ISSN 2304-974X

Ukrainian Food Journal

Volume 3, Issue 3
2014

Kyiv **Київ**
2014

УДК 663/664

Ukrainian Food Journal is an international scientific journal that publishes innovative papers of expert in the fields of food science, engineering and technology, chemistry, economics and management.
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Editorial office address:

National University
of Food Technologies
Volodymyrska str., 68
Ukraine, Kyiv 01601

Адреса редакції:

Національний університет
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Scientific Council of the National University of Food Technologies recommends the journal for printing. Minutes № 2, 02.09.2014

Рекомендовано вченою радою Національного університету харчових технологій. Протокол № 2 від 02.09.2014 р.

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Food quality and safety
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Харчова інженерія	Процеси та обладнання
Харчова хімія	Нанотехнології
Мікробіологія	Економіка та управління
Фізичні властивості харчових продуктів	Автоматизація процесів
Якість та безпека харчових продуктів	Упаковка для харчових продуктів
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Global Impact Factor (2014)
CABI full text (2014)
Directory of Research Journals Indexing (DRJI) (2014)
Universal Impact Factor (2014)

Рецензія рукопису статті. Матеріали, представлені для публікування в «Ukrainian Food Journal», проходять «Подвійне сліпе рецензування» двома вченими, призначеними редакційною колегією: один є членом редколегії і один незалежний учений.

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Інструкції для авторів та інша корисна інформація розміщені на сайті
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Редакційна колегія

Contents

^{238}U, ^{232}Th and ^{40}K in wheat flour samples of Iraq markets

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Keywords:

Radioactivity
Wheat
Flour
Food
Iraq
Gamma
Spectroscopy

Article history:

Received 04.07.2014
Received in revised form 08.08.2014
Accepted 02.09.2014

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Abstract

Introduction. Wheat flour is a nutritious type of food that is widely consumed by various age groups in Iraq. This study investigates the presence of long-lived gamma emitters in different type of wheat flour in Iraqi market.

Materials and methods. Uranium (^{238}U), Thorium (^{232}Th) and Potassium (^{40}K) specific activity in (Bq/kg) were measured in (12) different types of wheat flours that are available in Iraqi markets. The gamma spectrometry method with a NaI(Tl) detector has been used for radiometric measurements. Also in this study we have calculated the internal hazard index, radium equivalent and absorbed dose rate in all samples.

Results and discussion. It is found that the specific activity in wheat flour samples were varied from (1.086±0.0866) Bq/kg to (12.532±2.026) Bq/kg with an average (6.6025) Bq/kg for^{238}U, For ^{232}Th From (0.126±0.066) Bq/kg to (4.298±0.388) Bq/kg with an average (1.9465)Bq/kg and for ^{40}K from (41.842±5.875) Bq/kg to (264.729±3.843) Bq/kg with an average (133.097) Bq/kg. Also, it is found that the radium equivalent and the internal hazard index in wheat flour samples ranged from (3.4031) Bq/kg to (35.1523) Bq/kg with an average (19.6346) Bq/kg and from (0.0091) to (0.1219) with an average (0.0708) respectively.

Conclusion. This study prove that the natural radioactivity and radiation hazard indices were lower than the safe.

Introduction

Natural radioactivity is caused by the presence of natural occurring radioactive matter (NORM) in the environment. Examples of natural radionuclides include isotopes of potassium (^{40}K), uranium (^{238}U and its decay series), and thorium (^{232}Th and its decay series). In addition to being long-lived (in the order of 1010 years), these radionuclides are

typically present in air, soil, and water in different amounts and levels of activity. Natural radionuclides are found in terrestrial and aquatic food chains, with subsequent transfer to humans through ingestion of food. As such, international efforts were brought together collaboratively to apply adequate procedures in investigating radionuclides in food [1], and to set essential guidelines to protect against high levels of internal exposure that may be caused by food consumption [2,3].

Since wheat flour is one of the essential foods that is consumed in Iraqis daily lives, the desire to establish a national baseline of radioactivity exposure from different types of wheat flour samples that available in Iraq markets is very critical. Wheat flour is a powder made from the grinding of wheat used for human consumption. Wheat flour, the "Staff of Life", has been an essential commodity to human existence through the centuries and is currently the most widely consumed staple food. Moreover, numerous studies were conducted worldwide to investigate natural radionuclides in food consumed in different parts of the world [4-7]. For a systematic treatment, a methodical approach is undertaken that focuses on a wheat flour type of food per study. Because wheat flour is popular among all ages, the current study focuses on investigating the natural radioactive content in all times of food.

Materials and methods

Sample Collection and Preparation. Twelve samples of the most available types of flour were collected from the local markets in Iraq to measure natural activity. The types of samples are listed in Table (1). After collection, each flour sample was kept in a plastic bag and labeled according to its name. These samples were packed in a 1 L polyethylene plastic Marinelli beakers of constant volume to reach a geometric homogeneity around the Detector, then the respective net weights were measured and recorded with a high sensitive digital weighing balance with a percent of ±0.01%. After that, the plastic Marinelli beakers were sealed with a PVC tape, and stored for about one month before counting, to allow secular equilibrium to be attained between ^{222}Rn and its parent ^{226}Ra in uranium chain [8].

Table 1

Types and orign of wheat flour samples in this study

No.	Sample code	Name of Samples	Origin of samples
1	F1	Good sentences	Lebanon
2	F2	Fine semolina	Saudi Arabia
3	F3	Altunsa	Turkey
4	F4	Sirage	Turkey
5	F5	Barrash	Turkey
6	F6	Rehab	IRAQ
7	F7	Sankar	Turkey
8	F8	Super	Turkey
9	F9	Donya	Turkey
10	F10	Suphan	Turkey
11	F11	Farina	Turkey
12	F12	Sayf	Turkey

Measurement System. Natural radioactivity levels were measured using a gamma spectrometer which includes gamma multichannel analyzer equipped with NaI(Tl) detector of (3"×3") crystal dimension as Figure (1). The gamma spectra were analyzed using the ORTEC Maestro-32 data acquisition and analysis system. The detector had coaxial closed-facing geometry with the following specifications: The calculated resolution is 7.9% for energy of 661.66 keV of ^{137}Cs standard source. Relative efficiency at 1.33 MeV ^{60}Co was 22.2% and at 1.274 MeV ^{22}Na was 24.4%. The detector was shielded by a cylindrical lead shield in order to achieve the lowest background level. An energy calibration for this detector was performed with a set of standard γ-ray 1-μCi active ^{137}Cs, ^{60}Co,^{54}Mn, and ^{22}Na sources. In this study, the activity concentration of ^{40}K was determined directly from the peak areas at 1460 keV. The activity concentrations of ^{238}U and ^{232}Th were calculated assuming secular equilibrium with their decay products. The gamma transition lines of ^{214}Bi (1765 keV) were used to calculate activity concentration of radioisotope in the ^{238}U-series. The activity concentrations of radioisotope in the ^{232}Th-series were determined using gamma transition lines of ^{208}Tl (2614 keV). The counting time for each sample was at 18000 sec.

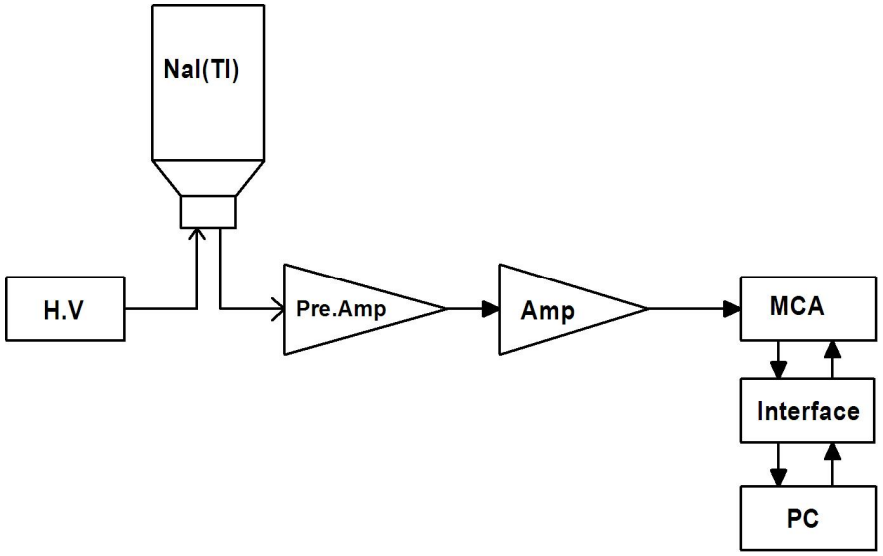

Figure 1. Block diagram of a spectrometer system

Calculation of Activity. Since the counting rate is proportional to the amount of the radioactivity in a sample, the Activity Concentration (*Ac*) which can be determined as a specific activity as the follows [9]:

$$Ac = \frac{C - BG}{\varepsilon\% \, M \, t \, I_\gamma} \tag{1}$$

Where *Ac* is the specific activity, *C* is the area under the photo peaks, *ε%* is percentage of energy efficiency. I_γ is the percentage of gamma-emission probability of the radionuclide under consideration, *t* is counting time, *M* is mass of sample and *BG* is background.

Radium Equivalent Activity. Radium equivalent activity (Ra_{eq}) is used to assess the hazards associated with materials that contain ^{238}U, ^{232}Th and ^{40}K in Bq/kg [8], which is, determined by assuming that 370 Bq/kg of ^{226}Ra or 260 Bq/kg of ^{232}Th or 4810 Bq/kg of ^{40}K produce the same γ dose rate. The $Ra_{eq}$of a sample in (Bq/kg) can be achieved using the following relation [8,10,11]:

$$Ra_{eq} = A_U + (1.43 \, x \, A_{Th}) + (A_k x \, 0.077) \quad (2)$$

Internal Hazard Index. This hazard can be quantified by the internal hazard index (H_{in}) [8,12-13]. This is given by the following equation:

$$H_{in} = (A_U/185) + (A_{Th}/259) + (A_K/4810) \quad (3)$$

The internal hazard index should also be less than one to provide safe levels of radon and its short-lived daughters for the respiratory organs of individuals living in the dwellings.

Results and discussion

The specific activity due to ^{238}U, ^{232}Th and ^{40}K in different kinds of wheat flour samples has been measured as shown in Table (2) and Figures (2), (3) and (4) respectively. The specific activity of ^{238}U was found in the range of (1.086±0.0866) Bq/kg to (12.532±2.026)Bq/kg with an average (6.6025) Bq/kg, ^{232}Th from (0.126±0.066)Bq/kg to (4.298±0.388)Bq/kg with an average (1.9465)Bq/kg and ^{40}K from (41.842±5.875) Bq/kg to (264.729±3.843)Bq/kg with an average (133.097) Bq/kg. The radiation hazard indices, radium equivalent and internal hazard indices were calculated for all samples in this study as shown in Table (3) and Figure (5).The internal hazard (H_{in}) and radium equivalent varied (3.4031)Bq/kg to (35.1523)Bq/kg with an average (19.6346)Bq/kg and from (0.0091) to (0.1219) with an average (0.0708)respectively.

Table 2

Specific activity of ^{238}U, ^{232}Th and ^{40}K in some types of wheat flour

Sample Code	Specific activity in (Bq/Kg)		
	U^{238}	Th^{232}	K^{40}
F1	1.086±0.0866	3.411±0.322	179.089±3.187
F2	9.991± 1.715	3.340±0.356	264.729±3.843
F3	3.391±2.241	0.796±0.504	96.509±2.446
F4	5.102±1.861	2.462±0.475	120.555±5.5134
F5	2.243±2.303	1.646±0.394	47.805±5.025
F6	6.599±1.852	1.375±0.655	100.892±6.289
F7	11.078±2.848	4.298±0.388	79.767±6.499
F8	----------	0.126±0.066	41.842±5.875
F9	6.048±1.526	1.561±0.664	109.061±6.643
F10	6.196±3.127	1.652±0.684	191.549±7.006
F11	12.532±2.026	2.685±0.573	175.257±6.510
F12	6.370±2.307	---------	190.104
Average	**6.6025**	**1.9465**	**133.097**

There is a variation in the specific activity of radionuclides in different wheat flour samples, for example (F1) which is Turkish Farina has lowest ^{238}U concentration, while (F11) which is Lebanese Good sentences has the maximum value, (F8) Turkish Super has the lowest ^{232}Th concentration while the maximum is (F7) also Turkish Sankar, and the lowest ^{40}K concentration is (F8) which is Turkish Super and the maximum is (F2) Saudi Arabia Fine semolina. The results obtained show that the specific activity of ^{238}U, ^{232}Th and ^{40}K in all wheat flour samples appeared lower than recommended limit of UNSCEAR (2008) [15].The values of all the radiation hazard indices in this study (radium equivalent and internal hazard indices)are lowest value in sample (F8) Turkish Superand and the highest value in sample (F2) Saudi Arabia Fine semolina. The result of the radiation hazard indices are lower than recommended limit of UNSCEAR (2008)[15].

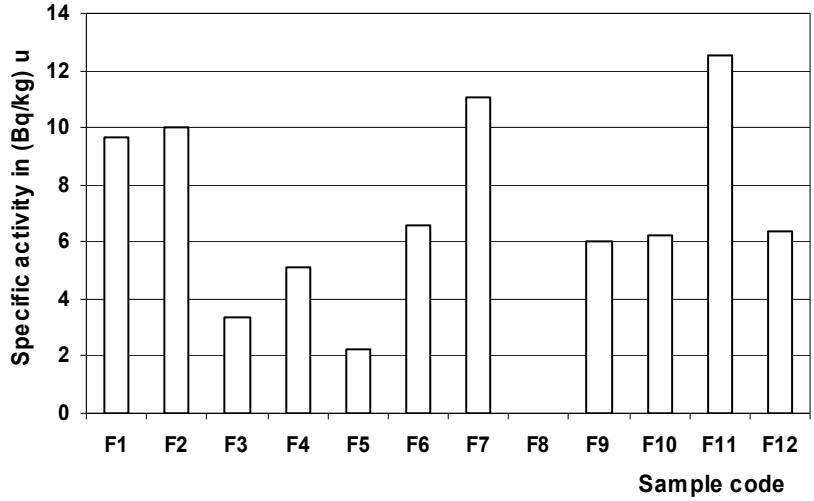

Figure 2. Specific Activity of ^{238}U in (Bq/Kg)

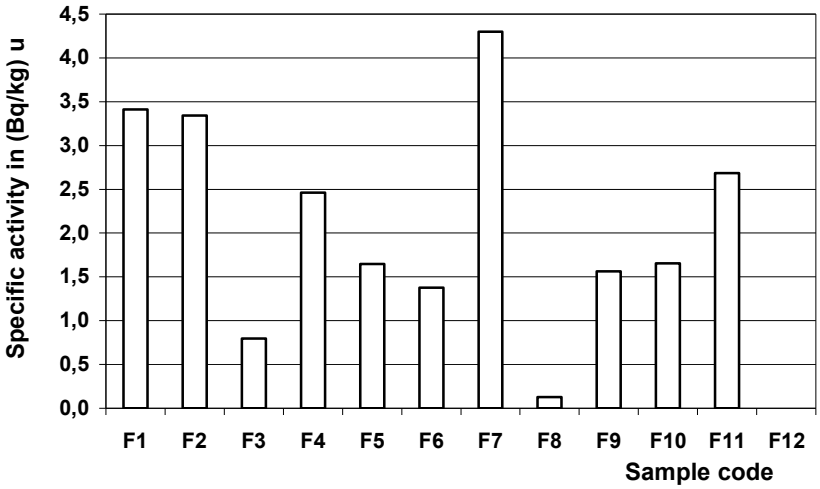

Figure 3. Specific Activity of ^{232}Th in (Bq/Kg)

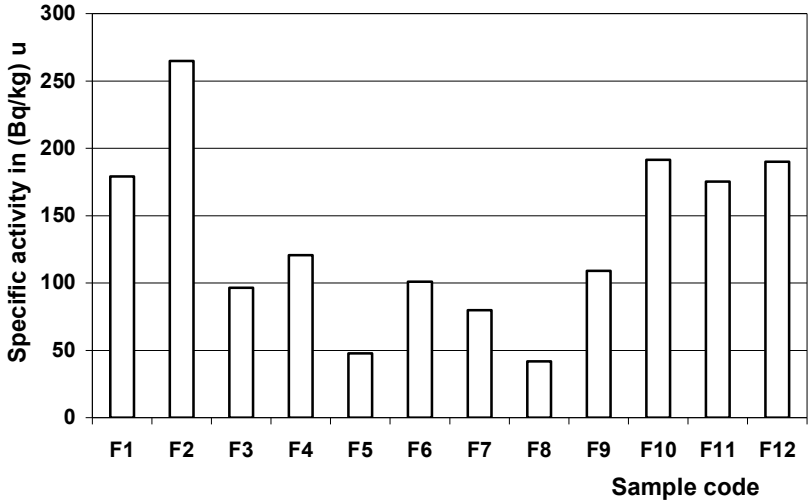

Figure 4. Specific Activity of ^{40}K in (Bq/Kg)

Table 3

Radiological hazard indexes in some types of wheat flour

Sample Code	H_{in}	Raeq (Bq/kg)
F1	0.1027	28.3441
F2	0.1219	35.1523
F3	0.0414	11.9621
F4	0.0621	17.9068
F5	0.0284	8.2789
F6	0.0619	16.335
F7	0.0931	23.3670
F8	0.0091	3.4031
F9	0.0614	16.6801
F10	0.0797	23.309
F11	0.1145	29.8681
F12	0.07395	21.0081
Average	**0.0708**	**19.6346**

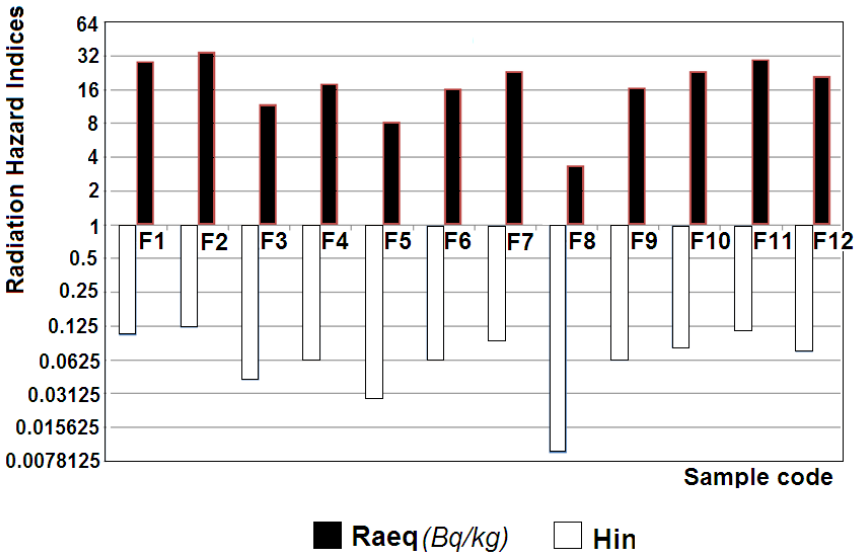

Figure 5. A radiation hazard indexes for wheat flour samples

Conclusions

The present study is the important at the national level to investigate radioactivity of wheat flour that is available in Iraqi markets. It is found that consumption of wheat flour as the foodstuff is safe for all ages of people in Iraq. The findings of this work will help in establishing a baseline of radioactivity exposure to the general public from ingestion of foodstuff.

Acknowledgements. *I would like to knowledge all those contributed in declaring this issue. Special thanks to the staff of the department of physics at Kufa university.*

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The quality of drinking water in Poland

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Keywords:

Water
Quality
Supply
Sewerage
Poland

Article history:

Received 12.04.2014
Received in revised form 14.06.2014
Accepted 02.09.2014

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Abstract

Introduction. An analysis of the drinking water quality and the degree of access to water supply and sewerage system in Poland was conducted.

Materials and methods. Method of analysis of secondary statistical data was applied, mostly based on data available in the materials of the Central Statistical Office in Warsaw, the Waterworks Polish Chamber of Commerce in Bydgoszcz and the National Water Management in Warsaw.

Result and discussion. 60 % of Poles do not trust to drink water without prior boiling. Water flowing from the taps, although widely available, is judged to be polluted, with too much fluorine or not having the appropriate consumer values (colour, smell and taste). The current water treatment systems can however improve them, although such a treatment, i.e. mainly through chlorination of water, deteriorates its quality in relation to pure natural water. The result is that fewer and fewer Poles drink water directly from the tap. They also less and less use tap water to cook food for which the bottled water is trusted more. Reason for that is that society does not trust the safety of the water supplied by the municipal water companies. The question thus is: Are they right?

Tap water in Poland meets all standards since it is constantly monitored by the water companies and all relevant health services. Tap water supplied through the water supply system can be used without prior boiling. Studies have shown that only the operating parameters of water, such as taste, odour and hardness, are not satisfactory everywhere, different in each city, and sometimes in different districts of cities, often waking thoughts among users about its inappropriateness. The lowered water value can be easily improved at home through the use of filters. In conclusion, due to constant monitoring and investment in upgrading treatment processes, the quality of tap water has improved significantly in the last years.

Conclusion. The results first allow assessing the level of water supply and sewage systems in the country and second drawing conclusions as to the quality of water available to the residents of Poland.

Introduction

On 28 July 2010, the General Assembly of the United Nations (UN) adopted a resolution according to which the right to clean drinking water and sanitation has officially been recognised as a fundamental human right. Access to and quality of drinking water is also one of the Millennium Development Goals, which have been put forward on the basis of the Millennium Declaration accepted by the Member States of the United Nations (189 countries, including Poland) during the so-called Millennium Summit of the United Nations in New York in September 2000.

Equally, a number of business studies conducted by UNDG[1] considered the widespread availability of drinking water as one of the main objectives of development. The justification of such a categorisation was the fact that access to running drinking water is still not granted to approximately 884 million people worldwide, and diseases caused by non-potable water, or as a result of its absence, still make one and a half million children die under five years of age each year. Clean water is understood appropriate for consumption without further treatment and health or human life [1]. However, according to the World Health Organization (WHO) "as much as 80 % of all diseases of modern civilisation have to do with the quality of drinking water" [2].

The global problem of scarcity of water resources proves the demands of the UN to ensure access to clean water to all people on earth justifiable and not only limited to developing countries only. The problem has been present for years also in highly industrialized countries, where the level of pollution in general results in deteriorating water quality in water supply systems. Since all chemical compounds contained in municipal sewage systems and in industrial and agricultural production cycles are excreted into the environment, they inevitably leak into the ground water, surface water and deep water too, thereby reaching drinking water from the tap, from wells or mineral and spring waters.

Materials and methods

The method of analysis of secondary statistical data was applied, mostly based on data available in the materials of the Central Statistical Office in Warsaw, the Waterworks Polish Chamber of Commerce in Bydgoszcz and the National Water Management in Warsaw.

Results and discussion

Statistical dimension of water and sewage system in Poland. According to the Yearbook of the Central Statistical Office (GUS), "Environmental Protection in 2011 and 2012" and "Statistical Yearbook of the Republic of Polish 2012", the systems of collective water supply - water systems - served in 2011 about 87.6% of the population of the country, including 95,4% of the urban and 75.7% of the rural population. In contrast, the collective sewage systems - sewer systems - were used by 63.5% of the population, respectively 86.7% of the urban population and 27.8% of the rural population [3]. Changes in water supply and sewage in urban and rural areas in the period 2000-2011 are presented in Table 1.

[1] UNDG – United Nations Development Group.

Table 1

General characteristics of water supply and sewage in Poland in the years 2000-2011

Category		Year			
		2000	**2005**	**2010**	**2011**
Total population of the country	**thousands**	**38 254**	**38 157**	**38 529**	**38 538**
Total number of cities	-	880	887	903	908
Urban population	**thousands**	**23 670**	**23 424**	**23 416**	**23 385**
Cities/towns with waterworks	-	877	886	901	906
Length of active distribution waterworks nets in cities	klm	50 067	54 872	61 003	62 009
Number of cities operating waterworks' nets	-	845	881	873	901
Urban population using the services of water supply systems provided by public water supply	thousands	21 889	22 219	22 171	22 303
	%	**91,7**	**94,9**	**95,3**	**95,4**
Urban population using sewege services provided by public sewer systems / sewage treatment plants*	thousands	19 828	19 908/ 20 234	20 156/ 20 614	20 279/ 20 670
	%	**83,0**	**84,5**	**86,1/88,6**	**86,7/88,4**
Length of active waterworks in cities	klm	34 948	43 310	51 493	54 194
Rural population	thousands	**14 584**	**14 733**	**15 113**	**15 152**
Rural population using waterwork services provided by public water supply	thousands	8 870	10 755	11 368	11 472
	%	**60**	**73**	**75,2**	**75,7**
Length of active distribution waterworks nets in village	klm	161 831	190 729	211 885	216 291
Rural population using sewage services provided by public sewer systems collecting system, i.e. sewage networks / sewage treatment plants	thousands	-	2 799/ 3 006	3 749/ 4 307	4 207/ 4 631
	%	**11,5/10,8**	**19,0/ 20,4**	**24,8/ 28,8**	**27,7/ 30,6**
Length of active waterworks	thousands	16 162	36 820	55 566	63 551

Source: RP GUS Statistical Annual, Warsaw, 2000, 2005, 2012.

*Number of people using the sewer network / number of people using the wastewater treatment plant.

When analysing the above table, one can see that in the cities sewer systems development can keep pace with the development of systems of public water supply, however as to the rural areas, one can observe large differences in this respect. That might be partly explained with the fact that there is a considerable dispersion of rural housing. 15.1 millions inhabitants do live in more than 40 thousand villages, which due to technical and economic aspects demands for individual solutions to wastewater collection and treatment necessary to ensure adequate protection of the environment [4]. However, this does not change the fact that the sewage systems in rural areas served only 27.8% of the rural population. That also makes additional problems because environmental pressure exerted by households that are not connected to the sewage systems produces a significant portion of wastewater discharged directly into the environment, which deteriorates the environment and hence on the quality of water resources.

Legal regulations concerning the quality of drinking water supplied by water companies. Water companies operating in Poland are required to comply with standards adapted to the European Union (EU) regulations [5]. What concerns a broader water management, the most important piece of legislation in the EU is the Water Framework Directive (WFD) No 2000/60 EC.

The basic premise of the directive is the protection of water against pollution at its source: in accordance with its demands formulated in 2015, the EU is to achieve a "good water status". One of the priorities of the WFD is the elimination of the so-called "priority substances", i.e. the environmentally most dangerous chemical substances produced by industry and agriculture. In particular, such substances as DDT, PCB, PCT, aldrins, dieldrins, isodrins and HCH were to be completely eliminated [6].

The WFD regulation also changed the water cleanliness evaluation system and the economic water utility functioning in Poland since 1970 and replaced them with the assessment of the general ecological status. According to the Decree of the Minister of Environment from 11 February 2004 on the classification in presenting the status of surface and ground water, concerning the method of monitoring and interpreting the results and the presentation of the status of these waters, the rating of the waters can range from class I to class V [7]. Only water classified as belonging to the class V is not suitable for human consumption. Water quality belonging to the categories I to IV can be delivered to the population after treatment and appropriate processing in the required water quality. The Decree of the Minister of Environment from 27 November 2002 concerning the requirements as to be met by surface and ground water used for public consumption distinguishes three categories of quality of water intended for human consumption: I, II, III - classified according to the degree of treatment [8].

As a result of adaptation of the Polish legislation to the requirements of the directive concerning control of water quality, a "Water Law" [9], an Environment Protection Law [10] as well as law on collective water supply and sewage collection have been passed [11].

When it comes to the same sanitary standards for water, the most important piece of legislation is the directive of the EU Parliament and the EU Council on the quality of water intended for human consumption specifying the standards on the chemical, physical and biological properties needed to be met by water supplies [12].

Water intended for consumption must not, even potentially, constitute a danger to human health. The directive defines both the parameters of acceptable concentration of harmful substances for the human body (substances and toxic, mutagenic, carcinogenic compounds) and such parameters as colour, turbidity, total number of bacteria, total organic carbon, taste and smell. Although they do not have a direct impact on health of consumers, their task is still to determine the effectiveness and quality of the water treatment process. Standards concerning a number of indicators in force under the directive are more restrictive than those recommended by the WHO [13].

Surveillance of the water quality intended for human consumption is controlled in Poland by the State Sanitary Inspection (SSI) [14]. The systematic control of water is carried by the county health inspector. The quality of water intended for human consumption must comply with the requirements set out in the Regulation of the Minister of Health of 29.03.2007 on the quality of water as issued at the 20th April 2010 [15].This regulation intends to implement the EU directive (OJ EU L 1998).

Subject to a special rigor is raw surface water (before treatment), which is regulated by the decree issued by the Minister of the Environment in 27th Nov 2002 regarding the requirements to be met by surface water used for public supply and human consumption [16].

Standards governing the admissible concentrations of selected compounds in drinking water.

Very dangerous to human health is a situation when the standards for microbiological purity of water are exceeded. Microbiologically contaminated water resulting primarily from human and animal waste may contain pathogenic bacteria, viruses, protozoan as well as helminths (intestinal parasite) causing gastrointestinal disease and other infectious diseases. In accordance with the current regulation of the Minister of Health of 20 04.2010r, the water must therefore be completely free of impurities such as *Escherichia coli* and *Enterococcusfaecalis* [17]. The regulation also specifies the admissible concentrations of chemicals with a significant and direct relevance to the health safety of consumers. One important group among them are nitrates, of which already traces can be found in most waterworks in the country. They are substances produced by natural processes related to agriculture, which penetrate into the deeper layers of soil and from there into the water. They are particularly and directly dangerous for infants and young children. They may also indirectly threaten the health of adults. They are also conducive for nitrosamines, which in turn have been proved to promote mutagenic and carcinogenic processes when exposed to them.

Another group of substances dispersed in waterworks throughout the country are fluorides. They are commonly used in phosphate fertilizers for agricultural purpose in Poland [18]. In addition to these frequently occurring compounds, the list of harmful substances includes *inter alia* elements such as quicksilver (mercury), nickel, lead, selenium, boron, and other organic and inorganic compounds. Among them, special attention should be paid to the chlorine and all its derivatives. In contrast to other substances listed in the regulation, chlorine is not considered as pollution that enters water in an undesirable way. On the contrary, it is intentionally added to water through the water treatment plants in order to minimise the bacteriological risk.

The water taken from the surface water passes through multiple purification steps, the last of which is its disinfection. There are many methods for water disinfection. The basic distinction consists between the physical and chemical methods. Physical methods include UV radiation, ultrasound and disinfection using thermal techniques. Such methods are relatively new and very expensive and, above all, are not as effective and sustainable as chlorination with regard to preventing the formation and growth of bacterial communities. Therefore, the application of chemical methods, which is mainly based on the use of chlorine or chlorine dioxide, or ozone and potassium permanganate, is still much more popular around the world.

Disinfection of drinking water is one of the most important factors that contributed to the prolongation of human life because it virtually eliminated cholera epidemic, typhoid fever, etc [19]. At the same time, however, chlorine in large doses is not conducive to human health and its related compounds, which are formed by reaction of chlorine in water with other substances, are also toxic. Particularly dangerous are the trihalomethanes (THMs). According to the WHO, the risk of death due to cancer caused by THM is as low as 1/100-1/1000 compared to the risk of death due to bacteria in not germ-free water [20].

Research is currently conducted on the effects of chlorine in diseases such as atherosclerosis, heart attacks, bowel and bladder cancer or gradual loss of memory [21]. These studies are, however, very difficult because chlorine disinfection is so widespread in highly developed societies that it is virtually impossible to find people that have not been exposed to its impact for a long time. Finally, it should be mentioned that chlorine's most serious shortcoming is its effect on water flavour in Poland as well as its high

concentration, both having a decisive influence on the negative opinion of Poles about water supply [22].

The aroma of chlorine is so strong that even water containing 10% of chlorine as compared to the standard is widely considered as distasteful. However, the sole criterion for regulating the issue of taste and odour of water in the decree is whether they are "acceptable to the consumer".

Changes in the quality of waterworks in the opinion of the controlling institutions. Information on the assessment of waterworks and sanitary wells and on the quality of water delivered from these devices are prepared in accordance with the Regulation of the Minister of Health of 29 March 2007 on the quality of water intended for human consumption [23]. The data have been developed on the basis of the results conducted in the field and followed laboratory tests carried out by the sanitary and epidemiological stations. Control of the water supply was performed on the specific points in the waterworks systems, as agreed between the relevant county sanitary and epidemiological station and the manager of the waterworks. Waterworks were grouped according to their capacity. On the basis of physical, chemical and bacteriological tests, two categories of devices are named; one providing good water, i.e. corresponding with the sanitary requirements and, second, supplying bad water not doing so. The second group has not been discovered in the study.

In 2011, the control of the water quality intended for human consumption was conducted by the State Sanitary Inspectorate in respect of a total of 8 831 of 8 965 water supply facilities registered on the 31st December 2011, i.e. 98.5 %. Table 2 illustrates the detailed data.

Table 2

The quality of water supplied to the population for consumption in 2011

Category	Device				Population supplied with water correspondiong with sanitary requirements in % of the population using facilities
		Controlled devices			
Waterworks with performance of m^3/day	As evidenced at 31.12.2011	Total	Delivering water in total in %		
			Corresponding with Sanitary requirements	Not corresponding with Sanitary requirements	
Below 100	4 176	4 101	90,7	9,3	92,4
100 – 1000	4 112	4 063	93,7	6,3	93,1
1000 – 10000	613	603	93,5	6,5	95,2
10000 - 100000	60	60	95,0	5,0	97,0
above 100000	4	4	100,0	0	100,0

Source: Self-compilation based upon RP GUS Statistical Annual, Warsaw 2012, pp. 103.

Waterworks devices on which tests were conducted were divided into groups according to their performance in water operation in m3 per day. First group of such devices was one with capacities below 100m3 per day. In 2011, there were 4176 such devices in the evidence, of which 4101 were tested, i.e. 98.2%. 90.7% of water from these

devices met the necessary sanitary requirements, which corresponded with 92,4% of the population using the water from these devices.

Another group are the devices of which the daily performance ranges from 100 to 1000m3 per day. In 2011, there were 4112 such devices, of which 4063 has been controlled. As to this group, about 93.7% of the devices met the satisfactory sanitary requirements, which in this case meant 93.1% of the population using these devices to get water.

Another threshold in the daily performance of water supplies, which was determined by the GUS, is 10000m3, which means that it includes devices with capacities from 1,000 to 10,000 m3 per day. In 31st December 2011, 613 such devices were evidenced in Poland, of which 603 were tested as to the quality of water in terms of sanitation. This group of water devices showed a lower performance by 0.2 percentage points compared to the previous group. This means that 93.5% of water tested on these devices met the sanitary requirements. This result corresponds with 95.2% of the population using and being provided with water meeting the standard water quality intended for human consumption (Journal of Law of Poland, No 61, pos. 4170).

Another type of water supply devices, on which water quality testing was performed were devices operating daily with from 10,000 to 100,000 m3 of water. There were 60 such devices in 2011 in Poland and on each of them water quality was tested and monitored. These devices are characterized by the fact that about 95% of water quality testing conducted on them indicated no breaches on water quality as required by the Polish law, which met the requirements up to 97% as to the delivery of water to the population.

The last group of water supply devices are the largest in its capacity, i.e. with capacity going beyond 100,000 m3 a day. There were only 4 of such type of water equipment in Poland and all of them were tested as to water quality. The results of these studies showed the best performance in terms of the water quality as in each case the tested water met sanitary requirements. The percentage of population supplied with water meeting sanitary requirements, i.e. water quality meeting 100% of the requirements in using the largest facilities, was the highest among all groups amounting to 100 %.

Equally “Brita”, the company manufacturing water filters (for, among others, removing chlorine) conducted in 2010 an independent study of water quality in 10 selected Polish cities. The water was analyzed by the Institute of Chemistry of the University of Warsaw. Brita decided to participate in the program because of the public opinion polls showing that 60% of Poles do not trust the tap water quality. The results confirmed the study of Chief Sanitary Inspector (GIS) that water is safe and meets all standards. However, as it comes to the usability of water, especially its smell and taste, it often leaves much to be desired. According to Brita, the bad taste of water is linked to the low hardness of water, where chlorine is perceptible.

In the ranking of the surveyed cities concerning the best taste of water was in Zakopane, Lodz and Gdansk, followed by Warsaw, Bialystok, Lublin, Poznan and Wroclaw. The worst taste water had Katowice and Krakow. Similarly, in the assessment of water odour Zakopane and Gdansk were best, while the most repulsive smell of water had Lublin, Wroclaw and Katowice. Brita tests also confirmed that the vast majority of urban concentrations of harmful substances in water were visibly below the limit. [24] The test conducted by Brita examined the indicator parameters and microbiological purity, the content of organic compounds as well as the concentrations of metals and inorganic compounds.

The results of laboratory tests of all water samples delivered from different cities confirmed that the water from the water supply meets all standards and is safe for human

consumption. All tested samples of tap water were characterised by a high bacteriological, physico-chemical and chemical purity.

Conclusions

There is a lot of concern about drinking tap water among Poles. However, as research shows, these concerns are unjustified. Tap water in Poland meets all standards since it is constantly monitored by the water companies and all relevant health services. Tap water supplied through the water supply system can be used without prior boiling. Studies have shown that only the operating parameters of water, such as taste, odour and hardness, are not satisfactory everywhere, different in each city, and sometimes in different districts of cities, often waking thoughts among users about its inappropriateness. The lowered water value can be easily improved at home through the use of filters. In conclusion, due to constant monitoring and investment in upgrading treatment processes, the quality of tap water has improved significantly in the last years.

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The role of milk proteins in the structure formation of dairy products

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Keywords:

Protein
Milk
Structure

Article history:

Received 15.05.2014
Received in revised form 19.07.2014
Accepted 02.09.2014

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Abstract

Introduction. The structure of dairy products is a complex of proteins, fat, minerals and water that determines the texture and sensory properties of the product.

Material and methods. The fermented milks (using the example of yogurt), cheese, ice cream, aerated milk and frozen fruit desserts have been researched. Scientific articles, published during 2000 and 2014 years, as well as theses and monographs of dairy science have been analysed too. Methodology of the investigation is based upon the use of the methods of analysis, comparison and synthesis.

Results and discussion. The scientific understanding of the milk proteins' role in the structure formation of dairy product has been summarized. Negligible changes of structure as a result of compositional or technological changes can lead to shifts in the stability, texture and rheology of products, which are closely related to each other. The allowance of these properties has significant influence on the manufacturing.

Acid coagulation is a major functional property of milk proteins, which used in the structure formation of cheese and fermented dairy products. However, the form and properties of milk curd depend on the heat treatment of milk before fermentation. Milk proteins exhibit other functional properties (emulsification and partial coalescence of fat globules, aeration and foam stability during a churning, viscosity increasing of external phase) in the development of structure in the ice cream, aerated milk and frozen fruit desserts.

Conclusions. It is expedient to use results into a further study of the structure formation mechanism of dairy products and the development of recommendations in order to an efficient production.

Introduction

For all dairy products including curd, cheese, yoghurt, ice-cream, whipped cream and desserts structure governs the quality, in particular the texture, solubility, flow, viscoelasticity and fracture characteristics. The structure of dairy products is the spatial arrangement and interaction of constituents and structural elements (such as proteins, carbohydrates and lipids) of at the nano-, meso- and microscale. Different methods can be employed to modify structure and texture, which may then influence the creation (generation) and the release of flavour volatiles [1-5]. This in turn influences the sensory perception of texture and flavour by consumers. In recent years, there have been significant advances in our understanding of milk systems and milk components' interaction. Improvements in structure formation have been accompanied by massive changes in the scale of many milk/dairy processing operations, and the manufacture of a wide range of new dairy products.

Milk proteins play a crucial role in many food products, especially in dairy product [6-13]. Milk proteins are the best characterized and most widely used food proteins due to their abundance, ease of isolation and crucial role in human nutrition [14, 15]. Milk proteins distinguish themselves from most other food proteins in that they naturally exist in an aqueous environment and are thus readily soluble. This solubility is combined with a high nutritional value, bland flavour profile and wide array of desirable functional properties, such as emulsification, foaming, gelation and heat stability [14, 16-18].

Material and methods

The fermented milk (the case of yogurt), cheese, ice cream, whipped milk and frozen fruit desserts have been studied. Scientific articles, published during 2000 and 2014 years, as well as theses and monographs of dairy science have been analysed. Methodology of the investigation is based upon the use of the methods of analysis, comparison and synthesis.

Results and discussion

Milk is an emulsion of fat globules in an aqueous phase. The aqueous phase consists of three major groups of components which participate in the formation of dairy products: proteins (casein and whey proteins), milkfat (milkfat globules, lipoproteins), and lactose (milk sugar) [19]. Two classes of milk proteins exist. These are the caseins and the whey proteins, which represent ~75 % and 25 % of protein in bovine milk, respectively. The most abundant casein family consists of several fractions (mainly α_{s1}-, α_{s2}-, β-, κ-casein) and most of them exist in a colloidal particle known as the casein micelle [20]. These casein micelles are highly hydrated, containing ~75 % of water and consist of ~10000 casein molecules, as well as small quantities of calcium phosphate (fig. 1).The second protein group in milk is the whey proteins which include heat-sensitive, globular, water soluble proteins, of which α-lactalbumin, β-lactoglobulin, serum albumin and the immunoglobulins are the most abundant [21].

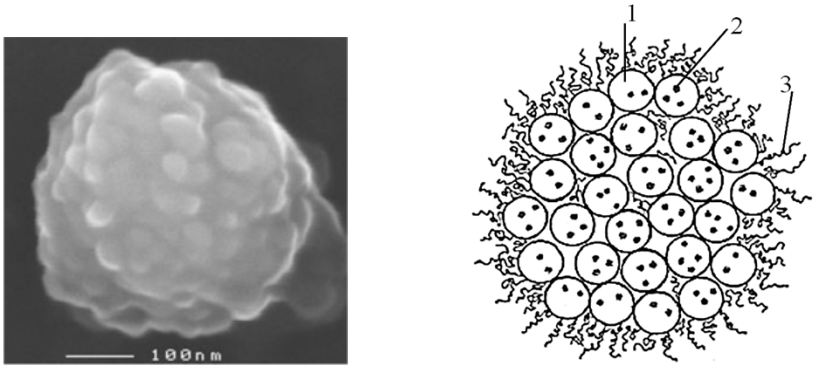

Fig. 1. Scanning electron micrograph (left) [22] and schematic outline (right) of a casein micelle: 1– submicelle, 2 – protruding peptide chain, 3 – calcium phosphate [23].

Functional properties of milk proteins. The functional properties of proteins may generally be classified into two main groups, hydrodynamic or hydration related, which includes water absorption, solubility, viscosity, and gelation. Functional properties such as emulsification, foaming, and film formation are related to the surface-active properties of proteins [16]. Proteins usually exert several inter-dependent functional properties simultaneously in each food application [24].

The functional properties of proteins are governed by their structural characteristics (e.g., size, charge, and surface hydrophobicity) [14, 25]. These intrinsic properties are themselves affected by many extrinsic or environmental factors, such as pH, ionic strength, and temperature, and also by interactions between the proteins and other materials in the food system [16, 26].

Milk protein can provide desirable viscosity and texture of dairy foods. The ability of protein to hydrate and thus entrap or bind water is important in many food technologies. It is known that, viscosity is related to quality attributes, such as physical appearance and mouthfeel. Water associates with protein via hydrogen bonding to polar groups [18]. Occasionally, non-polar groups are forced into water as a part of a specific protein structure. In addition, water may be held physically in capillaries within the product or trapped within the food structure by surface forces. In general, proteins, that are completely soluble, are less effective at water binding than those that are less soluble [16]. An important aspect of protein hydration is the rate and extent of swelling.

Milk proteins have excellent emulsifying properties and are therefore used in many food formulations as emulsifying agents [27]. Casein possesses high surface hydrophobicity with a well-balanced distribution of hydrophilic and hydrophobic domains as well as a high degree of conformational flexibility, which allows them to interact strongly at the oil-water interface. Moreover, a number of researchers have reported that β-casein is adsorbed in preference to α_{s1}-casein and other proteins in emulsions stabilized by a mixture of purified β- and α_{s1}-caseins, as it is the most surface active and hydrophobic [8, 16]. Whey proteins also adsorb rapidly to, unfold and reorientate at the oil-water interface forming emulsions that are only slightly less stable than those formed with casein under the same conditions. The state of the droplet size distribution reflects the emulsifying capacity of the proteins, the energy input during emulsion formation, as well as the effects of various factors (such as pH, temperature, ionic strength, and ratio of the two phases) on the surface activity of the proteins [8].

As milk proteins are surface active, they have the ability to adsorb to the air-water interface during foam formation [21]. Essential for the formation of protein-based foams is

a rapid diffusion of the protein to the air-water interface to reduce surface tension followed by partial unfolding of the protein. Further interactions between protein molecules at the interface lead to the formation of a cohesive film with a certain degree of elasticity, which stabilizes the foams [16]. Caseinates generally give higher foam overruns but produce less stable foams than whey proteins [28]. Whey proteins are capable of forming a cohesive structure surrounding the foam bubbles as well as providing excellent surfactant properties.

It is well known that partial heat denaturation of the proteins improves the foaming characteristics of whey proteins [26]. However, partial hydrolysis of whey proteins with proteolytic enzymes increases the foam volume but reduces its stability. Limited hydrolysis of whey proteins combined with heating at 55-70 °C gives excellent overrun and stability, provided the pH is between 7 and 8 before whipping [26].

Milk proteins have the ability to form rigid, heat-induced irreversible gels that hold water and fat and provide structural support [18]. The ability of milk proteins to undergo gelation upon the addition of acid or rennet to milk is well known. The heat-induced gelation of whey proteins involves a series of steps, starting with the unfolding of protein molecules, followed by their aggregation in aqueous solution [25]. A gel is formed when the extent of aggregation exceeds some critical level; a three-dimensional, self-supporting network that traps the solvent in the system is formed. When the extent of aggregation is below some critical minimum, soluble aggregates or a precipitate will form.

In general, heating a protein solution above the minimum denaturation temperature of the constituent proteins is required for gel formation. The strength of whey protein gels is affected by the concentration and purity of the protein. A protein concentration of 7.5% or greater is needed to form a strong gel at pH 7.0 upon heating for l0 min at 100 °C [25]. Pure solutions of β-lactoglobulin can form gels at 5 and 4% protein, respectively, after heating for 15min at 90 °C. As the protein concentration is increased, the number of potential interactions between molecules is enhanced, resulting in an increasing of gel strength, a reducing of gelling time, and a finer gel network. A gel hardness increases with increasing heating temperature and time when other factors are maintained. Heating rate also affects the gelation process. Slow heating allows the proteins enough time for unfolding and aggregation, resulting in much stronger gels.

The unique properties of caseins and whey proteins, their interactions during processing (e.g., heat treatment), and their interaction with salts, are responsible for the desirable properties of a wide array of popular dairy food products, including cheese, yoghurt, ice-creams, milk desserts and milk shakes.

Gelation of milk proteins is the crucial first step in both cheese and fermented milk manufactures [29, 30]. However, the proteins' coagulation is different in these two technologies. Cheese production requires a combination of acidification and enzymatic hydrolysis of milk proteins whereas for fermented milk production is necessary only acidification, as the result the milk curd is different (fig. 2). In addition, the way in which milk coagulates is controlled by heating.

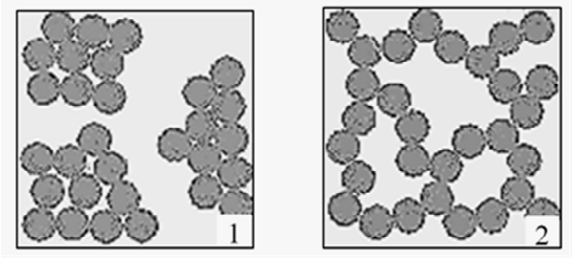

Fig. 2. Casein micelles coagulate: into clusters in the cheese production (1), into branched chains in the fermented milk production (2) [31].

Fermented milks (using the example of yogurt). Fermented milks are obtained by fermentation by suitable microorganisms resulting in reduction of pH with coagulation. There are numerous types of fermented milks manufactured in different parts of the world. Throughout the world, around 400 names are applied to traditional and industrially made fermented milk products. Each type of fermented milk involves specific microorganisms, based primarily on the optimum growth requirements of the starter cultures (i.e., mesophilic and thermophilic microflora). However, there are strong similarities between manufacturing technologies used.

Yogurt has traditionally been made from milk that had been heated almost to boiling. Coagulation of the milk proteins is induced by thermophilic bacteria, such as *Lactobacillus delbrueckii subsp. bulgaricus* and *Streptococcus salivarius subsp. thermophiles*. The milk is coagulated by a slowly increasing concentration of lactic acid as the bacteria metabolize lactose. The proteins do not precipitate (as would happen following an addition of a large amount of lactic acid) but form a gel. Its ability to retain all the water present in the milk is the result of a peculiar microstructure of the protein network. It consists of short branched chains of casein micelles (fig.2) and resembles a sponge with very small pores [31]. In fat-containing products, the presence of (large) fat globules obscures the finer details of pores and strands. The diameter of these pores varies considerably, with larger pores in gels made at a high gelation temperature (usually <30 urn). Lee, W. J. and J. A. Lucey report [32] that yogurt gels made from milk heated at high temperature (>80°C) had a more cross-linked and branched protein structure with small pores compared with milk heated at low temperature.

Heat treatment of milk and the concomitant denaturation of whey proteins affect the characteristics of the acid-gel. When milk is heated at >70°C, the major whey proteins, such as, β-lactoglobulin are denatured [25]. During denaturation β-lactoglobulin interacts with the κ-casein on the casein micelle surface by disulfide bridging [5, 33]. The result is a complex which makes the casein micelle surface markedly coarser. Casein micelles with the κ-casein–β-lactoglobulin complex formed on their surfaces have a limited ability to aggregate. Consequently, short branched micelle chains are formed. Soluble complexes of denatured whey proteins with κ-cascin also associate with the micelles during the acidification process.

The effects of whey protein denaturation on the gel properties can be ascribed to several factors [34].

Firstly, the concentration of gelling protein increases due to the contribution of the denatured whey proteins in the gel structure (2.8% in unheated milk versus 3.3% in heated milk).

Secondly, denatured whey proteins which are associated with the casein micelle could act as a bridging material between the micelles. As denatured whey proteins contain reactive thiol groups, disulfide interactions can also occur. These effects can increase the number and strength of bonds between the protein particles.

Thirdly, whey protein aggregates can act as an additional bridging material.

According to Lee, W. J. and J. A. Lucey, stirred yogurt can have very large clusters of caseins presumably created by the collisions and shearing during the mixing process [35]. Cayot et al. [36] report that the consistency index in stirred yogurts, calculated from the Ostwald model, increased as milk heating temperature increased from 70 to 100°C. An increase in milk heating temperature causes an increasing of apparent viscosity and provides mouth-coating attributes [3, 35]. The characteristic three-dimensional gel matrix of set yogurt is no longer visible in stirred products.

Cheese. Cheese is a concentrated protein gel, which occludes fat and moisture. Its manufacture essentially involves gelation of milk, dehydration of the gel to form a curd and

treatment of the curd. Cheese is made from milk that hadn't or had been heated at lower temperature than fermented milks. In result of this treatments milk consists of casein micelles with smooth surfaces [31]. Casein micelle surfaces interact with other casein micelles and form large micellar clusters from which whey separates easily (fig.2.). It is possible to use both rennet-induced and acid-induced coagulations in cheesemaking, however, rennet-induced gelation of milk is used more often [30].

Proteolytic enzymes such chymosin are used to destabilize casein micelles and make them to coagulate [37]. The enzyme is an endopeptidase, which in milk of pH 6.7 cleaves very specifically the Phe105-Met106 bond of κ-casein [38]. K-casein is split into para-κ-casein and caseinomacropeptide (CMP) of which para- κ-casein is insoluble, while CMP is soluble. Para- κ-casein has not the colloid-protective property of κ-casein. Extensive cleavage of the κ-caseins present in the hairy brush results in destabilisation of the micelle. The micelles coagulate and form a gel [11, 39].

Enzyme-induced gelation of milk is hindered by a variety of factors, which either:

• restrict access of the enzyme to (κ-casein), for example complexation of denatured whey protein with κ-casein at the micelle surface, as a result of high heat treatment [39];

• act as obstacles to the aggregation and fusion of rennet-treated casein micelles, for example κ-casein/ β-lactoglobulin appendages at micelle surface, or serum κ-casein/ β-lactoglobulin particles [40].

The milk gel, obtained during enzyme-induced gelation, consists of casein micelle clusters and short chains. They encapsulate fat globules – the natural large corpuscular particles present in milk. Void spaces in the casein matrix are filled with the whey [41]. Following gel formation, the resultant milk gel is subjected to a number of operations that promote the release of whey, an approximate tenfold concentration of the casein, fat and micellar calcium phosphate components, and a transformation to a curd with much higher dry matter content than the original milk gel [42].

During the dehydration process of the gel, protein concentration and aggregation continue via various types of intra- and intermolecular interactions [43], including calcium bridging, hydrophobic interactions between lipophilic domains and electrostatic interactions (other than calcium bridging). The strength of these interactions is modulated by ionic strength, pH, calcium and temperature, and hydrolysis of proteins to peptides, which alters the hydrophile/lipophile balance of the proteinaceous fraction.

Of particular interest in relation to milk composition and cheese quality is the impact of the proportion of intact α_{s1}-casein content in milk on casein aggregation, strength of the enzime-induced milk gel and texture of the final cheese [37]. The sequence of residues 14-24 is a strongly hydrophobic domain and confers intact α_{s1}-casein with strong self-association and aggregation tendencies in the cheese environment. This domain also has 3 mol of glutamate, which are expected to contribute to intra- and intermolecular calcium bridges. It has been suggested that self-association of α_{s1} -casein in cheese via these hydrophobic 'patches', leads to extensive cross-linking of *para*-casein molecules and thus contributes to the overall continuity and integrity of the casein matrix in the cheese curd. The early hydrolysis of α_{s1} -casein at the phenylalanine23-phenylalanine24 peptide bond results in a marked weakening of the *para*-casein matrix and reductions in fracture stress and firmness of the cheese during maturation [4]. This hydrolysis is a key step in mediating the conversion from a fresh rubbery curd to a mature cheese with the desired textural and properties [42].

Lydia Ong et. al highlight the potential of using milk with increasing concentrations of protein to increase the total cheese yield [41]. The increased protein concentration decreases the volume of the sweet and salty whey, potentially reducing the cost associated with processing this by-product. Protein addition could also be used as a tool when cheese with lower moisture content is required and

led to only subtle changes in the microstructure, with denser gels, denser milled curds and larger fat globules in the pressed cheese. The cheeses made with higher milk protein are harder than cheeses made with unstandardised milk.

Ice cream and aerated desserts. Other widely popular products in which milk proteins play a crucial role are ice cream and aerated desserts. The structure of ice cream and frozen aerated desserts can be described as a complex colloid consisting of three internal phases (fat globules, some partially coalesced, and their adsorbed interfacial material; air bubbles and their adsorbed interfacial material; and ice crystals) surrounded by a freeze-concentrated aqueous serum or matrix phase that contains the sugars, proteins, polysaccharides and salts [12].

An ice cream mix is first prepared which contains fat, milk solids non-fat (MSNF), sweeteners, emulsifiers and stabilizer. Initial processing of this mix typically involves formulation, homogenization and pasteurization, following which it is aged for at least four hours at 4°C or lower. This last step induces sufficient crystallization of the fat and restructuring of the emulsion droplet surface to facilitate sufficient partial coalescence of the fat droplets during freezing. The aged mix is then simultaneously aerated and frozen, typically using a continuous scraped-surface ice cream freezer.

Milk proteins are added as part of the MSNF component. The protein's content of a mix is usually about 4% [44]. Milk proteins contribute strongly to emulsification of the fat and to partial coalescence of the fat globules and fat structure formation during ice cream manufacture [45]. It is critical that the emulsion droplets are stable during mix preparation, but yet susceptible to partial coalescence during the freezing stage in manufacture. This can happen because the fat droplets are primarily covered by milk protein immediately after emulsification, but are gradually displaced by low molecular mass emulsifiers (e.g., monoglycerides) during aging of the ice cream mix [46].

Milk proteins play a crucial role in the stabilization of air bubbles during the initial stages of ice cream manufacture [15]. During the manufacture of ice cream, air is incorporated in ice cream to approximately 50 % of the volume phase of the final product. It needs to be rapidly covered by surface active compounds to stabilize this expanding air-liquid interface [12]. In ice cream, milk proteins dominate the air-water interface (fig 3).

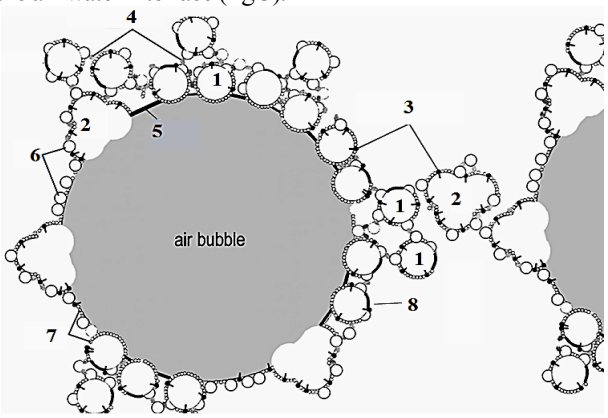

Figure 3. Model for a stabilized air bubble in ice cream and frozen aerated desserts [47]:
1 – intact fat globule attached to the air bubble via calcium bridges; 2 – partial destabilized fat agglomerate; 3 – emulsifier; 4 – calcium bridges; 5 – β-casein; 6 – casein micelle; 7 – casein submicelle; 8 – whey protein.

In addition to emulsification and aeration, milk proteins play a crucial role in structuring the external phase of ice cream. The hydration of milk proteins is important for the rheological properties of the ice cream. Milk proteins are partially incompatible with the added polysaccharides. The resulting networks of polysaccharide and aggregated protein may be partially responsible for controlling recrystallization of the ice phase during storage and temperature fluctuations [48].

In a recent study T. Huppertz shows that, high pressure processing (HPP) of ice cream mixes strong effects on the rheological properties of the mixes and ice cream prepared from these mixes [49]. For instance, viscosity of the ice cream mixes can be increased more than 25-fold by treatment at pressures exceeding 400 MPa. These effects of HPP on ice cream mix can also be largely related to changes in the milk proteins in ice cream mix (the casein micelles have been disrupted) [49]. Like heat treatment, HPP treatment can result in the denaturation of whey proteins, which results in the formation of whey protein aggregates and the association of denatured whey proteins with the casein micelles [50, 51]. Structuring of milk proteins in ice cream by HPP or other means thus offers opportunities for the replacement of fat and stabilizers in ice cream without compromising on hedonic quality parameters.

Moreover, milk proteins can provide the same functional properties (aeration, emulsification) in the structure formation of other dairy dessert products such as milk shakes, whipped cream, frozen aired desserts [13, 52, 53].

Conclusions

Milk proteins provide the structural elements responsible for the textural and melting properties of dairy products. Their ready hydration and strong interactions with each other and with various other components make them valued ingredients in food applications.

The technological properties of milk are strongly influenced by the stability of the casein micelles. Deliberate destabilization of the casein micelles resulting in coagulation or gelation is exploited in the production of a range of dairy products, including all cheese varieties and fermented milks. Another important feature of the milk proteins is their strong interactions with one another. Heat temperature treatments have marked effect on their interaction and solubility at neutral pH. This characteristic is reflected in the high viscosity of proteins' solutions and their ready ability to form foams and emulsions.

It is expedient to use results of review into a further study of the structure formation mechanism of dairy products and the development of recommendations in order to an efficient production.

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Discourse of the form and concentration of surfactants to ensure the sustainability foam-emulsive products

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Keywords:

Cake
Mix
Caseinate
Foaming
Stability

Article history:

Received 02.06.2014
Received in revised form 19.06.2014
Accepted 02.09.2014

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Abstract

Introduction. Development of dry mixes for making spumy and emulsion products are topical, because nowadays there is a tendency to minimize the time spent on the process of cooking, which is achieved by the use of semi finished products high degree of readiness.

Materials and methods. Foaming ability was determined by the method of multiplicity of the foam, the stability of unstable foam- by the half-life method of foam, highly resistant foam - as a ratio of the height of the column of foam after exposure for 24 hours.

Results. Was determined the influence of sunflower oil on the foaming ability and half-life foam of systems «sodium caseinate-oil». It was found that getting systems with high index of foaming capacity and foam stability in the presence of oil in the system is impossible without the use of low molecular weight surfactants. Substantiated recommendations regarding the feasibility of using two surfactants in systems «sodium caseinate-surfactants-oil», which provide the necessary kinship surfaces air, fat and water phases. it has been found that the use of 2,5...3,5% mono-and diglycerides of fatty acid sand Lecithin's 0.15...0.25% in the content of sodium caseinate about 0.5% allows to receive the stable foam-emulsive systems containing sunflower oil 7...8% and foaming ability about 640±1%.

Conclusions. It is established that for ensuring high indicators foaming capacity and stability of foam-emulsive systems required the use of low-molecular surfactants. The research results, is recommended to use when developing technology of foam-emulsive products.

Introduction

Given the specificity of functioning of the restaurant industry (fragmented dislocation within settlements, reducing the area of industrial facilities, specialization, etc) successful manufacture of food products with foam-emulsive structure, representatives of which are desserts, finishing semi-finished products (creams), layers of cakes and pastries, possibly

on the basis of semi finished products high degree of availability, the use of which will provide stable quality parameters and safety of the finished product in the technological flow.

For existence on the food market of Ukraine is a wide assortment of multifunctional semi finished products and food concentrates in the form of dry and liquid mixtures [1], the volume of production and technological characteristics not satisfy fully the needs of institutions the restaurant industry. The main reasons are the unstable properties of prescription mixtures during foaming and storage of finished products; using as part of semi finished products hydrogenated vegetable oils - palm, palm kernel, soybean, which has a number of drawbacks, including the main - have transisomers of fatty acids; absence domestic production of semi-finished products.

Therefore development of dry fatty semi finished product for the production of food products with foam-emulsive structure is relevant, as it using will reduce the time and production areas providing the quality and safety of the finished product, create wide variety of desserts and pastry, able to satisfy the requirements of the modern consumer's by implementing business processes B2B and B2C.

With the implementation of the traditional method of making a dry fat-containing mixture limiting factor is the significant energy consumption in the production of semi finished products, which are produced by spray drying the emulsion pre-condensed product. The scientists of Kharkiv State University of Food Technology and Trade proposed a fundamentally new way of obtaining fat dry semi finished products (hereinafter - semi finished products) by spraying a mixture of fat based on sunflower oil on the powdered filler. This approach can reduce the energy consumption for the production of semi-finished products and provide high quality and stable indicators foam-emulsive products based on them.

Development of a new method for producing semi finished requires scientific substantiation prescription composition (form and concentration of surface-active substances (SAS) and technological parameters of its production (temperature and duration of recovery, churning, storage, etc.), for implementation of which he will meet the following requirements:

- have a commodity form of dry mixture with constant organoleptic, physicochemical and microbiological parameters during a specified period of storage;
- restoring by mixing with drinking water, followed by stirring to dissolve the ingredients, followed by the formation foam-emulsive system of its mechanical dispergation;
- foam-emulsive systems based on whipped semi finished should be technologically compatible with food ingredients and /or products in the form of fruit berry, chocolate and other fillers to create a wide range of culinary and confectionery.
- restored semi-finished product must have high performance foaming capacity and foam stability, ensuring its use in technology of dessert products and finishing semis.

The main and essential condition to obtain a foam emulsion products is the use of foaming agents, including traditionally used macromolecular compounds protein (egg white, milk), polysaccharide (methylcellulose, hydroxylpropylmethyl cellulose) nature and low molecular weight surfactants. In this important scientific and practical aspect of obtaining foam emulsion systems is to stabilize their structures in general, including the presence of a fatty phase, along with other factors affecting the formation of organoleptic and physic-chemical characteristics of products, such as textural homogeneity, shape stability, and others.

It is advisable to define the criteria for selecting surfactants dry fatty semi finished to obtain a foam emulsion systems:

- first, surfactants must ensure complete dissolution of the components during recovery of semi finished (the first stage) and emulsification fat phase (the second phase), which is in the dispersed state;
- secondly, by the reasonable using of surfactants high foaming ability and foam stability should provide initial indicators of foam systems throughout the period of storage and sales;
- thirdly, the foaming agent (or system foaming agent - stabilizer) should not alter their functional and technological properties of conditions for the introduction of fillers regardless of their chemical composition, colloidal state, allowing create a wide range of products from foam emulsion structure.

In the works of national and international scientists [2-5] is pointed out that one of the factors stabilizing stability of spumy systems is structural-mechanical, which is achieved by increasing the strength of interfacial adsorption layers (IAL). Providing strength IAL done by using macromolecular-surfactants (proteins). For the foam-emulsion systems it is necessary to regulate the strength IAL. In particular on stage whipping important is decrease in strength of IAL at the interface water-oil to form fat crystals capable of coalescence at the interface water-air and simultaneously increase the strength of IAL on the verge of water -air is realized by using a mixture of surfactants (proteins and low molecular weight surfactants) [6-8]. In studies noted that the above named course of the process achieved by adsorption surfactants at the phase interface - competitive, associative and layered.

During exploratory studies demonstrated that combined use of macromolecular (proteins) and surfactants with low molecular weight for rational ratio increases the mechanical strength of the foam systems by preventing thinning foam films and significantly prolongs duration of the existence of the foam. Also, use as part of semi-finished fat phase in the form of vegetable oil (sunflower), likely will improve the solubility of low molecular weight surfactants.

Given this, the aim of these studies is the justification for type and concentration surfactants by identifying patterns of change foaming capacity and stability of food foams systems that simulate the composition of dry fat-free cake mix for the production of foam-emulsion products.

Materials and methods

In order to study the rational content of the main prescription components studied foaming ability (FA), the half-life of foam (HLF) and the stability of foams (SF). Experimentally was found regularities FA, HLF and SF on the concentration of sodium caseinate, surfactants, sunflower oil in the systems.

Spumy systems were obtained by churning prescription mixtures of defined composition. The mixture was prepared by dissolving low molecular weight surfactants in sunflower oil at a temperature of 60 ... 70ºC and followed by mixing with an aqueous solution of sodium caseinate. Whipping was performed in 5×60^1s using a mixer at a speed of rotation of the working organ 29 s^{-1}.

Foaming ability of systems was determined by the method and calculated by the formula:

$$ПЗ = 100\frac{V_F}{V_S}$$

V_F - volume of foam cm^3;

V_S - volume of solution before churning, cm^3.

The stability of foams unstable systems expressed through a half-life of foam ($\tau^{1/2}$), that determined the time during which the foam column destroyed half of the original height of the foam. Persistence of stable foams was determined as the ratio of the height of the foam column after holding for 24×60^2s at a temperature of 20,0 ± 0,5 ºC to the total height of the sample, expressed as a percentage.

Results and discussion

In order to study the type and concentration surfactants consisting of semi-finished researched the patterns of change ability of foaming and half-life of foams food systems «sodium caseinate-oil», «sodium caseinate-surfactants», «sodium caseinate-surfactants-oil».

Based on previous studies as raw that contains protein was selected sodium caseinate at a concentration of 0.5...2.0% low molecular weight surfactants - E471, E473, E481, E322, E472e (Table 1). The content of sunflower oil in the systems was investigated varied in the concentration range 0...10%.

Table 1

Characterization of surfactants

Name of surfactants	The properties of surfactants
E471 Mono- and diglycerides of fatty acids	Nonionic surfactants, HLB = 3…4, iodine number – 80g I/100g
E471 Mono- and diglycerides of fatty acids	Nonionic surfactants, HLB = 3…4, iodine number – 3g I/100g
E473 Sucrose esters of fatty acids	Nonionic surfactants, HLB = 13…15
E481 Sodium stearoyl-2-lactylate	Anionactive surfactants, HLB = 16…18
E322 Lecithins	Amphoteric surfactants, HLB = 4
E472a Acetic acid esters of mono- and diglycerides of fatty acids	Nonionic surfactants, HLB = 2…3

In the first phase of research identified patterns of foaming «sodium caseinate-oil» (Fig. 1).

It is proved that aqueous solutions of sodium caseinate 1.0%, 1.5% and 2.0% due to the high surface-active properties form foam system FA indicators which constitute 580 ±1%, 550±1%, 500 ±1%, respectively but these systems are characterized by low stability of the foam, as HLF these systems is 28×60^1s, 16×60^1s, 15×60^1s and 60cm respectively. Introduction to oil system leads to its emulsification and is accompanied by a decrease in the above parameters for all concentrations of sodium caseinate. This fact is probably due to the destruction of the foam when added to a system of sunflower oil, which is a consequence of the reorientation of the protein due to changes in its adsorption on the interface water-air boundary for adsorption at water-oil [9]. Systems with a concentration of sodium caseinate about 0.5% in the presence of oil are not capable of churning.

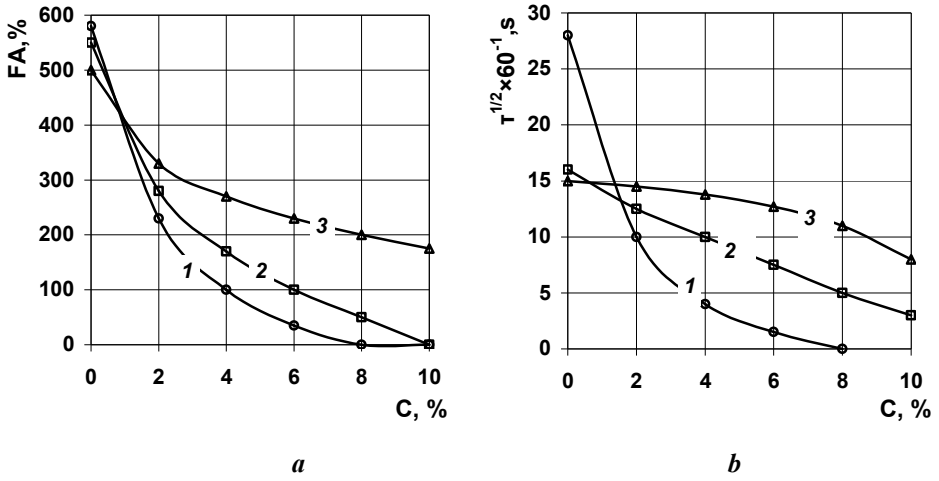


Fig. 1. Dependence of the FA (a) and HLF (b) of systems «sodium caseinate-oil» on the content of sodium caseinate concentration:
1(○) - 1,0; 2(□) - 1,5; 3(Δ) - 2,0

Experimental results show that the foam-emulsion system with high and stable indicators of foaming ability and stability of foam based on sodium caseinate, which serves as a foaming agent and emulsifier simultaneously receive impossible. Thus for maintain the set of indicators is necessary using of low molecular weight surfactants [10].

Formulated a working hypothesis that requires theoretical and experimental discourse and evidence that the mechanism of formation and stabilization of foam-emulsion systems based on the dry fatty semi finished product , comprising a fatty phase is emulsification of fat phase , followed by foaming , crystallization fat phase after recovery contributing to the stabilization of foams by absorption of fat crystals and their koalistsention the air bubbles and blocked Plateau- Gibbs channels , thereby preventing the drainage of fluid and form a plastic consistency.

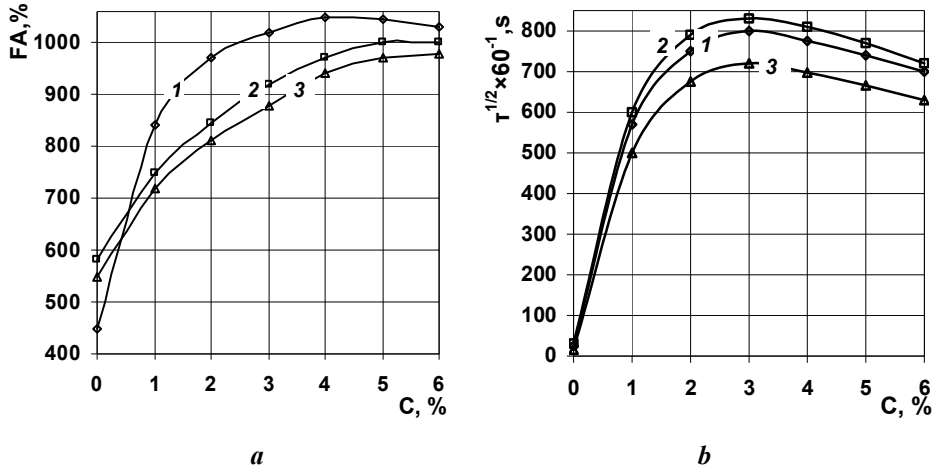
Was predicted that above named processes are achieved by using a mixture of macromolecular semi finished (in our case - sodium caseinate) and surfactants with low molecular weight , on the one hand, provides high indicators FA and HLF, and, on the other - crystallization of the fat phase of partial desorption of proteins from interfacial surface water-oil.

To substantiate form and concentration of low molecular weight surfactants to stabilize foam-emulsion products defined patterns of foaming «sodium caseinate-surfactants». The choice of surfactants based on securing the flow of processes allows obtaining stable over time foam-emulsion system. During the pilot study were used ionic, nonionic, amphoteric surfactants of different value of hydrophilic-lipophilic largest balance (HLB) (Table 1). Of all the surfactants which was used GRAS status (used without restrictions) having all except E481 and E473: their maximum permitted level shall not exceed 5 g/kg of finished product [11]. Given the properties of surfactants with low molecular weight (Table 1), the scientific interest is the use of E481 and E473 based on the high value of HLB and the ability to foaming.

In view of the aforecited was researched FA and HLF of systems «sodium caseinate-surfactants» (Figure 2-6). It was established that under the same concentrations of surfactants in systems «sodium caseinate-surfactants» foaming process is different.

Analysis of the data obtained suggests that the dependence of the FA and HLF are worn not linear character. With increasing concentration surfactants E471 (3g I/100g) at concentrations of sodium caseinate in the system of 0.5%, 1.0% and 2.0% of FA increases and reaches a maximum value for the concentration of sodium caseinate, 0.5% surfactants E471 – 3,5...4,5% constitutes 1050 ±1%. The biggest HLF system characterized protein concentration of 0.5 ... 1.0% and surfactants E471 (3g I/100g) 2.5...3.5%, which HLF is (720...830)×60^{-1}s. Extreme character of dependence systems "sodium caseinate-E471" is probably related to the fact that the protein begins to be associated with micelles surfactants in the aqueous phase and desorbed from the interfacial surface. This leads to a lack of a surfactant at the interface water-air to provide strength interfacial adsorption layers needed to stabilize foamy tapes.

By using surfactants E471 (80g I/100g) as opposed to SAS E471 (3g I/100g) with increasing concentrations FA and HLF are reduced. You can ascertain that surfactants E471 (80g I/100g) acts antifoam (Fig. 3) and is unable to stabilize spumy system.



a *b*

Fig. 2. Dependence of the FA (a) and HLF (b) systems "sodium caseinate - E471» from the content E471 (83g I/100g) sodium caseinate concentration, %:
1(◊) - 0,5; 2(□) - 1,0; 3(Δ) - 1,5

In systems «sodium caseinate-E481» with increasing concentration of sodium caseinate foaming capacity increases and reaches maximum values for the content of sodium caseinate 1.5% and 0.5% and the E481 800 ± 1%. The maximum concentration of surfactant E481 due to the requirements of maximum allowable concentrations [8], according to which the content of the surfactant in the dessert products are limited (Fig. 4).

In systems «sodiumcaseinate-E473» with increasing concentration of SAS E473 FA and HLF increased and reach maximum values of FA that is 620 ±1% by E473 content of 0.5% and 1.0% of sodium caseinate. The maximum value of the HLF system is characterized by the content of sodium caseinate 1.5% and 0.5% of E473 is (340±1)×60^{-1}s. The maximum concentration of surfactants E473 requirements stipulated maximum permissible concentrations [8], according to which the content of the surfactant in dessert products limited (Fig. 5).

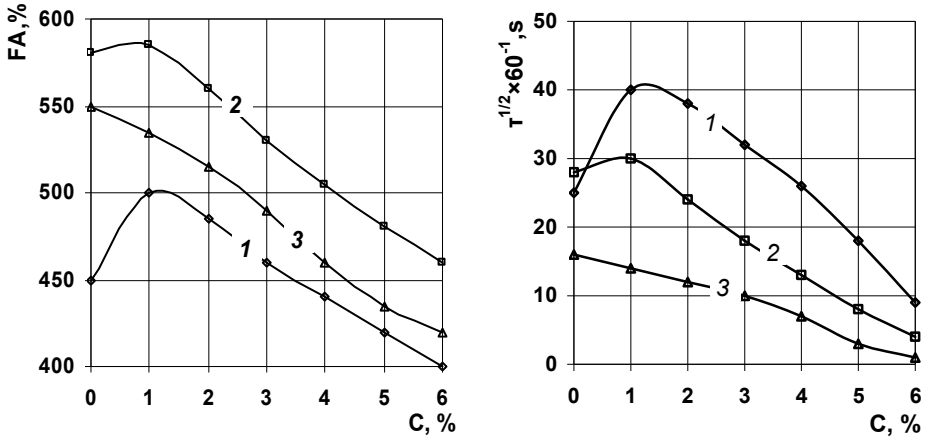


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Fig. 3. Dependence FA (a) and HLF (b) of systems «sodium caseinate - E471» content -E471 (80g I/100g) at concentrations of sodium caseinate, %:
◊ - 0,5; □ - 1,0; Δ - 1,5

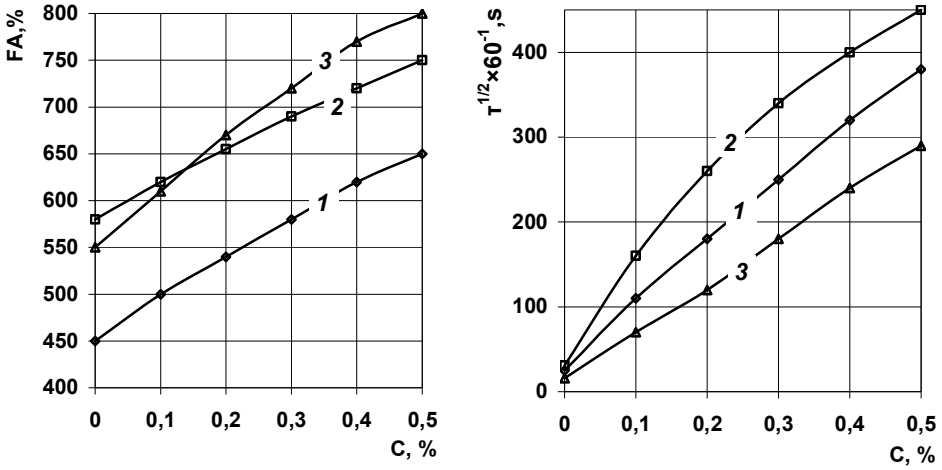

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Fig. 4. Dependence of the FA (a) and HLF (b) of system «sodium caseinate-E481» for the content of E481 sodium caseinate concentration,%:
◊ - 0,5; □ - 1,0; Δ - 1,5

Analyzing the data presented in Fig. 1 found that the increase in the content of sodium caseinate and surfactants E472a improves FA; under certain conditions HLF increases and reaches maximum values of 750 ±1%, 900 ±1% and 900 ±1% for the concentration of protein in the system of 0.5%, 1.0% and 2.0% respectively and surfactants E472e 4...5% (Fig. 6).

Systems «sodium caseinate-E322» is not able to churning. Perhaps SAS E322 leads to extrusion of protein from interphase water-air that E322 serves defoamers.

Based on the data obtained by foaming ability of «sodium caseinate-surfactants» surfactants can be arranged in series: E481 > E471 (3g I/100п) > E472e > E473 > E471 (80g I/100п) > E322, but this does not correlate with the value of HLB and is probably due to the low molecular weight surfactant packing parameters in the interfacial layers. That surfactants occupy different space, which in turn is likely to determine the conditions of compatible adsorption with sodium caseinate.

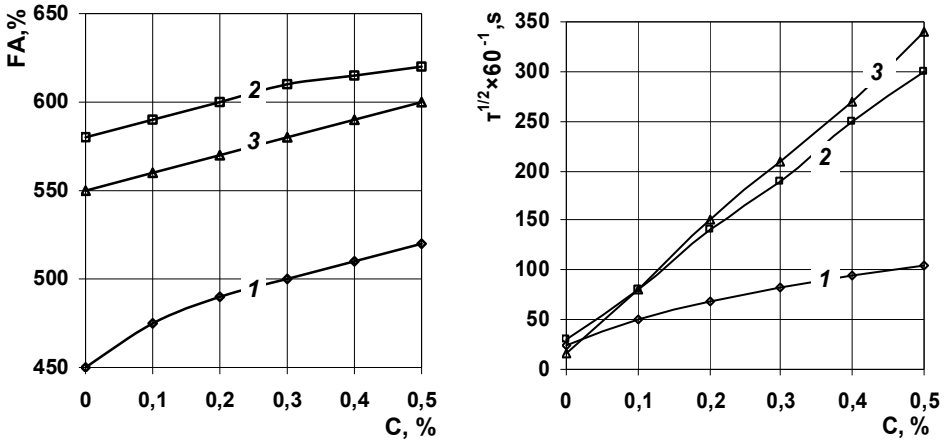

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Fig. 5 - Dependence of the FA (a) and HLF (b) of system «sodium caseinate-E473» for the content of E473 sodium caseinate concentration,%:
1(◊) - 0,5; 2(□) - 1,0; 3(Δ) - 1,5

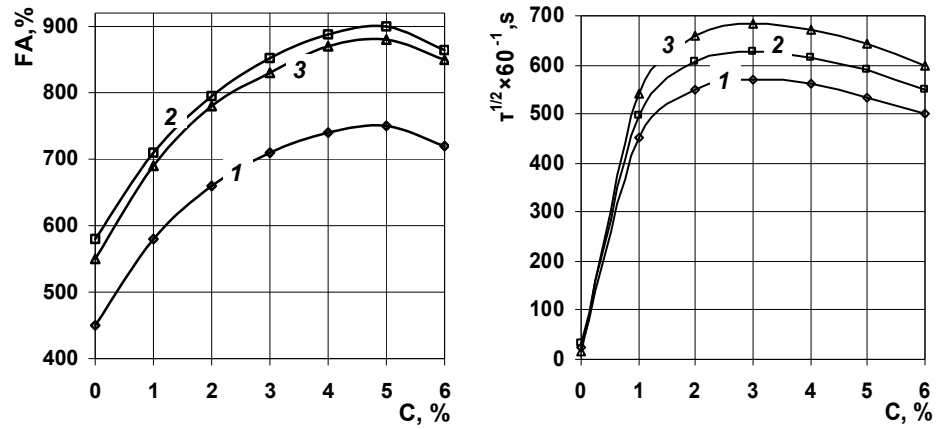

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Fig. 6 - Dependence of the FA (a) and HLF (b) of system «sodium caseinate-E472a» for the content of E472a sodium caseinate concentration,%:
1(◊) - 0,5; 2(□) - 1,0; 3(Δ) - 1,5

Determined that the most rational use of SAS E471 (3g I/100g) at concentrations of 3,0...4,0% and sodium caseinate 0,5...1,0%, which has advantages to other SAS in magnitude of FA and HLF besides E471 has the status of GRAS.

Based on the fact that a part of semi-finished product is supposed to use sunflower oil, it is necessary to determine the patterns of FA and SF of systems «sodium caseinate-surfactants - oil» in order to establish reasonable concentrations of the three-component system (Fig. 7).

It was established that the dependence of foaming ability of system «sodium caseinate-E471-oil» (Fig. 7a) is extreme in nature with a maximum at a concentration of sodium caseinate 0.5% and SAS E471 is 2.5...3.5% oil content is 7.5% (650±1%). Comparing the findings with the research FA and HLF systems «sodium caseinate-oil» shows that using of E471 can significantly improve the stability of foams in the presence of oil. The stability of foams (Fig. 7b) with increasing concentrations of E471 increases, however, with increasing oil content SF decreases.

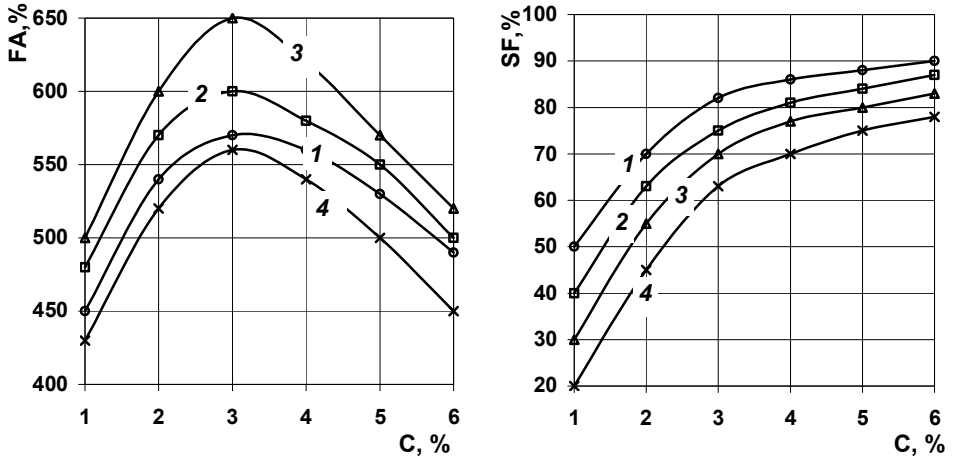

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Fig. 7. Dependence FA (a) and SF (b) of systems "sodium caseinate - E471 – oil" content -E471 (3g I/100g) for oil content:
1(○) - 2,5; 2(□) - 5,0; 3(Δ) - 7,5; 4(×) - 10, 0

So systems which containing surfactants E471 have most foaming ability – 2.5...3.5% oil 8…7% sodium caseinate – 0.5%. Using E471 (3g I/100g) in these concentrations provides foaming, emulsification and crystallization of fat, which helps stabilize the foam is probably due to the absorption of fat crystals in air bubbles and blocked Plato-Gibbs channels, thereby preventing the drainage of fluid.

In order to increase the stability and plasticity of foam-emulsion systems additionally introduced E322 (Fig. 8). Based on the working hypothesis and previous research FA of systems «sodium caseinate-E322» surfactants E322 provides desorption of protein from the interfacial surface. However, please note that the E322 should ensure desorption of protein with only from interphase water-oil because its concentration should be negligible. In this case, the use of SAS E322 will provide coalescence of fat phase on the air bubbles, resulting in increased stability and plasticity of foam and simultaneously high foaming ability.

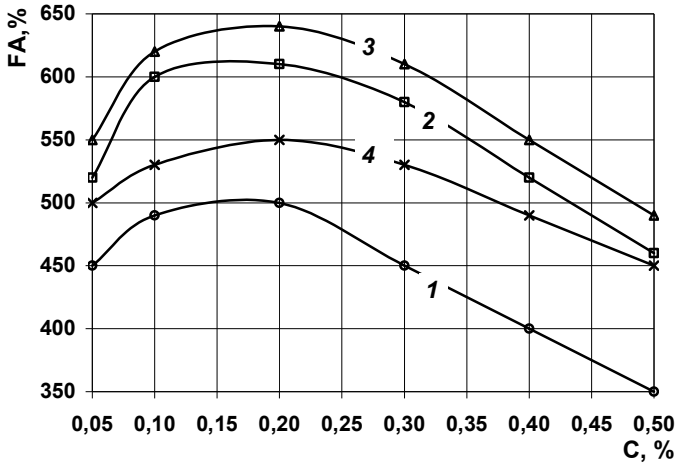

Fig. 8. Dependence FA (a) of systems «sodium caseinate-E471-E322-oil» content – E322 for oil content:
1(○) - 2,5; 2(□) - 5,0; 3(Δ) - 7,5; 4(×) - 10,0

In the systems which were research the content of SAS E471 (3g I/100g) is constant and is 3.0%.

Was established that dependence FA from the content E322 systems «sodium caseinate-E471-E322-oil» wear nonlinear character. Determined that the most foaming ability (640±1%) have a systems which containing oil 7.5% by content surfactants E322 – 0.2%. With increasing protein concentration FA is decreases. This behavior can be explained by competitive adsorption of surfactants and proteins in the system. Despite the fact that FA of systems using two surfactants (E471 and E322) is lower than using one – E471, this system is characterized by a 100% resistance during 24×60^2s.

Conclusions

1. Given the latest trends of food market Ukraine was proved expediency of developing dry lipid semi finished product for the production of food products with foam-emulsion structure and use of a fundamentally new method for producing dry and fat semi-finished from sunflower oil by spraying of fat mixture in powdered filler.
2. Experimentally confirmed working hypothesis which is the formation and stabilization of foam-emulsion systems is achieved by using a mixture of of sodium caseinate and surfactants with low molecular weight on the one hand, provides high indicators of FA and SF, and the other – the crystallization of the fat phase partial by desorption of proteins from interphase water-oil.
3. Determined that the introduction of sunflower oil in the system reduces foaming ability and foam stability at all concentrations of sodium caseinate in the system and leads to the destruction of the foam, which determines the need for the introduction of surfactants.
4. Investigated Influence of six surfactants with different HLB on foaming ability and stability of foams in systems «sodium caseinate-surfactants». Established that the use of surfactants can improve the foaming ability and stability of foams in system

"sodium caseinate-surfactants» and placed in in a series of descending of FA: E481 > E471 (3g I/100g) > E472e > E473 > E471 (80g I/100g) systems «sodium caseinate-E322» are unable to foaming.

5. Experimentally proved that the most rational use of SAS E471 (3g I/100g) at concentrations of 3,0... 4,0% and the content of sodium caseinate 0,5...1,0%, which has advantages compared with other surfactants. SAS E471 provides crystallisation of fat phase, increases foaming ability and stability of foams in the presence of oil.
6. To ensure 100% foam stability of emulsion systems during 24×60^2s proven the expediency of using a mixture of surfactants – E471 and E322. With the simultaneous use of E471 and E322 achieving by crystallization of a fatty phase, desorption of protein from interphase water-oil to form a product with spumy plastic consistency.
7. Substantiated content of main prescription components in fat dry semi-finished that must be provided in an aquatic environment after recovery dry and fat semi-finished products, such as: sodium caseinate – 0.5%, oil 7...8%, SAS E471 – 2,5…3,5%, surfactants -E322 – 0,15…0,25%.

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Development of technological modes for preparation of mineral water for sports drinks

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Keywords:

Beverage
Water
Desalination
Freezing

Article history:

Received 14.06.2014
Received in revised form 23.07.2014
Accepted 02.09.2014

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Abstract

Introduction. Conducted research study is devoted to development of technological modes of desalination of natural mineral medical-table sodium chloride water for water treatment technologies in the production of beverages for athletes.

Materials and methods. Samples of initial water and water that has been desalinated using the experimental installation with different modes were investigated. Measuring of temperature mode of crystallizer was carried out using temperature sensors and digital thermometer. Quality indicators of the water samples using Photometer Palintest 7500 and standard techniques were determined.

Results and discussion. The influence of different factors of the process of freezing on the quality of desalinated natural mineral medical-table sodium chloride water "Kuyalnik" was investigated. The patterns of distribution of components of initial water between the frozen solid phase, and a concentrated solution in the process of freezing are identified. For the majority of the investigated factors order of traffic was such: $Ca^{2+} > HCO^{-}_3 > (Na^{+} > Cl^{-}) > (Mg^{2+} > SO^{2-}_4 > K^{+})$, and with a decrease in water salinity so: $Ca^{2+} > SO^{2-}_4 > (Na^{+} > Cl^{-}) > (HCO^{-}_3 > Mg^{2+} > K^{+})$.

Summary of the study results allowed to recommend the following technological parameters of the carrying out the process of desalination of natural mineral sodium chloride water by freeze: operating temperature mode of crystallizer, which is changing in the process from -2 to -4 ° C, the concentration of carbon dioxide in the water at the beginning of the process of freezing - 3,7 g/dm^3, duration of the desalination process (process without cooling) - 60 minutes, one step of freezing, melting of solid phase under ambient conditions without prior separation of the frozen solid phase. With such technological modes of the carrying out the process of freezing it is possible to obtain water with mineral composition, mainly with existing relevant recommendations to the mineral composition of beverages for athletes.

Conclusion. As a result of scientific research an improved method for organizing the process of desalination by freeze was suggested.

Note. * Kurchevich I.V. – maiden name Kovalenko I.V.

Introduction

While an overall reduction in the rate of growth in demand for traditional soft drinks the today demand for beverages for special purposes with certain functional properties is growing. Significant market volume of such beverages makes drinks for athletes. Its share of the total consumption of soft drinks in the world is 2 % and of the consumption of functional drinks – 37 %. A forecast of the global sales for such beverages provides an increase of 39,08 % from 2011 up to 2016 [1,2]. For Ukraine, the beverage market for athletes is new and at the same time is promising. The main reasons for the growth of the interest to sports drinks is associated with the following: firstly, they are necessary for the diet of professional athletes. After all, the purpose of these drinks is effective replenishment of fluids lost in body, providing of the body with "quick energy" in the form of carbohydrates, as well as micro-, macro- and other substances that are necessary for the effective activities, for example, during physical activity, and after it, as well as for build muscle [3]. In addition, such drinks are correctional food for adherents of a healthy lifestyle. Indeed, in Ukraine, followed by Europe, the number of people who are actively involved in fitness, physical therapy, and lead a healthy lifestyle is constantly growing. Ukraine also participates and organizes the holding of various sports competitions at international level, and therefore the presence of domestic products of drinks for athletes will have a positive impact on the image and economics of the country.

For today, there is no consensus regarding the most effective formula of sports drinks. But it is known that such drink have to taste good, and its consumption has to make a contribution for increasing of organism's efficiency. It should be noted that the known formulas of sports drinks are simple. The basis of sports drinks is a carbohydrate-saline solution, and their characteristic is increased compared with conventional soft drinks, the content of salts of sodium, potassium, and other components. For changing of the physiological properties of sports drinks in its chemical composition it is necessary primarily to adjust carbohydrate concentration and the type of content of the electrolyte, solution osmolality and content of flavoring substances. Most beverages for athletes regarding their chemical composition are approximately the same. Osmolality of isotonic beverages usually is 280-340 mosmol/kg, the content of carbohydrates is 6-8% (glucose, fructose, sucrose and maltodextrin), while the concentration of sodium and potassium amounts to 20-30, and 5 mmol /l, respectively [4, 6].

The basis of a sports beverage like any other soft drink is water, which is 85-95 % of the total mass. Technological scheme of water treatment is determined by initial chemical composition of water, which in turn depends on the source of water supply, natural and climatic conditions. For the beverage production the water from artesian wells is mainly used. Such water is hardly polluted with substances of human origin and longtime preserve physicochemical properties unchanged. However, the content of sodium and potassium in such water in not enough for making beverages for athletes based on it. In this regard, salts are added to water artificially [5, 6]. Precisely from this point of view the use of natural mineral waters is promising for production of beverage for athletes. It is also important that the minerals contained in mineral water, are better absorbed by the human body, in comparison with those that are made to drinks in the form of salts. In addition, certain health-giving properties of the mineral water allow reinforcing positive physiological effects on consumer beverage [6, 7].

In Ukraine, the most known natural mineral waters are found. For the beverage industry for athletes can be used sodium chloride mineral water that relate to table and medical-table kind of water with mineralization up to 5 mg/dm^3. Such water is close in

composition to quality mineral composition of drinks for athletes. But as the concentration of certain minerals is above recommended one, it is necessary to reduce it. To solve this problem, the authors offer to use a method of desalination by freeze.

Analysis of the advantages and disadvantages of modern methods of water desalination showed that freeze desalination method is characterized by low energy costs for process, lack of scaling and lack of the need to use chemicals for regeneration of work surfaces. Moreover the unique properties of chilled water are known, through which it is better assimilated by the body and bring a healthy and rejuvenating effect on the human. At the same time, the practical use of the freezing desalination method of natural mineral water is hampered by lack of recommendations on effective technological modes of this process. In this regard, the following purpose was stated: to develop the technological modes of desalination by freeze of natural mineral medical-table sodium chloride water for water treatment technologies in the production of beverages for athletes. To achieve this goal following tasks were solved:

– An effective way to organize the process of desalination water by freeze was proposed;

– The influence of different factors of the process of freezing on the quality of desalinated of natural mineral medical-table sodium chloride water was studied;

– Certain patterns of distribution of components of initial water between the frozen solid phase and a concentrated solution in the process of freezing were determined;

– The results of experimental studies were summarized and rational technological modes of desalination process of natural mineral medical-table sodium chloride water were identified.

Materials and methods

To increase the effectiveness of water desalination by freeze it was suggested to conduct it at variable during the process temperature of coolant in the crystallizer. At the same time in the beginning of the process the coolant temperature was maintained at the level required for supercooling of water and formation of germ of ice crystal on the external surface of the crystallizer. Further coolant temperature was varied in accordance with the liquidus line of natural mineral water, with little difference in temperature (0,6 ... 1,5 ° C) between the temperature of coolant and cryoscopic water temperature. In addition, it was suggested to saturate the mineral water before freeze with carbon dioxide to produce gas hydrates. It is known that water molecules through hydrogen bonds form a crystal lattice, and the gas molecules are placed in the inner cavities of the lattice, wherein held by Van der Waals forces [8]. This prevents the inclusion of other molecules and ions dissolved in the water substances in the ice structure [9]. Therefore, it was assumed that the saturation of mineral water with carbon dioxide before the freeze would enhance the increase of degree of desalination.

For experimental studies the natural mineral sodium chloride water "Kuyalnik" with total mineralization 3... 4 g/dm^3 was used. When performing the experimental study the influence of temperature mode of the crystallizer, carbon dioxide concentration in the initial water ($C_{carb.d.}$), water pH, initial common mineralization and temperature of water, duration of separation of solid frozen phase on quality of desalinated water were investigated. In the initial and desalinated water the content of ions of sodium, potassium, calcium, magnesium, chlorides, sulphates and bicarbonates, dissolved carbon dioxide, the pH and other water quality were determined. For this purpose, standard techniques were used.

The total impact of these factors of the process of freezing on the distribution of ions

between the frozen out solid phase and concentrated solution was evaluated by the magnitude of the coefficient of involving ions in the solid phase (K_i, %):

$$K_i = (C_{s.p.} / C_{i.w.}) \cdot 100 , \quad (1)$$

where $C_{s.p.}$ – ion concentration in the melt of the solid phase, mg/dm^3;

$C_{i.w.}$ – ion concentration in the initial water, mg/dm^3.

Investigation of the process of water desalination was carried out on experimental installation made in the Odessa National Academy of Food Technologies. Installation is equipped with modern control and measurement instrumentation. In the installation a freezing out of water was carried on the outer smooth surface of a seven vertical tubular crystallizers with an outer diameter of 12 mm and height 337 mm [10]. To study the influence of temperature modes on quality of desalinated water the following temperature modes of crystallizer (TX) were used: I - variable in the process, t_x = -2 ... -4 ° C, II - variable in the process, t_x = -3 ... - 5 ° C; III - a constant in the process, t_x = -5 ° C. For these temperature modes provided freezing of solid phase up to a thickness of 9 mm in all experiments the duration of the freezing process (excluding the duration of the water cooling process to onset temperature of its crystallization) was 60 min for the mode I, 45 min for mode II and 36 minutes for mode III. In modes I and II the creation of conditions for the water crystallization at the cooling surface was achieved by reducing the temperature of intermediate coolant in the beginning of the process of minus 5 °C. Since the first crystals on the surface of crystallizer the temperature of the coolant increased, and then changed automatically in the above ranges. In all experiments, the initial mass of desalinated of water was 2,32 kg.

Measuring of temperature mode of crystallizer was carried out using temperature sensors TCM – 002 and digital thermometer DS18B20, measurement of volume of water was carried out using measuring cylinders (PJSC "Steklopribor"), thickness and height of frozen out solid phase - with calipers L-150.

To investigate the influence of carbon dioxide concentration on the quality of desalinated water the packaged mineral water was degassed. Degassing of water was conducted by heating up to t = 90 ° C (for obtaining water samples $C_{\text{carb.d.}}$ = 0,27 g/dm^3), and by heating it to the boiling point and holding at that temperature for 9...10 min (for obtaining the water samples $C_{\text{y.r.}}$ g/dm^3 = 0).

In experimental studies were also used the water samples, which were not subjected to degassing. In water samples before degassation the carbon dioxide concentration was equal to 3,7 g/dm^3.

For processing and analysis of obtained experimental data modern mathematical packages, in particular the "Excel", were used.

Results and discussion

Analysis of the experimental data obtained during the investigation of the influence of temperature modes on the quality of desalinated water, showed that the best degree of desalination is achieved at a temperature mode of crystallizer I, regarding both ions and other physico-chemical parameters of water quality. For example, at a temperature range I the sodium cations are involved in the solid phase by 10...12 % smaller than when temperature conditions II and III (Fig. 1). At the variable temperature mode t_x = -2...-4 °C (mode I) the best degree of desalination also of other ions is achieved. Therefore, in the

course of further studies of the influence of other factors of the process of desalination on its quality temperature regime I was used. It should be noted that at this stage of study water samples, which were completely degassed were used.

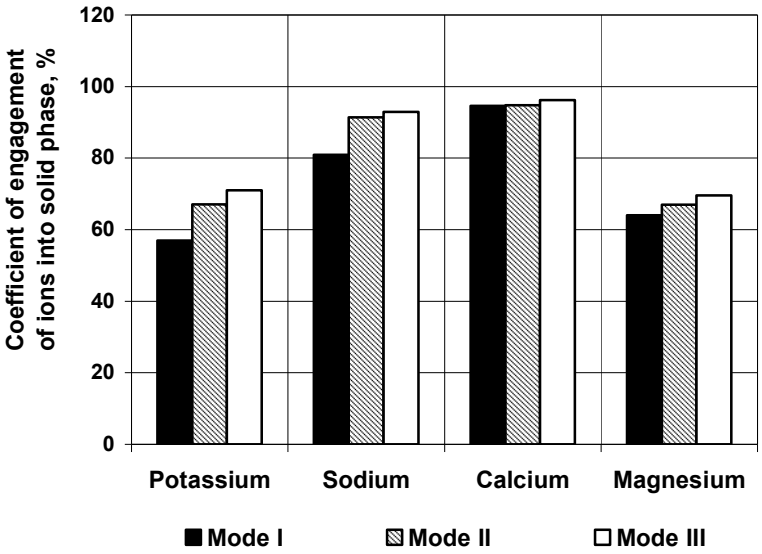

Fig.1. Influence of temperature mode of the process of freezing on the cationic composition of desalinated water

In course of experimental study of the influence of the carbon dioxide content in the mineral water before desalination on the quality indicators after freezing out the water samples with an initial value of dryness equal to 3280 mg/dm^3 and carbon dioxide contents equal to 0; 0,27 and 3,7 g/dm^3 were used. At the specified concentrations of carbon dioxide water pH was 8,32; 5,9 and 4,88 respectively.

Analysis of the obtained experimental data has shown that water, pre-saturated with carbon dioxide at a concentration of 3,7 g/dm^3 is better desalted. Under these conditions of carrying process in the solid phase less than 20 % of potassium ions, less than 12 % - sodium ions, less than 15 % - calcium ions, less than 6 % - magnesium ions are involved when compared with a process when desalted water is pre-saturated with carbon dioxide not (Fig. 2). Increasing efficiency of the process of water desalination in this case is explained by obtaining hydrates of carbon dioxide and ousting more impurities from the water from crystallization front.

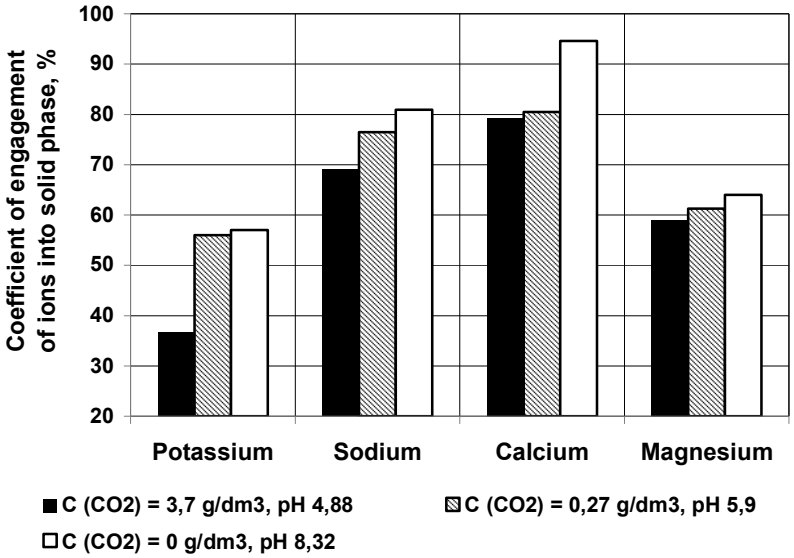

Fig. 2. Influence of the initial amount of carbon dioxide on the cationic composition of desalinated water

Adding of carbon dioxide to the initial water has reduced its pH, and there is very few published data on the patterns of influence of this factor on the quality of desalinated water by freeze. Therefore further studies have been conducted about the influences of content in water of ascorbic acid as a substance adding of which lowers the pH. It was added to the initial degassed water to a pH value that is equal to 4,88 (similar pH at $C_{carb.d.}$ = 3,7 mg/dm^3). Results of investigation were compared with the results obtained in the desalination of water samples with the same pH, but obtained by saturating water with carbon dioxide. It is found that the addition of ascorbic acid in water before freeze affects specifically on variation of its quality in the desalination process: at a solid phase at 39,3% involvement of magnesium ions is increased and involvement of potassium ions and calcium sulfate by 11,1; 40 and 15,1 % respectively is decreased. At the same time the effectiveness of freezing process (for total mineralization) is deteriorated by 15 %. Thus, it was found that the decreasing of pH of the water before desalination, in particular by the addition of ascorbic acid in it, is impractical.

Natural mineral water at the outlet from borehole has a temperature 8...12 ° C, but depending on the ambient temperature can be heated up to 20 ° C or higher. Therefore the influence of water temperature before freezing (in the range 8...20 °C) on its quality after desalination was investigated. In studies the samples of water with $C_{carb.d.}$ = 3,7 g/dm^3 were used. Analysis of the study's results has shown that the lowering of the initial temperature of the initial water improves the quality of desalinated water. With that, this improvement at all indicators of water quality did not exceed 5%, so further cooling of the water before freezing is not necessary.

Also the influence of initial common salinity of water on changing the quality of the desalination process is studied. For studies water with a salinity of 3,22 g/dm^3 and 2,37 g/dm^3 was used. As the samples with a lower concentration of salts desalinated water after the first stage of freezing was used.

It has been stated that reducing of the mineralization of the initial water affect on the distribution character of ions between liquid and solid phases during desalination. At the same time the involvement of the solid phase of chloride for 4,4%, potassium – 14,4% Sodium - 4,9%, sulfates - for 22,1% increases and reduced the involvement of calcium ions at 6,9%, magnesium - 22,3%, hydrocarbons - 16,1%.

It should also be noted that although a two-stage freezing allows to reach a greater degree of initial desalination of mineral water, but the efficiency of the process of separation on the desalinated water and the concentrate of impurities in the second stage of desalination is lower than in the first one. In addition, deeper desalination of natural mineral water "Kuyalnik" in case it is used for the production of beverages for athletes is impractical. It is explained by the fact that after one-step freezing of initial water, which is pre-saturated with carbon dioxide at a concentration of 3,7 g/dm^3, and when a temperature mode I the quality of desalinated water needed for sports drinks production is reached.

Based on calculations according to the experimental data of coefficients K_w the nature of the influence of factors of the freezing process to the order of motion of ions in the solid phase is defined:

- change of temperature mode of crystallizer, carbon dioxide concentration in original water, pH and initial temperature of water does not influence the order of motion of ions in the solid phase. In all experimental studies performed it was as follows: $Ca^{2+} > HCO_3^- > (Na^+ > Cl^-) > (Mg^{2+} > SO_4^{2-} > K^+)$. It was found that the ions listed in brackets may be interchanged with one another due to insignificant difference in their percentage;

- change of initial salinity of water affects the order of ions motion in the solid phase. For example, when reducing the initial mineralization of natural sodium-chloride water from 3,22 to 2.37 g/dm^3 the motion order of ions in the solid phase chznge from said above to the next: $Ca^{2+} > SO_4^{2-} > (Na^+ > Cl^-) > (HCO_3^- > Mg^{2+} > K^+)$.

To confirm the stated order of ions motion, there were conducted a study of influence of separation duration of the solid phase (spontaneous runoff of concentrated solution from the surface of frozen phase under action of gravity in the environment conditions) on the quality of desalinated water. It was found that separation of the solid phase for 60 min allow to reduce the content of ions of dissolved salts in desalinated water on 28...62,4 %, and separation of the solid phase for 100 min - on 36...69,7 % in contrast to desalinated water, which was obtained without separation of the solid phase. However, during separation water purification from magnesium ions and sulfates was most efficient. And most chelated ion, which was the least extracted from the solid phase during separation, was calcium.

In the course of experimental study performance there were also received dependences reflecting the influence of temperature of crystallizer, concentration of carbon dioxide in initial water, pH, temperature and salinity of initial water to such kinetic characteristics of desalination by freeze as changing with time of height and thickness of the solid phase, as well as water temperature. Peculiarity of changes the kinetic characteristics is that adding carbon dioxide to the initial water significantly affected the height of the frozen solid phase. At the same time increasing of the height of solids was equal to 6 mm, compared with the solid phase obtained from the sample of degassed water.

Summary of the study results allowed to recommend the following technological parameters of the carrying out the process of desalination of natural mineral sodium chloride water by freeze: operating temperature mode of crystallizer, which is changing in the process from -2 to -4 ° C, the concentration of carbon dioxide in the water at the beginning of the process of freezing - 3,7 g/dm^3, duration of the desalination process (process without cooling) - 60 minutes, one step of freezing, melting of solid phase under

ambient conditions without prior separation of the frozen solid phase [11, 12]. With such technological modes of the carrying out the process of freezing it is possible to obtain water with mineral composition, mainly with existing relevant recommendations to the mineral composition of beverages for athletes (Table 1).

Table 1

The electrolyte content in sports drinks and in desalinated water, prepared on the claimed process

Ions	Recommended mineral composition of drinks for athletes, mg/dm^3 (Pat. RU 2375930 Composition non-carbonated sports drinks, non-carbonated sports drink and method for producing, 2009)	Mineral composition of desalinated water on claimed method
Na^+	230…1725	750…850
K^+	117…780	11…13
Mg^{2+}	12…364,5	15…45
Ca^{2+}	20…600	20…85

Lacking in water content of, e.g., potassium ions, will be compensated by the adding of carbohydrate compositions in water prepared in concentrated form.

Conclusion

1. As a result of performance of experimental studies the regularities of influence of such factors of freeze desalination process as operating temperature of crystallizer, pH, temperature and salinity of the initial natural sodium chloride water on quality indicators of prepared water, the order of the ion motion in solid phase, as well as changes in the characteristics of the solid and liquid phase were revealed.
2. The results of experimental studies are summarized and recommendations on the method and technological modes of desalination process by freeze of natural mineral medical-table sodium chloride water for technologies in the production of beverages for athletes are made.

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High-energy discrete processing in technology of extraction of wool grease

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Keywords:

Wool
Grease
Lanolin

Article history:

Received 10.06.2014
Received in revised form 23.07.2014
Accepted 02.09.2014

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Abstract

Introduction. Existing ways of extraction of wool grease have the high cost price and are not harmless. For increase of efficiency of extraction of wool grease in work application high-discrete processing (HDP) wool-washing water is offered.

Materials and methods. Determination of conductivity, RedOx-potential, temperature, pH and the total number of lipid-water ions was carried out using a combined tester Combo HI 98129 («HANNA Instruments»). Concentration of free radicals was determined by titration method. Viscosity change of wash water under the influence of HDP was investigated by the method of measurement by an Ostwald. Influence of duration of the HDP to change the surface tension of the wash water was measured by counting drops.

Results and discussion. As a result of HDP, there is a change of physical and chemical properties of the wash water, namely: reduction of conductivity wool-washing water (from 2969 μS/cm to 2837 μS/cm) and the total ion content (1487 mg/l to 1298 mg/l), increased pH environment (8.35 to 9.40), temperature (from 18°C to 43°C) and RedOx-capacity (from 60 mV to 93 mV). This is because HDP helps create areas of high concentration of mechanical energy, which leads to a high impact strength and high pressure. Temperature rise in turn affects the hydrogen bonds, with the collapse cluster complexes of water and hydration shells around ions with the formation of free radicals, which means, that the presence of chemical reactions in the water. Reduced viscosity (with $1{,}034 \cdot 10^{-3}$ Ns/m^2 to $0{,}903 \cdot 10^{-3}$ Ns/m^2) and surface tension (from 39.86 cN/m to 37.56 cN/m) of wash water under the influence of the HDP is due to breaking of hydrogen bonds of water associates and the weakening of the forces of attraction between the molecules within the clusters and in the surface layer – structural changes of water. The most important chemical and structural changes occur in the washings at 180 with the processing time.

Conclusions. Under the influence of the HDP occur chemical and structural changes that contribute to the intensification of the process of extraction of wool grease.

Introduction

Fat contained in sheep's wool, due to specific properties, is an indispensable raw material for various industries such as food, medical, cosmetic, mechanical engineering, as well as in production of military-technical and military-space specialty [1, 2].

The composition of wool grease (lanolin) is very complex and till now has not been studied thoroughly. Mostly it is a mixture of esters of high alcohols (cholesterol isocholesterol etc.) with higher fatty acids (myristic, palmitic, cerotic et al.) and free high molecular alcohols [3].

The most valuable feature is its ability lanolin emulsified to 180-200% of its own weight of water up to 140% glycerol and 40% ethanol (70% concentration) to form an emulsion of «oil-water». Addition of a small amount of lanolin to fats and hydrocarbons sharply increase their miscibility with water and aqueous solutions, which resulted in its widespread use in the composition of the hydrophilic-lipophilic bases [4].

In the food industry the use of lanolin is allowed in all countries because of the lack of evidence on the safety of the substance. International designation of the food additive is E 913 [5-7].

In food production lanolin is used as glazes agent and flame damper [8]. Glaze with the addition of lanolin shine and pleasant appearance of products, and also plays a role in the formation of taste. Flame dampers prevent foaming and make uniform consistency of the product. Additive E 913 can be found in the composition of the glaze on the following foods: pastry flour products, candy, chocolate, jelly beans, nuts and chewing gum. Extend the application of lanolin as a component of the coating mixes for fruit. Such mixtures give the fruit trade appearance, allow longer keep them attractive to the consumer. Most often these procedures are subject to oranges, lemons, limes, apples, pineapples, peaches, pears, melons, plums [9].

Due to the vast scope of lanolin in wool fat demand is constantly increasing. However, now in Ukraine wool grease virtually all of which could produce a valuable product – lanolin, lost along with the washings. In addition, untreated wash water harms the environment and creates environmental problems. Therefore, the maximum recovery of wool grease from washing solutions is an important issue.

Literary review

To date, for the extraction of wool grease from waste solutions used physical and mechanical or chemical methods [10].

Among the physical and mechanical methods for recovering wool grease the most widely separator (processing of cleaning solutions in a centrifugal field) and flotation-separator (flotation cleaning solutions) methods [11]. The average number of trapped fat by using physical and mechanical methods of fat extraction is 60-65%. However, these methods have several disadvantages: sophisticated equipment, high consumption of water, detergent and energy, lower the quality of the fat-lanolin in this way, because of its pollution and exposure to use in the cleaning chemicals.

Chemical methods include a washing treatment solution with different chemical reagents: acid chloride of lime, calcium chloride, bentonite (colloidal clays), organic solvents [12]. Completeness of extraction of fat using these methods, up to 90%, but the fat clogged by impurities, detergents, has high acidity. In addition, these methods are required equipment, resistant to chemicals [4].

As a result of these factors, the existing methods of extracting wool grease have a high cost and are environmentally unfriendly.

According to [13], the washings resulting from the washing of wool comprise suspended solids, such as sand, clay, wool fibers, dissolved mineral salts, mainly sodium chloride, potassium and magnesium. Organic components wash water – an alkaline agent (soap, soda, surfactants), fatty acid salts, wool grease (Table 1). It should be noted that the composition of the wash water varies depending on the type of processed wool and its mode of washing.

Table 1

The indicators of quality of wash water

Indicator	**Fine wool**	**Semifine wool**	**Coarse wool**
Concentration of suspended solids, g/l	15-25	15-17	40-70
Wool grease concentration, g/l	12-20	10-15	1-3
Solids, g/l	35-50	45	15-75
Ash content of dry residue, %	35	40	40
Transparency, cm	0	0	0
pH	10-11	9-10	8-10

Given the relatively high alkalinity and the presence of surfactants, wool grease is water stable emulsion state, so the conventional methods of extraction are inefficient and require intensification. According to the authors, the most promising in this respect are the physical methods of influence.

So, today is known to use a physical method of intensification of obtaining wool grease, which is purified by electro-dialysis suspended solids wool-washing of water by electro-coagulation, which enables up to 89% of wool grease, deodorize and return the purified water in the wash cycle of wool [14].

As an alternative method of extraction of the wool fat from wool-washing water foreign scientists proposed method which based on the action of the microwaves (8 min, 750 W, 2450 MHz), in combination with a co-solvent acetone-hexane (1: 1) [15].

Innovative direction in the extraction technology is the use of wool grease HDP. The essence of this method consists in the fact that the implementation in the bulk liquid in an open or closed vessel, specially shaped impulse electric discharge zone around its formation having extremely high hydraulic pressures which can perform useful mechanical work, and supported by a complex physical and chemical phenomena [16, 17].

In order to intensify the process of extraction of wool grease in the work carried out determination of physical and chemical properties of wool-washing water under the influence of the HDP.

Materials and methods

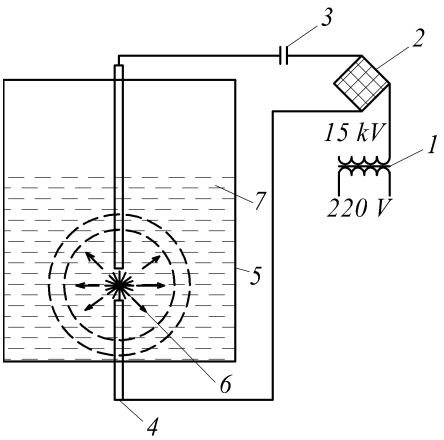
The study was the water after washing semifine Tsigal wool. Table 2 shows the characteristic parameters wash water, which further exposed to HDP.

Electrical discharge treatment was carried out in a laboratory setup (Fig. 1), which was developed by the Institute of Pulse Processes and Technologies NAS of Ukraine (Nikolayev), together with scientists from Kherson National Technical University.

Table 2

Quality indicators used wash water

Indicator	Value
Suspended solids, g/l	16.6
The particle size of contaminants, microns	100
Wool fat content, g/l	7-8
Surfactant content, mg/l	0.7
Total hardness, mEq/l	11.6
Transparency, cm	2
Turbidity, mg/l	132
pH	7.65



1 – boosting transformer;
2 – diode bridge;
3 – condenser;
4 – electrodes;
5 – the reactor vessel;
6 – zone of occurrence of the discharge;
7 – liquid.

Fig. 1. Schematic diagram of the laboratory setup

Equipment performances are presented in Table. 3.

Table 3

Equipment features

Name of the parameter	Value
Mains current	AC, single phase
Frequency, Hz	50±0.1
Supply voltage, V	220±22
Efficiency, at least	0.7
Operating voltage, kV	15
Pulse repetition frequency, Hz	1.5
Capacity of the capacitor bank, uF	0.5
Power consumption, W	400

Wool-washing water with varying exposure time from 30 s to 300 s exposed the electrical discharge.

Electrical conductivity, RedOx-potential, temperature, pH and the total number of ions is determined by the combined tester Combo HI 98129 («HANNA Instruments»). Accuracy of data values in the measured intervals are ± 0.5%.

Free radical concentration was determined by consumption of oxalic acid, which reacts only with radicals by permanganometric titration [18].

Viscosity change of wash water under the influence of HDP was investigated by the method of measurement by an Ostwald runtime fluid outflow via a glass capillary viscometer [19], and the surface tension (ST) – stalagmometric method [20] by counting drops.

Results and discussion

To determine the effect of HDP on the physical and chemical properties of wool-washing water in the measured indicators such as specific conductivity (σ), RedOx-potential, temperature (T), pH and the total number of ions (ΣI) are done. The results are shown in Table 4.

Table 4

Research of influence HDP on indicators of washing waters

τ, *s*	**σ**, *μS /cm*	**RedOx-potential**, *mV*	**T**, *°C*	**pH**	**ΣI**, *mg/l*
0	2969	60	18	8.35	1487
30	2917	64	25	8.80	1414
60	2875	67	28	8.88	1348
90	2867	68	31	9.07	1340
120	2861	71	35	9.13	1333
150	2861	85	43	9.32	1324
180	2849	86	43	9.37	1310
240	2841	89	43	9.36	1304
300	2837	93	43	9.40	1298

Analysis of the results showed that with increasing duration of HDP decrease the conductivity of wool-washing of water and the ions, increasing the pH of the medium, temperature and RedOx-building. This is because HDP helps create areas of high concentration of mechanical energy, which leads to a high impact strength and high pressure. Temperature rise in turn affects the hydrogen bonds, with the collapse cluster complexes of water and hydration shells around ions with the formation of free radicals, which means that the presence of chemical reactions in the water.

But the information on chemical reactions in the washings after washing of wool fiber is absent. Therefore, it was determined by the quantity of waste in the washings of free radicals in the HDP. The results are shown in Fig. 2.

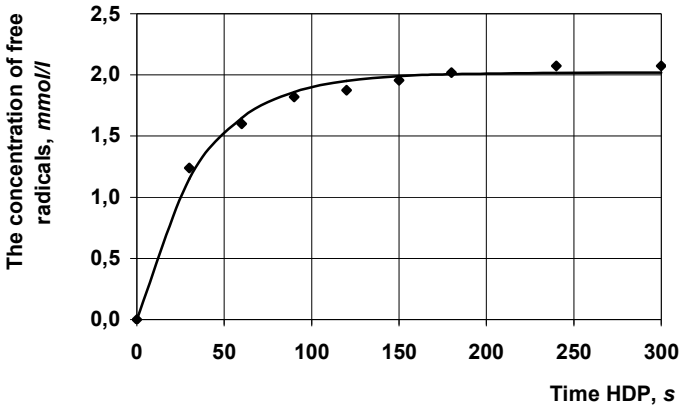


Fig. 2. The dependence of the concentration of free radicals on the duration of the HDP

According to data presented in Fig. 2, the concentration of free radicals increases with the duration of the HDP. Moreover, within the first 30 s of processing, a sharp increase in free radical concentration to 1.63 mmol/l. With further increasing treatment time up to 180 s free radical concentration increases uniformly (2.02 mmol/l), and more 180 s – does not lead to a significant increase in their concentration (2.75 mmol/l).

According to [16, 17, 21] cavitations lead not only to chemical, but also for structural changes in the water. In the works Vitenko T.N. [17, 22] shows that the restructuring of water is characterized by a change in viscosity and surface tension. Therefore, in the study, we investigated the effect of the duration of HDP on the viscosity and ST wash water. The data obtained are presented in Fig. 3 and 4.

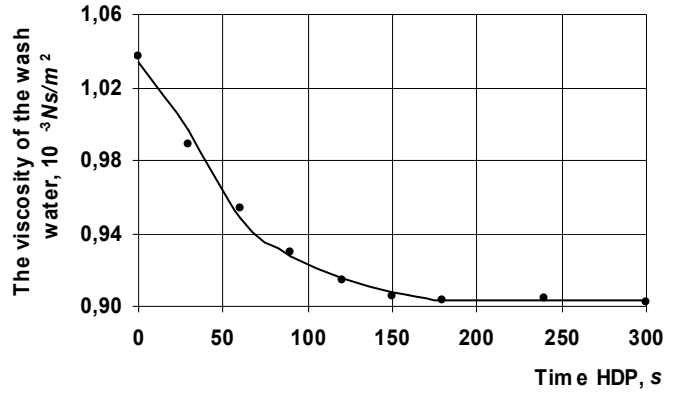


Fig. 3. The effect of the duration of HDP on the viscosity of the wash water

Analysis of the results presented in Fig. 3 shows that an increase in the HDP, there is a decrease in viscosity wash water. Thus, during processing, the water for 60 s there is a considerable decrease of the viscosity from $1.2 \cdot 10^{-3}$ *Ns/m*^{2} to $0.86 \cdot 10^{-3}$ *Ns/m*^{2} and with duration of greater than 180 s comes to equilibrium water system under study. This, in our opinion, can be explained by the fact that under the influence of cavitations is the process of restructuring the water.

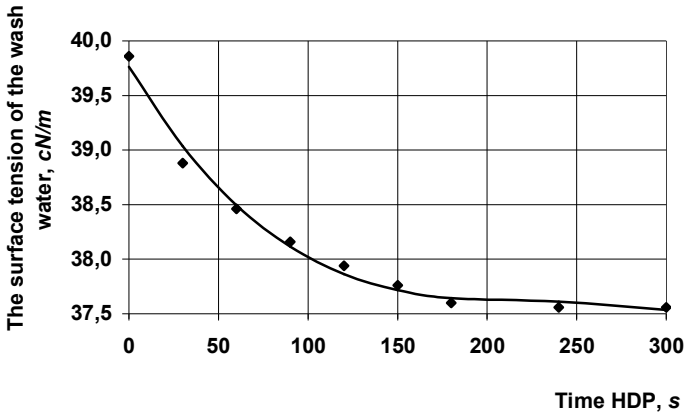


Fig. 4. Effect of the HDP, on ST wash water

Determination results of ST showed that its maximum decline from 39.75 cN/m to 37.70 cN/m is observed when the duration of treatment with 180 s. With further increase of the HDP, ST does not change significantly. This can be explained by the fact that as a result of high discrete exposure hydrogen bonds break water associates forces of attraction between molecules within the clusters and the surface layer are weakened, which leads to reduction in ST.

Comprehensive analysis of the results of the determination of physical and chemical properties wash water indicates that the action of HDP occur chemical and structural transformations that change the properties of all the components of the lipid-system.

The most important chemical and structural changes occur in the washings at 180 s with treatment duration.

Conclusions

1. To improve the efficiency of extraction of wool grease are proposed use of HDP wool-washing water.
2. Influenced HDP in fat-containing wool-washing waters going changes in the physical and chemical properties, namely: lowering conductivity and the total content of ions, increase RedOx-potential, temperature, pH and concentration of free radicals.
3. Reduced viscosity and surface tension of the wash water by the action of HDP leads to structural transformations lipid-system.
4. The most significant changes in the washings occur after 180 s HDP.
5. Chemical and structural transformations wool-washing water, which occur under the influence of HDP promote intensification of the process of extraction of wool grease.

Further studies will be aimed at studying the effect of HDP on the extraction efficiency of wool grease extraction and wash water separator means.

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Influence of the constituent alpha acids of Ukrainian varieties of hops and hop preparations on quality indicators of mash and beer

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Keywords:

Hops
Alpha-acid
Kohumulon
Mash
Beer

Article history:

Received 19.05.2014
Received in revised form 29.07.2014
Accepted 02.09.2014

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Abstract

Introduction. The aim of the study is to establish the dependence of the bitterness of mash and the beer intoxication on the quality and quantity of the homologues of alpha acids in the Ukrainian varieties of hops, and on the content of cohumulone in alpha acids in particular.

Materials and methods. Aromatic and bitter hop sorts of Ukrainian selection with different content of cohumulone in alpha-acids were investigated and so was the beer, made of these components. High performance liquid chromatography (HPLC) was used to determine the amount and composition of bitter hop substances and their transformation products in the brewing process; also there were spectrophotometric methods for quality control of bitterness of hopped mash and finished beer in use.

Results and discussion. The composition of bitter substances of aromatic and bitter hop sorts of Ukrainian selection was analyzed and so the beer, made of them. It was noted that the alpha-acids of the analyzed sorts incorporate a wide range of cohumulone content rated from 16.7% in the Kumyr sort to 44,1% in the Ruslan sort. The dependences between the quality and quantity of the bitter hop sorts and bitterness and quality of hopped mash and beer were established. The content of cohumulone in alpha-acids of hops has to be less than 28% to obtain quality bitter beer. The role of the beta-acid compounds in the formation of bitter mash, hopped with aroma hop varieties with a ratio of beta to alpha acids acids around one, is much more important compared to the bitter varieties.

Conclusions. The conducted researches show that in applying the bitter hops with different compositon of alpha-acids for mash intoxication, this usage is more effective in the sorts that have a large content of cohumulone.

Introduction

Diverse in nature and chemical structure of substances that make up the hops give beer a typical bitter taste, specific aroma and determine many other important biotechnological properties. The compounds of hops are effective agents for the deposition of high-nitrogen compounds of mash take part in lighting , foaming, and exhibiting bactericidal and preserving effect on the final product, increasing the stability of beer in his storing.

In the previous studies of domestic and foreign scientists [1-4], it was found that beer brewed with hops or hop varieties of certain drugs varies considerably according to the nature of bitterness, flavor and aroma. This is due to the feature of the biochemical composition of bitter substances, polyphenolic compounds and essential oils of aromatic and bitter hop sorts. The different ratios of the components of these compounds influence the taste and aroma of beer in their own way. Therefore, the selection of sorts with optimal composition of bitter substances in order to brew beer with excellent quality and bitterness are the important issues as for the Brewers Association of America, so for European and Ukrainian brewers.

The major part in the formation of bitter beer [1,2,5] for hopping mash belongs to the alpha acids, which consist of humulone, cohumulone, adhumulone, prehumulone and posthumulone. Moreover, depending on the length of the side chains of acyl residue at the second carbon atom of the hexadiene ring changes the solubility of homologues of alpha acids; meanwhile, this rule takes place: the longer the side chain is, the lower is the solubility. That's why cohumulone's solubility is much higher, than humulone's or adhumulone's [1].

The isomers of original bitter hop substances, which are contained in its cones in small quantities and formed during boiling mash with hops, affect the specific qualities of beer the most. During boiling, alpha-acids transform into iso-alpha-acids and, as a result, the hexadiene ring of alpha-acids becomes a pentadiene ring of iso-alpha-acids [1]. The iso-alpha-acids are more soluble in mash and more bitter than alpha-acids [1, 2] and form 90 – 95% of the general bitterness of beer.

It is a known fact [1, 4], that isohumulone, isocohumulone and isoadhumulone have almost the same degree of bitterness. However, during boiling mash with hops isomerization of homologues of alpha – acids proceeds with the formation of various isocompounds. The proportion of homologues of alpha acids is very important here. Czech hops (sort Zhatetskyy) is characterized by high content of humulone , adhumulone (80%), while in German and American resinous sorts such as Hercules, Tomahawk cohumulone is predominant (50%). Cohumulone transfers into an isomer much better than the other alpha-acids' components, that's why the hop sorts with a high amount of cohumulone are more bitter. But this fraction is credited with a negative role in the formation of bitter beer [6]. However, although, humulone dominates in the Czech sorts composed of alpha acids, the bitterness if Czech beer is represented mainly by isohumulone. During the processing of hop varieties with superior content of cohumulone beer contains mostly iso-cohumulone , and the quality of bitterness, according to M. Kusche etc. is much worse [7, 8]. It is possible that the quality difference of the original alpha acids is at the same time the cause of a known difference in the quality of the bitterness of beer, which can be very essential. That is why the selection of varieties with optimal composition of bitter substances to obtain a beer of excellent qualified bitterness is a live issue to the Brewers Association of America [6] European brewers [7] and Ukrainian beer brewers [1].

As can be seen from the analysis of the literature, the composition of bitter hop substances of foreign sorts and their homologues' impact on the quality of bitter beer are

well studied. In contrast, similar studies with native hop varieties were barely held. In this regard, to ensure a stable and high-quality beer bitterness it is important to investigate the effect of individual components of the alpha acids of domestic varieties of hops and hop preparations on quality indicators of mash and beer.

The aim of the study was to establish the dependence of the bitter mash and the quality of beer intoxication on the quantity and the quality of the homologues of alpha acids of domestic hop sorts including the content of cohumulone composed of alpha acids.

Materials and methods

The researches were held in a certified laboratory of the department of Biochemistry of hop and beer Institute of Agriculture in Polessye of NAAS of Ukraine. The cones of aromatic and bitter hop sorts of Ukrainian selection of different content of cohumulone composed of alpha acids and beer made of them were investigated.

In the studies there were the modern international physical and chemical methods of analysis of bitter substances of hops and hop preparations and products of their transformation during brewing in use, such as: HPLC, spectrophotometry and also quality control methods of hopped mash of finished beer which are harmonized with the methods of the European Brewing Convention [1,9,10].

Methods of research of quality hop indicators. Sampling hops of each sort was carried out in the phase of full technical maturity. The average weight of a sample for identification and biochemical studies was at least 0.5 kg of dry hops.

The bitter hop substances are: α- and β – acids and their components, cohumulone in particular was extracted from the hop cones by an organic solvent – methanol. The ratio between the weight of hop cones and extractant was 1:10. The number of α-and β-acids and content of cohumulone in composition of α-acids were determined by high performance liquid chromatography. Chromatography was carried out using a liquid chromatograph Ultimate 3000 with UV detector at 35 degrees Celcium. The column with a size of 100 x 2.1 mm, which was filled with sorbent Pinacle DV C18 on 3 microns was used. The solution of methanol, water and acetonitrile was used as a mobile phase in the ratio of 38:24:38. The international standard ISF-3 was used for the quantitative determination of the components of bitter substances.

Methods of research of quality indicators of mash and beer. Experimental beer brewing with hop samples were conducted in the laboratory and in the Brewery Institute, with capacity of 100 liters of beer per cycle, which quite adequately simulates the real conditions of the brewing industry. The experimental preparation and congestion filtration were performed using an acceptable technology. Mash was prepared from 100% barley malt. After a full set mash was boiled for 30 min. Afterwards different hop sorts were put into mash in each option of the experiment; this process was represented in two installments: 85% at the beginning of intoxication, 15% - for 15 minutes. before the end of intoxication. The total duration of boiling mash with hops was 90 min. The bitterness of mash, which is formed in the process of boiling with hops as a result of extraction and isomerization of bitter hop substances, was determined on a spectrophotometer according to the method of EMU 8.8. (international method MI). The method is based on measuring the optical density of isooctane extract obtained by extraction of bitter hop substances of acidified hopped beer mash with isooctane (2,2,4-trimethylpentane) on a spectrophotometer at the wavelength of 275 nm against isooctane.The bitterness was calculated in terms of optical density; the quantity of bitterness is expressed in international units of bitterness - EMU units.

Results and discussion

The influence of cohumulone of bitter hop sorts on the quality of mash.

The bitter substances of hop sorts of Ukrainian selection, including alpha – acids, have a wide range of cohumulone content, rated from 16.7% in sort Kumyr to 44.1% in sort Ruslan. For research, we have selected hop varieties of bitter type with minor deviation of alpha acids and the ratio of beta acids to alpha-acids and with different content of cohumulone as a part of of alpha acids (Table 1).

Table 1

Characteristics of bitter substances of the studied hop varieties

№	Hop sort	Content of α - acids, %	Cohumulone in α - acids, %	Content of β - acids, %
1	Kumyr	7,2	16,7	3,9
2	Granite	7,2	19,6	3,3
3	Nasar	7,3	26,4	4,9
4	Promin’	7,5	29,0	4,1
5	Xanthi	6,2	35,1	4,0
6	Ruslan	6,7	44,1	4,7

The laboratory beer brewing was conducted with the given hop sorts, the number of alpha – acids and cohumulone, which was put in 1 dm^3 of mash, was calculated. The bitterness oh hopped mash was identified using spectrophotometer.

With the normalization of domestic hop varieties of bitter type, according to Industrial Technological Instructions, the same amount of alpha acids is put into mash (nearly 60 mg/dm^3) but a different amount of cohumulone rated from 10,0 mg/dm^3 in hop sort Kumyr to 26.4 mg/dm^3 in sort Ruslan. Thus, the magnitude of bitterness of hopped mash also varies from 33.1 units. EMU (sort Kumyr) to 41.1 units. EMU using hop varieties Xanthi, as reflected in fig. 1.

From the analysis of Table. 1 we see that in hops of sort Xanthi the amount of cohumulone composed of alpha acids was 52.2% more compared to the lowest content of cohumulone in hops of sort Kumyr. Thus, according to the data in Fig. 1 the quantity of bitterness of hopped mash increased by 19.5% compared to the sort Kumyr . That is, with increasing mass fraction of cohumulone composed of alpha acids of hop sort Xanthi by 1%, the value of of bitterness of hopped mash increases by 0.37%. During intoxication of mash by hop sort Ruslan with significantly higher content of cohumulone composed of alpha acid the quantity of mash virtually unchanges.But, if in hop sort Ruslan the amount of cohumulone composed of alpha acids was 62.1% more compared to the hop sort Kumyr, the value of bitterness of mash, hopped by this hop sort would increase only by 17.3% compared to the sort Kumyr. With the increase of mass fraction of cohumulone composed of alpha acids of sort Ruslan by 1% the quantity of of bitterness of hopped mash increases by only 0.28%. After analyzing the ratio between growth of cohumulone composed of alpha acids and the change of the value of bitterness of mash, hopped by the given hop sorts, the conclusion follows: with growing proportion of of cohumulone composed of alpha acids by 1%, the value of of bitterness of mash, hopped by the bitter domestic hop crops, increases from 0.24% for sort Granite to 0.42% for sort Promin’. The research findings expain why we do not always get a stable normalized beer bitterness during the normalization of mash on the content of alpha acids.

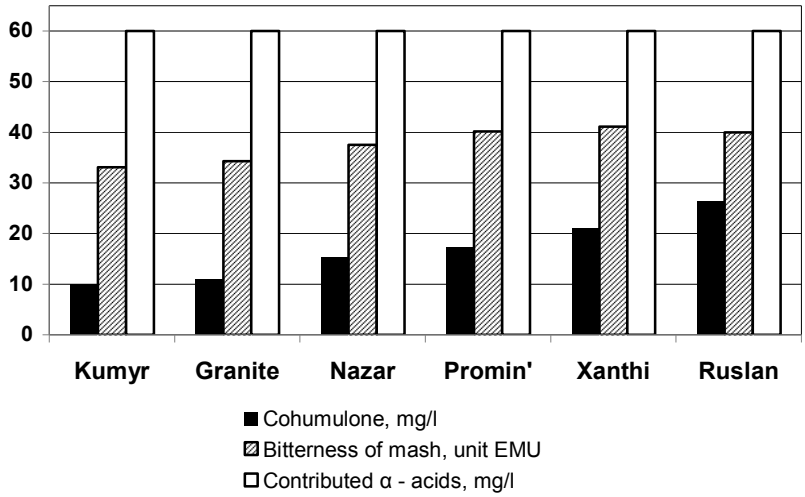

Fig. 1. The number of bitter hop substances, made to the mash and defined in it

It was found by the conducted studies, that at application for intoxication of mash by bitter hop sorts with different composition of alpha acids, it is more effective to use them for sorts with a high content of cohumulone.

The influence of cohumulone in aromatic hop sorts on the quality of mash and beer.

To establish the correlation dependencies, we have also chosen to study a group of aromatic hop varieties with different content of cohumulone composed of alpha acids and small deviation of ratio of beta – acids to alpha – acids (Table 2).

Table 2

The characteristic of bitter substances in aromatic hop varieties

№	Hop sort	Content of α - acids, %	Cohumulone in α - acids, %	Content of β - acids, %	Ratio of α/β – acids
1	Hmeleslav	3,7	22,1	4,1	1,01
2	Slavonian	4,6	23,3	5,9	1,29
3	Zagrava	6,1	25,6	6,6	1,06
4	Haidamak	4,8	28,8	5,6	1,17

At the mini – brewery of the Institute beer was brewed with the given hop sorts after laboratory beer brews and their analysis. The intoxication was performed by classical technology at the rate of 60 mg of bitter hop substances per 1 dm^3 of mash.

During the research we determined the number of put beta acids and cohumulone to 1 dm^3 of mash and the resulting value of mash, that is displayed in Figure 2.

The findings indicate that by the industrial technological Instruction, in normalization of various hop sorts the same amount of alpha acids is put into mash (60 mg/dm^3) but a different number of cohumulone (from 13.2 dm^3 in hop sort Hmeleslav to 17.3 dm^3 in sort

Haidamak. Herewith, The magnitude of bitterness of hopped mash also varies from 24.1 units EMU to 32.6 units EMU. But, if in a hop sort Haidamak the amount of cohumulone composed of alpha acids was 23.3% more compared to the lowest content of cohumulone in hop sort Hmeleslav, the value of bitterness of mash, hopped with a given hop sort, would increase by 26,1 % compared to Hmeleslav. So, with the increase of mass fraction of cohumulone composed of alpha acids of sort Haidamak by 1%, the quantity of of bitterness of hopped mash is increased by 1.1%, while for bitter hop sorts, which have a ratio of beta acids to alpha acids – 0,3-0, 6, this index was much lower and was only 0,24-0,42.

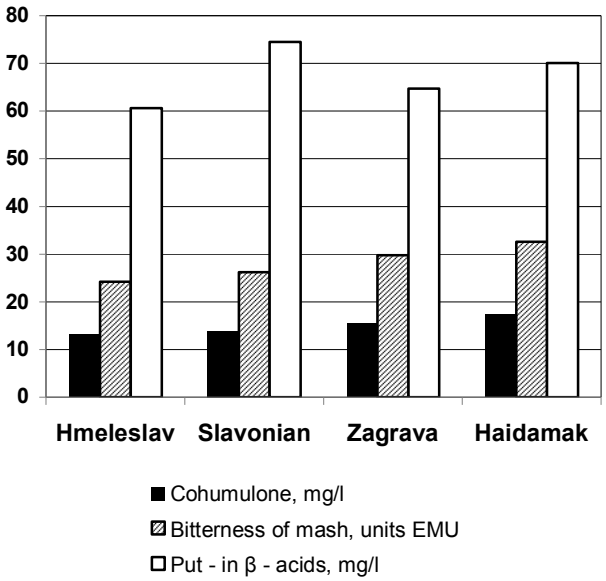

Fig. 2. The number of put – in and defined bitter substances of aromatic hop sorts in mash

The results revealed that in the formation of bitterness of mash, hopped with aromatic hop sorts from the ratio of beta acids to alpha acids around 1, the role of beta-acids' compounds is much higher compared to the bitter varieties.

The defined dependences are also stored in the study of finished beer, characteristics of which are shown in Table 3.

Table 3

The content of bitter substances and polyphenolic compounds in beer samples

№ sample	Hop sort of the beer	Bitterness of beer, units EMU	Total polyphenols, mg/dm^3
1	Hmeleslav	15,07	196,0
2	Slavonian	19,64	180,4
3	Zagrava	23,58	172,0
4	Haidamak	24,51	178,0

Organoleptic evaluation of beer was estimated on a closed tasting according to the requirements imposed on the given variety of beer in 25-point system (Instructions for technochemical control of the brewing industry from 25.12.90). Organoleptic evaluation of

the quality of beer prototypes and it's biochemical evaluation show that all the samples satisfied the requirements of current ISO 3888-99. Beer. General specifications, but but they differed greatly in taste, aroma and character of bitterness (Table 4).

Table 4

Technological evaluation of the studied hop varieties

Options	Names of quality indicators							
					Taste			
	Transparency	Colour	Foaming	Flavour	Fullness	Hop bitterness	Total evaluation in points	Evaluation
Hmeleslav	3	3	5	3,4	4,0	4,0	22,4	excellent
Slavonian	3	3	5	3,8	4,2	4,5	23,5	excellent
Zagrava	3	3	5	3,6	3,9	4,1	22,6	excellent
Haidamak	3	3	5	3,5	3,7	3,8	22,0	excellent

The conducted studies have shown that the best beer was received while hopping mash by a hop sort Slavonian with delicate aroma. Beer had a nice flavor, fresh hop aroma and delicate, unresidual bitterness. For the given beer sample with hop the smallest amount of cohumulone but the largest amount of beta – acids was put in (Fig. 2).

Beer with aromatic hop sorts of Zagrava and Hmeleslav also was of an excellent quality. Beer of these options had nice flavor and aromatic properties. The bitterness of the 1st sample was soft, bound, conformed with the composition of the drink, but insufficient. The third sample of beer had a balanced, intense, a little excessive, but pleasant bitterness.

The fourth sample of beer had a good taste, but it was inferior to the aroma and hop bitterness to other samples. The committee members noted the slightly rough bitterness.

We have noted that in the first sample of beer, which was made with a hop sort Hmeleslav with the smallest amount of cohumulone and beta acids, bitterness of beer was the lowest. With increasing content of cohumulone composed of alpha acids from 22.1% in hop sort Hmeleslav to 28,8% in sort Haidamak and with increasing amount of put – in cohumulone with the given hop sorts from 13.2 to 17.3 mg to 1 dm^3 the bitterness of beer also increases, as spectrophotometric so organoleptic. Thus, the content of cohumulone composed of alpha acids of hops should be less than 28% to obtain high-quality beer bitterness.

So, the different representatives of bitter hop substances have different bitterness both in total intensity and for individual taste nuances. Taking into account the maximum qualities of all the components of a group of bitter substances allows efficient use of the most expensive raw materials, creating new beers.

Conclusions

1. The quality and the quantity of of beer bitterness depends on the varietal characteristics of hops, that is, on the quantity and quality of the homologues of alpha-and beta-acids fraction.

2. When applying hops with a slight deviation of ratio of beta – acids to alpha – acids and different composition of alpha acids, for mash intoxication, more efficient use of it is for varieties with a high content of cohumulone. The content of cohumulone composed of alpha acids of hops should be less than 28% to obtain high-quality beer bitterness.
3. The role of the beta-acid compounds in the formation of bitter mash, hopped with aroma hop varieties with a ratio of beta to alpha acids acids around one, is much more important compared to the bitter varieties.

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Optimization of the process of egg omelet production with fillings with extended storage period

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Keywords:

Egg
Omelet
Storage
Pressure

Article history:

Received 12.06.2014
Received in revised form 23.07.2014
Accepted 02.09.2014

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Abstract

Introduction. Optimization of the egg omelets (EO) production using high pressure (HP) will allow to produce a minimum cost product during manufacturing and also to obtain a product with high consumer properties.

Materials and methods. The concerned product is - EO - a mixture of liquid egg with grated or chopped cheese, xanthan gum, water or milk and spices. The EO manufacturing process consisted of packing the mixture in an airtight container with heating and processing in the high pressure installation. The EO suitability for long-term storage was evaluated by the "water activity" term. The EO quality was evaluated by an expert. There was used the undetermined Lagrange multipliers method to obtain the optimal process parameters.

Results. As a result of the central composite rotatabel plan there was developed optimization model allowed to obtain the optimal EO HP processing parameters: pressure – 690 MPa, temperature – 122^0C, treatment duration – 7×60s, 14g of water on 100 g of melange, 13 g of dry milk on 100 g of melange, xanthan gum content - 0,75% of the total mixture mass, 25 g of cheese on 100 g of melange. These indicators allow to obtain the EO process parameters with the next indicators: water activity - 0.704 and comprehensive quality Score - 0.98 that characterize the product as a product with high quality indicators stable over a long period of storage.

The developed model analysis with using of Student's t test, Fisher dyspepsia and predicted optimization values calculation errors confirmed the reliability of the optimization parameters obtained values and the optimization model reliability. The calculations results for the given optimization parameters are presented as confidence intervals, confirming that their experimental values do not exceed the respective intervals and thus confirm the results authenticity.

Conclusions. These results have practical significance and were adopted as the basis for the technical documentation elaboration of the EO long term storage and the HP process equipment design for implementation of this process.

Introduction

Chicken eggs are one of the most valuable human food products and are used in the preparation of a large number of dishes, among which the leading position is taken by egg omelets (EO). Unfortunately, this product is not suitable for long-term storage, and is cooked at mass catering establishment on an as-needed basis. At the same time, taking into account the high nutritional value of the product, upon conditions of providing its high nutritional and consumer properties for long-term storage, it can be recommended for use in expeditions and camping trips, remote regions of the country, for the formation of strategic reserves of the armed forces and navy and also in egg-processing, food-manufacturing industry and public catering establishments. The investigations within the sphere of omelet production with long-term storage are held in several European countries and the USA.

It is the most appropriate to use high pressure (HP) for the development process of EO with extended storage period that provides microbiological purity of the processed products during storage preserving its enzymatic-vitamin complex.

We have suggested the mixed egg omelets with various fillings: egg omelets with cheese, bacon, fried mushrooms with long-term storage period. The process of egg omelet production consists of mixing of liquid chicken egg with grated or hashed cheese (or other ingredients), xanthan gum, that provides the final product with form-holding properties, water or milk, added spices (salt, pepper), after which the resulting mixture is packed in a hermetic resilient container, heated, dipped into a working chamber, high-pressure system [1, 2].

The work objective aims to determine the optimal parameters for the process of egg omelet (EO) production with extended storage period using high-pressure technology.

Materials and methods

Analysis of a priori information and preparatory experimental studies make it possible to identify experimentation areas, and to select the variables that affect the quality of the product and its safety during long-term storing.

The quality of EO is assessed by the expert method based on tasting and evaluation of the organoleptic properties of the product.

For the purpose of suitability evaluation of EO for long storage we used the index of «water activity (a_w)» which represents the product characteristic established by its chemical composition and hygroscopic capacity. The rate of water activity affects the intensity of progressing reactions of product, such as lipid oxidation, melanoidin formation, activity of enzymatic and microbiological processes; provides more accurate information as compared with a total moisture content in respect of microbial, chemical and enzymatic stability of perishable foods such as EO, and can be used to forecast its storing ability and determining the optimal storage conditions [3, 4].

The work has been conducted on the basis of Fundamental Research Laboratory "Application of high pressure in food technology", Donetsk national university of economics and trade named after Mykhailo Tuhan-Baranovskyi [5].

The optimization procedure has been developed according to methodology which have been previously approbated in the course of treatment optimization of other products with the application of high-pressure [6].

Through the use of active experiment we have assessed the effectiveness of the complex impact of several factors on the quality of the developed food product, in

particular, cheese omelet. Dependent variables include: y_1 – water activity (a_w); y_2 complex performance criterion (K). Factor affecting the indices of: x_1 – pressure (P, MPa); x_2 – temperature of working high-pressure chamber (t, ^{0}C); x_3 – treatment time (τ, c); x_4 – mass of water per 100 g of melange (*g*); x_5 – mass of dry milk per 100 g of melange (*g*); x_6 – xanthan gum (% of the total mass of mixture); x_7 – mass of cheese per 100 g of melange (*g*).

Results and discussion

Table 1 provides the natural and code values of the first three factors, the magnitudes of which are defined on the basis of preparatory seven-factor experiments.

Table 1

Characteristics of experimental factors

Planning characteristics	Factors					
	Code values			Natural values		
	x_1	x_2	x_3	P, MPa	t, C^o	τ, c
Ground level (0)	0	0	0	700	100	450
High level (+1)	+1	+1	+1	815	120	575
Low level (–1)	–1	–1	–1	585	80	325
Upper "star" point (+α)	1,68	1,68	1,68	506,8	66,4	240
Lower "star" point (–α)	–1,68	–1,68	–1,68	893,2	133,6	660
Variability interval	-	-	-	115	20	125

Since the results of these experiments indicate linear dependence of the water activity on the majority of factors, then in order to determine this dependence on the specified seven factors we have applied fractional limit replication with limit number of factors for the eight experiments.

Table 2

Plan of experiment to determine the coefficients of linear model

x_0	x_1	x_2	x_3	x_4	x_5	x_6	x_7	y_1
1	1	1	1	1	1	1	1	0,705
1	1	-1	-1	-1	-1	1	1	0,82
1	-1	-1	1	1	-1	-1	1	0,775
1	-1	1	-1	-1	1	-1	1	0,82
1	-1	-1	-1	1	1	1	-1	0,795
1	-1	1	1	-1	-1	1	-1	0,775
1	1	1	-1	1	-1	-1	-1	0,81
1	1	-1	1	-1	1	-1	-1	0,745

We have evaluated eight model coefficients of the following saturated plan (Table 3):

Table 3

Coefficient of linear model

x_7	x_6	x_5	x_4	x_3	x_2	x_1	x_0
-0,00063	-0,00688	-0,0144	-0,00937	-0,03063	-0,00313	-0,01063	0,780625

For the purpose of release of the linear effects from the first-order interactions we have used the saddle-point method. On application of the method there is added a new replication, all the signs of which are contrary to the original one, that means the fulfillment of the experimental plan recorded in Table 4.

Table 4

Plan of subsidiary experiment

x_0	x_1	x_2	x_3	x_4	x_5	x_6	x_7	y_1
1	-1	-1	-1	-1	-1	-1	-1	0,795
1	-1	1	1	1	1	-1	-1	0,775
1	1	1	-1	-1	1	1	-1	0,785
1	1	-1	1	1	-1	1	-1	0,705
1	1	1	1	-1	-1	-1	1	0,745
1	1	-1	-1	1	1	-1	1	0,81
1	-1	-1	1	-1	1	1	1	0,775
1	-1	1	-1	1	-1	1	1	0,82

Table 5

Coefficient of subsidiary linear model

x_7	x_6	x_5	x_4	x_3	x_2	x_1	x_0
0,01125	-0,005	0,01	0,00125	-0,02625	0,005	-0,015	0,77625

Hereafter we received the coefficients of generalized linear model:

Table 6

Coefficients of generalized linear model

x_7	x_6	x_5	x_4	x_3	x_2	x_1	x_0
0,005312	-0,00594	-0,0022	-0,00406	-0,02844	0,000937	-0,01281	0,778438

After the supplementing, we leave only statistically significant coefficients in the model:

$$y_1 = 0,778 - 0,013x_1 - 0,028x_3$$

To determine the dependence of the complex quality factor y_2 on pressure, temperature and time we applied a central composite uniform-rotatable planning for the three factors, the construction of which is connected with the performance of twenty experiments of double resistibility. Repetition provides increased precision of estimates and contributes to extraction of weak signals out of noise. Apart from that we also referred to randomization which is represented by random order of experiment implementation aimed to eliminate of systematic errors.

At the first stage we have conducted the central composite rotatable planning (CCRP) the characteristics of which are given in Table 1, and the plan in provided in Table 7.

Table 7

CCRP matrix

No	Code factor score			Natural factor score			Response function
	x_1	x_2	x_3	P, MPa	t, C°	τ, c	y_2
1	-1	-1	-1	585	80	325	0,84
2	1	-1	-1	815	80	325	0,86
3	-1	1	-1	585	120	325	0,94
4	1	1	-1	815	120	325	0,89
5	-1	-1	1	585	80	575	0,92
6	1	-1	1	815	80	575	0,87
7	-1	1	1	585	120	575	0,95
8	1	1	1	815	120	575	0,88
9	-1,68	0	0	506,8	100	450	0,92
10	1,68	0	0	893,2	100	450	0,83
11	0	-1,68	0	700	66,4	450	0,91
12	0	1,68	0	700	133,6	450	0,96
13	0	0	-1,68	700	100	240	0,91
14	0	0	1,68	700	100	660	0,93
15	0	0	0	700	100	450	0,96
16	0	0	0	700	100	450	0,94
17	0	0	0	700	100	450	0,95
18	0	0	0	700	100	450	0,96
19	0	0	0	700	100	450	0,95
20	0	0	0	700	100	450	0,96

Table 8

Model coefficients and its computational error

b	x_1	x_2	x_3	x_1x_2	x_1x_3	x_2x_3	x_1^2	x_2^2	x_3^2
0,964572	-0,02242	0,025795	0,007642	-0,01314	-0,01229	-0,01379	-0,03078	-0,00576	-0,01451
0,005907	0,003921	0,003921	0,003921	0,005121	0,005121	0,005121	0,003821	0,003821	0,003821

Determination coefficient R^2 =0,939508. Let us write the resulting model:

$$y_2 = 0{,}965 - 0{,}022x_1 + 0{,}026x_2 + 0{,}008x_3 - 0{,}013x_1x_2 - 0{,}012x_1x_3 - 0{,}014x_2x_3 - 0{,}031x_1^2 - \\ - 0{,}006x_2^2 - 0{,}015x_3^2$$

Let us verify it's adequacy.

y_2							
Exper.	**Calculation**	**Exper.**	**Calculation**	**Exper.**	**Calculation**	**Exper.**	**Calculation**
0,84	0,8633	0,87	0,8876	0,91	0,905	0,94	0,9646
0,86	0,8693	0,95	0,981	0,96	0,9917	0,95	0,9646
0,94	0,9688	0,88	0,8853	0,91	0,9108	0,96	0,9646
0,89	0,9222	0,92	0,9154	0,93	0,9365	0,95	0,9646
0,92	0,9307	0,83	0,8401	0,96	0,9646	0,96	0,9646

y_u – the value of response function in the u-th experiment at the centre point of the design;

$\overline{y_0}$ – the average value of response function in n_0 experiments at the centre point of the design;

$$S_{ao}^2 = \frac{\sum_{j=1}^{N}\left(y_j^e - y_j^p\right)^2 - S_y^2(n_0-1)}{N - \frac{(n+2)(n+1)}{2} - (n_0-1)};$$

The resulting model is adequate on the basis of Fisher's variance ratio: $F_p = 4,67 < F_m = 5,05$ at significance value of 0.05, the degrees of freedom:

$$f_1 = N - \frac{(n+2)(n+1)}{2} - (n_0-1) = 20 - \frac{(3+2)(3+1)}{2} - (6-1) = 5$$
$$f_2 = n_0 - 1 = 6 - 1 = 5.$$

In our case, it is clear that a priori considerations has been significantly confirmed due to the fact that not only linear factor effects, but also pairwise interactions and quadratic effects have been confirmed. Among three linear effects we have outlined two: the effect of the factors of pressure and the factor of experiment duration. Based on the quantitative estimation of the coefficients, their influence on the course of experiment is more substantial than the temperature. Temperature in the selected variability interval does not perform such a significant impact on this figure, since the linear coefficient is smaller in this case. But the influence of this factor has been manifested equally with other factors in a pairwise interactions. The content of interaction effect is that the effect of one factor depends on the level of another factor.

Graphical analysis of two-dimensional graphs of the regression equation and the equiscalar lines at a fixed value of one of the three factors found that the maximum values of the complex quality parameters are in the field of experiment. This allows us to the apply the methods of classical analysis to find the extremum. In order to find the optimal parameter of values x_1, x_2, x_3 the first "compromise" optimization problem has been formulated in this way. It is needed to find the value of controlling factors that provide the maximum $y_2 = f(x_1, x_2, x_3)$ at the given value $y_1 = \phi_1(x_1, x_2, x_3)$. The importance of independent variables at that point should be in the experimental field the boundaries of which are defined by the value of factors at the "star" points. Analytically, this can be written as an expression $\phi_2(x_1, x_2, x_3) = x_1^2 + x_2^2 + x_3^2 = R^2$ in which the factor space is represented by a sphere of R -radius and the center located at the center of the experiment. Thus we obtain the "compromise" optimization problem:

To maximize the function:

on condition that: $\begin{cases} y_1 = 0,778 - 0,013x_1 - 0,028x_3, \\ x_1^2 + x_2^2 + x_3^2 = R^2. \end{cases}$

To solve this problem, we used the the Lagrange's method of undetermined multipliers. For this purpose we constructed the objective function $F_1(x_1, x_2, x_2, \lambda_1, \lambda_2)$ which is the sum of optimization equation y_2 and corresponding product of φ_1, φ_2 by multipliers λ_1, λ_2:

$$F = 0,965 - 0,022x_1 + 0,026x_2 + 0,008x_3 - 0,013x_1x_2 - 0,012x_1x_3 - 0,014x_2x_3 - 0,031x_1^2 -$$
$$-0,006x_2^2 - 0,015x_3^2 + \lambda_1(0,778 - 0,013x_1 - 0,028x_3 - y_1) + \lambda_2\left(x_1^2 + x_2^2 + x_3^2 - R^2\right)$$

In accordance with the method of Lagrange computational algorithm we built the system of equations that contain derivatives of the objective function for all independent replaceable and Lagrange multipliers:

$$\frac{\partial F}{\partial x_1} = -0,022 - 0,013x_2 - 0,012x_3 - 0,062x_1 - 0,013\lambda_1 + 2\lambda_2 x_1$$

$$\frac{\partial F}{\partial x_2} = 0,026 - 0,013x_1 - 0,014x_3 - 0,012x_2 + 2\lambda_2 x_2$$

$$\frac{\partial F}{\partial x_3} = 0,008 - 0,012x_1 - 0,014x_2 - 0,030x_3 - 0,028\lambda_1 + 2\lambda_2 x_3$$

$$\frac{\partial F}{\partial \lambda_1} = 0,778 - 0,013x_1 - 0,028x_3 - y_1$$

$$\frac{\partial F}{\partial \lambda_2} = x_1^2 + x_2^2 + x_3^2 - R^2$$

To solve the resulting system of equations we used the integrated package MAPLE 13. Values are calculated by changing the radius of the sphere R in the range from 1,628 to 0 and setting y_1 where practicable as smallest. The characteristic parts of computational results are shown in Table 9:

Table 9

Computational results for optimal values of factors

R	**Code factor score**			**Response function**	
	x_1	x_2	x_3	y_2	y_1
0,4	-0,229	0,285	-0,162	0,974	0,786
0,64	-0,1	0,6	-0,2	0,98	0,786
0,9	0,577	-0,449	-0,525	0,924	0,786
1,68	1,361	-0,443	-0,879	0,864	0,786

Optimal data is recorded in the second row of Table 9, when the value of the complex quality factor becomes maximum, equal to 0.98. Optimal solutions with the coded and natural values are shown in Table 10.

Table 10

Optimal values

Code factor score			**Natural factor score**			**Response function**	
x_1	x_2	x_3	P, МПа	t, C^o	τ, с	y_2	y_1
-0,1	0,6	-0,2	695	122	425	0,98	0,786

Since the expert estimation of organoleptic qualities of omelet which is the complex quality factor cannot be conducted simultaneously for all seven control factors (for this purpose you need to hold simultaneously, for example, in double repeatition 326 CCRP experiments), we have made a decision on a consistent replacement of the third factor (linear coefficient is three times smaller than the corresponding coefficients of the first and the second factors) by the other factors.

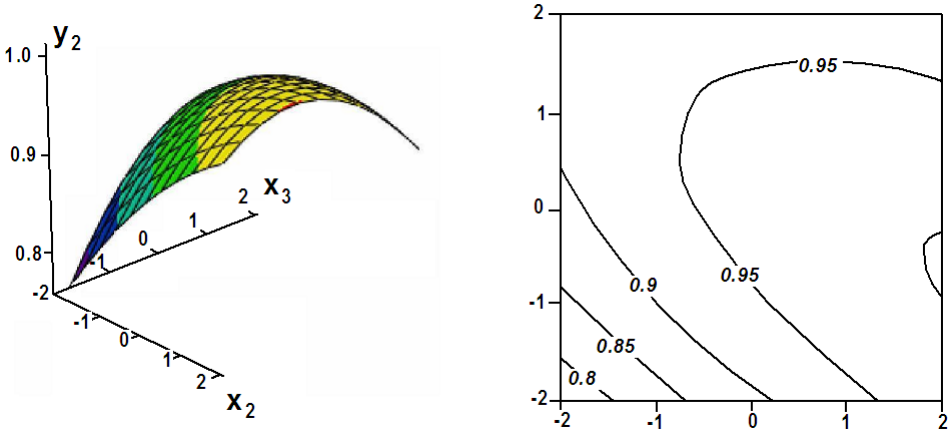

Fig. 1. Response surface and equiscalar lines for regression as x_1=-0,1.

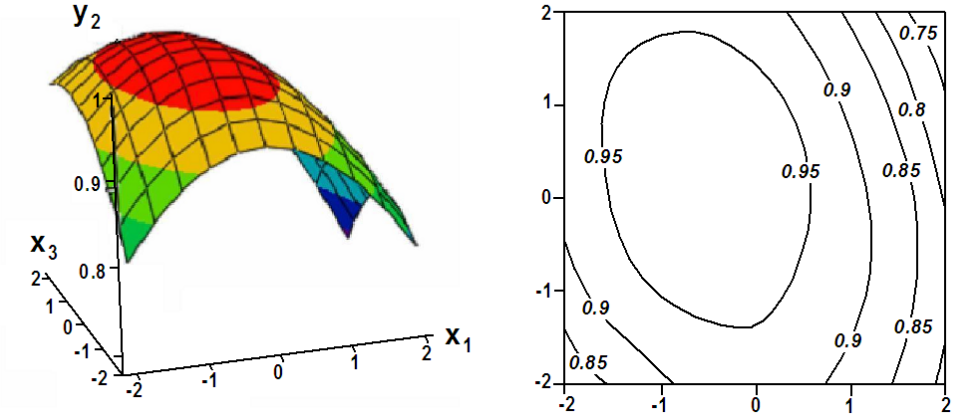

Fig. 2. Response surface and equiscalar lines for regression as x_2 = 0,6

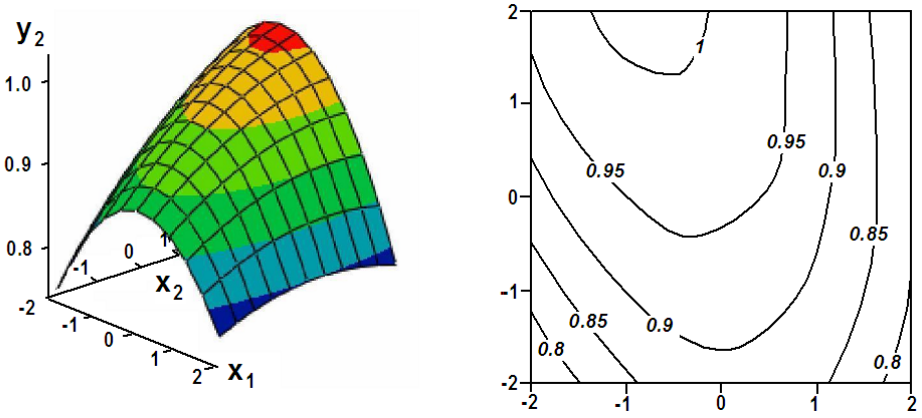

Fig. 3. Response surface and equiscalar lines for regression as x_3 = - 0,2

For all models, we checked the significance of regression coefficients. Since we work with the orthogonal design, they are determined with one and the same dispersion. Next for the regression coefficients we calculated the confidential interval with a certain confidential probability. In this equation the criterion (the Student's criterion) has the same number of the degrees of freedom as the error mean square. The coefficient of significance, if its absolute value is greater than the confidential interval.

Insignificant regression coefficients were excluded and again we carried out the model verification with the significant coefficients.

If instead of x_3 we will include x_4 to the plan of experiment, Table 1 will appear as follows:

Planning characteristics	Factors					
	Code values			Natural values		
	x_1	x_2	x_4	P, MPa	t, C^o	x_4, с
Ground level (0)	0	0	0	700	100	13
High level (+1)	+1	+1	+1	815	120	15
Low level (–1)	–1	–1	–1	585	80	11
Upper "star" point (+α)	1,68	1,68	1,68	893,2	133,6	16,36
Lower "star" point (–α)	–1,68	–1,68	–1,68	506,8	66,4	9,64
Variability interval	-	-	-	115	20	2

No	Code factor score			Natural factor score			Response function
	x_1	x_2	x_4	P, MPa	t, C^o	x_4, с	y_2
1	-1	-1	-1	585	80	11	0,93
2	1	-1	-1	815	80	11	0,91
3	-1	1	-1	585	120	11	0,94
4	1	1	-1	815	120	11	0,93
5	-1	-1	1	585	80	15	0,95
6	1	-1	1	815	80	15	0,93
7	-1	1	1	585	120	15	0,96
8	1	1	1	815	120	15	0,95
9	-1,68	0	0	506,8	100	13	0,96
10	1,68	0	0	893,2	100	13	0,94
11	0	-1,68	0	700	66,4	13	0,91
12	0	1,68	0	700	133,6	13	0,94
13	0	0	-1,68	700	100	9,64	0,92
14	0	0	1,68	700	100	16,36	0,96
15	0	0	0	700	100	13	0,96
16	0	0	0	700	100	13	0,94
17	0	0	0	700	100	13	0,95
18	0	0	0	700	100	13	0,96
19	0	0	0	700	100	13	0,95
20	0	0	0	700	100	13	0,96

Table of coefficients and its computational errors

b	x_1	x_2	x_4	x_1x_2	x_1x_4	x_2x_4	x_1^2	x_2^2	x_4^2
0,95333	-0,00686	0,008091	0,010788	0,0025	0	0	-0,00116	-0,01002	-0,0047
0,005269	0,003498	0,003498	0,003498	0,004568	0,004568	0,004568	0,003409	0,003409	0,003409

Determination coefficient R^2 =0,949504

$$y_2 = 0,953 - 0,007x_1 + 0,008x_2 + 0,011x_4 + 0,0025x_1x_2 - 0,001x_1^2 - 0,010x_2^2 - 0,005x_4^2$$

The resulting model is adequate on the basis of Fisher's variance ratio: $F_p = 0,08 < F_m = 5,05$ at significance value of 0,05, the 5 degrees of freedom.

Table 11

Optimal decision

Code factor score			Natural factor score			Response function	
x_1	x_2	x_4	P, MPa	t, C°	x_4, с	y_2	y_1
-0,11	0,63	0,52	694,5	122,6	14,04	0,96	0,77

If instead of x_3 we will include x_5 to the plan of experiment, Table 1 will appear:

Planning characteristics	Factors					
	Code values			Natural values		
	x_1	x_2	x_5	P, MPa	t, C°	x_5, с
Ground level (0)	0	0	0	700	100	14
High level (+1)	+1	+1	+1	815	120	15,5
Low level (–1)	–1	–1	–1	585	80	12,5
Upper "star" point (+α)	1,68	1,68	1,68	893,2	133,6	16,52
Lower "star" point (–α)	–1,68	–1,68	–1,68	506,8	66,4	11,48
Variability interval	-	-	-	115	20	1,5

No	Code factor score			Natural factor score			Response function
	x_1	x_2	x_5	P, MPa	t, C°	x_5, с	y_2
1	-1	-1	-1	585	80	12,5	0,95
2	1	-1	-1	815	80	12,5	0,93
3	-1	1	-1	585	120	12,5	0,96
4	1	1	-1	815	120	12,5	0,95
5	-1	-1	1	585	80	15,5	0,93
6	1	-1	1	815	80	15,5	0,91
7	-1	1	1	585	120	15,5	0,94
8	1	1	1	815	120	15,5	0,93
9	-1,68	0	0	506,8	100	14	0,96
10	1,68	0	0	893,2	100	14	0,94
11	0	-1,68	0	700	66,4	14	0,91
12	0	1,68	0	700	133,6	14	0,94
13	0	0	-1,68	700	100	11,48	0,95
14	0	0	1,68	700	100	16,52	0,92
15	0	0	0	700	100	14	0,96
16	0	0	0	700	100	14	0,94
17	0	0	0	700	100	14	0,95
18	0	0	0	700	100	14	0,96
19	0	0	0	700	100	14	0,95
20	0	0	0	700	100	14	0,96

Table of coefficients and its computational errors

b	x_1	x_2	x_5	x_1x_2	x_1x_5	x_2x_5	x_1^2	x_2^2	x_5^2
0,95327	-0,00686	0,008091	-0,00956	0,0025	0	0	-0,00078	-0,00964	-0,0061
0,002457	0,001631	0,001631	0,001631	0,00213	0,00213	0,00213	0,00159	0,00159	0,00159

Determination coefficient R^2 =0,9262

The resulting model is adequate on the basis of Fisher's variance ratio: $F_p = 0,13 < F_m = 5,05$ at significance value of 0,05, the 5 degrees of freedom.

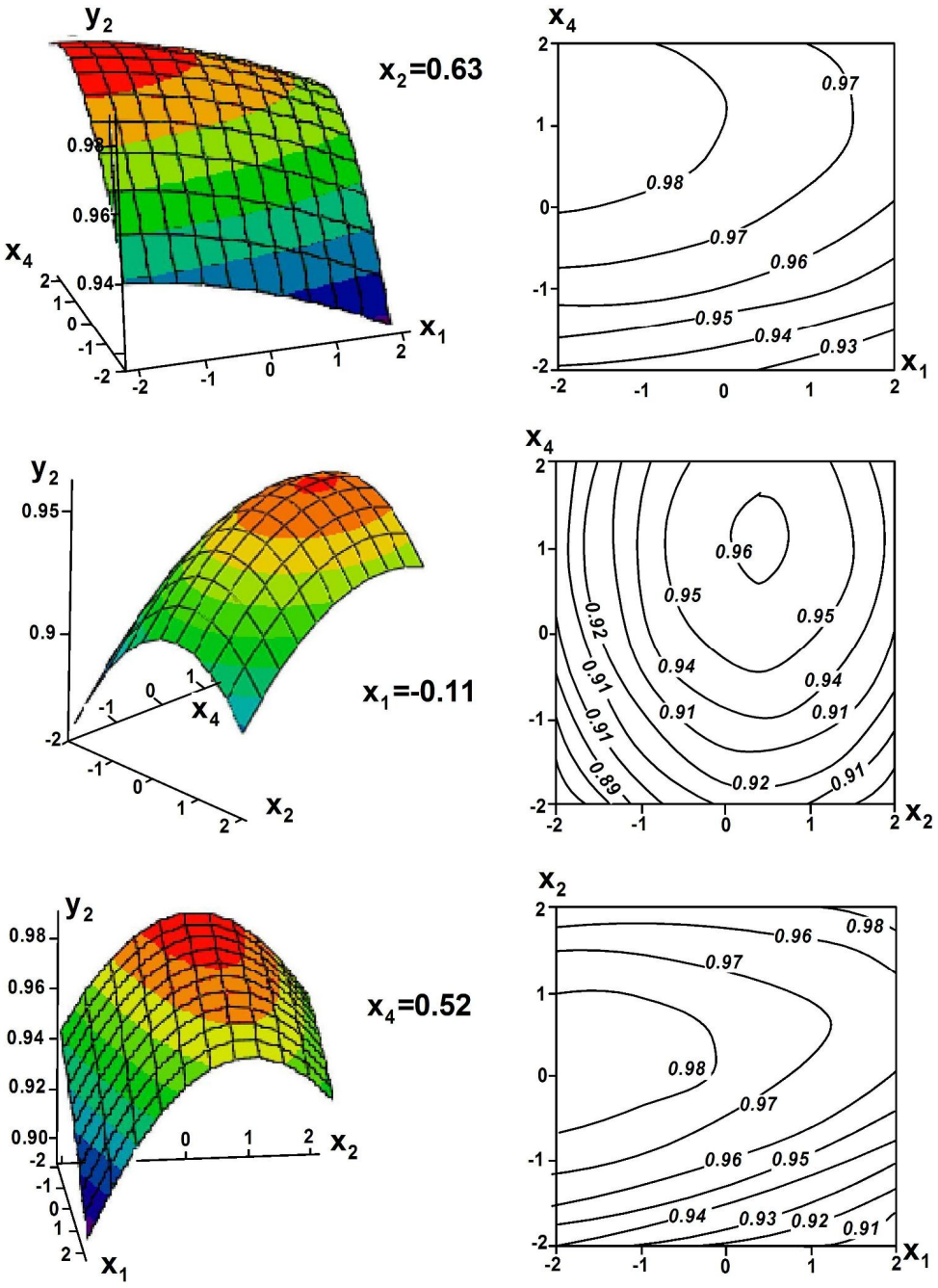

Fig. 4. Response surface and equiscalar lines for regression as $y_2 = f(x_1,x_2,x_4)$ at the subsequently fixed x_1= - 0,11, x_2 = 0,63 and x_4 = 0,52

Table 12

Optimal decision

Code factor score			Natural factor score			Response function	
x_1	x_2	x_5	P, MPa	t, C°	x_5, г	y_2	y_1
-0,14	0,65	-0,28	693	123	13,58	0,98	0,78

If instead of x_3 we will include x_6 to the plan of experiment, Table 1 will appear:

Planning characteristics	Factors					
	Code values			Natural values		
	x_1	x_2	x_5	P, MPa	t, C°	x_5, г
Ground level (0)	0	0	0	700	100	14
High level (+1)	+1	+1	+1	815	120	15,5
Low level (–1)	–1	–1	–1	585	80	12,5
Upper "star" point (+α)	1,68	1,68	1,68	893,2	133,6	16,52
Lower "star" point (–α)	–1,68	–1,68	–1,68	506,8	66,4	11,48
Variability interval	-	-	-	115	20	1,5

No	Code factor score			Natural factor score			Response function
	x_1	x_2	x_5	P, MPa	t, C°	x_5, г	y_2
1	-1	-1	-1	585	80	12,5	0,95
2	1	-1	-1	815	80	12,5	0,93
3	-1	1	-1	585	120	12,5	0,96
4	1	1	-1	815	120	12,5	0,95
5	-1	-1	1	585	80	15,5	0,93
6	1	-1	1	815	80	15,5	0,91
7	-1	1	1	585	120	15,5	0,94
8	1	1	1	815	120	15,5	0,93
9	-1,68	0	0	506,8	100	14	0,96
10	1,68	0	0	893,2	100	14	0,94
11	0	-1,68	0	700	66,4	14	0,91
12	0	1,68	0	700	133,6	14	0,94
13	0	0	-1,68	700	100	11,48	0,95
14	0	0	1,68	700	100	16,52	0,92
15	0	0	0	700	100	14	0,96
16	0	0	0	700	100	14	0,94
17	0	0	0	700	100	14	0,95
18	0	0	0	700	100	14	0,96
19	0	0	0	700	100	14	0,95
20	0	0	0	700	100	14	0,96

Table of coefficients and its computational errors

b	x_1	x_2	x_5	x_1x_2	x_1x_5	x_2x_5	x_1^2	x_2^2	x_5^2
0,95327	-0,00686	0,008091	-0,00956	0,0025	0	0	-0,00078	-0,00964	-0,0061
0,002457	0,001631	0,001631	0,001631	0,00213	0,00213	0,00213	0,00159	0,00159	0,00159

Determination coefficient R^2 =0,919309

$$y_2 = 0,953 - 0,01x_1 + 0,009x_2 - 0,010x_6 + 0,004x_1x_2 - 0,008x_2^2 - 0,006x_6^2$$

The resulting model is adequate on the basis of Fisher's variance ratio: $F_p = 0,9 < F_m = 5,05$ at significance value of 0,05, the 5 degrees of freedom.

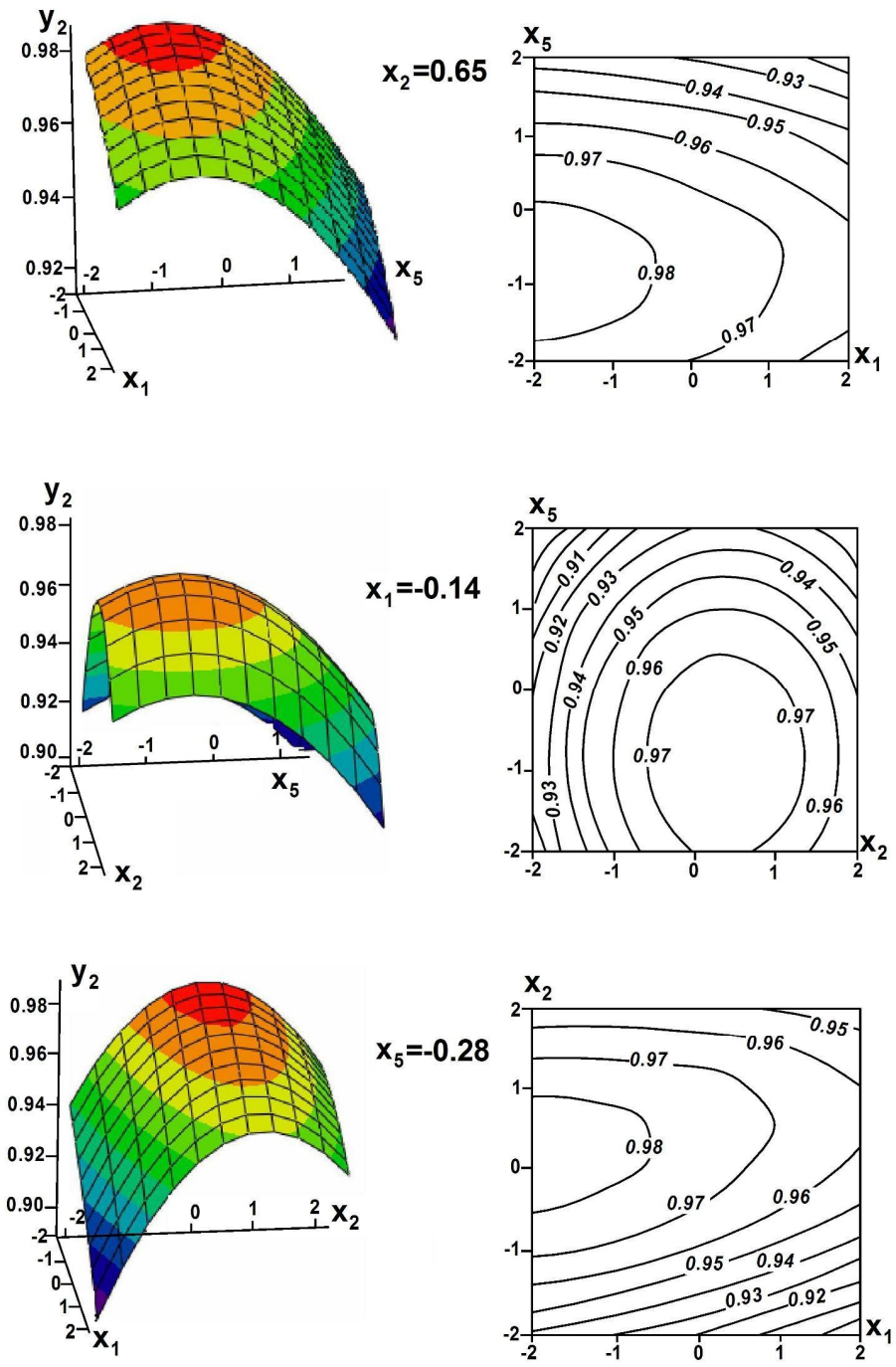

Fig. 5. Response surface and equiscalar lines for regression as $y_2 = f(x_1,x_2,x_4)$ at the subsequently fixed x_1= - 0,11, x_2 = 0,63 and x_4 = 0,52

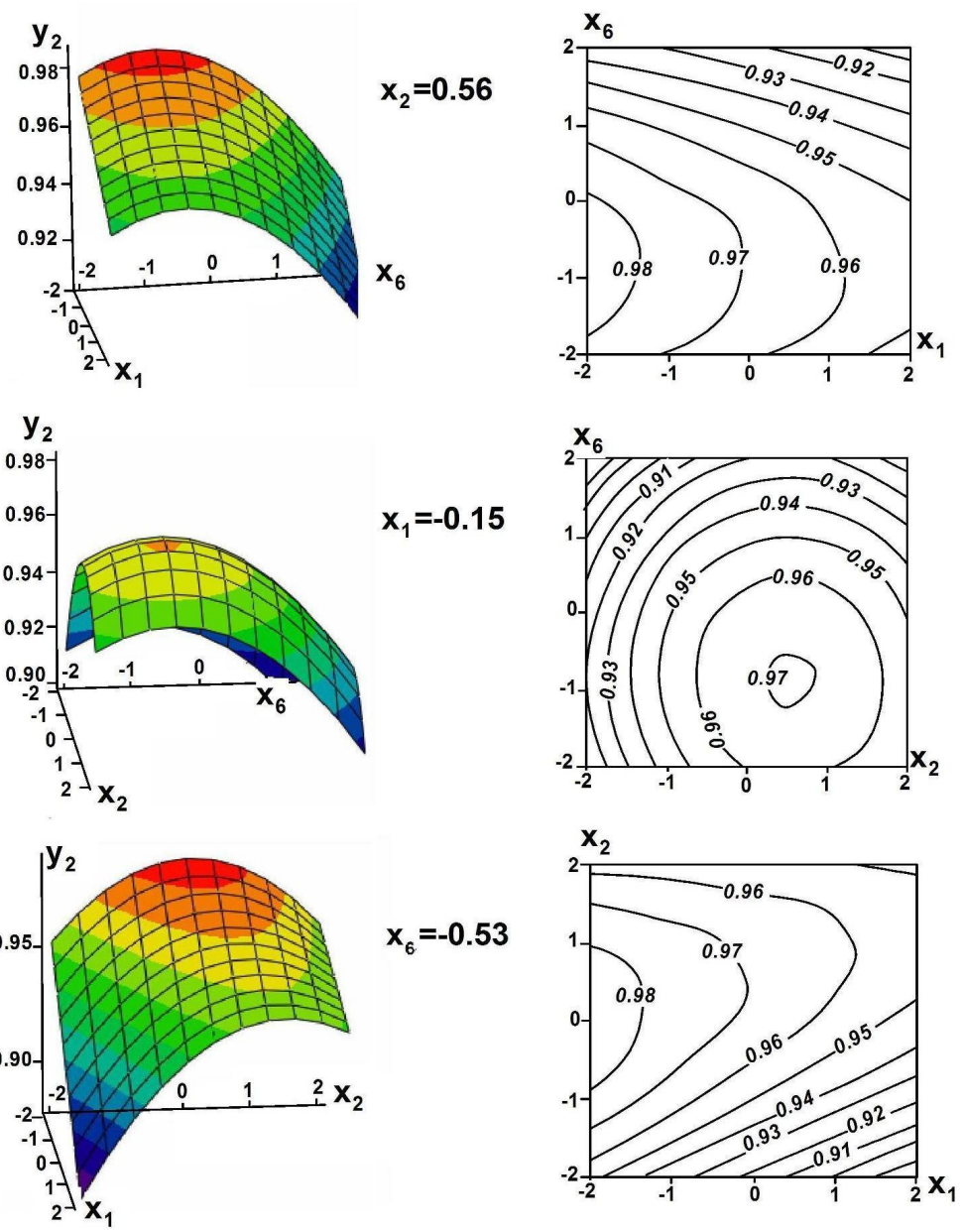

Fig. 6. Response surface and equiscalar lines for regression as $y_2 = f(x_1,x_2,x_4)$ at the subsequently fixed x_1= - 0,11, x_2 = 0,63 and x_4 = 0,52

Table 13

Optimal decision

Code factor score			*Natural factor score*			*Response function*	
x_1	x_2	x_5	P, MPa	t, C^o	x_5, *г*	y_2	y_1
-0,14	0,65	-0,28	693	123	13,58	0,98	0,78

If instead of x_3 we will include x_7 to the plan of experiment, Table 1 will appear:

Planning characteristics	Factors					
	Code values			Code values		
	x_1	x_2	x_7	P, MPa	t, C°	x_7, с
Ground level (0)	0	0	0	700	100	24
High level (+1)	+1	+1	+1	815	120	30
Low level (–1)	–1	–1	–1	585	80	18
Upper "star" point (+α)	1,68	1,68	1,68	893,2	133,6	34,08
Lower "star" point (–α)	–1,68	–1,68	–1,68	506,8	66,4	13,92
Variability interval	-	-	-	115	20	6

No	Code factor score			Natural factor score			Response function
	x_1	x_2	x_5		x_1	x_2	x_5
1	-1	-1	-1	585	80	18	0,94
2	1	-1	-1	815	80	18	0,93
3	-1	1	-1	585	120	18	0,96
4	1	1	-1	815	120	18	0,94
5	-1	-1	1	585	80	30	0,95
6	1	-1	1	815	80	30	0,93
7	-1	1	1	585	120	30	0,96
8	1	1	1	815	120	30	0,95
9	-1,68	0	0	506,8	100	24	0,97
10	1,68	0	0	893,2	100	24	0,94
11	0	-1,68	0	700	66,4	24	0,92
12	0	1,68	0	700	133,6	24	0,95
13	0	0	-1,68	700	100	13,92	0,94
14	0	0	1,68	700	100	34,08	0,95
15	0	0	0	700	100	24	0,96
16	0	0	0	700	100	24	0,94
17	0	0	0	700	100	24	0,95
18	0	0	0	700	100	24	0,96
19	0	0	0	700	100	24	0,95
20	0	0	0	700	100	24	0,96

Table of coefficients and its computational errors

b	x_1	x_2	x_7	x_1x_2	x_1x_7	x_2x_7	x_1^2	x_2^2	x_7^2
0,953316	-0,00809	0,008091	0,002697	0	0	0	0,000702	-0,00638	-0,00284
0,002574	0,001709	0,001709	0,001709	0,002232	0,002232	0,002232	0,001665	0,001665	0,00166

Determination coefficient R^2 =0,866061

$$y_2 = 0,953 - 0,008x_1 + 0,008x_2 + 0,003x_7 - 0,006x_2^2 - 0,003x_7^2$$

The resulting model is adequate on the basis of Fisher's variance ratio: $F_p = 0,231 < F_m = 5,05$ at significance value of 0,05, the 5 degrees of freedom.

Table 14

Optimal decision

Code factor score			Natural factor score			Response function	
x_1	x_2	x_7	P, MPa	t, C°	x_7, с	y_2	y_1
-0,17	0,51	0,25	691,5	120,2	25,5	0,98	0,77

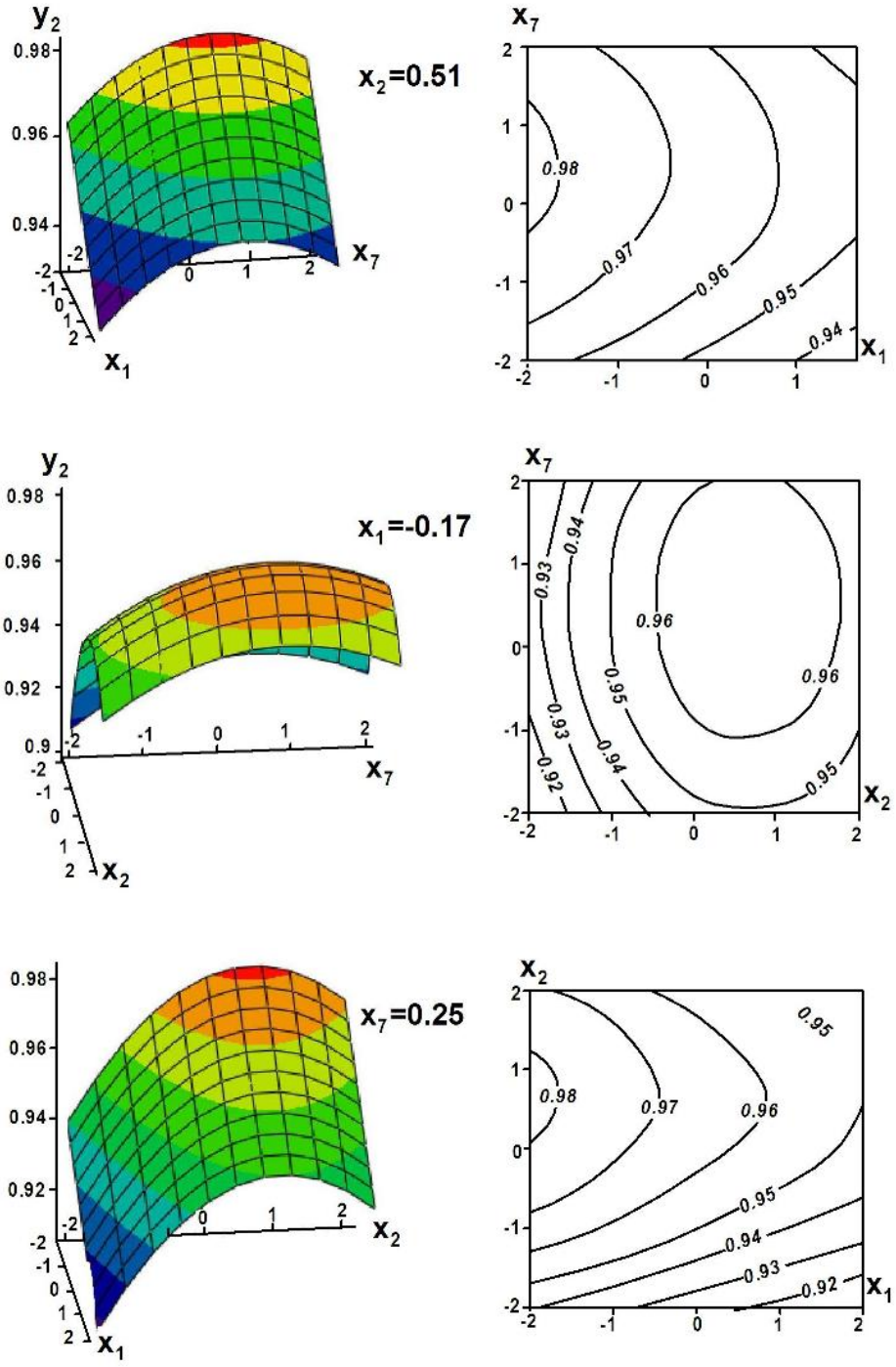

Fig. 7. Response surface and equiscalar lines for regression as $y_2 = f(x_1,x_2,x_4)$ at the subsequently fixed x_1= - 0,11, x_2 = 0,63 and x_4 = 0,52

Statistical analysis has been concluded by the model interpretation of research object. It has been performed according to the following algorithm. We conducted the experimental testing of the detected optimal parameters and evaluation of the degree of accuracy and reliability of the parameter values. Under the listed optimum values of factors we have carried out ten replicates for all seven factors, results and their statistical analysis which are given in Table 15.

Table 15

Optimization results

Optimization parameters	Parameter value		Dispersion S^2	Criterion t_p	Inaccuracy δ	Confidential interval
	y_i^p	y_i^e				
y_1	0,98	0,941	0,005	1,74	0,051	0,929-1,0
y_2	0,786	0,748	0,0045	1,79	0,048	0,738-0,834

The verification of Student's criterion has been confined to the comparison of calculated values with those given in the table $t_T = 2,26$ (the number of degrees of freedom $f = 9$) for the confidential probability of 0.95. These values indicate that the differences between the computational and experimental data are inappreciable.

The error of predicted value of optimization parameter:

$$\delta = \frac{t_T \sqrt{S^2}}{\sqrt{n}}$$

The results of calculations according to the enlisted optimization parameters, represented in the form of confidential intervals, show that their experimental values do not go outside the corresponding intervals, and thus confirm the validity of the obtained results.

Conclusions

By this means the implemented research makes it possible to get optimal processing parameters for EO with HP: x_1 – 690 MPa, x_2 – 122^{0}C, x_3 – 7×60sec, x_4 – 14 g of water per 100 g of melange, x_5 – 13 g of dry milk per 100 g of melange, x_6 – xanthan gum content - 0,75% of the total mass of mixture, x_7 – 25 g of cheese per 100 g of melange. The following optimal indicators of process parameters make it possible to obtain EO with indicators $в_1$ = 0,704 and $в_2$ = 0,98, that characterizes this product as the product with high quality indices that are stable over a long period of storage.

The obtained results are of practical importance and can be taken as the basis for the design of corresponding technological high-pressure equipment.

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Yoghurt enrichment with natural bee farming products

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Keywords:

Pollen
Bee
Powder
Yogurt

Article history:

Received 05.06.2014
Received in revised form 23.07.2014
Accepted 02.09.2014

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Abstract

Introduction. Bee pollen is a unique and unparalleled natural bioactive substances source. Using it in conjunction with the popular functional fermented milk product - yogurt will expand its product range and increase the biological value.

Materials and Methods. Dried bee pollen's moisture determination was made by gravimetry methods, based on the sample weight loss due to desiccation, until constant weight was reached. Test and control yogurt samples were studied by applying standard techniques for milk and milk products set forth in the regulations of Ukraine.

Results and discussion. It is found that bee pollen pellet drying to a moisture content of 2 - 4%, increases the flow rate of powder almost by 90%. The sample having moisture content of 2% will have a bulk density exceeding 12.5% compared to the sample having moisture content of 10%. Raw output will also increase by 3.7%. By contrast, apparent density and weight fraction of losses decreases, which has a positive impact on pollen efficiency of use and distribution in bulk yogurt. Moreover, the weight fraction of losses decreases by fourfold (4.6% vs. 1%).

It was experimentally determined that pollen can deteriorate microbiological characteristics of yogurt.

It was proved that treatment of crushed bee pollen pellet sample with ultraviolet allows improving yogurt microbiological safety indicators. Namely, to reduce the presence of coli-forms to 0, mould – to 10 CFU/cm³.

Conclusions. The proposed bee pollen pellet treatment method will improve the technological and microbiological characteristics of pollen powder. This provides for yoghurt production biotechnology using bee farming products.

Introduction

Malnutrition reduces age of human life by 2-3 times. Up to 90% of diseases are directly related to malnutrition. [1].

Nutrition basis incorporate the food intake balance principle, thus ensuring optimal body's need for food and bioactive capable of exhibiting their maximum efficiency in the body.

Certain food products or components have healthful and prevention benefits. These products are known as “functional food products”. For the first time they have been exported to the European market from Japan in 1996 [2, 3, 4].

These food products can include fruits and vegetables, whole grains, dietary fibers and other substances including functional components: carotenoids, flavonoids, minerals, vitamins and similar substances [5].

Functional characteristics of many traditional fermented milk drinks are discovered and studied. Currently there are new food products enriched with useful components under development.

Among all functional food products yogurt is considered to be ideal medium for nutritional ingredients delivery. [6] Especially, such as components of some bee farming products (honey, royal jelly, bee pollen pellet).

Bee pollen pellet has a form of dense balls. Each such ball is covered with agglutinating water - and fat-soluble substances. The first ones consist of nectar mono- and disaccharides, other contain propolis components. Since agglutination substances do not dry quickly, the fresh pollen pellet moister content is 25-30%. Therefore, after collection it must be dried to a residual moisture content not exceeding 10%, which ensures its storage for 240 days at room temperature, and 360 - at 12 ° C below 0 [7, 8, 9].

Bee pollen contains proteins, amino acids, carbohydrates, minerals, fats. It also includes hydrocarbons, organic acids, vitamins, sterols, flavoring, flavonoids, higher alcohols, phosphatides, phenolic and other biologically active substances. Due to such composition the pollen can exhibit activity of various types: antioxidant, antibacterial, hepatoprotective, antihypoxanth, etc. [7,10, 11].

Such a wide enough action range ensured pollen pellet application in apitherapy, alternative and traditional medicine [7,12]. Its application in the food industry is quite insufficient. There are several patents of Ukraine for art of manufacture of butter using powdered pollen (UA 96219 1. Method for Making Butter with Filltr; UA 94284 Method for Making Butter with Filltr; UA 94478 Method for Making Butter with Filltr), sweet creamed curds using bee farming products, including pollen (UA 47718 Cottage-Cheese Dessert) and fish rolls using fillings of plant origin (UA 67388 Рулет рибний функціонального призначення "Дімаре"; UA 67390 Fish Rolls Functional Setting "Marino", UA 67389 Fish Rolls Functional Setting "Royal", UA 67391 Fish Rolls Functional Setting "Atlantis").

Products listed above are wholesome and important, but they have no probiotic effect on human body, like yogurt. Besides, the above specified sources have no sufficient information on pollen preparation technology for use. Therefore, the use of bee pollen pellet to enrich and improve yoghurt remains an open question.

Materials and methods

The following was used for experimental process: bee pollen pellet; milk with a fat content of 3.2%; DVS-starter cultures Streptococcus thermophilus, Lactobacterium delbrueckii subspecies bulgaricum, Lactobacterium acidophilum made by Bulgarian manufacturer Genesis Laboratories. All raw materials meet the regulatory requirements for this type of product.

Bee pollen pellet samples were prepared by drying in a convection oven at a temperature of 32 ± 2°C to a moisture content of 10, 8, 6, 4 and 2%. To determine water weight fraction in bee pollen pellet samples the drying method was used, as well as methods proposed by Portuguese scientists Maria G.R. Campos, Stefan Bogdanov, Ligia Bicudo de Almeida-Muradian, Teresa Szczesna, Yanina Mancebo, Christian Frigerio, Francisco Ferreira [13].

Pollen grinding was performed using laboratory mill-pounder "Pulverisette – 2" to a particle size of 10-15 microns. In all cases, samples were ground to better homogenization of the batches and a rate of each of the samples (approximately 2 g, except method IV which used approximately 1 g) was submitted to the process. All batches were analyzed in triplicate, except for the Karl Fischer's, which was made in two duplicates.

Dried bee pollen's moisture determination was made by gravimetry methods, based on the sample weight loss due to desiccation, until constant weight was reached. Moisture content of samples submitted was calculated using the Equation 1:

$$\%moist = 100 - \left[\frac{m' - t}{m - t} \cdot 100\right] \quad (1)$$

where:

m = total mass of the system (glass + sample) at the beginning of the process;

m' = total mass of the system (glass + sample) at the end of the process;

t = mass of glass used.

Quartz treatment of pollen pellet thin layer performed using non-ozone bactericidal lamp made by German manufacturer Osram -ОББ-15ПП model "15W T8/G13".

Flow rate, bulk density and other technological parameters of pollen powder were determined by weighing. Microbiological studies were carried out according to standard study procedures set forth in standard process documentation of Ukraine.

Bactericidal treatment was carried out in a dry room, the humidity of which didn't exceed 5-10%. Dryness of air was observed to prevent sticking and clumping of fine pollen powder particles and improve its mixing with milk base.

Yogurt control and test samples were produced under similar laboratory conditions of the same raw materials and characterized by availability of bee pollen pellet content treated using different methods (UV-treated and untreated). Its content in test yoghurts was 0.15%.

There were three sample made. First sample (K) - control sample without fillers. Second (O1) – test sample containing milled to a particle size of 10 micron pellet UV-untreated. Third (O2) – test sample with pollen pellet powder that was subjected to antimicrobial treatment.

All fermented milk drinks samples were acidified to reach the acidity level of 90°T at 39 ± 2°C. Then samples were cooled to a temperature of 10 ± 2°C. Yogurt was stored in sealed packaging (glass containers of 150 cm³ with screw-tight plastic lids) at 4 ± 2°C.

The final value of each indicator was equal to the average value following the results of this indicator triple measurement.

Yogurt samples were analyzed on a third day of storage.

Mathematical data processing performed using standard set of computer programs integrated in Microsoft Office Excel 2010.

Results and discussion

Pollen grinding can cause problems since insufficiently dried product leads to the blockage and failure of the system. Significant powders loss as a consequence of substances sticking on mill parts. Therefore, study was undertaken regarding the effect of pollen pellet moisture content on grinding efficiency.

The data obtained during the determination of raw materials yield and loss are shown in Table 1.

Table 1

Bee pollen loss at the stage of grinding

Characteristics	Moisture, %				
	10	**8**	**6**	**4**	**2**
Amount of pollen, g	150	150	150	150	150
Yield rate, g	143,1	145,35	147,15	148,35	148,5
Pollen loss, %	4,6	3,1	1,9	1,1	1

After grinding of five pollen samples weighing 150 g dried to the different (10, 8, 6, 4 and 2%) moisture content, we found that the water content in raw material directly affects its yield and share of losses. Sample with 10% of moisture content had the lowest yield rate - 143.1, the highest yield rate was obtained from samples having 4 and 2% of moisture content - 148.35 and 148.5 g, respectively, with the difference between them of only 0.15 g. The difference in this value between sample having 10 and 4% of moisture content was 5.25 g, which was ≈ 8%. This is significant. Since, according to the formulations in TU U15.5-00493706-002: 2009, 5.25 g of pollen can be used to produce 350 - 1750 g of finished yogurt.

The experiment found that the rate of raw material loss characterized with direct proportion to the moisture content of bee pollen samples. Namely, raw material loss decreased with the moisture content decrease. The lowest loss rate was observed in pollen having moisture content of 4 and 2%. The difference between these samples was 0.1%. Losses of sample containing 10% of moisture were 4.6%, which is 3.6% higher than the sample having moisture content of 2 % and 3.5 – compared to sample having 4% of moisture content.

In practice, unmilled pollen drying can be used until it reaches moisture content of 4%. It will be rational in terms of cost efficiency in the raw material preparation process for using it in biotechnology of yoghurt with natural bee farming products.

By studying the technological characteristics of the bee pollen pellet powder we can assess its quality and predict the mixing process with a milk base. As it is known, that the more uniform is powder, the more uniformly it will be distributed in a liquid medium [14].

Dependency study was performed regarding technical parameters of the bee pollen pellet powder and its moisture content. Results for the bulk weight, bulk density are shown in Table 2, and flow rate – in Figure 1.

Table 2

Technological characteristics of bee pollen pellet powder

Characteristics	Moisture, %				
	10	8	6	4	2
Apparent density, g/cm^3	0,56	0,58	0,6	0,62	0,63
Bulk density, g/cm^3	0,78	0,77	0,77	0,76	0,76

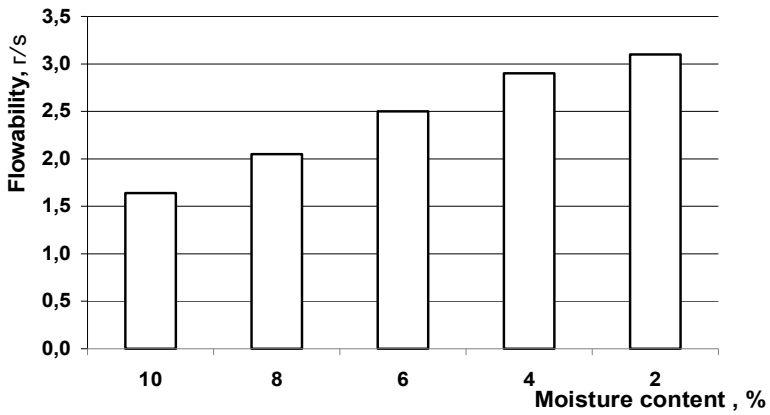

Figure 1. Pollen pellet powder flow rate and moisture content dependency

Powder technological data change depending on its moisture content is directly proportional to the flow rate and bulk density and inversely proportional to the apparent density. Results for samples having moisture content of 4 and 2% had insignificant differences. Therefore, for costs reason, same as in the previous case, it may be advisable to dry the pollen pellet to the moisture content of four percent.

Based on previous studies, as well as studies of foreign scientists, pollen can become a source or growth factor for adverse yogurt microbial population [15].

The values obtained as a result of microbiological study of control and test (O1) yogurt samples are summarized in Table 3.

Table 3

Bacteriological index for yoghurt with bee pollen pellet

Name of indicator	Sample	
	К	О1
Coli-forms in 0,1 g	not detected	in 1g
Pathogens, including Salmonela, in 25 cm^3	not detected	not detected
Staphylococcus aureus, в 1,0 cm^3	not detected	not detected
* Yeast, CFU/cm^3, no more than	50	50
in sample	not detected	not detected
*Mould fungi, CFU/cm^3, no more than	50	50
in sample	11	72

* – according to the current regulations of Ukraine.

Yogurt control sample is fully consistent with regulatory requirements to such product. O1 sample did not meet the standards in terms of two indicators. In 1g of O1 sample O1 there were coli-forms detected, which is not allowed. Mould fungi CFU exceeded the permissible level by 22 CFU/g.

In connection with the foregoing, it was decided to treat the powder derived from pollen with the ultraviolet lamps and analyze results obtained. Study was carried out only based on those indicators, the results of which were unsatisfactory (availability of coli-forms and moulds). The results obtained are shown in column chart with grouping in Fig. 2.

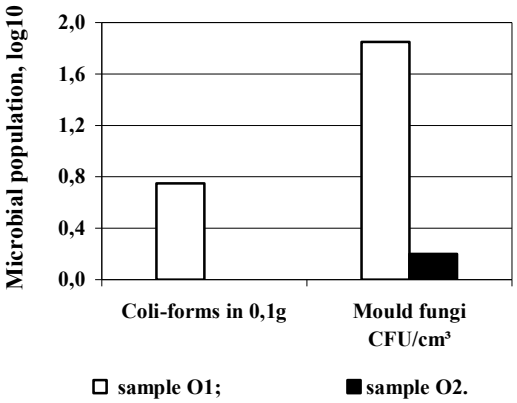

Fig.2. Microbiological indicators of test yogurt samples with bee pollen pellet

Pollen treatment using quartz lamp (O2) assisted in reducing the mould content to a level below the reference and maximum permissible. Number of coli-form bacteria in O2 sample decreased to zero. Other microbial safety indicators remained unchanged.

Thus, reducing the bee pollen pellet moisture content prior grinding to 4-2% will facilitate the grinding process and obtain powder with satisfactory technological parameters.

Pollen pellet powder ultraviolet treatment prior it's adding to the prepared milk base prevents adverse microbial population indicators growth in the finished fermented milk drink.

Conclusions

Bee pollen pellet drying to the moisture content of 4-2% enables preventing its substance sticking to the operating items of grinding devices and obtaining powder with satisfactory technological parameters.

Pollen powder treatment with bactericidal lamps prior adding the milk base will reduce the risk of adverse microbial population ingress.

Described methods allow using bee pollen pellet for fermented milk drinks production technology.

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Influence of carbon-bearing raw material on microfungus *Blakeslea Trispora* biomass producing

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Keywords:

Carotenoid
Biomass
Microfungus
BAS

Article history:

Received 02.07.2014
Received in revised form 13.08.2014
Accepted 02.09.2014

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Abstract

Introduction. This paper investigates influence of hydrated fullerenes on degree of accumulation bioactive substances of microfungus Blakeslea trispora.

Materials and methods. In this research effort detection of fatty-acid composition in amino acids, carotenoids and sterols biomass by means of using methods of high-performance liquid chromatography, adsorption and disjunctive chromatography in thin-layer sorbent and spectrophotometric; gravimetric method; method of direct spectrophotometration in benzene took place.

Results and discussion. It has been induced that application of hydrated fullerenes in microfungus Blakeslea trispora nutrient medium promotes increasing accumulation in biomass quantity of carotene on 32,3 %; asparaginic, glutamic acids and leucine.

Reproportion carbon to nitrogen by means of adding to microfungus Blakeslea trispora nutrient culture medium hydrated fullerenes did not influence on the biomass amino acid structure any.

Obtained data of fatty-acid composition in microfungus Blakeslea trispora lipoid fraction indicate about significant predominance unsaturated fatty acids and, as a result of this, we have advance of use microfungus Blakeslea trispora biomass as a source of biologically active substances for establishing a new kind of prophylactic action goods.

Introduction

Microfungus *Blakeslea trispora*, owing to its high carotinsynthesizing ability, is the most promising producer of β-carotin and is advanced industrial basic material among other microorganisms and plants [1]. Hydrated fullerenes — high-persistent fine-dispersed aqueous solution of native fullerenes, which, unlike other fullerenes, have properties of lyophobic molecular-colloidal systems and are growth-stimulating agents and antioxidants

[2, 3, 4]. Special properties of fullerenes are their water repellency and their ability to oxidation due to high electronegativity, notably their ability to attach any more than six free electrons to oneself [5].

Materials and methods

In this research effort detection of fatty-acid composition in amino acids, carotenoids and sterols biomass took place. A quantitative composition of biologically active substances in the microfungus *Blakeslea trispora* biomass samples, obtained in different culture conditions: in traditional nutrient medium and with adding to it hydrated fullerenes; was studied.

Definition of fatty-acid composition in biomass pilot samples was carried out with use of method of high-performance liquid chromatography by the instrumentality of chromatograph Shimadzu Gl-14B with electronic data processing [7].

For detection sterols in microfungus *Blakeslea trispora* biomass, we obtained unsaponifiable fractions of biomass samples. For complete total (qualitative and quantitative) definition 3β-hydroxysterols we applied methods of adsorption chromatography and thin-layer chromatography and spectrophotometric. Saponification of samples was carried out with the use of petroleum-ether (40…60 °C) as extractant, elimination of solvent — in vacuum under temperature 30…35 °C, while detection of unsaponifiable fraction — with gravimetric method.

Content of carotenoids we estimated by means of method of direct spectrum-photometric measurements in benzol under wave length 456 nm. Content of carotenoids calculated in conformity with 100 g band-and-hook hinge of virgin sample [9].

For detection of amino acids quantity in microfungus *Blakeslea trispora* biomass samples, we previously applied normalized amino acids mixture with well-known concentration of every amino acid on the column of autoanalyser [10]. In accordance with chromatogram, we calculate peak area (or peak height) of every amino acid. Formula evaluation of number of micromoles in every amino acid (X_1) in observable solution stated below:

$$X_1 = S_1 / S_o, \quad (1)$$

where S_1 - peak area (or peak height) of amino acid in observable sample;

S_0 - peak area (or peak height) of the same amino acid in solution of normalized amino acids mixture, which corresponds to 1 micromole quantity of every amino acid.

In the samples of microfungus *Blakeslea trispora* dried biomass we carried out content test for carotenoids and vitamin E, as well as content test for ubiquinone (coenzyme Q_{10}) [16]. For detecting this substances, we saponified band-and-hook hinge of biomass samples via potassium hydroxide alcoholic solution and extracted via diethyl ether. Extracts were washed off with water up to neutral pH magnitude, were dried by means of anhydrous sulfuric sodium, were filtrated and evaporated by the use of rotary evaporator. Unsaponifiable fraction (solid residual) was dissolved in benzol.

Extracts of unsaponifiable matter had been simultaneously separated and determined content of carotenoids, ubiquinone and vitamin E in them [15].

Content of vitamin E and ubiquinone in aliquots of summarized unsaponifiable matter in observable samples was determined after two sequential chromatographies: adsorption (preparative) thin-layer chromatography with silicagel mark LS 5/40 μm in system hexane-ether (correlation respectively 70:30), and analytic chromatography on impregnated plates

(5 % hexadecane in light petroleum ether, fraction 40…60 °) Silufol uv 254 in system acetone-water (correlation accordingly 90:10). In the capacity of control samples we used standards Q_9, Q_{10} and α-tocoferol ("Serva").

Content of ubiquinone we determined after chromatographic separation components of unsaponifiable fractions of samples in re-computation on dry fraction at wave length 275 nm in ethanol according to difference between extinctions of oxidated and reduced forms in 15 minutes after adding to probe 0,02 ml 2,5 % borane sodium aqueous solution.

Content of vitamin E we determined after chromatographic separation components of unsaponifiable fractions of samples by the use of Emery-Engel reaction with photometric method at wave length 520 nm.

For determining sterols in microfungus *Blakeslea trispora* biomass, we obtained unsaponifiable fractions of biomass samples. For complete general (qualitative and quantitative) detection 3β-hydroxysterols we used methods of adsorption and disjunctive chromatography in thin-layer sorbent and spectrophotometric. Saponification of samples was carried out with the use of petroleum-ether (40…60 °C) as extractant. Elimination of solvent was carried out in vacuum under temperature 30…35 °C. Detection of unsaponifiable fraction was carried out with gravimetric method.

For qualitative and quantitative detection 3β-hydroxysterols we used method of thin-layer chromatography. Localization of investigated materials evaluated per standards: ergosterine, cholesterol, fucosterol, β-sitosterol. Supplementary standard was precursor of sterols — squalene.

Quantitative determinations were carried out using method of color chemical reactions with the use of spectrophotometric measurements.

Components of unsaponifiable fraction we separated on carotenoid fraction (contain only squalene) and noncarotenoid fraction (contain sterols and steroids).

Results and discussion

Composition of amino acids in microfungus *Blakeslea trispora* samples, that were obtained in various culture conditions, denotes on increasing number of certain amino acids in the samples of biomass (table 1) and content of carotenoids (table 2).

From this findings of investigation (table 1), it can be concluded that total content of amino acids in microfungus *Blakeslea trispora* biomass presented with all principal amino acids. Reproportion carbon to nitrogen by means of adding to nutrient medium hydrated fullerenes did not influence on the biomass amino acid structure any.

As a result of findings, which is stated below in the Table 4, content of unsaturated fatty acids in check and test biomass samples, that were obtained under different culture conditions, practically is quite indistinctive.

Table 1

Amino acid composition of microfungus *Blakeslea trispora* biomass test specimens

Amino acids	Content in biomass on conventional nutrient solution		Content in biomass with adding to nutrient medium hydrated fullerenes	
	mg	*%, in mg*	*mg*	*%, in mg*
Lysine	0,3555 ± 0,02	6,79 ± 0,41	0,8340 ± 0,07	8,25 ± 0,68
Histidine	0,1634 ± 0,02	3,02 ± 0,22	0,2554 ± 0,02	2,52 ± 0,12
Arginine	0,2111 ± 0,01	3,84 ± 0,24	0,3882 ± 0,04	3,84 ± 0,21
Asparaginic acid	0,5168 ± 0,17	9,63 ± 0,81	1,6141 ± 0,17	15,94 ± 1,34
Threonine	0,3598 ± 0,03	6,74 ± 0,53	0,4956 ± 0,05	4,90 ± 0,39
Serine	0,3395 ± 0,03	6,43 ± 0,42	0,4957 ± 0,05	4,91 ± 0,42
Glutamic acid	1,8597 ± 0,02	16,05 ± 1,02	1,9887 ± 0,21	19,65 ± 1,71
Proline	0,1100 ± 0,01	1,91 ± 0,13	0,0978 ± 0,008	0,91 ± 0,06
Glycine	0,5289 ± 0,04	9,93 ± 0,64	0,6127 ± 0,08	6,05 ± 0,53
Alanine	0,4109 ± 0,03	7,65 ± 0,52	0,8006 ± 0,09	7,91 ± 0,65
Cystine	0,0109 ± 0,00	0,18 ± 0,01	0,0190 ± 0,002	0,19 ± 0,02
Valine	0,2319 ± 0,01	4,47 ± 0,36	0,3968 ± 0,04	3,92 ± 0,35
Methionine	0,0206 ± 0,00	0,38 ± 0,25	0,0573 ± 0,006	0,57 ± 0,05
Isoleucine	0,5231 ± 0,04	4,44 ± 0,18	0,4762 ± 0,05	4,70 ± 0,34
Leucine	0,5299 ± 0,04	9,87 ± 0,37	1,0238 ± 0,07	10,11 ± 0,97
Tyrosine	0,2321 ± 0,02	4,12 ± 0,22	0,3249 ± 0,02	3,21 ± 0,21
Phenylalanine	0,2339 ± 0,02	4,54 ± 0,24	0,2422 ± 0,03	2,39 ± 0,06

Table 2

Content of carotenoids in microfungus *Blakeslea trispora* biomass test specimens

№	Denomination of a sample	Content of carotenoids, g/100 g
1	Biomass on conventional nutrient solution	0,720 ± 0,064
2	Biomass with adding to nutrient medium hydrated fullerenes	0,800 ± 0,082

Content of sterols in microfungus *Blakeslea trispora* biomass samples is adduced in the Table 3.

Table 3

Content of sterols in microfungus *Blakeslea trispora* biomass samples

№	**Denomination of a sample**	**Unsaponifiable fraction,** % from biomass sample	**Squalen,** % from unsaponifiable fraction	**Noncarotenoid fraction**, %	**β-sitosterol,** % from unsaponifiable fraction
1	Biomass on conventional nutrient solution	**10,89 ± 1,12**	**7,50 ± 0,78**	**1,71 ± 0,19**	**0,15 ± 0,02**
2	Biomass with adding to nutrient medium hydrated fullerenes	**14,41 ± 1,51**	**9,06 ± 1,01**	**1,95 ± 2,02**	**0,26 ± 0,04**

Table 4

Fatty-acid composition of microfungus *Blakeslea trispora* biomass

№	**Name of acid**	**Content in biomass on conventional nutrient solution**, mg %	**Content in biomass with adding to nutrient medium hydrated fullerenes, mg %**
1	$C_{14:0}$ myristic	-	0,8329 ± 0,09
2	$C_{16:0}$ palmitic	8,6913 ± 0,9	8,957 ± 0,9
3	$C_{16:1}$ palmitic-oleic	0,8381 ± 0,8	-
4	$C_{18:0}$ stearic	4,6892 ± 0,5	4,6211 ± 0,5
5	$C_{18:1}$ oleic	21,9756 ± 2,1	20,9858 ± 2,3
6	$C_{18:2}$ linoleic	61,0342 ± 6,2	59,0434 ± 4,8
7	$C_{18:3}$ linolenic	1,2153 ± 0,1	3,2598 ± 0,3
8	$C_{20:1}$ gadoleic	0,4410 ± 0,03	-
9	$C_{22:0}$ behenic	1,2102 ± 0,1	1,0332 ± 0,1

Obtained data of fatty-acid composition of lipid fraction in microfungus *Blakeslea trispora* biomass indicate about significant predominance unsaturated fatty acids, that stipulates high indices of acidity and peracidity numbers. Withal presence of huge variety of fatty acids indicates about availability of employment of microfungus *Blakeslea trispora* biomass as a source of biologically active substances for the purpose of creation of new types of production with prophylactic action [17, 18].

Synthetic data, concerned in the question of content of biologically active substances in microfungus *Blakeslea trispora* biomass, are presented in the table 5.

Table 5

Content of biologically active substances (BAS) in microfungus *Blakeslea trispora* biomass samples

№	Biologically active substances	Content in biomass on conventional nutrient solution	Content in biomass with adding to nutrient medium hydrated fullerenes
1	Carotenoids, mg %	635 ± 49	840 ± 79
2	General lipids, %	19,5±2,2	18,6±1,6
3	Ubiquinones, mg %	0,10 ±0,01	0,08±0,006
4	β-sitosterol, % from unsaponifiable fraction	0,15±0,02	0,36±0,04
5	Squalen, % from unsaponifiable fraction	7,50±0,78	9,06±1,01
6	Protein, %	2,29±0,20	1,82±0,15
7	Phospholipids in re-calculation on lecithin, mg %	246,9 ± 20,12	252,0 ± 22,1

On the ground of presented data (in table 5), we can predicate about existence in microfungus *Blakeslea trispora* biomass not only carotenoids, but also another different biologically active constituents.

Conclusion

It has been induced that application of hydrated fullerenes in microfungus *Blakeslea trispora* nutrient medium promotes increasing accumulation in biomass quantity of carotene on 32,3 %, asparaginic, glutamic acids and leucine, and variation of some other amino acid composition characteristics.

Reproportion carbon to nitrogen by means of adding to microfungus *Blakeslea trispora* nutrient culture medium hydrated fullerenes did not influence on the biomass amino acid structure any.

Obtained data of fatty-acid composition in microfungus *Blakeslea trispora* lipoid fraction indicate about significant predominance unsaturated fatty acids and, as a result of this, we have advance of use microfungus *Blakeslea trispora* biomass as a source of biologically active substances for establishing a new kind of prophylactic action goods.

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Rape phosphatide concentrate in the technologies of surfactants production by the Actinobacteria

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Keywords:

Gordonia
Rhodococcus
Biosurfactants
Phosphatid
Concentrate

Article history:

Received 01.07.2014
Received in revised form 03.08.2014
Accepted 02.09.2014

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Abstract

Introduction. Due to the fact that the production of microbial surfactants is limited by the low yield of end products and high cost of processes, the actual task is to optimize and reduce the cost of the technology of biosurfactants synthesis. One of the solutions of this problem is to use the industrial wastes, including rape phosphatide concentrate (PC).

Materials and methods. Hexadecane and rape phosphatide concentrate (2%) were used as a carbon source in a nutrient medium for the cultivation of bacteria. Lipids were extracted from a cell mass and supernatant by the mixture of chloroform-methanol 2:1. The qualitative analysis of metabolites was performed by a thin layer chromatography.

Results and discussion. The peculiarities of synthesis of biosurfactants by strains *G. rubripertincta* UCM Ac-122 and *R. erythropolis* Au-1 during the growth on the nutrient media with rape phosphatide concentrate as a carbon source was studied. Quantity of biomass was 9.4 – 10.1 g/l, exopolymers – 8.9-9.5 g/l and the content of cell-bound trehalose lipids was 1.37 – 2.26 g/l; whereas the content of exogenous trehalose lipids – metabolites of *R. erythropolis* Au-1 was 2.95 g/l. It was found that the addition of trehalose lipids (0.01 g/l) to the nutrient medium caused the increase of biomass on 14.6 – 17.0 % and cell-bound lipids on 13.9 – 15.5 %.

Conclusions. Rape phosphatide concentrate is economically viable carbon source in the technologies of surfactant production by Actinobacteria. Its use promotes an increasing of exogenous surfactants strain *R. erythropolis* Au-1 in 3-fold compared with cultivation on nutrient medium with hexadecane. Trehalose lipids show a stimulating effect on growth and synthesis of biosurfactants by strains of *G. rubripertincta* UCM Ac-122 and *R. erythropolis* Au-1.

Introduction

Microbial synthesis of surfactants is a perspective direction of biotechnology. Biosurfactants attract considerable interest due to their potential advantages if compared with their synthetic analogues in many fields of environmental, food, biomedical and other industrial applications. However, several factors limit the large-scale production of these compounds, in particular, the low yield of a product and the high cost of downstream processes. Therefore, important tasks are to search new active microorganisms-producers, to increase efficiency of biosurfactant's synthesis and to make technology of biosurfactant production cheaper [1, 2].

It was established that the bacterial strains *Gordonia rubripertincta* UCM Ac-122 and *Rhodococcus erythropolis* Au-1 from the collection of microorganisms of Danylo Zabolotny Institute of Microbiology and Virology, National Academy of Sciences of Ukraine are perspective producers of biosurfactants [3, 4]. These bacteria synthesize exogenous polymers (EP) with emulsifying properties and complexes of surfactant lipids, the main component of which are trehalose lipids (TL). It is known that Actinobacteria, in particular of genus *Rhodococcus*, are able to consume actively a wide range of water-insoluble carbon sources. The microbial cell wall of these bacteria consists mainly of mycolic acids and trehalose lipids, so it is cognate with hydrophobic substances [5]. Based on these data, the cultivation of actinobacteria for accumulation of biomass and cell-bound surfactants is often conducted on nutrient media with hydrophobic carbon sources, particularly, with hexadecane (HD) [6], but the use of this substrate is impractical from the economical point of view.

The use of the alternative substrates such as agro-based wastes is one of the attractive strategies for economical biosurfactant production [7]. In particular, it was shown that the cultivation of *Acinetobacter* sp. IMV B-7005 was carried out using a mixture of molasses and fumarate [8], *Nocardia vaccinii* K-8 – glycerol [9], bacteria of the genus *Pseudomonas* – overheated sunflower oil [1] and so on. However, the results of the studies do not resolve all the issues of the optimization of biosurfactants technology.

Thus the aim of our work was to study the synthesis of biosurfactants by strains *G. rubripertincta* UCM Ac-122 and *R. erythropolis* Au-1, using phosphatide concentrate (PC), which is a by-product of rapeseed oil and diesel fuel production.

Materials and methods

Bacterial strains *G. rubripertincta* UCM Ac-122 and *R. erythropolis* Au-1 from the Ukrainian collection of microorganisms of D. Zabolotny Institute of Microbiology and Virology were used. Cultivation of bacteria was carried out using the following nutrient medium (g/l): $NaNO_3$ – 3.0; yeast extract – 1.0; K_2HPO_4 – 2.0; KH_2PO_4 – 2.0; $MgSO_4 \times 7H_2O$ – 0.5; sodium citrate – 1.0 (pH 6.8-7.0). As carbon sources were used hexadecane or rape phosphatide concentrate (trademark "Majola") of the following composition (%): oil – 72.91; not fatty additives – 13.22; phosphatides – 12.39; moisture – 1.48. Microorganisms were cultivated in 750 ml Erlenmeyer flasks with 150 ml medium on the rotary shaker (220 rpm) at 28-30 °C during 5 days.

Cells were separated by centrifugation at 6000 rpm for 15 min. The biomass was determined by gravimetric method. The surface tension of CLS was determined by Du-Nui method [10] with tensiometer KRÜSS K6 ("KRÜSS" GmbH, Germany).

For determining the emulsifying activity 10 ml of the culture liquid supernatant was mixed with 10 ml of Vaseline oil during 2 minutes and transferred into a measuring tube.

The emulsification index (E_{24}) was determined after 24 h as the ratio of the height of emulsion layer to the total height of the liquid in the tube [10].

Lipids were extracted from cell mass and CLS with the mixture of chloroform-isopropanol (2:1). This extract was evaporated under vacuum to constant weight.

Exopolymers were precipitated from CLS by acidification with 10% hydrochloric acid to pH 3, then the mixture was kept at 4˚C for 12 h. The precipitate was separated by centrifugation (6000 rpm, 15 min.), washed, filtered and dried to constant weight at a temperature of 60˚C.

Qualitative analysis of lipids was performed by thin layer chromatography (TLC) on plates Sorbifil PTSH-AF-A-UF (CJSC «Sorbpolymer», Russia). Mobile phase [11]: chloroform-methanol-water 65:15:2. Lipids were preliminary identified by spraying plates with specific reagents:

a. 5 % alcohol solution of phosphorus molybdenum acid (total lipids);

b. 4-methoxybenzaldehyde reagent (glycolipids);

c. 5% alcoholic solution of ninhydrin (peptide lipids).

The influence of biosurfactants on cultivation of Actinobacteria was studied by adding their solution at a concentration of 0.01 g/l to the culture medium.

Results and discussion

The growth parameters of strains *G. rubripertincta* UCM Ac-122 and *R. erythropolis* Au-1 on the nutrient media with phosphatide concentrate and hexadecane were studied. The data from the experiments are presented in the Table 1.

Table 1

The growth parameters of the strains *G. rubripertincta* UCM Ac-122 and *R. erythropolis* Au-1 on the nutrient media with phosphatide concentrate and hexadecane

Bacterial strains	Carbon sources	Surface tension, mN/m	Emulsifying activity E_{24}, %	Exopoly-mers, g/l	Biomass, g/l	Biosurfac-tants, g/l
R. erythropolis Au-1	HD	31,5±0,5	7,6±0,5	5,1±0,3	13,3±0,7	3,36±0,20
	PC	48,5±0,5	60,6±2,3	9,5±0,6	10,1±0,6	1,37±0,13
G. rubripertincta UCM Ac-122	HD	39,7±0,2	55,7±2,8	5,8±0,4	10,4±0,5	3,16±0,16
	PC	41,5±0,4	54,9±1,8	8,9±0,7	9,38±0,5	2,26±0,11

HD – hexadecane.

PC – phosphatide concentrate.

The increase of exopolymers content in 1.9 times, reduction of the biomass content on 23.9 %, and the cell-bound lipids – in 2.45 times was shown when the PC was used compared to HD for cultivation of *R. erythropolis* Au-1. The CLS, obtained in the nutrient medium with PC, had higher emulsifying activity (60.6%) then CLS obtained using HD (7.6 %) (Table 1). Also, it was shown that the cultivation of *G. rubripertincta* UCM Ac-122 on the nutrient medium with PC (compared with the use of HD) caused the increase of exopolymers content on 54% and reduction of the biomass accumulation and cell-associated lipids (biosurfactants), respectively, on 9.8 % and 28.5 %. The emulsifying activity and the surface tension of the CLS with PC remained practically unchanged (Table 1).

The effect of the use of rape PC on the quality of the cell-associated lipids was studied. The data are presented in Fig.1. It was shown that the *R. erythropolis* Au-1 strain produced glycolipids: trehalose-mono-mykolates, trehalose-di-mykolates, trehalose esters and fatty acids when uses both carbon sources. When the strain was cultivated on the nutrient medium with PC, there was the increase of amount of phosphatidic acids and fatty alcohols, also small amounts of peptide lipids were present. The strain *G. rubripertincta* UCM Ac-122 produced glycolipids, peptide lipids and neutral lipids when using HD and PC (Fig.1).

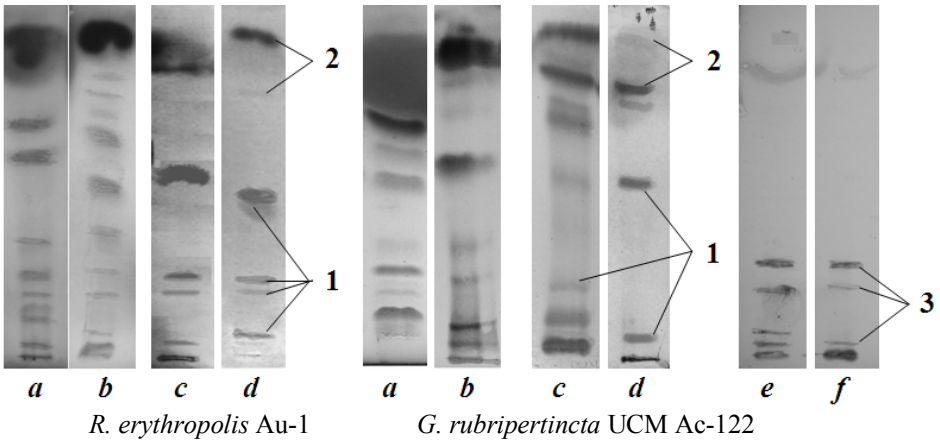

Fig.1. Thin layer chromatograms of cell-associated total lipids (a, b), glycolipids (c, d) and peptide lipids (d, e) of bacterial strains *R. erythropolis* Au-1 and *G. rubripertincta* UCM Ac-122. The carbon source – hexadecane (a, c, e) and phosphatide concentrate (b, d, f):
1 – trehalose lipids; 2 – neutral lipids; 3 – peptide lipids.

It is known that the strain *G. rubripertincta* UCM Ac-122 synthesizes cell-bound biosurfactants [4], so lipids were extracted from the cell mass. But the bacteria of genus *Rhodococcus* also produce exogenous biosurfactants [6]. Based on these data, we studied the presence of exogenous surfactants synthesized by *R. erythropolis* Au-1. It was showed that the strain produces exogenous lipids, but their amount changes significantly depending on the of carbon source – 2.95 g/l when rape PC was used and 0.98 g/l when HD was used (Fig. 2). It was established that the total amount of surface-active lipids was unchanged, but the concentration of exogenous biosurfactants was increased.

We used the thin layer chromatography for the control of composition of cell-bound and extracellular lipids of strain *R. erythropolis* Au-1. It was shown that this strain during growth in nutrient medium with hexadecane as carbon source synthesized small amounts of exogenous lipids; but, the use of phosphatide concentrate can significantly increase the production of those surfactants.

The investigated Actinobacteria are considered as promising producers of both biosurfactants and exopolymers. The data on the production of EP by the strains *R. erythropolis* Au-1 and *G. rubripertincta* UCM Ac-122, the yield of which lies within the range 8.9-9.5 g/l depending on the bacterial strain and carbon source are presented in Table 1. The emusification properties of the selected EP with Vaseline oil were studied (Fig. 3).

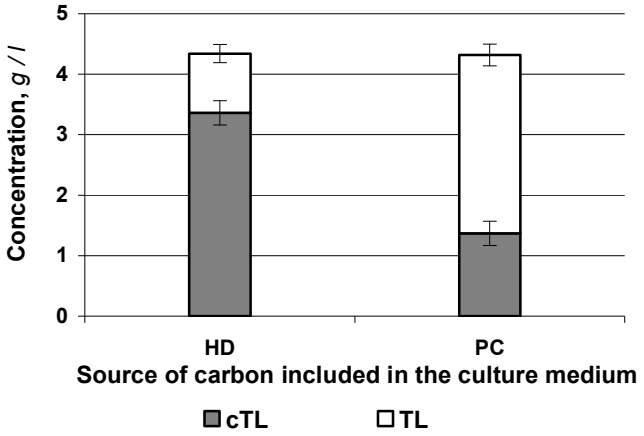

Fig. 2. Effect of carbon sources on the synthesis of biosurfactants by *R. erythropolis* Au-1
TL – exogenous lipids, the main component of which is trehalose lipids.
cTL – cell-associated lipids, the main component of which is trehalose lipids.
HD – hexadecane, PC – phosphatide concentrate.

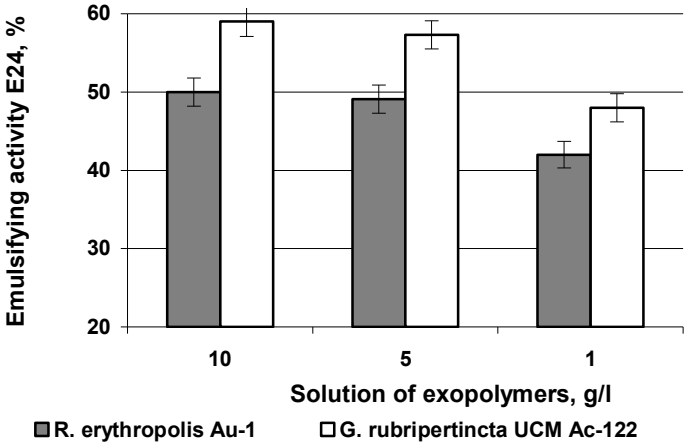

Fig. 3. Emulsification indices of the EP solutions of various concentrations with Vaseline oil

It was confirmed that EP is the main emulsification factor of the culture liquid supernatant. Thus, the EP solutions (10 g/l and 5 g/l) have high emulsification activity, and the further reduction of concentration resulted in decrease of the emulsification index E_{24} to 42-48% depending on a producer.

Thus, CLS of Actinobacteria can be considered as effective emulsifiers. The stability of the emulsions (28 days) of vaseline oil with CLS of the studied microorganisms, obtained via cultivation on the nutrient medium with PC were studied as well. The data are given on the Fig. 4.

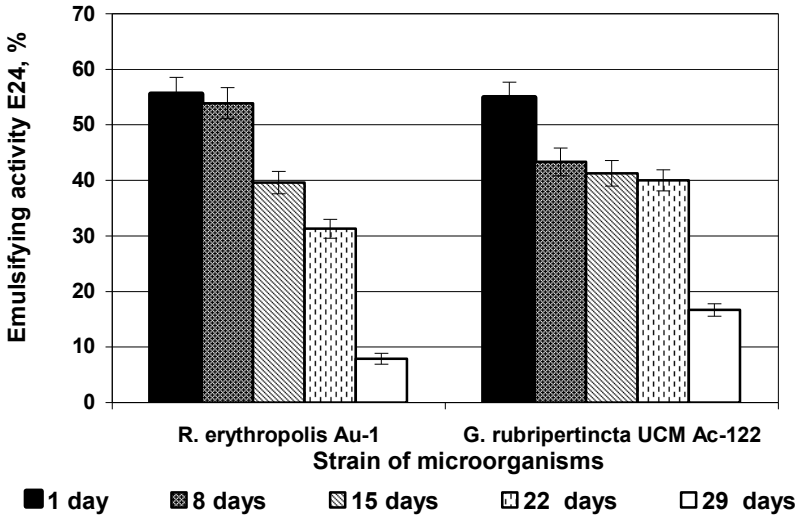

Fig. 4. The stability in time of the emulsions of Vaseline of with CLS of the studied Actinobacteria

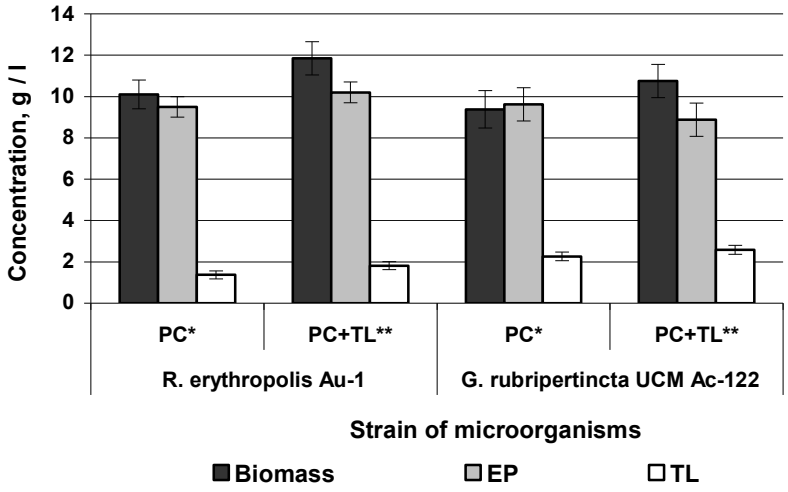

Fig.5. Effect of trehalose lipids on the growth of strains of *G. rubripertincta* UCM Ac-122 and *R. erythropolis* Au-1

PC * – carbon source phosphatide concentrate 20 g/l.
PC+TL** – carbon source phosphatide concentrate 20 g/l plus trehalose lipids (0.01 g/l).
EP – expolymers. TL – trehalose lipids.

It was revealed, the emulsification activity of the CLS of the strain *G. rubripertincta* UCM Ac-122 was rather high (around 40 %) during three weeks, while the the CLS of the strain *R. erythropolis* Au-1 was losing its properties much faster.

It was shown, that the CLS of Actinobacteria, cultivated on the nutrient medium with PC, have high emusification activity (their E_{24} is 55-57 %). Emulsions of the bacterial CLS with vaseline oil remain stable during 3 weeks.

It is known that biosurfactants can influence the permeability of cell membranes [12], enzymatic activity [13] and are able to enhance the action of other substances [14]. Based on these data, it was decided to study the effect of biosurfactants on the growth of *R. erythropolis* Au-1 and *G. rubripertincta* UCM Ac-122 (Fig. 5).

We have found that the addition of the TL solution to the culture medium during the bacteria growth had no effect on the quality of the produced biosurfactants. However, it was shown that, depending on the strain, the increase in biomass and cell-associated lipids, made respectively, 14.6 - 17.0 % and 13.9 - 15.5 % (Fig. 5). The concentration of exopolymers was practically unchanged.

Conclusions

1. It was established that bacterial strains *G. rubripertincta* UCM Ac-122 and *R. erythropoli*s Au-1 effectively consumed the rape phosphatide concentrate as a carbon source – the bacterial biomass was 9.4-10.1 g/l.
2. It was shown that biosurfactants were actively synthesized in the nutrient medium with rape phosphatide concentrate – the content of a cell-bound lipids was 1.37-2.26 g/l. Moreover, the content of exogenous trehalose lipids – metabolites of *R. erythropolis* Au-1 – has increased in 3 times if compared to the use of hexadecane.
3. The composition of biosurfactans synthesized by *G. rubripertincta* UCM Ac-122 and *R. erythropolis* Au-1 was determined, they consist of glycolipids (trehalose mycolates) phospho-, peptide and neutral lipids. The qualitative composition of biogenic surfactants was practically unchanged when using different sources of carbon.
4. It was shown, that CLS is an effective emulsifier, and the main factor which determines its emulsifying properties is EP. The yield of expolymers made 5,1-9,5 g/l depending on the strain-producer and carbon source.
5. It was established that the addition of the trehalose lipids (0.01 g/l) to a nutrient medium during cultivation of actinobacteria coused the increase of biomass on 14.6-17.0 % and cell-associated lipids – on 13.9-15.5 %, the amount of exopolymers remained unchanged if compared with the control.
6. Therefore, the rape phosphatide concentrate is a promising cost-effective carbon source for microbial surfactants technologies.

Investigations were conducted in the framework of the project STCU 5965

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The influence of design parameters of rotary dryer on sunflower seeds drying

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Keywords:

Sunflower
Drying
Rotary
Dryer

Article history:

Received 09.06.2014
Received in revised form 19.07.2014
Accepted 02.09.2014

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Abstract

Introduction. In order to improve the drying of sunflower seeds in the apparatus of the rotary type, it is appropriate to model processes in this devices using computer simulation software.

Materials and methods. Simulation of sunflower seeds drying was based on the finite element method using the software package Flow Vision (company "TUSYM") and mathematical and statistical methods.

Results. Mathematical models were obtained that show the dependence of pressure of coolant (air) in the drying chamber of rotary dryer on the rate of the coolant, the open cross-sectional area of the gas distributor plate and its resistance, the dependence of duration of sunflower seeds drying on fill factor of the drying chamber and its volume as well as the final material moisture content.

The equilibrium distribution of the coolant pressure in the drying chamber of rotary dryer was obtained. It provides a constant height of the fluidized bed of sunflower seeds and quality of its drying.

The design of rotary dryer was improved by providing the tangential supply of coolant and installing a spiral partition under gas distribution grid, which allows to uniformly distribute the coolant in the drying chamber.

Conclusion. The drying process of sunflower seeds in a rotating dryer was improved. It is advisable to use the experimental result when choosing the mode of drying at the design stage of drying equipment.

Introduction

The existing constructions of dryers consist of different elements designed to heat the air and to mix the cold air with coolant, heat chambers, drying chambers, chambers for mixing dried grains with wet, chambers for cooling grain and its maturing, and so on. There are a number of different methods and classifications of dryers depending on the combination of these elements. Designs of dryers influence such process parameters as temperature, duration of staying of the product in the dryer and temperature distribution in the fluidized bed height.

When choosing a dryer for sunflower seeds drying there are problems associated with changes of oil quality indicators, the destruction of bran covering through drying, fire hazard, the uneven heating and drying, increased coolant flow, low productivity and long duration of drying.

Therefore there is a question for choosing the rational design of dryers for drying of sunflower seeds or improving the existing ones.

After analyzing the existing designs of dryers for sunflower seeds drying, their advantages and disadvantages the rotary dryer with fluidized bed was selected for improvement, which will provide drying of sunflower seeds with minimal materials consumption, low energy intensity and reasonable performance. This is achieved by using a sectional dryer, which provides a tangential supply of heat to the mixed seed and by installing of partition under the grid, which provides the same height of the fluidized bed through cross section of the dryer and uniform drying of sunflower seeds.

Fluidized bed dryers are widely used in the food industry due to the simplicity of constructional design.

This paper presents the investigation of the infenence of constructional features of the improved design of rotary dryer on drying process of sunflower seeds.

The technological value of sunflower seeds is determined by its oil content that is important to maintain during drying. During the drying process synthesis or decay of fatty oil components can occur. The direction of these changes depends on the seed moisture, temperature and duration of the drying process. Under optimal mode of drying oil content in sunflower seeds increases. Accompanying substances contained in the seeds such as phosphates, carotenoids, sterols, waxy substance, passes to the oil.

The problem number one at present is the development of new methods for drying of grains and oilseeds, creating of small dryers, and in particular improving of dryers with fluid (boiling) layer known for its high efficiency and speed of drying, simplicity of construction and operation, performance quality and flexibility of drying process control.

Recently in addition to physical models mathematical models are often used when creating new types of equipment and improving of existing ones. These calculations allow to follow the technological processes in the equipment and optimize them with less time and material resources.

Materials and methods

At present the patterns of structural effects arising from the interaction of fluidized (boiling) layer and the degree of influence of these effects on the intensification of heat transfer process are not carefully studied. To determine the expediency of the use of rotary dryer during the drying of sunflower seeds, it is necessary to conduct further invessigation and mathematical modeling.

The software package Flow Vision was used to simulate the coolant motion, its velocity vector distribution and determine the pressure in the drying chamber, to build diagrame and visualization of the nature of air motion and to obtain the experimental data.

The geometric model of the drying chamber was developed to determine the main design parameters of the equipment and rational modes which are able to ensure the effective implementation of the drying sunflower seeds in graphics editors (Fig. 1). The model of air chamber was developed to study the air flow motion under the drying grid (Fig. 2).

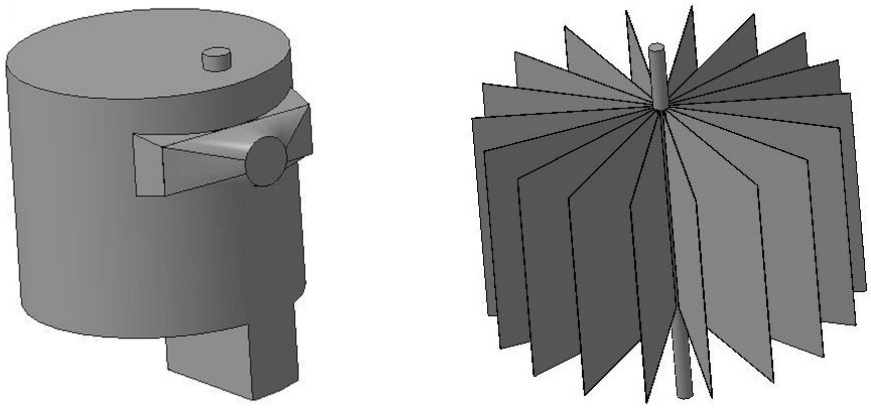

Fig. 1 The geometric model of the drying chamber and blades

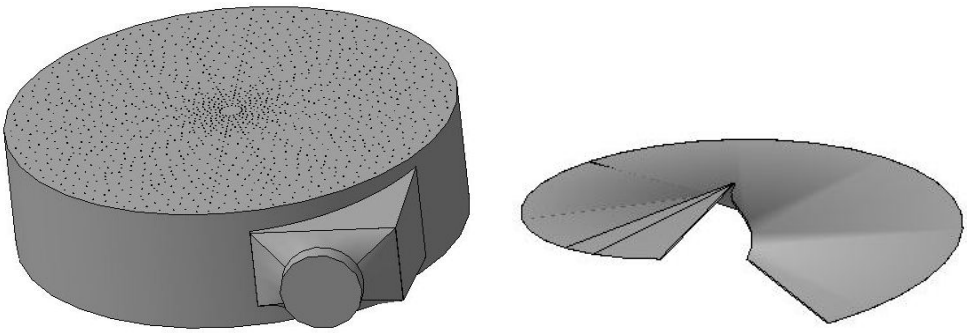

Fig. 2 The model of air chamber and partition

The procedure of the research in the software package Flow Vision consist of the next step:

1. Open the Flow Vision file with the studied model.
2. Choose the mathematical model for calculation using the available models in the program complex Flow Vision and the calculated parameter. In our case the calculated model is "Incompressible fluid" because the laws of this model fully meet the challenge.
3. Imput the boundary conditions for model. Boundary conditions should be three: the coolant outlet boundary conditions, boundary conditions of the chamber wall, partitions, blades, shaft, grid, and boundary condition of coolant input.
4. Input the physical properties of the model.
5. Specifiy the number of computational cells along the each axis of the coordinate system of the model.
6. Specifiy criteria for mesh adaptation for solution and boundary conditions.
7. Specifiy the parameter of calculation methods .
8. Start of calculation without user intervention.
9. Viewing the calculation results in graphical form (visualization of the results of the calculation).

10. Defining and saving of numerical calculations of the parameters in the form of files.

11. Evaluation of the accuracy of calculations.

After the simulation such images of the results are expected to get (Fig. 3...5):

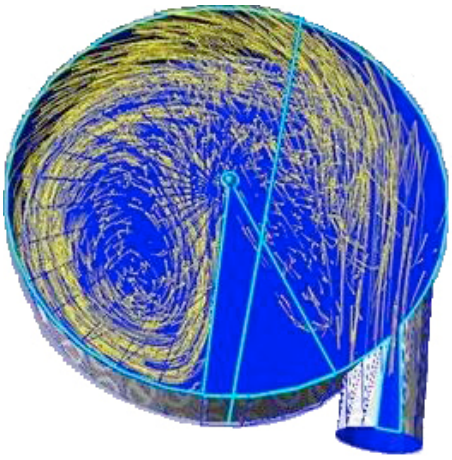

Fig. 3 Simulation of motion (velocity) of the coolant at the bottom of the chamber under the partition

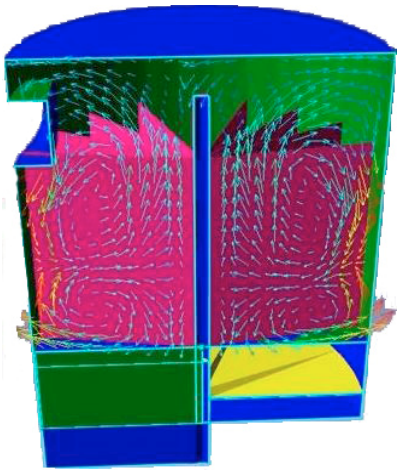

Fig. 4 Velocity distribution in the cross section of the drying chamber

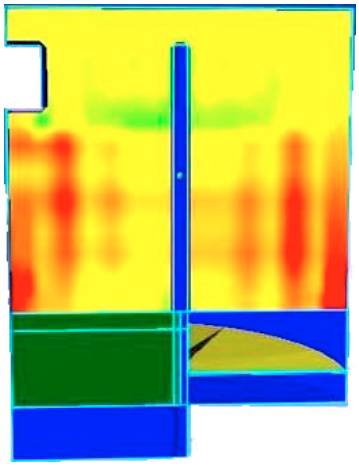

Fig. 5 Distribution of pressure in the cross section of the drying chamber as fill

Typically, the static model is supplied in the form of linear or non-linear, algebraic or transcendental equation or system of equations or inequalities. If information about the dependence of the characteristics is insufficient for their accurate identification or connections are random, the object of modeling will be considered as a "black box" for which only inputs and outputs are allocated, and internal communications are considered unknown.

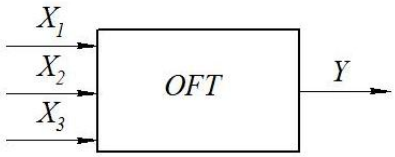

Fig. 6 General scheme of mathematical and statistical model

Consider the situation when the object hes one output variable and number of input variables. Such objects in the conceptual model are presented in the form shown in Fig. 6, where X_1, X_2, X_3 are input variables (factors. regressors), Y is output variable (review). To establish the optimal technological regime of drying of sunflower seeds it is necessary to develop a mathematical model of the process by full factorial experiment.

Results and discussions

The main objective of the study is to analyze the distribution of coolant and intensity of the drying agent under the drying chamber and the equal pressure above the grid, as this factor is one of the key figures in obtaining high-quality parameters of drying. When drying it is necessary to enable the optimal conditions for the process: the speed of the coolant should be 1...2 m/s, the open area of the grid through which the coolant passes should be 0,01...0,05%, the grid resistance during the passage of air through the openings should be 0,75...0,9. High speed contributes to a sharp increase in energy consumption.

It was found that the maximum rate of the air (coolant) occurs at the entrance to the chamber, then after hitting the walls its speed decreases and movement occurs in the radial direction.

Analyzing the distribution of vector velocity of the coolant in the drying chamber, it was found that the greatest air velocity is observed near the walls of the drying chamber, as the rotating blades of the dryer accelerate the movement of the air particles, which taking run bump on the walls of the shell. The layer of sunflower seeds begins to twist forming circulation areas. Closer to the center of these areas the speed reduces because of the reduced radius of the area where the coolant motion occur. The flow is aligned higher forming a fluidized bed and is drawn with drops of water through the pipe of coolant drainage.

According with outbreaks of vector velocity of the coolant it was found that the layer of the air captured by blades of rotary dryer form funnels moving along a spiral trajectory. Under the action of gravity component funnels evenly distribute throughout the volume between the blades forming circulation areas. This facilitates the process of fluidized bed. In this state, the layer resembles a boiling liquid acquiring some of its properties. Also the close contact is achieved between sunflower sund and drying agent that intensifies the drying process.

Analyzing the distribution of the coolant pressure in the drying chamber it can be seen that a significant impact on its distribution in the fluidized bed hes the pressure of the layer and the grid. That's why the biggest pressure will be above the grid surface of the drying chamber.

Also it was found that the pressure in the drying chamber is uniform through its height and provides the equal height of fluidized bed. This would allow to dry sunflower seeds evenly throughout its volume. The pressure is aligned over the blades since the fluidized bed height is only 1450 mm while the height of blades is 1500 mm.

The lowest value of coolant pressure is observed at the inlet to the chamber and the maximum on the wall. This is because the coolant enters the cell, and then moving over the grid pressure on the chamber walls and consequently increases.

Simulation of the coolant velocity showed the turbulence in the lower chamber, in a fluidized bed, between the blades and over them. It was found that the larger area of contact of the product with the coolant will be the more intensive will be the drying process.

Analyzing the results of the investigation it can be said that the pressure in the chamber is uniform over its height. It would allow high-quality to dry sunflower seeds in a fluidized bed forming the same height of fluidization.

The improved design of rotary dryer (patent 77691, UA) works as follows.

Rotary dryer (Fig. 7) consists of three chambers: the upper drying, the middle drying and the lower cooling. Wet granular material is introduced into the upper drying chamber 1 while the coolant is fed through tubes 2 above the partition 11 below the grid 4 into the drying chamber 1, creating a fluidized bed. The product is moved by means of the blades 10 driven by drive 8 through shaft 5. The spent coolant is removed through the nozzles 3 to the atmosphere from loading zone to unloading zone. The placement of partition 11 below the grid 4 and the tangential supply of the coolant allow evenly to distribute the coolant throughout the volume of the drying chamber and to provide the equal height of the fluidized bed product that will intensify the drying process. The drying of seeds in each sector is carried out periodically. The dryer runs continuously.

The seeds moisture decreased from 18…20 to 5...9 % per cycle duration approximatdy in 8 min. (drying 4-5 min., cooling 2-3 minutes.) without degradation of the quality of seeds during the drying of sunflower seeds in a rotating dryer at a temperature of coolant 160...170 °C and the height of layer 250 mm. In addition, this method of drying significantly reduces the seeds infestation.

Similarly, the drying process takes place in all chambers. The coolant is fed with a lower temperature in the cooling chamber. Fig.7b depicts the drying chamber, where the drying agent enters the air injection chamber and then passing through the holes in the grid enters the drying chamber. The material slowly moves to the unloading point into the chamber below. Before being discharged the next section is cut off from the air by the solid sector and is discharged through a special unit. The dried product is discharged from the cooling chamber through a device 7. Pouring of the product from chamber to chamber occurs through a hole in the grid.

An important factor to intensify the drying process in a rotating dryer is a uniform distribution of the drying agent under the grid and fluidized bed height above the grid. For this purpose the mathematical modeling was used for its investigation. Such calculations allow to optimize the process and to obtain the numerical values of parameters that can not be measured by existing instruments. To solve this problem the mathematical and statistical models were developed to determine the pressure in the drying chamber and optimal duration of drying.

The input parameters that influence the pressure in the drying chamber are: v_c – velocity of the coolant in the holes of gas distribution grid; φ – open cross-section area of the grid; C – resistance coefficient of the grid. The input parameters that influence the duration of the drying process are: β – fill factor of the chamber by material; $V_{d.c.}$ – the volume of the drying chamber; $\omega_2 = 5...10\%$ – the final moisture content of the material.

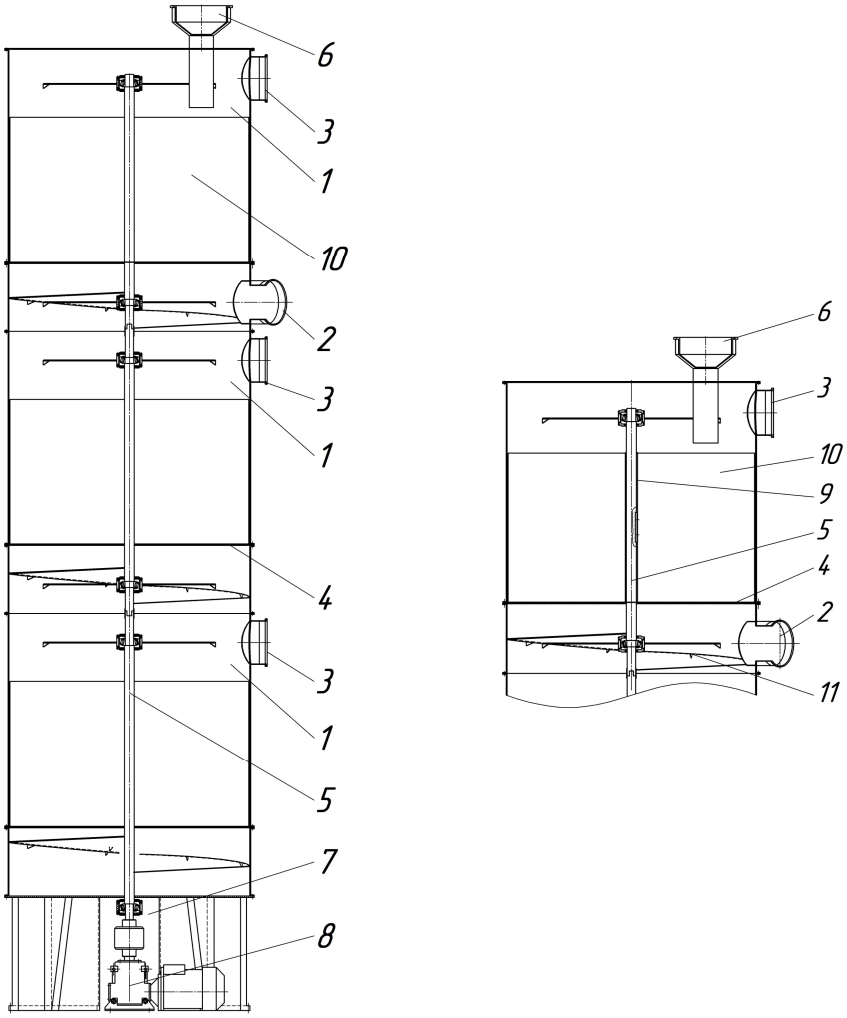

Fig. 7 The Rotary Dryer (a – sectional view of dryer, b – drying chamber):
1 - drying chamber; 2 - pipe of coolant supply; 3 - drainage pipe; 4 - perforated grid; 5 - drive shaft; 6 - boot device; 7 - unloading device; 8 - drive; 9 - tube; 10 - blade; 11 - partition

The mathematical models were defined using a full factorial experiment.
The mathematical model of the pressure in the drying chamber:

$$P = 12,97 - 2,75 \cdot \frac{v_c - 1,5}{0,5} - 5,09 \cdot \frac{\phi - 0,03}{0,2} - 2,69 \cdot \frac{v_c - 1,5}{0,5} \cdot \frac{\phi - 0,03}{0,02} -$$
$$-1,49 \cdot \frac{v_c - 1,5}{0,5} \cdot \frac{C - 0,82}{0,08} - 0,07 \cdot \frac{\phi - 0,03}{0,2} \cdot \frac{C - 0,82}{0,08} + 5,127 \cdot \frac{v_c - 1,5}{0,5} \cdot \frac{\phi - 0,03}{0,2} \cdot \frac{C - 0,82}{0,08} \quad (1)$$

The mathematical model of the duration of the drying process:

$$\tau = 9,72 + 4,1575 \cdot \frac{\beta - 0,3}{0,2} + 5,5625 \cdot \frac{V_{\text{d.c.}} - 15}{5} + 2,16 \cdot \frac{\omega_2 - 7,5}{2,5} + \\ + 0,5175 \cdot \frac{\beta - 0,3}{0,2} \cdot \frac{V_{\text{d.c.}} - 15}{5} - 1,2 \cdot \frac{\beta - 0,3}{0,2} \cdot \frac{\omega_2 - 7,5}{2,5} - 0,6 \cdot \frac{V_{\text{d.c.}} - 15}{5} \cdot \frac{\omega_2 - 7,5}{2,5} - \\ - 2,7175 \cdot \frac{\beta - 0,3}{0,2} \cdot \frac{V_{\text{d.c.}} - 15}{5} \cdot \frac{\omega_2 - 7,5}{2,5} \quad (2)$$

The obtained mathematical models allow to calculate the required parameters of drying of sunflower seeds and ability to influence the quality of the final product.

Conclusion

1. The design of rotary dryer was improved. The installing of tangentially placed nozzles and spiral partition in the lower chamber were confirmed by the results of studies performed using the software package Flow Vision.
2. The proposed reconstruction makes it possible to evenly heat and dry the product in a fluidized state at any point of intersection of the drying chamber without disturbance of its properties.
3. Mathematical models for determining the pressure of the coolant in the drying chamber and duration of drying of sunflower seeds were obtained that allow determining the optimal working modes of dryer.

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Simulation of the particle motion in devices with vertical sectioning of workspace

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Keywords:

Treatment
Sectioning
Shelf
Particle

Article history:

Received 22.06.2014
Received in revised form 25.07.2014
Accepted 02.09.2014

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Abstract

Introduction. The relevance of the topic is determined by the wide using of suspended bed apparatus during the heat treatment of dispersed materials.

Materials and methods. Analytical studies were carried out using the classical provisions of gas and fluid mechanics and technical fluid mechanics. Physical experiment was done on the development of industrial design multistage shelf device.

Results and discussion. The mathematical model to calculate the residence time of a particle in shelving unit is developed, its adequacy confirmed by experimental studies. The model can be applied for the drying, cooling, granulation processes calculation. The residence time of a single particle on a shelf in operating mode from 2 to 20 seconds, depending on the constructive execution shelf and the gas flow rate. The mutual influence of particles during their stay on the shelf increased by an average of 40 times. For the regime of particle motion in fluidized bed (constricted movement) the maximum time can be up to 20 minutes. Changing the angle of the shelf and its length has little influence as compared with a change in the hydrodynamic regime of gas flow. Design of shelf significantly affect the residence time of the particles in the apparatus only in compressed motion regime. This work theoretically and experimentally proved the existence of different regimes shelf apparatus.

Conclusions. The influence mechanism of design shelf and hydrodynamic regime of the gas flow on particle residence time in multistage gravity shelf apparatus is established. The research results are the basis of engineering calculation of equipment with a vertical sectioning of the workspace.

Introduction

The most widely in the chemical and food technology convective method of heat treatment is widespread [1-3]. It involves the transfer of heat from the coolant (air, inert gases and smoke) to the surface of the material during heating.

One of the methods of convective heat treatment is material contact with the coolant in suspended or semi suspended state [4-8]. It can take place in drum apparatus, the fluidized bed apparatus, pneumatic tubes-dryers [9-13].

Each of mentioned types of equipment is characterized by certain disadvantages. Drum machines and the fluidized bed apparatus have large sizes and significant power consumption. Pneumatic tubes drying do not provide the required contact time of wet material with coolant and characterized by a large height.

In recent years carried out a search for new highly efficient methods of convective heat treatment of granular materials. Gravity machines with vertical sectioning of interior space (shelving units) are one of the most perspective designs. It occupies an intermediate position between fluidized bed and pneumatic tubes devices. Specific air flow in such devices smaller than in the case of fluidized bed (0,5-0,6 kg/m^3 against 1,4-2,8 kg/m^3), unit load by the product for the same types of equipment – 0,1-0,5, and 15-20 kg/(m^2·s) respectively [14].

These types of devices are used in industry as air classifiers, coolers, dryers. The use of multistage contact between gas and grains on cooling section of vortex pellet is proposed [A method for producing granules in suspended layer and device for its implementation, application No.a201403429, 03.04.2014]. At the residence time of the material in these devices exert major influence organizing gas flow movement and design shelf contacts.

Objective - to develop mathematical instrument to calculate the residence time of the dispersed phase in the multistage shelf devices, experimental verification of the adequacy of mathematical models.

Materials and methods

In this work the analytical and experimental methods are used.

Mathematical modeling of hydrodynamic flows was carried out on the basis of classical mechanics provisions of liquid, gas and technical hydromechanics. Solving equations of the mathematical model was conducted by using the computer algebra system Maple 12.

Experimental studies carried out on research and industrial models multistage shelf devices. The experimental setup is presented in fig. 1.

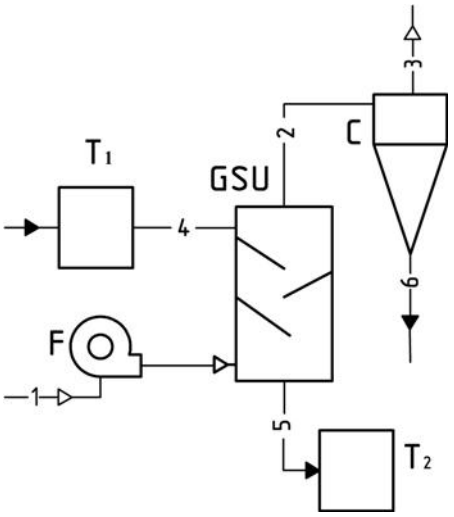


Fig. 1. Schematic diagram of the experimental setup for the study of hydrodynamics shelf devices:
F – fan; GSU – gravitational shelf unit;
C – cyclone; T_1 – container (tank) for source material;
T_2 – container (tank) for waste material.
1 – the air; 2 – exhaust air; 3 – cleaned exhaust air; 4 – the initial material; 5 – waste material; 6 – fine material

Air flow consumption is controlled by diaphragm chamber as the primary instrument, measuring differential pressure transducer and an analog device. Changing the air flow was conducted by using sliding latch that is located after the fan.

Consumption of particulate material is controlled by flow meter of bulk materials. Changing the particulate material consumption carried out by dosing device that is located on the pipeline granular material.

The distribution of the gas flow velocity in the workspace shelf device was investigated, using 5-channel spherical aerodynamic probe. Aerodynamic probe pulse pipelines connected to the micromanometer that was registered data measurements. Calibration of the probe is executed by Prandtl (Pitot) tube in an aerodynamic tube with strong orientation in space.

The residence time of the particles in the volume of the device controlled with a stopwatch. For compressed motion of particles on the shelf, the method "tracer" particles are used. As a model material polypropylene granules with a size of 2-3 mm are used. For granules first calculated (early fluidization velocity) W_{g1} and then (initial speed of particles) W_{g2} critical velocity gas flow [15].

Reliability of the experimental results caused by the use of exhaust practice methods.

Results and discussion

Consider the motion of a particle between shelf spaces (fig. 2).

If the working gas velocity in the holes is $W>W_{g1}$ it will be kept in suspension until achieving value $W=W_{g2}$, which causes it passing. If air velocity is $W<W_{g2}$, then this $\Delta W = W_{g2} - W$ difference will result in movement of the particle velocity down. If $W<W_{g1}$ particle will move in a gravitational mode falling layer with a sharp decrease in the residence time on the shelf. Time τ movement along the shelf at an angle $\gamma = 90°$ and length L is equal to

$$\tau = \frac{L}{\Delta W}. \qquad (1)$$

In the case when shelf set at a slight angle (in practice within the 10-35°), the speed ΔW that characterizes the motion of a particle from top to bottom have a rolling component $F_r = f(\Delta W \cdot \sin\gamma)$, because the normal pressure force particles on the shelf are $F_n = f(\Delta W \cdot \cos\gamma)$ and therefore, the normal components of acceleration and speed will be compensated normal reaction of shelf N (fig. 2).

Thus, the movement of particles along the shelf by the equation

$$\tau = \frac{L}{\Delta W \sin\gamma}, \qquad (2)$$

at $\gamma = 90^{\circ}$ in the previous expression simplifies to (1).

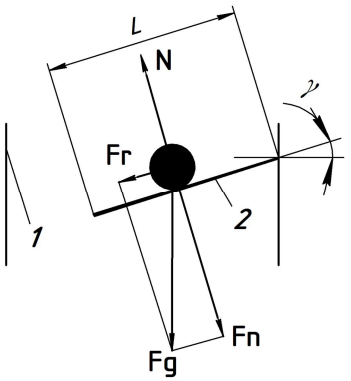


Fig. 2. Power Analysis of particulate material on an inclined shelf contact:

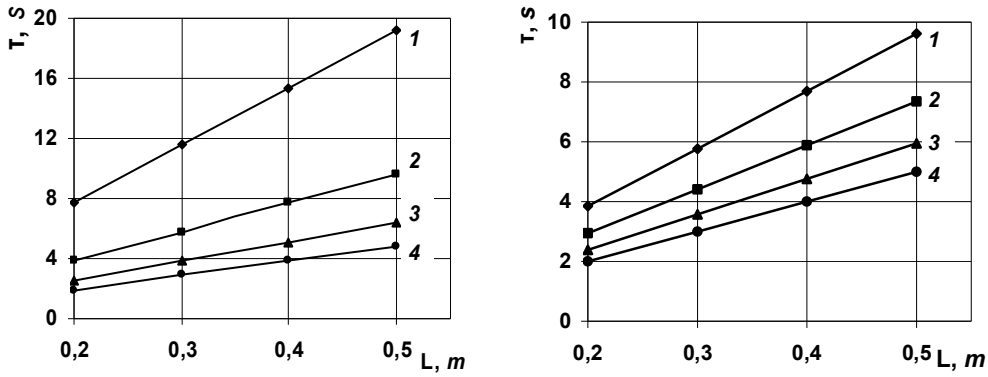
F_g – gravity, N;
F_r – rolling force, N;
F_n – normal pressure force particles on the shelf, N;
N - shelf reaction, N;
γ – shelf angle to the horizontal, deg;
1 – the body of apparatus;
2 – perforated sloping shelf

The ratio of particle time along the shelf inversely proportional to the sine of the angle of inclination of the shelf:

$$\frac{\tau_1}{\tau_2} = \frac{\sin\gamma_2}{\sin\gamma_1} \tag{3}$$

From these considerations we can determine a constructive influence on particle residence time between shelf spaces. For example, reducing the angle of the shelf, achieved an increase in the residence time of the dispersed particles at this stage.

Calculation results of the residence time of single particles on the shelf under different conditions are presented in fig. 3.



ΔW, m/s:
1 – 0.1; 2 – 0.2; 3 – 0.3, 4 – 0.4.

γ:
1 = 15°; 2 = 20°; 3 = 25°; 4 = 30°.

Fig. 3. The residence time of particles on the shelf (single particle motion)

Equation (2) to determine the particle residence time on the shelf that moves independently of the other particles is considered its free movement. This free movement is observed only at low volume content of the dispersed phase in the two-phase system (δ<0,01 m^3/m^3), where the distance between the particles is such that there is not any collisions or mutual influence of particles. At $\delta \geq 0{,}01$ m^3/m^3 (compressed motion of a particle) system behavior changes: the distance between the surfaces of particles or dimensions aisle between particle become smaller of their diameter. The particle cannot freely slip between two other [16-18]. It is necessary to consider the effect of collisions of particles with each other. In addition, the collision of particles in two-phase system may also occur in the case where the dispersed phase consists of poly disperse particles or particles with different density.

Consideration of phenomenon of compressed particle motion and power of interfacial interaction is possible with the introduction coefficient of particle stringency χ.

For coefficient of stringency, particles based on different schemes of arrangement obtained different formulas [19,20]. Specifically, the scheme with the free falling calculated by the formula

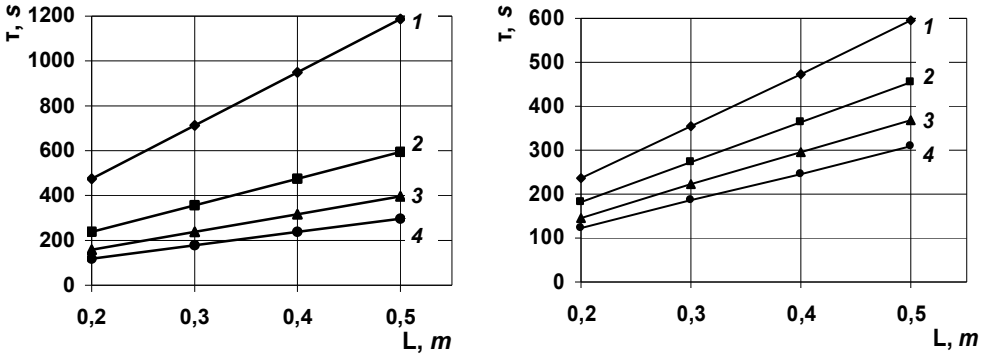
$$\chi = (1-\delta)^{-m}, \tag{4}$$

where δ = 0,6 (free backfill of random nature [19]); m = 3-5 [15].

Therefore, the expression (4) takes the form

$$\tau = \frac{L \cdot \chi}{\Delta W \sin \gamma}. \quad (5)$$

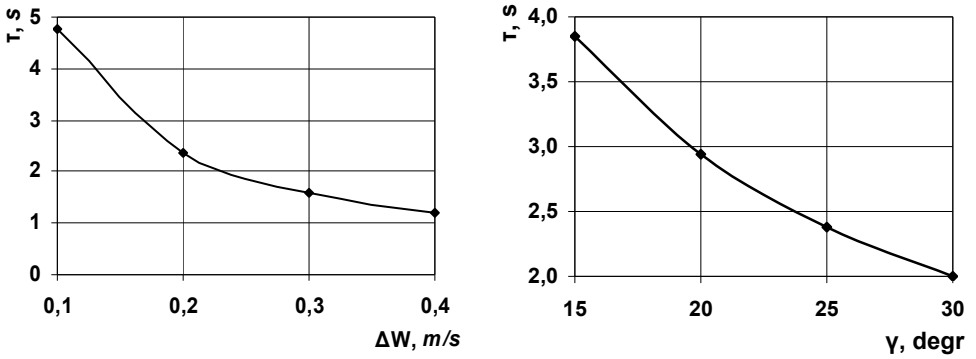
Calculation results of particle residence time on the shelf in compressed regime motion for different initial conditions are presented in fig. 4.



ΔW, m/s:
1 – 0.1; 2 – 0.2; 3 – 0.3, 4 – 0.4.

γ:
1 = 15°; 2 = 20°; 3 = 25°; 4 = 30°.

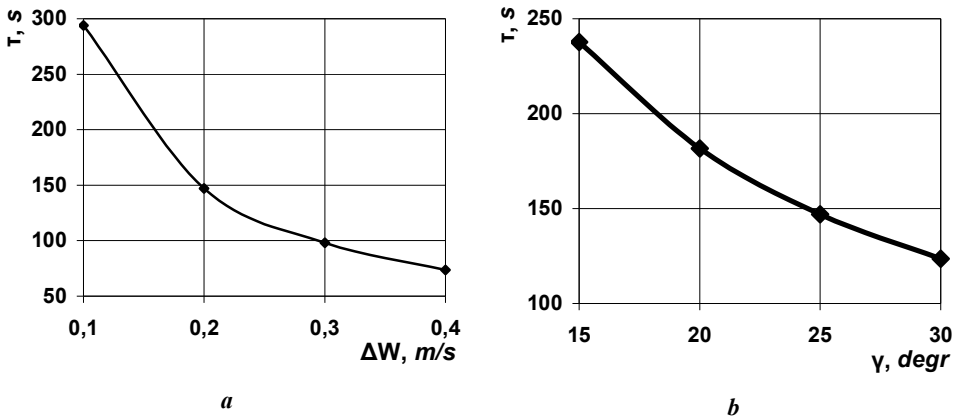
Fig. 4. The residence time of particles on the shelf (stringency particles motion)



a *b*

Fig. 5. The particle residence time on the shelf with length L = 0, 2 m (single particle motion):
a – γ = 25°; *b* – ΔW = 0,2 m/s

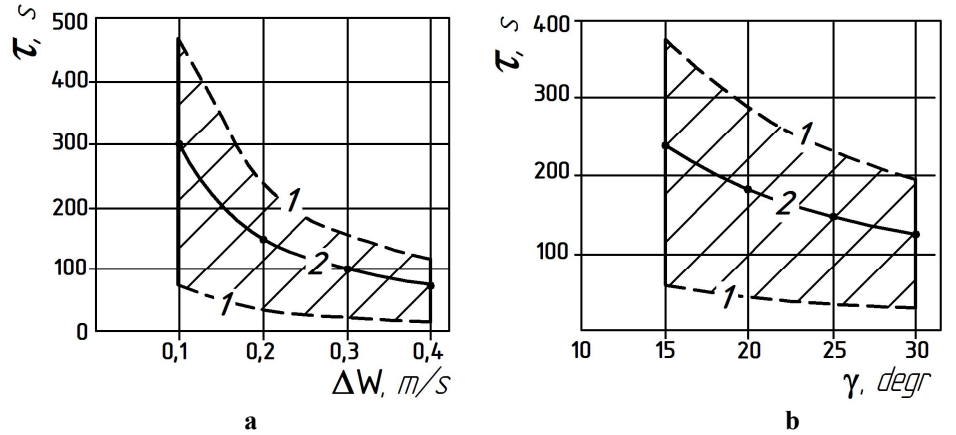
In figs. 5,6 the experimental results of determining the particle residence time on the shelf in its single mode and compressed motion depending on the angle of the shelf and the difference of velocities according to formulas (2) and (5). The obtained results allow us to determine the total particle residence time in the working space of the machine depending on the number stages contact with the gas flow and shelf design.



a *b*

Fig. 6. The particle residence time on the shelf with length L = 0, 2 m (stringency particles motion):
a – γ = 25°; *b* – ΔW = 0,2 m/s

Comparison of theoretical calculations of the particle residence time on the shelf in the range *m* from 3 to 5 in formula (4), and experimental determination of this parameter (in the case of compressed motion of dispersed particles) gives satisfactory results (fig. 7).



a **b**

Fig. 7. The particle residence time on the shelf with length L = 0,2 m (compressed motion of particles):
a – γ = 25°; *b* – ΔW = 0,2 m/s;
1 – theoretical calculation range; 2 – experimental data

In fig. 8 shows the data of experimental research of dispersed particles residence time on a shelf in compressed motion mode with regard to operating mode of shelf apparatus. Research results indicate a sharp increase in dispersed particle, residence time on the shelf at weighted layer (zone III) and closer to zero particle residence time on the shelf when you reach a second critical gas flow rate (removal of particles from the weighted layer zone V).

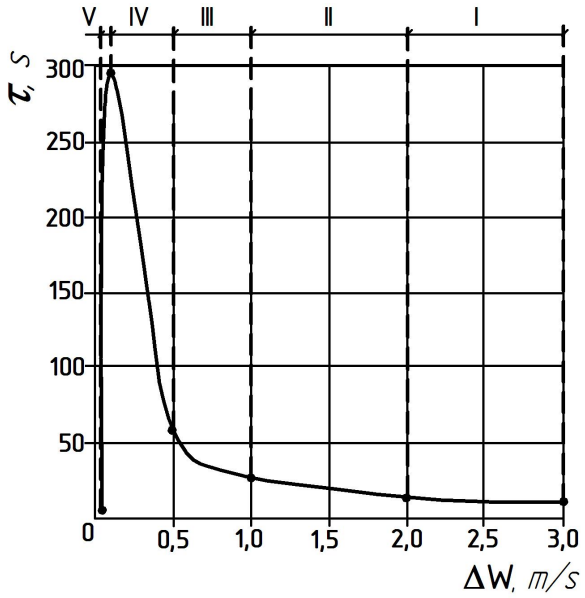


Fig. 8. Experimental study of particles residence time on the shelf in compressed motion regime (L = 0,2 m, γ = 25°):
regimes (according to [21]):
I – falling gravitational layer regime;
II – first transitional regime;
III – weighted layer regime;
IV – second transitional regime;
V – entering particulate material regime

Conclusions

1. A theoretical model for calculating the particle residence time on a shelf in a multistage apparatus.
2. The features of the calculation of particles residence time of it single and compressed movement on the shelf.
3. The influence of shelf design and hydrodynamic motion of the gas flow on particle motion duration on the shelf.
4. It is proved that the design of the shelf significantly affect particles residence time in the apparatus only in its compressed motion regime.
5. According to the calculation of residence time particles on the shelf proved the existence of different hydrodynamic regimes of operation.
6. The results of the analytical solution of the equations of the mathematical model are confirmed experimentally.

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Modern aspects of occupational safety at meat industry enterprises

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Keywords:

Safety
Work
Injuries
Risk
Accident

Article history:

Received 04.05.2014
Received in revised form 16.07.2014
Accepted 02.09.2014

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Abstract

Introduction. Analyzing causes of injury on Meat Processing Plants give an opportunity to create reasonable and effective ways of prevention and decreasing risks of workers injuries.

Methods and materials. The method of an accidental statistical analysis is used during the studies to define general traumatical tendencies in the meat industry of Ukraine which happened within 2003 – 2013 years as well as the method of a priori ranking factors on the results of the expert survey.

Results and discussion. The stage of industrial injuries in the meat industry of Ukraine during 2003-2013 is analyzed. The results of the analysis of the distribution of occupational injuries from machinery, equipment, vehicles, devices the usage of which led to the accident are presented. Identified the most common traumatic factors and jobs | in the meat industry of Ukraine. Found the most traumatic situations in the meat industry due to imperfect safety guard in moving parts of equipment (26%), lack of blocking devices of drive stationary equipment (9%), and engine malfunction (3%).

Conclusion. Results of research can be used in improving management decisions projects that can provide safe working conditions on meat processing plants.

Introduction

Despite overall tendency of decreasing number of accidents in the Ukrainian food industry, generally the average level of accidents and occupational injuries still is extremely high.

Only during 2003-13 years there were injured over 9.86 thousands of people in the food industry. The 633 of them died [*Koshil O.G., Kostrovenko L.N. (2014), Statistical bulletin. Accidents at workplace in 2003 – 2013, State Statistic Committee of Ukraine, 2004 - 2014*].

The result of researching showed the meat industry is one of the most dangerous and traumatic among observed industries.

The study of the conditions and safety, as well as other potential causes and circumstances of occupational injuries in the meat processing industry of AIC will give a chance to develop reasonable and effective ways of preventing and reducing the risk of injury to workers in the sector.

Aim: to provide an analysis for discovering potential reasons and sources of occupational injuries of the meat industry workers.

Objects of researching: conditions of work in the meat processing industry during 2003-13 period.

Material and methods

The research is based on the example of Ukraine meat industry of different capacities.

Occupational injuries are investigated. Industrial accident is the phenomenon which is characterized by mixture of on-work industrial injuries and accidents.

The research is made with the help of using the method of industrial accidents statistical analysis occurred in meat industry enterprises of Ukraine during 2003-2013 to define general traumatical tendencies in the meat industry of Ukraine as well as the method of a priori ranking factors on the results of the expert survey.

Results and discussions

For the analysis and assessment of safety in the meat industry due to incompletely statistics in the field of agriculture about factors that affect the safety it's reasonably to use the method of expert estimations. The reliability of peer review is based on the assumption that in the case of coordination of experts' estimation the reliability is guaranteed [1].

Usage of peer review assumes that the opinion of the expert group is more reliable than the opinion of individual experts [1-2]. The method of collective peer review was very widespread and is commonly used to transfer the experience of leading experts in almost all fields of knowledge and production [1-2].

The three groups of experts took part in research: representatives of labor services and engineering and technical personnel of enterprises of the meat industry, scientific workers of universities and research institutes.

Total number of involved experts – 25 people. To avoid false data it was provided anonymity, but it was taken into account the data that characterize the age, experience, position and education.

Based on the analysis of regulations by the form of H-1 and 7-THB were developed questionnaire survey for experts.

Based on the method of peer review in accordance with the requirements [1-2] the performed data processing by method of a priori ranking factors in the following order:

1. The results of peer review data are presented in a matrix of rank.

Matrix of results of expert evaluation indicators

Experts	**Factors**				
	$\mathbf{X_1}$	$\mathbf{X_2}$	**…**	**…**	$\mathbf{X_i}$
1	a_{11}	a_{12}	…	…	a_{1i}
2	a_{21}	a_{22}	…	…	a_{2i}
j	a_{j1}	a_{j2}	…	…	a_{ji}

2. Calculates the sum of ranks for factors

$$\left(\sum_{1}^{m} a_{ij}\right)$$

where a_{ij} – rank of each i –factor of j – experiment; m – number of experts; n – number of factors.

3. Determination of the average amount of ranks:

$$\frac{\sum_{1}^{n}\sum_{1}^{m} a_{ij}}{n}.$$

4. Calculated deviation from the average amount of ranks:

$$\Delta i = \sum_{1}^{m} a_{ij} - \frac{\sum_{1}^{n}\sum_{1}^{m} a_{ij}}{n}$$

5. Identifying squares of deviations from the average sum of ranks, i.e. the sum of squares of deviations:

$$s = \sum_{1}^{m} (\Delta i)^2$$

6. These data allow us to build high priori chart ranks, after assessing the degree of agreement opinions of the group of experts on the importance of selected factors on the coefficient of concordance (agreement), ω:

$$\omega = \frac{12s}{m^2(n^3 - n) - m\sum_{1}^{m} T_j}$$

where $T_j = \sum (t_j^3 - t_j)$;

t_j – number of equal ranks in j-ranking.

7. Testing conditions agreement of expert opinion:

$\omega = 1$ – evaluation of all experts are the same;

$\omega = 0$ – experts gave different results and views.

8. Valuing coefficient of concordance was carried out on the criterion $\chi 2$-distribution with the number of degrees of freedom f=n–1.

The value of $\chi 2$-criterion was got according to formula:

$$\chi^2 = \frac{12s}{mn(n+1) - \frac{1}{n-1}\sum_{1}^{m} T_j}$$

The hypothesis about the availability of coordination of expert opinion may be accepted, if the given number of degrees of freedom tabular $\chi 2$ value less than estimated for the 5% level of local importance.

Thus, the weight of each factor and the consistency of experts' opinions are determined during the process of peer review.

Research of sanitation has showed that the level of whole-body vibration does not meet 15% of the surveyed jobs, meteorological parameters do not meet the requirements in 35% of cases, the noise level – in 13% of cases, the results of measurements of artificial and natural light – in 37 % of cases. Provision of household premises employees does not

exceed 75%, in 48% cases there are no showers and rest rooms do not meet the requirements of room for meals in the enterprises. Mandatory medical examinations in 50% of cases not carried out in full and only formally [3].

At the place where the accident occurred, the most traumatic is the main production workshops – (58%), auxiliary production workshops – (21%), area of enterprises – (11%), vehicles – (13%).

The study shows that 83% of accidents occur during day shifts. The reason is that the maximum number of workers in the first shift at work performs the greatest amount of work with the slaughtering, processing carcasses deboned meat. The maximum number of accidents (25% of the total) occurs at second and third hours from the beginning of the day shift.

The distribution of occupational injuries according to types of traumatic factors is presented in table 1.

The most common traumatic factor in the meat industry is that workers often were injured by objects, parts that move, rotate (production equipment), including manual labor equipment such as knives, saws etc. The injury of workers by conveyors and conveyor elements is 26% of the total cases.

Table 1

The distribution of occupational injuries according to types of traumatic factors in the meat industry of Ukraine, 2003–2013

Traumatic factor	Percentage
Injury by objects, parts that move, rotate (production equipment), including manual labor equipment such as knives, saws etc	21
Fall from the height	14
Transport accidents	12
Injury as result of explosions: tanks of fuel lubricants, pressure vessels, steam and water heating boilers, fires	10
Injury due to a fall, collapse items, meat carcasses	5
Injury by plant vehicles	5
Hazardous and toxic substances poisoning	5
Injury by conveyor elements	5
Burns from hot water and steam	4
Injury by chemical solutions during processing equipment	3
Injury as a result of the collapse of building structures	3
Injury by electrical current	3
Effects of Ionizing radiation	1
Hypothermia	1
Other	8

Approximately 30% of accidents are not associated with the use of machines and equipment: falls, fires, collapses of building structures, tanks explosions of fuel and lubricants, the effect of chemical solutions during processing of equipment.

Road traffic accidents and injury by factory transport represents 19% of all occupational injuries.

Approximately 5% of the cases are poisoning by harmful and toxic substances and burns: hot water, steam.

Especially traumatic types of work are: transportation, loading and unloading, repair and maintenance of machinery and equipment.

Distribution of occupational injuries by occupation (for the most hazardous occupations) is presented in table 2.

Table 2

Distribution of occupational injuries by occupation in the meat industry of Ukraine, 2003–2013

Occupational groups	Percentage
Driver	16
Livestock killer	16
Loader	12
Locksmith	12
Meat handler	12
Carcass handler	8
Meat workshop operator	8
Boiler room operator	5
Watcher	3
Engineer	3
Other	5

It was found ten occupational groups where was recorded the greatest risk of traumatic situations: drivers (16%), livestock killer (16%), loaders (12%), locksmiths (12%), meat handlers (12%), carcass handlers (8 %), meat workshop operator (8%), boiler room operator (5%), watchers (3%) and engineers (3%).

For localization of injuries, according to anthropological data in the meat industry it must be noted a large number of upper extremity injuries – 50% of all injuries. Approximately 20% are broken bones of the skeleton, lower extremities, and 10% for head injury. Mechanical injury were received by about 90% were workers, burns – 10%.

Also was admitted contribution of number of injuries according to the length of work in enterprises of the Ukrainian food industry: 20 years or more (24%), 10 to 15 years (12%), from 5 to 10 years (11%), between 1 and 5 years (25%) 1 year (28%). This can be explained solely by psychological factors in accidents; young workers (5 years of experience) are not experienced in carrying out hazardous work. Employees with experience of 5 to 20 years have more experience and therefore they are more cautious when performing dangerous work. For workers with experience of over 20 years of performing their assigned work partly accompanied by an extremely negative factor "addiction" to the risks and hyperbole own experience of "standard situations" in their work.

Consideration of the distribution of accidents by age showed that most injuries are received by workers of the age to 40 – 63% of all injuries.

Technological equipment of most meat processing plants is obsolete and physically lost time warranty. Much of the equipment used at slaughter and processing of livestock, performs its technological features, but has virtually no defense mechanisms.

In 23% of hard character accidents the main reason is usage of faulty technique. Traumatic situation caused by the imperfection of protective fencing equipment of moving parts (26%), lack of blocking devices of stationary machines drives (9%), engine failure (3%).

Distribution of occupational injuries according to the most traumatic equipment for meat processing industry is presented in table 3.

Table 3

The distribution of machinery, equipment, vehicles, machinery, vehicles, the usage of which has led to an accident in the meat industry of Ukraine, 2003–2013

Source of accident	Percentage
Steam and hot-water boilers	25
Conveyors	22
Equipment for the primary processing of livestock	17
Forcemeat mixers	10
Pumping stations	8
Electrically heated equipment	5
Lines of sausage production	5
Machines for meat dumplings production	5
Other	3

As it is seen from the table 3, the most dangerous equipment are: steam and hot-water boilers, conveyors of different types, equipment for the primary processing of livestock, forcemeat mixers, pumping stations, machines for meat dumplings production, lines of sausage production etc. The poor organization of the labor process was named as the main reason of great number of injuries (over 69%) [*Koshil O.G. Statistical bulletin. Accidents at workplace in 2003 – 2013 / Koshil O.G., Kostrovenko L.N. -K. : State Statistic Committee of Ukraine, 2004 - 2014*]: lack of discipline and control over the performance of work by the supervisor (35%), access to work without appropriate training on health and safety (14%), access to the work without proper training (5%).

Other organizational reasons include: the work at premises and production facilities that do not comply to with building regulations; lack of personal protective equipment, lack of necessary documentation (instructions for safety, outfits, tolerances, etc), and lack of work mechanization. Also it is found that 20% of the victims were in a state of alcohol intoxication.

Conclusions

The calculation of indicators of occupational injuries by peer review and analysis of statistical data in the form of acts H-1 and 7тнв that took place in the meat industry for the period 2003...13, to determine the most important factors associated with the causes, sources and circumstances of accidents cases almost by all classifiers.

The most common traumatic factor in the meat industry is damage done by objects, parts that move, rotate (production equipment), including manual labor equipment such as knives, saws, this factor creates 21% of total cases.

Were found ten occupational groups where was recorded the greatest risk of traumatic situations and types of injuries received by employees of the meat industry.

A distribution of machinery, equipment, vehicles, machinery, vehicles, the usage of which has led to an accident in the meat industry in Ukraine for the period 2003...13 years.

Found that most of the traumatic situation in the meat industry are caused by moving parts equipment and lack of safety gears (26%), lack of blocking devices of stationary machines drives (9%), engine failure (3%).

Therefore, further important step in prevention of occupational injuries in the meat industry will be constructive development of protective fencing and locking devices equipment. Modeling of traumatic situations in the workplaces of meat processing plants.

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Анотації

Харчова безпека

^{238}U, ^{232}Th and ^{40}K у зразках пшеничного борошна на ринку Іраку

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Вступ. Пшеничне борошно як тип харчування широко споживається різними віковими групами населення в Іраку. Мета досліджень - вивчення наявності довговічних джерел гамма-випромінювання в різних типах пшеничного борошна на іракському ринку.

Матеріали і методи. Питома активність (Bq/kg) урану (^{238}U), торію (^{232}Th) і калію (^{40}K) були виміряні в 12 різних типах пшеничного борошна, які доступні на іракському ринку. Для радіометричних вимірювань використано спосіб гамма-спектрометрії з NaI(Tl)-детектором. Розраховано індекс внутрішньої небезпеки, еквівалент радію і поглинена доза у всіх зразках.

Результати та обговорення. Питома активність у зразках борошна пшениці варіюється від 1,086 ± 0,0866 до 12,532 ± 2,026 Bq/kg за середньої 6,6025 Bq/kg для ^{238}U, для ^{232}Th - від 0,126 ± 0,066 до 4,298 ± 0,388 Bq/kg за середньої 1,9465 Bq/kg, для ^{40}K - від 41,842 ± 5,875 до 264,729 ± 3,843 Bq/kg за середньої 133,097 Bq/kg. Крім того, еквівалент радію та індекс внутрішньої небезпеки в зразках пшеничного борошна коливаються від 3,4031 до 35,1523 Bq/kg за середніх значень 19,6346 Bq/kg і від 0,0091 до 0,1219 із середнім показником 0,0708 відповідно.

Висновок. Індекси природної радіоактивності та радіаційної небезпеки пшеничного борошна на ринку Іраку нижчі за небезпечні рівні.

Ключові слова: *радіактивність, пшениця, борошно, харчування, Ірак.*

Якість питної води в Польщі

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Вступ. Проведено аналіз якості питної води і ступеня доступу до водопостачання й каналізації в Польщі.

Матеріали та методи. Застосовано метод аналізу вторинних статистичних даних, наявних в матеріалах Центрального статистичного бюро у Варшаві, Польської господарчої палати в м. Бидгощ і Національного управління водними ресурсами у Варшаві.

Результати та обговорення. 60% поляків незважаючи на доступність, вважається забрудненою, може містити надлишок фтору або не має відповідних споживчих якостей (колір, запах і смак). Але існуючі системи очищення води можуть поліпшити її якість за рахунок хлорування, хоча це погіршує її якість порівняно з

чистою природною водою. У результаті все менше споживачів п'ють воду безпосередньо з під крана, зменшують використання водопровідної води для приготування їжі, надаючи перевагу воді в пляшках. Причина полягає в тому, що суспільство не довіряє безпеці води, яка постачається муніципальними водопровідними компаніями. Постає питання, чи має воно рацію?

Водопровідна вода в Польщі відповідає всім стандартам завдяки постійному контролю водних компаній і використання відповідних методів очищення. Водопровідна вода, що подається через системи водопостачання, може використовуватись без попереднього кип'ятіння. Дослідження показали, що такі робочі параметри води, як смак, запах і твердість не завжди є задовільними. Вони різні в кожному місті, а іноді і в різних районах міста, через що користувачі вважають її непридатною до вживання. Зниження показників цих параметрів води може бути легко досягнуто за рахунок використання фільтрів. Зазначимо, що завдяки постійному моніторингу та інвестиціям в модернізацію процесів обробки, якість водопровідної води останнім часом значно поліпшилась.

Висновки. Результати дозволили оцінити якість водопостачання й каналізації, а також зробити висновок про якість води, доступної для жителів Польщі.

Ключові слова: *вода, пиття, водопостачання, Польща.*

Харчові технології

Значення білків молока у формуванні структури молочних продуктів

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Вступ. Структура молочних продуктів являє собою складну упорядковану взаємодію білків, жирів, вуглеводів, мінеральних речовин і води, що визначає консистенцію й органолептичні показники продукту.

Матеріали і методи. Досліджувались кисломолочні напої (на прикладі йогурту), сири сичужні, морозиво, збиті молочні та заморожені фруктові десерти. Зроблено аналіз наукових статей за 2000-2014 рік, а також дисертацій і монографій вчених, які працюють даної галузі науки. Методологія дослідження ґрунтується на використанні методів аналізу, порівняння й узагальнення.

Результати та обговорення. Узагальнено наукове розуміння ролі білків молока у формуванні структури молочних продуктів. Незначні зміни структури продукту в результаті зміни компонентів чи технологічних параметрів можуть призвести до зміни стабільності, консистенції і реологічних властивостей продукту, що суттєво вплине на процес виробництва.

Здатність до коагуляції під дією кислого середовища – це основна функція білків молока, що використовується під час формування структури сиру і кисломолочних продуктів. При цьому форма і властивості молочного згустка залежать від теплового оброблення молока перед сквашуванням. У формуванні структури морозива, збитих молочних і заморожених фруктових десертів молочні білки проявляють інші функціональні властивості: емульгування і часткова коалесценція жирових глобул; формування і стабілізація піни у процесі збивання, загущення дисперсійного середовища продукту.

Висновки. Результати доцільно використати для подальшого вивчення закономірності формування структури молочних продуктів і розроблення рекомендацій щодо їх ефективного виробництва.

Ключові слова: *білок, молоко, структура.*

Обґрунтування виду і концентрації поверхнево-активних речовин для забезпечення стійкості піноемульсійних продуктів

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Вступ. Розробка сухих сумішей для приготування піноподібної та емульсійної продукції є актуальною, оскільки спостерігається тенденція зниження до мінімуму витрат часу на процес приготування їжі, що досягається використанням напівфабрикатів високого ступеня готовності.

Матеріали і методи. Піноутворюючу здатність визначали методом кратності пін, стійкість нестійких пін - методом напіврозпаду пін, високостійких пін – як відношення висоти стовпа піни після витримки впродовж 24 годин.

Результати. Визначено вплив соняшникової олії на піноутворюючу здатність та період напіврозпаду піни систем «казеїнат натрію-олія». Отримання систем з високими показниками піноутворюючої здатності та стійкості піни, за наявності в системі олії, неможливе без використання низькомолекулярних поверхнево-активних речовин. Обґрунтовано рекомендації щодо використання двох поверхнево-активних речовин у системах «казеїнат натрію-ПАР-олія», що забезпечують необхідну спорідненість поверхонь повітряної, жирової та водної фаз. Використання 2,5…3,5% моно- та дигліцеридів жирних кислот та лецитину 0,15…0,25% за вмісту казеїнат натрію 0,5% дає змогу одержати стійкі піноемульсійні системи із вмістом соняшникової олії 7…8% та піноутворюючою здатністю 640±1%.

Висновки. Для забезпечення високих показників піноутворюючої здатності та стійкості піноемульсійних систем необхідне використання низькомолекулярних поверхнево-активних речовин. Результати рекомендовано використовувати при розробці технологій піноемульсійних продуктів.

Ключові слова: *казеїнат, піноутворення, стійкість.*

Розробка технологічних режимів підготовки мінеральної води для спортивних напоїв

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Вступ. Наукове дослідження присвячене розробці технологічних режимів опріснення природної мінеральної лікувально-столової хлоридної натрієвої води для технології водопідготовки у виробництві напоїв для спортсменів.

Матеріали і методи. Досліджували зразки вихідної води та води, опрісненої за допомогою виморожувальної установки при різних режимах. Вимірювання температурного режиму роботи кристалізатора здійснювали за допомогою датчиків

температури і цифрового термометра. Показники якості зразків води визначали за допомогою фотометра Palintest 7500 і стандартних методик.

Результати. Досліджено вплив різних факторів процесу виморожування на якість опрісненої природної мінеральної лікувально-столової хлоридної натрієвої води «Куяльник». Визначено закономірності розподілу компонентів вихідної води між вимороженою твердою фазою і концентрованим розчином у процесі виморожування. При цьому для більшості досліджуваних факторів порядок руху був таким: $Ca^{2+} > HCO^{-}_3 > (Na^{+} > Cl^{-}) > (Mg^{2+} > SO^{2-}_4 > K^{+})$, при зменшенні мінералізації води таким: $Ca^{2+} > SO^{2-}_4 > (Na^{+} > Cl^{-}) > (HCO^{-}_3 > Mg^{2+} > K^{+})$.

Рекомендовано такі технологічні параметри проведення процесу опріснення природної мінеральної хлоридної натрієвої води виморожуванням: температурний режим роботи кристалізатора, що змінюється в процесі від -2 до -4 °С, вміст вуглекислого газу у воді на початку процесу виморожування – 3,7 г/дм^3, тривалість процесу опріснення (без урахування процесу охолодження) – 60 хв, один ступінь виморожування, плавлення твердої фази в умовах навколишнього середовища без попереднього сепарування вимороженої твердої фази. За таких технологічних режимів проведення процесу виморожування можна отримати воду з мінеральним складом, який в основному відповідає чинним рекомендаціям щодо мінерального складу напоїв для спортсменів.

Висновки. Рекомендовано використовувати удосконалений спосіб організації процесу опріснення води виморожуванням.

Ключові слова: *напій, вода, опріснення, виморожування.*

Високоенергетична дискретна обробка в технології вилучення вовняного жиру

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Вступ. Для підвищення ефективності вилучення вовняного жиру запропоновано застосування високоенергетичної дискретної обробки (ВДО) вовномийних вод.

Матеріали і методи. Визначення питомої електропровідності, RedOx-потенціалу, температури, pH середовища та загальної кількості іонів ліпідовмісної води проводилося за допомогою комбінованого тестера Combo HI 98129 («HANNA Instruments»). Концентрація вільних радикалів визначалася шляхом перманганатометричного титрування. Зміну в'язкості промивних вод під впливом ВДО досліджено за методом Оствальда. Вплив тривалості ВДО на зміну поверхневого натягу промивних вод визначено сталогмометричним методом.

Результати. В результаті ВДО відбувається зміна фізико-хімічних властивостей промивної води, а саме: зниження питомої електропровідності (з 2969 мкСм/см до 2837 мкСм/см) і загального змісту іонів (з 1487 мг/л до 1298 мг/л), підвищення показника pH середовища (з 8,35 до 9,40), температури (з 18°С до 43°С) і RedOx-потенціалу (з 60 мВ до 93 мВ). Це пояснюється тим, що ВДО сприяє створенню області з високою концентрацією механічної енергії, яка призводить до виникнення великої ударної сили і високого тиску. Підвищення температури, у свою чергу, впливає на водневі зв'язки, при цьому руйнуються кластерні комплекси води і гідратні оболонки навколо іонів з утворенням вільних радикалів, наявність яких свідчить про хімічні перетворення у воді. Зниження в'язкості (з 1,034 $\cdot 10^{-3}$Нс/м^2 до 0,903 $\cdot 10^{-3}$Нс/м^2) і поверхневого натягу (з 39,86 сН/м до 37,56 сН/м) промивних вод під дією

ВДО пояснюється розривом водневих зв'язків асоціатів води, ослабленням сил взаємного притягання між молекулами всередині кластерів і в поверхневому шарі – структурним перетворенням води. Найбільш значні хімічні і структурні зміни в промивних водах відбуваються при тривалості обробки 180 с.

Висновки. Під дією ВДО відбуваються хімічні та структурні перетворення, що сприяють інтенсифікації процесу вилучення вовняного жиру.

Ключові слова: *вовна, жир, ланолін.*

Вплив складових альфа-кислот українських сортів хмелю і хмельових препаратів на якісні показники сусла та пива

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Вступ. Мета дослідження – встановлення залежності величини гіркоти сусла і якості охмеління пива від кількості і якісного складу гомологів альфа-кислот українських сортів хмелю, зокрема від вмісту когумулону в складі альфа-кислот.

Матеріали та методи. Досліджувались ароматичні та гіркі сорти хмелю української селекції з різним вмістом когумулону в складі альфа-кислот і пиво, виготовлене з них. Використано високоефективну рідинну хроматографію для визначення кількості та складу гірких речовин хмелю та продуктів їх перетворення в процесі пивоваріння, а також спектрофотометричні методи контролю якості гіркоти охмеленого сусла й готового пива.

Результати та обговорення. Альфа-кислоти досліджуваних сортів мають у своєму складі широкий діапазон показника вмісту когумулону: від 16,7% у сорті Кумир до 44,1% у сорті Руслан. Встановлені залежності між кількістю і якісним складом гірких речовин хмелю та гіркотою і якістю охмеленого сусла й пива. Вміст когумулону в складі альфа-кислот хмелю для одержання якісної гіркоти пива має бути менше 28%. Роль сполук бета-кислот в утворенні гіркоти сусла, охмеленого ароматичними сортами хмелю із співвідношенням бета-кислот до альфа-кислот близько одиниці, набагато вища порівняно з гіркими сортами.

Висновки. Для охмеління сусла хмелем гіркого типу більш ефективно використовувати сорти з високим вмістом когумулону в альфа-кислотах.

Ключові слова: *хміль, альфа-кислота, когумулон, сусло, пиво.*

Оптимізація процесу виробництва яєчних омлетів з наповнювачами тривалого терміну зберігання

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Вступ. Оптимізація процесу виробництва яєчних омлетів (ЯО) з використанням високого тиску (ВТ) дасть змогу виробляти продукт з високими споживчим властивостями за мінімальних затрат.

Матеріали і методи. Досліджуваний продукт - ЯО – суміш рідкого курячого яйця з тертим або дрібно нарізаним сиром (або іншими інгредієнтами), ксантанової камеді, водою або молоком, спецій. Процес виробництва ЯО складався з пакування суміші у герметичний контейнер, нагрівання й обробки в установці високого тиску. Придатності ЯО до тривалого зберігання оцінювали за показником «активність води». Якість ЯО оцінювали експертним методом. Для одержання оптимальних параметрів процесу застосовано метод невизначених множників Лагранжа.

Результати. Розроблена оптимізаційна модель дозволила одержати оптимальні параметри процесу обробки ЯО ВТ: тиск – 690 МПа, температура – 122^0С, довготриваліть обробки – 7×60с, 14 г води на 100 г меланжу, 13 г сухого молока на 100 г меланжу, вміст ксантанової камеді - 0,75% від загальної маси суміші, 25 г сиру на 100 г меланжу. Дані показники параметрів процесу дали змогу одержати ЯО з показниками: активність води - 0,704, комплексний показник якості - 0,98, що характеризують цей продукт як продукт з високими якісними показниками, стабільними протягом тривалого терміну зберігання.

Аналіз розробленої моделі з використання критеріїв Стьюдента, Фішера, диспепсії та розрахунок помилки прогнозного значення параметрів оптимізації підтвердили надійність отриманих значень параметрів оптимізації та достовірність оптимізаційної моделі.

Висновки. Результати взяті за основу при розробці нормативно-технічної документації на ЯО тривалого терміну зберігання та проектуванні технологічного обладнання ВТ для реалізації цього процесу.

Ключові слова: *яйце, омлет, зберігання, тиск, активність, вода.*

Збагачення йогурту натуральними продуктами бджільництва

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Вступ. Використання бджолиного пилку в поєднанні з популярним функціональним кисломолочним продуктом – йогуртом, надасть можливість розширити асортимент і підвищити його біологічну цінність.

Матеріали і методи. Визначення вологи в чотирьох зразках бджолиного пилку, висушених до різної вологості, здійснювалося гравіметричним методом, в основі якого лежать втрати маси зразка в результаті висихання до сталого значення. Дослідний і контрольний зразки йогурту досліджували шляхом застосування стандартних мікробіологічних аналізів для молока і молочних продуктів.

Результати та обговорення. Висушування бджолиного обніжжя до вологості 2 - 4% призводить до підвищення сипучості порошку майже на 90%. Зразок вологістю 2% буде мати насипну масу вищу на 12,5%, ніж зразок 10% вологості. Вихід сировини також збільшиться на 3,7%. Густина, масова частка втрат, навпаки, зменшуватимуться, що має позитивний вплив на ефективність використання та розподілу пилку в масі йогурту. До того ж масова частка втрат знизиться більше, ніж у 4 рази (4,6% порівняно з 1%).

Пилок може погіршувати мікробіологічні характеристики йогурту. Обробка зразка подрібненої бджолиного обніжжя ультрафіолетом дає змогу поліпшити мікробіологічні показники безпеки йогурту. А саме, знизити наявність коліформ до 0, цвілі до 10 КОЕ/см^3.

Висновки. Запропонований спосіб обробки бджолиного обніжжя надає можливість поліпшити технологічні та мікробіологічні показники порошку пилку, тому його доцільно використовувати в біотехнології виробництва йогурту з натуральними продуктами бджільництва.

Ключові слова: *пилок, бджола, йогурт.*

Біотехнологія, мікробіологія

Вплив вуглецевовмісної сировини на продукування біомаси мікрогриба Blakeslea Trispora

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Вступ. Досліджувався вплив гідратованих фулеренів на ступінь накопичення біологічно активних речовин мікрогрибом *Blakeslea trispora.*

Матеріали і методи. Проводилось визначення жирно-кислотного складу в біомасі амінокислот, каротиноїдів і стеролів з використанням методів високоефективної рідинної хроматографії, адсорбційної і роздільної хроматографії в тонкому шарі сорбенту та спектрофотометричного методу; гравіметричним методом; методом прямого спектрофотометрирування в бензолі.

Результати. Застосування гідратованих фулеренів у середовищі культивування мікрогриба *Blakeslea trispora* сприяло збільшенню накопичення в біомасі кількості каротину на 32,3 %, аспарагінової, глутамінової кислот і лейцину.

Зміна співвідношення вуглецю до азоту за рахунок внесення до поживного середовища культивування мікрогриба *Blakeslea trispora* гідратованих фулеренів не вплинула на амінокислотний склад його біомаси.

Отримані дані про жирно-кислотний склад ліпідної фракції мікрогриба *Blakeslea trispora* свідчать про значне превалювання ненасичених жирних кислот і перспективність використання біомаси мікрогриба *Blakeslea trispora* як джерела біологічно активних речовин для створення нових видів продукції профілактичної дії.

Ключові слова: *каротиноїд, біомаса, мікрогриб, БАР.*

Ріпаковий фосфатидний концентрат у технологіях синтезу поверхнево-активних речовин актинобактеріями

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Вступ. У зв'язку з тим, що виробництво мікробних поверхнево-активних речовин (біоПАР) лімітується низьким виходом цільових продуктів і високою вартістю процесів, актуальним завданням є оптимізація та зниження вартості технологій біоПАР. Одним із шляхів вирішення даної проблеми є використання відходів промисловості, зокрема ріпакового фосфатидного концентрату (ФК).

Матеріали і методи. Як джерела вуглецю у складі поживного середовища для культивування бактерій використовували гексадекан або ФК (2%). Ліпіди екстрагували з клітинної маси та супернатанту культуральної рідини сумішшю хлороформ-метанол 2:1. Якісний аналіз метаболітів проводили методом тонкошарової хроматографії.

Результати та обговорення. Встановлено особливості синтезу біоПАР штамами *G. rubripertincta* УКМ Ac-122 та *R. erythropolis* Au-1 при рості на поживному середовищі з ФК як джерелом вуглецю. Кількість біомаси становила 9,4-10,1 г/л, екзополісахаридів – 8,9-9,5 г/л, клітинно-зв'язаних трегалозоліпідів – 1,37-2,26 г/л; при чому вміст екзогенних трегалозоліпідів – метаболітів *R. erythropolis* Au-1 становив 2,95 г/л. Розчин трегалозоліпідів при внесенні до поживного середовища за концентрації 0,01 г/л сприяв підвищенню вмісту АСБ на 14,6 – 17,0 %, клітинно-зв'язаних ліпідів – на 13,9 – 15,5 %.

Висновки. Ріпаковий фосфатидний концентрат є економічно вигідним джерелом вуглецю для технологій поверхнево-активних речовин актинобактерій. Його використання сприяє підвищенню вмісту екзогенних ПАР штаму *R. erythropolis* Au-1 у 3 рази порівняно з культивуванням на поживному середовищі з гексадеканом. Трегалозоліпіди проявляють стимулювальний вплив на ріст і синтез біоПАР штамами *G. rubripertincta* УКМ Ac-122 і *R. erythropolis* Au-1.

Ключові слова: *Gordonia, Rhodococcus*, *біоПАР, фосфатидний концентрат.*

Процеси та обладнання харчових виробництв

Вплив конструктивних параметрів ротаційної сушарки на сушіння насіння соняшнику

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Вступ. З метою удосконалення процесу сушіння насіння соняшнику в апаратах ротаційного типу доцільно провести моделювання технологічних процесів в них з використанням програмних засобів комп'ютерного моделювання.

Матеріали і методи. Моделювання процесу сушіння насіння соняшнику проводилося на основі методу кінцевих елементів із застосуванням програмного пакета Flow Vision та методів математичної статистики.

Результати. Отримані математичні моделі показують залежність тиску теплоносія (повітря) в сушильній камері ротаційної сушарки від швидкості теплоносія, живого перерізу газорозподільної решітки і її опору та залежність тривалості процесу сушіння насіння соняшнику від коефіцієнта заповнення сушильної камери та її об'єму, а також від кінцевої вологості матеріалу.

Отримано рівномірне розподілення тиску теплоносія в сушильній камері ротаційної сушарки, що забезпечує сталу висоту киплячого шару насіння соняшнику та якісне його висушування.

Удосконалено конструкцію ротаційної сушарки, а саме: забезпечено тангенційне підведення теплоносія та встановлено спіралеподібну перегородку під газорозподільною решіткою, що рівномірно розподіляє його в сушильній камері.

Висновки. Результати дослідження доцільно використати при виборі режимів сушіння на етапі проектування сушильного обладнання.

Ключові слова: *соняшник, сушіння, ротор, сушарка.*

Моделювання руху частинки в апаратах з вертикальним секціонуванням робочого простору

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Вступ. Актуальність теми обумовлена широким застосуванням апаратів зваженого шару в процесах термічної обробки дисперсних матеріалів.

Матеріали і методи. Аналітичні дослідження проведено з використанням класичних положень механіки рідини та газу і технічної гідромеханіки. Фізичний експеримент здійснено на дослідно-промисловому зразку багатоступеневого поличного апарата.

Результати та обговорення. Розроблена математична модель для розрахунку часу перебування частинки в поличному апараті, її адекватність підтверджено результатами експериментальних досліджень. Модель може бути застосована для розрахунку процесів сушіння, охолодження гранулювання.

Час перебування одиночної частинки на полиці в робочому режимі складає від 2 до 20 секунд залежно від конструктивного виконання полиці та швидкості газового потоку. За наявності взаємного впливу частинок час їх перебування на полиці збільшується в середньому у 40 разів. Для режиму руху частинки у зваженому шарі (стиснений рух) максимальний час може складати до 20 хвилин. Зміна кута нахилу полиці та її довжина мають незначний вплив порівняно зі зміною гідродинамічного режиму руху газового потоку. Конструкція полиці значно впливає на час перебування частинки в апараті лише в режимі стисненого руху. В роботі теоретично й експериментально обґрунтована наявність різних режимів робот поличного апарата.

Висновки. Встановлено механізм впливу конструкції полиці та гідродинамічного режиму руху газового потоку на час перебування частинки в багатоступеневих гравітаційних поличних апаратах. Результати досліджень

покладені в основу методики інженерного розрахунку обладнання з вертикальним секціонуванням робочого простору.

Ключові слова: *обробка, секціонування, полиця, частинка.*

Безпека життєдіяльності

Сучасні аспекти охорони праці на підприємствах м'ясної промисловості

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Вступ. Аналіз причини травмування на м'ясопереробних підприємствах дає змогу розробити обґрунтовані й ефективні шляхи профілактики і зниження ризику травмування працівників.

Матеріали і методи. Під час проведення досліджень нещасних випадків, які виникли на підприємствах м'ясної промисловості України за період з 2003 р. по 2013 р., визначення загальних тенденцій щодо травматизму у м'ясній промисловості застосований метод статистичного аналізу та метод апріорного ранжування факторів за результатами експертного опитування.

Результати та обговорення. Проаналізовано стан виробничого травматизму у м'ясній промисловості України за період з 2003 по 2013 р. Наведено результати аналізу розподілу випадків виробничого травматизму від обладнання, устаткування, машин, механізмів, транспортних засобів, експлуатація яких призвела до нещасного випадку. Виявлено найбільш поширені травмуючі фактори і професії| в м'ясній промисловості України. Більшість травмонебезпечних ситуації в м'ясній промисловості обумовлені недосконалістю захисних огорож рухомих елементів устаткування (26%), відсутністю блокуючих пристроїв приводів стаціонарних машин (9%), несправністю двигуна (3%).

Висновок. Результати дослідження рекомендовано використовувати для вдосконалення проектів управлінських рішень щодо забезпечення безпечних умов праці працівників м'ясопереробних підприємств.

Ключові слова: *безпека, праця, травматизм, ризик, м'ясо, підприємство.*

Аннотации

Пищевая безопасность

^{238}U, ^{232}Th and ^{40}K в образцах пшеничной муки на рынке Ирака

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Введение. Пшеничная мука как тип питания широко потребляется разными возрастными группами населения в Ираке. Цель исследований - изучение присутствия долгоживущих источников гамма-излучения в разных типах пшеничной муки на иракском рынке.

Материалы и методы. Удельная активность (Bq/kg) урана (238U), тория (232Th) и калия (40K) были измерены в 12 разных типах пшеничной муки, доступных на иракском рынке. Для радиометрических измерений использован способ гаммы-спектрометрии с NaI(Tl)-детектором. Рассчитан индекс внутренней опасности, эквивалент радия и поглощенная доза во всех образцах.

Результаты и обсуждение. Удельная активность в образцах муки пшеницы варьируется от 1,086 ± 0,0866 до 12,532 ± 2,026 Bq/kg при средней 6,6025 Bq/kg для ^{238}U, для ^{232}Th - от 0,126 ± 0,066 до 4,298 ± 0,388 Bq/kg при средней 1,9465 Bq/kg, для ^{40}K - от 41,842 ± 5,875 до 264,729 ± 3,843 Bq/kg при средней 133,097 Bq/kg. Кроме того, выявлено, что эквивалент радия и индекс внутренней опасности в образцах пшеничной муки колеблются от 3,4031 до 35,1523 Bq/kg при средних значениях 19,6346 Bq/kg и от 0,0091 до 0,1219 со средним показателем 0,0708 соответственно.

Вывод. Индексы естественной радиоактивности и радиационной опасности пшеничной муки на рынке Ирака находятся ниже опасных уровней.

Ключевые слова: *радиактивность, пшеница, мука, питание, Ирак.*

Качество питьевой воды в Польше

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Введение. Проведен анализ качества питьевой воды и степени доступа к водоснабжению и канализации в Польше.

Материалы и методы. Применен метод анализа вторичных статистических данных, имеющихся в Центральном статистическом бюро в Варшаве, Польской хозяйственной палаты в г. Быдгощ и Национальном управлении водными ресурсами в Варшаве.

Результаты и обсуждение. 60% поляков не употребляют питьевую воду без предварительного кипячения. Вода, которая течет из кранов, несмотря на доступность, считается загрязненной, может содержать избыток фтора или не имеет соответствующих потребительских качеств (цвет, запах и вкус). Но существующие системы очистки воды могут улучшить ее качество за счет хлорирования воды, хотя

это ухудшает ее качество относительно чистой природной воды. Результатом является то, что все меньше потребителей пьют воду прямо из крана, уменьшают использование водопроводной воды для приготовления пищи, предпочитают воду в бутылках. Причина в том, что общество не доверяет безопасности воды, поставляемой муниципальными водопроводными компаниями. Возникает вопрос, оправданы ли эти опасения?

Водопроводная вода в Польше соответствует всем стандартам благодаря постоянному контролю водных компаний и использованию соответствующих методов очистки. Водопроводная вода, подаваемая через системы водоснабжения, может использоваться без предварительного кипячения. Исследования показали, что такие рабочие параметры воды, как вкус, запах и твердость не всегда являются удовлетворительными. Они разные в каждом городе, а иногда в разных районах города, из-за чего часто среди пользователей возникает впечатление о ее непригодности. Снижение показателей этих параметров воды может быть легко достигнуто за счет использования фильтров. Отметим, что благодаря постоянному мониторингу и инвестициям в модернизацию процессов обработки качество водопроводной воды в последние годы значительно улучшилось.

Выводы. Результаты позволили оценить качество водоснабжения и канализации, а также сделать вывод о качестве воды, доступной для жителей Польши.

Ключевые слова: *вода, питьё, водоснабжение, Польша.*

Пищевые технологии

Значение белков молока в формировании структуры молочных продуктов

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Введение. Структура молочных продуктов представляет собой упорядоченное взаимодействие белков, жиров, углеводов, минеральных веществ и воды, которое определяет консистенцию и органолептические показатели продукта.

Материалы и методы. Продукты, которые исследовались: кисломолочные напитки (на примере йогурта), сычужные сыры, мороженое, взбитые молочные и замороженные фруктовые десерты. Сделан анализ научных статей за 2000-2014 годы, а также диссертаций и монографий ученых, работающих в этой области науки. Методология исследования основана на использовании методов анализа, сравнения и обобщения.

Результаты и обсуждение. Обобщенно научное понимание роли белков молока в формировании структуры молочных продуктов. Незначительные изменения структуры продукта, в результате изменения компонентов или технологических параметров могут привести к нарушениям в изменению стабильности, консистенции и реологических свойств продукта, что существенно влияет на процесс производства.

Способность к коагуляции под действием кислой среды – это основная функция белков молока, используемая при формировании структуры сыра и кисломолочных продуктов. При этом форма и свойства молочного сгустка зависят от тепловой

обработки молока перед сквашиванием. В формировании структуры мороженого, взбитых молочных и замороженных фруктовых десертов молочные белки проявляют другие свойства: эмульгирование и частичная коалесценция жировых глобул, формирование и стабилизация пены в процессе взбивания, загущение дисперсионной среды продукта.

Выводы. Результаты целесообразно использовать для дальнейшего изучения закономерностей формирования структуры молочных продуктов и разработки рекомендации для их эффективного производства.

Ключевые слова: *белок, молоко, структура.*

Обоснование вида и концентрации поверхностно-активных веществ для обеспечения устойчивости пеноэмульсионных продуктов

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Введение. Разработка сухих смесей для приготовления пенообразной и эмульсионной продукции является актуальной, поскольку в настоящее время наблюдается тенденция снижения к минимуму затрат времени на процесс приготовления пищи, которое достигается использованием полуфабрикатов высокой степени готовности.

Материалы и методы. Пенообразующую способность определяли методом кратности пен, стойкость нестойких пен - методом полураспада пен, высокостойких пен - как отношение высоты столба пены после выдержки в течение 24 часов.

Результаты. Определено влияние подсолнечного масла на пенообразующую способность и период полураспада пены систем «казеинат натрия-масло». Получение систем с высокими показателями пенообразующей способности и стойкости пен, при наличии в системе масла, невозможно без использования низкомолекулярных поверхностно-активных веществ. Обоснованы рекомендации относительно целесообразности использования двух поверхностно-активных веществ в системах «казеинат натрия-ПАВ-масло», обеспечивающие необходимое сродство поверхностей воздушной, жировой и водной фаз. Установлено, что использование 2,5...3,5% моно-и диглицеридов жирных кислот и лецитина 0,15...0,25% при содержании казеинат натрия 0,5% позволяет получить устойчивые пеноэмульсионные системы с содержанием подсолнечного масла 7...8% и пенообразующей способностью 640 ±1%.

Выводы. Для обеспечения высоких показателей пенообразующей способности и стойкости пеноэмульсионных систем необходимо использование низкомолекулярных поверхностно-активных веществ. Результаты исследований рекомендуется использовать при разработке технологий пеноэмульсионных продуктов.

Ключевые слова: *казеинат, пенообразование, стойкость*

Разработка технологических режимов подготовки минеральной воды для спортивных напитков

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Введение. Научное исследование посвящено разработке технологических режимов опреснения природной минеральной лечебно-столовой хлоридной натриевой воды для технологии водоподготовки в производстве напитков для спортсменов.

Материалы и методы. Исследовали образцы исходной воды и воды, опресненной с помощью вымораживающей установки при различных режимах. Измерение температурного режима работы кристаллизатора осуществляли с помощью датчиков температуры и цифрового термометра. Показатели качества образцов воды определяли с помощью фотометра Palintest 7500 и стандартных методик.

Результаты и обсуждение. Исследовано влияние разных факторов процесса вымораживания на качество опресненной природной минеральной лечебно-столовой хлоридной натриевой воды «Куяльник». Определены закономерности распределения компонентов исходной воды между вымороженной твердой фазой и концентрированным раствором в процессе вымораживания. При этом для большинства исследуемых факторов порядок движения был таким: $Ca^{2+} > HCO^{-}_{3} > (Na^{+} > Cl^{-}) > (Mg^{2+} > SO^{2-}_{4} > K^{+})$, а при уменьшении минерализации воды таким: $Ca^{2+} > SO^{2-}_{4} > (Na^{+} > Cl^{-}) > (HCO^{-}_{3} > Mg^{2+} > K^{+})$.

Рекомендовано такие технологические параметры проведения процесса опреснения природной минеральной хлоридной натриевой воды вымораживанием: температурный режим работы кристаллизатора, изменяющийся в процессе от -2 до -4 °С, содержание углекислого газа в воде в начале процесса вымораживания – 3,7 г/дм^3, длительность процесса опреснения (без учета процесса охлаждения) – 60 мин, одна ступень вымораживания, плавление твердой фазы в условиях окружающей среды без предварительного сепарирования вымороженной твердой фазы. При таких технологических режимах проведения процесса вымораживания можно получить воду с минеральным составом, соответствующим рекомендациям относительно минерального состава напитков для спортсменов.

Выводы. Рекомендуем использовать усовершенствованный способ организации процесса опреснения воды вымораживанием.

Ключевые слова: *напиток, вода, опреснение, вымораживание.*

Высокоэнергетическая дискретная обработка в технологии извлечения шерстного жира

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Введение. Существующие способы извлечения шерстного жира имеют высокую себестоимость и являются неэкологичными. Для повышения эффективности извлечения шерстного жира предложено применение высокоэнергетической дискретной обработки (ВДО) шерстомойных вод.

Материалы и методы. Определение удельной электропроводности, RedOx-потенциала, температуры, pH среды и общего количества ионов липидосодержащей воды проводилось с помощью комбинированного тестера Combo HI 98129 («HANNA Instruments»). Концентрация свободных радикалов определялась путем перманганатометрического титрования. Изменение вязкости промывных вод под влиянием ВДО исследовано по методу Оствальда. Влияние длительности ВДО на изменение поверхностного натяжения промывных вод измерено сталогмометрическим методом.

Результаты и обсуждение. В результате ВДО происходит изменение физико-химических свойств промывной воды, а именно: снижение удельной электропроводности шерстомойных вод (с 2969 мкСм/см до 2837 мкСм/см) и общего содержания ионов (с 1487 мг/л до 1298 мг/л), повышение показателя pH среды (с 8,35 до 9,40), температуры (с 18°С до 43°С) и RedOx-потенциала (с 60 мВ до 93 мВ). Это объясняется тем, что ВДО способствует созданию области с высокой концентрацией механической энергии, которая приводит к возникновению большой ударной силы и высокого давления. Повышение температуры влияет на водородные связи, при этом разрушаются кластерные комплексы воды и гидратные оболочки вокруг ионов с образованием свободных радикалов, наличие которых свидетельствует о химических превращениях в воде. Снижение вязкости (с 1,034 $\cdot 10^{-3}$Нс/м^2 до 0,903 $\cdot 10^{-3}$Нс/м^2) и поверхностного натяжения (с 39,86 сН/м до 37,56 сН/м) промывных вод под действием ВДО объясняется разрывом водородных связей ассоциатов воды, ослаблением сил взаимного притяжения между молекулами внутри кластеров и в поверхностном слое – структурным преобразованием воды. Наиболее значительные химические и структурные изменения в промывных водах происходят при продолжительности обработки 180 с.

Выводы. Под действием ВДО происходят химические и структурные преобразования, способствующие интенсификации процесса извлечения шерстного жира.

Ключевые слова: *шерсть, жир, ланолин.*

Влияние составных альфа-кислот отечественных сортов хмеля и хмелевых препаратов на качественные показатели сусла и пива

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Введение. Цель исследования - установление зависимости величины горечи сусла и качества охмеления пива от количества и качественного состава гомологов альфа-кислот украинских сортов хмеля, и в частности, от содержания когумулона в составе альфа-кислот.

Материалы и методы. Исследовались ароматические и горькие сорта хмеля украинской селекции с различным содержанием когумулона в составе альфа-кислот и пиво, изготовленное из них. Использовано высокоэффективную жидкостную хроматографию для определения количества и состава горьких веществ хмеля и продуктов их превращения в процессе пивоварения, а также спектро-

фотометрические методы контроля качества горечи охмеленного сусла и готового пива.

Результаты и обсуждение. Альфа-кислоты исследуемых сортов имеют в своем составе широкий диапазон показателя содержания когумулона от 16,7 % в сорте Кумир до 44,1 % в сорте Руслан. Установлены зависимости между количеством и качественным составом горьких веществ хмеля и горечью и качеством охмеленного сусла и пива. Содержание когумулона в составе альфа-кислот хмеля для получения качественной горечи пива должно быть менее 28 %. Роль соединений бета-кислот в образовании горечи сусла, охмеленного ароматическими сортами хмеля с соотношением бета- кислот к альфа-кислотам около единицы, гораздо выше по сравнению с горькими сортами.

Выводы. Для охмеления сусла хмелем горького типа более эффективно использовать сорта с высоким содержанием когумулона в альфа-кислотах.

Ключевые слова: *хмель, альфа-кислота, когумулон, сусло, пиво.*

Оптимизация процесса производства яичных омлетов с наполнителями длительного срока хранения

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Введение. Оптимизация процесса производства яичных омлетов (ЯО) с использованием высокого давления (ВД) позволит производить продукт с высокими потребительскими свойствами при минимальных затратах.

Материалы и методы. Исследуемый продукт - ЯО - смесь жидкого куриного яйца с тертым или мелко нарезанным сыром (или другими ингредиентами), ксантановой камеди, водой или молоком, специй. Процесс производства ЯО состоял из упаковки смеси в герметичный контейнер, нагрева и обработки в установке высокого давления. Годности ЯО к длительному хранению оценивали показателем «активность воды». Качество ЯО оценивали экспертным методом. Для получения оптимальных параметров процесса был применен метод неопределенных множителей Лагранжа.

Результаты. Разработана оптимизационная модель, которая позволила получить оптимальные параметре процесса обработки ЯО ВТ: давление - 690 МПа, температура - 122°С, продолжительность обработки - 7×60с, 14 г воды на 100 г меланжа, 13 г сухого молока на 100 г меланжа, содержание ксантановой камеди - 0,75% от общей массы смеси, 25 г сыра на 100 г меланжа. Данные показатели параметров процесса позволяют получить ЯО с показателями: активность воды - 0,704 и комплексный показатель качества - 0,98, характеризующих этот продукт, как продукт с высокими качественными показателями, стабильными в течение длительного срока хранения. Анализ разработанной модели с использованием критериев Стьюдента, Фишера, диспепсии и расчет ошибки прогнозного значения параметров оптимизации подтвердили надежность полученных значений параметров оптимизации и достоверность оптимизационной модели. Результаты вычислений по приведенным параметрам оптимизации, представлены в виде доверительных интервалов, подтверждают, что их экспериментальные значения не выходят за

пределы соответствующих интервалов и, следовательно, подтверждают достоверность полученных результатов.

Выводы. Полученные результаты были приняты за основу при разработке нормативно-технической документации на ЯО длительного срока хранения и проектировании технологического оборудования ВТ для реализации этого процесса.

Ключевые слова: *яйцо, омлет, хранение, давление, активность, вода.*

Обогащение йогурта натуральными продуктами пчеловодства

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Введение. Использование пчелиной пыльцы в сочетании с популярным функциональным кисломолочным продуктом – йогуртом, позволит расширить его ассортимент и повысить биологическую ценность.

Материалы и методы. Определение влаги в четырех образцах пчелиной пыльцы, высушенной до разной влажности, осуществлялось гравиметрическим методом, который основан на потери веса образца в результате высыхание до постоянной массы. Опытный и контрольный образцы йогурта исследовались путем применения стандартных микробиологических анализов для молока и молочных продуктов.

Результаты и обсуждение. Высушивание пчелиной обножки до влажности 2 - 4% приводит к повышению сыпучести порошка почти на 90 %. Образец влажностью 2 % будет иметь насыпную массу выше на 12,5 % нежели образец 10 % влажности. Выход сырья также увеличится на 3,7 %. Объемная плотность, массовая доля потерь, напротив, уменьшаться, что имеет позитивное влияние на эффективность использования и распределения пыльцы в массе йогурта. При чем, массовая доля потерь снизится больше чем в 4 раза (4,6 % против 1 %).

Пыльца может ухудшать микробиологические характеристики йогурта.

Обработка образца измельченной пчелиной обножки ультрафиолетом позволит улучшить микробиологические показатели безопасности йогурта, а именно, снизить наличие колиформ до 0, наличие плесени - до 10 КОЕ/см^3.

Выводы. Предложенный способ обработки пчелиной обножки позволяет улучшить технологические и микробиологические показатели порошка пыльцы. Это позволяет использовать ее в биотехнологии производства йогурта с натуральными продуктами пчеловодства.

Ключевые слова: *пыльца, порошок, йогурт, микробиология.*

Биотехнология, микробиология

Влияние углеродсодержащего сырья на продуцирование биомассы микрогриба Blakeslea Trispora

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Введение. Исследовано влияние гидратированных фуллеренов на степень накопления биологически активних веществ микрогрибом *Blakeslea trispora.*

Материалы и методы. Проводилось определение жирно-кислотного состава в биомассе аминокислот, каротиноидов и стеролов с использованием методов высокоэффективной жидкостной хроматографии, адсорбционной и разделительной хроматографии в тонком слое сорбента и спектрофотометрического; гравиметрическим методом; методом прямого спектрофотометрирования в бензоле.

Результаты. Применение гидратированных фуллеренов в среде культивирования микрогриба *Blakeslea trispora* способствовало увеличению накопления в биомассе количества каротина на 32,3 %; аспарагиновой, глутаминовой кислот и лейцина.

Изменение соотношения углерода к азоту за счет внесения в питательную среду культивирования микрогриба *Blakeslea trispora* гидратированных фуллеренов не повлияло на аминокислотный состав его биомассы.

Полученные данные жирно-кислотного состава липидной фракции микрогриба *Blakeslea trispora* свидетельствуют о значительном преобладании ненасыщенных жирных кислот и, перспективность использования биомассы микрогриба *Blakeslea trispora* как источника биологически активных веществ для создания новых видов продукции профилактического действия.

Ключевые слова: *каротиноид, биомасса, микрогриб, БАВ.*

Рапсовый фосфатидный концентрат в технологиях синтеза поверхностно-активных веществ актинобактериями

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Введение. В связи с тем, что производство микробных поверхностно-активных веществ (биоПАВ) лимитируется низким выходом целевых продуктов и высокой стоимостью процессов, актуальной задачей является оптимизация и снижение стоимости технологий биоПАВ. Одним из путей решения данной проблемы является использование отходов промышленности, в частности рапсового фосфатидного концентрата (ФК).

Материалы и методы. В качестве источников углерода в составе питательной среды для культивирования штаммов *G. rubrupertincta* УКМ Ас - 122 и *R. erythropolis* Au -1 использовали гексадекан или рапсовый фосфатидный концентрат (2%). Липиды экстрагировали из клеточной массы и супернатанта культуральной жидкости смесью хлороформ-метанол 2:1. Качественный анализ метаболитов проводили методом тонкослойной хроматографии.

Результаты и обсуждение. Изучены особенности синтеза биоПАВ штаммами *G. rubrupertincta* УКМ Ас-122 и *R. erythropolis* Au-1 при выращивании на питательной среде с рапсовым фосфатидным концентратом как источником углерода. Количество АСБ составляло 9,38-10,1 г/л, екзополисахаридов – 8,9-9,5 г/л, клеточно-связанных трегалозолипидов – 1,37-2,26 г/л; причем концентрация экзогенных трегалозолипидов – метаболитов *R. erythropolis* Au-1 составило 2,95 г/л. Установлено, что при внесении в питательную среду раствора трегалозолипидов в концентрации 0,01 г/л количество АСБ увеличивалось на 14,6-17,0%, клеточно-связанных липидов – на 13,9 - 15,5%.

Выводы. Рапсовый фосфатидный концентрат является экономически выгодным источником углерода для технологий поверхностно-активных веществ актинобактерий. Его использование способствует повышению содержания экзогенных ПАВ штамма *R. erythropolis* Au-1 в 3 раза по сравнению с культивированием на питательной среде с гексадеканом. Трегалозолипиды проявляют стимулирующее влияние на рост и синтез биоПАР штаммами *G. rubripertincta* УКМ Ас-122 и *R. erythropolis* Au-1.

Ключевые слова: *Gordonia, Rhodococcus*, *биоПАВ, фосфатидный концентрат.*

Процессы и оборудование пищевых производств

Влияние конструктивных параметров ротационной сушилки на сушку семян подсолнечника

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Введение. С целью усовершенствования процесса сушки семян подсолнечника в аппаратах ротационного типа проведено моделирование технологических процессов в них с использованием программных средств компьютерного моделирования.

Материалы и методы. Моделирование процесса сушки семян подсолнечника проводилось на основе метода конечных элементов с применением программного пакета Flow Vision и методов математической статистики.

Результаты. Полученные математические модели показывают зависимость давления теплоносителя (воздуха) в сушильной камере ротационной сушилки от скорости теплоносителя, живого сечения газораспределительной решетки и ее сопротивления и зависимость продолжительности процесса сушки семян подсолнечника от коэффициента заполнения сушильной камеры и ее объема, а также от конечной влажности материала.

Получено равномерное распределение давления теплоносителя в сушильной камере ротационной сушилки, что обеспечивает постоянную высоту кипящего слоя семян подсолнечника и качественное его высушивания.

Усовершенствована конструкция ротационной сушилки, а именно: обеспечен тангенциальный подвод теплоносителя и установлена спиралевидная перегородка под газораспределительной решеткой, которая равномерно распределяет его в сушильной камере.

Выводы. Результаты исследования целесообразно использовать при выборе режимов сушки на этапе проектирования сушильного оборудования.

Ключевые слова: *подсолнух, сушка, ротор, сушилка.*

Моделирование движения частицы в аппаратах с вертикальным секционированием рабочего пространства

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Введение. Актуальность темы обусловлена широким применением аппаратов взвешенного слоя в процессах термической обработки дисперсных материалов.

Материалы и методы. Аналитические исследования проведены с использованием классических положений механики жидкости и газа и технической гидромеханики. Физический эксперимент осуществлен на опытно-промышленном образце многоступенчатого полочного аппарата.

Результаты. Разработана математическая модель для расчета времени пребывания частицы в полочном аппарате, её адекватность подтверждена результатами экспериментальных исследований. Модель может быть применена для расчета процессов сушки, охлаждения гранулирования.

Время пребывания одиночной частицы на полке в рабочем режиме составляет от 2 до 20 секунд в зависимости от конструктивного исполнения полки и скорости газового потока. При наличии взаимного влияния частиц время их пребывания на полке увеличивается в среднем в 40 раз. Для режима движения частицы во взвешенном слое (стеснённое движение) максимальное время может составлять до 20 минут. Изменение угла наклона полки и ее длина имеют незначительное влияние по сравнению с изменением гидродинамического режима движения газового потока. Конструкция полки значительно влияет на время пребывания частицы в аппарате только в режиме сжатого движения. Теоретически и экспериментально обосновано наличие различных режимов работы полочного аппарата.

Выводы. Установлен механизм влияния конструкции полки и гидродинамического режима движения газового потока на время пребывания частицы в многоступенчатых гравитационных полочных аппаратах. Результаты исследований положены в основу методики инженерного расчета оборудования с вертикальным секционированием рабочего пространства.

Ключевые слова: *обработка, секционирование, полка, частица.*

Безопасность жизнедеятельности

Современные аспекты охраны труда на предприятиях мясной промышленности

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Введение. Анализ причин травматизма на мясоперерабатывающих предприятиях позволяет разработать обоснованные и эффективные способы профилактики и снижения риска травматизма работников.

Материалы и методы. При проведении исследований несчастных случаев, которые возникли на предприятиях мясной промышленности Украины за период с 2003 г. по 2013 г., для определения общих тенденций травматизма в мясной промышленности применены методы статистического анализа и априорного ранжирования факторов по результатам экспертного опроса.

Результаты и обсуждение. Проанализировано состояние производственного травматизма в мясной промышленности Украины за период с 2003 г. по 2013 г. Представлены результаты анализа распределения случаев производственного травматизма от оборудования, машин, механизмов, транспортных средств, эксплуатация которых привела к несчастному случаю. Выявлены наиболее распространенные травмирующие факторы и профессии в мясной промышленности Украины. Большинство травмоопасных ситуации в мясной промышленности обусловлены несовершенством защитных ограждений движущихся элементов оборудования (26%), отсутствием блокирующих устройств приводов стационарных машин (9%), неисправностью двигателя (3%).

Выводы. Результаты исследования рекомендуем использовать при совершенствовании проектов управленческих решений по обеспечению безопасных условий труда работников мясоперерабатывающих предприятий.

Ключевые слова: *безопасность, труд, травматизм, риск, мясо, предприятие.*

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Наукометричні бази визначають рейтинг як журналу, так і окремих авторів за кількістю посилань на статті. Електронні системи опрацьовують кожен елемент списку – авторів, назву статті та видання, номер, рік та інші елементи.

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Всі визнані світові стандарти передбачають оформлення списку літератури лише латинськими символами. При оформленні посилань на джерела, написані кирилицею, необхідно проводити транслітерацію. Користуючись програмами транслітерації, слід уважно вказувати, з якої мови проводиться транслітерація – української чи російської. Застосовуючи спеціальне програмне забезпечення для транслітерації з української мови використовуємо лише **Паспортний (КМУ 2010)** тип транслітерації, а з російської – тип **МВД,** в яких використовуються лише символи англійського алфавіту.

Для задоволення вимог як українських стандартів, так і визнаних в науковому середовищі наукометричих баз, редакційна колегія просить авторів оформлювати **два списки літератури** – згідно українського стандарту, та згідно вимог, описаних нижче.

1. Посилання на статтю.

Автори (рік видання), Назва статті, *Назва журналу (курсивом)*, том (номер), сторінки.

Всі елементи після року видання розділяються комами.

Приклад:

Український стандарт	**Стандарт Harvard**
Пирог Т.П. Використання мікробних поверхнево-активних речовин у біології та медицині / Т.П. Пирог, А.Д. Конон, А.Б. Скочко // Біотехнологія. – 2011. – Т. 4, № 2. – С. 24–38.	Pyroh T.P., Konon A.D., Skochko A.B. (2011), Vykorystannia mikrobnykh poverkhnevo-aktyvnykh rechovyn u biolohii ta medytsyni, *Biotekhnolohiia*, 4(2), pp. 24-38.

2. Посилання на книгу.

Автори (рік), *Назва книги (курсивом)*, Видавництво, Місто.

Всі елементи після року видання розділяються комами.

Український стандарт	**Стандарт Harvard**
Раєвнєва О.В. Управління розвитком підприємства: методологія, механізми, моделі: монографія / О.В. Раєвнєва. – Харків, 2006. – 496 с.	Raievnieva O.V. (2006), *Upravlinnia rozvytkom pidpryiemstva: metodolohiia, mekhanizmy, modeli,* Kharkiv.

3. Посилання на електронний ресурс.

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Приклад посилання на статтю із електронного видання:
Barbara Chmielewska (2012), Differentiation of the standard of living of families in countries of the European Union, *Ukrainian Food Journal*, 2(2), pp. 230-241, available at: http://ufj.ho.ua/Archiv/UKRAINIAN%20FOOD%20JOURNAL%202013%20V.2%20Is.2.pdf

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(2013), *Svitovi naukovometrychni bazy*, available at: http://www1.nas.gov.ua/publications/q_a/Pages/scopus.aspx

Приклад оформлення списку літератури:

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Наукове видання

UKRAINIAN FOOD JOURNAL

Volume 3, Issue 3
2014

Том 3, № 3
2014

Підп. до друку 03.09.2014 р. Формат 70x100/16.
Обл.-вид. арк. 14.11. Ум. друк. арк. 13.43.
Гарнітура Times New Roman. Друк офсетний.
Наклад 100 прим. Вид. № 16н/14. Зам. №

НУХТ. 01601 Київ-33, вул. Володимирська, 68

Свідоцтво про державну реєстрацію
друкованого засобу масової інформації
КВ 18964-7754Р
видане 26 березня 2012 року.