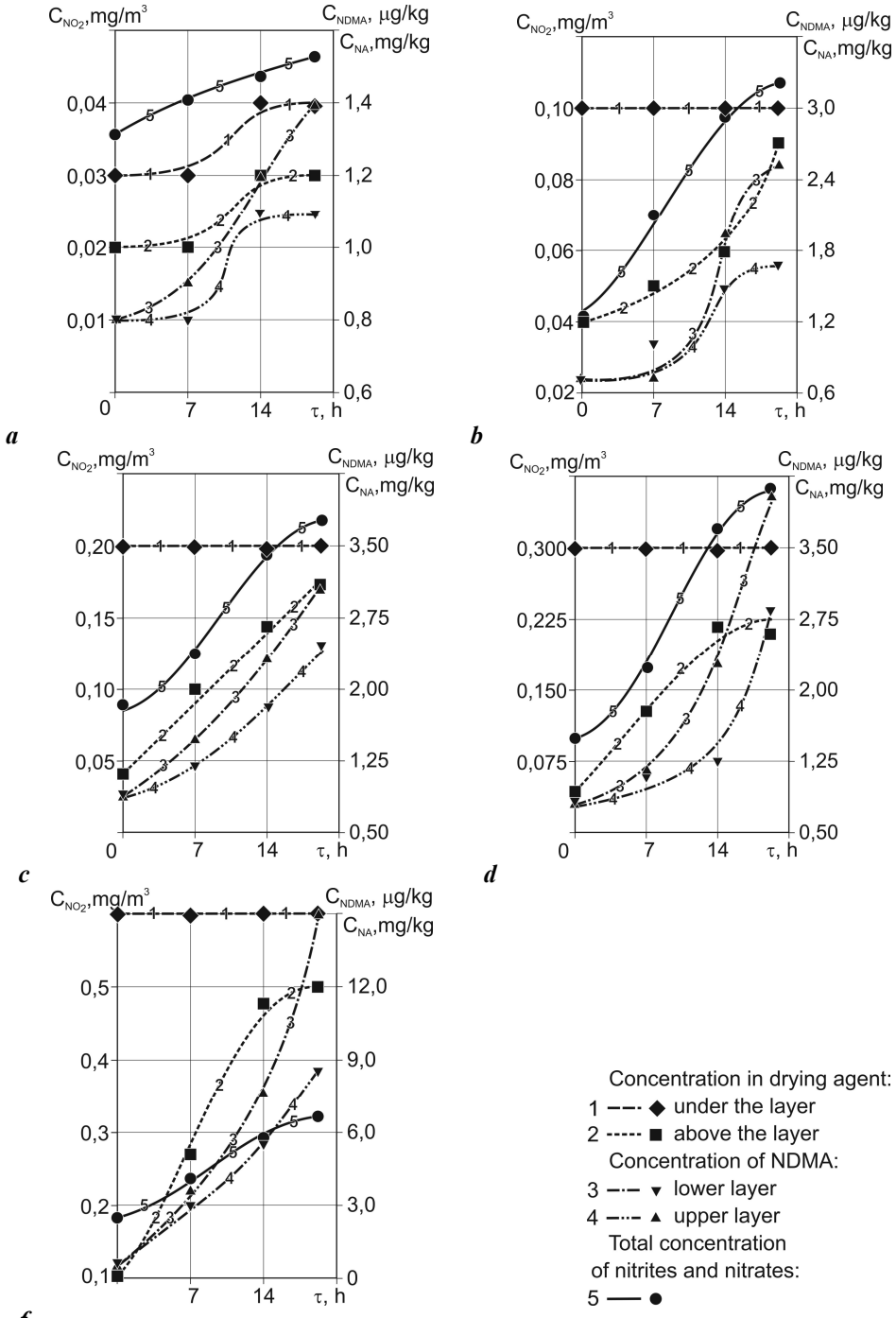

Fig. 2. **Malt drying with drying agent, containing nitric oxide**s:
a – without feeding; feeding of NO_2 with concentration, mg/m^3:
b – 0,1; *c* – 0,2; *d* – 0,3; *f* – 0,6.

Results of experiments show that the process of drying characteristic of real-life environment was reproduced. It can be assumed from dependence of temperature change and humidity on time, as well as good quality of malt.

It was established that nitric oxide, containing in drying agent, penetrates the malt, almost not being absorbed. A small change of nitric oxide concentration in drying agent at the output of the layer, as a rule, occurring at the final drying stage, can be explained by partial NO_2 reduction, oxidation of nitrogen in the air during the period of increase in temperature of drying agent and less intensive sorption of NO_2 by the malt layer with relatively low humidity of it (Fig.2, *a-f*).

Change in concentration of nitric dioxide in drying agent while its penetrating the malt layer is indicative of absorption of nitric dioxide by malt layer. More intensive sorption of NO_2 occurred during the first stage of drying that can be explained by the presence in malt a large quantity of free moisture, which is a good absorber of nitric dioxide. During this stage, absorption of nitric dioxide occurs throughout the whole layer. At that, driving force is the difference of NO_2 concentrations in drying agent and on the surface of the malt.

During the second stage of drying, in which humidity of malt is less than maximal hygroscopic one, zone of moisture evaporation moves to seeds and the intensity of absorption of nitric dioxide lowers. During the drying intensity of absorption of nitric dioxide is insignificant, that can be explained by little amount of moisture in the layer. Insignificant growth in difference of concentration of nitric oxide in drying agent while its penetrating the malt layer at the end of drying is not indicative of the growth in intensity of NO_2 sorption by the malt layer during this period and can be explained by its partial reduction to NO, which is confirmed by growth in concentration of NO at the output of the drying agent from the layer.

During the first stage of drying up to 85% of nitric dioxide, absorbed by malt during the whole drying process, is absorbed. With duration of drying of 12, 20 and 30 h, this period lasts, correspondingly, first 7…9, 12…14, 17…19 h.

The amount of absorbed nitric dioxide equals 35…50 % of its total quantity, put into the layer during the whole drying process. Absorption is realized through moisture with formation of nitrous acid (HNO_2) and products of its dissociation. It is confirmed by the growth in concentration of nitrites and nitrates in the malt during its drying.

Tracing the dynamics of changing of the quantity of nitrites and nitrates in the malt, one should admit that germs of malt contained 1…7 mg/kg of nitrites and nitrates. It can be explained by their ingress in the malt with process water during the soak and with air during the growing of malt. During the process of drying of malt, the growth in concentration of nitrites and nitrates was observed, the intensity of their accumulation becoming higher together with increase of concentration of nitric dioxide in drying agent at the input to the layer. Concentration of nitrites and nitrates in dried malt equaled 2…9 mg/kg. Percentage of nitrites was 4…5 times lower than percentage of nitrates, that can be explained by instability of nitrites. Concentrations of nitrites and nitrates in malt are several times higher than the ones, which are needed to form NDMA in prohibitive amounts (estimated at mcg/kg). By the growth in concentration of nitrites and nitrates increased the amount of NDMA.

Concentration of nitric dioxide in drying agent influences the intensification of formation of NDMA in malt, which was observed during all the tests. Increase of concentration of nitric dioxide in drying agent from 0,1 to 0,6 mg/kg leads to 6…7 time the amount increase in concentration of NDMA in malt. Percentage of NDMA in malt at the same time increases to 8…15 mcg/kg (Fig.2, *b-f*) and is the highest permissible amount

according to "The state sanitary regulations and rules "Medical requirements to the quality and safety of food substances and foodstuff" Order of Ministry of Health Protection of Ukraine № 1140 (29.12.2012).

Results of the tests on drying of malt with air without batching of nitric oxides in drying agent (malt being cooked using distilled water) nevertheless display the formation of nitrites, nitrates and NDMA in malt, which means that the layer of malt absorbed nitric oxide from the air. Thus, during the drying of malt in industry with clean air, which lasted 20 h, the increase of NDMA concentration in malt from 0.8 to 1,3 mcg/kg was observed (Fig.2, *a*).

Research of NDMA formation depending on technological modes of malt drying proved that decrease in duration of malt drying from 30 to 12 hours lowers the concentration of NDMA in malt not more than to 1.6 times and does not lose the task of radical decrease in concentration of NDMA in malt.

When the temperature of malt increases, accumulation of NDMA in it passes more intensively. It can be explained by activation of dissociation processes of NA with increase in temperature to more than 60 °C.

Humidity of malt also influences the formation of NDMA. Sorption of nitric oxides intensifies when the humidity of malt increases. Besides, humidity intensifies reactions of nitrosation of amines, in consequence of which increases concentration of NDMA in malt.

Conclusion

All things considered, among the factors, influencing the amount of NDMA in malt, the most important one is concentration of nitric dioxide at the input to the layer of malt. Limiting values of amount of NO_2 in drying agent should be conditional upon concentration of NDMA in malt, defined by hygienic regulations. That is why in order to achieve guaranteed quality of the product, one should establish the limit of concentration of NDMA in malt equaling 15 mcg/kg. Drying of malt with drying agent with concentration of nitric dioxide up to 0,4 mg/m^3 guarantees concentration of NDMA lower than this limit. This concentration should be limiting in the field of development of modern heating vent systems.

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Perfection of equipment for improvement of dough semi finished

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Abstract

Introduction. Improve the process of bread-making is possible through the use of intensive mixing, improvement of its fermentation and formation.

Materials and methods. Investigated wheat yeast dough of white wheat flour(ARS 465) and mixing processes, fermentation and formation of an experimental equipment in which these operations are combined.

Results and discussion. The necessity of complex perfection of process of production of rusk warest comes up from the traditional method of production, wide usage of hand labour and bulky equipment. Design of mixing-fermentation-forming unit, which allows to combine the processes of continuous intensive dough mixing, aerated dough pieces fermentation and formation directly to the baking plate. The unit provides a reduction in car-hardware circuits and reduces the cost to operate the equipment.

Viscosity of the dough is decreasing while the intensity of machining is increasing due to the weakening of connections between the particles of the dough.

Increasing the content of gas phase decreases the viscosity of the dough and increasing the average flow velocity. The quantity of gas greater than 40% and a pressure gradient of 0.3-0.4 MPa lead to destruction of the gas bubbles.

The exponential dependence of the mean flow velocity *w* on the compaction pressure P, (0,1-0,4) MPa. with different contents of the gas phase G (0 - 45)%

The dependence of the coefficient of the cord dough expansion from the angel of the entrance in the molding channel has the extreme. The optimal value of the taper entrance - 70-80°.

Conclusion. The results should be used in the design of new and reconstruction of existing production lines of bakery products.

Introduction

Lately the expansion of demand and variety of rusk products, especially it touches the wares of small diameter. However for their production traditional technology and equipment are used. Continuous forming of dough cord is interrupted for a portion stowing of flags on sheets for del standing on the cradles of proofers. The duration standing for the rusk sleepers of small diameter in a few times exceeds duration of baking of this sort of rusks, that means that providing of the productivity of stove an area proofers must be in a few times more area of hearth del, and taking into account the small geometrical sizes of wares the volume proofers is used very uneffective.

The practice of baking companies shows widespread adoption of intensive technologies of preparing dough in kneading machines with intense action. Without deterioration of the finished products without dough way to prepare the dough can be successfully used for rusks products.

The disadvantage of crackers in the traditional way is the need of large industrial areas and a large number of production personnel.

Using our proposed method of production and distribution with loosening in dynamic conditions will ensure continuity of process handling dough purveyances.

We have suggested the way for dough separation, which lies in the combining of the processes of molding and loosening of dough blanks in one aggregate by extrusion yeast dough, filled by the carbon dioxide, with no additional stages of dough cords' processing. Its usage requires comprehensive study of influence of geometry parameters of the forming channel on the measures, surface state and the character of porosity of the dough cord and the ready products.

The essence of any process of molding lies in the directed deformation of material with the help of the appropriate instrument. At the molding of extrusion the forming element is matrix, in particular, its channel. Geometry parameters of the channel determine the parameters of the extrudate and the quality of its surface.

Materials and methods

We investigated, the proposed experimental equipment for intensive mixing, which ensured that all three stages of mixing dough. The working body consists of three parts: the tape, screw with variable step.

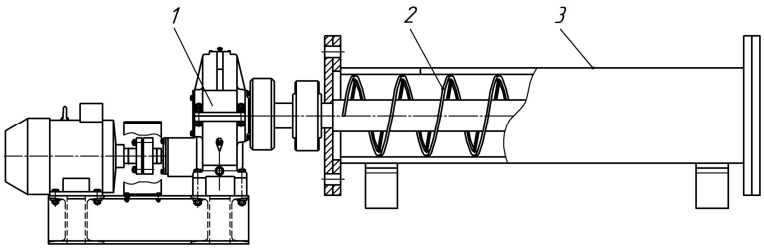

Fig.1. There is a chart of experimental fluidizer research of intensity of treatment of dough.
1 - occasion; 2 - working organ (scruw); 3 - corps.

The main indicator of the structural and mechanical properties the dough is the effective viscosity. We have conducted the research to determine changes in viscosity of the dough, depending on the specific work flow per knead.[2]

For the research of the influence of the geometry parameters of the forming matrix on the process of extrusion of gas filled dough, we have created experimental installation (Fig. 2), which allows to conduct the wide spectrum of the study as kinetic factors: middle speed of the flow, volume, mass production and the dynamic one.

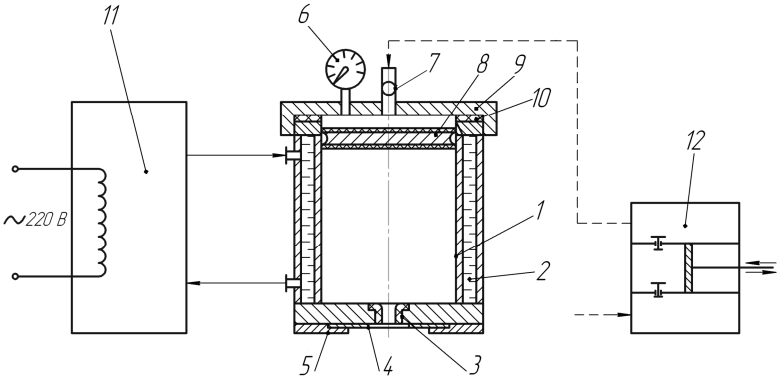

Fig.2. The scheme of the installation for the study of the process of extrusion of the yeast dough.

1 – cylindrical body; 2 – water shirt; 3 – matrix; 4 – knife; 5 – guide yoke; 6 – manometer; 7 – stopping valve; 8 – piston; 9 – cover; 10 – compactor; 11 – ultrathermostat; 12 – compressor.

The influence of the geometry of the forming channel was studies with the usage of the matrix with a various angle of the entrance, exit and the length.[3]

Results and discussion

Analysis of experimental data (Fig.3.) showed that the viscosity of the dough is decreasing while the intensity of machining is increasing due to the weakening of connections between the particles of the dough and the forces of viscosity is overcoming by increasing of the kinetic energy of the molecules.

As a consequence from the experimental data, reducing of viscosity occurs also during the time of fermentation of the dough and especially intensively during the first hours of fermentation. The value of viscosity after 1 hour of fermentation with the consumption of 30 J / g specific work per batch is the same that is during 3 hours of fermentation with consumption of 7.5 J / g specific work per batch. Therefore, changes in the structural and mechanical properties of dough which occurs during the fermentation process due to repeated stretching during the formation of gas bubbles can be achieved by intensive mechanical treatment of the dough during kneading.

Application of the intensive mechanical treatment during the dough mixing process allows to reduces the process of fermentation of the dough and to distribute yeast cells more uniformly throughout the whole volume of the dough, which promotes the formation of more centers of gassing and obtain a uniform fine-pored structure finished products.

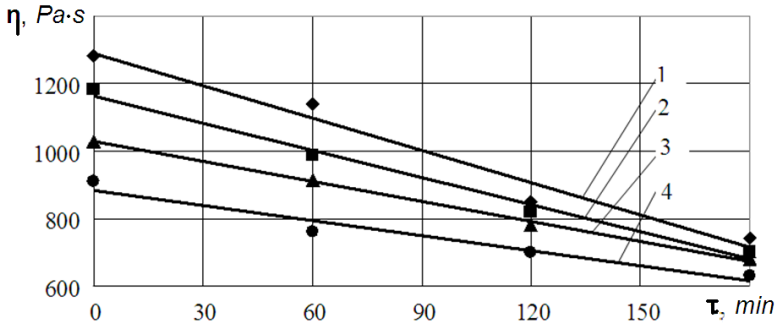

Fig. 3. Dependence of the effective viscosity of the dough from the time of fermentation when the specific work is:
1 - 7.5; 2 - 15; 3 - 22.5 ; 4 - 30 *J/g.*

The saturation of the dough by the oxygen dioxide at the expense of the fermentation leads to the reduction of the viscosity of dough, increase of the average speed of the flow and consumable characteristics (Fig. 4). The molding is possible in the zone of the lowest parameters of the pressure 0,2-0,4 MPa, security of the enough consumable characteristics of the process without defects on the surface of the extrudate.

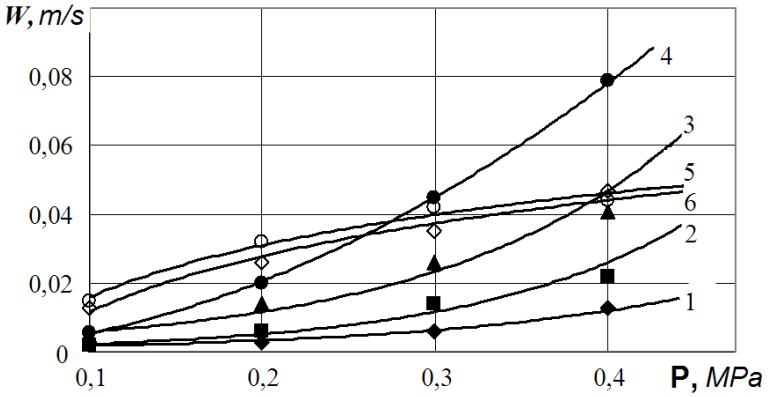

Fig.4. Dependence of the average speed of the extrusion of the dough cord of pressure with the content of gas phase, %:
1 – 0; 2 – 8,6; 3 – 23; 4 – 36; 5 – 42; 6 – 46

Average flow seep increases with the increase of the content of gas phase. The amount of gas more than 40% (graphs 5,6) and gradient of pressure 0,3-0,4 MPa lead to the destruction of the gas bubbles, pressure inside of them exceeds the power of the surface tension and the border of the firmness of their sides. The state of the surface of the dough cord decreases. Defects connected with the irregularity of the flow appear, as well as gaps of the solid surface layer of the dough and the loss of the kinetic energy of the flow. It is witnessed by the character of the graphs.

With the smaller values of the pressure 0,1-0,25 MPa the surface layer doesn't destroy, but a larger porosity of the ready item in the result of the pores' merge is observed, as well as gaps inside the dough cord is observed. Equation of the dependence of the average speed

of the flow w from the pressure of extrusion P,MPa with different content of the gas phase G, % for the constant mode, when the irregularity of the flows are not observed (graphs 1-4) has the look of:

$$w = 0{,}045e^{0{,}06G}\mathrm{P}^{(-0{,}1G+1{,}9)}$$

In the flow of the non-Newton liquid at the exit of the formation channel pressures normal to the surface of the shift appear and continue to run. The phenomenon of the swelling of the flow didn't have value with the usage of the extrusion process for the traditional molding of the dough blanks, as after molding, cord is being processed additionally.

The usage of the extrusion gas filled dough without the subsequent stages of the processing before the baking need a comprehensive study of the very process. It is necessary to determine the influence of the geometry parameters of the molding channel on the size, condition of the surface and the character of the porosity of the dough cord and the made items.

For the quantitate evaluation of the diameter increase of the dough cord in the comparison with the diameter of the molding channel we used the coefficient of the expansion, which takes into account non-Newton character of the flow and increase of the size of the extrudate in the result of the allocation of the gas phase. The coefficient of the expansion was defined as a ratio of the cord diameter to the diameter of the molding channel.

The research showed that with the increase of the length of the molding channel the value of the coefficient of the expansion decreases in the result of the structural changes of the components of the extrudate, which strengthen its carcass, orient the molecules along the flow, which decreases the coefficient of the expansion. In the long channel the energy of the flow is being lost as a result of the friction and increase of the shift deformation in the surface zone of the extrudate. The fall of the pressure in such channel runs slowly, gradient of the change of pressure in the bubbles isn't significant and such slow allocation of gas leads not to the formation of the new centers of its formation, but to the growth of the existing bubbles of gas and formation of the coarse-pored structure of the extrudate.

With the increase of the length of the channel the energy losses on the viscosity friction and elastic flow deformation increase, in the result of which the kinetic energy of the flow decreases (Fig.5).

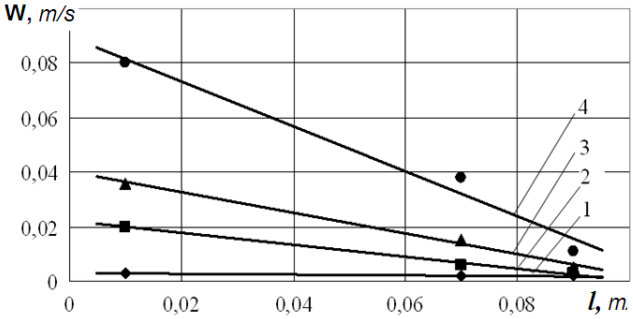

Fig.5. Dependence of the average speed of the extrusion from the length of the channel with the pressure, MPa:
1 – 0,1; 2 – 0,2; 3 – 0,3; 4 – 0,4.

For the study of the dependence of the coefficient of the expansion from the angle of the entrance in the molding channel and content of the oxygen dioxide in dough, matrix with the different entrance angle were used.

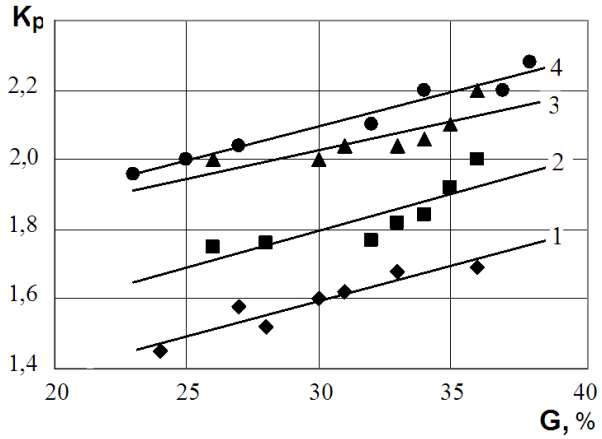

Fig.6. Dependence of the coefficient of the expansion from the content of the gas phase in the dough with the value of the angel of the entrance in the molding channel:
1 –20°; 2 –35°; 3 - 90°; 4 –65°.

The study showed (Fig.6), that the graph of the dependence of the coefficient of the cord dough expansion from the angel of the entrance in the molding channel has the extreme. The optimal value of the taper entrance - 70-80°. We agree that it is connected with the time of the dough passage in the channel, which is enough for the restruction of the high-molecular connection. These connections determine the structure of the dough, reduction of the voltage at the entrance in the channel and change of the molecules' orientation.

At the values of the entrance angle in the channel higher than 80°, the zone of the entrance into the channel is short. The time of the dough staying in this specific zone is shorter than the duration of the relaxation of the pressures, which appear with the constriction of the flow. Execution of the entrance into the channel under the direct angle is considered to be unnecessary in the result of the increase of the pressures and energy loss of the flow, which lead to the decrease of the diameter of the cord at the exit. With the decrease of the angle of the entrance, the overall length of the channel increases and the flow energy loses.

Conclusion

On the basis of the research of mixing and extruding processes of the gas-filled dough we propose the design of mixing-fermentation-forming unit, which allows to combine the processes of continuous intensive dough mixing, aerated dough pieces fermentation and formation directly to the baking plate.

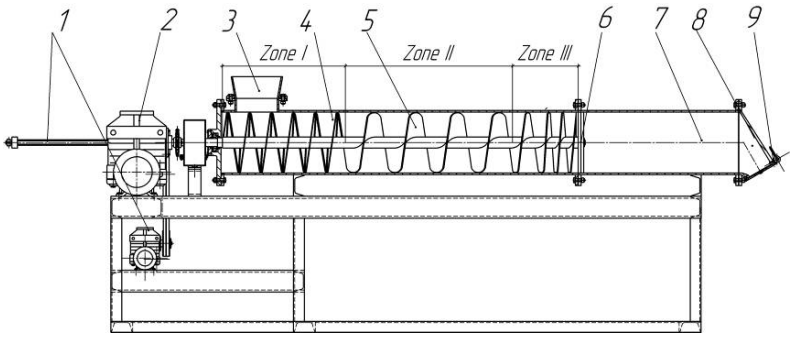

Fig. 7. Mixing-fermentation-forming unit:
1 – driver, 2 - reception funnel, 3 - mixing chamber , 4 - working body, 5 - mechanism of regulation of the intensity of mixing, 6 - fermentation chamber, 7- forming matrix, 8 - gate, 9 - mechanism of discharge.

There are screw tools installed in the mixing zone, which desing foresees the provision of three-phase mixing of dough, namely: mixing of the components is done with the spiral tool (zone I), mixing occurs with the minimal use of energy due to use of screw with the large pitch (zone II) and at the stage of dough plastification – the intensive mechanical processing by the screw tools with variable pitch (zone III).

Use of the screw with the decreasing pitch at the final stage of mixing provides the necessary pressure for feeding into the fermentation chamber

Thereby the carried out research allowed to determine the influence of the geometry of the molding channel and the content of the gas phase to the character and structure of the porosity of extrudate at the molding of the gas filled dough.

The results should be used in the design of new and reconstruction of existing production lines of bakery products.

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Scientific bases of method of synthesis for the structure of machines that provide packing process by foodstuffs

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Abstract

Introduction. On condition of optimization of process of packeting rationally to use the synthesis of structure of packing machine combinatorics-logical methods.

Materials and methods. A process for sorting and search of new combinations are used for generuting of structures in the array of analogues and prototypes. For this aim it is possible to choose the next methods of description of the generalized structures for packing machines : tabular, algebraic, logical and network models.

Results and discussion. The oriented multigraph is used for the synthesis of structure of packing machines, and also for optimization of separate decisions. The system of limitations and целивые function is generalized for this purpose.The system of limitations is confirmed, and gives an opportunity to describe data of choice of elements for a multicount model, and objective function. It allows to optimize different structural descriptions for decisions. The decision of task of structural synthesis consists of the oriented arcs of multigraph. During the use of this method one class of of packing machines can be presented as oriented multigraph.

In such multigraph great number of multiarcs and it $Z=\{Zi\}$, $i=\overline{1,n}$ and great number of tops – $S=\{Si\}$. An arc will be activated on condition of activating of all her exits. The common amount of variables in similar models is described by means of expression $3n+K+M$, and an amount of equalizations and inequalities is in the system of limitations - $7n+K+L+1$, for n – common amount of elements of the incorporated structure for a packing machine, K – amount of incoming connections; L – amount of the forbidden combinations.

Conclusion. A problem of structural synthesis is brought to the tasks of the discrete linear programming. The system of limitations, that is described in a task, can define the stages for the choice of elements of multicount model, and objective function. It gives an opportunity to optimize different structural descriptions of decisions.

Introduction

A modern packing equipment is the difficult technical system. A basic function for the system is implementation of basic operations, auxiliary operations and additional operations in the process of packing [1].

Machines that target at the process of packing of products, they will execute the identical amount of operations approximately. Wide introduction of microprocessors and mechatronic control system gives an opportunity to create the packing machines-automats of new generation [2]. Creation of such generation of packing machines is based on their hierarchical construction from the functional system of the mechatronics modules. In this case for optimization of packing process it is needed to optimize the structure of machine with taking into account of mechatronics connections. As a rule in the technical systems consider that a synthesis is project procedure. As a result combination of the different modules (elements) comes true in single unit - machine (system) [3].

Materials and methods

In engineering sciences of understanding of synthesis will divide into three components: to the synthesis of construction, synthesis of parameters and synthesis of structure.Procedure of synthesis of structure of machine in the theory of the automated planning is the not very studied process [4].

Methods the adopted by the combinatorics of logistic found most application in the automated planning among plenty of tasks based on a structural synthesis.

Ці способи базуються на загальній теорії комбінаторики.

These methods are based on the general theory of combinatorics [5,6,7].

Id est for this purpose, to do structures, it is necessary to do sorting and search of new combination in the array of analogues and prototypes.

This method will be effective at such accepted suppositions [8]:

- the technical system (packing machine) has the developed structure with large amount of elements and connections;
- a packing machine belongs to the class of objects that have the identical functional setting;
- the great number of analogues and prototypes has considerable power for the effective search of new combinations in such combinatorics space;
- the functional modules of packing machines may have are characterized good ability for by a combinatorics

This method of synthesis can be to such facilities of description of the generalized structures of packing machines: [9,10] tabular, logical and network models of algebra.

Widest application among these models got morphological tables, many-particle columns (N - partial), alternative trees (And are trees, I-АБО-trees) and oriented multigraph.

Method of oriented multigraphs most perspective among of the enumerated methods of description of structure [11].

Results and discussion

The oriented multigraphs are this generalization of the oriented graphs. They appear from the directed multiedges that can have a few entrances and a few exits in a general case.

On a picture the presented process of packeting of products in a consumer container as multigraph.

The technological process of packing consists of such basic and auxiliary operations.

Z_1 – environment; Z_2 – preparation of products; Z_3 – forming of consumer container; Z_4 – dosage of products; Z_5 – preparation of consumer container (pack) is to packing; Z_6 – packing of products; Z_7 – sealing-in of packing; S_1 – properties of products; S_2 – properties of packing material; S_3, S_4 – properties of products and packing material; S_5, S_6 – properties of dose of products and formed packing; S_7 – properties of the packaged products and packing; S_8 – properties of packing unit.

In practice packing processes have a considerable great number of variants of sequence for implementation of technological operations.

In given the applied technological operations are elements that form the combinatorics surplus structure of process.

In accordance with understanding the operations is are multiribs. Their entrances of Si describe the sequence of implementation.

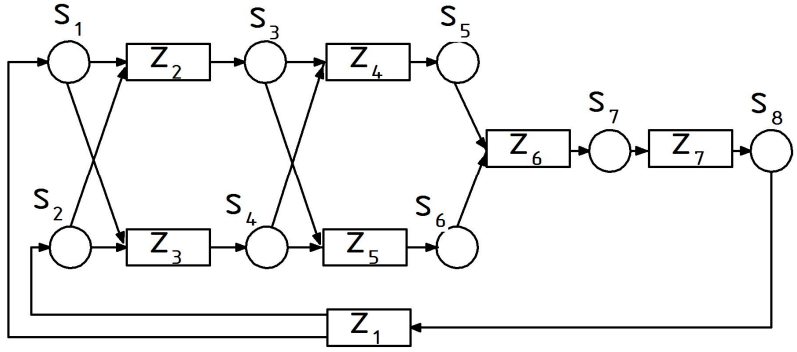

Fig. 1. The oriented multigraph describes about the generalized structure of technical process packing of food products in a consumer container.

During packing of products there are terms of use of operation there are the fixed values: exactness of dosage; impermeable parameters of packing; durability of welding or glue is on sutures; exactness and quality marking, for auxiliary packing facilities and others like that.

Realization of operation allows to change these descriptions, that gives an opportunity to apply other operations.

An operation of packeting will be complete on condition of receipt of new numeral parameters.

A combinatorics logical model gives new decisions at the reasonable association of elements. combinatorics of association gets the great number of variants that give an opportunity to decide the task of optimization for multigraphs on condition of large number of connections elements.

The compact and well-organized structure of technological process (Fig.1) will ground to count her decision as some the multiways for conducts from the great number of tops (S1, S2) to the great number of S8.

On a picture the present structure as a general and simple, but in the real terms the process of packeting consists of great number of the stages (elements) and they can be realized by different structural working organs.

In such case it is needed to have methodology.

If through in (Z) to designate the entrances of arc of Z, and through out (Z) are exits of Z and great numbers of multiarcs - C, then in (C) will enter structures of C, and out (C) her exits.

A structure is named a multicycle, if for it correlation of in (C) = D is executed, id est it has an empty set of entrances.

The decision of task of structural synthesis consists in any not surplus multicycle that contains the element of Z1, id est environment.

Taking into account of element of Z1 guarantees globalness of multicycle. It means that it, in accordance with a requirement specification on planning of packing machine, connects entrances and exits of environment and does not close on some local elements that is located into multigraphs.

Not surplus means that a multicycle does not contain superfluous elements, what unnecessary for the decision of the put task.

The thus oriented multigraphs is flexible, more expressive next to other methods of presentation of structure.

Be what generalized structure can be described by the language of multigraphs without the losses of information. The oriented multigraphs give an opportunity to synthesize valuable structures in that there are copulas between elements. It is important properties of multigraphs, because morphological matrices, alternative trees generate the most primary type of structure.

Connectedness, combinatorics power, ability to describe multifunction elements - all these properties of oriented multigraphs give an opportunity to decide the tasks of structural optimization [8].

For the decision of these lacks of task of structural synthesis decide in discrete programming mathematical form.

During of this method one class of packing machines is for as oriented multigraphs. In such multigraphs by the great number of multiarcs is $Z=\{Z_i\}$, $i=\overline{1,n}$ and great number of top – $S=\{S_i\}$.

Formalization of task is taken to the following:

1. Z_i, $i=\overline{1,n}$

for $Zi=\begin{cases}1, \text{if an arc is included in a decision;}\\ 0, \text{if an arc is not included in a decision.}\end{cases}$

2. $y_{i,j}$, $i=\overline{1,n}$, $j=\overline{1,r_j}$ де $y_{i,j}$ – exit of element Z_i under a number j, a r_i – common amount of exits of element Z_i.

It is possible to consider that:

$$y_{i,j}=\begin{cases}1, \text{if j initial connection of element of } Z_i \text{ is activated;}\\ 0, \text{if in initial connection of element of } Z_i \text{ not activated.}\end{cases}$$

3. x_{ik}, $i=\overline{1,n}$, $k=\overline{1,m_i}$, де x_{ik} – k- entrance of element Z_i, a m_i – incurrence of entrances of this element.

Will consider that:

$$x_{ik}=\begin{cases}1, \text{ if } k \text{ - entrance connection of element of } Z_i \text{ is activated;}\\ 0, \text{ if } k \text{ - entrance connection of element of } Z_i \text{ is not activated.}\end{cases}$$

Z_i, $y_{i,j}$, x_{ik} – the variables for a record systems of limitations and objective function in the task of structural synthesis on elements with restrictive combination.

If it is needed to take into account physical terms then enter auxiliary arguments.

The decision of task of structural synthesis consists of the oriented arcs of multigraphs. An arc will be activated then when all her exits are activated. This condition will write down as such system of equalizations :

$$r_i \times Z_i = \sum_{j=1}^{r_i} y_{ij}; \quad i=\overline{1,n} \tag{1}$$

This system of equalizations is compatible then, when $Z_i=0$ but all variables $y_{i,j}=0$, або $Z_i=1$, всі $y_{i,j}=1$.

For labilizing of element of structure it is needed to revolt all it entrance copulas. It means that $Z_i=1$ then and only after, when $x_{ik}=1$, $k=\overline{1,m_i}$.

If $x_{ik}=0$, then $Z_i=0$. For the record of this condition in the type of algebra will enter n of auxiliary variables $u_i \in \{0,1\}$, $i=\overline{1,n}$. In such case will consider the set of inequalities :

$$\sum_{k=1}^{m_i} x_{ik} - m_i \geq -m_i u_i; \tag{2}$$

$$Z_i - 1 \geq -u_i; \tag{3}$$

$$\sum_{k=1}^{m_i} x_{ik} \geq m_i Z_i; \tag{4}$$

$$\sum_{k=1}^{m_i} x_{ik} - m_i < 1 - u_i; \quad for \quad i=\overline{1,n} \tag{5}$$

Possibly $Z_i=1$. At this condition subsystem (3) executed at be what values u_i . From (4) it goes out that $x_{ik}=1$, $k=\overline{1,m_i}$. Subsystem (5) assumes an air $0<1-u_i$ from $u_i=0$, $i=\overline{1,n}$ and subsystem (2) executed automatically.

If $Z_i=0$, then system (4) executed automatically for be what values of arguments in left her part. Subsystem (3) taken to the kind $u_i \geq 1$ what has an only decision, $u_i=\overline{1,n}$, $i=\overline{1,n}$, Putting these values in expressions (2) and (5) obsessed:

$$\sum_{k=1}^{m_i} x_{ik} \geq 0; \qquad \sum_{k=1}^{m_i} x_{ik} < m_i.$$

For formalization of condition of indignation of entrances of elements of the generalized structure of packing process all variables of kind x_{ik} та y_{ik} it is needed to put in order graphic methods on the values of their indexes. After this operation every variable $x_{ik}(y_{ik})$ will get a new single index $\alpha(i,k)$, $\beta(i,j)$, what shows the number of variable in the graphic order.

Will designate through $M = \sum_{i=1}^{n} r_i$; *and* $K = \sum_{i=1}^{n} m_i$;

A rectangular matrix is possibly set (0,1) $P = \left\| p_{ij} \right\|$ to the size K x M, in that:

$$p_{ij} = \begin{cases} 1, \text{if entrance } x_i \text{ provided with exits } y_i; \\ 0, \text{if entrance } x_i \text{ not provided with exits } y_i; \end{cases}$$

Then set of inequalities that formalize the condition of providing of indignation of entrances it is possible to write down in such kind:

$$\sum_{j=1}^{M_i} p_{ij} \geq x_i; \qquad i = \overline{1,k} \tag{6}$$

In this expression of i and j - number of variables of x_i, y_j in the new graphic order.

If x_i, then there will be even one constituent of kind in a that sum 1×1. It means that the activated exit that will provide an entrance is x_i. If x_i=0, then inequality is executed automatically.

Be what faithful decision of task of structural synthesis must execute the put requirement specification and answer the functional setting. For this purpose it is needed and enough to plug in development an element that characterizes an environment. This condition can be written down as expression:

$$Z_1 = 1. \tag{7}$$

System equalizations of inequalities (1) – (7) represents basic physical sense of task of structural synthesis on the generalized structure of packing machine, that over is brought as the oriented enormous count.

Be what decision of this system presents by a possible variant of structure of packing machine. The system is open because assumes including of additional limitations that take into account the features of making decision in a certain situation. By means of the entered variables it is possible to set forth different terms that limit combination of structural elements generally speaking to access. Next to it systems of equalizations (1) – (7) it is invariant, and also it can be used in combination with different objective functions.

Objective functions, for the decision of far of project situations, it can write down in a kind:

$$\sum_{i=1}^{n} Z_i \to \min \tag{8}$$

$$\sum_{i=1}^{n} C_i Z_i \to \min \tag{9}$$

$$\sum_{i=1}^{n} \sum_{j=1}^{r_i} y_{ij} \to \min \tag{10}$$

$$\sum_{i=1}^{n} \sum_{j=1}^{m_i} x_{ij} \to \min \tag{11}$$

$$\sum_{i=1}^{n} \sum_{j=1}^{r_i} y_{ij} + \sum_{i=1}^{n} \sum_{j=1}^{m_i} x_{ij} \to \min \tag{12}$$

Will analyse the brought having a special purpose units over.

Function (8) minimizes the amount of elements of structure. At all equal terms such decision gives an opportunity to get a packing machine with higher operating properties and more simple in making.

Function (9) minimizes the self-weighted sum of structural elements. Weigher coefficients can be different after physical semantic numerical descriptions and indexes. For example, it can be cost, mass, sizes and others like that, id est those that compare to the parameters of the generalized structure. Objective functions (10) – (12) minimize the incurrence of entrances, exits, and also incurrence of all connections between the chosen elements. At implementation of these terms packing machines will have higher reliability indexes and less charges on service.

Thus all dependences that characterize the generalized structure are linear, and the range of definition of variables is a great number {0,1}. The put task to the search of optimal structure of packing machines behaves to the tasks of the linear boole programming. The methods of decision of models of this type are deeply enough represented in the results of researches [12,13]. Common amount of variables in such models is determined the from expression 3n+K+M, and an amount of equalizations and inequalities is in the system of limitations -7n+K+L+1, so n – common amount of elements of the generalized structure of packing machine K – amount of initial connections; L – amount of the forbidden combinations.

Conclusion

1. Among the numerous methods of structural synthesis that has wide searchabilities there in space of analogues and prototypes.is oriented multigraphs.
2. This method of decision of task gives an opportunity to get the structures of packing machines that are basis for realization of tasks of optimization of structure.
3. For the correction of basic defect of multigraphs are largenesses and impossibility to describe the additionals what for fixed at choice elements, it is suggested to erect the problem of structural synthesis to the tasks of the discrete linear programming. The systems of limitations, that determines the terms of choice of elements of мультіграфовій model, and objective functions that give an opportunity to optimize different structural descriptions of decisions, selected this purpose.

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Optimization of power supply system at food production enterprises

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Abstract

Introduction. Improve the efficiency of reactive power compensation in food factories advisable by applying a two-level system control sources of reactive power.

Materials and methods. It is research developed a comprehensive compensation system, provides a shift in the emphasis of reactive power sources capacity management: from decentralizing to ensuring the system commitment in solving problem that is conceptually related to the optimization of power consumption mode at the industrial enterprises.

Results and discussion. Reactive power consumption during the day is uneven.

Hierarchical structure and high complexity is inherent to the system of reactive power compensation at the enterprises. During the day the generated power should overlap not less than for 80-90% with schedule of consumed reactive power. It should be noted that due to this principle of control static source of reactive power with combined regulation has the same performance as the smooth and stepped source of reactive power, but unlike the stepped source of reactive power, reactive power allows you to regulate smoothly, and unlike smoothly regulated sources of reactive power do not cause significant distortions of voltage waveform in the power supply system. Operation mode of all reactive power sources must meet schedule of reactive power consumption. The proposed systematic approach to compensation allows improving the economic performance of all reactive power sources significantly. To improve the power factor condenser units are used.

Conclusions. The results recommended for use in the food industry to improve the efficiency of electricity.

Introduction

The main production of food industry enterprises occupies small territory (excluding pumping stations). They have power voltage of 35 ... 10 kV and high-voltage distribution network of 6 ... 10 kV. Power transformers at these plants usually exceed 750 kV·A, thus reactive power compensation needs to be provided.

Power supply organization sets the mode of company's compensating devices work. Capacity of unregulated power batteries is taken as the least reactive load network. Typically, multi-stage regulation should be used. Reactive power adjustment is an ideal method from many points of view. The controller turns on in the power network node. Condensing unit can be multisection and regulation can be maintained with sufficient accuracy according to schedule of reactive load.

The criterion of rational solution to the problem of reactive power compensation is the minimum of stated expenses. They include costs of compensating, regulatory and related devices, as well as expenses on reactive power regulation and its transfer through the power supply system elements. These expenses include components that do not depend on the value of reactive power, thus there was developed a methodology of determining compensating devices capacity that does not require considering the absolute costs of power supply system elements [1,2,3].

Reactive power consumption during the day is uneven. Operation mode of all reactive power sources must meet schedule of reactive power consumption. Power of compensating devices should be changed according to schedule of reactive power consumption. The use of individual compensation capacitor helps to eliminate the use of complex and expensive devices of capacitor installations power control that are needed to complete the centralized compensation installations in transmission substations [1,2,3].

Materials and methods

Hierarchical structure and high complexity is inherent to the system of reactive power compensation at the enterprises. At the industrial enterprises capacitors and synchronous engines are used to compensate reactive load [2,3]. The most widely spread are capacitors. Small mass, absence of rotating parts, minor loss of energy, simplicity of maintenance, safety and reliability in exploitation allow the use of capacitors for reactive power compensation at all levels of power supply [Patent of Ukaine № 34943, Method of connecting individual capacitor condensators having reactive power compensation of induction motor. Shesterenko V.Y., Siryj O.M., Baluta S.M., Maschenko O.A. Published on 26.08.2008]. Synchronous engines are widely used at the enterprises to drive devices that do not require speed control. Engines can run with advanced power factor and compensate reactive power of other power receivers. Compensating ability of engine is determined by the load on its shaft, voltage and excitation current.

In shops with lots of low-power engines individual compensation is not always effective. In such cases, a centralized compensation with capacitors installation near the transformer substation plant is used.

Reactive power of j station network

$$Q(t) = \sum_{j=1}^{n} \left[Q_j(t) - Q_{KY\,i} \right], \quad (1)$$

where $Q(t)$ - reactive power of load, Q_{KY} - power capisity of condensing units.

For chosing condensing units their function should be studied.

$$f = \sum_{i=1}^{n} r_i \left[\sum_{j=1}^{i} (Q_j - Q_{KY\,j}) \right]^2 + \sum_{j=1}^{i} \sum_{e=1}^{i} K_{je}, \quad (2)$$

where Q_j - mathematical expectation of reactive power of load in j–station,

K_{je} - correlation moment of random values $Q_j(t)$ and $Q_e(t)$.

Losses of electrical power

$$\Delta W_i = \frac{r_i}{U_{nom}^2} \cdot \sum_{k=1}^{\omega} T_k \left[M_k(P_i^2) + M_k(Q_i^2) \right], \quad (3)$$

where $M_k(P_i^2)$ - mathematical expectation of active power, $M_k(Q_i^2)$ - mathematical expectation of square reactive power, ω - number of intervals of stationarity and ergodicity, T_k - duration of these intervals.

If there are few condensing units at the enterprise, multi-stage regulation of total reactive power is applied by means of different time enabling or disabling individual cells according to the load schedule. Total capacity of unregulated sources should not exceed the consumption power in the hours of low load, because reactive power should not be transferred from the enterprise power network into power supply system.

The analysis of modern Ukrainian and foreign scientific papers on the subject of reactive power compensation is conducted and existing regulatory systems of reactive power are summerised and evaluated.

Results and discussion

Regulation of reactive power sources capacity may be conducted by: voltage, load current, reactive power load, time of day and external signal [2,3].

Let us consider these methods in detail. Adjustable voltage is very effective way if the supply lines have high inductive reactance. This applies mainly to rural power supply systems, where overhead power lines dominated. The method can improve the quality of voltage for power receivers.

Regulation by full power is implemented very simply. Capacitors are disabled while reducing load. If compensation is done at substation power leads, the efficiency of the method decreases as line's load may be different. In addition, the decrease in the load of industry equipment leads to cos φ fall. The method can be recommended for common customers.

Regulation by reactive power is an ideal method from many points of view. The controller turns on in the network power node. Capacitor unit can be multisection and regulation may be maintained with sufficient accuracy according to reactive load schedule.

Regulation by time of day is a simple and effective way of control. The signal for compensating device sections switching is sent by a timer with appropriate program. The program is developed on the basis of retrospective analysis of load schedule. If the actual

schedule will be different from the developed model, the method can give significant errors in regulation.

Regulation by external signals and reactive power is provided by the system of reactive power complex compensation. The system allows you to maintain the optimal flows of reactive power in the electrical power supply system elements, to optimize the flows in real time, to use company compensating devices with maximum effectiveness, since disabling of compensating devices in the times of reactive power shortage is not allowed in the node of power supply system.

The power of unregulated capacitor batteries is taken by the least reactive load of power supply system. It is usually necessary to apply multi-stage regulation.

The basic principle of smooth regulation is laid down in the change of conduction angle or time during which the thyristor remains open and passes current. As the conduction angle decreases, there is also a decrease in the effective value of the first harmonic of current, flowing through the capacitor, and so does the capacity that is given by capacitor battery to the power supply system. Change of thyristors conduction angle in a circle with a capacitor battery cannot be conducted by the change of control angle, that is, by the change in the time of their discovery. This regulation is known to be accompanied by significant current free throws and provides almost no effect on the regulation. Smooth regulation of capacitor battery, equipped with a thyristor switch, is achieved by artificial disabling thyristors. Terms of thyristor disabling are formed when the voltage is negative or cathode potential is greater than anode potential. To perform the specified correlation of value potentials special device is used - the source of current pulses for force close of thyristors. The following technical indicators of capacitor battery that is controlled by thyristors are considered to be the most significant:

1) the range of reactive power or the capacity of reactive power source to change this power gradually from minimum to maximum;

2) performance or the time during which the reactive power source is able to change generated capacity from one value to another;

3) harmonic components of total current that characterize the quality of compensation and filtering harmonic power of generated reactive power source.

The listed characteristics of above discussed reactive power sources are interrelated and depend on the network in which the reactive power source is turned on. Thus, expanding the range of regulation causes the deterioration of the harmonic composition of reactive power source current. This effect is also reached by the growing correlation between installed capacity of reactive power sources and output of short circuit at the point of its installation, which can contribute to creation of resonance events. For smooth regulation, there is practically reasonable limited range, which has as its capacity upper and lower limit [2,3,4].

Synchronous engines are used to drive mechanisms with long operating hours, including pumps, fans, etc. National electrical industry enterprises produce synchronous engines with the rated advancing power factor equal to 0.9 and can be used as a source of reactive power. In this respect technical possibility to use synchronous engines is limited to the greater reactive power that it can generate without breaching the conditions of acceptable stator and rotor heating. Synchronous engines allow both to vary infinitely reactive power that is generated by changing excitation current and to keep it constant. The use of synchronous engines as sources of reactive power can reduce the amount of other compensating devices. When conducting technical and economical comparison of synchronous engines with other sources of reactive power, defining active power is

required. The bulk of the costs will be determined by the cost of active power losses (which is the disadvantage of synchronous engines).

Consumer of electricity is obliged to maintain the level of reactive power in accordance with the power supply system requirements. With this reactive power is set and controlled between maximum and minimum in the power supply system, Q_{e1} and Q_{e2} respectively [2,3]. Intermediate modes are not controlled, and the consumer can exploit the compensating devices to his liking during 60-80 % of the day time. Thus, the total power of compensating devices in industrial enterprise is defined by power supply system, and the way of distributing reactive power sources in the nodes of enterprise power supply system, their operation time and control options can be selected according to the adopted optimization criteria.

In modern schemes the methods of distributing compensating devices in power supply system nodes are used: in proportion to the reactive load of nodes, with a minimum of aggregate costs and minimum of energy loss [2,3]. Due to the high degree of reactive power compensation at the projected enterprises, and the use of multisection capacitor units that are usually installed on the transformer substations, the latter two methods do not provide large benefits, while labor costs for their calculations are one level higher. Method of capacitor batteries power control according to their voltage is justified only in nodes where there is a shortage of reactive power. Due to the fact that there is the tendency to full compensation of reactive power at the nodes of its consumption, the method of regulation by reactive current should be considered progressive.

Local regulation through individual regulators allows minimizing energy losses in consumer power supply systems that are caused by reactive power overflows. However, this type of regulation does not allow taking into account working hours of the power supply system and consumer's capacity units may be disabled during periods of reactive power shortage in power supply system.

During the day the generated power should overlap not less than for 80-90% with schedule of consumed reactive power. It is always necessary to provide disabling unregulated compensating devices at weekends and during non-working hours. Disabling can be done manually or automatically. The number of capacitor sections should be chosen depending on the nature of the reactive power schedule.

Step-adjustable capacitor units are made with different number of adjustable sections. These units of stepped adjustment allow you to maintain the value of the parameter that is set to the measuring body of control unit within set limits. It is their added advantage in comparison to unfixed shunt capacitor batteries. The disadvantage of such devices is the inability for accurate setting regulation, because battery power changes discretely, increasing or decreasing at once in value of one section capacity.

Step-adjustable source of reactive power is a capacitor unit, consisting of a number of capacitors, connected to total power leads over contactors or semiconductor keys (counter-parallel turned on thyristors). Power supply organization sets working mode for company compensating devices. For enterprises with more uneven load demand automatic regulation should be provided: excitation of synchronous engines, the power of the capacitor batteries.

Combined regulation of capacitor batteries is based on a combination of the two methods of regulation, namely stepped and smoothly. This combination allows the use their best qualities and get new top features of regulated static source of reactive power [2,3]. On the basis of this lies the combination of several degrees of capacitor batteries that are controlled by thyristors, with a degree within which reactive power varies smoothly. The method of reactive power smooth change varies, it is either a capacitor battery that is enabled by thyristor switch and disabled with a help of special source of controlled current

pulses, or it is permanently switched capacitor battery, the power of which is equal to single capacity of degree, parallel to which the same power reactor controlled by thyristors is enabled. This enabling allows you to gain power smoothly from zero to the boundary equal to the degree of power, and then using the appropriate system control and synchronization allows you to enter the first degree, at the same time reducing to zero power of smoothly regulated degree. In between degrees the power of static compensator is equal to power of lower degrees and power of smoothly regulated degree. Reduction of power is implemented in the same way. In case of forcing, all degrees are enabled and smoothly regulated degree reaches its maximum value. If you need a full reset of received power, control and synchronization system disables both static compensator degree and planned-regulated section.

It should be noted that due to this principle of control static source of reactive power with combined regulation has the same performance as the smooth and stepped source of reactive power, but unlike the stepped source of reactive power, reactive power allows you to regulate smoothly, and unlike smoothly regulated sources of reactive power do not cause significant distortions of voltage waveform in the power supply system. Among the disadvantages of this regulation method the need for carefully organized systems of control and synchronization may be noted.

Great hopes are now set on centralized regulation, which is performed by connecting condenser units to automated systems of supervisory control in power supply system. But the system requires a considerable amount of sensors and connecting channels that is a challenging task. In addition, centralized regulation takes into account primarily the interests of power supply system and can lead to an overestimation of energy losses in the individual consumers' power supply systems.

Optimality criterion in efficient management of compensation is minimum power losses. A significant reserve of efficiency increase may be a system of complex reactive power compensation that is created on the basis of modern technical and computational tools [2,3]. The system allows you to change the emphasis in management of compensating devices capacities from decentralization to ensuring systematic commitment of solving problem that is conceptually related to the optimization of power consumption mode at the industrial enterprise.

System of reactive power complex compensation takes into consideration the requirements of power supply system at the interface of power supply systems and consumers' ones, and simultaneously considers power regulation of high-voltage capacity units, batteries for voltage lower than 1000 V, the level of reactive power, which is produced by synchronous engines. To improve the power factor condenser units are used. By means of the reactive power controller we change the reactive power of capacitor batteries, compensating devices (or synchronous engines) [1, 2, 3].

For minimizing losses and accurate fulfillment of power supply system requirements with respect to reactive power, signal that comes to the regulators in the lines of power supply system grows faster over time. Thus here occurs switching of low-power capacitor installations, causing changes in the power factor. If the new factor meets the requirements of power supply system as to the amount of consumed reactive power, power at the output of voltage regulator drops to zero and the signals are also reduced.

Efficiency ratio of compensatory devices use:

$$\Psi = \frac{\sum_{1}^{n} Q_i t_i}{T \sum_{1}^{n} Q_i}, \tag{4}$$

where Q_i - reactive power of compensating devices, quarter;

t - the duration of the compensating device work during the year, hours;

T - the duration of the company work during the year, hours.

By changing the efficiency ratio of reactive power sources use it is possible to increase performance of low efficiency devices.

To choose compensating devices it is enough to minimize the function

$$f = \sum_{i=1}^{n} r_i \left[M^2(Q_i) + D(Q_i) \right] \tag{5}$$

where $M(Q_i)$ - mathematical expectation of Q on i-site of power supply system, $D(Q_i)$ - dispersion of this power value.

Maximum capacity of compensating devices

$$Q_M = M(Q_\Sigma) + \beta\delta_2 \ , \tag{6}$$

where $M(Q_\Sigma)$ - mathematical expectation of reactive power, consumed in power supply system, δ_x - the standard deviation of power, β - multiplicity of dispersion extent.

By reducing the transmitted reactive power, losses of active power are reduced to 0.12 kW / kVAr and depend on the distance to a power source. During compensation it is necessary to consider the following general requirements: unlike active power reactive one can be generated at any point in power supply system; approximation of reactive power sources to consumers facilitates unloading of the system; reactive power balance must be maintained for all nodes of electric power supply.

When switches in the power lines are not enough, in some time the signal will reach the level that will cause switching in the degree of capacitor installation on the main site (or changes in the operating mode of synchronous engines). After such a switch commutation of low-power installations becomes possible in the lines of power supply system for more accurate support of reactive power required value. If the signal meets the requirements to connect additional section of battery and $tg\varphi$ in line is close to zero, connection will not happen. Additional sections will be connected only in those lines where own reactive power is not completely offset. Thus, close to optimal power factor will be hold up in lines of power supply system. Only when all the capacitor installation power on the main site is used, the growth of signal will be possible to such a level that the condenser units in lines will switch regardless of signal of local deliverer [2, 3].

A significant advantage of two-level method of reactive power sources regulation is complex control of reactive power flow and simultaneous regulation of all sources of reactive power at the enterprise. However, in contrast to the remote control, where according to the signal from control point switching is done, regardless of $tg\varphi$ in branch, this method proposes to take into account the level of two signals - from the local sensor and from starting regulator. Switching of capacitor batteries sections occurs selectively, in some branches, and only under certain signal levels. Reactive power consumption during

the day is uneven. Operation mode of all reactive power sources must correspond to the schedule of reactive power consumption. The smallest specific losses are typical for condenser battery with voltage above 1000 V. The greatest occur in low power synchronous engines. The smaller are losses in compensating devices, the better it is to use them in continuous working mode and vice versa, compensating devices with larger losses should be connected transitorily. For example, to cover reactive loads in the hours of maximum power, and also to cover peaks in the graph [5-14].

Thus, in the long-term, baseline mode it is better to use high-voltage compensating devices. Regulated compensating devices with voltage of 0.4 kV and synchronous engines with low losses (high power, speed) - to cover the main graphic, synchronous engines with high specific losses - only to offset short-term peaks in the graph.

The system is done on the basis of the NOVAR type controller, Czech made. The work is introduced in Dnipropetrovsk Dairy. Result of implementation is to reduce energy losses by 23% and the amount of reactive power payment by 78%.

Conclusions

1. Reactive power consumption during the day is uneven. Operation mode of all reactive power sources should correspond to the schedule of reactive power consumption. Compensating devices power should be changed according to schedule of reactive power consumption.
2. Hierarchical structure and high complexity is inherent to the systems of reactive power compensation at the enterprises. Optimality criterion in efficient management of compensation is minimum power losses.
3. Significant potential for raising the efficiency of the system can be the system of complex compensation of reactive power that is created on the basis of modern technical and computational tools. The system allows you to change the emphasis in management of compensating devices capacities from decentralization to ensuring systematic commitment of solving problem that is conceptually related to the optimization of power consumption mode at the industrial enterprise.
4. The system of complex compensation allows you to maintain the flow of reactive power in the elements of power supply system at the optimum level, with maximum effect to use set sources of reactive power, as far as disabling of compensating devices is not allowed in times of reactive power shortage in the power supply system node.

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Calculation of final heating temperature of turbogenerator stator winding for control over development of winding thermal damage

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Abstract

Introduction. It is important for control of turbogenerator to accurately predict the final temperature of the thermal process, which increase in the event of defects in the mashine. Methods of technical diagnostics for manage the development of the defect is necessary.

Materials and methods. Based on the analysis of classical and graphical methods for calculating the final temperature of the stator windings have developed a new method for calculating the steady-state temperature electrical insulation of the stator winding.

Results and discussion. Classical method can be used at a constant value of heat transfer coefficient. That is, when the cooling system is in mode stator and stator temperature rise caused by uncontrolled variations in load turbogenerator. Graphical method is simple to use, but not imprecise. Especially when the magnitude of the proposed steady-state temperature is judged by the results of the measurements only in the initial stage of the heating process of the stator cores. The proposed method of thermal process on the basis of divergence partly compensates the shortcomings of the above-mentioned methods and allows us to analyze the thermal stresses of the stator winding rod.

Conclusion. Using modern methods of information technology allow the use of graphical method to predict the final temperature of heating turbogenerator stator winding. A dikompozition task analysis of the temperature field of the stator winding rod will expand its understanding of the dynamics of change and improve the accuracy of diagnosis.

Introduction

In the second part of XX century power industry in our country was developing at a brisk pace. Dozens of powerful thermal, atomic and hydroelectric power plants were put into operation, where hundreds of synchronous generators – turbogenerators and hydrotreaters (TH) with capacity up to 1200 MW, produced billions kilowatt-hour of electric power. "Small" energetics was developing rapidly as well. In order to supply electric power to plants producing sugar and alcohol, TH with capacity up to 10 MW were put into operation on Central Heat Stations of practically all Ukrainian plants.

Commissioning of large quantity of TH within relatively small period of time lead to the situation that after 30 years (250000 hours of operation), i.e. today, majority of those machines have exhausted or practically exhausted specified resources. To replace these TH with new machines quickly, without reducing the quality of produced energy, is quite expensive and difficult to implement for any country. Therefore, extension of service life and ensuring reliable work of equipment that has exhausted its resources specified by manufacturing plants, are urgent national problems which can be solved with application of technical diagnostics methods.

Emergency shutdown of TH for repair work causes considerable damage to generating companies. Therefore, electric power producers usually try to "extend" to planned shutdown of TH in course of which all defects detected during diagnostics are removed. However, it is necessary to take into account that in case of wrong assessment of diagnostics results, for example, assessment of development speed or degree of defect hazard, economic damage can be more considerable. In this connection, creation of conditions for exploitation of virtually defective TH becomes main task of their operation management or problem of detected defect development management [1].

Development management of defect detected in course of diagnostics can be realized by means of creation of TH exploitation conditions when defect is not developing completely, is developing at minimum and controlled speed or is removed as a result of implementation of modern accepted and justified solution concerning repair work.

According to statistics, majority of defects and further failures in TH operation consequently occur due to deviation from nominal parameters of thermal processes taking place inside working generator.

Any electric machine, including TH, contains a set of various units (brass stator and rotor winding, steel magnetic conductors, variety of structural details) that require different conditions of cooling and have different values of thermalphysic characteristics (thermal conductivity, thermal capacity). All this leads to inevitable differences in temperature of separate units (parts) in working TH. At the same time it is important that temperature of each unit of machine did not exceed the limit.

It is known that load capacity of TH in most cases is determined by temperature of its windings and cores, namely actual conditions of heat extraction that was produced during operation of TH. Stationary thermal processes take place during continuous electrical load in TH. With increase of load, active power loss increases as well. At the same time, in course of nonsteady thermal process temperature of TH units increases to a certain set value which can exceed allowable value.

Thus, overheating of TH stator and rotor windings – electrical insulation and winding material, may cause interturn closure and even lead to formation of cracks in copper winding. All these conditions lead to considerable decrease of reliability and, consequently, of TH operational life.

At the same time, temperature of separate units and whole TH may increase not only due to increase of electrical load. This may happen due to failures of cooling system that is installed in all modern TH or any other defects occurring inside machine.

Cooling system of modern TH represents technologically composite component of electric power manufacturing system. Depending on performed functions all components in cooling system can be divided into two parts. One part of the system is structural component of TH designed for direct removal of heat produced by electric current. These are ducts in stator winding shafts where liquid coolant is supplied as well as ducts in rotor winding and TH cores for transportation of cooling gas.

Second, larger part of cooling system, is located outside TH. This is a complex of devices that ensure availability of necessary parameters of cooling media and their supply to TH. It is worth noting that temperatures and expenses of liquid and gaseous coolants in cooling systems of TH, as a rule, are not controlled.

Despite technical complexity of TH cooling system, significant malfunctions in its work and increase of temperature in separate unit of TH may occur due to seemingly not so emergent defects of the system. For example, partial obstruction of shaft ducts through which cooling liquid is transported may cause nonsteady thermal process and increase of temperature in one shaft (group of shafts) of TH stator winding.

Nonsteady thermal processes may have much larger time lag, comparing to electrical transient processes [2]. In its turn, larger part of defects that may cause nonsteady thermal process in TH, as a matter of fact, are defects prone to development in time [3].

For development management of such defects it is essential to not only determine the fact of temperature change, for example of TH unit. It is important to forecast the value of final temperature of nonsteady thermal process as precisely as possible – value of newly fixed temperature of this TH unit, as well as duration of the process – time to newly fixed temperature. Depending on the value of newly fixed temperature of defective TH unit which may appear lower, equal to or higher than allowable temperature, it will be necessary to make decision concerning further TH operation.

Thus, if predictable values of final temperature of TH unit defective condition development appear to be lower than allowable, decision not to change the load of TH may be approved. Otherwise, it shall be necessary to make decision about reducing the load, namely, to what extent and how quickly it will be done, or TH shutdown.

At the same time it is important to determine location of temperature change in TH, the size of which may give evidence about heat exchanging processes inside machine. Thus, in series of modernized TH, stator winding temperature is determined on the basis of results of water temperature measurement at the outlet of each winding shaft. However, more often stator winding temperature is determined on the basis of thermometer readout located over electrical insulation of shafts. It is clear that water temperature at the outlet of the shaft and temperature of electrical insulation of the shaft differ numerically. At the same time, according to our evidence this difference may reach 10K. Under such circumstances, methods of comparison of temperature measurement results with allowable values of TH stator winding temperature shall differ.

Materials and methods

Anticipating the final heating temperature of the stator winding turbogenerator were considered and analyzed the classical method of calculating the final temperature transient thermal process and graphical method for determining the final temperature. Based on the

above-mentioned deficiencies identified by developed a new method for calculating the steady-state temperature electrical insulation of the stator winding.

Results and discussion

In essence, final temperature value of nonsteady thermal process may be predicted on the basis of information from expert database which, unfortunately, cannot cover all possible causes of such process in TH or on the basis of result of nonsteady thermal process calculation.

Method of nonsteady thermal process calculation in electric machine mentioned in [2, 4] and series of other publications, without exaggeration, may be considered classical. Object of heating here, namely electric machine, is considered to be uniform solid body. At the same time, meaning of temperature of the object is not used for determination of thermal condition of the object, but surplus temperature of the object (heated machine unit) in respect of temperature of cooling medium or else – superheat temperature.

When TH load increases, that is, heating of TH to a certain higher value of fixed temperature, active power losses ΔP_1 increase as well. As far as one part of thermal energy dQ, which is released in TH stator winding shafts during time $d\tau$ of electric current effect, is expended on temperature increase of shafts $dQ_{\text{м}}$, and second part $dQ_{\text{в}}$ – is removed through cooling system of machine, therefore equation of thermal balance looks the following way:

$$dQ_1 = \Delta P_1 \cdot d\tau = dQ_{\text{м}} + dQ_{\text{в}} = c_{\text{м}} \cdot m_{\text{м}} \cdot d(\Delta T_{1\text{м}}) + \alpha \cdot S \cdot \Delta T_{1\text{м}} \cdot d\tau$$

where $c_{\text{м}}$ and $m_{\text{м}}$ – are thermal capacity and mass of stator winding shaft material - copper, respectively;

$\Delta T_{1\text{м}} = T_{1\text{м}} - T_{\text{хв}}$ – surplus temperature (overheating) $T_{1\text{м}}$ of stator winding shaft in respect of temperature T_{cw} of cooling water at the inlet of TH.

where α and S – heat-transfer coefficient and heat-exchange surface area.

With increase of temperature of winding (value $\Delta T_{1\text{м}}$), the portion of heat removed by cooling system is increasing and portion of heat accumulated in TH stator winding shaft is reducing. Therefore, different condition of machine thermal equilibrium (machine unit) will be attained at a certain value of surplus temperature $\Delta T_{1\text{м.к}}$.

As far as in condition of thermal equilibrium all heat produced in stator winding shafts under electric current is removed through cooling system $c_{\text{м}} \cdot m_{\text{м}}\ d(\Delta T_{1\text{м}})=0$, then thermal balance equilibrium looks the following way:

$$c_{\text{м}} \cdot m_{\text{м}} \cdot d(\Delta T_{1\text{м}}) = \alpha \cdot S \cdot \Delta T_{1\text{м}} \cdot d\tau \ .$$

Taking into account that at the moment of TH loading variation, namely at the beginning of nonsteady thermal process at $\tau=\tau_0=0$, temperature of winding shaft exceeded temperature of cooling medium at the value $\Delta T_{1\text{м.0}}$, consequently, with the help of abovementioned solution of differential equation with regard to final fixed temperature we get:

$$\Delta T_{1\text{мк}} = \Delta T_{1\text{м}} / [(1 - e^{-\tau / K_\tau}) + \Delta T_{1\text{м}0} \cdot e^{-\tau / K_\tau}] \ . \qquad (1)$$

Value of time constant K_τ – period during which copper shaft of stator winding with mass $m_{\text{м}}$ and thermal capacity $c_{\text{м}}$, will reach surplus temperature $\Delta T_{1\text{мк}}$ at heat release power ΔP_1 provided, all that heat is expended exclusively on shaft heating, can be calculated using the following formula:

$$K_\tau = c_м \cdot m_м / (\alpha \cdot S). \quad (2)$$

At $\tau=\tau_0=0$ и $T_{1м.0}=0$, namely, when temperature of the shaft equals temperature of cooling medium and TH loading variation took place, on the basis of equation (1) we will get:

$$\Delta T_{1мк} = \Delta T_{1м} / (1 - e^{-\tau/K_\tau}), \quad (3)$$

$$(dT_{1м} / d\tau)_{\tau=0} = tg\beta = I_1^2 \cdot \gamma / (\rho_м \cdot c_м \cdot S). \quad (4)$$

Figure 1 shows kinetics of object superheat temperatures calculated in accordance with equation (1) – curve 1 and equation (3) – curve 2.

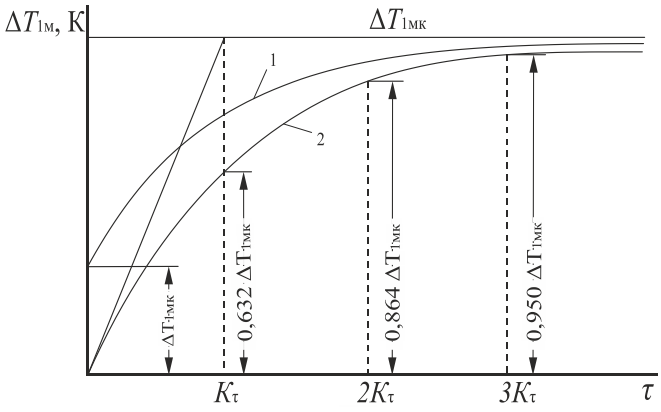

Fig. 1. Calculation results of kinetics of superheat temperature of the stator winding rod

As follows from the results of analysis, the abovementioned method of calculation of nonsteady thermal process final temperature can be used only in cases when TH temperature increase results from change of machine electrical load. At the same time, value of time constant K_τ of nonsteady thermal process does not change, which means that for every specific TH its value may be defined during commissioning or in course of machine testing upon completion of planned repair.

In cases when value of heat-transfer coefficient α, meaning K_τ, changes as a result of defect, the abovementioned method of calculation of nonsteady thermal process final temperature is not quite suitable.

More acceptable for determination of nonsteady thermal process final temperature of TH heating, caused by defect, is the so-called graphical method introduced in the 30s of previous century [5]. To determine final temperature of electrical machine overheating with the help of this method, the following procedures are performed graphically.

From the moment of beginning $\tau_0=0$ of stator winding shaft temperature change over equal intervals $\Delta\tau=(\tau_1-0)=(\tau_2-\tau_1)=(\tau_3-\tau_2)$ superheat temperature is measured in ΔT_1 ΔT_2 ΔT_3, respectively, and on the basis of results of measurement a part of kinetic dependence is built $\Delta T=f(\tau)$ (fig.2). Then, from X-axis from points τ_1, τ_2, τ_3, vertical lines are drawn to intersection with curve $\Delta T=f(\tau)$. Across obtained points on the curve $\Delta T=f(\tau)$, 1, 2, 3, respectively, horizontal lines are drawn, on which, upon intersection with Y-axis, respective changes in superheat temperature of TH stator winding shaft are indicated.

Thus, on horizontal line, drawn from point 1 upon intersection with axis ΔT, section $\Delta T_{10}=\Delta T_1-\Delta T_0$ is indicated which characterizes change of superheat temperature of TH stator winding shaft within time interval from 0 to τ_1. On horizontal lines, drawn from

points 2 and 3, left from Y-axis, are indicated intervals $\Delta T_{21}=\Delta T_2-\Delta T_1$, $\Delta T_{32}=\Delta T_3-\Delta T_2$, respectively, that characterize changes of surplus temperature of the shaft within time intervals $\tau_2-\tau_1$ and $\tau_3-\tau_2$.

Following the performance of the above mentioned operations there appear points 1*, 2*, 3*on the left from Y-axis of diagram $\Delta T=f(\tau)$. Axis of intersection of straight line that passes through those points with Y-axis of diagram $\Delta T=f(\tau)$ is the desired final superheat temperature of TH stator winding shaft $\Delta T_к$, namely, which will be fixed in the machine upon completion of nonstedy thermal process.

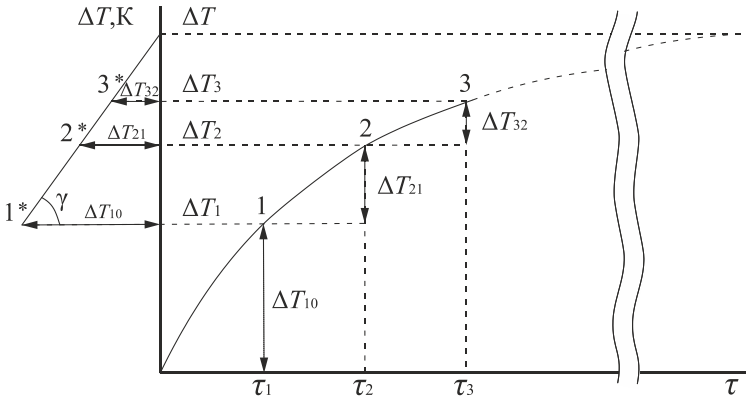

Fig.2. Determination of the final superheat temperature of the stator winding bar graphically

To determine final temperature of nonsteady process, for example heating of stator winding shaft due to defect, it is not difficult to implement auxiliary program into computer program of diagnostics of TH technical state. According to that auxiliary program at the moment of beginning of shaft temperature change $\tau_н$ and further at specified time τ_1 and τ_2, it is necessary to measure shaft superheat temperature: ΔT_0, ΔT_1 and ΔT_2, respectively. Then, final superheat temperature of stator winding shaft with defect may be calculated the following way:

$$\Delta T_к = (\Delta T_1 - \Delta T_0)\cdot tg\gamma + \Delta T_1 = \frac{(\Delta T_1 - \Delta T_0)\cdot(\Delta T_2 - \Delta T_1)}{(\Delta T_1 - \Delta T_0)-(\Delta T_2 - \Delta T_1)} + \Delta T_1 . \qquad (5)$$

Disadvantage of the abovementioned graphic method of determination of TH shaft (unit) final superheat temperature is insufficient accuracy of exponent building $\Delta T=f(\tau)$ and calculation of $\Delta T_к$ according to three points that have small distance from one another in time and distance on the initial section of the exponent. In addition to that, taking into account possibility of continuous measurement of equipment work parameters as well as continuous processing of results of these measurements, graphic method implemented with the help of modern information technologies may be used for forecasting of final temperature of nonsteady thermal processes taking place inside TH.

It was noted earlier that result of measurement of TH stator winding temperature depends on location of thermometer sensing element. Taking into account the fact that electric insulation of machine windings is the most sensitive element of TH to temperature change (increase), apart from graphic method described above, we suggest using our method of calculation of fixed temperature of TH stator winding shafts (electric insulation), theoretical justification of which is described below.

Cross-section (across *x-axis*) of TH stator winding shaft can be represented in the form of double-layer wall which on one side is washed by cooled distilled water (fig.3). Across *Z*-axis here:

1 – Copper layer (Cu) with thickness D_1 (coordinates – $D_1 \geq z \geq 0$) having thermal conductivity coefficient $\lambda_м$, in which electric current is effective *I*, that induces emission of heat with volume density q_v=value of which is proportional I^2/r in the layer with resistance *r*.

2 – Layer of electric insulation with thickness $d=D_2-D_1$ (coordinates – $D_2 \geq z \geq D_1$), having thermal conductivity coefficient $\lambda_и$;

3 – Section, where distilled water (H_2O) is circulating, temperature of which $T_в$ is changing across *x*-axis.

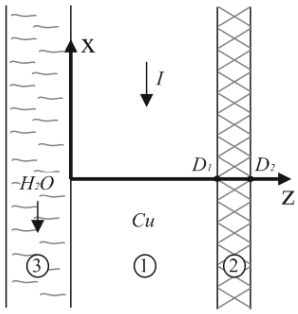

Fig. 3. Model rod windings of the stator.

In one-dimensional statement boundary value problem of calculation of copper part $T_м$ temperature and electric insulation T_e of TH stator winding shaft looks the following way:

$$-\lambda_м(d^2T_{1м}/dz^2)=q_v \quad -\lambda_e(d^2T_e/dz^2)=0, \qquad -\lambda_м(dT_{1м}/dz)=\alpha\cdot(T_в-T_{1м}) \quad z=0, \tag{6}$$

$$T_{1м}=T_e|_{z=D_1} \quad \lambda_м(dT_{1м}/dz)=\lambda_e(dT_e/dz)|_{z=D_1} \quad z=D_1, \qquad (dT_e/dz)|_{z=D_2} \quad z=D_2, \tag{7}$$

where $\alpha_в$ – is heat-transfer coefficient from copper part of the shaft to water.

In the fixed mode temperature of cooling water is increasing across *x*-axis, but in the presence of disturbance is changing across time τ.

Taking into account the fact that temperature of cooling liquid when circulating inside stator winding shaft (across *x*-axis) is changing only from 30ºC to maximum 80ºC, as well as considerable inertia of thermal processes, when solving practical tasks of calculation of copper part $T_м$ temperature and electric insulation T_e of the shaft using models (6), (7), it is preferred to consider variables *x* and τ as parameters.

From the results of analysis of heat-exchange process on models (6), (7) it may be seen that, in general, case solution to the boundary-value problem looks the following way:

$$T_{1м}=A_0z^2+A_1z+A_2, \tag{8}$$

$$T_e = B_1 z + B \,. \tag{9}$$

Therefore, to determine numeric values of copper temperature $T_м$ of TH stator winding shaft, electric insulation $T_и$ of the shaft as well as thermal gradients in specific points z=0, z=D_1, z=D_2, it is necessary to define values of coefficients A_0, A_1, A_2, B_1, B_2. It is worth noting that as follows from results of analysis of equations (6) and (8), desired value of coefficient A_0 may be calculated the following way:

$$A_0 = -q_v / (2 \cdot \lambda_м) \,. \tag{10}$$

It means that values of remaining coefficients A_1, A_2, B_1 и B_2 shall be reasonably calculated using information about value A_0 and value q_v – the main temperature-forming parameter.

In its turn, from the results of analysis of equations (7) and (9) it appears that coefficient B_1=0 and, consequently, T_e=B_2=*const*. It means that temperature of electric insulation across z-axis does not change, that is, temperature gradient in insulation layer equals zero and numeric value of insulation temperature equals temperature of copper shaft in the point of intersection with coordinate z=D_1.

Besides, it appears from condition of continuous heat flow on the boundary surface of materials z=D_1 that $(dT_e/dz)|_{z=D1}$. It means that stator winding shaft copper reaches maximum temperature in the point of intersection with coordinate z=D_1.

In the result of transformations we get the following equation for calculation of coefficients A_1, A_2, B_1 and B_2 across A_0 and q_v:

$$A_1 = -2 A_0 D_1 = D_1 (q_v / \lambda_м) \,, \tag{11}$$

$$A_2 = A_1 (\lambda_м / \alpha_в) + T_в = D_1 (q_v / \alpha_в) + T_в \,, \tag{12}$$

$$B_2 = A_0 D_1^2 + A_1 D_1 + A_2 = (q_v / \alpha_в) \cdot D_1 + [q_v / (2 \cdot \lambda_e)] \cdot D_1^2 + T_в \,. \tag{13}$$

On the basis of results of equation analysis (11)-(13) it appears that difference between maximum $T_м|_{z=D1}$=B_2 and minimum $T_м|_{z=0}$=A_2 temperatures of copper layer may be calculated the following way:

$$\Delta T_{1м} = B_2 - A_2 = [q_v / (2 \cdot \lambda)] \cdot D_1^2 \,.$$

Difference $\Delta T_{м\text{-}в}$ between maximum temperature of shaft copper $T_м|_{z=D1}$=B_2 and temperature of cooling water $T_в$ will look the following way:

$$T_{м\text{-}в} = B_2 - T_в = (q_v / \alpha_в) \cdot D_1^2 \,.$$

This implies that maximum temperature gradient on the boundary “copper – cooling water” equals A_1=$(q_v/\lambda_м)$·D_1.

Here we shall point out that, as a matter of fact, similar results may be obtained for model which represents hollow cylinder inside of which cooling medium is circulating and on the outside covered with insulation. Similar to examined above, such model may be analysed with or without regard for its heat exchange with environment, for example, by means of natural convection.

As was stated above, in course of nonsteady heat-exchange process temperature of cooling water changes not only during circulation, but in course of time. In that case analytical solution to the problem regarding temperature and temperature gradient in copper part of the shaft, where electric current is effective, which produces volumetric heat emission, may be significantly complicated. Therefore, methods of numeric computation are usually applied for analysis of thermal processes in lead wires [6].

Alternatively to all known methods and methodologies of calculation of thermal processes in lead wires concept of average temperature may be introduced on the basis of volume of stator winding shaft copper part or its separate components in direction of cooling media flow. This approach is implemented for analytical analysis of thermal processes in TH stator winding by means of transformation of differential equation of nonsteady heat conductivity for shaft copper in partial derivatives:

$$(c\rho)_{\text{м}} \cdot (\partial T_{1\text{м}} / \partial \tau) - \nabla \bullet (\lambda_{\text{м}} \cdot \nabla T_{1\text{м}}) = q_v , \qquad (14)$$

where $(c\rho)_{\text{м}}$ – is volumetric thermal capacity of shaft copper as a product of mass thermal capacity to copper density;

$\nabla \bullet$ – divergence;

$\nabla T_{1\text{м}}$ – temperature gradient in copper part of the shaft;

in general differential equation of nonsteady heat conductivity for average volume V of temperature $\overline{T}_{1\text{м}} = V^{-1} \int T_{1\text{м}} dV$ of shaft copper part or any other function related to temperature. Divergence theorem serves as theoretical background for realization of such transfer [7], in accordance with it, to obtain random volume V (рис.4), limited by closed surface S and random vector function $\vec{F}$,the following conditions have to be observed:

$$\oint_s \vec{F} \cdot d\vec{S} = \int_v (\nabla \vec{F}) dV . \qquad (15)$$

In equation (15) $d\vec{S} = \vec{n} \, | d\vec{S} |$ – it is surface element directed to unit norm $\vec{n}$ on the surface S.

As a result of substitution in equation (14) of expression of heat flow density vector resulting from Fourier's law $\vec{q} = -\lambda \nabla T$, by multiplying members of equation by dV and integration according to volume, we will get equation for calculation of average temperature according to volume of copper part of TH stator winding shaft at $(c\rho)_{\text{м}}$=*const*:

$$(c\rho)_{\text{м}} \cdot (\partial \overline{T}_{1\text{м}} / \partial \tau) = \overline{Q}_v - \overline{Q}_s , \qquad (16)$$

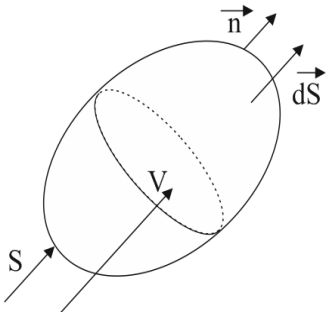

Fig. 4. The divergence theorem.

where $\overline{T}_{1\text{м}} = V^{-1} \int_v T_{1\text{м}} dV$, $\overline{Q}_v = V^{-1} \int_v q_v dV$, $\overline{Q}_s = V^{-1} \oint_s \vec{q}_s \cdot d\vec{S}$ — are, respectively: average volumetric temperature of copper part of TH stator wining shaft, average value of heat emitted in the volume of copper part of the shaft as a result of current effect, average value of heat removed by cooling water from surface S of copper part of the shaft.

In accordance with equation (7) value of heat flow density $\overline{q}_s$ is determined by conditions of heat exchange between copper part of the shaft in which electric current

is effective and cooling water. It depends on heat-transfer coefficient $\alpha_{в}$, water temperature $T_{в}$ and temperature of shaft copper $T_{м}|_{z=0}$, which in equation (6) shall be substituted by $\overline{T}_{1м}$.

Taking into account assumptions described above, equation (11) will be the following:

$$(c\rho)_{м} \cdot (d\overline{T}_{1м} / d\tau) = \overline{Q}_{v} - K(\overline{T}_{1м} - T_{в}), \quad (17)$$

where K – is coefficient, value of which is proportional to heat-transfer coefficient and water.

In general view, solution to equation (17) regarding changes in the time of average temperature of stator winding copper part can be represented in the form of total of the exponent and straight line, where exponential nature of change $\overline{T}_{1м}$ is determined by complex $K\overline{T}_{1м}$, and linear nature – by complex $(\overline{Q}_{v} + KT_{в})$. At $d\overline{T}_{1м} / d\tau = 0$, average temperature of stator winding shaft copper part reaches fixed value that equals:

$$\overline{T}_{1мк} = (\overline{Q}_{v} + KT_{в}) / K. \quad (18)$$

Since integral of solution to equation (16), represented in generalized form –

$$(d\overline{T}_{1м} / d\tau) = f(T_{1м}) = a + b \cdot \overline{T}_{1м}, \quad (19)$$

where *a=const*, *b=const* according to [8] is the following:

$$\int d\overline{T}_{1м} / f(T_{м1}) = b^{-1} \cdot \ln(a + b\overline{T}_{1м}) = \int d\tau, \quad (20)$$

then, calculation of fixed temperature in TH stator winding shaft copper part performed using divergence theorem may cover cases of nonsteady heat exchange. Thus, for practical calculations of typical values of temperature and temperature gradients in copper and electric insulation of TH stator winding shaft that are determining the level of thermal damages in a certain TH unit and the whole TH, block diagram described in fig.5 may be suggested.

Block 1 – variant calculation in accordance with equation (8) with ratios (10)-(13), of temperature distribution across cross-section of TH stator winding shaft.

Block 2 – variant calculation of temperatures in typical points of TH stator winding shaft.

Block 3 – variant calculation in accordance with equation (17) of fixed value of temperature in TH stator winding shaft.

Block 4 – variant calculation in accordance with equation (19) of average temperature change in TH stator winding shaft.

Block 5 – variant calculation in accordance with equation (19) of time to fixed average temperature in TH stator winding shaft.

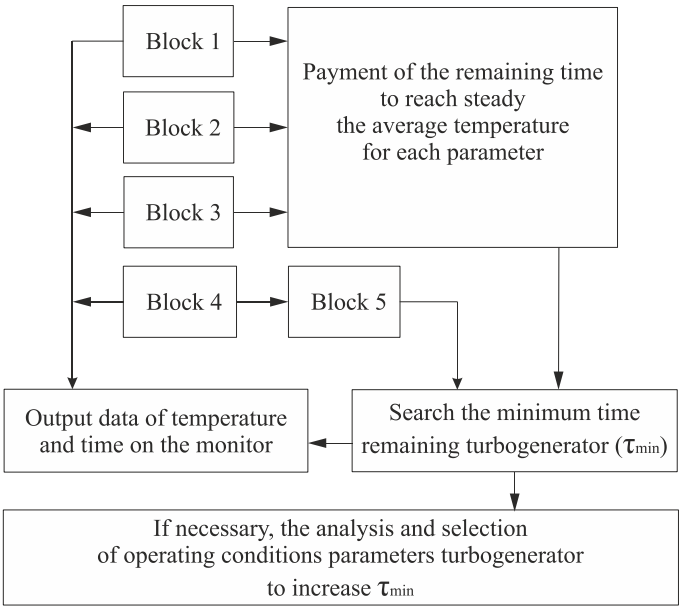

Figure 5. Block diagram of the calculation of the thermal state of a node turbogenerator

Conclusion

- Application of modern methods of information technologies allows usage of graphic method for final temperature determination of induction motor heating in order to predict final heating temperature of turbogenerator stator winding.
- When using decomposition approach, the problem of temperature field analysis of turbogenerator stator winding shaft can be divided into two parts: calculation of temperature distribution across cross-section of the shaft in quasisteady approximation with temperature analysis and temperature gradients in typical points of the shaft; calculation of nonsteady distribution of shaft average temperature with integral ratios of heat supply by electric current and removal by liquid heat-transfer agent.
- Implementation of decomposition approach for temperature field analysis of turbogenerator stator winding shaft allows expanding the notion of dynamics and space variation of temperature field and space variation of stator winding shaft temperature field, increasing reliability of technical state diagnostics of turbogenerator stator winding.

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Returning heat flow during thermal treatment of food

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Abstract

Introduction. Adaptation of newest thermophysical measuring devices permit to receive a new information concerning to technological processes, so permit to use sparingly of energy and raw materials.

Materials and methods. Highly sensitive and fast-response compact heat meter – disc diameter of 20 mm and a thickness of 1,2 mm – was used during study of hard cheese ripening. The temperature of air in camera was 10±0,25°C in accordance with regulations.

Results and discussion. Result of direct measurement of heat flux with heat meter, which was mounted at the top center surface of the piece of a green cheese is unexpected: near 30 % of the heat which is released in the cheese and discharging with the cooling air is returned to the cheese.Return of heat to cheese is a ballast load for the chiller of ripening cheese chamber. Its elimination or minimization is a source of energy and resources saving. The fact that the return (inverse) of the heat flow in the refrigeration of food processing was not known in the world of science. Ballast heat fluxes can occur in the heat treatment of food products, for example, during stabilization of the surface layer of cooked sausages with oscillating infrared roasting. Inversion heat flow occurs when the heat meter is on the opposite side (in shadow) of the transmitter. The selection of the coagulation time and the voltage on the emitter managed to reduce ballast heat flux in the central layers to one-third and the inverse flow of these layers - to zero. The maximum heat flux (and with it the total energy consumption) is reduced by 15-20 %. The cooling process is necessary to make special arrangements. Reducing the temperature control range during refrigerating treatment would reduce the amount of heat ballast, but would be reduced in proportion and amount of heat withdrawn per cycle "on-off". Reduced cycle time would lead to more rapid wear of chiller parts. If is not possible, you need to install a thermostatic switch as far as possible from the chilled goods.

Conclusion. Established fact that the possibility of ballast heat flows - one more argument in favor of a change to absorption chillers with heat recovery, the potential of which is large enough for any food enterprises, including dairy and cheese factory.

Introduction

Ripening is a very involved process in which the microbes present in the green cheese slowly change the chemical composition and so its texture and flavor. The change is overwhelmingly in the direction of dismantling complex organic molecules into simpler, smaller ones: lactose into lactic acid and carbon dioxide, fats into fatty acids, proteins into smaller chains of amino acids, individual amino acids, and even ammonia (NH_3) [1]. These and other exothermic processes are the reason for organization of continuous heat elimination from cheese.

Materials and methods

Technological parameters of food products (outward appearance, structure, fat and moisture content, et cetera) are closely connected with their thermal properties (intensity of heat transport, thermal conductivity, reflecting property and soon). This connection was demonstrated in [2] with adducing instances from dairy industry. Some of physical properties are typical technological characteristic at the same time – temperature, density, viscosity, temperature of melting or boiling [3]. Adaptation of newest thermophysical measuring devices permit to receive a new information concerning to technological processes, so permit to use sparingly of energy and raw materials.

Highly sensitive and fast-response compact heat meter – disc diameter of 20 mm and a thickness of 1,2 mm – was used during study of hard cheese ripening [4]. The temperature of air in camera was 10±0,25 °C in accordance with regulations.

Direct measurement of heat flux q, W/m^2 with heat meter, which was mounted at the top center surface of the piece of a green cheese with paraffin, for 22 th day of ripening, gave the curve taken on Fig.1. Result is unexpected: near 30 % of the heat which is released in the cheese and discharging with the cooling air is returned to the cheese.

Result and discussion

Return of heat to cheese is a ballast load for the chiller of ripening cheese chamber. Its elimination or minimization is a source of energy and resources saving.

To our knowledge, the fact that the return (inverse) of the heat flow in the refrigeration of food processing was not known either in domestic or in the world of science.

Perhaps this is due to the fact that this information was first obtained by direct measurement of the heat flux. Heat meter responds not only to turn on and off the refrigeration unit, but the fluctuation of the heat flow rate due to changes in the velocity of cooling air flowing around cheese, which are difficult to graphically display performance in computer graphics.

Ballast heat fluxes can occur not only in the refrigeration, but in the heat treatment of food products. For example, the results presented of the study of on Fig. 2 and 3 the process of stabilization of the surface layer of cooked sausages with oscillating infrared roasting. Heat meter diameter of 14 mm and a thickness of 1.5 mm was fixed at the inner side of the hollow cylinder, wherein the extrusion molded loaf recipe for milk sausage, and a second similar calorimeter under the surface layer 2.5 mm thick meat. After electric coagulation the piece of sausage loaf removed from the cylinder and placed in a heat chamber model for rotating cylindrical support. Energy supply to sausage was made with an infrared emitter (Fig. 2). The stabilization time of the surface layer (roasting) was 5 - 7 min, speed of the rotation - approximately 1 rev / min.

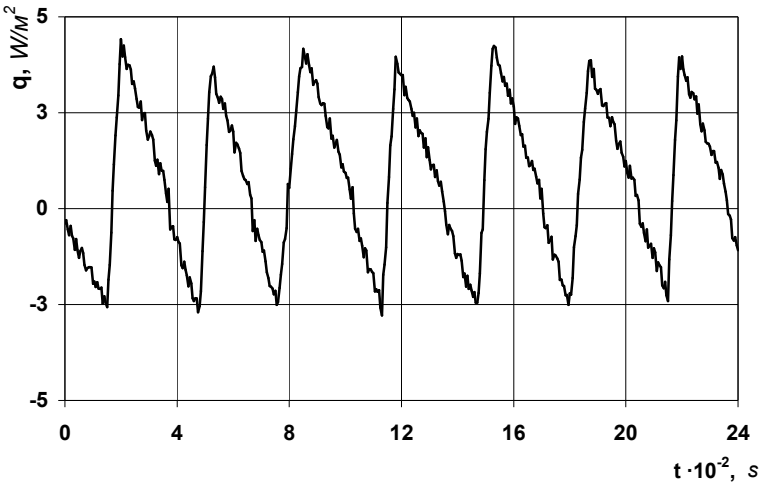

Fig. 1. The heat flux through the surface layer of the cheese during ripening.

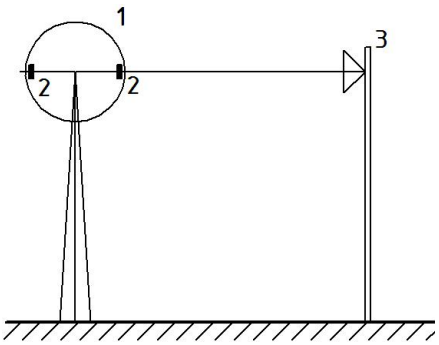

Fig. 2. Scheme of infrared stabilizing surface layer sausage

1 - long loaf sausage
2 - heat meters
3 - emitter.

Two heat meters were placed on opposite sides of the cylindrical sausage, so that when the signal of one of them is maximal (against the emitter), the second - close to the minimum or even negative (Fig. 3). Inversion heat flow occurs when the heat meter is on the opposite side (in shadow) between the transmitter and the ambient temperature is lower than the surface of the specimen. Thus, the cause of the reverse flow of heat is the same as in the cheese ripening - temperature difference "product surface - surrounding air" changes sign.

With the initial roasting regime parameters: temperature sausage after coagulation of 62 ° C, the maximum heat flux through the surface of the specimen 3 - 3.3 kW/m^2 (curve 1 on Fig. 3)- unnecessary for technology transit flow to the deeper layers (curve 2 Fig. 3) make up to two thirds of the resulting flow through the surface. Inversion of heat flow with heat meters is fixed not only on the surface of the sausage, but at a depth of 2.5 mm. The selection of the coagulation time and the voltage on the emitter managed to reduce ballast heat flux in the central layers to one-third (curve 1 in Fig. 4), and the inverse flow of these layers - to zero (curve 2 in Fig. 4).

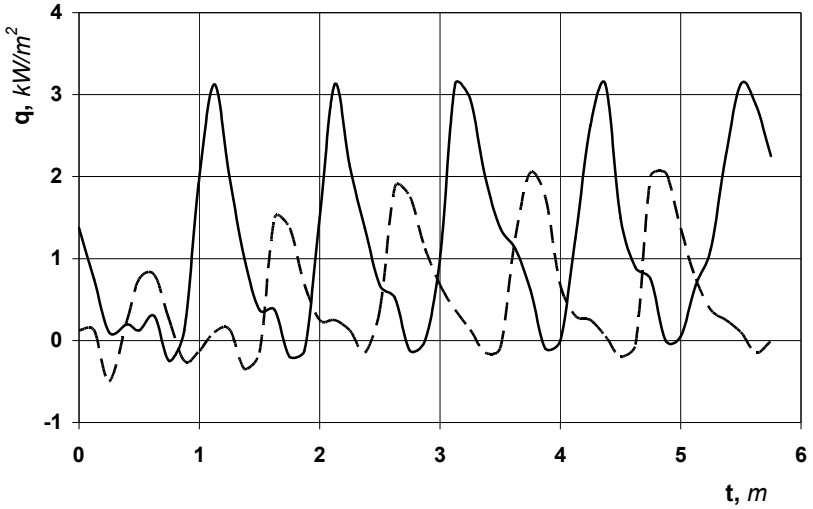

Fig. 3. The heat flux through the surface of the loafs (1) and a depth of 2.5 mm (2) before investigation.

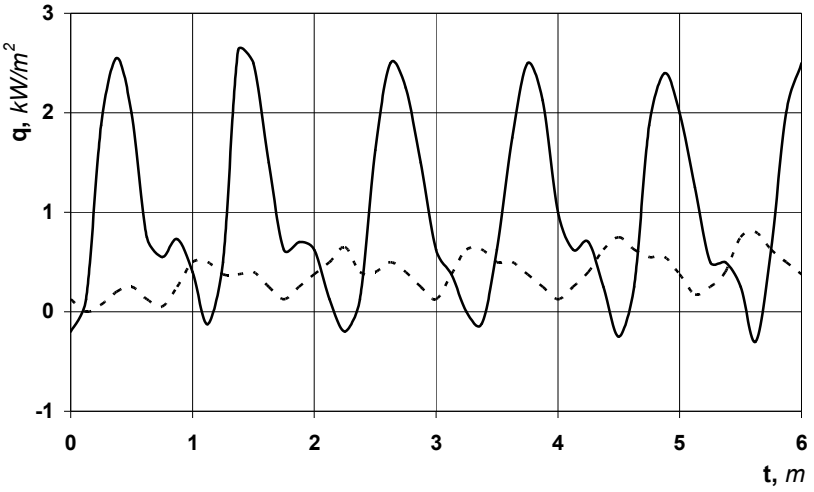

Fig. 4. The heat flux through the surface of the loafs (1) and a depth of 2.5 mm (2) after the selection of the parameters of rational roasting.

The maximum heat flux (and with it the total energy consumption) is reduced by 15-20 %. Thus, a direct measurement of the density of heat flow can develop rational modes of heat treatment of food products and identify features of thermal energy transfer that are not available in the measurement of temperature.

This is because the heat flux is determined not by the temperature at the point of product, but its gradient at this point in accordance with the first Fourier law

$$q = -\lambda grad\,(t) = -\lambda \frac{dt}{dn}, \qquad (1)$$

where λ - thermal conductivity of the product, W/(m·K), n - the direction of heat transfer. The minus sign means that the vectors of the heat flux q, W/m^2 and the temperature gradient $grad(t)$, K/m, oriented in opposite directions. In other words, the temperature shows only potential of heat energy and density of the heat flow - direction and the intensity of its transfer.

Conclusion

If the heat treatment in the ballast heat flows relatively easy to fight, then the cooling process is necessary to make special arrangements. Thus, in the case considered cheese ripening heat removal was performed using a compressor refrigeration system and maintain the coolant temperature at 10 ± 0,25 °C thermostatic device produced. Reducing the temperature control range would reduce the amount of heat ballast, but would be reduced in proportion and amount of heat withdrawn per cycle "on-off". However, the cycle time would be reduced, which would lead to more rapid wear of chiller parts. The only side effect of reducing the useful range of temperature control is to reduce the thickness of the surface layer of cooled material, in which the alternating heat transfer.

The ideal solution to eliminate ballast flow of heat using compressor chillers is the availability of products in the treatment chamber buffer capacity - room, where the air is well mixed. If this is not possible, you need to install a thermostatic switch as far as possible from the chilled goods. Established fact that the possibility of ballast heat flows - one more argument in favor of a change to absorption chillers with heat recovery, the potential of which is large enough for any food enterprises, including dairy and cheese factory.

Regardless of which system is used of heat Abstraction, it is necessary to avoid inflow of fresh air into the cooling and freezing food, the heat leakage through the fence refrigerating compartment post including burning electrical lamps, because all this is a source of ballast heat flows.

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An increasement of general occupational safety level at food industry plants

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Abstract

Introduction. A purpose of research is to increase the occupational safety level through elaboration of general injury risk model at food processing.

Material and methods. Research object is an occupational traumatism at food industry plants. The research was carried out using method of the principal components for determination of main traumatism factors and work injury risk prognostication.

Results. We've improved the general injury risk model at food processing, which considers all the variety of industrial and socio-economical factors comprehensively, and is built upon the pattern of accident occurrence, wherein each accident is linked to its reason. This approach, based on data from the mandatory annual reporting forms, allows to perform the analysis of direct causal connections in traumation process and to detect both basic and hidden reasons of injuries, including types of events leading to accidents. It was found that the most efficient way to provide filtering of statistics and visualize results is the principal components method. Usefulness of this method in the analysis of data on occupational injuries is based on its capability to reduce the information amount and identify the most significant factors of industrial traumatism. Due to main properties of the principal components method, it is suited to prognostication of significant initial indications number, with relatively few auxiliary (latent) variables which display the reasons of traumatism, ensuring the smallest prognosis error.

Introduction

The problem of determining the causes of occupational injuries is crucial for effective prevention of unwanted effects at all levels of health and safety management. To solve this problem has been done a lot in the areas of investigation, recording and analyzing of the direct causes of occupational injuries [1–3]. However, there is no simple answer to the question of how the general characteristics of production, state of assets, and state supervision of safety and resource needs of safety affect on the occupational injuries. That is there are currently no external factors potentially able to influence the injuries (addition

to the general considerations which are based on logic generalization and subjective perceptions). In the currently known research and practice analysis that focus on the impact of external factors on injury are used: comparison of the dynamics of gross domestic product and the injury levels [4], assessment of injury – rates of injuries per unit of production [5], expert assessment of the impact of external factors on occupational injuries [6] etc. That is taken into account only some of the characteristics of external factors that can not perform a comprehensive assessment of the impact on getting injuries of the entire range of industrial and socio-economic factors, which greatly impoverishes the results of analysis and does not take into account the trend of changes in external factors to correct for the prevention of occupational injuries.

A purpose of research is to increase the occupational safety level through elaboration of general injury risk model at food processing.

Research object is an occupational traumatism at food industry plants.

Material and methods

To analyze the direct cause-and-effect relationships that occur during injury, used the circuit of accidents that displays statistics about the immediate causes of occupational injuries [7]. Using this scheme, the tasks of improving informativeness of available statistics about the main causes of occupational injuries and kinds of events that lead to an accident were solved. The main source of information is acts of investigation of accidents and the results of their generalization in the form of mandatory annual statistical reports. In these forms stand out 16 major causes of accidents and 15 types of traumatic events that have traditionally been analyzed separately, independently one from the other.

To enhance the information content in the work investigates a binary mix (group) "cause of injury – type of traumatic event", that repeatedly increases the number of possible options (varieties) of causes of injury, hidden in the statistics form № 7-ТНВ, and allows more specifically and purposefully determine how to prevent injuries.

The study of binary groups based on causal chain [7], shown in Fig. 1.

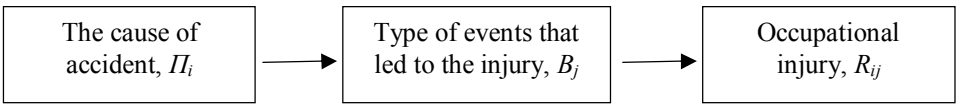

Fig. 1. Scheme occurrence of accidents

Assume that for the assessments of circuit components (Fig. 1) uses quantitative characteristics as the risk indicators. That is causes of traumatism assesse in terms of the risk of injury for each of the reasons $П_i$ (i – cause of injury index, i = 1,2,...,16), and the kinds of events that led to injury – in terms of risk that correspond to each traumatic event B_j (j - kind of traumatic event index, j = 1,2,...,15). Indicators of risk of injury in general R and for certain causes or kinds of events are determined by the frequency of accidents: $R^t = N^t / N_c$, N^t – number of injured with fatalities or no fatalities or the number of persons injured by certain causes $П_i$ or kinds of events B_j (with fatalities or no fatalities results), N_c – average number of employees. For ease perception of numbers accepted to multiply them by 100 000. Indicator risk in this case is interpreted as the number of injured or killed at work per year per hundred thousand workers (international practice).

Results and discussions

For research and development of a general model of risk of occupational injuries at food industry enterprises we should define basic categories and concepts.

The risk of occupational injuries in the work will be understood as quantitative manifestation of risk of accident in the production. A common approach for risk assessment of occupational injuries foresees the analysis of industrial accidents by the totality of signs prescribed by law.

In general, the risk of industrial injuries can be defined as:

$$R = \sum_{i=1}^{n} S_i P_i \,, \tag{1}$$

S_i – consequences of an accident, P_i – probability (frequency) of an accident, n – number of accidents.

To determine the consequences of an accident S_i can use economic indicators that can assess the risk of R in monetary units.

The risk of accidents at the enterprise using a single dimensionality when calculating the consequences can be represented as the sum of the components

$$R = R_1 + R_2 + R_3 + R_4 \,, \tag{2}$$

R_1 – risk of death; R_2 – risk of disability; R_3 – risk of injury; R_4 – risk of micro injury.

At the same time if similar meanings of consequences of accidents or when they can not be estimated (eg in case of death of the victim), the calculation of risk can only be made for the likelihood of accidents. More topical for the definition of risk is to determine the causes of occupational injuries.

Specificity of statistical information on the causes of traumatism and kinds of events that led to the accident is if the condition performed [8]:

$$R^t = \sum_{i=1}^{16} P(\Pi_i^t) = \sum_{j=1}^{15} P(B_j^t) \,, \tag{3}$$

that is the overall risk of traumatism R^t equal to the amount of risk (probability of injury) for the reasons or the amount of risk an accident (probability of injury) by the kinds of events.

Feature of statistics on the causes of injury at the enterprise is the fact that every accident is only responsible one reason and only one kind of traumatic event. That is the risk of injury for each of the traumatic event depends only on one of the reasons given in the statistical bulletins [9–10]:

$$P(B_j^t) = f\left[P(\Pi_i^t)\right]. \tag{4}$$

Since the risk of an accident – it is likelihood of injury in the enterprise with indicators of risk can perform actions provided for the theory of probability. It is known that the conditional probability $P_A(B)$ called the probability of an event B, calculated under the condition that the event A has occurred [8, 11]. That is taking into account the scheme of cause-effect relationship [7], it is assumed that for the calculation of the probability (risk) of injury from a particular event in the manifestation of certain causes of injury can apply conditional probability. To calculate the conditional probability uses Bayes formula:

$$P_{\Pi}(B_j) = \frac{P(B_j)P_{Bj}(\Pi_i)}{P(\Pi_i)}. \quad (5)$$

Given that the statistical base is structured with the condition (3) and (4) simultaneously, equation (5) takes the form:

$$P_{\Pi i}(B_j) = \frac{P(B_j)P(\Pi_i)}{\sum_{i=1}^{n} P(\Pi_i)}. \quad (6)$$

Formula (6) performed calculations of the matrix risk of injury in the enterprise. This matrix has the form:

$$R_{ij}^{t} = \begin{vmatrix} R_{\Pi 1B1} & R_{\Pi 2B1} & \dots & R_{\Pi 16B1} \\ R_{\Pi 1B2} & R_{\Pi 2B2} & \dots & R_{\Pi 16B2} \\ \dots & \dots & \dots & \dots \\ R_{\Pi 1B15} & R_{\Pi 2B15} & \dots & R_{\Pi 16B15} \end{vmatrix}, \quad (7)$$

$R_{\Pi 1B1},...,R_{\Pi 16B15}$ – value of risk of injury for binary systems "cause risk of injury – kind of traumatic event", $i = 1,2,...,16$ – amount of the main causes of injury in the production Π_i that is fixed in the currently valid form of classification mandatory statistical reporting №7-ТНВ [9–10], $j = 1,2,...,15$ – amount of the main kinds of traumatic events.

To check the results obtained using formula (7), the study uses two methods. The first method – comparing calculated by formula (7) matrices of risk with obtained by direct filling matrices by the results of analysis of acts of investigation of accidents. The second method – is a method analytical solution of the system of linear equations obtained using the method of principal components and regression analysis.

The essence of the second method is that performed component analysis of statistical information body on the causes of traumatism Π_i.

It is used such feature of principal components that are statistically unlinked, that by definition are orthogonal. This feature provides a regression relationship between the risk of injury due to traumatic events (dependent variables) and values of the principal components obtained in the analysis of risk of injury causes (independent variables)

$$B_j = f(\Gamma_{\Pi p}) \quad (8)$$

Justification of the applicability of the method of principal component analysis of occupational injuries statistics. One of the tasks of the method of principal components is to find smaller subspaces in the orthogonal projection on which the deviation of the data (standard deviation from the mean) is maximized. At the same time raises the challenge of building such an orthogonal coordinate transformation, in which the correlation between individual coordinates are converted to zero.

The method of principal components based on the problem of best approximation of a finite set of points of straights and planes. Given a finite set of vectors $x_1, x_2, ..., x_m \in R^n$. For each $k = 0,1,...,n-1$ among all k – dimensional linear subspaces in R^n necessary to find a such $L_k \subset R^n$ that the sum of squared deviations x_i from L_k will be minimal $\sum_{i=1}^{m} dist^2(x_i, L_k) \to \min$, where $dist(x_i, L_k)$ – Euclidean distance from a point to a linear subspace.

Any $k-$ dimensional linear subspaces in R^n can be defined as the set of linear combinations $L_k = \{a_0 + \beta_1 a_1 + ... + \beta_k a_k | \beta_i \in R\}$, where the parameters β_i ranging over the real line R, $a_0 \in R^n$ and $\{a_1,...,a_k\} \subset R^n$ – orthonormalized vector set $dist^2(x_i, L_k) = \left\| x_i - a_0 - \sum_{j=1}^{k} a_j (a_j, x_i - a_0) \right\|^2$, where $\|\bullet\|$ – Euclidean norm, (a_j, x_i) – Euclidean scalar multiplication.

Or, in coordinate form:

$$dist^2(x_i, L_k) = \sum_{l=1}^{n} \left(x_{il} - a_{0l} - \sum_{j=1}^{k} a_{jl} \sum_{q=1}^{n} a_{jq} (x_{iq} - a_{0q}) \right)^2 .$$

Solving the problem of approximation for $k = 0,1,...,n-1$ has given by a set of nested linear subspaces $L_0 \subset L_1 \subset L_2 \subset ... \subset L_{n-1}$, $L_k = \{a_0 + \beta_1 a_1 + ... + \beta_k a_k | \beta_i \in R\}$. These linear subspace defined by a set of orthonormal vectors $\{a_1,...,a_{n-1}\}$ (principal component vectors) and the vector a_0, which is sought by solving the minimization problem for $L_0 : a_0 = \arg\min_{a_0 \in R^n} \sum_{i=1}^{m} dist^2(x_i, L_0)$.

The usefulness of the method of principal components in the analysis of data of occupational injuries is based on possible reduction in information analysis and identification of the most significant factors of occupational injuries. At the same time principal component vectors can be found as the solution of optimization problems similar to the following algorithm:

1. Centering the data (by subtracting the mean values): $x_i := x_i - \bar{X}$ and $\sum_{i=1}^{m} x_i = 0$;
2. Finding the first principal component as the solution of the problem: $a_1 = \arg\min_{\|a_1\|=1} \left(\sum_{i=1}^{m} \left\| x_i - a_1 (a_1, x_i) \right\|^2 \right)$. If the solution is not unique, then choose one of them.
3. Calculate the data projection on the first principal component: $x_i := x_i - a_1 (a_1, x_i)$.
4. Find the second major component as a solution to the problem $a_2 = \arg\min_{\|a_2\|=1} \left(\sum_{i=1}^{m} \left\| x_i - a_2 (a_2, x_i) \right\|^2 \right)$. If the solution is not unique, then choose one of them. Find the projection on $(k-1)$-main component: $x_i := x_i - a_{k-1} (a_{k-1}, x_i)$; 2*k*. Find *k*- principal components as a solution to the problem: $a_k = \arg\min_{\|a_k\|=1} \left(\sum_{i=1}^{m} \left\| x_i - a_k (a_k, x_i) \right\|^2 \right)$. If the solution is not unique, then choose one of them.

Taking into account capabilities of modern modeling tools (Mathcad, Mathlab, Mathematica, Mapple, etc.) specified algorithm for statistical data series

$X = \begin{bmatrix} x_{11} & \dots & x_{1m} \\ \cdots & \ddots & \cdots \\ x_{n1} & \dots & x_{nm} \end{bmatrix}$ where there are signs of m and n observations can be written as follows:

1. Normalized the components of the vectors (rows) of the matrix X by an operation $z_i = \frac{x_{ji} - \overline{x_i}}{\sigma_{x_i}}, j = 1,...,n, i = 1,...,m$, σ_{x_i} – average deviation of a random variable X from the mean value for a column of the matrix X. We obtain the matrix Z size $n \times m$.
2. From the matrix Z finds correlation (covariance) matrix $R = \left[r_{ij} \right]_{m \times m}$
3. Finds the set of eigenvalues of the matrix R and organizes it by reducing components $\lambda_i, i = 1,...,m$
4. Form a diagonal matrix with the eigenvalues of the matrix R $\Lambda = \begin{bmatrix} \lambda_1 & \cdots & 0 \\ \cdots & \ddots & \cdots \\ 0 & \cdots & \lambda_m \end{bmatrix}$
5. From the matrix R form a matrix of eigenvectors of the matrix $U = \begin{bmatrix} (u_{11},...,u_{1m}) \\ ... \\ (u_{n1},...,u_{nm}) \end{bmatrix}$
6. Finds the solution of the problem in a matrix $A = U\sqrt{\Lambda}$, where $\sqrt{\Lambda}$ is the matrix of roots on each element of the matrix Λ.

Found vectors $\{a_1,...,a_{n-1}\}$ are orthonormal simply as a result of solving the optimization problem, but to prevent due to error of calculation the violate of mutual orthogonality of vectors of principal components can be included $a_k \perp \{a_1,...,a_{k-1}\}$ in the conditions of the optimization problem.

The advantage of the described method to the analysis of statistics of injury is that it can almost always be used, regardless of the distribution of random variables – indicators of injury. However, this method is not always effective reduces the dimensionality of the given constraints on the accuracy. The straights and planes do not always provide a good approximation. For example, data can be described with sufficient accuracy by any curve, and the curve can be tricky located in the area of data. Also in the case of an isotropic distribution of data ellipsoid of scattering will be as hyper sphere and that is why will not be possible to reduce scattering by approximation methods.

Justification of the applicability of the method of principal components to predict occupational injuries. Due to the basic properties of the method of principal components is fairly successfully be used to predict the statistics of occupational injuries, while providing the smallest prediction error. Let us show that using the first p' principal components $z^{(1)}, z^{(2)},..., z^{(p')}$ when $p' < p$, output signs $x^{(1)}, x^{(2)},..., x^{(p)}$ are achieved the best prediction of these characteristics among all forecasts, which can be constructed using p' linear combinations of a set of p – random signs.

Let us explain in more detail aforementioned. Let it is necessary to replace the output researched p - dimensional vector of observations X on the vector $Z = \left(z^{(1)}, z^{(2)}, ..., z^{(p')}\right)^T$ lower dimension p', in which each component would be a linear combination p output (or auxiliary) features without losing too much information. Informativeness of new vector Z depends on to what extent p' introduced auxiliary variables make it possible to "restore" p output characteristics by using the appropriate linear combinations $z^{(1)}, z^{(2)}, ..., z^{(p')}$. One can imagine that the mistake σ forecast X on Z is determined by the residual dispersive matrix vector X by subtraction from it of the best prediction for Z that is matrix $\Delta = \left[\Delta_{ij}\right]$, and $\Delta_{ij} = E\left\{\left(x^{(i)} - \sum_{l=1}^{p'} b_{il} z^{(l)}\right)\left(x^{(j)} - \sum_{l=1}^{p'} b_{jl} z^{(l)}\right)\right\}$. $\sum_{l=1}^{p'} b_{il} z^{(l)}$ – best in the sense of least squares prediction $x^{(i)}$ by components $z^{(1)}, z^{(2)}, ..., z^{(p')}$. Forecast error of X on Z is defined as some specified function of the matrix elements $\Delta = \left[\Delta_{ij}\right]$, that is $\sigma = f(\Delta)$, and $f(\Delta)$ defines some quality criterion prediction.

Consider the following measures of forecast error:

1. $f(\Delta) = Tr(\Delta) = \Delta_{11} + \Delta_{22} + ... + \Delta_{pp}$ – based on the trace of the matrix $\Delta = \left[\Delta_{ij}\right]$;
2. $f(\Delta) = \|\Delta\| = \sqrt{\sum_{i=1}^{p}\sum_{j=1}^{p} \Delta_{ij}^2}$ – based on the Euclidean norm of the matrix $\Delta = \left[\Delta_{ij}\right]$.

It is proved that both measures are achieved simultaneously a minimum if and only if when as $z^{(1)}, z^{(2)}, ..., z^{(p')}$ elected the first p' major components of the vector X, and the value of forecast error $\sigma = f(\Delta)\ \sigma = f(\Delta)$ explicitly expressed by the last $p - p'$ eigenvalues of the original covariance matrix C or approximately by the last $p - p'$ eigenvalues $\lambda_{p'+1}, ..., \lambda_p$ covariance matrix $\hat{C}$ constructed from observations $X_1, X_2, ..., X_n$ [11].

In particular,

if $f(\Delta) = Tr(\Delta): \sigma \approx \lambda_{p'+1} + \lambda_{p'+2} + ... + \lambda_p$;

if $f(\Delta) = \|\Delta\|: \sigma \approx \sqrt{\lambda_{p'+1}^2 + \lambda_{p'+2}^2 + ... + \lambda_p^2}$.

Let us explain by the example the idea of predicting the initial signs $x^{(1)}, x^{(2)}, ..., x^{(p)}$ with a help of smaller than p number of linear combinations.

Example. When forming typical forming signs of causes of occupational injuries was studied statistics per 24 years (n = 24) of three main groups of conditions: the technical factor $x^{(1)}$, the organizational factor $x^{(2)}$ and the human factor $x^{(3)}$. According to the observations $\left(x_i^{(1)}, x_i^{(2)}, x_i^{(3)}\right), i = 1, ..., 24$ was defined sample covariance matrix

$$\hat{C} = \begin{bmatrix} 451{,}39 & 271.17 & 168{,}70 \\ 271{,}17 & 171{,}73 & 103{,}29 \\ 168{,}70 & 103{,}29 & 66{,}65 \end{bmatrix}$$

Own radical of this matrix C will be: $\lambda_1 = 680{,}0$, $\lambda_2 = 6{,}5$, $\lambda_3 = 2{,}86$.

The matrix of eigenvectors will be:

$$U = \begin{bmatrix} -0,813 & -0,495 & -0,307 \\ 0,545 & -0,832 & -0,101 \\ -0,205 & -0,249 & 0,946 \end{bmatrix}.$$

As a result, as the main components we obtain:

$$z^{(1)} = -0,81x^{(1)} - 0,50x^{(2)} - 0,31x^{(3)},$$
$$z^{(2)} = 0,55x^{(1)} - 0,83x^{(2)} - 0,10x^{(3)},$$
$$z^{(3)} = -0,21x^{(1)} - 0,25x^{(2)} + 0,95x^{(3)}.$$

Here $x^{(1)}, x^{(2)}, x^{(3)}$ are the deviation of the number of accidents due to technical factors $x^{(1)}$, organizational factors $x^{(2)}$ and human factors $x^{(3)}$ from their mean values.

In this example $p = 3$. Let us define as the goal of reducing the dimension of the output factor space to unity ($p' = 1$) that is to describe all three groups of features by using linear combinations of just one auxiliary variable.

According to the above property "auto forecast» of principal components let us take as this one secondary variable the first principal component, ie variable $z^{(1)} = -0,81x^{(1)} - 0,50x^{(2)} - 0,31x^{(3)}$.

By the method of least squares unknown coefficients b_{i1} calculated by the expression:

$$b_{i1} = \frac{\operatorname{cov}\left(x^{(i)}, z^{(1)}\right)}{Dz^{(1)}} = \frac{-0.81\operatorname{cov}\left(x^{(i)}, x^{(1)}\right) - 0,50\operatorname{cov}\left(x^{(i)}, x^{(2)}\right) - 0,31\operatorname{cov}\left(x^{(i)}, x^{(3)}\right)}{Dz^{(1)}}.$$

Substituting in this formula values $\operatorname{cov}\left(x^{(i)}, x^{(j)}\right)$ taken from the covariance matrix C for our example we obtain

$$x^{(1)} = b_{11}z^{(1)} + \varepsilon^{(1)} = -0,81z^{(1)} + \varepsilon^{(1)},$$
$$x^{(2)} = b_{21}z^{(1)} + \varepsilon^{(2)} = -0,50z^{(1)} + \varepsilon^{(2)},$$
$$x^{(3)} = b_{31}z^{(1)} + \varepsilon^{(3)} = -0,31z^{(1)} + \varepsilon^{(3)},$$

$\varepsilon^{(i)}$ – random (residual) forecast error of output component for the first principal component $z^{(1)}$.

If as a relative forecast error of output characteristics $x^{(i)}$ for the first principal component $z^{(1)}$ select a value $\delta_i = 100\left(\frac{D\varepsilon^{(i)}}{Dx^{(i)}}\right)$ the forecast error in this example would be $\delta_1 = 2\%, \delta_2 = 1,2\%, \delta_3 = 0,8\%$.

The total relative forecast error of features $x^{(1)}, x^{(2)}, x^{(3)}$ by $z^{(1)}$ can be calculated by the expression $\delta_{сум.} = 100\left(\frac{Tr(\Delta)}{D\left(x^{(1)} + x^{(2)} + x^{(3)}\right)}\right) = 100\frac{\lambda_2 + \lambda_3}{\lambda_1 + \lambda_2 + \lambda_3} = 1,36\%$, which confirms sufficient efficiency of the method of principal components to predict the statistical characteristics, including and for the prediction of risk of occupational injuries.

This example shows the applied orientation of component analysis, in particular for forecast tasks (auto forecast) of a large number of initial indicators for occupational injuries

with a small number of auxiliary (latent) variables that express the reasons for this phenomenon, visualization of multidimensional data and the selection of typically formed signs of injury.

To solve research problems associated with obtaining accurate statistical solution of the problem for injury risk values for binary groups "cause an accident - a kind of traumatic event" can use not only the principal components (which account for the bulk of the total variance of the array input data), but the whole components, covering the entire total variance of causes of risk of injury at the workplace. The system of regression equations for B_j then will look like:

$$\left.\begin{aligned} B_1 &= a_1^1 + b_1^1 \Gamma k_1 + b_2^1 \Gamma k_2 + b_3^1 \Gamma k_3 + \ldots + b_{16}^1 \Gamma k_{16}; \\ B_2 &= a_1^2 + b_1^2 \Gamma k_1 + b_2^2 \Gamma k_2 + b_3^2 \Gamma k_3 + \ldots + b_{16}^2 \Gamma k_{16} \\ B_3 &= a_1^3 + b_1^3 \Gamma k_1 + b_2^3 \Gamma k_2 + b_3^3 \Gamma k_3 + \ldots + b_{16}^3 \Gamma k_{16} \\ &\ldots \\ B_{15} &= a_1^{15} + b_1^{15} \Gamma k_1 + b_2^{15} \Gamma k_2 + b_3^{15} \Gamma k_3 + \ldots + b_{16}^{15} \Gamma k_{16} \end{aligned}\right\}, \quad (9)$$

The main components are determined through the input set of risk indicators for causes of injury by a system of equations

$$\left.\begin{aligned} \Gamma k_1 &= d_1^1 + c_1^1 \Pi_1 + c_2^1 \Pi_2 + c_3^1 \Pi_3 + \ldots + c_{16}^1 \Pi_{16}; \\ \Gamma k_2 &= d_1^2 + c_1^2 \Pi_1 + c_2^2 \Pi_2 + c_3^2 \Pi_3 + \ldots + c_{16}^2 \Pi_{16} \\ \Gamma k_3 &= d_1^3 + c_1^3 \Pi_1 + c_2^3 \Pi_2 + c_3^3 \Pi_3 + \ldots + c_{16}^3 \Pi_{16} \\ &\ldots \\ \Gamma k_{16} &= d_1^{15} + c_1^{15} \Pi_1 + c_2^{15} \Pi_2 + c_3^{15} \Pi_3 + \ldots + c_{16}^{15} \Pi_{16} \end{aligned}\right\}, \quad (10)$$

Substituting the values of the principal components of the system of equations (9) into the equation system (10) and equating all but one value of Π_i to zero we obtain the value of risk of injury for a particular binary group "cause an accident – the kind of traumatic event".

For example, a binary value $B_1\Pi_1$ "accident due to design flaws, imperfections and lack of reliability of the production, vehicles" equation to determine the risk of injury is:

$$P(B_1\Pi_1) = a_1^1 + b_1^1 (d_1 + c_1^1 + \Pi_1 + d_2 + c_1^2 + \Pi_2 + \ldots + d_{16} + c_1^{16} + \Pi_{16}). \quad (11)$$

Coefficients a, b, c, d calculated using component and regression statistics injuries.

Using the method of principal component for analysis of the main causes of accidents are more appropriate m output variables $X_1, X_2, X_3, \ldots, X_m$ replace their p linear combinations [12]

$$Y_k = a_{1k} X_1 + a_{2k} X_2 + a_{3k} X_3 + \ldots + a_{jk} X_j + \ldots + a_{mk} X_m, \quad (12)$$

$k = 1, 2, 3, \ldots, p$; $j = 1, 2, 3, \ldots, m$.

Amount of p new variables that explain the bulk of the variance of input variables (indicators) are usually much smaller than the number of m – variables X_j. Coefficients a_{jk} from equations (12) are calculated under the following conditions [12]: 1) the amount of variance of variables $Y_k\,(k = 1, 2, 3, \ldots, p)$ equals the sum of variances of the input

parameters $X_j\,(j=1,2,3,...,m)$; 2) The variable Y_k is ordering largely by reducing their variance; 3) all Y_k are mutually independent.

New variables $Y_k\,(k=1,2,3,...,p)$ that meet these conditions are the main components.

Algorithm for the principal components is as follows [12]:

1. Using the input parameters calculated covariance or correlation matrix S and the vector of average values $\bar{x}$ of these parameters.

2. Identified the eigenvalues $\lambda_1,\lambda_2,\lambda_3,...,\lambda_j,...,\lambda_m$ of the matrix, for that is solved the equation

$$|S-\lambda I|=0, \tag{13}$$

where $I-$ identity matrix of size $m\times m$.

The eigenvalues λ_j are the variance of principal components, they are placed in a row from largest to smallest.

3. Calculated the fate variances of principal components in their sum. The main components of the fate of the contribution which the small amount of variance, are excluded from further analysis, using only the p first component.

4. Calculated the coefficients a_{jk} of the first p – eigenvectors of covariance or correlation matrix. Using these coefficients are recorded equation of each p component. In particular for the main k components of the equation takes the form (12), but the input variables are normalized.

5. The transition from the fixed to the input variables by substitution $X_{jn}=\frac{X_j-\bar{x}_j}{\sigma_f}$ are performed.

6. Calculated the value of the principal components for each measure for each facility or research. Data are entered into the table, for example:

7. The interpretation of the principal components of the position of the object and tasks of research and a comprehensive analysis of certain components is performed.

Thus, based on the methods of regression and factor analysis formed a general model of risk of occupational injuries (3-11), which comprehensively links likelihood of an accident with a frequency of accidents in the enterprise with the full range of reasons.

Signs	**Factors**					
	F_1	F_2	. . .	F_m	. . .	F_n
1	α_{11}	α_{12}	. . .	α_{1m}	. . .	α_{1n}
2	α_{21}	α_{22}	. . .	α_{2m}	. . .	α_{2n}
. . .	. . .	. . .	. . .	. . .	. . .	. . .
j	α_{j1}	α_{j2}	. . .	α_{jm}	. . .	α_{jn}
. . .	. . .	. . .	. . .	. . .	. . .	. . .
n	α_{n1}	α_{n2}	. . .	α_{nm}	. . .	α_{nn}
V_r						
Percentage of summarily dispersions						

Conclusions

The general model of risk of occupational injuries at food industry enterprises should be comprehensively consider the influence on traumatism of the full range of industrial and socio-economic factors and be based on the scheme of occurrence of accidents in which every fact of an accident associated with the prerequisite of its occurrence. This approach allows for the analysis of direct causal relationships that occur during getting injury and identify both basic and hidden cause of occupational injuries, as well as types of events that lead to accidents on the basis of a form of mandatory annual reporting.

To provide filtration of statistical data and visualization of results for handling existing statistics of occupational injuries is the most appropriate method of principal components. The usefulness of the method of principal components in the analysis of data of occupational injuries is based on possibilities of reduction in information analysis and identification of the most significant factors of occupational injuries. Due to the basic properties of the method of principal components is fairly successfully be used to predict the statistics of occupational injuries with a small number of auxiliary (latent) variables that express the reasons for this phenomenon, while providing the smallest prediction error.

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Modeling of risk of hazardous industrial facilities in emergencies

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Abstract

Introduction. The system existing of comprehensive protection of high-risk industries, are ineffective because there is a need to focus efforts and resources on the most dangerous areas.

Materials and methods. For evaluation of the risk of an industrial facility constructed model of accident (an emergency). Spato-structural evolution of the risk of accident implemented using complex mathematical models of stochastic adaptive genetic matrix modeling.

Results and discussions. The first mathematical model of the complex is a system of nonlinear analytical equations, allowing to calculate the space-time accident (an emergency). Spatio-temporal structure $Sc_j \in \{Sc\}_{ac}$ may ask an expert or be using other mathematical models. The respective model is nonlinear, discrete mathematical model with unknown operators $\hat{F}_{ij}$, defined algorithmically. The third mathematical model is linear analytical equations with unknown values system of factors $X_1, X_2, ..., X_k$ and function priorities P that are using methods of the theory of fuzzy sets.

Conclusions. The complex mathematical model, that can be practically implemented for solving the task of monitoring of dangerous objects in the food industry, ahead of time to forecast the spatio-temporal evolution of exposure at hazardous an industrial facility depending on the scenario of an emergency.

Introduction

In the present time in man-made emergency probability of occurrence of has a tendency to increase. Data circumstances justify the need to change views on the role and place of hazardous industrial facilities and leads to the fact that high-risk zone, which include such objects are local, short-sighted and are dictated by the flow of any emergency is to practically implement the relevant task. It is essential to create a complex mathematical models, which are able to predict risk spatio-temporal evolution of dangerous

industrial facility depending on the scenario of an emergency. Well-known methods of risk assessment destruction is unsuitable for the calculation of spatio-temporal evolution of risk through subjectivism, innumerable plural versions of decisions and low reliability. Spatio-temporal assessment of risk destruction hazardous industrial facilities should be based on spatio-temporal models of evolution any accident (an emergency). The assessment risk needs in turn quantitative characteristics of the accident (an emergency) in every point the evolutionary model.

Materials and methods

We investigate the dynamics of occurrence and emergency situations with the help mathematical models of spatial-structural evolution and the development of a mathematical model of the interaction of the structural elements of an industrial facility.

This models of establish an organisation and engage a risk management approach which can allow them to take reasonable decisions and engage adapted actions. This approach goes beyond the simple respect of applicable regulations.

The mathematical models is provided of the various risk identification and evaluation methodologies that are being used as in the food factory and plants, as another industrial facilities both qualitative and quantitative reviews.

Results and discussion

The majority of thousand registered potentially dangerous objects majority does not create considerable problems and does not influence substantially on safety of population and environment possible. Emergency on such objects, mostly, does not spread even outside a workshop and does not fall under classification of "extraordinary situation". In addition, through legislative vagueness and different interpretations of questions in this sphere, in some regions potentially dangerous objects take into account twice.

Permanent growth of amount potentially dangerous objects caused and from to a great extent that existing regulatory acts expressly do not establish exact including excluding criteria taking or not taking of them info potentially dangerous objects and the duties of economic entity in relation to the implementation of authentication procedure of potentially of dangerous objects.

It is based on the analysis of results, that is based on an analysis of the dynamics of development failure (an emergency) decision can be made on human functioning of industrial facility. Is of building two models - mathematical model spatio-structural evolution failure (an emergency), that is able to offer the most likely options for its development, and mathematical models of interaction between structural elements industrial facility, which is capable of assessing the various sets this object structural elements in the course leakage accident (an emergency). For reduction will use the names of the mathematical model accident (an emergency) and a mathematical model failure (an emergency) in accordance with.

In quality plural structures failure (an emergency) will consider possible scenarios of development. We will define the script, as a sequence of events: $Sc_i=\Psi\{Q_{1i}, Q_{2i}, \ldots, Q_{ki}, \ldots, Q_{mi}\}$, where Ψ – is the order. The event Q_{ki} will present as a *set* $\langle\{i_A\} \in I_A, \{j_B\} \in J_B, k \in L\rangle$, where $\{i_A, \{j_B\}$ – plural parties A and B the objects that take part in events; k – a host, a dangerous object structural elements for the control of an object around which and which develops an event $k=_{\in} A$ v B.

Thus structure failure (an emergency) is a different combination of the following dangerous object, which is arranged in time.

The result of events Q_{ki} depends on the plural variables $a^1_{ki}, a^2_{ki}, \ldots, a^n_{ki}$ and parameters $a_1, a_2, \ldots, a_m$ that are grouped with the help of non-linear equations in integrated circuit indicators $t_{ki}, x^1_k\ x^2_{ki} \ldots, x^j_{ki}$. Variables and parameters are quantitative characteristics separate units, structural elements of a dangerous object integrated circuit indicators describe the accident (an emergency) and scenario failure (an emergency) in general.

The following integrated circuit indicators are considered: the duration scenario failure (an emergency), human losses, loss material and technical resources, infrastructure and environmental damage loss.

Playing scenario is determined by the conditions $T_i \equiv T\left(Sc_i\right) = \sum_{k=1}^{k_{\max}} t_{ki}; \quad k_{\max} : \exists j \in \{1,2,\ldots,l\} : x^j_{k_{\max}} > x^j_{cr}$, where x^j_{cr} – critical importance of integral indicators.

Integrated circuit indicators are nonlinear functions $t_{ki}(a^1_{ki}, a^2_{ki}, \ldots, a^n_{ki}, a_1, a_2, \ldots, a_m)$, $x^j_{ki}(t_{ki}, a^1_k, a^2_{ki} \ldots, a^i_{ki}, a_1, a_2, \ldots, a_m)$, $j=1, 2, \ldots, l$.

Taking into account the fact that variables $a^1_{ki}, a^2_{ki}, \ldots, a^n_{ki}$ depend on the sequential number events κ and structures i and scenario (an emergency), we can cut mark motorcade $\langle a^1_{ki}, a^2_{ki}, \ldots, a^n_{ki}, a_1, a_2, \ldots, a_m \rangle$ through Q^j_k, distinguishing thus value set variables and parameters failure (an emergency) in time k on the structure of the events – Q_{ik}.

Then in a short recording $t_{ki} = t_{ki}\ (Q^j_k); x^j_{ki} = x^j_{ki}\ (t_{ki}, Q^j_k)$.

For example, that the plural scenarios $\{Sc\}$ there is a plural operators $\{\hat{F}\}$, such that any scripts $Sc_i, Sc_j \in \{Sc\}$ puts in compliance with the operator $\hat{F}_{ij} : Sc_i = \hat{F} : Sc_j$.

The plural $\{Sc\}$ will allocate two subsets – acceptable $\{Sc\}_{ac}$ and unacceptable $\{Sc\}_{unac}$ scenarios, so that $\{Sc\}_{ac} \cup \{Sc\}_{unac} = \{Sc\}$.

Plural $\{Sc\}_{ac}$ is generated with plural $\{Sc\}$. action on the last consistent rules filter-rules $\langle P_1, P_2, \ldots, P_n \rangle$, that is $\{Sc\}_{ac} = \langle P_1, P_2, \ldots, P_n \rangle \{Sc\}$ data set filter determines the logic, which can leak accident (an emergency).

Dataset filter determines the logic, at which failure can occur (an emergency).

The specifics and complexity of risk of smoking failure (an emergency) needs according to the authors of the use of categorical judgments algebra logic to his assessment and the transition to a more flexible system fuzzy assessments. Risk of smoking failure (an emergency) – R can be assessed only by taking into account the plural factors $X_1, X_2, \ldots, X_k$, on the basis of which it is possible to create such events. The $X_1, X_2, \ldots, X_k$ in turn you can get blur analysis based on criteria set, which describe each of these factors.

Depending on the influence of the accident (an emergency for development) factor that can change its caused not only the people of factors $X_1, X_2, \ldots, X_k$, but also their importance as the leakage events. Therefore, it makes sense to introduce some function priorities $P_k(t_m, Q_{mi})$ on a plural $X_1, X_2, \ldots, X_k$, which will manage risk factors in each spatiotemporal point of failure (an emergency).

Use input symbol here formalized problem statement research.

The subset selected expert-critical points $\theta_{k_1 i}, \theta_{k_2 i}, \ldots, \theta_{k_m i}, \ldots, \theta_{k_n i} \in Sc_i$ scenario failure (an emergency) Sc_i and relevant they integrated indicators $t_m = \sum_{i=1}^{k_m} t_{k_m i}$, $x^g_m = x^g_{k_m i}\left(t_{k_m i}, \theta^i_{k_m}\right) g = \overline{1, \ldots, l}$ determine spatio-temporal distribution risk of failure (an emergency):

$$R\left(t_m, \theta_{k_m i}\right) = \sum_{\beta} P_\beta\left(t_m, \theta_{k_m i}\right) \mu X_\beta\left(x^1_m, x^2_m, \ldots, x^l_m\right) ; \qquad (1)$$

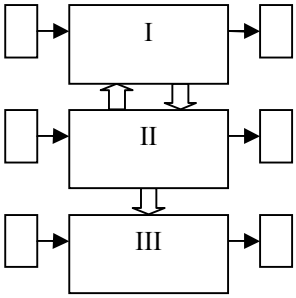

Figure 1. The structural scheme of mathematical models for the spatio-temporal evolution of risk failure (an emergency)

Granted

$$Sc_i = \widehat{F}_{ij} Sc_j : \quad T_i + \delta T < T_j, \forall j \in \{Sc\}_{\text{unac}}, i \in \{Sc\}_{ac} \tag{2}$$

Where δT is the small, prepay set option.

Problem solution (1) – (2) may be at the expense of complex interrelated mathematical models, structural scheme which is shown in fig. 1. operators $\widehat{F}_{ij}$ that are asked algorithmically.

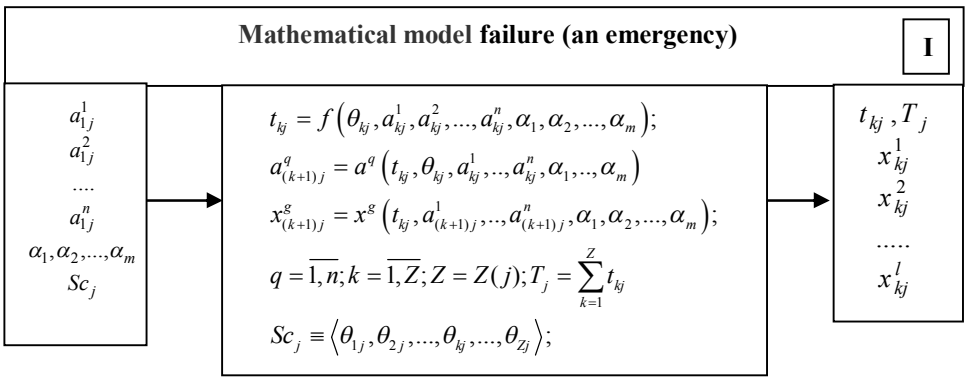

Figure 2. The first mathematical model failure (an emergency) of the complex is a system analytical non-linear equations

The first mathematical model (fig. 2) of the complex is a system analytical non-linear equations, that give the possibility to calculate existential results failure (an emergency). An unknown model is spatio-temporal structure failure (an emergency), that is a version of the scenario $Sc_j \in \{Sc\}_{ac}$.

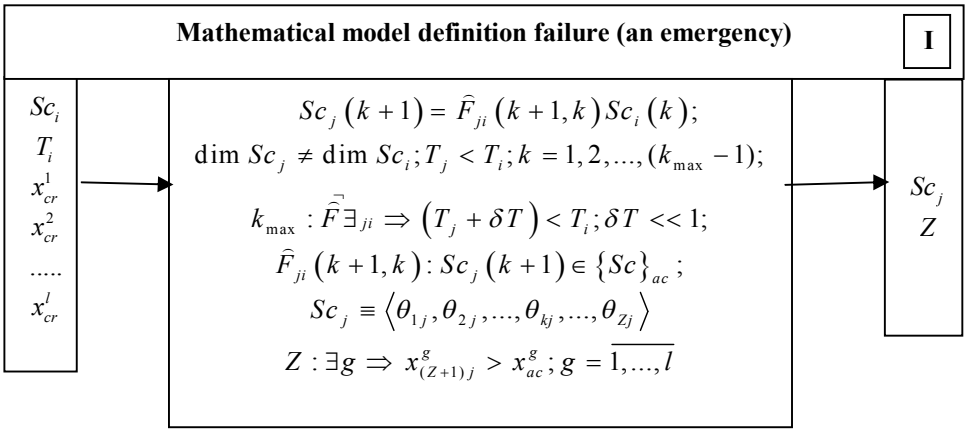

Figure 3. The second mathematical model definition failure (an emergency) of the complex is a system analytical non-linear equations

This structure can ask an expert, or to be the second mathematical model (fig. 3). The respective model is a nonlinear, discrete mathematical model with unknown.

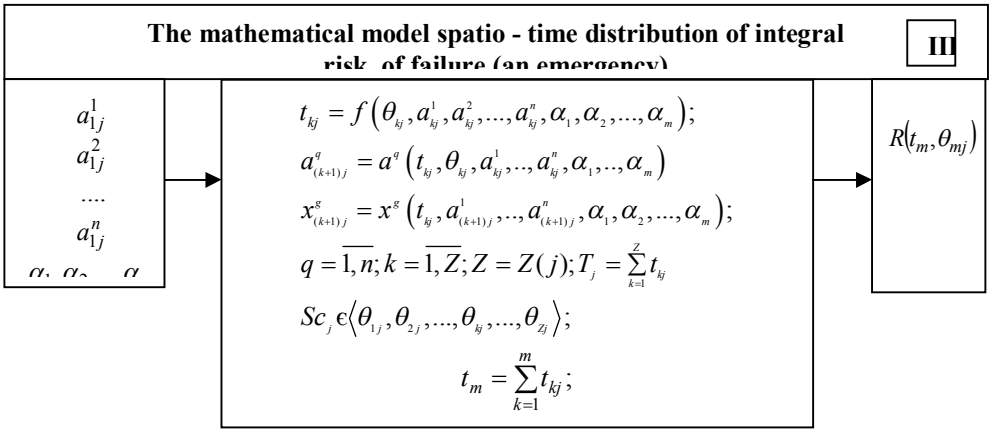

Figure 4. The second mathematical model definition failure (an emergency) of the complex is a system analytical non-linear equations

The third mathematical model (fig. 4) is linear analytical equations with unknown values system factors X_1, X_2, …, X_k, and function priorities P that are using fuzzy set theory of methods of the theory.

The proposed complex models can work in several variants. If the structure failure (an emergency) is known, then the spatio-temporal Evolution is used scheme risk $1 \oplus 3$ without the use of second model. If it is necessary to calculate the results (emergency situation) on a specified structure, it is used only the first model. If it is necessary only structure failure (an emergency situation) is used in combination models $1 \oplus 2$. Finally, the unknown structure failure (an emergency) for the spatiotemporal evolution scheme is applied risk $1 \oplus 2 \oplus 3$. Each of the aforementioned combinations can find their own practical application.

In order to fulfill a mathematical model definition failure (emergency situation) (fig.1), you need to identify operators of evolution $\hat{F}_{ij}$ the given model. You can show that the including iterations $k \to k_{max}$ corresponding task is reduced to the calendar planning with limited resources equivalent tasks. The mathematical setting this problem is formulated as follows: the plural scenarios failure (an emergency) $\{Sc\}$ to find such a scenario $Sc^{opt}(T; x_1, x_2, ..., x_n) \in \{Sc\}$, which is:

$$Sc^{opt}\left(T; x_1, x_2, ..., x_l\right): \quad T = \min_{j \in M_{Sc}} \sum_{k=1}^{G_j} \max_{i \in \theta_k} (t_{ik}^j + \Delta t_k^j) \equiv \min_{j \in M_{Sc}} T^j \tag{6}$$

When limits:

$$\sum_{k=1}^{n+1} \max_{i \in \theta_k} (t_{ik}^j + \Delta t_k^j) = \sum_{k=1}^{n} \max_{i \in \theta_k} (t_{ik}^j + \Delta t_k^j) + \max_{i \in \theta_{n+1}} (t_{i(n+1)}^j + \Delta t_{(n+1)}^j) \tag{7}$$

$$\forall \theta_k \bigcap \theta_{k+1} \neq \varnothing: \quad t_{\theta_k}^j + t_{\theta_{k+1}}^j \neq t_{\theta_{k+1}}^j + t_{\theta_k}^j \tag{8}$$

$$G_j : \left(\forall i \in \overline{1,l} : x_i \leq x_i^{cr}\right) \wedge \left(G_j + 1\right) : \left(\exists i \in \overline{1,l} : x_i > x_i^{cr}\right) \tag{9}$$

where M_{Sc} – plural scenarios failure (an emergency);

T^j – playing j-th scenario (an emergency);

G_j – the number of events in j-th scenarios;

t^j_{ik} – is the time for attracting i-th object to k-th events in j-th accident scenarios (an emergency);

Δt^j_k – is the time to implement the k-th events in j-th accident scenarios (an emergency);

t^j_{Qk} – playing Q_k-th events in j-th scenarios;

x_i, $i=1, l$ – settings model failure (an emergency).

Restrictions (7) indicates the absence breaks between events. condition (8) indicates the dependency of scenario (an emergency) from the following events in it. restrictions (9) is bound to the resources and infrastructure integrity parties failure (an emergency). These restrictions are conditions of completion failure (an emergency). The task generation scenario (an emergency) (6)–(9) is the task with limited resources. It belongs to the class tasks not поліноміальної complexity (NP-task), and can not be solved in exact methods.

The complexity lies within $L^k < N_{Sc} < (L(2^M - 1))^k$, where L – is the number blocks, M – is the number objects, k – is the number of events in a variant scenario failure (an emergency) Sc.

He characterizes pluralize options scenarios failure (an emergency), on which you want to search decision task (6)–(9).

For solving tasks (6)–(9) the method matrix genetic modeling, which is a modification of the classical genetic algorithm of Holland. His feature is that in the proposed matrix variable length code quality, with its columns is landscaped a set of events that characterize the selected scenario failure (an emergency), and terms indicate the part of the accident (an emergency) in the selected events.

Matrix method genetic modeling stochastic adaptive method, containing the following operators and options :

$$GM = \left(N, f, \theta, \Omega_1, \Omega_2, \psi, \eta, \xi, \tau\right) \tag{10}$$

where N – principal plural numbers making scenario;

f – the target function that coincides with (6) and calculated using mathematical model failure (an emergency);

Q – the operator that randomly selects v=1,2 scenarios of plurals N;

Ω_1 – operator exchange plots code width (the operator krosingoveru 1 kinds);

Ω_2 – the operator code exchange plots along the length (operator krosingoveru 2 kinds);

Ψ – the operator mutation randomly selected events scenario of plurals N.

As a result of actions operators Ω_1, Ω_2, Ψ is created v=1,2 options script that is modifications selected parental scenarios.

Procedure of applying operators Ω_1, Ω_2, Ψ is determined by random number generator, so that in general there were conditions:

$$\begin{gathered} n \to n_\tau : P_{\Omega_1}(n) \to \overline{P}_{\Omega_1} \\ n \to n_\tau : P_{\Omega_2}(n) \to \overline{P}_{\Omega_2} \\ n \to n_\tau : P_{\psi}(n) \to \overline{P}_{\psi} \\ \overline{P}_{\Omega_1} + \overline{P}_{\Omega_2} + \overline{P}_{\psi} = 1 \end{gathered} \tag{11}$$

where n – is the number iterations algorithm;

n_t - the number iterations, in which the algorithm is finishing its work;

$P_{\Omega 1}(n)$, $P_{\Omega 2}(n)$, $P_{\psi}(n)$ – possibility of operators Ω_1, Ω_2, Ψ on n – iteration;

$\overline{P}_{\Omega_1}$ – the average probability of operator кросинговеру 1 kind to v=2 selected scenarios;

$\overline{P}_{\Omega_2}$ – the average probability of operator кросинговеру 2 kind to v=2 selected scenarios;

$\overline{P}_{\psi}$ – the average probability of mutation operator to v=1 selected scenario.

Next in the order the following in (11) – the operator for filtering η, that mayor created scenarios and corrects in accordance with the rules logic failure (an emergency). Finally operator ξ is destroying v=2 worst on value functions f scenarios of plurals $N+v$; τ – criterion stop algorithm that is bad limit (9) tasks (6).

Thus, operators of Evolution F are specified in the form iteration process:

$$\hat{F} = \hat{M}(k+1)\hat{R}(m,n,k+1)Rand\left\{\Omega_1, \Omega_2, \Psi\right\} \tag{12}$$

where:

the operator changes in the structure matrix scenario: $R_{and}\{\Omega_1, \Omega_2, \Psi\}$;

operator checking validity sensor size:

$$\hat{R}(m,n,k+1) = \begin{cases} \dim(m,n) \to \dim(m+1,n); & \forall i : x_i \le x_i^{cr} \\ 1; & \exists i : x_i > x_i^{cr} \end{cases} \tag{13}$$

Operator checking the logic matrix scenario:

$$\hat{M}(k+1) : \tilde{S}c_{k+1} \in \{Sc\} \to Sc_{k+1} \in \{Sc\}_{ac}; \quad \{Sc\}_{ac} \subset \{Sc\} \tag{14}$$

These operators are chosen in this way, to the tasks (6) – (9).

The mathematical model failure (an emergency) and a mathematical model definition scenario (an emergency) Program implemented in programming language Java.

Conclusions

As a result, the proposed model spatio-temporal development (evolution) risk in case of emergencies (emergency situations) hazardous industrial facilities of which is permitted under the influence of different natural disasters and technical disasters with possible mass

impression people. The modeling accident development (an emergency) give comparative size at different variants scenarios that points to their development, stability realized models and methods to random phenomena.

Proposed a comprehensive mathematical model to determine the spatiotemporal evolution of risk of industrial facilities in case of emergencies (an emergency), which can be used during the development of plans of liquidation accidents such on the enterprises of food industry.

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Abstracts in Ukrainian

Анотації

Харчові технології

Дослідження властивостей м'ясної сировини при солінні розсолами

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Вступ. Досліджено механізм формування кольорових характеристик модельних м'ясних систем із низьким вмістом міоглобіну на стадії соління на зміну кольорових характеристик м'ясної сировини в процесі соління.

Матеріали і методи. Визначення відносного вмісту міоглобіну і його похідних проводили методом відбивної спектроскопії на спектрофотометрі СФ-18, вміст загальних пігментів - екстрагуванням пігментів м'яса спочатку водним, а потім солянокислим ацетоном з подальшим фотоколориметруванням витяжки при довжині хвилі 540 нм відносно солянокислого ацетону; інтенсивність забарвлення - на фотоелектроколориметрі КФ-77 при довжині хвилі 540 нм відносно дистиляту, визначення спектрів та інтегральних кольорових характеристик - на спектрофотометрі Cary 50.

Результати. Встановлена доцільність використання в технології м'ясопродуктів колорантів на основі препаратів гемоглобіну крові забійних тварин Vepro 70 Col P і Апро Ред як складових багатофункціональних розсолів для корегування кольору шинкових виробів з високим рівнем ін'єктування та з різним рівнем вмісту міоглобіну у м'ясній сировині. Раціональна концентрація препаратів гемоглобіну (Vepro 70 Col P і Апро Ред) для забарвлення м'ясних систем з вмістом жиру до 10 % склала відповідно 0,5 % і 0,6 % за одночасного використання 0,05 % ізоаскорбату Na і 0,006 % нітриту натрію.

Висновки. Результати рекомендовано застосовувати в сучасних технологіях виробництва шинкових виробів з використанням інтенсифікуючих способів соління.

Ключові слова: *розсіл, кольоровість, нітрозопігмент, міоглобін, барвник.*

Жирнокислотний склад молочних рослинно-жирових продуктів

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Вступ. Для збагачення поліненасиченими жирними кислотами та підвищення біологічої й харчової цінності спредів з харчовими волокнами запропоновано вносити продукти переробки шипшини – олію та шрот. Доведено доцільність і можливість використання вищеназваної рослини для молочного рослинно-жирового продукту емульсійного типу з харчовими волокнами Citri-Fi.

Матеріали і методи. Методом газорідинної хроматографії ідентифіковано піки зразків спредів із продуктами переробки шипшини. Встановлено, що отриманий молочний рослинно-жировий продукт емульсійного типу містить більше незамінних поліненасичених жирних кислот порівняно з маслом вершковим, що входить до рецептури спредів.

Результати. Встановлено, що в дослідженому спреді зменшується кількість насичених і ненасичених жирних кислот: капринової (на 1,136 %), лауринової (на 1,958 %), міристинової (на 3,03 %), пальмітинової (на 6,454 %), стеаринової (на 1,016 %), арахінової (на 0,229 %)) і трансизомерів, які при вживанні продукту можуть спричинити серцево-судинні захворювання (на 1,305 % порівняно з вершковим маслом). Основною ω-3 кислотою в молочно-жирових продуктах з харчовими волокнами є ліноленова, порівняно з маслом вершковим її вміст збільшується на 0,038 %. Серед ω-6 кислот у зразках масла переважає лінолева, якої стає більше на 0,458 %, лінолевої (цис-9, цис-12 $C_{18:2}$) – на 15,282 %. Із мононенасичених у спреді з продуктами переробки шипшини дещо менше таких жирних кислот, як міристоолеїнова, пальмітоолеїнова, гептадеценова, елаїдинова, але більше олеїнової (на 1,831 %). Отримані результати можуть бути використані при встановленні біологічної цінності спредів з продуктами переробки шипшини відповідно до сучасних положень нутриціології.

Ключові слова: *спред, жир, олія, шипшина, молоко.*

Моделювання складу сумішевих олій методом купажування

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Вступ. З метою збагачення харчового раціону населення есенціальними жирними кислотами використано метод купажування рослинних олій, який дає змогу одержати жирові продукти збалансованого складу з традиційними смаковими властивостями.

Матеріали і методи. Фізико-хімічні показники якості олій визначали за стандартними методиками; планування експерименту й оптимізацію технологічних процесів здійснювали експериментально-статистичним методом на основі програмного пакета Паскаль; жирнокислотний склад олій визначали методом газової хроматографії.

Результати та обговорення. Досліджено й уточнено склад жирних кислот рослинних олій холодного пресування. Розроблено і науково обґрунтовано склад купажів на основі соняшникової олії з додаванням олій рижію, льону та волоського горіха, які гарантують раціональне співвідношення ω-6/ω-3 жирних кислот з урахуванням рекомендацій їх споживання. Досліджено перебіг автокаталітичного і гідролітичного окиснення купажів при зберіганні їх за температури 20±2 ºС за вільного доступу світла та повітря. Встановлено суттєве уповільнення швидкості накопичення пероксидів і вільних жирних кислот при купажуванні 35% горіхової або

40% рижієвої олії з відповідною кількістю соняшникової олії. Одержано дані про знижену стабільність сумішевих олій з використанням лляної олії та рівняння для розрахунку гарантійного терміну зберігання купажованих олій на основі соняшникової олії.

Ключові слова: *олія, купажування, жир, кислота, ω-3 кислота, окиснення.*

Скринінг штамів для ферментації м'ясної сировини

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Вступ. Перспективним у технології виробництва ферментованих м'ясних продуктів є застосування бактеріальних препаратів, які містять в одній композиції молочнокислі бактерії та мікроорганізми інших таксономічних груп.

Матеріали і методи. З метою вивчення кількісного і якісного складу мікрофлори м'ясних розсолів проведено аналіз 6 зразків. Ізоляти перевірені на реакцію за Грамом, морфологію клітин, утворення каталази, продукування CO_2 з глюкози, гідроліз аргініну, редукцію нітрату, наявність каталазної й ароматоутворюючої активностей. Зразки також випробувані на здатність рости при 10 °С і 45 °С і при pH 3 і 9,2, толерантності до 4% і 15% солі. Протеолітична активність культур визначалася в середовищі МПА з 5% розчином NaCl і 10% гідролізованого молока.

Результати. Чисельність бактерій у $см^3$ розсолу не перевищує мільйонів клітин. Найпоширенішими родами є *Lactobacillus, Micrococcus* та *Staphylococcus*. Наявність нітратредукувальної, каталазної й ароматоутворювальної активностей встановлено у 52 % відібраних штамів бактерій. Зі зростанням солоності середовища зменшувалась кількість штамів, здатних до росту. Майже всі групи мікроорганізмів зростають у температурних межах (10-40) ^{0}С. Переважна більшість штамів стафілококів здатна до гідролізу молочних білків. За сукупністю біологічних і технологічних ознак відібрано 2 високопродуктивних штами стафілококів та 5 штамів молочнокислих бактерій.

Висновки. Властивості відібраних штамів бактерій дають підстави залучити найкращі з них для виробництва ферментованих м'ясних продуктів.

Ключові слова: *м'ясо, ферментація, скринінг.*

Раціональне використання колагену

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Вступ. Актуальність дослідження полягає в обгрунтуванні вибору низькосортної м'ясної сировини як матриці для зв'язування іонів кальцію - безпечної, ефективної і доступної.

Матеріали і методи. Колагеновмісна сировина – рубець ВРХ, джерело кальцію – стулки мідій, ферментний препарат – колагеназа харчова. Ферментний препарат обирали на основі аналізу літературних джерел.

Результати. Встановлювали раціональні параметри pH (6,8 - 7,0), температури (12 ± 1 ° С), тривалості (3:00), гідромодуль (1:1) і кількість ферментного препарату для ефективного протеолізу на модельних системах (0,1%). За допомогою повного факторного експерименту з подальшим математичним моделюванням у проблемно-орієнтовному пакеті MathCad отримували математичну модель залежності тривалості і температури протеолізу. Параметром оптимізації обрано вміст амінного азоту аміногрупи, що отримували з рубця ВРХ. Дослідження продовжуються, планується отримання підтвердження даних модельного середовища при протеолізі рубця ВРХ.

Висновки. Результати рекомендовано використовувати в м'ясній галузі харчової промисловості в спеціальному харчуванні – геродієтиному. Розробка надає можливість знизити вартість готового продукту, збагатити його мікроелементами і поліпшити засвоєння організмом людини.

Ключові слова: *м'ясо, рубець ВРХ, сировина, геронтологія.*

Оптимізація умов виділення дієтичної добавки з адаптогенною активністю з печериці двоспорової (*Agaricus bisporus*)

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Вступ. У сучасних умовах адаптаційні та захисні системи організму не можуть адекватно контролювати гомеостаз і реагувати на зміни, що відбуваються в навколишньому середовищі, тому актуальним є розроблення препаратів з адаптогенною активністю на основі регіональної сировини.

Матеріали і методи. Досліджувані препарати являють собою твердий залишок після обробки грибів низкою екстрагентів: киплячою водою, розчинами 3,7 % HCl при кімнатній температурі, 3,0 – 7,0 % NaOH при температурі 98 °С протягом 1,5 – 4,5 год. Зразки характеризували за такими показниками: антиоксидантна активність (АОА), біфідогенний ефект (БГЕ), сорбція холевої кислоти (СХК). АОА зразків визначали тіоціанатним методом (після ініціації перекисного окислення ліпідів); БГЕ – за кількістю клітин біфідобактерій, що виросли за їх наявності; СХК – спектрофотометрическим методом.

Результати. Отримано лінійні рівняння регресії, які адекватно описують залежності АОА, БГЕ і СХК виділених препаратів від досліджуваних факторів: концентрації лужного агента й тривалості обробки сировини. В рівняннях для АОА і БГЕ коефіцієнти парної взаємодії значущі і мають достатньо великі значення. Встановлено, що при низьких концентраціях розчинів лугу із збільшенням тривалості обробки показник АОА значно зростає, в області високих значень C_{NaOH} вплив тривалості обробки менший. Збільшення масової частки натрій гідроксиду в розчині призводить до істотного зростання АОА тільки при мінімальній експозиції. На БГЕ препаратів переважно впливає концентрація лугу – підвищення C_{NaOH} з 3,0 до 7,0 % при мінімальній тривалості обробки супроводжується зменшенням кількості мікроорганізмів більш ніж утричі. При мінімальних значеннях концентрації лужного агента збільшення тривалості обробки призводить до зниження даного показника, а при максимальних – спостерігається протилежний ефект. На ступінь прояву препаратами СХК впливає як концентрація лужного розчину, так і тривалість обробки. Зі зростанням концентрації лугу СХК підвищується, збільшення тривалості

обробки, навпаки, призводить до його зниження. Оптимальними умовами отримання дієтичної добавки з адаптогенною активністю з печериці двоспорової є обробка сировини киплячою водою, 3,7 % розчином HCl при кімнатній температурі, 5,1 % розчином лугу при температурі 98 °С протягом 4,2 год з параметрами: АОА такої добавки становить 90,0 %, СХК - 22,4 мг/г добавки, БГЕ відповідає $1{,}5 \cdot 10^{12}$ КУО/см^3.

Висновки. За умови підтвердження адаптогенних властивостей в умовах *in vivo* дієтична добавка може бути рекомендована як препарат профілактичної дії. В Україні не виробляються препарати з адаптогенною активністю, отримані на основі регіональної сировини.

Ключові слова: *оптимізація, дієтична добавка, адаптоген, активність.*

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 з використання промислових відходів для одержання практично цінних мікробних метаболітів, в тому числі й олієвмісних.

Матеріали і методи. 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 та 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 самою 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.*

Харчова хімія

Вилучення Р-вітамінного комплексу з листя зеленого чаю

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Вступ. Р - вітамінний комплекс із зеленого чаю має високу антиоксидантну дію катехінів, тому його можна використати для профілактики й лікування найрозповсюдженіших захворювань, у патогенезі яких важливу роль відіграє активація вільнорадикального окиснення.

Матеріали і методи. Досліджено крупнолистовий зелений байховий чай. Для вилучення вітаміну Р використано методи простої та багатократної екстракції. Визначення кількості екстрагуючих речовин проводили шляхом випарювання, після цього проводилося зважування.

Результати та обговорення. Для забезпечення високого вмісту вітаміну Р в зеленому чаї доцільно використати оптимальні умови його екстрагування.

Найбільш повне вилучення цільових сполук досягається при екстрагуванні протягом 60 хв (подальше збільшення часу екстрагування не призводило до збільшення кількості екстрактивних речовин). Максимальне вилучення цільових сполук спостерігалось при екстрагуванні сировини з розміром частинок <1мм. Дослідження кратності екстракції показало, що доцільним є проведення двократного екстрагування.

Висновки. Розробка біологічно активних добавок на основі природних антиоксидантів є актуальною проблемою, а флавоноїди зеленого чаю – перспективні об'єкти для збагачення харчових продуктів. Оптимальним для вилучення вітаміну Р із зеленого чаю є співвідношення сировина – екстрагент 1 : 40, тому що збільшення кількості розчинника не призводить до зростання кількості флавоноїдів в екстракті.

Ключові слова: *флавоноїд, катехін, вітамін Р, екстракція, зелений чай.*

Визначення вмісту мікроелементів (Cr, Al, Pb) у питній воді м. Києва за допомогою атомно-адсорбційного аналізу

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Вступ. Одним з найбільш вагомих факторів якості життя у великих містах вважається контроль вмісту мікроелементів. З цією метою широко застосовується атомно-адсорбційний аналіз з електротермічною атомізацією (ETAAS) з використанням хімічних модифікаторів.

Матеріали і методи. Всі вимірювання концентрації Al, Cr та Pb у зразках води були виконані за допомогою атомно-адсорбційного спектрофотометра Сатурн-3 МП, обладнаного графітовим електротермічним атомізатором (Графіт 2).

Результати та обговорення. Суттєва різниця в концентрації свинцю зафіксована у двох зразках води з озера, що можна пояснити близьким проляганням траси біля озера в Голосіївському районі і його забрудненням бензиновими присадками, які містять цей елемент. На жаль, вміст Al в підземній річці Либідь суттєво перевищує

ГДК, що може бути пов'язано з тривалим використанням труб із високим вмістом цього елемента, а також результатом неконтрольованого використання миючих засобів і детергентів. Наявність великої кількості хрому пояснюється як природними, так і антропогенними факторами (наприклад, вилужуванням твердих промислових відходів, які можуть забруднювати воду внаслідок інтенсивної забудови міста). Питна вода річок також характеризується підвищеною кількістю хрому.

Висновки. Забруднення води, спричинене наявністю свинцю, є незначним. Зважаючи на високу концентрацію, найбільшу увагу слід приділити вмісту Al і Cr у різних джерелах питної води м. Києва. Цікаво, що споживання води, збагаченої хромом, може позитивно впливати на людей, хворих на цукровий діабет, оскільки в них незначна кількість цього мікроелемента в плазмі крові.

Ключові слова: *вода, пиття, ETAAS метод, мікроелемент.*

Процеси і обладнання харчових виробництв

Аналіз процесу утворення n-нітрозодиметиламіну в пивному солоді

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Вступ. У статті розглянуто питання утворення канцерогенних речовин при виробництві пива. Показано, що основним технологічним процесом, який впливає на накопичення N-нітрозодиметиламіну в пиві, є сушіння пивоварного солоду. Визначальним фактором, що впливає на вміст N-нітрозодиметиламіну в солоді, є концентрація діоксиду вуглецю на вході в шар солоду.

Об'єкти і методи дослідження. Дослідження проводились при режимах, характерних для сушарок ЛСХА. Вимірювання концентрації оксидів азоту здійснювалася на газоаналізаторі типу 645 ХЛ 20, принцип роботи якого базується на хемілюмінесцентному методі визначення оксиду азоту.

Результати та обговорення. Більш інтенсивне поглинання діоксиду вуглецю спостерігалося під час першої стадії (постійної швидкості) сушіння, що пояснюється наявністю в солоді великої кількості вільної вологи - поглинача діоксиду вуглецю. На інтенсифікацію процесів утворення N-нітрозодиметиламіну в солоді найбільший вплив має концентрація діоксиду вуглецю в сушильній агента, що відзначено в усіх дослідах.

Граничні значення вмісту NO_2 в сушильній агента обумовлюються заданими гігієнічними нормами концентрації НДМА в солоді, тому для гарантованої чистоти продукту межа концентрації НДМА у виробленому солоді повина становити не більше 15 мкг/кг. Таку концентрацію забезпечує сушіння солоду сушильним агентом із вмістом NO_2 в ньому не більше 0,4 мг/м^3. Це значення має бути граничним у розробці сучасних тепловентиляційні систем.

Ключові слова: *солод, сушіння, n-нітрозодиметиламін.*

Удосконалення обладнання для приготування тістових напівфабрикатів

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Вступ. Підвищити ефективність процесу виробництва хлібобулочних виробів можливо шляхом інтенсивного замішування тіста, удосконалення його бродіння та формування.

Матеріали і методи. Досліджували пшеничне дріжджове тісто з борошна вищого ґатунку та процеси замішування, бродіння і формування на розробленій експериментальній установці, в якій ці операції поєднано.

Результати. Необхідність комплексного удосконалення процесу виробництва хлібобулочних виробів випливає з широкого використання ручної праці, громіздкого обладнання при традиційному способі виробництва. Конструкція змішувально-бродильно-формувального агрегата дозволяє об'єднати процеси безперервного інтенсивного замішування тіста, бродіння та формування розрихлених тістових заготовок безпосередньо на під хлібопекарської печі. Агрегат забезпечує скорочення машино-апаратурної схеми і знижує витрати на експлуатацію обладнання.

В'язкість газонаповненого тіста лінійно знижується зі збільшенням витрат питомої роботи і швидкості зсуву через послаблення взаємодії між частинками тіста. Підвищення вмісту газової фази призводить до зменшення в'язкості тіста та збільшення середньої швидкості потоку. Кількість газу більше 40% і градієнт тиску 0,3-0,4 МРа спричиняють руйнування газових бульбашок. Одержано експоненційну залежність середньої швидкості потоку *w* від тиску пресування Р від 0,1 до 0,4 МРа при різному вмісті газової фази G від 0 до 45 %. Залежність коефіцієнта розширення тістового джгута від кута входу у формувальний канал має екстремум. Оптимальне значення конусності входу – 70 - 80°.

Висновки. Результати доцільно використати при проектуванні нових і реконструкції існуючих ліній виробництва хлібобулочних виробів.

Ключові слова: *заміс, тісто, екструзія, бродіння, формування*

Наукове обґрунтування методу синтезу структури машин для пакування харчових продуктів

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Вступ. Для оптимізації процесу пакування доцільно виконувати синтез структури пакувальної машини комбінаторно-логічними методами.

Матеріали і методи. Для генерування структур використовується перебір і пошук нових поєднань у масиві аналогів і прототипів при застосуванні засобів опису узагальнених структур пакувальних машин (табличні, алгебраїчні, логічні та мережні моделі).

Результати та обговорення. Орієнтований мультиграф використано для синтезу структури пакувальних машин, а також оптимізації окремих рішень. Для цього сформульовані системи обмежень і цільові функції. Обгрунтована система обмежень, яка визначає умови вибору елементів мультиграфової моделі, та цільової

функції, що надає можливість оптимізувати різні структурні характеристики розв'язків. Розв'язок задачі структурного синтезу складається з орієнтованих дуг мультиграфа. Під час застосування цього методу один клас пакувальних машин представляють у вигляді орієнтованого мультиграфа. У такому мультиграфі множиною мультидуг є Z={Zi}, *i*= , а множиною вершин – S={Si}. Дуга буде активована тоді, коли активовані всі її виходи. Загальна кількість змінних у таких моделях визначалась із виразу 3n+K+M, а кількість рівнянь і нерівностей у системі обмежень - 7n+K+L+1, де n – загальна кількість елементів узагальненої структури пакувальної машини, К – кількість вихідних зв'язків, L – кількість заборонених комбінацій.

Висновок. Проблема структурного синтезу зведена до задач дискретного лінійного програмування. Для цього сформульована система обмежень, яка визначає умови вибору елементів мультиграфової моделі та цільової функції, що надають можливість оптимізувати різні структурні характеристики розв'язків.

Ключові слова: *пакування, машина, синтез, модуль, мультиграф.*

Автоматизація виробничих процесів

Оптимізація систем електропостачання підприємств харчової промисловості

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Вступ. Підвищити ефективність компенсації реактивної потужності на харчових підприємствах доцільно шляхом застосування дворівневої системи керування джерелами реактивної потужності.

Матеріали і методи. Досліджується розроблена система комплексної компенсації, яка забезпечує зміну в акцентах керування потужностями КУ від децентралізації до забезпечення системної цілеспрямованості вирішення проблеми, що концептуально пов'язано з оптимізацією режиму електроспоживання на промисловому підприємстві.

Результати та обговорення. Споживання реактивної потужності протягом доби нерівномірне. Системам компенсації реактивної потужності підприємств притаманна ієрархічна структура та висока складність. Протягом доби потужність, що генерується, повинна не менше, як на 80-90% збігатися з графіком споживаної реактивної потужності. Джерело реактивної потужності з комбінованим регулюванням має таку саму швидкодію, як і плавне та ступінчасте джерело реактивної потужності, але на відміну від ступінчастого джерела реактивної потужності дозволяє регулювати реактивну потужність плавно, а на відміну від плавно регульованого джерела реактивної потужності не викликає у мережі значних спотворень форми кривої напруги. Режим роботи всіх джерел реактивної потужності повинен відповідати графіку споживання реактивної потужності. Запропонований системний підхід до компенсації дозволяє суттєво підвищити економічні показники всіх джерел реактивної потужності. Для підвищення коефіцієнта потужності

застосовані конденсаторні установки. Робота впроваджена на Дніпропетровському молокозаводі. Результат впровадження – зменшення втрат електроенергії на 23 %, а суми оплати за реактивну енергію на 78 %.

Висновки. Результати рекомендується застосовувати на підприємствах харчової промисловості з метою підвищення ефективності систем електропостачання.

Ключові слова: *реактивна потужність, електропостачання, компенсація.*

Розрахунок кінцевої температури нагріву обмотки статора турбогенератора з метою управління розвитком теплового дефекту

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Вступ. Для управління роботою турбогенератора важливо точно спрогнозувати кінцеву температуру теплового процесу, яка може зрости при виникненні в машині дефектів. Для управління розвитком дефекту доцільно використати методи технічної діагностики.

Матеріали і методи. На основі аналізу класичного і графічного методів розрахунку кінцевої температури обмотки статора турбогенератора був розроблений новий метод розрахунку температури електричної ізоляції обмотки статора, що встановилася, з використанням сучасних методів інформаційних технологій.

Результати та обговорення. Класичний метод можна використовувати при незмінній величині коефіцієнта тепловіддачі, тобто коли система охолодження працює в статорному режимі, а підвищення температури статора викликано неконтрольованою зміною навантаження турбогенератора. Графічний метод простий у використанні, але не відрізняється точністю, особливо коли величину передбачуваної температури, що встановилася, визначають за результатами вимірювань тільки в початковій стадії процесу нагрівання стрижнів статора турбогенератора. Запропонований метод теплового процесу на основі дивергенції частково компенсує недоліки вищеназваних методів і дозволяє аналізувати температурні напруги стрижня обмотки статора турбогенератора.

Висновки. Декомпозиція завдання аналізу температурного поля стрижня обмотки статора дає змогу розширити уявлення про динаміку його змін і підвищити достовірність діагностики.

Ключові слова: *турбогенератор, охолодження, статор, діагностика, прогнозування.*

Баластні теплові потоки під час термічної обробки харчових продуктів

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Вступ. Застосування новітніх засобів теплофізичних вимірювань дозволяє отримати нову інформацію, що надає можливість економити енергію і продукти.

Матеріали і методи. Малогабаритний високочутливий і малоінерційний тепломір (диск діаметром 20 мм і товщиною 1,2 мм) використовували при дослідженні дозрівання твердого сиру. Температуру повітря в камері підтримували на рівні 10 ± 0,25 ° С терморегулятором.

Результати та обговорення. Результати прямого вимірювання щільності теплового потоку тепломіром, розташованим у центрі верхньої поверхні головки сиру, виявилися несподіваними: близько 30 % тепла, яке виділяється з сиру, повертається в головку. Ця повернена теплота є баластним навантаженням на холодильну установку камери, його усунення або мінімізація є джерелом енерго- і ресурсозбереження.

Баластні потоки тепла можливі також при тепловій обробці харчових продуктів, наприклад, у процесі стабілізації поверхневого шару вареної ковбаси осцилюючим інфрачервоним обігрівом. Підбором часу коагуляції і напруги на випромінювачі вдалося знизити баластний тепловий потік у центральні шари на дві третини, а інверсний тепловий потік з цих шарів - до нуля. Максимальний теплоприток, а з ним і загальні витрати енергії були знижені на 15 - 20 %.

Зменшення температурної заставки на терморегуляторі при холодильній обробці могло б зменшити теплової баласт, але призвело б до передчасного зносу деталей холодильної машини. Якщо немає можливості влаштувати камеру перемішування повітря перед камерою дозрівання, потрібно встановлювати терморегулятор якнайдалі від охолоджуваного продукту.

Висновки. Можливість баластних теплових потоків при холодильній обробці – це ще один аргумент на користь переходу на абсорбційні холодильні машини, джерело енергії для яких є на будь-якому харчовому підприємстві, включаючи молоко- і сирзаводи .

Ключові слова: *тепло, потік, оброблення, баласт, тепломір.*

Безпека життєдіяльності

Підвищення загального рівня безпеки праці на підприємствах харчової промисловості

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Вступ. Метою дослідження є підвищення рівня безпеки праці на підприємствах харчової промисловості за рахунок удосконалення загальної моделі ризику виробничого травматизму на харчовому підприємстві.

Матеріали і методи. Застосовано метод головних компонент для визначення основних чинників травмування працівників галузі та прогозування ризиків виробничого травматизму.

Результати. Удосконалено загальну модель ризику виробничого травматизму на підприємстві харчової промисловості, що базується на комплексному врахуванні впливу на травматизм усього спектру виробничих і соціально-економічних чинників та будується на основі схеми виникнення нещасного випадку, у якій кожен факт нещасного випадку пов’язується з передумовою його виникнення. Зазначений підхід, на підставі даних з форм обов’язкової щорічної звітності, дозволяє здійснювати

аналіз безпосередніх причинно-наслідкових зв'язків, що мають місце у процесі травмування, та виявляти як основні, так і приховані причини виробничого травматизму, а також види подій, що призводять до нещасного випадку. Встановлено, що для забезпечення фільтрації статистичних даних і візуалізації результатів для обробки наявної статистики виробничого травматизму найбільш доцільним є метод головних компонент. Корисність цього методу при аналізі даних виробничого травматизму грунтується на можливості зменшення обсягів аналізу інформації та визначення найбільш суттєвих факторів виробничого травматизму. Завдяки основним властивостям метод головних компонент достатньо успішно може бути використаний для прогнозування значного числа вихідних показників виробничого травматизму за порівняно малої кількості допоміжних (латентних) змінних, що виражають причини цього явища, забезпечуючи при цьому найменшу похибку прогнозу.

Ключові слова: *безпека, праця, травматизм, ризик, харчування.*

Моделювання розвитку ризику руйнувань небезпечних промислових об'єктів у надзвичайних ситуаціях

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Вступ. Існуючі системи комплексного захисту об'єктів підвищеної небезпеки промислових підприємств малоефективні, тому виникає необхідність зосередження сил і засобів на найбільш небезпечних напрямках.

Матеріали і методи. Для оцінювання ризику промислового об'єкта побудовано модель розвитку аварії (надзвичайної ситуації). Просторово-структурну еволюцію ризику виникнення аварії (надзвичайної ситуації) реалізовано за допомогою комплексу математичних моделей стохастичним адаптивним методом матричного генетичного моделювання.

Результати. Перша математична модель даного комплексу являє собою систему аналітичних нелінійних рівнянь, що дають змогу розрахувати просторово-часові результати аварії (надзвичайної ситуації). Просторово-часова структура $Sc_j \in \{Sc\}_{доп}$ може задаватися експертно або ж знаходитися за допомогою другої математичної моделі. Відповідна модель є нелінійною, дискретною математичною моделлю з невідомими операторами, що задаються алгоритмічно. Третя математична модель є системою лінійних аналітичних рівнянь з невідомими значеннями факторів $X_1, X_2, ..., X_k$ та функцією пріоритетів P, що знаходяться за допомогою методів теорії нечітких множин.

Висновки. Запропоновано комплексну математичну модель, яка може бути практично реалізована для вирішення завдання з моніторингу діяльності небезпечних об'єктів у харчовій промисловості, завчасно прогнозувати просторово-часову еволюцію ризику стану небезпечного промислового об'єкта залежно від сценарію розвитку надзвичайної ситуації.

Ключові слова: *безпека, ризик, аварія, руйнування, промисловість.*

Abstracts in Russian

Аннотации

Пищевые технологии

Исследование свойств мясного сырья при посоле рассолами

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Введение. Исследовано механизм формирования цветных характеристик модельных мясных систем с низким содержанием миоглобина на стадии посола на изменение цветных характеристик мясного сырья в процессе посола.

Материалы и методы. Определение относительного содержания миоглобина и его производных проводили методом отражательной спектроскопии на спектрофотометре СФ-18, содержание общих пигментов – экстрагированием пигментов мяса сначала водным, а затем солянокислым ацетоном с последующим фотоколориметрированием вытяжки при длине волны 540 нм относительно солянокислого ацетона; интенсивность окраски - на фотоэлектроколориметре КФ-77 при длине волны 540 нм в отношении дистилята, определение спектров и интегральных цветных характеристик - на спектрофотометре Cary 50.

Результаты. Установлена целесообразность использования в технологии мясопродуктов колорантов на основе препаратов гемоглобина крови убойных животных Vepro 70 Col P и Апро Ред как составляющих многофункциональных рассолов для корегирования цвета ветчинных изделий с высоким уровнем инъектирования и с различным уровнем содержания миоглобина в мясном сырье. Рациональная концентрация препаратов гемоглобина (Vepro 70 Col P и Апро Ред) для окраски мясных систем с содержанием жира до 10 % составила соответственно 0,5 % и 0,6 % при одновременном использовании 0,05 % изоаскорбата Na и 0,006 % нитрита натрия.

Выводы. Результаты рекомендовано применять в современных технологиях производства ветчинных изделий с использованием интенсифицирующих способов посола.

Ключевые слова: *мясо, рассол, цветность, нитрозопигмент, миоглобин, краситель.*

Жирнокислотный состав молочных растительно-жировых продуктов

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Введение. Для обогащения полиненасыщенными жирными кислотами и повышения биологической и пищевой ценности спредов с пищевыми волокнами предлагается вносить продукты переработки шиповника - масло и шрот. Доказана целесообразность и возможность использования вышеуказанного растения для молочного растительно-жирового продукта эмульсионного типа с пищевыми волокнами Citri-Fi.

Материалы и методы. Методом газожидкостной хроматографии идентифицировано пики образцов спредов с продуктами переработки шиповника. Установлено, что полученный молочный растительно-жировой продукт эмульсионного типа содержит больше незаменимых полиненасыщенных жирных кислот по сравнению с маслом сливочным, входящим в рецептуру спреда.

Результаты. Установлено, что в исследованной спреде уменьшается количество насыщенных и ненасыщенных жирных кислот: каприловой (на 1,136 %), лауриновой (на 1,958 %), миристиновой (на 3,03 %), пальмитиновой (на 6,454 %), стеариновой (на 1,016 %), арахиновой (на 0,229 %)) и трансизомеров, которые при употреблении продукта могут вызвать сердечно-сосудистые болезни (на 1,305 % по сравнению со сливочным маслом). Основной ω-3 кислотой в молочно-жировых продуктах с пищевыми волокнами является линоленовая, по сравнению с маслом сливочным ее содержание увеличивается на 0,038 %. Среди ω-6 кислот в образцах масла преобладает линолевая, которой становится больше на 0,458 %, линолевой (цис-9, цис-12 $C_{18:2}$ - на 15,282 %). С мононенасыщенных в спреде с продуктами переработки шиповника несколько меньше таких жирных кислот: миристоолеиновой, пальмитоолеиновой, гептадеценовой, елаидиновой, но больше олеиновой (на 1,831 %). Полученные результаты могут быть использованы при установлении биологической ценности спредов с продуктами переработки шиповника в соответствии с современными положениями нутрициологии.

Ключевые слова: спред, жир, масло, шиповник, молоко.

Моделирование состава смесевых масел методом купажирования

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Введение. С целью обогащения пищевого рациона населения эссенциальными жирными кислотами использован метод купажирования растительных масел, который позволяет получить жировые продукты сбалансированного состава с традиционными вкусовыми характеристиками.

Материалы и методы. Физико-химические показатели качества масел определяли по стандартным методикам; планирование эксперимента и оптимизацию технологических процессов осуществляли экспериментально-статистическим методом; жирнокислотный состав масел определяли методом газовой хроматографии.

Результаты и обсуждение. Исследован и уточнен состав жирных кислот растительных масел холодного прессования. Разработан и научно обоснован состав купажей на основе подсолнечного масла с добавками масел рыжика, льна и грецкого ореха, которые гарантируют рациональное соотношение ω-6/ω-3 жирных кислот с учетом рекомендаций их употребления. Исследовано течение автокаталитического и

гидролитического окисления купажей при температуре хранения *20±2 ºС* со свободным доступом света и воздуха. Установлено существенное замедление скорости накопления пероксидов и свободных жирных кислот при купажировании 35% орехового или 40% рыжикового масла с соответствующим количеством подсолнечного масла. Получены данные о пониженной стабильности купажа с использованием льняного масла, а также уравнение для расчета гарантийного строка хранения купажированных масел на основе подсолнечного масла.

Ключевые слова: *масло, купажирование, жир, кислота,* ω-3 кислота*, окисление.*

Скрининг штаммов для ферментации мясного сырья

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Введение. Перспективным в технологии производства ферментированных мясных продуктов является применение бактериальных препаратов, содержащих в одной композиции молочнокислые бактерии и микроорганизмы других таксономических груп.

Материалы и методы. С целью изучения количественного и качественного состава микрофлоры мясных рассолов проведен анализ 6 образцов. Изоляты были проверены на реакцию по Граму, морфологию клеток, образование каталазы, продуцирование CO_2 из глюкозы, гидролиз аргинина, редукцию нитрата, наличие каталазной и ароматобразующей активностей. Образцы также были испытаны на способность расти при 10 °С и 45 °С и при pH 3 и 9,2, толерантности до 4% и 15% соли. Протеолитическая активность культур определяли в среде МПА с 5% раствором NaCl и 10% гидролизованного молока.

Результаты. Численность бактерий в $см^3$ рассола не превышает миллионов клеток. Наиболее распространенными родами являются Lactobacillus, Micrococcus и Staphylococcus. Наличие нитратредуцирующей, каталазной и ароматообразовательной активностей установлено в 52% отобранных штаммов бактерий. С ростом солености среды уменьшалось количество штаммов, способных к росту. Почти все группы микроорганизмов ростут в температурных пределах (10-40) ^{0}С. Преобладающее большинство штаммов стафилококков способно к гидролизу молочных белков. По совокупности биологических и технологических признаков отобрано 2 высокопроизводительных штаммы стафилококков и 5 штаммов молочнокислых бактерий.

Выводы. Свойства отобранных штаммов бактерий дают основания привлечь лучшие из них для производства ферментированных мясных продуктов.

Ключевые слова: *мясо, ферментация, сринг.*

Рациональное использование коллагена

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Введение. Актуальность работы заключается в обосновании выбора низкосортного мясного сырья в качестве матрицы для связывания ионов кальция - безопасной, эффективной и доступной.

Материалы и методы. Коллагенсодержащее сырье - рубец КРС, источник кальция - створки мидий, ферментный препарат - коллагеназа пищевая. Ферментный препарат выбирали на основании літературного анализа.

Результаты. Необходимо определить рациональное количество ферментного препарата для эффективного протеолиза коллагенсодержащего сырья в технологических процессах и доказать экономическую целесообразность. Устанавливали рациональные параметры pH (6,8 - 7,0), температуры (12 ± 1 ° С), продолжительности (3:00), гидромодуль (1:1) и количество ферментного препарата для эффективного протеолиза на модельных системах (0,1 %). С помощью полного факторного эксперимента с последующим математическим моделированием в проблемно-ориентировочном пакете MathCad получали математическую модель зависимости длительности и температуры протеолиза. Параметром оптимизации выбрано содержание аминного азота аминогруппы, получаенного из рубца КРС. Исследования продолжаются, планируется получение подтверждения данных модельной среды при протеолизе рубца КРС.

Результаты рекомендуется использовать в мясной отрасли пищевой промышленности в специальном питании - геродиетическом. Разработка позволяет снизить стоимость готового продукта, обогатить его микроэлементами и улучшить его усвоение организмом человека.

Ключевые слова: *мясо, рубец КРС, сырье, геронтология*.

Оптимизация условий выделения диетической добавки с адаптогенной активностью из шампиньона двуспорового (*Agaricus bisporus*)

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Введение. В современных условиях адаптационные и защитные системы организма не могут адекватно контролировать гомеостаз и реагировать на изменения, происходящие в окружающей среде, поэтому разработка препаратов с адаптогенной активностью на основе регионального сырья является актуальной.

Материалы и методы. Исследуемые препараты представляют собой твердый остаток после обработки грибов рядом экстрагентов: кипящей водой, растворами 3,7 % HCl при комнатной температуре, 3,0 – 7,0 % NaOH при температуре 98 °С в течение 1,5 – 4,5 ч. Образцы характеризовали по показателям: антиоксидантная активность (АОА), бифидогенный эффект (БГЭ), сорбция холевой кислоты (СХК). АОА образцов определяли тиоцианатным методом (после инициации перекисного окисления липидов); БГЭ – по количеству клеток бифидобактерий, выросших в их присутствии; СХК – спектрофотометрическим методом.

Результаты. Получены линейные уравнения регрессии, адекватно описывающие зависимости АОА, БГЭ и СХК выделенных препаратов от исследуемых факторов: концентрации щелочного агента и длительности обработки сырья. В уравнениях для АОА и БГЭ коэффициенты парного взаимодействия имеют достаточно большие значения. Установлено, что при низких концентрациях щелочного агента с увеличением продолжительности обработки показатель АОА значительно

возрастает, в области высоких значений C_{NaOH} влияние длительности обработки проявляется меньше. Увеличение массовой доли натрий гидроксида приводит к существенному росту АОА только при минимальной экспозиции. На БГЭ препаратов преимущественно влияет концентрация щелочи – повышение C_{NaOH} с 3,0 до 7,0 % при минимальной длительности обработки сопровождается уменьшением количества микроорганизмов более чем втрое. При минимальных значениях концентрации щелочного агента увеличение длительности обработки приводит к снижению данного показателя, а при максимальных – наблюдается противоположный эффект. На степень проявления препаратами СХК влияет как концентрация щелочного раствора, так и длительность обработки. С ростом концентрации щелочи СХК повышается, увеличение длительности обработки, напротив, приводит к его снижению. Оптимальными условиями получения диетической добавки с адаптогенной активностью из шампиньона двуспорового является обработка сырья кипящей водой, 3,7 % HCl при комнатной температуре, 5,1 % раствором щелочи при температуре 98 °С в течение 4,2 ч. АОА такой добавки составляет 90,0 %, СХК – 22,4 мг/г добавки, БГЭ соответствует $1{,}5 \cdot 10^{12}$ КОЕ/см^3.

Выводы. При условии подтверждения адаптогенных свойств в условиях *in vivo* диетическая добавка может быть рекомендована в качестве препарата профилактического действия. В Украине отсутствуют полученные на основе регионального сырья препараты такой направленности.

Ключевые слова: *оптимизация, диета, добавка, адаптогенная активность.*

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, подсолнух, масло, культивирование.

Пищевая химия

Получение Р - витаминного комплекса из листьев зеленого чая

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Введение. Р - витаминный комплекс из зеленого чая имеет высокое антиоксидантное действие катехинов, поэтому его можно использовать для профилактики и лечения самых распространенных заболеваний, в патогенезе которых важную роль сыграет активация свободнорадикального окисления.

Материалы и методы. Исследован крупнолистовой зеленый байховый чай. Для изъятия витамина Р использовали методы простой и многократной экстракции. Определение количества экстрагируемых веществ проводили путем выпаривания с последующим взвешиванием.

Результаты и обсуждение. Для обеспечения высокого содержания витамина Р в зеленом чае целесообразно использовать оптимальные условия его экстрагирования.

Наиболее полное изъятие целевых соединений достигается при экстрагировании на протяжении 60 мин (дальнейшее увеличение времени экстрагирования не приводило к увеличению количества экстрактивных веществ). Максимальное изъятие целевых соединений наблюдалось при экстрагировании сырья с размером частичек <1мм. Исследование кратности экстракции показало, что целесообразно проводить двукратное экстрагирование.

Выводы. Разработка биологически активных добавок на основе естественных антиоксидантов является актуальной проблемой, а флавоноиды зеленого чая - перспективные объекты для обогащения пищевых продуктов. Оптимальным для изъятия витамина Р из зеленого чая есть соотношения сырье - экстрагент 1:40, так как последующее увеличение количества растворителя не приводит к росту количества флавоноидов в экстракте.

Ключевые слова: *флавоноид, катехин, витамин Р, экстракция, зеленый чай.*

Определение содержания микроэлементов (Cr, Al, Pb) в питьевой воде г. Киева с помощью атомно-адсорбционного анализа

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Введение. Одним из наиболее важных факторов качества жизни людей, проживающих в больших городах, является контроль содержания микроэлементов. С этой целью широко применяется атомно-адсорбционный анализ с электротермической атомизацией (ETAAS) с использованием химических модификаторов

Материалы и методы. Все измерения концентрации Al, Cr и Pb в образцах воды были выполнены с помощью атомно-адсорбционного спектрофотометра Сатурн-3 МП, оборудованного графитовым электротермическим атомизатором (Графит 2).

Результаты и их обсуждение. Существенные различия в концентрации свинца наблюдалась в двух образцах воды озер, что объясняется близким расположением трассы возле озера в Голосеевском районе и загрязнением воды присадками бензина, содержащих этот элемент. К сожалению, содержание Al в подземной реке Лыбидь существенно превышает ПДК, что может быть связано с продолжительным применением труб с высоким содержанием этого элемента, а также неконтролированного применения моющих средств и детергентов. Наличие большого количества хрома может ассоциироваться как с природными, так и антропогенными факторами. Это может быть связано с выщелачиванием твердых промышленных отходов, загрязняющих воду вследствие интенсивной застройки города. Питьевая вода рек также характеризуется повышенным содержанием хрома.

Выводы. Негативный эффект воды, вызванный наличием свинца, является незначительным. Принимая во внимание высокую концентрацию Al и Cr, наибольшее внимание следует уделить их содержанию в различных источниках воды г. Киева. Интересно, что потребление воды, обогащенной хромом, может положительно влиять на состояние здоровья больных сахарным диабетом, поскольку у них малое количество этого микроэлемента в плазме крови.

Ключевые слова: *вода, питьё, ETAAS метод, микроэлемент.*

Процессы и оборудование пищевых производств

Анализ процесса образования n-нитрозодиметиламина в пивном солоде

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Введение. В статье рассмотрены вопросы образования канцерогенных веществ при производстве пива. Показано что основным технологическим процессом, влияющим на накопление N-нитрозодиметиламина в пиве, является сушка пивоваренного солода. Определяющим фактором, влияющим на содержание N-нитрозодиметиламина в солоде, является концентрация диоксида углерода на входе в слой солода.

Объекты и методы исследования. Исследования проводились при режимах, характерных для сушилок ЛСХА. Измерение концентрации оксидов азота осуществлялась на газоанализаторе типа 645 ХЛ 20, принцип работы которого базируется на хемилюминесцентном методе определения оксида азота.

Результаты и обсуждение. Более интенсивное поглощение диоксида углерода наблюдалось во время первой стадии (при постоянной скорости) сушки, что объясняется наличием в солоде большого количества свободной влаги – хорошего поглотителя диоксида углерода. На интенсификацию процессов образования N-нитрозодиметиламина в солоде наибольшее влияние оказывает концентрация диоксида углерода в сушильном агенте, что отмечено во всех опытах.

Предельные значения содержания NO_2 в сушильном агенте оговариваются заданными гигиеническими нормами концентрации НДМА в солоде, поэтому для гарантированной чистоты продукта предел концентрации НДМА в выработанном солоде должен составлять не более 15 мкг / кг. Такую концентрацию обеспечивает сушки солода сушильным агентом с содержанием NO_2 в нем не более 0,4 мг/м^3. Это значение должно быть предельным в разработке современных тепловентиляционных систем.

Ключевые слова: *солод, сушка, n-нитрозодиметиламин.*

Усовершенствования оборудования для приготовления тестовых полуфабрикатов

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Введение. Улучшить процесс производства хлебобулочных изделий возможно путем использования интенсивного замеса теста, усовершенствования его брожения и формирования.

Материалы и методы. Исследовали пшеничное дрожжевое тесто из муки высшего сорта и процессы смешивания, брожения и формирования на разработанной экспериментальной установке, в которой эти операции объединены.

Результаты и обсуждение. Необходимость комплексного совершенствования процесса производства хлебобулочных изделий следует из широкого использования ручного труда, громоздкого оборудования при традиционном способе производства. Конструкция смесительно-бродильно-формовочного агрегата позволяет объединить процессы непрерывного интенсивного замеса теста, брожения и формирования разрыхленных тестовых заготовок непосредственно на под хлебопекарной печи. Агрегат обеспечивает сокращение машино-аппаратурной схемы и снижает затраты на эксплуатацию оборудования.

Вязкость газонаполненного теста линейно снижается с увеличением расхода удельной работы и скорости сдвига из-за ослабления взаимодействия между частицами теста. Повышение содержания газовой фазы приводит к уменьшению вязкости теста и увеличению средней скорости потока. Количество газа более 40% и градиент давления 0,3-0,4 МПа приводят к разрушению газовых пузырьков. Получена экспоненциальная зависимость средней скорости потока *w* от давления прессования P от 0,1 до 0,4 МПа при различном содержании газовой фазы G от 0 до 45%. Зависимость коэффициента расширения тестового жгута от угла входа в

формовочный канал имеет экстремум. Оптимальное значение конусности входа - 70-80 °.

Выводы. Результаты целесообразно использовать при проектировании новых и реконструкции существующих линий производства хлебобулочных изделий.

Ключевые слова: *замес, тесто, экструзия, брожение, формирование.*

Научное обоснование метода синтеза структуры машин для упаковывания пищевых продуктов

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Введение. Для оптимизации процесса упаковывания рационально использовать синтез структуры упаковочной машины комбинаторно-логическими методами.

Материалы и методы. Для генерирования структур используется сортировка и поиск новых комбинаций в массиве аналогов и прототипов при использовании следующих способов описания обобщённых структур упаковочных машин (табличные, алгебраические, логические и сетевые модели).

Результаты и обсуждение. Ориентированный мультиграф использован для синтеза структуры упаковочных машин, а также для оптимизации отдельных решений. Для этого обобщена система ограничений и целевые функции. Обоснована система ограничений, которая описывает условия выбора элементов мультиграфовой модели и целевой функции, что даёт возможность оптимизировать разные структурные характеристики решений.

Решение задачи структурного синтеза состоит из ориентированных дуг мультиграфа. Во время использования этого метода один клас упаковочных машин представляют в виде ориентированного мультиграфа. В таком мультиграфе множество мультидуг - это Z={Zi}, *i*=, а множиство вершин – S={Si}. Дуга будет активирована при условии активации всех её выходов.

Общее количество переменных в подобных моделях описывается с помощью выражения 3n+K+M, а количество уравнений и неравенств в системе ограничений - 7n+K+L+1, где n – общее количество элементов обобщенной структуры упаковочной машины, К – количество входящих связей, L – количество запрещённых комбинаций.

Вывод. Проблема структурного синтеза сводится к задачам дискретного линейного программирования. Обоснованная система ограничений позволяет описать условия выбора элементов мультиграфовой модели и целевой функции. Это даёт возможность оптимизировать разные структурные характеристики решений.

Ключевые слова: *упаковка, машина, синтез, мультиграф.*

Автоматизация технологических процессов

Оптимизация систем электроснабжения предприятий пищевой промышленности

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Введение. Повысить эффективность компенсации реактивной мощности на пищевых предприятиях целесообразно путем применения двухуровневой системы управления источниками реактивной мощности.

Материалы и методы. Исследуется разработанная система комплексной компенсации, которая обеспечивает изменение в акцентах управления мощностями КУ от децентрализации к обеспечению системной целенаправленности решения проблемы, что концептуально связано с оптимизацией режима электропотребления на промышленном предприятии.

Результаты и обсуждение. Потребление реактивной мощности в течение суток неравномерно. Системам компенсации реактивной мощности предприятий присуща иерархическая структура и высокая сложность. В течение суток генерируемая мощность должна не менее чем на 80-90 % совпадать с графиком потребляемой реактивной мощности. Источник реактивной мощности с комбинированным регулированием имеет такое же быстродействие, как и плавный и ступенчатый источник реактивной мощности, но в отличие от ступенчатого источника реактивной мощности позволяет регулировать реактивную мощность плавно, а в отличие от плавно регулируемого источника реактивной мощности не вызывает у сети значительных искажений формы кривой напряжения. Режим работы всех источников реактивной мощности должен соответствовать графику потребления реактивной мощности. Предложенный системный подход к компенсации позволяет существенно повысить экономические показатели всех источников реактивной мощности. Для повышения коэффициента мощности применены конденсаторные установки.

Робота внедрена на Днепропетровском молокозаводе. Результат внедрения – уменьшение потерь электроенергии на 23 %, а сума оплаты за реактивную энергию снизилась на 78 %.

Выводы. Результаты рекомендуется использовать на предприятиях пищевой промышленности с целью повышения эффективности систем электроснабжения

Ключевые слова: *реактивная мощность, электроснабжение, компенсация.*

Расчет конечной температуры нагрева обмотки статора турбогенератора с целью управления развитием теплового дефекта

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Введение. Температура обмоток и сердечников турбогенератора может возрасти при нарушении в работе системы охлаждения или возникновении в машине

дефектов. Для управления развитием дефекта с целью продления срока эксплуатации и надежной работы необходимо использовать методы технической диагностики.

Материалы и методы. На основе анализа «классического» и графического методов расчета конечной температуры обмотки статора турбогенератора был разработан новый метод расчета установившейся температуры электрической изоляции обмотки статора с использованием современных методов информационных технологий.

Результаты и обсуждение. Классический метод можно использовать при неизменной величине коэффициента теплоотдачи, то есть когда система охлаждения работает в статорном режиме, а повышение температуры статора вызвано неконтролируемым изменением нагрузки турбогенератора. Графический метод прост в использовании, но не отличается точностью. Особенно когда о величине предполагаемой установившейся температуре судят по результатам измерений только в начальной стадии процесса нагревания стержней статора турбогенератора. Предложенный метод теплового процесса на основе дивергенции отчасти компенсирует недостатки вышеназванных методов и позволяет анализировать температурные напряжения стержня обмотки статора турбогенератора.

Выводы. Декомпозиция задачи анализа температурного поля стержня обмотки статора позволяет расширить представление о его динамике изменений и повысить достоверность диагностики.

Ключевые слова: *турбогенератор, охлаждение, обмотка, статор, диагностика.*

Балластные тепловые потоки при термической обработке пищевых продуктов

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Введение. Применение новейших средств теплофизических измерений позволяет получить новую информацию, дающую возможность экономить энергию и продукты.

Материалы и методы. Малогабаритный высокочувствительный и малоинерционный тепломер (диск диаметром 20 мм и толщиной 1,2 мм) использовали при исследовании дозревания твердого сыра. Температуру воздуха в камере поддерживали на уровне 10±0,25 °С терморегулятором.

Результаты и обсуждение. Результаты прямого измерения плотности теплового потока тепломером, расположенным в центре верхней поверхности головки сыра, оказались неожиданными: около 30 % выделяющегося из сыра тепла возвращается в головку. Этот возврат является балластной нагрузкой на холодильную установку камеры, его устранение или минимизация является источником энерго- и ресурсосбережения. Балластные потоки тепла возможны также при тепловой обработке пищевых продуктов, например, в процессе стабилизации поверхностного слоя вареной колбасы осциллирующим инфракрасным обогревом. Подбором времени коагуляции и напряжения на излучателе удалось снизить балластный тепловой поток в центральные слои на две трети, а инверсный тепловой поток из

этих слоев – до нуля. Максимальный теплоприток, а с ним и общий расход энергии был снижен на 15 – 20 %. Уменьшение температурной заставки на терморегуляторе при холодильной обработке могло бы уменьшить тепловой балласт, но привело бы к преждевременному износу деталей холодильной машины. Если нет возможности устроить камеру перемешивания воздуха перед камерой дозревания, нужно устанавливать терморегулятор как можно дальше от охлаждаемого продукта.

Выводы. Возможность балластных тепловых потоков при холодильной обработке – еще один аргумент в пользу перехода на абсорбционные холодильные машины, источник энергии для которых есть на любом пищевом предприятии, включая молоко- и сырзаводы.

Ключевые слова: *тепло, обработка, балласт, поток, тепломер.*

Безопасность жизнедеятельности

Повышение общего уровня безопасности труда на предприятиях пищевой промышленности

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Введение. Целью работы является повышение уровня безопасности труда на предприятиях пищевой промышленности за счет совершенствования общей модели риска производственного травматизма на пищевом предприятии.

Материалы и методы. Применен метод главных компонент для определения основных факторов травмирования работников отрасли и прогнозирования рисков производственного травматизма.

Результаты и обсуждение. Усовершенствована общая модель риска производственного травматизма на предприятии пищевой промышленности, которая комплексно учитывает влияние на травматизм всего спектра производственных и социально-экономических факторов и строится на основе схемы возникновения несчастного случая, в которой каждый факт несчастного случая связывается с предпосылкой его возникновения. Отмеченный подход позволяет осуществлять анализ непосредственных причинно-следственных связей, которые имеют место в процессе травмирования, и обнаруживать как основные, так и скрытые причины производственного травматизма, которые приводят к несчастному случаю на основании данных из форм обязательной ежегодной отчетности. Установлено, что для обеспечения фильтрации статистических данных и визуализации результатов для обработки имеющейся статистики производственного травматизма наиболее целесообразным является метод главных компонент. Полезность этого метода при анализе данных производственного травматизма основана на возможности уменьшения объемов анализа информации и определения наиболее существенных факторов производственного травматизма. Благодаря основным свойствам метода главных компонент он достаточно успешно может быть использован для прогнозирования значительного числа исходных показателей производственного травматизма, сравнительно малым числом вспомогательных (латентных)

переменных, выражающих причины этого явления, обеспечивая при этом наименьшую погрешность прогноза.

Ключевые слова: *безопасность, труд, травматизм, риск, питание, промышленность.*

Моделирование развития риска разрушений опасных промышленых объектов в чрезвычайных ситуациях

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Введение. Существующие системы комплексной защиты объектов повышенной опасности промышленных предприятий малоэффективны, поэтому возникает необходимость сосредоточения сил и средств на наиболее опасных направлениях.

Материалы и методы. Для оценки риска промышленного объекта построена модель развития аварии (чрезвычайной ситуации). Пространственно-структурную эволюцию риска возникновения аварии (чрезвычайной ситуации) реализовано с помощью комплекса математических моделей стохастическим адаптивным методом матричного генетического моделирования.

Результаты обсуждение. Первая математическая модель данного комплекса представляет собой систему аналитических нелинейных уравнений, которые дают возможность рассчитать пространственно-временные результаты аварии (чрезвычайной ситуации). Пространственно-временная структура $Sc_j \in \{Sc\}_{доп}$ может задаваться экспертно или же определяться с помощью второй математической модели. Соответствующая модель является нелинейной, дискретной математической моделью с неизвестными операторами, которые задаются алгоритмически. Третья математическая модель является системой линейных аналитических уравнений с неизвестными значениями факторов $X_1, X_2, ..., X_k$ и функцией приоритетов P, которые определяются с помощью методов теории нечетких множеств.

Выводы. Предложена комплексная математическая модель, которая может быть практически реализована для решения задачи мониторинга деятельности опасных объектов в пищевой промышленности, заблаговременно прогнозировать пространственно-временную эволюцию риска состояния опасного промышленного объекту в зависимости от сценария развития чрезвычайной ситуации.

Ключевые слова: *безопасность, риск, авария, промышленость.*

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Requirements for article:

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Ukrainian Journal of Food Science публікує оригінальні наукові статті, короткі повідомлення, оглядові статті, новини та огляди літератури.

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Ukrainian Journal of Food Science

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Всі елементи після року видання розділяються **комами**.

Приклади:

1. Yannick Fayolle, Sylvie Gillot, Arnaud Cockx, Laetitia Bensimhon, Michel Roustan, Alain Heduit (2010), In situ characterization of local hydrodynamic parameters in closed-loop aeration tanks, *Chemical Engineering Journal*, 158(2), pp. 207-212.
2. Carlo Tocchi, Ermanno Federici, Laura Fidati, Rodolfo Manzi, Vittorio Vincigurerra, Maurizio Petruccioli (2012), Aerobic treatment of dairy wastewater in an industrial three-reactor plant: Effect of aeration regime on performances and on protozoan and bacterial communities, *Water Research*, 46(10), pp. 3334-3344.

Приклад оформлення статті, оригінал якої українською мовою:

1. 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.

За бажання після транслітерованої назви статті або журналу в {фігурних дужках можна дати переклад англійською мовою}.

Посилання на книгу

Автори (рік), *Назва книги (курсивом)*, Видавництво, Місто.
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Приклади:

1. Harris L. (1991), *Money theory*, McGraw-Hill Companies, Hardcover
2. Rob Steele (2004), *Understanding and measuring the shelf-life of food*, CRC Press.

Приклад оформлення статті, оригінал якої українською або російською мовою:

1. Donchenko L.V. (2000), Tekhnologiya pektina i pektinoproduktov, Deli, Moscow
2. Kirianova H.A. (2008), Udoskonalennia tekhnolohii termostabilnykh zheleinykh nachynok shliakhom ratsionalnoho vykorystannia hidrokoloidiv roslynnoho ta mikrobnoho pokhodzhennia: PhD tethis, NUHT, Kyiv.
3. Zalutskyi I.R., Tsymbaliuk V.M., Shevchenko C. H. (2009), Planuvannia i diahnostyka diialnosti pidpryiemstva, Novyi svit, Lviv.

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Приклад посилання на статтю із електронного видання:

1. 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
2. (2013), *Svitovi naukovometrychni bazy*, available at: http://www1.nas.gov.ua/publications/q_a/Pages/scopus.aspx

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