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Meat products for the nutrition of people with the overweight of body – pandemic of XXI century

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Abstract

Introduction. A basic task in solving a problem of overweight is development of such special foods which would give an opportunity to the people with the overweight of body to bring down body weight, consuming that or other product. Such effect can be attained by adding or changing a certain component in compounding by other one with high functional properties.

Materials and methods. Studied guinea fowl meat and ham balanced in amino acid and fatty acid composition. Methods of mathematical simulation of the finished product formulations, experimental methods of chemical composition, structure and mechanical properties of the product. Amino acid composition determined by ion chromatography analyzer amino acids of T-339. Raw fatty acid composition was determined by gas chromatography.

Results and discussion. For normal human body best ratio of essential fatty acids is considered to be 1:1:1. Most close to this indicator is ideal for fat wild ducks and guinea fowl (1:0.9:0.7 and 1:0.5:1.0). The worst the ratio of fatty acids is mutton fat (1:0.1:1.9). The ratio "polyunsaturated fatty acids" / "saturated fatty acids" is the best pork fat (0.27) and quail (0.21). The worst is fat wild duck (1.27), horse (0.58) and chicken fat (0.56) .For normal human body works best ratio of essential fatty acids is considered to be 1:1:1.

Boiled-smoked wis meat of guinea fowl ham has more balanced amino acid composition in comparing to the control standards. In the boiled-smoked ham there is higher content of valine (on 0,6%), lysin (on 0,71%), methionine (on 0,20%), threonine (on 0,69%), alanine (on 0,59%), aspartic (on 0,69%), and glycine (on 0,79%) comparatively with a control standard. A ham with meat of guinea-fowl approaches the albumen of chicken egg by the content of irreplaceable amino acids, and the content of such amino acids as a valine, isoleucine, leucine, lysin, alanine, arginine, aspartic, glycine, glutamic acid and tirosin is higher than in the albumen of chicken egg.

Conclusions. The boiled-smoked ham with meat of guinea-fowl has well balanced amino acid composition and is characterized by a high biological value and can be attributed to the accomplished foodstuffs by a content of irreplaceable amino acids.

Introduction

Research work is extremely relevant. Urgent is the development of new technologies improving food supplies, involving the use of nutrients with high functional and technological properties.

We should investigate the amino acid and fatty acid composition of raw materials and finished product. Also the structural and mechanical properties allow us objectively evaluate the consistency of the finished products.

The purpose of research – to expand the range of meat products for human nutrition overweight.

The peculiarities of technology and main quality characteristics for elaborated products are given.

Literature review

Obesity is a exess lipopexia in an organism (for B.V.Petrovsky). For diagnostics of obesity and determination of his degree (Table 1) use the index of body (IMT) weight, that is expected after a formula: BMI (kg/sq.m,) = body weight (kg) / height (m) of the grown man. In obedience to recommendations of WHO, this index does not spread to the expectant mothers, children, sportsmen and persons who are older than 65 [1].

Table 1

A connection of body weight with a risk of deseases

Weight of body	BMI, kg/sq.m.	Risk of deseases
Optimal weight	18,5–24,9	Average
Before overweight	25,0–29,9	Increased
Overweight of 1 degree	30,0–34,9	High
Overweight of 2 degree	35,0–39,9	Very high
Overweight of 3 degree	>=40,0	Extremely high

For today 312 million persons all over the world have BMI > 30,1; 1 billion of persons – BMI > 25, 15, and also 5 million children have excessive body weight [2].

Geography of obesity is wide: if in the 70th years of XX of century superfluous obesity and obesity was the problem of the exceptionally of developed countries, then presently she spread everywhere, and countries that develop already almost keep abreast of developed. For example , in China the number of people with overweight attained 15% (150 mln persons), a certain record is put on Near east and in North Africa, where the about half of women suffer from obesity or has an ovenweight [3, 4].

Obesity is conditionally separated on primary and secondary one. The primary (alimentary – constitutional) is an independent disease, secondary (symptomatic) – develops on a background of the cental nervous system deseases and deseases of endocrine system (in a case of parafunction of thyroid) , and also in the consequence of reception of some medicinal facilities (glucocorticosteroids, peroral contraceptives).The part of secondary obesity is only 1% cases. Alimentary-constitutional obesity meets mostly and develops in any age, however his first display is usually looked after in 11–13. Large value in an origin of alimentary – constitutional obesity the inherited inclination (45% cases) has [1].

Main reason of obesity and ovenweight is a energy disbalance between calories that is consumed by a man, and calories that he spends. A Basis of rise of global indexes of overweight and obesity are a few factors, among them there are a global change of feed that is characterized by an increase consumption of foods with high maintenance of carbohydrates and fats and at the same time law maintenance of vitamins and microelements. Fast food products with preservatives, chemical additions, dyes, sugar and him artificial substitutes, margarine and other pseudoproducts, including refined, alcohol, caffeine, a tobacco is inflicting enormous harm on organism. They poison an organism practically, causing the disbalance of insulin, thyroxine, endorphin and other hormones. And the main consumer of such "comfortable foods" are children of school age and people at the age before 30. "Artificial" carbohydrates cause the high getting up of level of insulin (from 3–10 to 22 mcU/ml), and it results also in considerable release of the serotonin (the hormone of hapiness) [7].

But the enhancement of well-being lasts no long and than that a depression from a less of the serotonin wouldn't appear, a brain begins to require the next dose of stimulators. So a dependence on stimulators appears. Insulin protects a brain from the excessive amount of sugar that destroys cages. But at the protracted surplus of insulin cages are closeing from him to be not overloaded. So there is insulin resistance (insensitivity). And, to overcome her, a pancreas begins to produce the additional amount of insulin under the action of that any blood sugar grows into fatty supplies.

Institute of gerontology National academy of medical sciences of Ukraine proved that degree of atherosclerotic violations for elderly people at calorie content of day's ration 1600–2100 kkal considerably less than, than in those the food ration of that presented 2650–3100 kkal [13].

Scientists (Rachel Beterham and Richard Atkinson) underline that the main reason of obesity is a wrong lifestyle. Research results are published in a magazine Science.

The problem of obesity can be decided as well as by the help of surgical and not surgical methods – proper nutrition, use of food supplements and others like that. Among surgical distinguish establishment of gastric bulb, by-passing of stomach.

For a dietary feed at obesity it is necessary to take into account :
-the use of diet with low calories amount;
-the limitation in the ration of carbohydrates that quickly grow into an organism in fat, and fats of animal origin and increase of vegetable ones;
-a frequent (to 6 times/twenty-four hours) feed with the exception of foods that excite an appetite (sharp seasonings, spicinesses and others like that);
-reduction of the amount of liquid and salt in a meal;
    -inhibition in the feed of unloading days [11].

As a problem of obesity can be warned by participation of representatives of food industry, then by a basic task in solving a problem of overweight is development of such special foods which would give an opportunity to the people with the overweight of body to bring down body weight, consuming that or other product. Such effect can be attained by adding or changing a certain component in compounding by other one with high functional properties.

The main point, that it was necessary to take into account there are a presence of sources of raw materials and speed of proceeding in raw material during new product development, and during creation of dietary product – functional properties and chemical composition also. For realization of researches meat of bird was select in this work.

The market of meat of bird is one of the most dinamically developed markets of food stuffs presently. The products of the poultry farming become all more attractive for home consumers, so as is one of the cheapest and popular in our country a source of proteins of

animal origin. Since olden times foods from a bird considered a delicious and useful meal. And it not by chance: in fact tender and fragrant meat of chickens, turkey-cocks, shutes, game has a high food value that does him unique food stuff. Excellent features of meat of bird : high digestibility; optimal content with optimal correlation of irreplaceable amino acids; low calorie content. Meat is divided into white and red. The white contains the less connective tissue and this tissue is more soft, tender and evenly up-diffused on all muscles.

The not mastered market of meat of bird are guinea-fowls. Meat of guinea-fowls belongs to the dietary delicacy products.By taste it reminds meat of pheasants and partridges, but considerably more tender. It contains a 25–27 % of proteins, to a 0,5–0,7 % of fat. Correlation of amino acids in an protein is especially favorable to the man. The yield of eatable parts to living mass presents 53–54 %. Eggs are more rich from chicken in relation to content of dry substances, lipids, vitamin A and carotenoids.

Meat of turkeies is an unique dietary product,which combines in itself propertis of chicken, veal and mutton, is rich in vitamins and, besides, is low-caloric, there is a low level of cholesterol in him. The meat of turkeies is in a wide demand in the USA, where it is used as a delicac, but in this country nevertheless yields to in the popularity to meat of chickens and broilers. Dietary meat of turkey-cocks in the rational feed of man is a source of valuable proteins. Chemical composition of meat and his calorie content at the different types of bird are different. Meat of turkey-cocks has a high food value, and young ones has the best indexes in presence in it proteins and their correlation with fat . In the carcasses of turkey-cocks the color of muscular fabric is different: chest muscles and muscles of wings have a white color, and muscles of feet – more dark, red. White meat is biologically more valuable. In him there is not only more protein but also the best correlation is both between valuable and inferior proteins and between single amino acids. Food value of meat of turkey-cocks isn't limited only by its sustenance. The meat also include significant amount of minerals especially calcium and phosphorus, vitamins of E and group B. The specific smell and taste are predefined relatively by a high presence in raw meat of extract substances (1,5–2,5%%). This group of organic compounds that go across during cooking of meat in clear soup. Meat of turkey-cocks has high taste qualities. It is tender and juicy. Muscular fibres are thin, and connecting tissue between them there is less than in other types of bird.

Thus, meat of turkey-cock and guinea-fowl is the perspective type of raw material for the production of meatproducts for people with the overweight of body, as has enhanceable maintenance of proteins and low content of fat.

Materials and methods

Article of research: meat of guinea-fowl and turkey-cock, hams.

The articles of research are both new foods, selected to consideration in this work and industrial foods that is already used.

Chemical composition of poultry meat was determined on base of laboratory "Globinskiy meat plant" (Ukraine).

Methods, that allow to describe chemical composition, food and biological value, organoleptic, functionally-technological,structural and mechanical and economic indexes of research objects, were used in the process.

The organoleptic evaluation of quality of sausage products and ready-to-cook foods came true on a 5-ball scale.

A organoleptic estimation came true in a next sequence:

- original appearance – by a structure, by a picture on a cut, by even distribution of pieces of mushrooms in stuffing, by the type of shell;
- a color – by sight on the cut of intermediate product;
- a smell (aroma), taste and succulence – absence or presence of extraneous smell, aftertaste, degree of expressed of aroma of spicinesses and salinity determined;
- consistency – by pressing on good.

Determination of amino acid composition was conducted in accordance with the method of ion exchange chromatography. Quality and quantitative determination of components consisted in dividing of them into separate components after the hydrolysis of proteins and determination of their quantitative estimation with the help of automatic analyzer of amino acids as T-339, on polystyrene sulfonate ion exchange resins of "Ostion LJ ANB" in Li-citrate buffer one column mode. The elutions of amino acids from a column conduct in turn by Li- by citrate buffers from pH 2,75 ± 0,01; pH 2,95 ± 0,01; pH 3,2 ± 0,02; pH 3,8 ± 0,02; pH 5,0 ± 0,2. Amino acids rectifying with the help of solution of ninhydrin on a running photometer at a length of waves by 560 nm. The results of detection was registered oneself by a variplotter on a paper in form the peaks of absorption of light of ninhydrin-positive substances in an eluate, that in number in direct ratio concentrations of this substance in solution. Correlation of solution of ninhydrin reagent and eluents is 1 to 2; temperature of thermostatic T1=38,5 °C; T= 65 °C. The prototype was diluted in Li-citrate buffer by pH 2,2 ± 0,02 and inflicted on a ion exchange column with the help of metering device. The quantitative estimation of хроматограм of pre-production model settles accounts in relation to standard mixture of amino acids of firm BioRaD. The amount of milligrams of every amino acid of A_i in the investigated solution calculates on a formula:

$$A_i = \frac{M_i S_i}{S_i^3},$$

where A_i is mass part of i-th amino acid, mg/100 g of protein;

Mi is molecular mass of i-th amino acid;

Si is area of peak of i-th amino acid on an aminogram from the investigated solution;

S_i^3 is an area of peak of i amino acid on an aminogram from solution of standard mixture of amino acids, that accords to one micromole.

Amino acid score was expected according to the certificate scale of FAO/WHO.

Method of calculation amino acid skore is taken to determination of relation of content of every irreplaceable amino acid in the investigated protein to their content in a standard – standard balanced in irreplaceable amino acids and recommended by the committee of WHO. Determined by a formula:

$$A = \frac{A_R}{A_I} \cdot 100\%$$

A_r is a content of irreplaceable amino acid in a 1 g of investigated protein, mg; A_i is a content of the same amino acid in a 1 g "ideal" protein, mg; 100 is a coefficient of count in percents.

An amino acid that limits a biological value, is considered that which have the lowest score.

Result and discussing

First, it was found content of water, protein, fat and ash in various types of poultry. The research results are presented in Table 2.

Table 2

The chemical composition of meat of different animal species

Meat type	Content in product, %			
	Moisture	Protein	Fat	Ash
Guinea fowl meat	**74,2**	**23,1**	**1,5**	**1,2**
Turkey meat	**71,6**	**22,2**	**5,1**	**1,1**
Meat of quails	**67,4**	**17,3**	**14,3**	**1,0**
Beef	69,2	20,0	9,8	1,0
Pork	51,5	14,3	33,3	0,9
Poultry	70,1	19,6	10,5	0,8

Table 3

Research of amino acid composition of meat of bird

Amino acids	Content, mg in 100 g of meat						
	Albumen of chicken's egg, %	Meat of guinea fowl		Meat of Turkey		Meat of quails	
		Amount, mg	%	Amount, mg	%	Amount, mg	%
Irreplaceable amino acids:							
Valine	**2,3**	0,599	**3,54**	0,555	**3,75**	0,713	**3,76**
Isoleucine	**3,3**	0,557	**3,30**	0,456	**3,08**	0,646	**3,41**
Leucinum	**6,9**	1,429	**8,46**	1,338	**9,03**	1,604	**8,47**
Lysin	**6,9**	1,606	**9,51**	1,437	**9,70**	1,789	**9,44**
Methionine	**7,4**	0,536	**3,17**	0,456	**3,07**	0,612	**3,23**
Threonine	**5,0**	0,782	**4,63**	0,716	**4,83**	0,881	**4,65**
Phenylalanine	**5,6**	0,922	**5,46**	0,740	**4,99**	0,852	**4,50**
Replaceable amino acids:							
Alanine	–	1,031	**6,10**	0,933	**6,30**	1,148	**6,06**
Arginine	**6,7**	1,096	**6,48**	0,959	**6,47**	1,272	**6,71**
Aspartic	**8,2**	1,488	**8,81**	1,248	**8,42**	1,613	**8,52**
Histidinum	**2,4**	0,554	**3,28**	0,601	**4,06**	0,829	**4,38**
Glycine	**3,6**	0,754	**4,46**	0,651	**4,39**	0,850	**4,49**
Glutamic acid	**12,6**	3,135	**18,55**	2,760	**18,63**	3,477	**18,35**
proline	**4,5**	0,863	**5,10**	0,621	**4,19**	0,922	**4,87**
Serine	**7,8**	0,744	**4,41**	0,694	**4,68**	0,841	**4,44**
Thyrosinum	**4,1**	0,613	**3,63**	0,547	**3,69**	0,691	**3,65**
Cystine	**2,3**	0,188	**1,11**	0,108	**0,73**	0,204	**1,07**

From the table we can see that poultry is characterized by higher protein and ash content and less fat. Also in guinea fowl meat contains 23.1% of protein, in turkey meat – 22.2% while beef contains 20.0% of protein; meat of quails contains 17.3% protein, and pork – only 14.3%. In the meat of farm animals significantly more fat compared to poultry was fixed.

So in guinea fowl the meat contains 1.5% of fat, in turkey meat – 5.1% and beef – 9.8% of fat; pork contains 33.3% of fat, while the quails meat only 14.3% that is explained by the specific conditions of life and differences in feed that eats the bird. To create products with high biological and nutritional value it is checked for balance amino acid and fatty acid composition of raw materials.

The biological value of product represents his ability to satisfy the requirement of organism in irreplaceable amino acids. For the estimation of biological value a method was used amino acid score method, that is based on comparison of amino acid composition of protein investigated to the standard in amino acid composition of ideal protein.

On the maintenance of amino acids meat of quail approaches the protein of chicken egg, and on maintenance such irreplaceable amino acids as a valine (on 1,24–1,46%%), isoleucine (on 0,09–0,11%),   leucine (on 1,56–2,13%), lysin (on 2,54–2,80%) and replaceable amino acids – alanine (on 6,06–6,30%), aspartic (on 0,22–0,61 %), histidin (on 0,88–1,98 %), glycine (on 0,79–0,89%%),glytamic acid (on 5,75–6,03%) and proline (on 0,37–0,60%)   excels him.

It goes to show that the investigated meat is balanced after amino acid composition, characterized by a high biological value and can be attributed to the valuable foodstuffs.

In the feed the important value acquires not only amount but also the quality of fats, especially content of polyunsaturated acids with the certain placing of double connections and cis- by configuration.

Fat and acid composition of raw material was determined at an assistance Ukrderzhmetstandart by the method of gas-liquid chromatography. The obtained data are presented in a Table 4.

Table 4

The composition of fatty acid animal fats

Fat	The content of essential fatty acids%			Ratio that characterize biological value of fat				
	MFA	PFA	NFA	MFA: PFA: NFA	PFA: NFA	$C_{18:2}/C_{18:1}$	$C_{18:2}/C_{18:3}$	ω_6/ω_3
Ideal	**33,3**	**33,3**	**33,3**	**1:1:1**	**0,2–0,4**	**>0,25**	**>0,7**	**4:1**
Beef	38,92	2,78	57,89	1:0,1:1,5	0,05	0,06	3,8	3:1
Porcine	43,28	7,47	50,10	1:0,2:1,2	0,27	0,2	9,7	4:1
Sheep	33,81	2,35	63,84	1:0,1:1,9	0,04	0,06	4,9	5:1
Horse	40,68	21,71	37,61	1:0,5:0,9	0,58	0,26	0,7	0,5:1
Guinea fowl	**38,50**	**7,10**	**51,2**	**1:0,2:1,3**	**0,13**	**0,15**	**14,0**	**7:1**
Turkey	**36,18**	**18,87**	**37,23**	**1:0,5:1,0**	**0,51**	**0,20**	**1,16**	**6,6:1**
Quail	**35,33**	**10,20**	**47,87**	**1:0,3:1,3**	**0,21**	**0,18**	**5,7**	**4,5:1**
Gallinaceous	49,81	17,78	32,41	1:0,4:0,7	0,56	0,38	17,0	23:1
Wild duck	**34,43**	**31,73**	**23,19**	**1:0,9:0,7**	**1,37**	**0,60**	**2,85**	**3,7:1**

For normal work of human organism the best ratio of essential fatty acids is considered to be 1:1:1. As we can see from the table most approached in this indicator to ideal is fat of wild ducks and guinea fowl (1:0.9:0.7 and 1:0.5:1.0). The worst ratio of fatty acids is mutton fat (1:0.1:1.9). As the ratio of PUFA / NLC the best is pork fat (0.27) and quail (0.21), and the worst is fat wild duck (1.27), horse (0.58) and chicken fat (0.56).

Ratios ω6:ω3 – are important indicators. Scientifically proved that at a fraction of essential fatty acids should be 4–6% of the energy value of the diet of an adult and relation to ωZ ω6 PUFAs should be 10: 1, and in violation of lipid metabolism − 5:1 i even 3:1. From the data of the table we can see that the ratio of ω6 / ω3 worst is chicken fat (23:1) and horse fat (0.5:1), while all other fats, the figure is at the optimum level.

In order to expand the range of dietary meat products we with the help of our mathematical modeling developed 6 recipes tavern guinea fowl meat and ham are the most favorite product among consumers (Table 5).

Table 5

Developed recipes tavern guinea fowl meat

Raw materials	Control "Meat of guinea fowl boiled in a shall, a/c	Example N1 (Guinea fowl meat +beef) (cooked)	Example N2 (Guinea fowl meat +beef) (sublimated)	Example N3 (Guinea fowl Meat +pork) (cooked)	Example N4 (Guinea fowl meat + chicken) (cooked)	Example N5 (Guinea fowl meat pork + beef + chicken +) (cooked)	Example N6 (Guinea fowl meat pork + beef + chicken +) (cooked)
The main raw material, kg							
Guinea fowl meat	100	50	50	50	50	20	30
Pork bold				50		40	25
Beef w / c		50	50				
Beef 1s						25	35
Chicken					50	15	10
Spices and auxiliary materials, r (100 kg of raw salt)							
Salt for food	2500	2500	2700	2500	2500	2500	2500
Integrated additive "SS 6"	600	600	600	600	600	600	600
Sodium nitrite	10	10	10	10	10	10	10
The functional additive N208	300	300	300	300	300	300	300
Water, L	15	15	15	15	15	15	15

All received products are of high quality with a special spicy taste and aroma with high biological value, balanced by amino acid and fatty acid composition, which can be recommended for usage in dietary nutrition.

Organoleptic quality assessment carried tasting tavern commission (14 people) at the Department of Technology of meat and meat products (Table 6).

Table 6

Organoleptic quality assessment made tavern

Sample	Outlook	Colour	Taste	Aroma	Consistence	Succulence	General mark
Control	4,72	4,28	4,50	4,80	4,81	4,87	4,66
Sample N1	4,97	5,00	4,83	4,98	4,90	5,00	4,95
Sample N2	5,00	5,00	5,00	5,00	5,00	5,00	5,00
Sample N3	4,76	4,74	4,44	4,77	4,67	4,51	4,65
Sample N4	4,50	4,39	4,28	4,74	4,67	4,44	4,50
Sample N5	4,61	4,72	4,28	4,83	4,72	4,78	4,64
Sample N6	4,74	4,72	4,28	4,67	4,83	4,50	4,56

As the table shows, all designed hams had higher total evaluation. They were succulent, of sweet taste and smell and attractive in outlook. The highest score (4.95 and 5.00) were ham, which was combined guinea fowl and beef meat (sample number 1 and N2), and the lowest – 4.5 got the sample where guinea fowl meat and chicken combined (recipe N4), but all the samples had high scores (from 4.50 to 5.00).

The structural and mechanical properties allow us objectively evaluate the consistency of the finished products to determine physical fitness tavern for use. The research results are presented in Table 7.

Table 7

Structural and mechanical properties of finished products

Sample	Cutting work, J	Cutting power, кН/м^2
Control	442,00 ± 9,1	113,54 ± 4,8
Sample N1	396,18 ± 6,5	110,20 ± 3,1
Sample N2	434,24 ± 8,2	105,30 ± 3,3
Sample N3	270,87 ± 6,3	86,02 ± 2,3

As we can see from the table reference sample has the biggest job (442.00 J) and cutting force (113.54 kN/m^2) compared with test samples. In the experimental samples cutting force is in the range of 86.02–110.20 kN/m^2, that indicates on rather soft

consistence. The information that we have got tells us that according to structural and mechanical indicators prepared ham are suitable for usage in dietary nutrition.

The research of amino acid composition of samples of cooked hams shown in Table 8.

This table shows that boiled-smoked ham has a balanced amino acid composition compared to control. In boiled-smoked ham it is observed higher levels of valine (0.6%), lysine (by 0.71%), methionine (at 0.20%), threonine (at 0.69%), alanine (at 0.59%), aspartic acid (to 0.69%) and glycine (at 0.79%)in comparing with the control sample.

According to the content of essential amino acids ham meat guinea fowl close to egg protein, and according to the content of of amino acids as valine, isoleucine, leucine, lysine, alanine, arginine, aspartic acid, glycine, glutamic acid, tyrosine surpasses it.

This indicates that the cooked ham and smoked guinea fowl meat have well balanced amino acid composition, it is characterized by high biological value and can be attributed to high-grade food for the content of essential amino acids.

Table 8

Amino acid composition of cooked hams

Amino acids	Egg protein, %	Content, mg per 100 g					
		Control			Cooked ham, smoked guinea fowl meat		
		Quantity, мг	%	Biological value of protein in %	Quantity, мг	%	Biological value of protein in %
Essential amino acids:							
Valine	2,3	0,500	4,59	92	0,545	5,19	104
Isoleucine	3,3	0,571	5,24	131	0,445	4,25	106
Leucine	6,9	0,911	8,36	119	0,745	7,30	104
Lysine	6,9	0,851	7,81	142	0,894	8,52	155
Methionine	7,4	0,246	2,26		0,258	2,46	
Threonine	5,0	0,527	4,84	121	0,580	5,53	138
Phenylalanine	5,6	0,542	4,15		0,401	3,82	
Replaceable amino acids:							
Alanine	–	0,594	5,46		0,634	6,05	
Arginine	6,7	0,747	6,86		0,664	6,33	
Aspartic acid	8,2	0,917	8,42		0,956	9,11	
Histidine	2,4	0,377	3,46		0,346	3,30	
Glycine	3,6	0,461	4,23		0,527	5,02	
Glutamic acid	12,6	2,203	20,22		2,121	20,21	
Proline	4,5	0,457	4,20		0,394	3,76	
Serine	7,8	0,508	4,66		0,490	4,67	
Tyrosine	4,1	0,439	4,03	136	0,371	3,54	123
Cystine	2,3	0,134	1,23	99	0,100	0,95	97

Conclusion

1. By amino acid and fatty acid composition poultry meat dominates upon farm animals. In guinea fowl meat contains the largest amount of methionine (0.561 mg), aspartic acid (2.321 mg), histidine (0.830 mg), glutamic acid (3.623 mg) and cysteine (0.459 mg). By the ratio MFA: PFA: NFA closest to the ideal (1:1:1) is a fat turkey (1:0.5:1.0).
2. With the help of mathematical modeling method we optimized six recipes of guinea fowl meat tavern.
3. According to the results of sensory analysis of the highest rating (5.00 points) got boiled ham, smoked guinea fowl meat and beef.
4. According to structural and mechanical properties (work and cutting force) the best are cooked ham with guinea fowl meat and pork, that have the lowest index of power (270.87 J) and force (86.02 kN/m^2) and cutting that characterize its softness.
5. It is established that the combination of guinea fowl meat with beef provides a product with a high content of essential (valine, lysine, methionine) and replacement (threonine, alanine, glycine and aspartic acid) amino acids, which are characterized by high biological value and can be attributed to proper food.

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Study on the content of aromatic components in wine of grape varieties selected at the Institute of Viticulture and Enology – Pleven

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Abstract

Introduction. The origin of aromatic substances of grapes, must and wine is determined by: aromatic substances of grapes passing in the must and wine; aromatic substances which are the product of biochemical phenomena (oxidation, extraction, hydrolysis) before fermentation; aromatic substances which are product of yeasts and bacteria conducting alcoholic and malolactic fermentations; aromatic substances formed during transformation as a result of wine processing; aromatic substances formed during prolonged storage or aging of the wines.

Materials and methods. The wines of grape varieties Storgoziya, Kaylashky rubin, Trapezitza, Rubin and Bouquet, selected at Institute of Viticulture and Enology – Pleven in the way of intra- and interspecific hybridization were studied. The grapes are vinified in the traditional way for producing of dry red wines. Gas chromatographic determination of the aromatic profile of wines was conducted.

Results and discussion. It was found that the amount of acetaldehyde in the investigated wines was within normal for red dry wines limits. The highest amount of acetaldehyde was found in wine obtained from grape variety Kaylashky rubin (83.80 mg/dm^3). In wines from grape varieties Rubin and Storgozia it was in traces, and in the wine of Trapezitza grape variety it was not found. From the fraction of higher alcohols 2–methyl-1–butanol was established only in the wine from Kaylashky rubin grape variety (269.80 mg/dm^3). 1-pentanol, imparting a pleasant flowery tone of wines, was found in wines from grape varieties Bouquet (71.79 mg/dm^3), Trapezitza (58.20 mg/dm^3), Rubin (29.00 mg/dm^3), as well as control Pinot Noir (15.49 mg/dm^3). From the fraction of the esters, the ethyl acetate was identified in all wines ($13–37$ mg/dm^3). Iso –buthyl acetate also present in all wines ($33.80–86.84$ mg/dm^3). Ethyl butyrate was found only in wine of Bouquet grape variety (164.60 mg/dm^3). From the group of terpenes geraniol and β – citronellol were identified.

Conclusions. The amount of acetaldehyde in the investigated wines was normal. With the greatest amount of higher alcohols 1–pentanol was established. Dominating ester was ethyl butyrate. The presence of terpenes was less marked.

Introduction

Aromatic substances of grapes, grape must and wine can be grouped according to their origin as follows:
- aromatic substances of grapes, which passing it in the grape must and wine and which are a product of the vine plant metabolism. They are called primary or varietal aromas. They are influenced by grape variety, soil conditions, climate, method of vine cultivation, phytosanitary condition of grapes, vineyard practices.
- aromatic substances that are the product of biochemical phenomena before fermentation (oxidation, extraction, hydrolysis) beginning after crushing of the grapes and continuing during the extraction of the must from solid parts i.e., during the processes of maceration.
- aromatic substances which are products of the yeast and bacteria metabolism during the alcoholic and malolactic fermentations. They are called secondary.
- aromatic substances that are formed in the transformation of other non-aromatic substances as a result of one or other treatment of wines, and in the first months of storage of new wine.
- aromatic substances resulting from post fermentation chemical or enzymatic reactions occurring during prolonged storage or during the wines aging. This is the so-called tertiary aroma or bouquet.
- aromatic substances obtained by the wine aging in oak barrels, and in the absence of air in bottles aging, whence derive many compounds that pass in the wine and participate in its aroma and bouquet [1].

These include an extremely large number of different chemical groups of substances (alcohols, aldehydes, ketones, volatile fatty acids and unsaturated esters, acetals, terpene compounds, etc.), which is characterized to have aroma and taste. Depending on their organoleptic characteristics, i.e. what tones in the aroma and taste of wine form, they are divided into two groups: non-specific and specific. First group includes substances with fruit aroma, flower aroma, herbs aroma, aroma of spices and more as well as representatives of fermentation aroma. They form the background that helps the expression and impact of the specific varietal aroma [2].

The terpenic substances – hydrocarbons, alcohols, aldehydes belong to the specific aromatic agents. At this time 70 different terpene compounds have been identified and studied. Their aroma is extremely strong when they are in a free state. They have a low threshold of perception (18–400 μg/dm^3). They are concentrated mainly in the grape skins [3]. Terpenes are a group of compounds relevant to the characterization of the wine aroma and its maturity [4]. Terpenes are contained in grapes, must and wine and they are not metabolized by the yeasts during fermentation [5]. Therefore, they can be used successfully for analytical varietal characteristics and determine the affiliation of wine corresponding to its production grape variety [6].

The intensified research interest about terpenes in recent years is related to the presence of their wide range of biological and pharmacological activities. Increased interest is observed on their antioxidant activity against reactive oxygen species which are involved in the pathological development of many important human diseases, such as neurodegenerative, cardiovascular, diabetes, and others [7]. It was found that geraniol (one of monoterpenes present in grapes) showed an anti-proliferative effect on cell growth of melanoma. A number of monoterpenes present in foods have shown antitumor activity in animal models or different cell lines, inhibiting carcinogenesis and showing effectiveness in the treatment of early and advanced cancers [8,9].

The main terpenes contained in the grapes from where passing in the wine are geraniol, linalool, terpineol, nerol, citronellol and farnesol. The first four are dominants.

Higher alcohols are other volatile compounds from the aromatic complex of wines. They are products of amino acid metabolism of the yeast cultures undergoing the fermentation. It is claimed that 75% of the aromatic complex, characterized wines, consists of various higher alcohols [10]. As the dominant component of the aromatic matrix, higher alcohols have the greatest impact on the sensory profile of the obtained wine, giving fruity notes. Their concentration in the wine is highly dependent on the presence in significant amounts of their precursor (amino acids) in grapes, and also on the ability of the selected yeast strain for actively metabolization of amino acids in the fermentation process.

Esters are next group in the line of domination in the composition of the wines aromatic matrix. According to Tao and Li [10], they represent 20–30% of all volatile substances in the wine. The esters are the products of esterification process, formed by coupling of the alcohols and acids in the wine [11]. Due to the fact that wine contains a significant number of alcohols and acids can be formed wide range of esters. Identified wine esters usually include ethyl esters, acetates and other esters of fatty acids fusels. They, as well as higher alcohols, have a significant contribution to the development of characteristic fruity and floral wine aroma, but high concentrations of some of them, such as ethyl acetate (ester of ethanol and acetic acid), represent an indicator of long-term storage and indicate a strong probability of acetic acid process (2014, Law on Wine and Alcohol Beverages, Bulgaria).

Until now in Bulgaria has not conducted comprehensive study evaluating the aromatic characteristics of wines from the traditional Bulgarian grape varieties for the area of the town of Pleven – Storgoziya, Kaylashky rubin, Trapezitza, Rubin and Bouquet. Modern analytical method of gas chromatography was used. This requires the implementation and realization of complex determination of aromatic characteristics of the traditional wines from the area of the town of Pleven, which is the motivation for the development of this scientific research.

Materials and methods

The study was done at the Institute of Viticulture and Enology (IVE) – Pleven in 2015. The subject of the study was red wine grape varieties Storgoziya, Kaylashky rubin, Trapezitza, Rubin and Bouquet, selected in IVE – Pleven by the way of intra- and interspecific hybridization. They are distributed in individual micro areas in Bulgaria. Interspecific varieties Storgoziya, Kaylashky rubin and Trapezitza have increased resistance to stress factors (low winter temperatures and mildew).

The parental forms of studied grape varieties are:

Storgozia – Bouquet x SV12375;
Kaylashky rubin – Pamid x Hybrid VI-2–15 x Gamay Noir x *Vitis amurensis*;
Trapezitza – Danube Gamza x Marseillaise early;
Rubin – Nebbiolo x Syrah;
Bouquet – Mavrud x Pinot Noir.
Pinot Noir variety of *Vitis vinifera* was used for control grape variety.
Vintage has been made after reaching technological maturity of the grapes.

Vinification was conducted in the traditional way of dry red wines producing in the experimental wine-cellar of IVE: crushing, pressing, sulphitation (50 mg/kg SO_2), inoculation with pure culture wine yeasts *Saccharomyces cerevisiae* (10 g/hl), temperature

of fermentation (25–28° C), removing of solids, malolactic fermentation, further sulphitation, storage.

The composition of grape pulp and obtained experimental wines from studied varieties in terms of basic chemical indicators were defined by generally accepted winemaking methods [13, 1].

Gas chromatographic determination of the aromatic components in wine distillates was done. The content of major volatile aromatic compounds was determined on the basis of stock standard solution prepared in accordance with the IS method 3752:2005 [14]. The method describes the preparation of standard solution with one congener, but the step of preparation is followed for the preparation of a solution with more compounds. The standard solution in this study include the following compounds (purity > 99.0%): acetaldehyde, acetone, ethyl acetate, methanol, isopropyl acetate, 1–propanol, 2–butanol, propyl acetate, 2–methyl-propanol, isobutanol, 1–butanol, isobutyl acetate, ethyl butyrate, butyl acetate, 2–methyl-1–butanol, 3–methyl-1–butanol, ethyl isovalerate, 1–pentanol, pentyl acetate, 1–hexanol, ethyl hexanoate, hexyl acetate, 1–heptanol, linalool oxide, phenyl acetate, ethyl caprylate, α-terpineol, nerol, β-citronellol, geraniol.

An amount of 1,0 g for each of congeners was diluted to 100 ml with 40% ethanol solution. 10 ml of this solution (with all added congeners) was diluted to 100 ml with 40% ethanol solution. From this stock solution was prepared the standard solution by adding 5 ml of the diluted solution in the 10 ml test tube, and adding 1 ml of the previously prepared solution of octanol (internal standard). The 2 µl of resulting standard solution was injected in gas chromatograph Varian 3900 (Varian Analytical Instruments, Walnut Creek, California, USA) with a capillary column VF max MS (30 m, 0,25 mm ID, DF = 0,25 µm), equipped with a flame ionization detector (FID). The used carrier gas was He. Hydrogen to support combustion was generated and supplied to the chromatograph via a hydrogen generator Parker Chroma Gas: Gas Generator 9200 (Parker, United Kingdom). The injection is manually by microsyringe.

The parameters of the gas chromatographic determination were: injector temperature – 220 °C; detector temperature – 250 °C, initial oven temperature – 35 °C/retention 1 min, rise to 55 °C with step of 2 °C/min for 11 min, rise to 230 °C with step of 15 °C/min for 3 min. Total time of chromatography analysis – 25,67 min.

Results and discussion

Table 1 presents the resulting values of aromatic components in red wines, harvest 2015.

The amount of acetaldehyde in the studied wines was normal for dry red wines (10.00 – 100.00 mg/dm^3). The greatest amount of acetaldehyde was observed in Kaylashky rubin (83.80 mg/dm^3) and Bouquet (77.00 mg/dm^3) versus control Pinot Noir (78.29 mg/dm^3). In the wines of Rubin and Storgozia the acetaldehyde was in traces, while in Trapezitza it is not found. These values indicate the correct operation with sulfur dioxide during alcoholic fermentation and after its completion, at the storage of the wines.

The higher alcohols content of the studied wines was in normal limits for dry red wines (300.00 – 600.00 mg/dm^3) and they have an influence on the wine aromatic complex . Most of them are formed during the alcoholic fermentation (from yeasts strains) and during the conditions of the winemaking. In wine from Kaylashky rubin the higher alcohol 2-methyl-1-butanol (forming volatile esters with the acids of the wine) was in the highest amount (269.80 mg/dm^3), while in the wines of other grape varieties it was not established. The 1-

hexanol (which confers grassy tone in the aroma) was not observed in the wines of studied grape varieties. This is an indicator for well ripened grapes. With the highest quantities of higher alcohols was observed 1-pentanol (pleasant flowery tone). At the wine of Bouquet grape variety its quantity was 71.79 mg/dm3, at Trapezitza – 58.20 mg/dm^3, at Rubin – 29.00 mg/dm^3. While in the control Pinot Noir it was only 15.49 mg/dm^3.

Table 1

Aromatic components of wines

Identified compounds, mg/dm^3	Studied wines					
	Rubin	Storgozia	Bouquet	Trapezitza	Kailashky rubin	Piton noir
Acetaldehyde	≈0.05	≈0.05	77.00	ND	83.80	78.29
Higher alcohols						
2–butanol	ND	ND	51.60	ND	ND	ND
2–methyl-1-butanol	ND	ND	ND	ND	269.80	ND
2–methyl-1-propanol	ND	9.70	16.00	37.70	17.67	27.54
1-pentanol	20.00	≈0.05	71.79	58.20	≈0.05	15.49
1-hexanol	ND	≈0.05	ND	ND	ND	ND
Esters						
Ethyl acetate	13.00	37.00	35.10	31.45	23.20	31.83
Iso-propyl acetate	ND	≈0.05	ND	≈0.05	ND	ND
Iso-butyl acetate	51.00	33.80	55.85	86.84	61.58	64.87
Ethyl butyrate	ND	ND	164.60	ND	ND	ND
Ethyl isovalerate	ND	ND	ND	ND	ND	≈0.05
Pentyl acetate	ND	≈0.05	≈0.05	10.18	ND	ND
Hexyl acetate	ND	≈0.05	≈0.05	≈0.05	≈0.05	≈0.05
Phenyl acetate	ND	ND	ND	ND	≈0.05	ND
Terpene compounds						
A-terpineol	ND	ND	≈0.05	ND	ND	ND
Linalool oxide	ND	≈0.05	ND	0.29	≈0.05	ND
Nerol	ND	≈0.05	ND	≈0.05	≈0.05	≈0.05
B-citronellol	0.26	0.51	0.26	0.30	0.14	0.30
Geraniol	ND	≈0.05	0.35	0.50	≈0.05	0.35

* *Note:* ND – Not detected

≈ traces (approximately equal to 0,05 mg/dm^3)

Esters are the largest and most diverse group of substances (0.20–0.50 g/dm^3), involved in formation of the wine aroma and bouquet. Ethyl acetate (13.00–37.00 mg/dm^3) was established in all studied varieties. It was identified in low amounts and play favorable quality role. In larger amounts (150.00–160.00 mg/dm^3) it has unfavorable effect on the organoleptic qualities of the wines. Another established ester in all varieties was iso-butyl acetate (33.80 mg/dm^3 in Storgozia; 51.00 mg/dm^3 in Rubin; 55.85 mg/dm^3 in Bouquet; 61.58 mg/dm^3 in Kaylashky rubin; and 86.84 mg/dm^3 in Trapezitza). In Pinot noir control it was in quantity of 64.87 mg/dm^3. Ethyl butyrate was found only in Bouquet – 164.60 mg/dm^3. Hexyl acetate was established in traces. The esters iso-propyl acetate, ethyl isovalerate and phenyl acetate were not established.

The presence of terpenes in the red grape varieties is very small. Table 1 shows that nerol and α – terpineol in the investigated varieties and control were not established. Geraniol was found in the wines from Trapezitza (0.50 mg/dm^3) and Bouquet (0.35 mg/dm^3), while in the control its quantity was 0.35 mg/dm^3.

The terpenic compound β – citronellol was present in all varieties in quantities of 0.14 mg/dm^3 in Kaylashky rubin to 0.51 mg/dm^3 in Storgozia.

Conclusions

The amount of acetaldehyde in the investigated wines was normal for dry red wines.

With the large quantities of higher alcohols in all wines was found 1–pentanol with pleasant flowery tone.

From the esters of wines, ethyl butyrate was established in highest value in wine from Bouquet – 164.60 mg/dm^3.

The presence of terpenes in the red varieties was very small.

There were no significant difference in the quantity and quality of aromatic components of wines from studied grape varieties and control grape variety.

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Justification of sedimentation stability of milk whey after electric spark processing

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Abstract

Introduction.The article focuses on the primary processing of milk whey, in particular, the prospect of its processing using electric spark discharges. Reasonability of the electric discharge application in whey processing technology is confirmed by experimental research as well as mathematical and statistical analysis.

Materials and methods. Mathematical modeling established a rational mode of electrohydraulic treatment of whey which is accompanied by a maximum dispersion of particles of precipitated casein dust.

Results and discussion. It has been confirmed that the average hydrodynamic diameter of milk whey particles decreased from $1697,5 \pm 82,38$ nanometer to $221,34 \pm 0,3$ nanometer after electric discharge processing with the peak voltage of 45 kV and discharge quantity of 25. The polydispersity index at that plummeted from 1,0 to 0,35...0,40, which characterizes the system as the one close to monodisperse state.

We have noticed that at the voltage of 30 and 35 kV and the discharge number of 5...15 the particle dispersion was insubstantial. The average particle size decreased only by 22...30%. It was also concluded that at the voltage growth as well as increase in a discharge number the peak values on the distribution curves shifted to the particle size of 500...1000 nm, while the average hydrodynamic diameter decreased. The best results during the electrohydraulic milk whey processing were achieved at the voltage of 45 kV and the discharge number amounting to 25.

The sediment volume in the processed whey decreased from $0,9…1,1$ to $0,1...0,2$ cm^3 at the voltage of 45 kV and the discharge number of 25.

Conclusions. It is proposed a technological scheme of primary milk whey processing using electro-hydraulic method.

Introduction

The plants having a small production volume in most cases return whey to agricultural commodity producers, which use it to feed the cattle. It is widely known that due to the fact it contains biologically valuable proteins of animal origin, milk whey is an irreplaceable product for feeding young cattle and swine. At that, nutritional value of 14 kg sweet or 17 kg sweet wheat equals to that of 1 kg of barley (12,5 megajoules of metabolizable energy and 11 % of cheese protein), however, the protein quality in whey due to a large amount of essential amino acid is considerably higher than in the case with barley [1, 2, 13]. That is why the maximum retaining of proteins in milk whey is topical.

Transporting and storing of organic whey which has not undergone preliminary preparation irrefutably leads to protein loss caused by deposition of casein dust particles. The latter, in their turn, impede heat exchange processes at heating to more than 65 ºC. At that, protein intensively exudes on the surface of the heat-exchange apparatus, forming a burn-on which is hard to get rid of. It leads not only to the sharp decrease in the quantity of a valuable component, but also lowers the pasteurization efficiency, makes the equipment cleaning more difficult.

Unwanted denaturation of whey proteins and their aggregation with casein dust can be avoided provided that mild modes (such as thermisation) [3, 4] are used, but it will not prevent from the unwanted deposition.

That is why the research aimed at the search for the new ways of whey processing, which allow retaining all the valuable components, ensuring the sedimentation system stability is of a particular interest.

The ability of a system to resist the particle deposition is characterized by sedimentation stability. It is ensured with the help of a variety of factors, depending on which kinetic sedimentation stability (KSS) and thermodynamic sedimentation stability (TSS) are distinguished [5, 6].

Kinetic sedimentation stability (KSS) (Formula 1) is typical for disperse systems with comparatively coarse particles. It is measured with the help of a value which is inversely proportional to a sedimentation constant (Ssed). In its turn, sedimentation constant depends on the rate of sedimentation (u) (formula 2):

$$KSS = \frac{1}{S_{sed}} = \frac{9\eta}{2r^2(p - p_0)} \qquad (1)$$

$$u = \frac{2g(p - p_0)r^2}{9\eta}, \qquad (2)$$

in which g is free fall acceleration; p, p_0 are density values of a disperse phase and dispersive medium correspondingly; r is a particles' radius; η is the medium's viscosity.

For particles the size of which amounts to less than 0,1 micrometer, thermal motion and diffusion are taken into account. During the process of the particles' deposition concentration changes according to the height of a liquid column – in higher layers it decreases, whereas in lower ones this value increases. These systems are characterized by thermodynamic sedimentation stability, which is directly connected to sedimentation and diffusion balance (formula 3).

$$TTS = \frac{k_B T}{v g(p - p_0)},$$ (3)

in which v is the volume of particles, $v = \pi r^3 / 3$; T is temperature, $k_в$ is a constant.

The organic whey contains particles the size of which equals up to 50 nanometers, while the coagulated particles of casein dust amount to maximum 2–2,5 micrometers [1], that is why in the first place kinetic sedimentation stability has to be taken into account in this system.

As it can be seen from the formula 1, KSS value is higher for smaller particles. Thus, dispersion is viewed as an acceptable way to address the problem of unwanted coarse casein dust particles and the remnants of curd's sedimentation.

The majority of methods based on the range of mechanical and physical effects (cleavage, grinding, crushing of particles, super-high-speed flow of liquid through the narrow gap 'valve seat-valve', adiabatic boiling in the vacuum, disk dispersion, hydrodynamic cavitation, impact, pulse, ultrasonic medium disturbance etc.) ensure disintegration of particles to a medium diameter of 1–2 micrometers and larger.

The given rate of dispersion is not suitable for achieving our aim, since the size of coagulated casein dust particles remaining in whey after ripening or sedimentation of the basic product, which are able to form unwanted sediment, amounts to 2–2,5 micrometers [1].

Electrophysical methods are believed to be promising in this case, as they not only contribute to dispersing, but also decreasing the amount of microscopic flora in general [7–9]. High-voltage pulse in liquid, resulting in electrohydraulic effect, seems to be of particular interest to us. The essence of this method is in forming within a volume of liquid pulsed electric discharge, causing high hydraulic pressure as well a variety of physical and chemical phenomena to emerge. The latter include hydrodynamic shock, linear liquid flow at super-high-speed, impulse cavitation, polydisperse ultrasonic radiation, the effect of plasma in a spark channel, accompanied by infrared, ultraviolet radiation, impulse electromagnetic fields etc. [10, 12].

There is insufficient amount of data concerning the influence of this electrophysical method on the content and qualitative characteristics of milk whey, which is also true for prospect of its realization for dispersion of coagulated casein dust particles and decrease in the level of biological contamination.

Having taken into account all the facts given, we believe that the improvement of primary milk whey processing by using the hydraulic effect is bound to be a topical and promising line of research.

Materials and methods

The object of the research was milk whey with mass fraction of protein amounting to 1,0...1,5 %, received during the production of non-fat cottage cheese.

The milk whey processing with electric discharge was carried out in the experimental technological complex consisting of the surge current generator GIT50-5×1/4S, discharge chamber, measuring and auxiliary instruments [8].

Discharge circuit and processed medium parameters were as follows:
- voltage equaled 30–45 kV in increments of 5;
- the amount of discharge pulses 5–25 s in increments of 5;
- the energy in a discharge channel – 4,5–5,5 kilojoules;

- the volume of a discharge chamber amounted to 2700–3000 cm^3;
- temperature of the processed medium – 6 ± 2 °C, 20 ± 2 °C and 30 ± 2 °C.

Statistical distribution of the particle size in milk whey and its electrokinetic potential (*ζ-potential*) was researched using the method of dynamic light scattering in the analyzer *Malvern Zetasizer Nano ZS (Malvern Instruments Ltd*., Great Britain) with the detection angle of 173 °, helium-neon laser with its power amounting to 4 mW and a wavelength of 633 nm.

All the measurements in the research were made at the temperature of 25 °C. In order to control the results' repetitiveness every sample was measured at least three times. The size distribution in the intensity units was received from the correlation function analysis using the *General purpose* algorithm in the analyzer's *Zetasizer Software 6.20.*

We have carried out the multifactorial experiment followed by statistical data manipulation and defining corresponding mathematical relations between the average hydrodynamic diameter, polydispersity index, voltage and the number of electric discharges. The mathematical relations were generally presented in such an equation:

$$D = f\,(U,\,n) \text{ and } PI = f\,(U,\,n),$$

where *D* is an average hydrodynamic diameter, *PI* is a polydispersity index, *U* is voltage, *n* is the number of discharges.

Sedimentation process of milk whey particles was researched with software package based on the finite volume method which is used for modeling of 3–D liquid stream and gas in technical and natural objects and also for visualization purposes of this stream by computer Figure ic.

An analytical model of milk whey particles sedimentation process is based on the following equations of Navier-Stokes flow continuity:

$$\frac{\partial V}{\partial t} + \nabla(V \otimes V) = -\frac{\nabla P}{\rho} + \frac{1}{\rho}(\mu + \mu_t)\left[\nabla V + (\nabla V)^T\right] + \left(1 - \frac{\rho_{hyd}}{\rho}\right)g$$

$$\nabla V = 0,$$

where V – vector of relative velocity, m/s;
t – time, s;
P – relative pressure, Pa;
ρ – density, kg/ m^3;
μ, μ$_t$ – dynamic and turbulent viscosity, Pa·s;
ρ$_{hyd}$ – hydrostatical density, kg/m^3;
g – gravitational vector, m/s^2.

Results and discussion

The expediency of using the method offered in the technology of primary milk whey processing was supported by experimental research of particle size before and after processing, sedimentation system stability, microbiological whey readings and its storage life.

Having studied the dispersion phase whey transformations due to dispersion using the method given, we have defined the relation between the size of the particles and the processing parameters, namely voltage and the number of discharges.

In many real systems, including milk whey, the particle form is not spherical, that is why to the particles of this kind the notion of hydrodynamic radius is applied (diameter).

We have noticed that at the voltage of 30 and 35 kV and the discharge number of 5...15 the particle dispersion was insubstantial. The average particle size decreased only by 22...30%. It was also concluded that at the voltage growth as well as increase in a discharge number the peak values on the distribution curves shifted to the particle size of 500...1000 nm, while the average hydrodynamic diameter decreased. The best results during the electrohydraulic milk whey processing were achieved at the voltage of 45 kV and the discharge number amounting to 25. The distribution curves of the particle size in the unprocessed whey and the whey after electrohydraulic processing at the given parameters are shown on the Figure 1 (a, b).
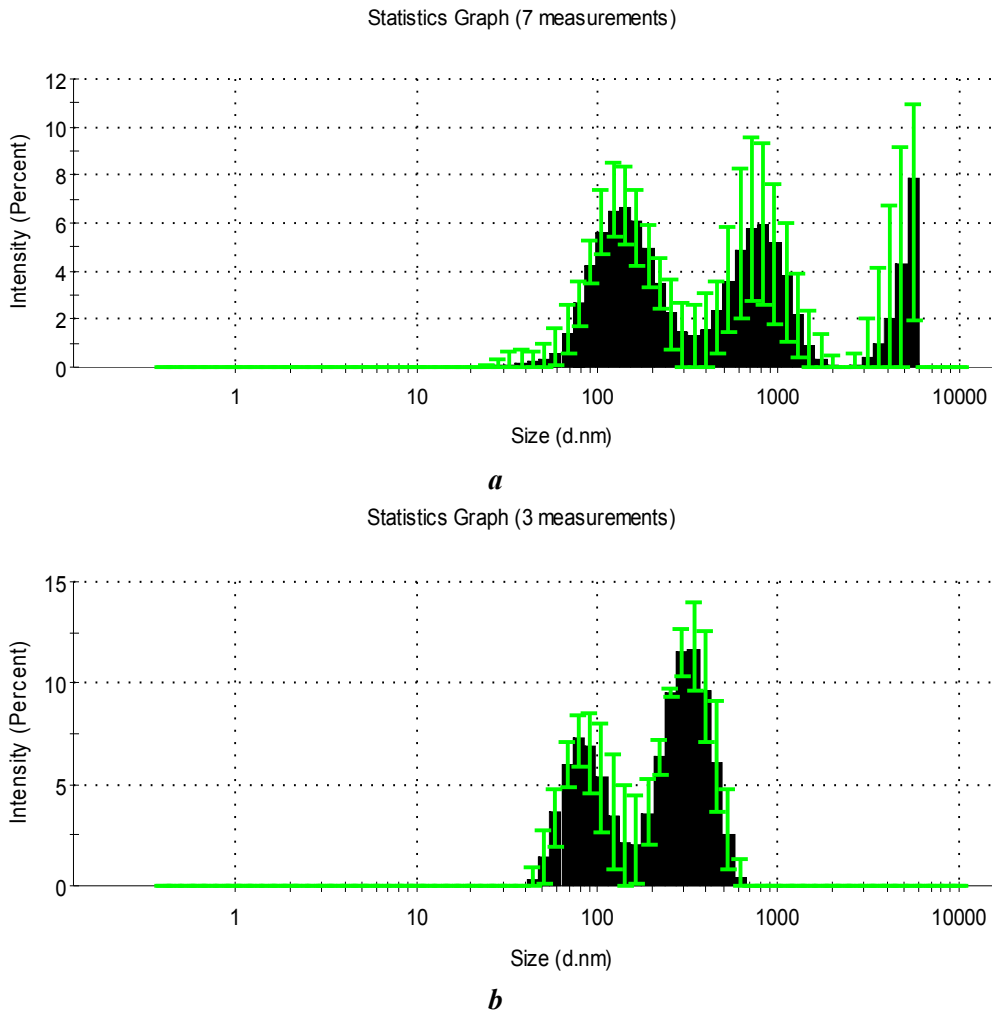

a

b

Figure 1. The distribution according to the milk whey particle size before (a) and after electrohydraulic processing at the voltage of 45 kV and the discharge number of 25 (b)

It was stated that the original whey contained the particles of a size amounting to more than 500 nm; their volume took up 89 %. The average hydrodynamic diameter of the particles was (1697,5 ± 82,38) nm, the polydispersity index equaled 1,0.

It has been found that after processing the average hydrodynamic diameter decreased from (1697,5 ± 82,38) nm to (221,34 ± 10,3) nm at maximum voltage and discharge number. The polydispersity index at that plummeted from 1,0 to 0,35...0,40, which characterizes the system as the one close to monodisperse state. The particles larger than 500 nm have not been found.

As the result of statistical data processing after the conducted research we have received the regression equations describing the influence of electrohydraulic processing parameters on the system dispersion degree characteristics – the average hydrodynamic diameter and polydispersity index. The Figure ical depiction of the received equations is shown in the form of a response surface (Figure 2).

Mathematical and statistical data processing confirmed that voltage U and the discharge number n substantially influence the particles' dispersion, providing us with the ability to define the rational parameters of electrohydraulic processing: the voltage amounts to 45 kV, whereas the discharge number equals 25.

a   *b*
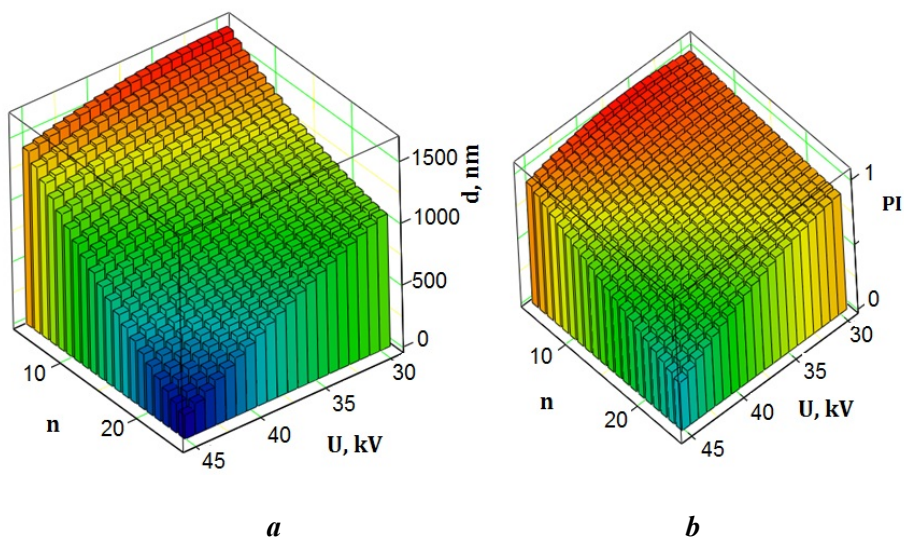
Figure 2. The response surfaces depicting the influence of voltage and discharge number during electrohydraulic processing on the average hydrodynamic particle diameter in milk whey (a) and polydispersity index (b)

Table 1

The results of statistical research data processing

No	Regulated index	Regression equation
1	The average hydrodynamic diameter	$D(U,n) = 71.4116 \cdot U - 2.167 \cdot U \cdot n - 1.01036 \cdot U^2 + 0.8817 \cdot n^2 + 9.283 \cdot n + 681.1$
2	The polydispersity index	$PI(U,n) = 0.1092 \cdot U - 0.00149 \cdot U \cdot n - 0.0014 \cdot U^2 + 0.000068 \cdot n^2 + 0.03685 \cdot n - 0.947$

We carried out mathematical modeling of sedimentation process of casein particles before and after electric spark processing. This model was prepared for the justification of preservation term for the processed whey without sedimentation and protein losses.

Visualization of sedimentation process is carried out with computer graph is presented on Figure 3.
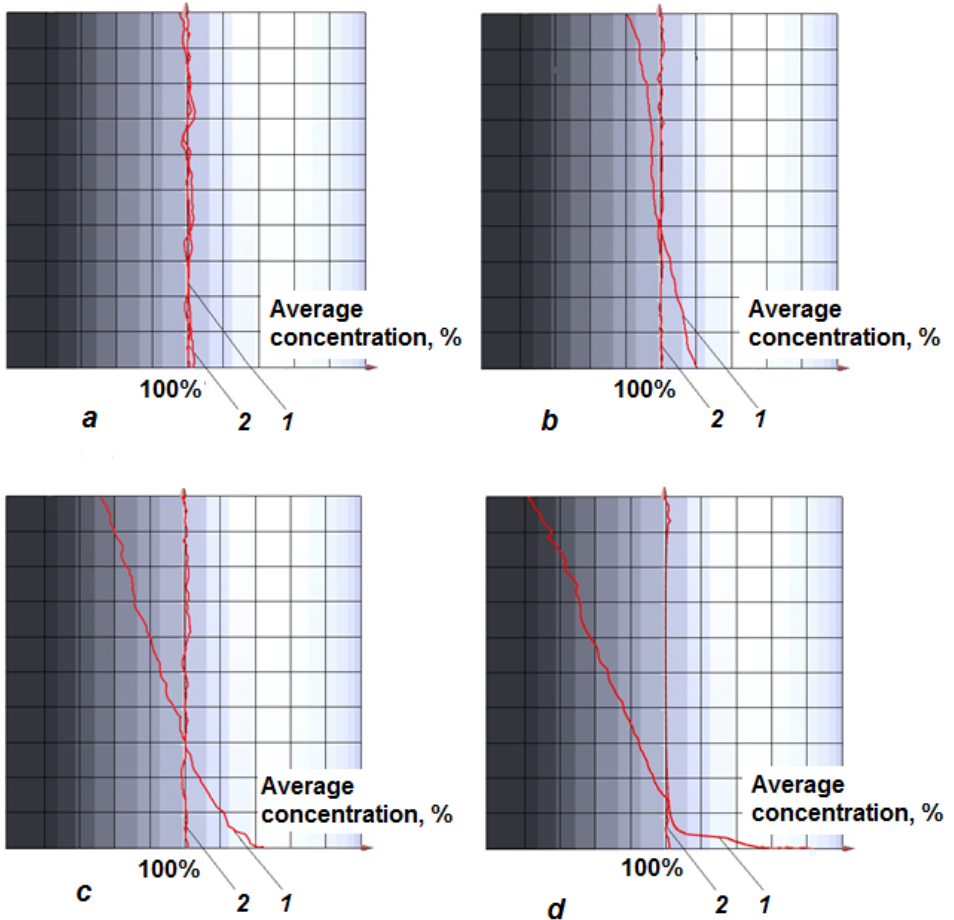
Figure 3. Change in particles concentration in milk whey during:
a – 2 hours, b – 24 hours, c – 48 hours, d – 72 hours

The results provide a basis for conclusion for preservation of sedimentation stability in the processed whey as long as 72 hours.

In order to measure the sedimentation stability of the whey particles before and after processing, we defined the rate of particle sedimentation and KSS (formulae 1 and 2), as well as the sediment volume, which parted as a result of forcible deposition in the gravitational field. It was concluded that resulting from the decrease in size of protein particles caused by electrohydraulic processing the rate of sedimentation became several times slower, whereas KSS increased. The sediment volume in the processed whey decreased from 0,9...1,1 to 0,1...0,2 cm^3 at the voltage of 45 kV and the discharge number

of 25. In the processed whey the visible protein deposit appeared only after 3 days of storing; conversely, the unprocessed whey contained deposited protein particles after just a few hours after it was put away.

The results concerning the electrokinetic potential indicate that system stabilizes and the process of whey particles' sedimentation slows down after electrohydraulic processing. In this way, at voltage of 45 kV, as the discharge number increases, the absolute value of ζ-potential of the processed whey particles increased from -0,06 ± 0,002 up to -4,02 ± 0,26 mV, illustrating that sedimentation stability in the processed milk whey rises.

On the basis of the conducted research we have created a flow chart of milk whey primary processing algorithm using electrohydraulic method (Figure 4).
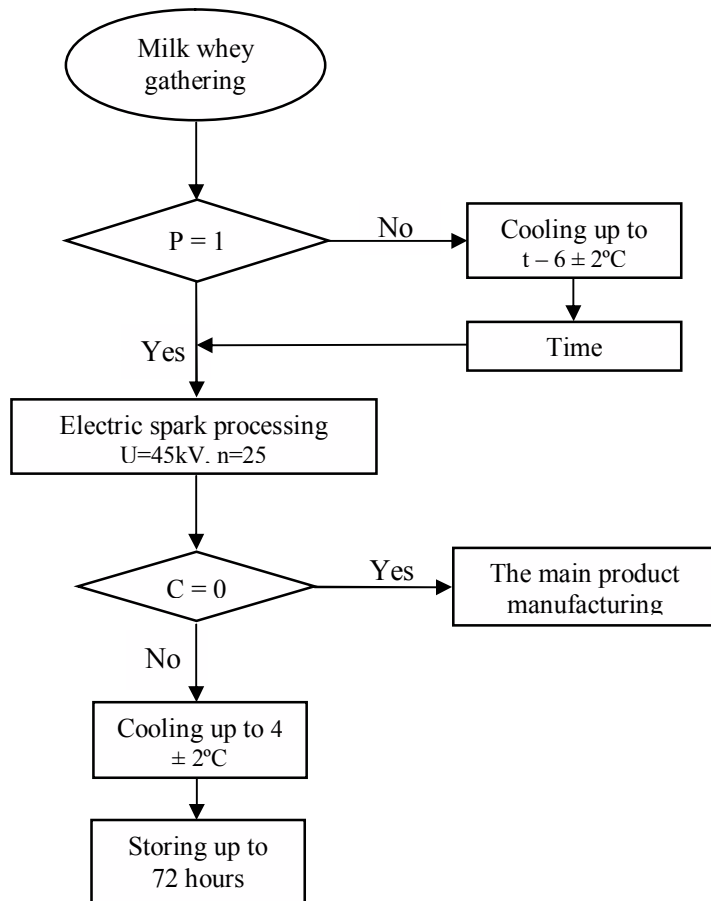
P=1 – checking whether it is possible to process milk whey after it was received;
C = 0 – defining whether milk whey will undergo further processing or storing.

Figure 4. The flow chart of milk whey primary processing algorithm using electrohydraulic method

The processing may be carried out right after milk whey receiving or interim reservation. After electric spark processing whey is used for further technological purposes depending on the type of the manufactured product.

According to the results of this research, after such processing milk whey may be stored for 48 hours retaining its sedimentation stability, organoleptic, physical, chemical and microbiological properties.

Thus, after a series of experiments we have come to a conclusion that electrohydraulic processing of cottage cheese whey ensures increase in its sedimentation stability due to dispersion of casein dust particles to the average hydrodynamic diameter ($221,34 \pm 10,3$) nm. The rational mode of cottage cheese processing was defined, namely voltage amounting to 45 kV, the discharge number equaling 25. It was proved that the given processing mode leads to a slowdown in sedimentation of particles and decrease in protein losses after primary processing.

Finally, the given technological scheme of milk whey primary processing using electrohydraulic method will allow stabilizing and retaining the quality of whey, as well as prolonging its storage life.

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Pasting characteristics of wheat and breadfruit flour blends

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Abstract

Introduction. This study was carried out to investigate the pasting characteristics of wheat (WF) and breadfruit (BF) flour blends for probable industrial uses**.**

Materials and methods. The breadfruit was sorted, washed, peeled, sliced, blanched, cooled, drained, dried at a temperature of 65^0C in cabinet dryer , milled into flour and blended with wheat flour at different ratios (100:0, 90:10, 85:15, 80:20,75:25, 100:0) of wheat: breadfruit flour. The composite flour blends were thereafter subjected to pasting characteristics analysis.

Results and discussion. The peak viscosity varied from 193.5 to 270.68RVU for the wheat-breadfruit flour and there were significant ($p<0.05$) differences in trough viscosity among the wheat-bread fruit flour samples. Trough viscosity gives a measure of the tendency of the paste to breakdown during cooking. The breakdown viscosity varied from 72.92 to 106.08 RVU. The final viscosity varied between 216.67 and 275.75 RVU with 100% breadfruit flour having the highest value of final viscosity and it indicates the stability of the cooked paste. The setback viscosity varied between 96.08 and 111.75 RVU. The peak time varied from 4.43 to 4.66 min with 100% wheat flour having the highest value and wheat-breadfruit composite flour blends at 15% had the lowest value. Significant ($p<0.05$) differences were observed in the pasting temperature of wheat-breadfruit flour blends. Pasting temperature gives an indication of gelatinization time during processing

Conclusion. The result revealed that as more and more breadfruit flour was added to wheat flour, there was improvement in the pasting characteristics of the composite flour.

Introduction

Flour is fine powder made from cereals. It can equally be produced from other starch based produce such as cassava, maize, yam, nuts etc. Flour is the major ingredient in bakery goods production and most especially bread which constitutes a staple in the diet of many countries. The availability of adequate supply of flour has often been a major economic and political issue. Flour produced from non wheat sources are otherwise known as composite flour. In many developing countries the use of composite flours have the following advantages (a) saving of hard currency, (b) promotion of high-yielding, native plant species (c) better supply of protein for human nutrition, and (d) better overall use of domestic agricultural production [1,2]

Breadfruit (*Artocarpus altilis*) is widely cultivated to appreciable extent in south-west states of Nigeria. Present level of breadfruit production in the south-western Nigeria has been estimated to about 10million tones dry weight per year with potentials for exceeding 100million tones every year [3, 4]. Breadfruit (*Artocarpus altilis*) is a tree and fruit native to Malaysia and countries of the south pacific and the carribean. It is an important food in these areas [5]. Breadfruit is a fruit tree that is propagated with the root cuttings and the average age of bearing first crop is between 4 to 6 years [6]. It produces its fruit up to three times and the number of fruits produced is very high. The fruit has been described as an important staple food of a high economic value [7]. The bread fruit pulps are made into various dishes; it can be processed into flour and used in bread and its biscuit making [6]. Breadfruit has also been reported to be rich in fat, ash, fibre and protein [8]. Despite the importance of this fruit, its production is faced with several problems including short shelf life and poor yield due to diseases [9]. The fruits are utilized in Nigeria within 5days of harvesting because of their short shelf lives. One way to minimize post-harvest losses and increase the utilization of breadfruit is through processing into flour. This is a more stable intermediate product.

Several information are available on the use of wheat-based composite flour in Nigeria comprising buckwheat [10], plantain [11], modified corn starch [12], waxy corn starch [13, 14], sunflower flour [15], chick pea [16] and bean flour [17]. Information is however scanty on the use of composite flour from wheat and breadfruit. Although breadfruit is a highly perishable, underutilized fruit and need more attention because of its nutritional qualities. This study is therefore aimed to produce flour blends from wheat and breadfruit and to determine its pasting characteristics of wheat and breadfruit flour.

Materials and Methods

Materials

Matured green ripe and wholesome breadfruit was purchased from a local market in Owode-Yewa, Ogun State, Nigeria. Commercial wheat flour (Golden penny) was purchased from Kuto market in Abeokuta, Ogun State. Equipment used includes cabinet dryer, desiccators, milling machine, mechanical sieve, mixer, digital weighing balance, stirrer, Rapid Visco analyzer (RVA), knife, bucket and stainless steel perforated tray

Methods
Production of Breadfruit Flour (BF)
The modified method of [9] was used for the preparation of breadfruit flour. The Breadfruit was thoroughly sorted to remove bad ones from the lot. The sorted fruit were

washed to remove adhering soil and dirts. This was followed with peeling. After peeling, the tuber were sliced to facilitate rate of drying and ease milling operation, the sliced tuber were blanched at 60 °C, for 15 min in order to inactivate enzymes that may cause browning reaction. These were then cooled, drained and followed by drying. After blanching, the chips were spread out uniformly on a stainless steel perforated tray and dried in a cabinet dryer at 65 °C for 24 hrs. Following drying, the slices chips were milled using laboratory hammer mill (Fritsch, D-55743, Idar-oberstein-Germany) and the milled sample was sieved (using 250 μm screen) to obtain the flour. The breadfruit flour was packed and sealed in polyethylene bags at ambient temperature 26 ± 2 °C and 760 mm Hg until further analysis

Blends formulation

The blends of wheat and breadfruit were mixed together using a Kenwood mixer (Model HC 750 D, Kenwood, Britain, UK). The flour blends were prepared by substituting wheat flour for breadfruit flour in the percentage proportion of 100:0, 90:10, 85:15, 80:20, 75:25, and 0:100 respectively.

Pasting characteristics of wheat-breadfruit composite flour

Pasting characteristics were determined with a Rapid Visco Analyzer (RVA TECMASTER, perten instrument). Three grams of sample were weighed into a dried empty canister, and then 25ml of distilled water was dispensed into the canister containing the sample. The suspension was thoroughly mixed properly so that no lumps were obtained and the canister was fitted into the rapid visco analyzer. A paddle was then placed into the canister and the test proceeded immediately automatically plotting the characteristic curve. Parameters estimated were peak viscosity, setback viscosity, final viscosity, trough, breakdown viscosity, pasting temperature and time to reach peak viscosity.

Statistical Analysis

Data obtained were subjected to statistical analysis. Means, Analysis of variance (ANOVA) were determined using SPSS Version 21.0 and the differences between the mean values were evaluated at p≤0.05 using Duncan's multiple range test

Results and discussion

The pasting properties of wheat-bread fruit flour blend is shown in Table 1.When starch-based foods are heated in an aqueous environment, they undergo a series of changes known as gelatinization and pasting. These are two of the most important properties that influence quality and aesthetic considerations in the food industry, since they affect texture and digestibility as well as the end use of starchy foods [18]. The pasting properties are important as it is used in predicting the behaviour of flour during and after cooking. The peak viscosity varied from 193.5 to 270.68 RVU for the wheat-breadfruit flour with 100% breadfruit flour having the highest value of 270.08 RVU and 100% wheat flour having the lowest value of 193.5 RVU. Significant (p<0.05) differences were observed in the peak viscosity of wheat-breadfruit flour. Peak viscosity is the highest viscosity achieved during cooking of flour pastes. It is the maximum viscosity developed by a starch-water suspension during heating [18]. It gives an indication of the ability of starch to swell freely before their physical breakdown. The variation in peak viscosity of wheat-breadfruit composite flour could be as a result of the amylose content of the starch [19]. Relatively

high peak viscosity of flour, are indication that the flour may be suitable for products requiring high gel strength and elasticity [20]. The high peak viscosity displayed by 100% bread fruit flour implies that the flour may be suitable for product requiring high gel strength and elasticity. The higher the breadfruit flour was added to wheat flour, the peak viscosity increases. The peak viscosity values obtained in this study was lower than the range of values (172.25 to 340.00 RVU) reported by [21] for instant yam-breadfruit composite but higher than that of 145.28 and 228.11 RVU for germinated tigernut reported by [22]. There were significant ($p<0.05$) differences in trough viscosity among the wheat-bread fruit flour samples. The trough viscosity is an indicative of additional breakdown of granules due to stirring, reflecting and stability of the hot paste. It gives a measure of the tendency of the paste to break down during cooking. As more and more wheat flour was incorporated, the trough viscosity was on the increase. Therefore, the higher the trough viscosity, the greater the ability of the paste to withstand breakdown during cooling. The trough viscosity obtained in this study was higher than the one reported by [22] for tigernut flour from germinated seeds. The breakdown viscosity varied from 72.92 to 106.08 RVU. The breakdown viscosity value is an index of the stability of starch [23].Break down viscosity measures the ability of paste to withstand breakdown during cooling. The higher the breakdown in viscosity, the lower there ability of the sample to withstand heating and shear stress during cooking [19]. 100% breadfruit flour had the highest value suggesting higher stability of starch. Oduro et al., [24] explained that starch with low paste stability or breakdown shows weak cross linking among the granules.

The final viscosity is the change in the viscosity after holding cooked starch at 50 °C. The final viscosity varied between 216.67and 275.75 RVU with 100% breadfruit flour having the highest value of 392.29RVU and 100% wheat flour having the lowest value of 216.67 RVU. It gives an idea of the ability of a material to form gel after cooking. Final viscosity is used to define the particular quality of flour and indicates stability of the cooked paste in actual use. It also indicates the ability to form paste or gel after cooling [20]. As more and more breadfruit flour was added to wheat flour, the final viscosity was on the increase suggesting higher resistance of paste to shear force during stirring. The variation in the final viscosity might be due to the sample kinetic effect of cooling on viscosity and the re-association of starch molecules in the samples [25]. The setback viscosity varied between 96.08 and 111.75 RVU. The peak time varied from 4.43 to 4.66mins with 100% wheat flour having the highest value of 4.66 min and wheat-bread fruit composite flour blends at 15% had the lowest value of 4.43 min. Setback is a measure of the stability of paste after cooking. It is a phase where during cooling of mixture, a reassociation between the starch molecules occurs to a greater or lesser degree. It therefore affects retrogradation or reordering of starch molecules which is associated with syneresis and weeping [26]. The higher the setback value, the lower the retrogradation during cooling and the lower the staling rate of the product made from the flour samples [27]. The low setback value obtained in 100% wheat flour indicates high stability after cooking [28]. Peak time is the time at which the peak viscosity occurred in minutes and it is a measure of the cooking time of the flour. The peak time varied from 4.43 to 4.66 min with 100% wheat flour having the highest value of 4.66 min and wheat-bread fruit composite flour blends at 15% had the lowest value of 4.43 min. Peak time for 100% wheat flour recorded the highest value for peak time suggesting more processing time.

The pasting temperature varied from 83.05 to 84.20. 100% wheat flour had the highest pasting temperature of 84.20 °C, while wheat-breadfruit composite flour blends at 25% had the lowest pasting temperature of 83.05 °C. Significant ($p<0.05$) difference were observed in the pasting temperature of wheat-breadfruit flour blends. Pasting temperature gives an

indication of the gelatinization time during processing. It is the temperature at which the first detectable increase in viscosity is measured. A higher pasting temperature implies higher water binding capacity; higher gelatinization [29]. 100% wheat flour recorded the highest pasting temperature which indicates the presence of starch that is highly resistant to swelling during cooking time.

Table 1

Pasting properties of wheat and breadfruit flour blends

WF:BF	Peak Viscosity (RVU)	Trough Viscosity (RVU)	Breakdown (RVU)	Final Viscosity (RVU)	Setback Viscosity (RVU)	Peak time (min)	Pasting Temp. (°C)
100:0	193.5^a	120.58^a	72.92^a	216.67^a	96.08^a	4.66^b	84.20^a
90:10	237.75^f	149.25^e	88.50^a	253.58^b	115.67^b	4.53^a	83.55^b
85:15	243.83^{ab}	145.00^b	98.83^a	264.92^e	108.58^{ab}	4.43^b	82.25^c
75:25	245.58^b	153.25^{bc}	92.33^c	270.25^b	117.00^{ab}	4.53^b	83.05^b
80:20	248.25^b	154.58^d	93.67^a	271.58^b	117.00^b	4.50^a	83.50^b
0:100	270.08^c	164.00^{cd}	106.08^b	392.29^c	111.75^{ab}	4.56^b	83.55^b

Mean values with different superscripts within the same column are significantly different (p <0.05)
WF- Wheat flour, BF- Breadfruit flour

Conclusion

The study showed that blending of wheat flour with breadfruit flour improved the pasting properties of the composite flour and this suggests that the flour blends will be useful in production of bread or other baking products. Therefore, breadfruit flour which can easily be processed from available raw material will go a long way in saving cost of production and improved product quality.

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Influence of algae on the change of butter quality indicators

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Abstract

Introduction. The aim is to investigate the influence of algae on the change of indicators of quality of butter during storage.

Materials and Methods of the study. One had chosen the samples of butter with the powder from laminaria, fucus, spirulina and cystoseira as the object of the study; the butter with mass fraction of fat 62,5% had been chosen for control. Samples have been stored at the temperatures of 3 ± 2 °C (above) and 7 ± 2 °C (below) for appropriate determining of the ongoing changes in samples' organoleptic properties (taste and smell) as well as the primary oxidation of products – Peroxide and hydrolysis of lipids at different stages.

Results of the study. The use of algae for butter production allows to extend product storage life twice. Therefore, the dynamics of organoleptic characteristics of butter containing algae showed a quality improvement for control samples during storage at a temperature of $+3 \pm 2$ °C at the 45th day by 4 points, those containing algae by 2 points; when stored under conditions of -7 ± 2 °C at the 65th day indicators decreased by 5 points in the control sample, and by 2 points if to talk about those containing algae. When storing the samples under conditions of the temperature of $+3 \pm 2$ °C, the change of the set of indicators takes place more intensively in comparison with storage conditions at a temperature of -7 ± 2 °C, which is explained by the influence of low temperatures. Peroxide value of fat in the control sample of the butter after 30 days was 4.9; peroxide value of the butter containing algae was from 3,2 to 3,5½ O mmol/kg, respectively. Similar dependence is set in the study of the hydrolysis of fat, as all kinds of algae slow the processes of accumulation of free fatty acids twice. We may presume, that the effect observed is caused by the presence of selenium, pigments, bioflavonoids in algae, and the formation of polysaccharide-lipid complexes on the surface of nanograins, which protect the fat phase from oxidation and hydrolysis.

Conclusions. Addition of algae to butter slows the deterioration of the organoleptic characteristics, as well as the processes of oxidation and hydrolysis of fat during storage both at low and high temperatures.

Introduction

One of the important directions of the food industry development is the use of natural antioxidants in technology of dairy products production to increase their storage life. Butter is a product containing a large amount of fat, which is subjected to hydrolytic and oxidative damage in the process of storage. Addition of natural antioxidants in butter contributes to maintaining high consumer performance of the product by blocking the accumulation of free radicals and free fatty acids. Numerous studies have shown, that the addition of herbal supplements improves the organoleptic characteristics of the product, has a positive effect on the formation of its structure and consistency, gives the product a high ductility index, thermal stability and spreadability, and slows oxidation processes during storage [1–6]. As the additives one had used herbal supplements of functional destination – polysaccharides with pectin and inulin, cryo-powder made of beetroot, blackcurrant buds, artichoke, carrot, with the addition of flax seeds etc. [2]. In the laboratories of the All-Russia Dairy Research Institute a wide range of oily paste with honey, cocoa, chicory, fruit and berry, vegetable and mushroom supplements, herbs and spices, and even with sea- or meat products had been developed [3].

In France, scientists had developed many delicacies based on butter and those contained vinegar mixed with a dry white wine, onions, sorrel, carbohydrates (sucrose and lactose), sodium glutamate, spices, dextrin, cereals flour, edible salts [7].

There are some scientific developments concerning complex addition of extracts of sage, cinnamon, rosemary, cloves, oregano, cumin and thyme [10, 11]. The aim of these types of butter development was the improvement of stable quality characteristics of the final product during storage due to the addition of natural antioxidants. Researchers have found that plant extracts and their supplements have improved organoleptic characteristics of the products, greatly enhanced their consumer characteristics and contributed to the formation of stronger structural links in monolith, inhibited the growth of microorganisms and slowed oxidation and hydrolysis processes during the storage [12]. At the same time, using the above mentioned ingredients in the butter production cannot solve urgent problems, such as elimination and prevention of iodine deficiency, entry into the diet such antioxidants like selenium, pigments, bioflavonoids and polysaccharides, which together improves organoleptic indicators of butter [13] and obviously will help to increase their storage life.

The development of butter with apricot and lemon powder is known to be done in Bulgaria and Germany [14, 15].

Currently, there is increased attention to algae, which contain a complex of organic and mineral substances essential for our body. Chemical composition of algae is characterized by containing high-molecular polysaccharides such as alginic acid (25%), mannitol (up to 21%), fructose (4%), vitamin B_1, B_2, B_{12}, A, C, D, E, pigments, bioflavonoids, iodine, selenium, etc. Therefore, algae considerably exceed usual terrestrial plants. Thus, the use of algae as supplements (additives) can solve the problem of the storage life prolongation and increase the biological value of the product.

The main objectives of this study is to determine the effect of algae supplements on the organoleptic characteristics and lipid indicators of quality during the storage under different temperature conditions.

Materials and methods

Butter with algae was produced using the method of high fat cream whipping. Adding those prepared additives was provided before the thermomechanical processing of fat cream. They used algae powder made of laminaria, fucus, spirulina, cystoseira. The amount of additives in the final product is determined by organoleptic method, so it was 4.0%for laminaria and fucus, 3, 0% for spirulina, and 3, 5% for cystoseira per 100 grams of product.

Control sample of butter with fat content of 62.5% was produced from the same raw material by the conventional technology.

The samples were stored under two temperature conditions: 3 ± 2 °C (above) and 7 ± 2 °C (below). They observed the changes in the organoleptic characteristics according to the method [13]. Before the first evaluating, the consistency of butter samples with algae was adjusted to the desired temperature. The consistency was measured at a temperature of 18 ± 1 °C by cutting. The main characteristics to judge were the stable or changeable butter structure, the presence or absence of moisture on the cut. The color of the test samples of butter with algae was determined by eye inspection. The smell and the taste was determined using organoleptic method: 5 g of the product was chewed for 30 seconds without swallowing, distributed across the mouth and has been got a taste captured in the initial moment of the sample placed on the tongue and after chewing.

Accumulation of primary oxidation products was determined by peroxide value [16].

The acid value was determined by titration of the fat sample by the solution of potassium hydroxide with phenolphthalein indicator [17]. All studies were conducted 5 times and were statistically registered.

Results and discussion

One of the main causes of butter quality decrease is the oxidative damage at its fat phase, which predetermine changes in product's flavor. Results on the change of organoleptic evaluation of butter samples with algae compared to the control (during the storage at a temperature of $+3 \pm 2$ °C) are shown in Figure 1.
All samples had acceptable organoleptic characteristics and had plastic moderately dense texture, pure and pleasant taste, and aroma of additives used.

The deterioration of the organoleptic characteristics during the storage was observed in all butter samples, however in the control sample these changes took place at a higher rate as compared with the samples with algae. Thus, on the 45th day of storage the reduction of the organoleptic characteristics in the control sample was of 4 points, while in the samples with algae – 2 points.

Freezing and cold storage slows the deteoration of product quality, which is also resemble with our data. Storage at a temperature of -7 ± 2 °C is characterized by the processes of slowing the deterioration of organoleptic characteristics (Figure 2).

The deterioration of organoleptic characteristics in the control sample is observed on the 55th day of the storage by 4 points, in the samples with algae – 2 points. The main defect of the butter at this stage is its weakly expressed oxidized and fatty taste.

The deterioration of organoleptic characteristics is caused by the processes of oxidation and hydrolysis of the product's fat phase.

Dynamics of changes in peroxide value of the butter with laminaria, fucus, spirulina and cystoseira during the storage at a temperature of 3 ± 2 °C is shown in Figure 3.

**Figure 1. Dynamics of changes of organoleptic characteristics of butter
at a storage temperature +3 ± 2 °C;**
Butter: 1 – control; 2 – with laminaria; 3 – with fucus;
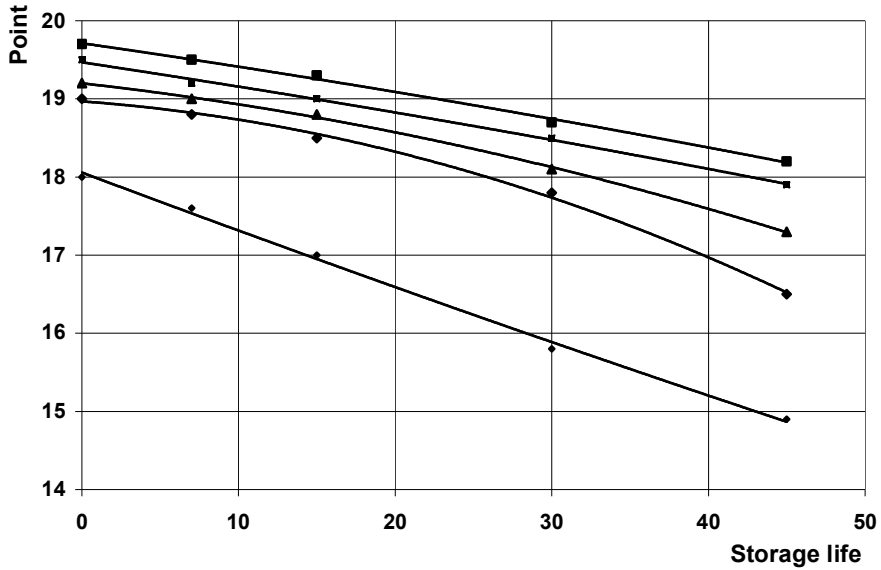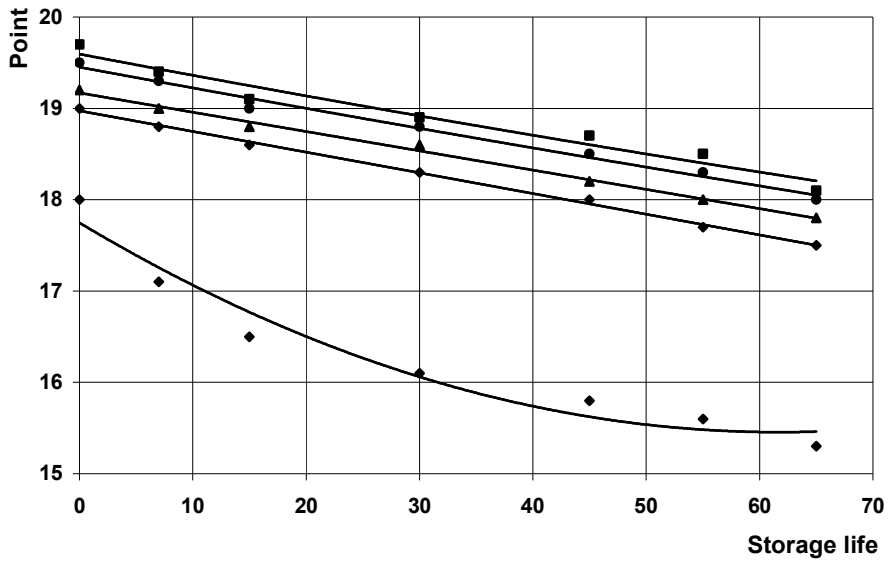4 – with spirulina; 5 – with cystoseira

**Figure 2. Dynamics of changes of organoleptic characteristics of butter
at a storage temperature -7 ± 2 °C;**
Butter: 1 – control; 2 – with laminaria;
3 – with fucus; 4 – with spirulina; 5 – with cystoseira

**Figure 3. Dynamics of peroxide value of fat in butter samples during the storage
at a temperature of 3 ± 2 °C;**
Butter: 1 – control; 2 – with laminaria; 3 – with fucus;
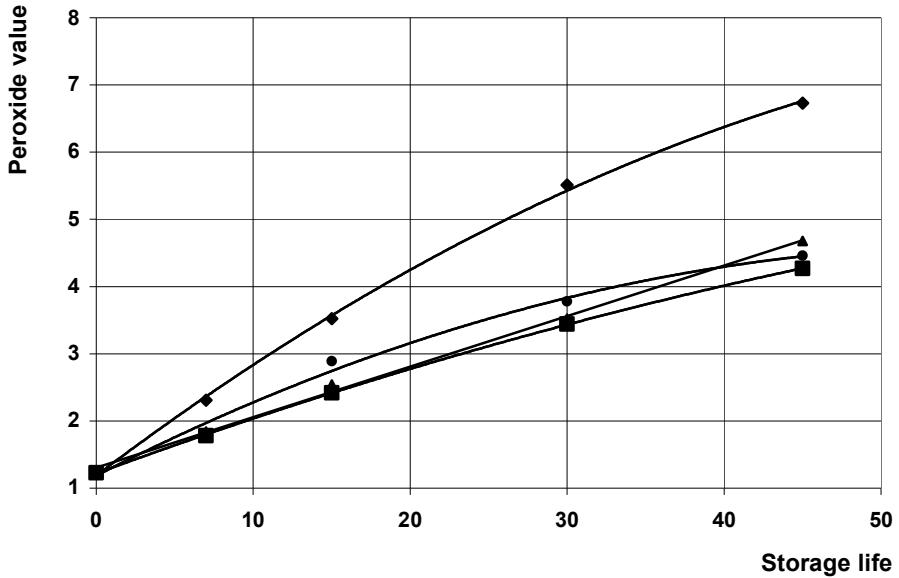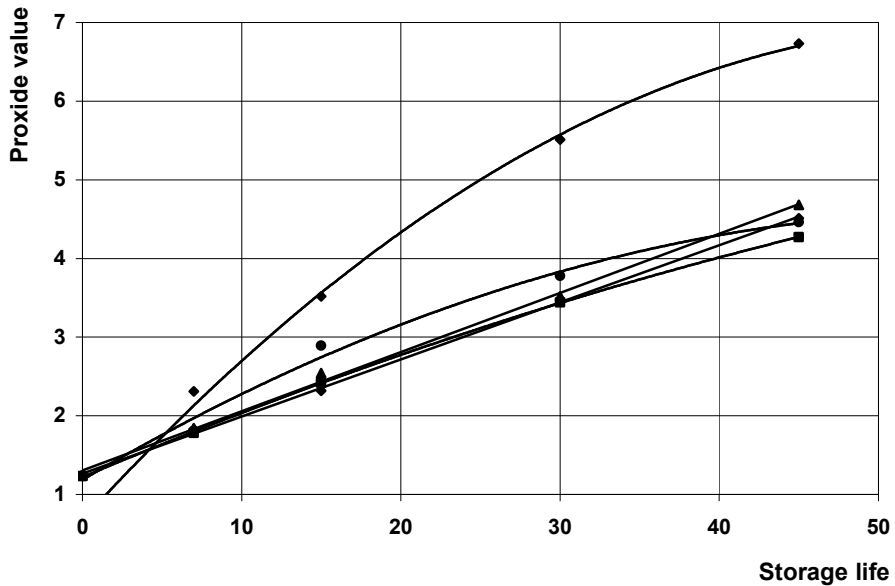4 – with spirulina; 5 – with cystoseira

**Figure 4. Dynamics of peroxide value of fat in butter samples during the storage
at a temperature of -7 ± 2 °C;**
Butter: 1 – control 2 – with laminaria; 3 – with fucus;
4 – with spirulina; 5 – with cystoseira

The processes of butter samples' oxidation are going along with identical dynamics of accumulation of primary products in all samples, but these changes are much greater in control samples compared to those samples with algae. Thus, algae supplements in butter slow the processes of primary fat oxidation.

During the first 15 days of storage the peroxide value increased in the experimental samples and was from 2.89 to 3.23 O ½ mmol/kg (so the butter is still fresh), and in control samples the peroxide value was 3.52 ½ O mmol/kg (unfit for the further storage).

On the 30th day of storage, the peroxide number in the test samples was: butter with laminaria – 3,44 ½ O mmol/kg, with fucus – 3.48 O ½ mmol/kg, with spirulina – 3.78 O ½ mmol/kg, and with cystoseira – 3.52 O ½ mmol/kg. These indicators show the freshness of the butter samples, but at the same time they show their unfit for the further storage. The control sample had substantially higher peroxide value – 5,51 ½ O mmol/kg; which supposes that the butter is characterized as the product is not to be stored.

The effect of algae on the deceleration of fat oxidation processes is also observed in the process of storage of samples at a low temperature (Figure 4).

It should be noted, that low temperatures affect on the intensity of oxidation processes in butter samples with algae compared with the control samples, and these indicators become lower.

Hydrolysis of fat with formation of free fatty acids can accelerate oxidation processes, because free, and not bounded in triglycerides, acids are oxidized first [3]. Dynamics of changes of fatty acid value of butter with algae during the storage at a temperature of $3 \pm 2°C$ is shown in Figure 5.

The results of these studies show that the hydrolysis of the butter fat with algae is slower than in control samples. Algae has no significant effect on the rate of flow of lipid hydrolysis process. The acid value of the control butter sample reaches 2.4 ml of KOH/g of fat on the 45th day of storage. By that time, the lowest indicator of fat value is observed in butter sample with laminaria – 1.8 ml of KOH/g of fat; and the highest – the sample with cystoseira – 2.0 ml of KOH/g off at.

Storage of butter at a temperature of -7 ± 2 °C discovers a slowdown in the product's hydrolytic processes (Figure 6). The intensity of the hydrolysis of fat under these storage conditions is lower in butter samples with spirulina.

Thus, algae added in butter slow down the process of deterioration of organoleptic characteristics, changes in oxidation and hydrolysis processes, and storage conditions also influence the changes of these indicators. Our findings largely prove previous studies that have shown the effect of herbal supplements on the complex quality parameters of a butter [2]. Thus, it was shown that the addition of cryo-powder, made of beet, inulin and flax seed, in butter deteriorates the formation of peroxides, hydroperoxides, secondary oxidation products and does not affect the hydrolysis of fat at the same time [8]. The addition of extracts of thistle milk also allows to increase the storage life of the product [6]. The peculiarity of plant components is that they consist pigments, bioflavonoids, vitamins, which are natural antioxidants and can provide antioxidative effect. Algae differ from terrestrial plants by the presence of selenium element, which is also a powerful antioxidant [18]. Polysaccharide-lipid complexes can be formed when adding algae powder in butter; in this case the ouward on the surface of nanograins is formed so it averts the oxidation and hydrolysis processes. Our surmise is proved by the studies carried out by T. Rashevska [2] concerning the addition of plant components in butter.

**Figure 5. Effect of algae addition on changes of fatty acid value of butter
at a storage temperature of +3 ± 2 °C;**
Butter: 1 – control 2 – with laminaria; 3 – with fucus;
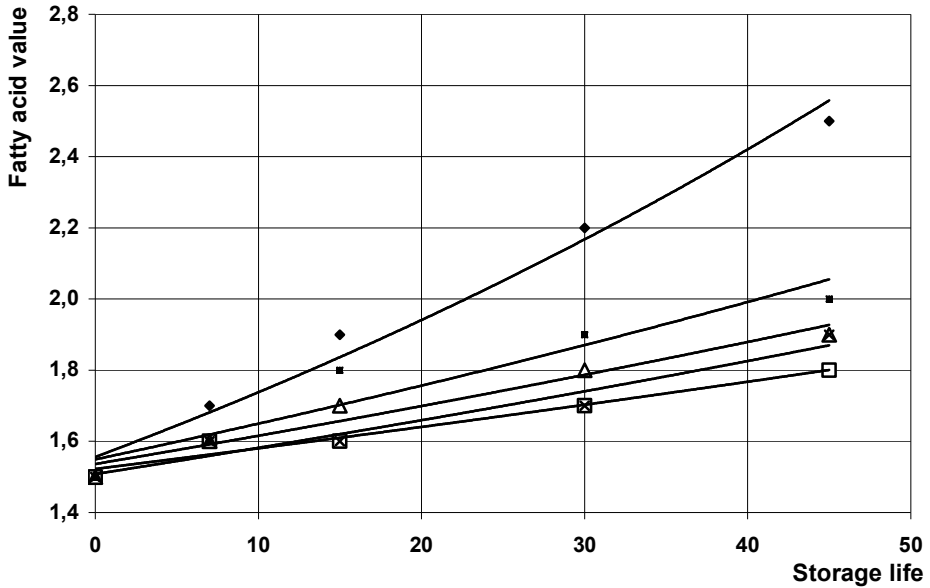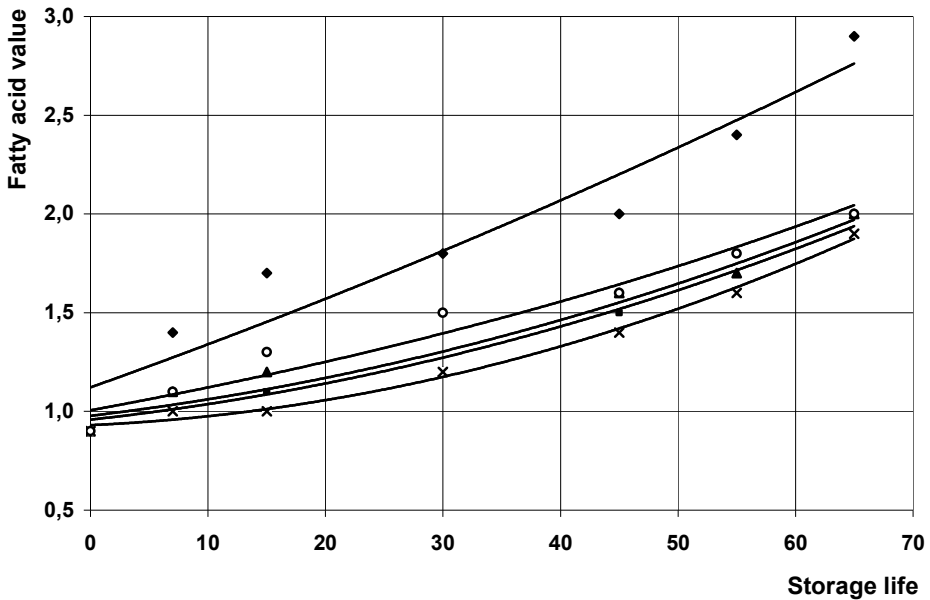4 – with spirulina; 5 – with cystoseira

**Figure 6. Effect of algae addition on changes of fatty acid value of butter
at a storage temperature of -7 ± 2 °C;**
Butter: 1 – control 2 – with laminaria; 3 – with fucus;
4 – with spirulina; 5 – with cystoseira

Research results suggest a protective role of algae against oxidation and hydrolysis processes resulting in deterioration of butter; thus, it contributes to a prolonged storage life of a product and its organoleptic characteristics under conditions of both low and high temperatures.

Conclusions

Addition of algae to butter slows the deterioration of the organoleptic characteristics, as well as the processes of oxidation and hydrolysis of fat during storage both at low and high temperature conditions. The effect observed may be caused by the presence of selenium element in algae, pigments, bioflavonoids, as well as the formation of polysaccharide-lipid complexes on the surface of nanograins, which protect the fat phase from oxidation and hydrolysis processes.

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Assessment of quality of vegetable powder by mixed method of heat supply

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Abstract

Introduction. The processes of structure formation in emulsion-type sauces using phyto- and oil carotene containing semi-finished product – a mixture fine powders of spicy-aromatic and carotene containing raw materials and oil in the environment. The prospect of using the technology developed semi low-calorie sauces emulsion type is the manifestation of surface-active properties of said plant material.

Material and methods. Structural and mechanical properties of the finished sauce was studied using a rheometer AR 2000EX. Forms of communication research in water samples sauces determined on derivatograph Q-1500D. Emulsifying properties of powders spicy-aromatic and carotene containing materials described by phase inversion points.

Results and Discussion. Due to the content of polysaccharides and essential oils, crushed and dried raw of spicy-aromatic and carotene containing able to create stable colloidal systems – emulsion type oil in water. Research emulsifying ability and fine powders of spicy-aromatic and carotene containing raw materials in emulsion oil in water showed that the emulsifying ability parsley powder is 16% and 36%, which is higher than the powder with dill and carotene containing raw materials respectively.

A determination of rheological properties depending on the concentration sauces phyto- and oil carotene containing semi-finished product. Ready sauce with a mass fraction phyto- and oil carotene containing semi-finished product 30% shear rate of 200 s^{-1} has an effective viscosity in the range of 22–50 Pa·s, which is optimal for the type of emulsion sauces.

Value Relations moisture in the form of emulsion-type sauces approaching the optimal concentration phyto- and oil carotene containing semi-finished product 30% by weight of the sauce. Thus there is a stronger binding moisture promotes aggregative stability system prevents their separation.

Conclusions. Sauces emulsion type, made on the basis of the developed intermediate product, have optimal rheological parameters. Thus, we can recommend phyto- and oil carotene containing semi-finished product for sauces emulsion type of high nutritional value without the use of additional emulsifiers, structure-synthetic nature.

Introduction

Expanding of restaurant network Bistro facilities, cafes, students dining, as the rapidly growing and dynamically developing sector of economy, which is characterized by deficiency of products that are with balanced nutritional and biological value, especially with using of vegetables [1]. In assortment, there are mainly carbohydrate-fat foods and in result, this is leading to a destruction of the structure of nutrition and growing of different illnesses of different nature, especially to obesity. So, it is an actual scientific and technical deal to involve dry vegetables to process streams production of culinary products in the network Bistro and it helps to particular or complete resolution of the problem. It is important to consider rehydration properties of dry vegetables in developing food products because they mostly effect on organoleptic, physical-chemical quality parameters and structural-mechanical properties of food products with their use.

The aim of research was to study rehydration properties of powder of cabbage for using in a number of food product technologies.

Materials and methods

In researches we have chosen powder of cabbage with a final humidity content of 7% which was received by mixed method of heat supply [2]. Powder of cabbage consists mainly from particles of 5..50 mm. In order to predict the behavior in a multi component food systems we researched its rehydration properties in polar environments: solutions of sodium chloride (0,5 and 1,7%), sucrose (1,1 and 5%), dimethyl acid (pH = 4.5) and sodium bicarbonate (pH = 6) at 20 and 40 °C by coefficient of water absorption [3] and microstructure researches.

Microstructure of powder was learned by optical (MBI-15) microscope with «passing» light. For preparing microscope preparations we have done preliminary recovery of powder in water at 25 °C with an exposure of 5 minutes [4].

The resulting slurry was applied to a glass slide and was wrapped with a cover.

Microstructure of researching powders study was performed by 400 times increase. Most common fields of view were photographed while watching preparations [5].

The size of the pores was determined to install Mac-Ben adsorption of water vapor [6].

We used thermal method of analyses for humidity connects in native and restored powders exploring which helps us to make sample temperature measuring, changes of its mass, changes of mass speed and enthalpy changes [14]. Curves were shot on Pauli-Erden Q-1500D derivatograph system on air with speed of temperature increasing at 5 C/min. Weight of samples was 150…250 mg. Speed of samples was 2 mm/min Alumina oxy at 2500°C was chosen as inert material.

Combined derivatograph curves consideration – differential-thermal analyses (DTA), thermogravimetric (TG), differential thermogravimetric (DTG) curves and temperature (T) gives us an opportunity to estimate chemical and physical transformations in researched sample while boiling with a given temperature increasing speed and to make quality and quantity assessment of this transformations [15].

According to obtained derivatogrames we made determining of the temperature peaks and intervals of its removing with different types of connection. Quantity of removed humidity was determined by TG curve in percents.

Results and discussions

Powder of cabbage by mixed method of heat supply process at temperatures of 50 and 70°C is selected as deemed «marginal», investigated the pore sizes by setting Mak-Ben. It presents results of investigations on the isotherms of water vapor in the samples from cabbage powders and the pore distribution curve radii (Figure 1, a-d).
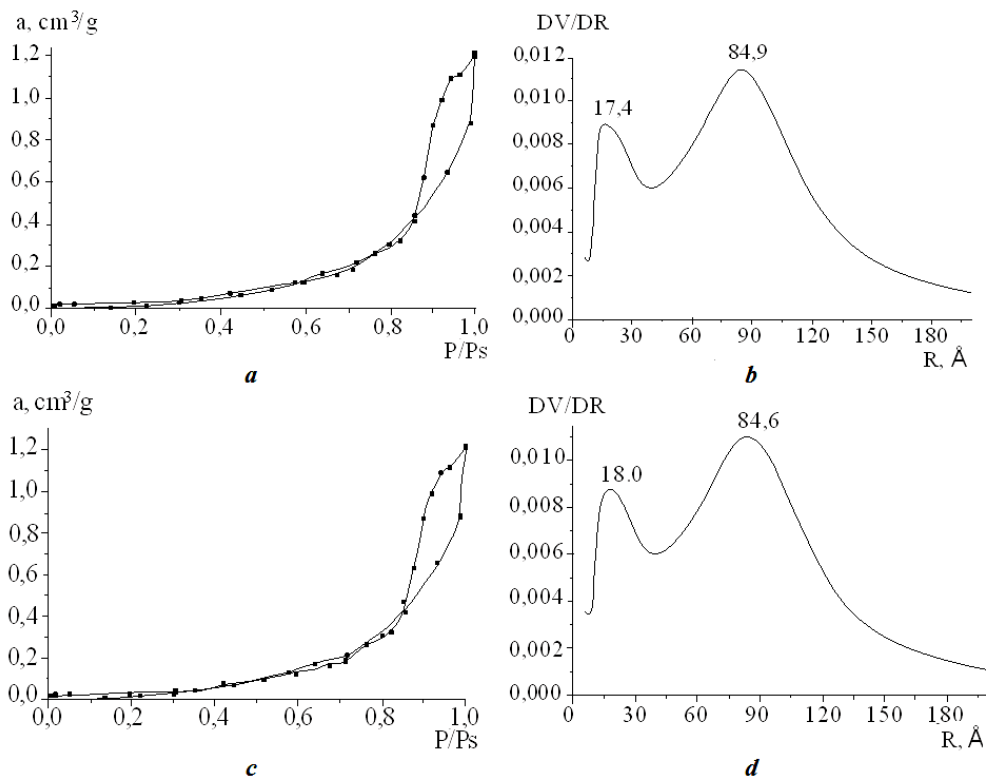
Figure 1. The adsorption isotherms of water vapor (a, c) and the distribution of pore radii (b, d) of the powder-dryer cabbage-mixed supply of heat

Structural characteristics of vegetable powders, MSH-derived and convective drying method, which have been removed in the water vapor, in Table 1.

By the analysis of adsorption isotherms of water vapor vegetable powders – Figure 1 – it can be concluded that the experimental samples MSH drying with same structure of adsorption. When this difference is insignificant in the presence of somewhat larger amounts of sample powder in the pores of the cabbage, which obtained 50 °C, as compared with the sample of 70 °C (Figure 1, a and c), since the first adsorption isotherm is somewhat higher that similarly in the graph the distribution of radius of pore. Therefore, the area under the curve of the powder sample of cabbage ZTP-drying 70 °C is greater, indicating that the more he has.

Structural characteristics of vegetable powders, which have been removed in water vapor

| Index	Meaning cabbage powders obtained by drying:		
	convection	MSH with 50 °C	MSH with 70 °C
The energy of activation of water, kJ/mol	4,5	3,1	3,2
Structer characteristics:			
The specific surface of the sample S, m^2/g	126	115	79
Square error of calculation of the surface, R^2	0,92	0,70	0,69
Sorption pore volume, V_s, cm^3/g	1,56	1,16	1,20
Diameter of the pores, D, 10^{-10}, m	792	403	608

Hysteresis curve (Figure 1, b and d) of samples of powder cabbage MSH drying indicates presence of small sizes of pore, and removing moisture from the delayed samples. This we see in the graphs and distribution of pore radius where the available time with the size of 17,4 and $18,0 \cdot 10^{-10}$ m (Table. 1).

Image of powder particles cabbage MSH-drying of native and reduced in polar media at different temperatures are shown in Figure 2. Analyzing the images of the microstructure (Figure 2) powder particles recovered from the cabbage, it can be stated that in the dehydration process is influenced by the type and temperature of the medium. Thus, it is seen that at 20 °C in various media on the surface of cells of vegetable tissue between the constituent components of the powder and water molecules solvate formed complexes (A) and is clearly seen in the images associated moisture adsorption layer (B) provided on the microstructure photographs. Moreover, a greater degree of dehydration process takes place in a medium with the pH of 6. The tissue regeneration powder in dilute solutions of sodium chloride (0,5%) and sucrose (5,0%) takes place in a similar way to the aqueous medium.

Powder of cabbage by mixed method of heat supply and restored in polar environments in different temperatures particle image is shown on Figure 2. Analyzing microstructure photos (Figure 2) of restored particles of powder of cabbage we can say that type and temperature of polar environment affect on hydratation process. On microstructure photos you can see that solvate complexes form in different polar environments on vegetable tissue surface cell between components of powder and molecules in 20 °C temperature. Bound of adsorption-connected humidity is clearly visible on photos. At the same time we have to determine that restoration process effects on pH environments. Mostly rehydratation process takes place in environment with pH = 6. Restoring of powder tissue in weak solutions of sodium chloride (0.5%) and sucrose (5,0%) is similar to water environment. Increasing of sodium chloride and sucrose concentration to 1,7 and 5,0 percents respectively is leading to deterioration of cell rehydratation process. This can be explained by high concentration and hydratation properties of this substances. And plasmolysis of cells appears with increasing of solutions temperature from 20 to 40 °C. On microstructure photos it is seen that restoration in milk at 20 °C is happening same to week solutions of sodium chloride and sucrose. Besides fat globules and milk proteins are kept on cells surface because of high presence of polysaccharides in this raw. With the increasing of restoring environment temperature, rehydration properties of powder from cabbage by mixed method of heat supply are increased to.
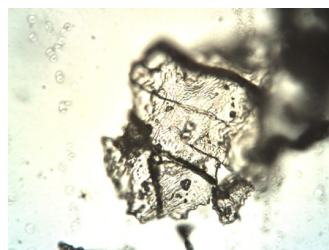
Particle the powder from cabbage

Sodium hydrogencarbonate solution, pH=6, (18 ± 2) °C
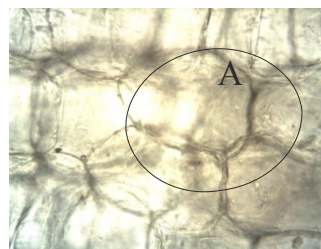
Sodium hydrogencarbonate solution, pH=6, (48 ± 2) °C

Ethanoic acid solution pH=4,5, (18 ± 2) °C
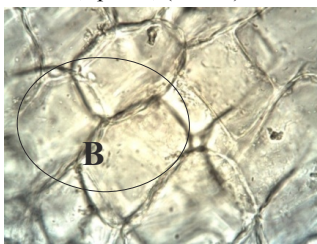
Ethanoic acid solution pH=4,5, (48 ± 2) °C
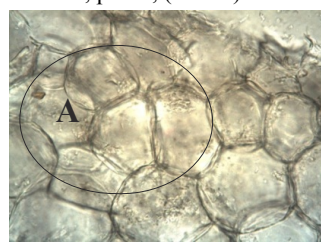
A solution of sodium chloride 0,5 %, (18 ± 2) °C
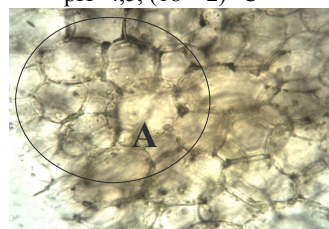
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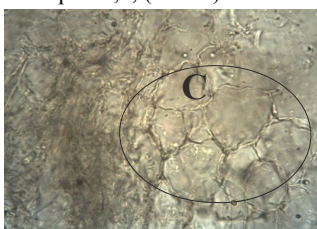
A solution of sodium chloride 1,7 %, (18 ± 2) °C

A solution of sodium chloride 1,7 %, (48 ± 2) °C
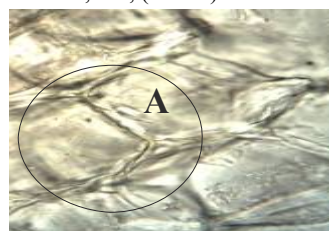
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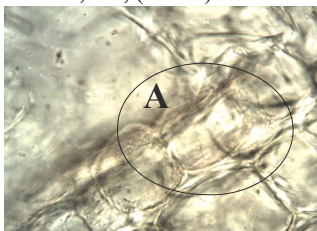
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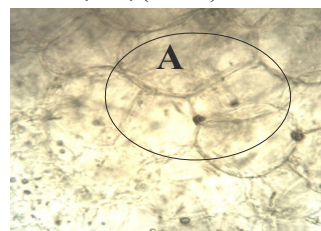
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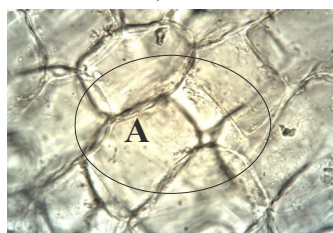
Sucrose solution 5 %, (48 ± 2) °C
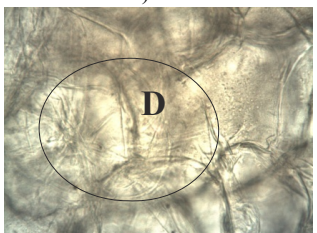
Milk (18 ± 2) °C
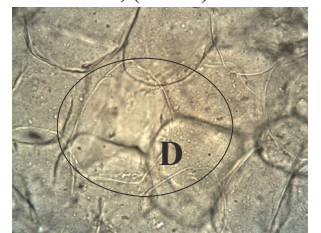
Milk (48 ± 2) °

Figure 1. Microscopic Structure of Powder of Cabbage which was recovered in different polar environments by different temperature (increase 400 times)

Detected of water absorption coefficient of the powder from cabbage (CWA) in these polar media at a temperature 20 ± 2 °C presented in Table 2. As seen from the table, the greatest value of CWA characterized vegetable powder samples MSH-drying in comparison to the convective manner regardless of the medium for recovery. Moreover, the CWA value is somewhat reduced in sodium chloride and sucrose in higher concentrations of 1,7 and 5,0% respectively, which was confirmed by microstructure powders (Figure 2).

Table 2

The coefficient of water absorption in polar mediums powder of cabbage

Polar mediums	Coefficient of water absorption, відн. од., powder of cabbage	
	Convection	**MSH-drying**
Sodium bicarbonate (pн = 6,0)	4,0 ± 0,1	6,2 ± 0,1
Solution of ethanoic acid (pн = 4,5)	4,0 ± 0,1	6,0 ± 0,2
Solution of sodium chloride 0,5 %	4,0 ± 0,2	6,2 ± 0,1
Sucrose 1,1 %	4,3 ± 0,2	6,1 ± 0,1
Sucrose 5,0 %	4,1 ± 0,1	5,0 ± 0,1

Connectives between components of structure in their enter play important role in forming structure of finished products, what effects on redistribution of humidity connects form and processes of fat phase crystallization. To establish the influence of drying method on the redistribution of humidity connects forms held by thermogravimetry method, we have done exploring of powder of cabbage water phase obtained by convective drying method and mixed heat supply after their recovery. Thermogravimetric method which is based on changes of mass and product enthalpy during the heating with given speed was used for exploring of humidity connectives forms in powder of cabbage samples. In result of exploring we obtained derivatohrames which were used for determining of removed humidity quantity, temperature peaks and intervals of its removing. According to our data we identified humidity connects forms and calculated their percentage – figure 3.

Rebinder standard classification of humidity connects forms was used during analyses of water phase connectives with powder components [9]. Energy of connects with material or thermodynamic principle was assigned as classification basis, that's why it has universal. According to given classification all connectives forms are divided into three big groups: physical-chemical, physical-mechanical and chemical.

Powder of cabbage derivatohrames obtained by different drying methods before the recovery are shown on Figure 4 b. Describing the DTA curves of exploring samples we can say that removing of humidity in them is same but in different temperature intervals.

Thus, for powder of cabbage obtained by convective drying, temperature peaks of removing firmly connected humidity are in range 65…160 °C. At the same time in unrecovered powder of cabbage obtained by mixed method of heat supply temperature interval of removing firmly connected humidity is shifted toward higher temperatures – 78…175 °C. Increasing temperature peak of removing humidity on 2 °C and diffuse peak on 9 °C also is observed in given sample. Received results show that in unrecovered powder of cabbage by mixed method of heat supply, the residual humidity is stronger connected with its components than in powder by traditional convective drying.
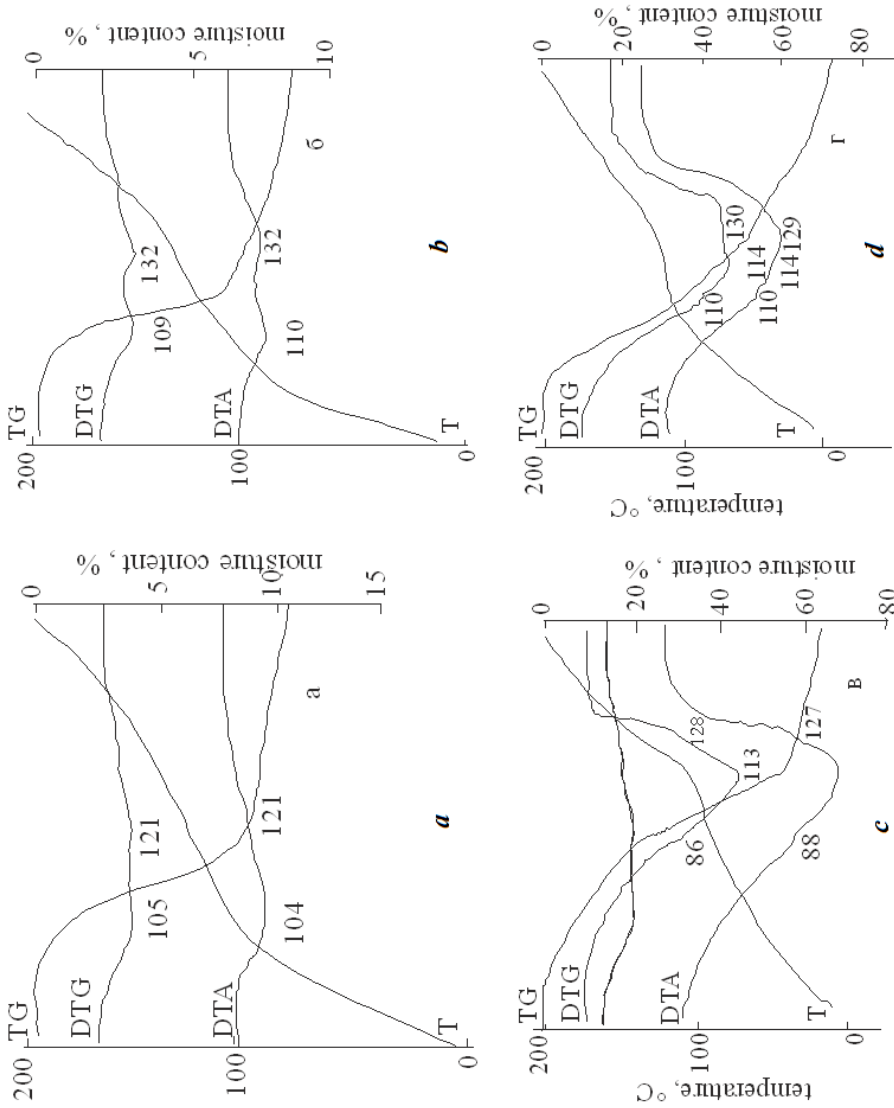
Figure 3. Powder of cabbage derivatohrames:
a – convective drying; b – mixed method of heat supply;c – convective drying, recovered in water; d – mixed method of heat supply, recovered in water

Comparing derivatohrames of recovered powder of cabbage (fig 3 c and d) it is seen that their ability to connect and retain humidity is different and depends of drying method. Thus, overall quantity of connected humidity in powder of cabbage received by convective drying is 71% and in powder by mixed method of heat supply – 80 %.

Describing DTA curve of recovered powder by convective drying (Figure 3 c), it is seen that peak of removing humidity us wide in low temperature interval – 32…102 °C. The relative amount of removed humidity is 63%. This indicates on blending of humidity removing temperature intervals with different forms of connection. According to Rebinder classification, this humidity is characterized by weak osmotic and mechanical connections with powder components [11].

Process of removing firmly connected humidity is characterized by a sharp peak at 110 °C and this shows that polymolecular connections are predominance. Comparing derivatohrames of explored powder samples it is seen that mixed method of heat supply process promotes the growth of firmly connected humidity quantity with poli- and monomolecular connections. Character of DTA and DTG curves of recovered powder indicates it (Figure 3 d).

The relative quantity of mechanical and osmosis humidity in the recovered sample is 47%. Firmly connected humidity is removed differentiated in two temperature intervals with removing peaks of 114 and 130°C, indicated humidity with poly- and monomolecular connections respectively. Relative quantity of it is 53%.

So, the results of exploring shows that using of mixed method of heat supply method promotes forming of powder of cabbage rehydration properties, that are more than in 1.5 times able to connect humidity with strong connections in comparing with convective drying. From the literature it is known [8] that systems in which microcapillaries are with a diameter not longer than 10^{-7} cm are demonstrated wide and characterized by large amount of strong connected humidity. Using the known literature data we can make a conclusion that hardware design and technological modes of mixed method of heat supply process contribute receiving powder with larger amount of micropores and microcapillaries in nanoscale range.

Conclusions

1. Powders obtained by drying of cabbage mixed method of heat supply at temperatures of 50 and 70 °C. Established by setting Mack Ben that the volume of pores cabbage powder obtained at 50 °C is greater than 70 °C. Most 1,5 times the surface adsorption of cabbage powder 70 °C allows us to conclude that the absorption of moisture in the powder will be correspondingly larger sample.

2. The results of the researches show that the receiving powder of cabbage by mixed method of heat supply promotes maximum saving of vegetable tissue microstructure and native properties of its components.

3. Hardware design and technological modes of mixed method of heat supply are proportional influenced on the formation of pores and capillaries in micro- and nanoscale range what helps to receive a dry product with high rehydration properties.

4. Hardware design and technological modes MSH-drying process is directly proportional to affect for size of pores and capillaries, in micro- and nano-range, to provide dried products with high rehydration properties.

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Effect of extruding on microbial indicators of feed mixtures

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Abstract

Introduction. To determine the quality of feed mixtures containing flax extract from serum was investigated microbiological parameters after extruding feed mixtures of different prescription in storage.

Materials and methods. Studied feed mixture of wheat, corn and flax extract on serum basis of different interest amount. Linen extract obtained by extraction in an active pulsation dispersant mixture is mixed and aperture extruding a temperature – 110–120 °C, pressure – 4.2 MPa, which allows almost completely disinfect it.

We investigated the change of microbiological feed mixtures during storage. The test samples were placed in cloth bags and stored for 2 months at 0 °C (refrigerator), + 20 °C (thermostat) and relative humidity – 45%.

Results and discussion. Humidity grain mixtures for extrusion samples is within 16.8–17.6%, after extruding from 13.3 to 13.5%, and over the shelf life of unchanged at +20 °C and a relative humidity of 45% designs humidity changes during storage of 13.3–13.5% to 15.3–16.1%.

Changing humidity extruded feed mixture to a large extent dependent on storage temperature and not on the number entered flax extract from the serum of the mixture.

Comparing the conditions and shelf life, it can be said that the change in humidity extruded feed mixture to a large extent dependent on storage temperature and not on the number entered flax extract from the serum of the mixture.

At the beginning and end of storage extruded forage mixture, characterized by relatively low levels of microbiological contamination. Not revealed the following groups of microorganisms as Escherichia coli (BGKP) pathogens. Total mesophilic aerobic and facultative anaerobic microorganisms (MAFAM) in all samples of mixtures is within acceptable limits (no more than $5 \cdot 10^5$ CFU/g).

Analysis of colonies of mesophilic aerobic microorganisms on agar peptidemeat found that they are characterized by large, small and medium size, white and yellow color, smooth and rough edges. The bulk of the microorganisms is coccoid bacteria whose cells are placed singly or clusters. The main morpho types bacteria isolated from grain extrudate is aerobic bacteria.

Conclusion. We recommend using extrusion process as an effective way to improve health quality extruded feed mixtures because it provides a nearly sterile product.

Introduction

Combination fodder – is much more difficult complex for keeping than grain, flour and cereals. It can be explained by the large number of components, which the fodder includes, and also by physical, chemical and biological properties of each component [10].

Different components have different critical humidity. So, the critical humidity of bone meal is 8.7%, of flour from Lucerne's leaves is 14.9%, cattle cake, solvent cake and from cottonseed is 11.5 and 12.8%. The critical humidity of feed depends of the components and can be 10.0–14.5%. Therefore, when its value is higher, than an intensification of biochemical processes and active development of microflora can happen. The combination fodder's microflora majority consists of microorganisms, which are inhabiting the grain mass [2, 8–11].

Combination fodder is a favorable nutritive ground for many microorganisms, especially for mold fungi. If there is enough level of humidity and a temperature is about 10–20 °C, then mold fungi formation happens faster, mold can produce a lot of heat, so they are the main reason of fire-fanging effect of grain. There are always different types of microorganisms in the fodder, which contain cereal crops. Such saprophytic microflora can multiply under normal conditions and it leads to lower level of nutritional value of the feed. However, the feed can also include pathogenic microorganisms, coliform bacillus bacteria, which aggravate the sanitary condition of the product. The feed Storage at low temperature and humidity can extend their safekeeping term. At low temperatures, neither the microorganisms nor insects cannot progress very fast, and also may less intensively occur in animal feed and various oxidation processes [1].

During the feed storage, its stability depends on the quality and quantity of ingredients included in the recipe. Accordingly, the terms of storage for various types of products were set out in the feed industry. In industrial complexes mixed cattle feed (also for poultry) can be stored for 1 month from the production, the shelf life of other feeds can be 2 months from the production time.

The development of microflora during storage of the product is always accompanied by a reduction of quality because of decomposition of organic substances and accumulation of waste products of microorganisms, which are dangerous for agricultural animals, poultry and fish.

The extrusion process can contribute to get high sterile product with low mass part of moisture, which gives an opportunity to extend its shelf life. At the same time, the advanced specific surface and increased hygroscopic cause negative effect of products' quality, which changes during the storage [3, 16].

Recently, the industry more and more attention paid to the use of oil crops not only for vegetable oils, but also as a source of complete protein, biologically active substances and various macro- and micronutrients.

Traditionally, protein and oil crops used to produce vegetable fats, which are then used for food and technical purposes. By-products after the removal of fat – cake and meal, are widely used for animal feeding and receiving various protein concentrate [6].

Recently, more attention is paid to the use of whole seeds of these crops as for food and for fodder purposes, particularly the use of such non-traditional crops as flax.

Recent studies increasingly reveal the full range of properties of flax seeds, biological value which determines not only the content and composition of fat, but also a significant content of protein, vitamins, enzymes, mucus, organic acids and minerals [15].

Production of feed for farm animals that could compete in quality with foreign analogues requires improvement of existing and development of new highly efficient

technologies. Today in Ukraine there is no perfect technology for the production of animal feed farm animals using flax seed, so to ensure the quality and competitiveness of animal feed products is necessary to introduce the latest technological operations and advanced methods of processing raw materials [7].

Materials and methods

During the experiments, the changes of microbiological status of extruded grain mixtures were explored during the storage by the following indicators: total number of microbial cells (MAFS), the presence of pathogens especially Salmonella, the presence colon bacillus bacteria (coliforms, CFU/g), the presence of anaerobes and aerobes. We used the grain of wheat, corn, and flax extract, based on wheat to create extruded batches of grain mixtures. Such mixtures had the following percentage composition:
- blend 1 – wheat – 45%:corn – 45%: flax extract, which is based on serum – 10%;
- blend 2 – wheat – 45%:corn – 40%: flax extract based serum – 15%;
- blend 3 – wheat – 40% corn 45%: flax extract based serum – 15%;
- blend 4 – wheat – 40% corn – 40%: flax extract based serum – 20%;

Flax extract, which is based on wheat, was obtained by extraction in pulsating dispersers, with the active diaphragm. There is a powerful cavitational effect on the dispersed phase in these apparatus that provides intensive secretion of bioactive substances in the volume of the solvent. There are some effectual technologies, which are used in various industries, which are based on application of pulsator aggregates of discrete-pulse energy input (DVI) with periodic change of pressure in the working chamber.

This method shows the new approach of heat and mass transfer intensification and hydro-mechanical processes in dispersion systems [5].

The influence of cavitation effects pulsating dispersant extraction was carried out at linseed, focusing on indicators of physical and chemical properties and biological value. For this purpose, flax seed milled 500 g with the addition of 3 liters of serum. Percolation process took 2 hours at 30 ºC. The extraction was carried out for 5 and 10 minutes. Research data extraction representation in Table 1.

Table 1

Physic-chemical characteristics of extracted liquid solution

Parameter	Extracted liquid solution	
	Processing time, s	
	300	600
Total mass fraction of dry substances, %	8,4	7,3
Raw protein, %	25,1	25,9
acidity, degree	4,4	4,0
Starch, %	11,4	11,0

So, after the researches we can say the following:

The number of dry substances is reduced in the sample solutions of milled flax, based on wheat according to different processing time in the apparatus, which shows better solubility under the pressure. Analyzing such indicators like acidity and starch, we noticed that they are inversely proportional to the extraction period in the apparatus and the protein's amount can increase in directly proportion to the extraction time reaches its maximum when the period of extraction continues at least 10 min.

It is known that the heat resistance of microorganisms depends on the properties of the environment, which is of floral mixture, which is heated, namely the quantity and condition of protein, fat, pH. Bacteriological determination of thermal death of microorganisms – that's when they lose the ability to restore their vital functions. The maximum temperature resistance of microorganisms is in a small range from pH 6.0 to 7.0 and beyond this range it decreases sharp. In our case, multi-factor mechanisms DIV leads to a significant increase in pH from 4.7 in the starting mixture to a pH of 6.5 to 6.8 after processing in a rotary pulse apparatus (RIA).

Khanoll A. M. and Riman G. I. set a staement that "Bacteria are consider dead if they lost the ability to refurbish even when they have the most optimal conditions for their existence. "When monofactorial heat cells get damaged, which in favorable conditions (environments) restore their vital activity, and in other conditions it leads to cell death [9, 16].

After the resumption of injury, which was caused by warming up and cells can multiply as cells, that did not receive the action of heat. It means that, the restoration of sub lethally thermal damage is a process, which takes place under specific conditions in which the ability to reproduce and normal structure and function of cells can regenerate. The death of the microorganisms from the action of heat depends on the duration of the process, the condition and environment's properties and only in the absence of resistance; the curve of destruction of microorganisms can be a line [13].

After the thermal process a certain number of microorganisms that are capable of restoration and further reproduction can survive. G. Lembke explained it in such way, that the action of energy the hydrogen bonds can be damaged in the cell, but they can be renewed due to the long-wave light or substances that carry an electrical charge and are able to contact with hydrogen [4].

Therefore, preliminary processing in the RIA before the extrusion, where there are mechanisms of discrete-pulse energy input, provides:
- the maximum reduction of vegetative bacteria;
- reduction of spore bacteria;
- reduction of mold and yeast.

This result is achieved at low temperature pasteurization, namely – 72–76 °C with an exposure of 2...3 minutes. Also keep in mind that the processing of RIA devices by multi-action mechanisms DIPE increases temperature 30−35 °C, which significantly affects the energy efficiency technology.

Results and discussion

Determination of the qualitative and quantitative content of microorganisms in extruded feed mixtures was carried out according to the rules for animal feed [4, 5].

To control the qualitative and quantitative composition of microorganisms were taken some samples from fresh prepared extruded mixtures, which consisted of wheat-corn-flaxseed extract, based on whey. Test samples were set in cloth bags and stored for 2 months at 0 °C (refrigerator), 20 °C (thermostat) and a relative humidity of 45%.

The moisture of the grain mixtures before the extrusion in the samples was in the range of 16.8–17.6%. The moisture content after extrusion ranged from 13.3 to 13.5%, and during the storage period it has not changed under the conditions: temperature 0 °C, relative humidity 45%. But at the temperature of +20 °C and relative humidity of 45% was recorded some changes of this index. The data changes of humidity (under conditions: temperature + 20 °C and relative humidity 45%) are shown in Figure 1.
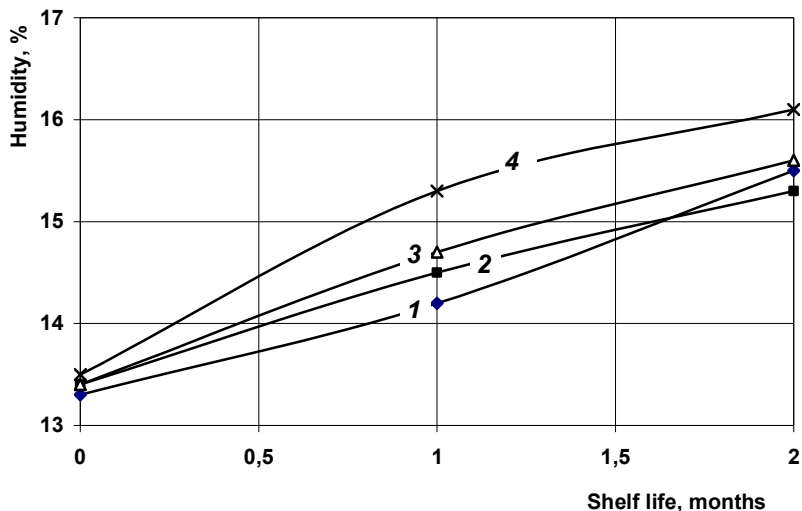
Figure 1. Change of moisture during storage prototypes:
1 – blend 1; 2 – blend 2; 3 – blend 3; 4 – blend 4;

As you can see from the figure, the change in humidity of explored samples under the normal conditions, increases during the storage and at the end of the second month of storage is 15.3 to 16.1%.

Comparing the conditions and period of storage, it is possible to say that changes in the moisture content of the extruded feed mixture largely depends on the storage temperature, and not on the amount of introduced flax extract whey in the mixture.

From the above words it follows that the moisture absorption by samples of a research largely depends on the storage conditions. The results of experiments regarding the level of microbiological contamination of extruded feed mixtures during storage are presented in Table 2.

Analyzing the data of Table 2 for all samples it shows that, as at the beginning, so at the end of storage of extruded feed mixtures, characterized by rather low level of microbiological contamination. During the exploring we did not detecte the following groups of microorganisms, such as colon bacillus bacteria and pathogens. The total number of mesophilic aerobic and facultative anaerobic microorganisms (SAFS) in all samples of mixtures is in the acceptable range (not more than $5 \cdot 10^5$ CFU/g) [10–16]. In experiments of the microflora of the mixtures it was found that each sample is characterized by its particular special microflora (Table 3).

Analyzing the colonies of mesophilic aerobic microorganisms on beef-extract agar set that they are characterized by large, small and medium sizes, white and yellow color, smooth and jagged edges. The main part of the microorganisms are coccal bacteria, whose cells are located one by one or in small groups (clusters). The main morphotypes of bacteria isolated from grain extrudates, are aerobic bacteria.

Change microbiological extruded feed mixtures during storage

The title of extruded product	The storage time (days)	The number of mesophilic aerobic and facultative anaerobic microorganisms	Colon bacillus bacteria,	Pathogens	Anaerobics
Temperature +20° C					
Blend N 1	0	< 10	no	no	no
	15	$2 \cdot 10$	no	no	no
	30	$9 \cdot 10$	no	no	no
	45	$1 \cdot 10^2$	no	no	no
	60	$1,7 \cdot 10^2$	no	no	no
Blend N 2	0	< 10	no	no	no
	15	$3 \cdot 10$	no	no	no
	30	$9 \cdot 10$	no	no	no
	45	$1,3 \cdot 10^2$	no	no	no
	60	$2,6 \cdot 10^2$	no	no	no
Blend N 3	0	< 10	no	no	no
	15	$5 \cdot 10$	no	no	no
	30	$1,1 \cdot 10^2$	no	no	no
	45	$1,7 \cdot 10^2$	no	no	no
	60	$3 \cdot 10^2$	no	no	no
Blend N 4	0	< 10	no	no	no
	15	$9 \cdot 10$	no	no	no
	30	$1,8 \cdot 10^2$	no	no	no
	45	$3 \cdot 10^2$	no	no	no
	60	$5 \cdot 10^2$	no	no	no
Temperature 0 °C					
Blend N 1	0	< 10	no	no	no
	15	< 10	no	no	no
	30	< 10	no	no	no
	45	< 10	no	no	no
	60	< 10	no	no	no
Blend N 2	0	< 10	no	no	no
	15	< 10	no	no	no
	30	< 10	no	no	no
	45	< 10	no	no	no
	60	< 10	no	no	no
Blend N 3	0	< 10	no	no	no
	15	< 10	no	no	no
	30	< 10	no	no	no
	45	< 10	no	no	no
Blend N 4	60	< 10	no	no	no
	0	< 10	no	no	no
	15	< 10	no	no	no
	30	< 10	no	no	no

Characteristics morphotypes of microorganisms isolated from extruded cereal mixes

Blends	Attitude to oxygen	Type of collonium	Size of Collonium	Shape of collonium
Blend 1	Aerobics	Round, white, with smooth edges	Small	Coccus, potty, accommodate with small groups
Blend 2	Aerobics	Round, white, with smooth edges	Small	Coccus, potty, accommodate with small groups
	Aerobics	Round, white, with jagged edges	Medium	Coccus, potty, accommodate one by one
Blend 3	Aerobics	Round, white, with smooth edges	Small	Coccus, potty, accommodate with small groups
	Aerobics	Round, yellow, with smooth edges	Medium	Coccus, potty, accommodate one by one groups
Blend 4	Aerobics	White, with jagged edges	Medium	Coccus, potty, accommodate one by one
	Aerobics	White, like amoeba	Big	Coccus, potty, accommodate one by one

Conclusions

The results of experiments show that a humidity of prototypes can change and it depends on storage conditions. At 0 °C and a relative humidity of 45% humidity samples does not change during two months of storage, and is in the range of 13.5 to 13.3%. At a temperature of + 20 °C and relative humidity of 45% moisture content of samples changed during storage from 13.3–13.5% to 15.3–16.1%. Extrusion is an effective way of improving the sanitary quality of extruded grain mixtures, because it allows reducing the number of microorganisms. The research of quantitative and qualitative composition of the microflora of extruded grain mix with the addition of flax extract, based on the whey showed that the total microbial number (SAFS) in all the test samples are situated in acceptable limits of not more than $5·10^5$ CFU/g). Indicators of bacillus coli bacteria were not detected. The absence of pathogenic and conditionally pathogenic microorganisms indicates the provision of adequate sanitary and hygienic conditions in the manufacture of extruded blends.

During the storage of experimental batches of extruded grain mixtures for two months at temperature of + 20 °C, there is a slight increase in microbiological parameters and at 0 °C there is no growth of microorganisms.

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Changes of micronutrient composition of biofortified vegetables at freezing and storage

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Abstract

Introduction. There were studied the changes of micronutrient composition of vegetables, biofortified by using "Riverm" manure at freezing and storage.

Materials and Methods. Materials – fresh and frozen samples of biofortified sweet pepper and pumpkin. For determination of micronutrients contents were used the methods of inversive voltammetry, liquid chromatography and also colorometric and titrometric methods.

Results and discussion. The samples of biofortified fruits of pepper and pumpkins are more valuable by iron content (7,4–14,6%), zinc (2,7–6,7%), cooper (2,1–6,6%), vitamin B_1 (20,9–44,7%), B_2 (18–34,3%), C (28–29%), carotenoids (by 11,6–22,8%) comparing with control.

The decrease of iron quantity in frozen biofortified vegetables in 6 month of storage is 4,5–5,4%, cooper – 2,6–2,7%, zinc – 2,1–2,3%. At freezing and storage biofortified pumpkins of Oleshkovsky variety lost 22,4% of vitamin C (control – 36,9%), 15,7% carotenoids (control – 23,7%), 15% of vitamin B_1 (control – 32,4%), 13,8% of vitamin B_2 (control – 26,2%). During the storage of frozen biofortified pepper of the sweet variety Scythian gold also took place the decrease of vitamins content: vitamin B_2 – by 13,8% (control –by 14,9%), vitamin B_1 – by 12,8% (control – by 14,1%), vitamin C – by12,7% (control – by 13,2%), carotenoids –by 5,3% (control – by 6,0%). The most quantity of vitamins was lost by the studied samples of vegetables directly at freezing. The control samples of frozen vegetables contained the less quantity of microelements and vitamins at all stages of research.

Conclusions. Freezing and storage of biofortified (planted using organic manure "Riverm") fruits of pepper and pumpkin lead to decrease of micronutrients content in them, but these changes are not so intense as in the control samples. The most losses of vitamins take place at freezing.

Introduction

In almost 50 countries of the world the biofortified products are planted and studied to spread them in farm enterprises. For today already almost 2 mln people take biofortified products. And since the significant number of countries accepts biofortification as a part of wider strategy, which aim is a fight against micronutrient deficits in human nourishment, there is a foresight that till 2030 more than 1 billion people will receive good from biofortified food products [1].

Biofortification differs from the ordinary fortification by the fact that its aim is an increase of harvest consumption value at growth and development of plants and not at processing when the important micronutrients are specially added according to the prescription. Since the foodstuff, enriched with the necessary micronutrients cannot be purchased by everyone because of their high cost, biofortified vegetable products can be planted and taken by the people of different prosperity. The different directions of biofortification exist and are developed in the world:
- Biofortification of rice, beans, sweet potato, manioc by iron;
- Biofortification of wheat, rice, millet, beans, sweet potato, manioc by zinc;
- Biofortification of sweet potato, manioc and maize by carotene;
- Biofortification of sorgho and manioc by amino acids and proteins [1].

For biofortification are selected the main cultures of human nutrition in the different world regions. Maize is irreplaceable in the food ration of dwellers of 22 African and Latin American countries. Wheat is an important crop and irreplaceable raw material of the production of foodstuff for 35% of people. Sweet potato is a main non-corn culture for the one fourth of Earth population, and manioc feeds near 800 mln people, who live mainly in African countries.

Biofortification is directed on accumulation of micronutrients, which lack in food ration influences the significant part of world population – iron, zinc, selenium, iodine, vitamin A, folic acid [2–6]. At that there are taken into account the data, that asiderotic anemia is revealed in 30% of pregnant women and women of reproductive age [7]; the cause of death of almost 450 thousand children up to 5 year is the lack of zinc [8]; selenium deficiency leads to the loss of resistivity, to cancer and viral diseases, iodine one – to thyroid gland diseases, β-carotene – to diseases of eyes.

For Ukrainians fresh and processed vegetables is an important component of many national dishes and irreplaceable everyday source of series of essential compounds. Biofortification of vegetables must favor the overcoming of existent deficiency of iron, vitamin A, iodine, zinc that most negatively influences preschool children and pregnant women [9].

Today the use of gene modification as the method of biofortification is the most profitable strategy but it is rather long-term process and is not generally approved. That is why the significant attention in the world is paid to the traditional selection and use of organic manures with the special composition for increasing content of vital micronutrients in edible parts of plant.

Analyzed the information sources, one can make a conclusion that the most important part of researches, carried out in the world last years, is devoted to the study of features of accumulation of carotene [10–13], iron [14–17], zinc [18–19], selenium [20–22], iodine [23–25] in biofortified corn cultures and vegetables. We did not reveal any data as to the influence of special organic manures on the mineral and vitamin composition of vegetables, planted in Ukraine, and also on the changes of content of separate components at their freezing and further storage.

Taking into account that the important component of everyday nourishment of Ukrainians is not only diverse vegetables but also the products of their processing, we studied the changes of micronutrients content in biofortified frozen samples of sweet pepper and pumpkin at storage. For biofortification of vegetables at planting the liquid eco-friendly organic manure of the new generation "Riverm" that includes all necessary elements for plant nutrition was used. This manure has series of advantages. Especially, this preparation provides preservation of microorganisms and products of their life activity – enzymes and growth substances. The useful microbiocenoses accelerate transformation of nitrogen compounds, activate the processes of cellulose fission into biologically active compounds that favor nitrogen fixation and transformation of phosphorus organic compounds in assimilated forms and also product the series of biologically active compounds (vitamins, amino acids, auxins) that improve growth and development of plant. "Riverm" is safe for plants, animals and humans, does not need the special preventive arrangements for use. Preparation is accepted by international organization System of Independent Certification (SIC) as eco-friendly manure that corresponds to international standard ISO 14024:1999 [26].

Materials and methods

The studied objects – fresh and frozen vegetables: pepper of Scythian gold variety and pumpkins of Oleshkivsky variety, planted using liquid, eco-friendly organic manure "Riverm". Vegetables were planted as seedlings. At the beginning seeds were soaked in 1 % solution of "Riverm" at temperature 20–25 ºC during 12 hours till their swelling then they were sowed out. In open soil were planted the healthy seedlings with well developed root and dark-green leaves. Before planting the roots of seedlings were soaked in 1,5 % solution of "Riverm" during 8 hours at temperature not lower than 22 ºC. At planting in hole were brought 100 g of 1 % solution. Extra-root feeding up was carried out in the period of active formation of vegetative mass and fruits; 3–4 % solution of "Riverm" was used. Control – fresh and frozen samples of vegetables, planted by the standard technology without using aforesaid manure. Vegetables were frozen at temperature –25–30 ºC; frozen products were stored during 6 month at temperature not lower than –18 ºC. Micronutrients content was determined in fresh, fresh frozen vegetables and also in vegetables after 3 and 6 month of storage.

For determination of zinc and cooper content was used the method of inversive voltammetry with linear deployment of potential on the hard electrode of carbonic material (graphite). This method is based on electrochemical concentration of metals at permanent potential that is in potentiostatic mode, on turning electrode and further dilution of received concentrate at the given speed of potential changes. At the measurement voltammogram is registered that is a current change depending on electrode potential. At presence of metal ions on voltammogram are the current peaks, which position on potential axis is a qualitative characteristic and height, proportional to the ion concentration in solution – quantitative one. Measurements were carried out on voltammetric analyzer AVA-2 according to instruction.

For determination of iron the colorimetric method was used, which essence is in the change of coloration intensity of solution of complex compound of bivalent iron with red ortophenantrolin. At first the dry mineralization of batch with mass 10 g is carried out. For this the sample is dried in drying cabinet at temperature 105 ± 5 ºC, then is wet with nitrogen acid for whole surface is covered and is warmed on water bath till the end of

evaporation. The processing by nitrogen acid was carried out twice. Then the batch is dried in electric furnace, gradually raising temperature by 50 ºC every min up to 450 ± 25ºC. Mineralization is continued till the grey ash. The cup with ash is taken away in 10 hours of ashing, cooled and wet with nitrogen acid. Nitrogen acid is evaporated on the water bath then in drying cabinet at temperature 140 ± 5 ºC. After cooling the cup is placed in cooled electric furnace, temperature is gradually brought to 300 ± 25 ºC, kept for 30 min. This cycle is repeated several times. Mineralization is finished when ash is white. The received ash is dissolved in 5 cm^3 of hydrochloric acid at warming on water bath, transferred to the measuring retort with holding capacity 50 cm^3, volume is added with water up to the mark. Then the solution of comparison and control solution are prepared for construction of calibrating graph. 10 cm^3 of iron solution with mass concentration 1 g/dm^3 are transferred into measuring retort with holding capacity 500 cm^3 and volume is added up to the mark with solution of hydrochlorid acid 0,01 mmol/dm^3. 0,5; 1,0; 1,5; 2,0; 2,5; 3,0 and 4,0 cm^3 of prepared solution that correspond to 10, 20, 30, 40, 50, 60, 80 mcg of iron are brought in measuring retort with holding capacity 50 cm^3. In each retort is added 1 cm^3 of ortophenatrolin, brought to pH 4–6 by sodium acetous. 1 cm^3 of ortophenatropin solution is brought in it and volume in added with water up to the mark. It is mixed up and in 15 min the optic density of comparison solution is measured relative to the control solution on spectrophotometer at wave length 20 mm. The control solution is prepared just the same as comparison one but without adding the iron solution. For getting graph on abscissa axis is put the iron mass, brought in the comparison solution, in mcg; on ordinate axis – optic density that corresponds to them. At studying product in measuring retort with holding capacity 50 cm^3 is brought the mineralizate solution in such volume for iron mass in retort corresponds to 20–80 mcg. Then hydroxylamine solution is added, pH is brought to 4–6. 1 cm^3 solution of ortaphanantrolin and in 15 minutes the optic density is verified.

The content of vitamin C was determined by titrimetric method, based on extraction of vitamin C by the hydrochloride acid solution with further visual titration by the solution of 2,6–dychlorophenolindophenol to the appearance of light pink coloration. Vitamins B_1, B_2 were determined by the method of fluorimetry, which essence is in acid and enzymatic hydrolysis of associated forms of vitamins, purification of hydrolyzate on the column with cation resin, oxidation and measurement of intensity of fluorescence at the wave length 320–390 nm of excited and 400–580 nm of radiated light.

For determination of carotenoids content was used the method of liquid chromatography of high divisible capacity. The samples were preliminary cooled, then comminuted. Carotenoids are extracted from the batch with mass 20 g using the solvent – *n*-hexane. Procedure was repeated 3–4 times with volumes from 50 to 150 cm. The received extract is rinsed with water to the neutral state. Then extract is evaporated at temperature that does not exceed 50 ºC. The remains of water are eliminated by drying with sodium sulfate. For getting the test solution with carotenoids concentration up to 5 mcg/cm^3 precipitations are solved again in *n*-hexane solvent. 10^{-6} dm^3 of the studied sample are injected in chromatograph. To get the quantitative values the area and height of peaks is determined.

Results and discussion

Since in many countries of the world the aim of biofortification is enrichment of plants with such mineral compounds as zinc, iron, cooper, we studied the features of the changes of their content in biofortified tomato and pumpkin vegetables at freezing and storage.

As the studied samples shown, the sweet pepper of Scythian gold variety, planted using "Riverm" manure, contains 2,02 mg/kg of iron that is by 0,15 mg/kg more than in vegetables, planted under standard conditions. Pepper also contains 2,69 mg/kg of cooper (control – 2,51 mg/kg). Analyzing the zinc content in the studied samples of pepper, one can make the following conclusions: pepper of Scythian gold variety, planted using "Riverm", accumulated 3,94 mg/kg of this microelement. It is by 0,26 mg/kg more than in control (Figure 1).
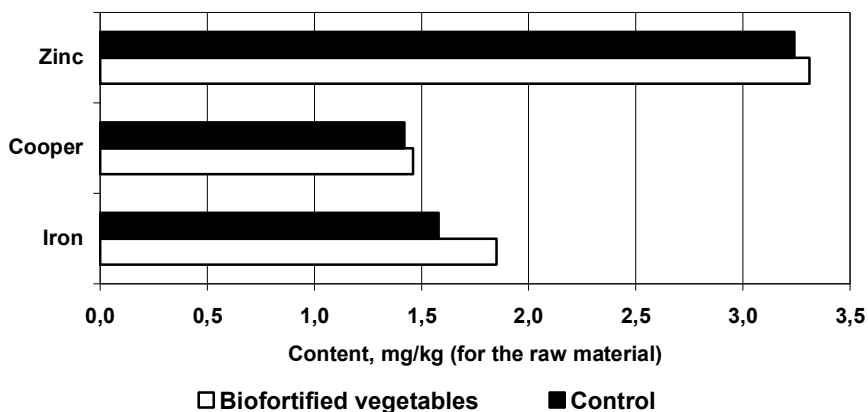
Figure 1. Content of microelements in studied samples of sweet pepper of Scythian gold variety

The content of iron, zinc and cooper in biofortified sweet pepper of Scythian gold variety after freezing and at storage did not undergo the essential changes. The iron losses for 6 month of storage: 0,09 mg/kg, cooper 0,07 mg/kg, zinc – 0,09 mg/kg (Figure 2).
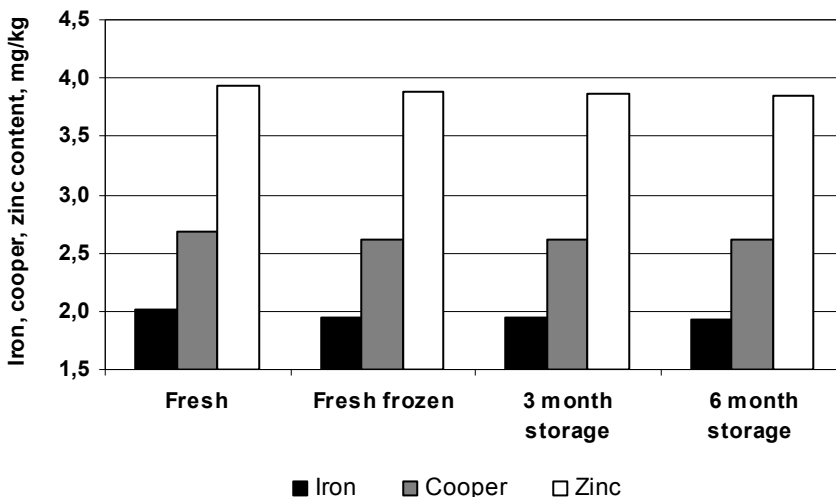
Figure 2. Changes of content of microelements in frozen biofortified sweet pepper of Scythian variety at storage

The cooper content if pumpkins of Oleshkivsky variety does not exceed 1,46 mg/kg. At comparison of cooper content in control samples and in vegetables, planted with "Riverm" it can be said that bofortified vegetable contain more mentioned microelement by 2,7%. (Figure 3).
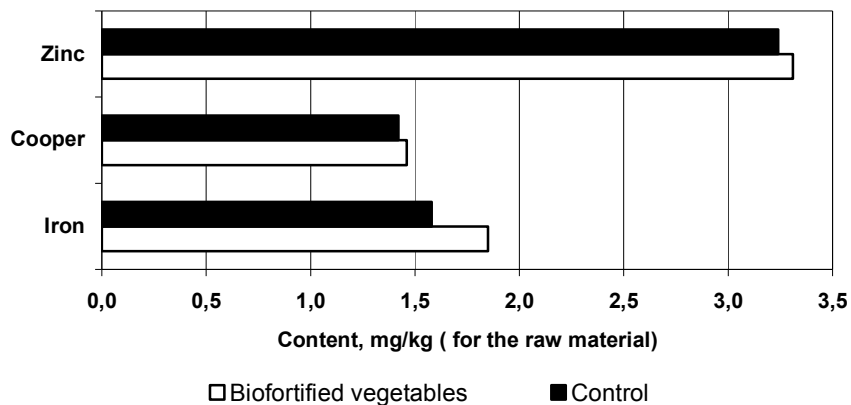
Figure 3. Content of microelements in studied samples of pumpkins of Oleshkivsky variety

As to iron – its content in biofortified pumpkins of Oleshkivsky variety is 1,85 mg/kg that is more than in control by 0,27 mg/kg. The zinc content in biofortified pumpkins of Oleshkivsky variety – 3,31 mg/kg (control – 3,24 mg/kg). So, the pumpkin samples, planted with "Riverm" manure differ by the more content of zinc, iron, cooper.

Biofortified pumpkins at freezing and storage underwent insignificant losses of iron, cooper, zinc. Fresh frozen pumpkins contained by 0,05 mg/kg less zinc, by 0,04 mg/kg less iron and by 0,03 mg/kg less cooper (Figure 4).
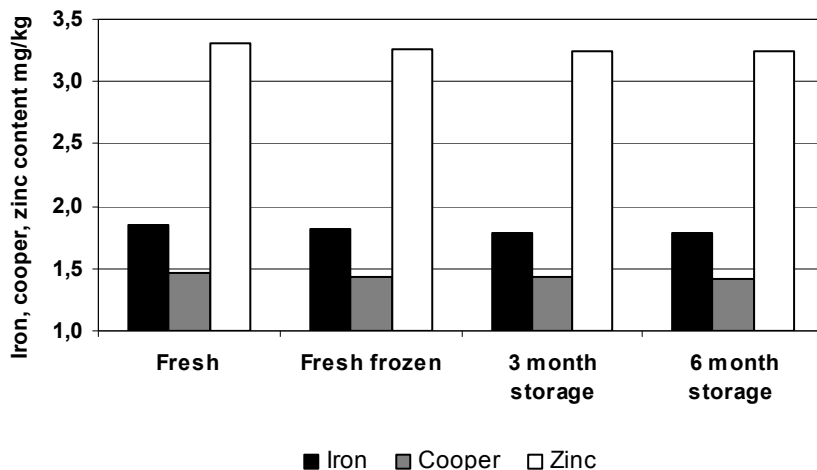
Figure 4. Changes of content of iron, cooper and zinc in frozen biofortified pumpkins of Oleshkivsky variety at storage

During the further storage the content of microelements was stable or underwent insignificant decrease.

There were also analyzed the changes of content of vitamins in fresh frozen products and at 6 month storage. At the study it was revealed, that fresh biofortified pumpkins of Oleshivsky variety contain 22,74 mg% of carotenoids and the control vegetables – 17,56 mg%. That is the studied samples are more useful by carotenoid content that are by 22,8 mg% more than in control (Figure 3). At the same time pumpkins of Oleshkivsky variety, planted using "Riverm" manure, exceed samples, planted using the standard technology by the content of vitamin C (by 6,1 mg%), vitamin B_1 (by 10,3 mg%), vitamin B_2 (by 4,38 mg%) and carotenoids(by 5,18 mg%).

At freezing and storage biofortified pumpkins of Oleshkivsky variety lost 4,71 mg% of vitamin C (control – 5,51 mg%), 3,46 mg % of vitamin B_1 (control – 4,14 mg%), 1,76 mg% of vitamin B_2 (control – 2,2 mg%), 3,58 mg% of carotenoids (control – 4,16 mg%). The control sample of pumpkins underwent more significant losses of micronutrients. It was noted, that the most losses of vitamins in biofortified vegetables of their general quantity: 76,9% – vitamin B_1, 80,1 % – vitamin B_2, 51,6% – carotenoids, 27% – vitamin C corresponded to the freezing process (Figure 5).
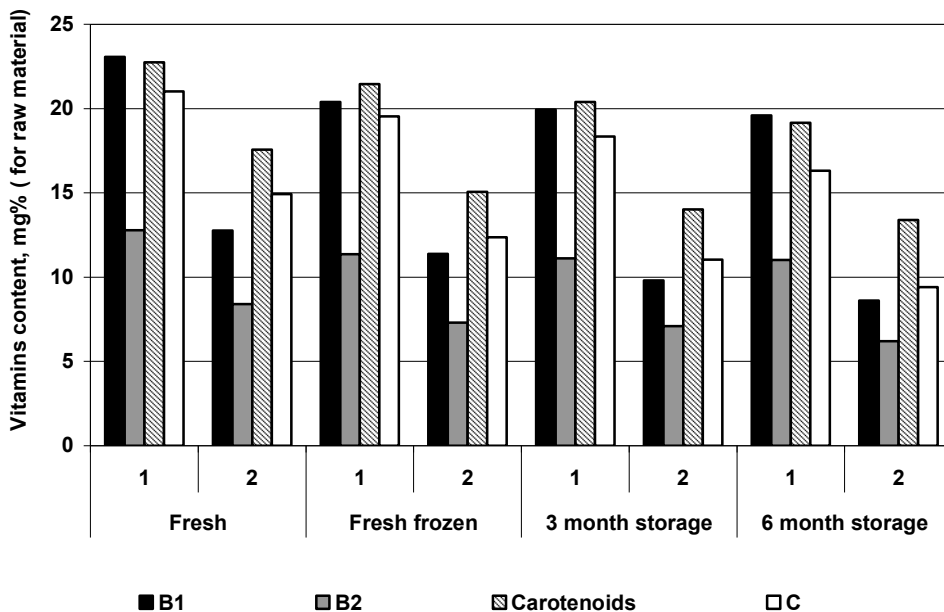
Figure 5. Changes of vitamins content at freezing and storage of biofortified pumpkins of Oleshkivsky variety:
1 – biofortified vegetables, 2 – control

Pepper of Scythian gold variety, planted using "Riverm", contains 175,34 mg% of vitamin C, that is by 49,54 mg% more than in samples, planted using the standard technology. The content of vitamin B_1 in sweet pepper – 172,1 mg%, whereas the control samples contain 136,36 mg% of it. In biofortified samples of sweet pepper of Scythian gold

variety were also revealed 56,14 mg% of vitamin B_2, that is by 10,10 mg % more than in control samples (Figure 6). The fresh frozen pepper contains 93 % of initial vitamin C (control – 86,8%), 92,6 % of initial content of vitamin B_1 (control – 90%), 92 % of initial content of vitamin B_2 (control – 91%) and 97 % of initial quantity of carotenoids (control – 95,8%).
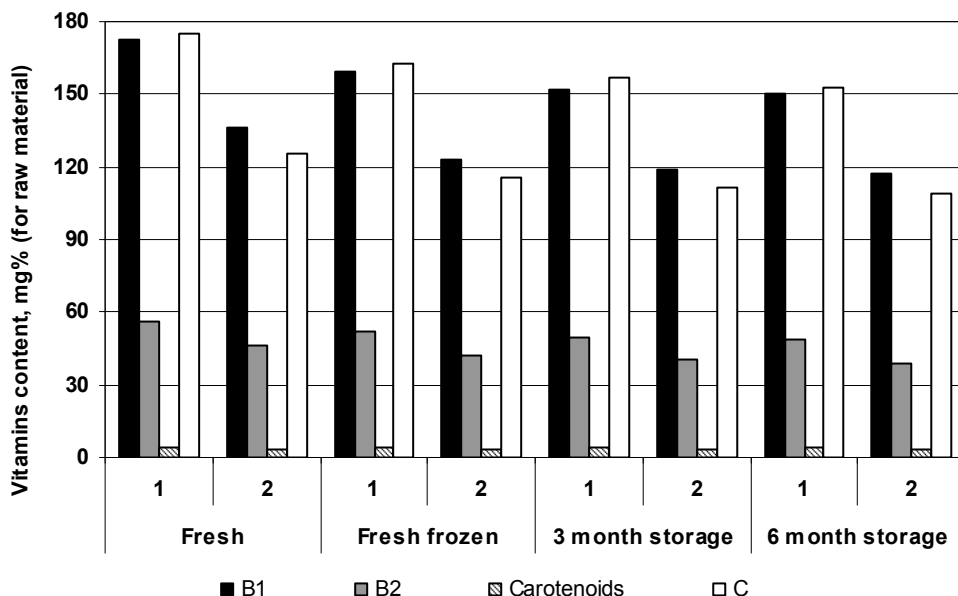
**Figure 6. Changes of vitamins content at freezing and storage
of biofortified pepper Scythian gold**
1 – biofortified vegetables,
2 – control

At storage the fruits of biofortified sweet pepper of Scythian gold variety lost 12,8% of vitamin B_1 (control – 14,1%), 13,8% of vitamin B_2 (control 14,9 %), 12,7% of vitamin C (control – 13,2%), carotenoids – 5,3% (control – 6,0%). The control samples of pepper like in the case of frozen pumpkins underwent the more significant losses of vitamins than biofortified ones that was, probably, a result of the features of planting. The most quantity of vitamins was lost by the studied samples directly at freezing. Especially, at this stage the losses of vitamin C reached 55,3% of the total losses (control – 63,8%), vitamin B_1 – 58,1% (control – 70,9%), vitamin B_2 – 58% (control – 62,9%), carotenoids – 76,2% (control – 77,0%)

Thus, freezing and storage of the sweet pepper of Scythian gold variety and pumpkins of Oleshkivsky variety lower the nutrients content in biofortified vegetables but not so intensively as in the control ones that lose their most quality at whole period of storage. The most losses of vitamins take place at vegetables freezing process.

Conclusions

1. The samples of biofortified pepper and pumpkins (planting using the organic eco-friendly manure "Riverm") are more valuable by the content of iron (by 7,4–14,6%), zinc (by 2,7–6,7%), cooper (by 2,1–6,6%), vitamin B_1 (by 20,9–44,7%), B_2 (by 18–34,3%), C (by 28–29%), carotenoids (by 11,6–22,8%), than the vegetable, planted under standard conditions (without using "Riverm").

2. The losses of iron for 6 month storage of frozen biofortified vegetables reach 4,5–5,4%, cooper – 2,6–2,7%, zinc – 2,1–2,3%.

3. The quantity of Vitamin B_1 at storage period depending on sort of biofortified vegetables decreases by 12,8–17,3%, vitamin B_2 – by 13,8%, vitamin C – by 12,7–22,4%, carotenoids – by 5,3–15,7%.

4. The control samples of vegetables undergo more losses of micronutrients that biofortified ones. The most losses of studied vitamins in biofortified vegetables of their total quantity correspond to freezing.

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Definition indicators of quality of the confectionery semi-finished product with powders from banana and carrot

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Abstract

Introduction. Research of technological properties of powders from the carrots and banana received by cold spray drying, with the purpose of definition the influence of plant raw materials on indicators of quality of a confectionery semi-finished product.

Materials and methods. Determination of dispersion of plant powders carried out by calculation of the sizes of powders particles using an eyepiece micrometer and an optical microscope at increase by 400 times. The research of physical and chemical indicators of quality of the received semi-finished products was defined by standard techniques.

Results and discussion. Determination of dispersion plant powders by microscopic method showed that the largest volume of particles in the studied samples is presented by fraction to 20 microns, this fraction in banana powder contained in volume of 81%, carrot – 78%. That is, the particles in the finished product will not be felt organoleptically.

Powder from banana is homogeneous behind small fractions of particles, presented by segments of spherical shape, uniform in all weight.

Powder from banana holds fat better (0,92 ml/g), which, on the contrary, has smaller water connecting ability (6,33%). The similar return tendency is shown also in powder from carrots: at bigger water absorption and water retention (6,93%) this powder has less ability to hold fat (0,89 ml/g).

When determining influence of the chosen dosages of the studied powders on organoleptic properties of a confectionery semi-finished product as rational was selected the powder dosage from carrots – 5% and powder from banana – 18% to prescription masses that allows to receive a confectionery semi-finished product with high flavoring properties, namely – uniform structure, a plastic consistence, with the taste and a smell inherent in this fruit.

The mass fraction of moisture of a confectionery semi-finished product with powder of carrots is 12,2% and with powder of banana – 11,6%. Mass fraction of fat of 25% and 18% respectively. Content of the reducing substances 4,4% and 4,2% are almost equal in the received semi-finished products. The size of crystals of the main fraction is 10–15 microns.

Conclusions. By results of researches, it is possible to recommend use of fine dispersed plant powders in confectionery production for the purpose of increase in nutrition value and expansion the range of finished goods.

Introduction

Today the chain of restaurant industry gets rapid development. One of the main groups of culinary products that are in demand in the industry are pastry. For their design using various semi-finished products: icing, fondant masses and creams. Considering it, appropriate and necessary to enhance the nutritional value and intensify production of semi-finished products

Fondant mass is prepared by boiling of prescription mix with the subsequent knocking down, tempering and formation. Fondant is a uniform crystalline plastic heterogeneous mass consisting of solid and liquid phases. Sugar fondant prepares from sugar and treacle, and for the corresponding types use certain improvers. Main types of the fondants made in food branch – sugar, dairy, creme brulee. But they have a low nutrition value both high the content of sugar and caloric content. Therefore during creation of new types of products with the raised nutrition value in this field by scientists often use additives from plant raw materials.

High content of moisture in plant raw materials is the reason of their instability at storage, as a result of bacterial, enzymatic and chemical damage. Drying is the most rational way of preserving, as in dried products microbiological processes are slowed down, and the composition of nutritious and biologically valuable substances remains close to natural. Therefore for enrichment the fondant masses expedient and necessary is use of fruit and vegetable powders concentrate that is biologically active compounds [1].

Dried fruit and vegetables are perspective raw materials for use in catering establishments and the food industry as allow avoiding seasonality of their consumption, to simplify operations on machining of raw materials and to reduce duration of technological process of preparation of dishes.

Production of confectionery semifinished products is possible when using dietary plant supplements which raw materials for obtaining can be medicinal plants. Feature of application of medicinal herbs is availability of a complex in them biologically active substances, indiscriminateness to cultivation and a possibility of their industrial procurement.

So, for example Falkovich B. A. for the first time by method of mechanical-chemical activation have received high-disperse systems – nettle pastes with use of effective extractants – alcohol and sunflower oil. It is established that nettle pastes contain biologically active agents in the dissolved condition providing their best assimilation with a human body. He has proved recommended dosages them in confectionery masses (fondant, praline, jelly) from a line item of requirements of organoleptic properties and enrichment by biologically active agents which are confirmed with production testing [2].

Dzhamaldinov B. A. in his scientific work tried to solve this problem using for production powders of semi-finished products wild-growing raw materials of the North Caucasus such as a medlar, a cornel and a wild-growing pear.

Thus he developed a way of receiving fatty paste and candies on the basis of powders of semi-finished products of wild-growing fruits. At the expense of it decrease in content of sugar in products was established [3].

As the moisture-holding agent in case of production fondant chocolates A. Gavva researched fine berry powder with the increased content of food fibers. It consists mainly of covers of berries of blackcurrant and black-fruited mountain ash. Covers contain considerable part of food fibers in relation to other components of berry. Powder has the developed specific surface that causes its capability to adsorption of moisture and swelling.

Moisture-holding substances connect part of free moisture in system, lead to increase in viscosity of candy weight [4].

Skvira M. A. has scientifically and experimentally proved feasibility and efficiency of application of leaves of a walnut and aqueous-alcoholic extract from walnut leaves in case of production sugar and dairy the fomdant confectionery.

It has shown positive influence walnut leaves and aqueous-alcoholic extract from walnut leaves on structural mechanical properties of fondant masses and quality of finished goods, has found positive influence of the brought additives on consumer properties of finished products, including a nutrition value, organoleptic, physical and chemical indicators, and also the impact on quality fondant products during storage.

Also it was revealed clinical efficiency developed the functional fondant candies consisting in normalization of function of a thyroid gland of the person. The found effect of selective accumulating of organic iodine of a thyroid gland, testifies to high quality of iodine in confectionery [5].

Maltsev P. has studied structural and mechanical and hygroscopic properties of food powders (sugar and molasses, apple, beet and dairy) for use in production of confectionery.

It has shown that use of powders on the basis of plant raw materials in production of confectionery allows to reduce a carbohydrate-fat and caloric content, to enrich with functional ingredients (food fibers, vitamins, minerals, organic acids, etc.), to expand the range of products. Powder technologies of confectionery are simple and economic, they allow to receive masses and products from previously set chemical properties and structure and to receive products of a functional purpose [6].

The new technologies based on use of physiologically functional ingredients of a natural origin allow to fill shortage of irreplaceable nutrients and to expand the range of confectionery production and finishing semi-finished products.

Therefore studying of technological properties of the powder from carrots and bananas received by cold spray drying and its influence on organoleptic and physical and chemical indicators of quality of confectionery semi-finished products was the purpose of our research.

Materials and methods

Materials. The subjects of research are plant powder with bananas and carrots, obtained by cold spray drying, manufactured in Switzerland, the company "Naturex AG". Also, quality of a ready confectionery semi-finished product using plant powders was investigated

Methods. Determination of dispersion of plant powders carried out by calculation of the sizes of powders particles using an eyepiece micrometer and an optical microscope at increase by 400 times. Preparation of samples was carried out by drawing dry samples on glass.

The coefficient of water absorption was defined as follows. Sample of powder (about 2,5 g) was placed in advance dried up glass cup with a capacity of 150 ml. Further the sample was filled in with the distilled water (50 ml) and left for swelling during 1.8×60^3 sec. The funnel with the filter was filled in with water, left on 1.8×60^3 sec, then weighed. Further filtered the glass cup contents via this filter then the funnel with the filter and a product was weighed again

At research of the ability to bind moisture of powder used a weighing method. For this purpose contributed a sample of powder in a centrifugal test tube and added water in the

ratio 1:20. The mixture was stirred and left for swelling at t=40ºC, for 2 hours. Then centrifugation was performed T=15 min with a frequency of rotation of 5000 rpm. Liquid which was formed was merged, previously determined in it the content of solids by the refractometer. The mass of wet sedimen was determined by weighing.

Emulsifying ability is determined by the maximum quantity of oil, it is entered into colloidal system to achievement of a koatservation under certain conditions.

For this purpose the simple of powder of 17 g was placed in a chemical glass with a capacity of 200 ml and during mixing added 100 ml of the distilled water at a temperature of 20 °C. Constantly mixing a sample, added from the burette vegetable oil with a speed of 5 ml/s to visual supervision point of separation of the emulsion (a koatservation point). Having measured volume of added oil, counted a koatservation point in ml/h

The principle of a method of determination of ability to hold fat consists that under certain conditions, oil is added to plant powder and after centrifugation the quantity free oils is defined.

Researches were conducted as follows: in the centrifuge tube brought a simple of powder of 4 g and added 20 ml of sunflower oil. Tube kept in the thermostat at a temperature of 20 °C, periodically mixing suspension within 30 min. After that centrifuged at 15000 rpm within 15 min. Measured volume of supernatant liquid (supernant).

The following physical and chemical indicators of quality of ready semi-finished products are investigated: a mass fraction of moisture by drying method, a mass fraction of fat by a refractometric method, the content of the reducing sugars by a feritsianid method.

Results and discussion

According to the described problem, functional and technological properties of powders from the banana and carrots received by cold spray drying have been studied.The main technological properties of plant powders are:
- Organoleptic properties
- Dispersion
- Renewable, ability to hold fat and emulsifying capacity

It is obvious that introduction of additives will cause the appearance of the finished product kind of color, aroma and taste. Therefore, special attention should be given to research organoleptic properties of powders. Both powders, homogeneous throughout the mass, granular consistency. Have a pleasant aroma, typical for powders from carrot and banana and in accordance orange and light yellow colors.

Table 1

Organoleptic indicators of plant powders

Indicator	Characteristic	
	Powder from banana	**Powder from carrot**
Appearance and consistence	Finely dispersed powder, homogeneous throughout the mass, granular texture, without visible inclusions and impurities.	
Taste and smell	Pleasant, pure, without notable particles of powder with flavor and taste of banana.	Pleasant, pure, without notable particles of powder with flavor and taste of carrot.
Color	Light yellow, homogeneous for all mass.	Orange, homogeneous for all mass.

Both powders are finely divided, uniform throughout the mass, granular consistency. Have the pleasant smell typical for powders from carrots and banana, and also respectively orange and light yellow colors.
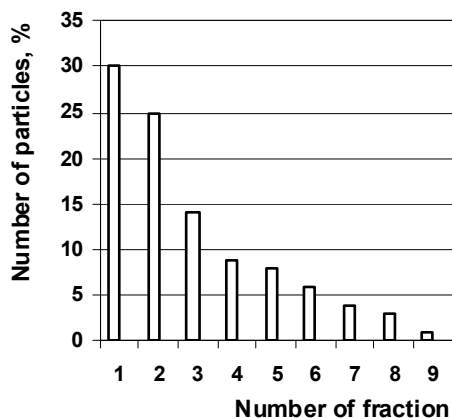
Figure 1. Powder from banan
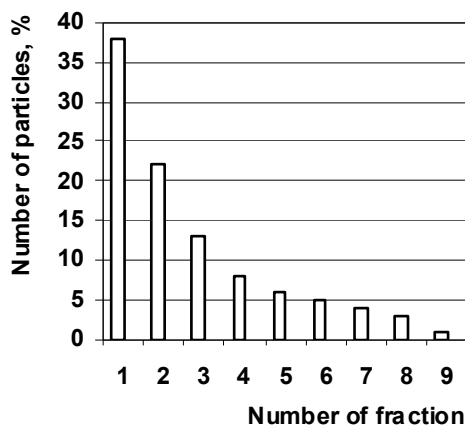
Figure 2. Powder from carrot

With the introduction into confectionery masses advisable to use powders with a particle size to15 microns and maintenance of this faction of 75...80%. Justification of these options is that particles with dimensions over 20...25 microns felt organoleptic and also cause emergence in confectionery masses existence of particles. Therefore, we investigated by microscopic method, dispersion of powders from banana (Figure 1) and carrot (Figure 2)

Numbers of fraction and the size of particles is presented in Table 2.

Table 2

Numbers of fraction and the size of particles

Number of fraction	1	2	3	4	5	6	7	8	9
Dispersion powder, microns	1–5	5–10	10–15	15–20	20–40	40–60	60–80	80–90	90–100

Determination of dispersion plant powders conducted by counting particle size of powders using eyepiece micrometer and optical microscope and an increase of 400 times. Making preparations carried out by drawing a dry sample on a glass slide.

Apparently from these figures, the largest volume of particles in the studied samples is presented by fraction to 20 microns, this fraction in powder from banana contains in the volume of 81%, carrots – 78%.

The structure of powder from banana by means of a microscopic method is investigated (Figure 3–4). Powder from banana is homogeneous by small fractions of particles (increase by 100 times). Powder is presented by segments of spherical shape, uniform in all weight
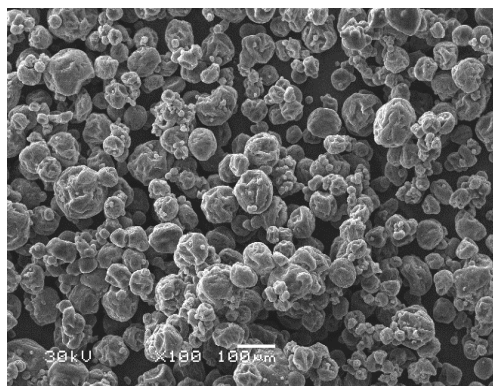
Figure 3. Powder from banana (x 100)

Figure 4. Powder from banana (x 500)

Also technological indicators of plant powders were investigated, namely: the ability to bind moisture, water absorption coefficient, the emulsifying ability and ability to hold fat. The research results are presented in Table 3.

With the above mentioned data it is visible that plant powders have rather high ability to bind moisture. The conducted researches indicate existence of groups OH, which are hydrophilicly active compounds that will promote water absorption of powders. Plant powders in average degree hold fat and have rather high emulsifying ability

Table 3

Technological properties of plant powders

Indicator	Research results	
	Powder from banana	Powder from carrot
Ability to bind moisture, %	6,33	6,93
Coefficient of water absorption, kg/kg	2,92	2,31
Emulsifying ability, ml/g	2,35	2,17
Ability to hold fat, ml/g	0,92	0,89

The best binds moisture is powder with carrots – 6.93%. Banana powder have higher emulsifying capacity 2.35 ml/g.

Better hold a fat is banana powder, which, by contrast, has less ability to bind moisture. A similar inverse tendency is shown for powder from carrots, at higher water absorption and ability to bind moisture this powder is less value hold a fat between researched powders. It is connected, obviously, with the high content of pectin substances in it, wich exhibiting high hydration properties and less value hold a fat.

Considering the above data, these powders were used as a structurant for production of confectionery semi-finished products which includes fondant mass, butter, surfactant and powders from carrot and banana.

In researches mass fractions of powder were defined with carrot 3, 5 and 7% by weight of the formulation. Influence of the chosen dosages on organoleptic properties of confectionery semi-finished product is investigated (Figure 5).
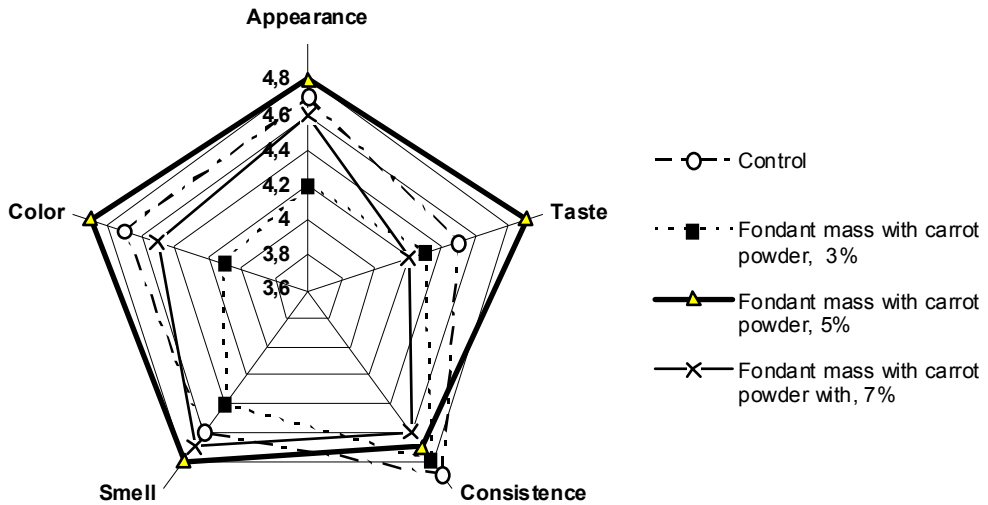
Figure 5. Organoleptic evaluation confectionery semi-finished product with powder from carrot

As can be seen as rational powder dosage can choose with carrot – 5%, that lets confectionery semi-finished product with high taste properties.

In the second case, the dosage was selected from banana powder in an amount of 12, 18 and 24% of the prescription weight. Impact of preferred dosages of the organoleptic properties of semi-finished confectionery (Figure 6)
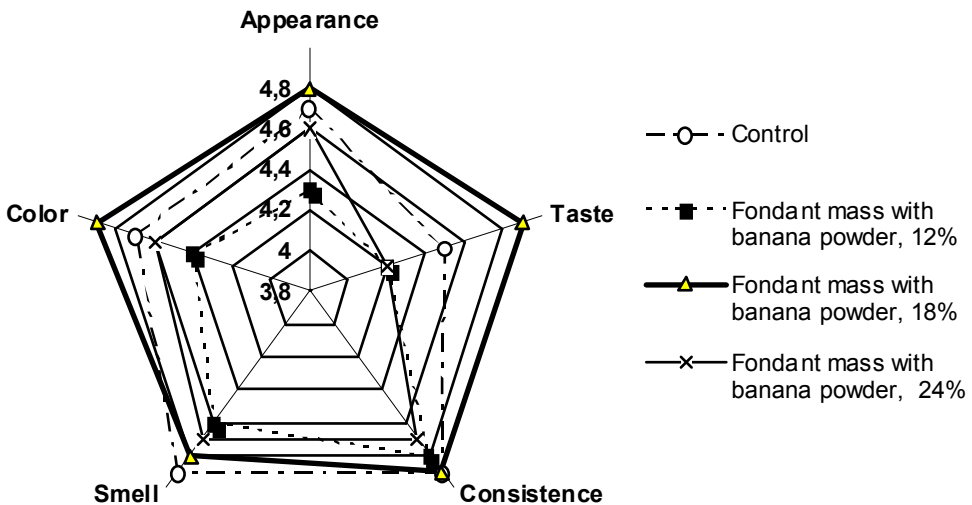

**Figure 6. Organoleptic evaluation confectionery semi-finished product
with powder from banana**

It allowed to receive confectionery semi-finished product with high taste qualities – namely homogeneous structure, plastic texture, with taste and odor characteristic of this fruit

Physico-chemical quality indicators of confectionery semi-finished product with powders are defined: mass fraction of moisture, mass fraction of fat, the content of reducing substances and size of crystals of the main fraction (Table 4).

Table 4

Physical-chemical indicators of quality confectionery semi-finished product with powder from carrot and banana

Indicators	Research results	
	With powder from carrot	With powder from banana
Mass fraction of moisture,%, not more	12,2	11,6
Mass fraction of fat, %	25	18
The content of reducing substances,%, not less	4,4	4,2
Size of crystals of the main fraction, micron	10–15	10–15

The mass fraction of moisture of a confectionery semi-finished product with powder of carrots is 12,2% and with powder from banana – 11,6%. Mass fraction of fat are 25% and 18% respectively. Content of the reducing substances in the received semi-finished products of almost equal 4,4% and 4,2%. The size of crystals of the main fraction – 10–15 microns.

Conclusions

Thus, based on the conducted researches of functional and technological properties of powders from the banana and carrots received by cold spray drying benefits of use of these plant ingredients are shown, due to good organoleptic properties to dispersion, the greatest amount of particles in powders is provided with sizes up to 20 microns, and a high ability to bind moisture and hold the fat.

Application of nonconventional dressers from plant raw materials allows not only to raise a nutrition value of confectionery products, to intensify engineering procedure, but also to give to products of therapeutic and preventative orientation

With respect thereto the actual and perspective direction of development of confectionery production is development of the competitive production technology the fondant masses enriched with physiologically functional ingredients.

Functional and technological properties of powder from carrots and the banana received by cold spray drying are defined.

It is shown that powders from carrots and banana of cold spray drying allows to receive a confectionery semi-finished product with attractive organoleptic properties and corresponding to physical and chemical indicators of quality.

Rational mass fractions of plant powders in prescription composition of confectionery semi-finished products was defined It is shown that the mass fraction of carrot powder – 5%, and banana – 18%, that providing attractive organoleptic properties)

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Using of enzymes to extract of rapeseed oil by pressing

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Abstract

Introduction. To extract lipids that are stored in a locked structure seed must overcome several barriers. The use of hydrolytic enzymes such as cellulases, hemitselyulaza, pectinase increases the permeability of such structures.

Materials and methods. It was used low-glucosinolate rapeseed varieties. For pre-processing enzyme selected following enzymes with extended spectrum of activity: Protolad (protease, 70 U / g enzyme, Ukraine) and Celulad (tsellyulaza, 300 U / g enzyme, Ukraine). To assess the quality of the resulting oil used methods for determining iodine, acid and peroxide numbers. Effectiveness was assessed by enzyme preparations instant shaking, and the residual amount of oil in the meal.

Results and discussion. The best results were obtained in samples of rapeseed that had moisture content of 4%. Enzymatic treatment of oily material over two hours is sufficient to reduce the residual cake oil content from 24.4% to 9.4%. Number enzyme 0.4% by weight of seeds is the best value. Enzymatic treatment in compression technology is a very effective way to increase the quantitative output of oil. Physical and chemical properties of the sample oil after the enzymatic treatment compared with the sample pressed rapeseed oil. The results meet the requirements of regulatory documents. Analysis of fatty acid rapeseed oil sample after enzymatic treatment showed an increase in linoleic and oleic acid and about 3% linolenic – more than 1% compared with the control. The content of other fatty acids in rapeseed oil samples had significant differences. Calculated regression equation for the dependence of oil on the concentration of the enzyme, the moisture content in the material before pressing and hydrolysis time on the basis of experimental data. Increasing the number of removed oil from rapeseed, which is subjected to enzymatic processing prior shows that enzymatic hydrolysis is a very effective method of pretreatment material before pressing. Adding the enzyme is carried out in aqueous solution. High seed moisture during processing is an unfavorable factor in economic terms, as the next stage of processing is the drying.

Conclusions. The main objectives of the study is improvement pretreatment method rapeseed, namely reducing seed moisture during enzymatic hydrolysis.

Introduction

The biological value of rapeseed oil is caused by the content of essential fatty acids such as linoleic and linolenic, that are not synthesized in the human body. There are more essential fatty acids in rapeseed oil than in olive one. Today, the production of rapeseed in Ukraine and its exports, ahead of soybean, ranks second and it is considered to be a strategic crop. One of the most common methods of oil extraction is the method of compressing specially prepared pre-seed and its further extraction using an organic solvent. These two process stages require more preparatory operations, considerable investments and affect the quality of finished products and environmental entire process, stage extraction is more complicated in hardware design. To extract lipids, which are kept in a locked structure seeds should be able to overcome several barriers. The use of hydrolytic enzymes such as cellulase, hemitselyulaza, pectinase in aqueous medium increases the permeability of the structure. The paper studies the use of enzymes for complex action pretreatment rape seeds meal to increase oil output by breaking down cell walls and membranes. Minimal residual cake oil content of the sample, which was subjected to enzymatic hydrolysis was 11.6% and the control – 24.4%. According to the results of research enzymatic treatment does not alter the oil quality indicators and improves the nutritional value of cake compared to the control samples, obtained without the use of enzymes. The resulting crude rapeseed oil in terms of quality met the requirements of the 1st grade oil. Today, rapeseed oil is one of the most popular vegetable oils in Europe, particularly in Germany. Production of edible oil has also begun to increase. Rapeseed meal is a high-protein product. 1 kg of rapeseed meal (with seeds) contains 400–500 grams of fat, 380 grams of protein, 1.9 – 4 times more than pea, wheat and barley flour do. In case of low-glucosinolates rapeseed varieties processing it is possible to include the derived meal into the food of functional purpose. The use of enzymes makes it possible to obtain high-quality products and reduce their production cost.

Traditionally, oil is extracted from oilseeds by pressing or solvent extraction methods. The pressing oils are paid most attention in terms of environmental safety [1, 2]. The process of mechanical extraction of oil is affected by a significant number of factors, which in turn depend on processing parameters of oil material [3, 4, 5, 6]. The fragments of intact cells and oleosoms, containing lipids are present in the material after traditional crushing, moistening and heat treatment due to incomplete destruction of the cell structure [7, 8, 9]. This results in increase of residual oil content in the meal. Oil extraction technology combined with the previous pressing is the most efficient, and therefore is widely industrial used.

In addition to high oil yield solvent extraction technology has several disadvantages. The organic solvent, used in the extraction process, is very flammable, toxic and expensive. As result, oil extraction process is characterized by the danger of explosion and extraction oil and meal are of low quality [10, 11, 12].

Thus, development of the technological way of oil extracting that can compete with the efficiency of solvent extraction method remains an important practical purpose. To create the optimal internal and external structure of the material to be mechanically pressed for oil production a number of manufacturing operations are used. One of them is using of different enzymes [13]. There are two main methods of extracting oil using enzymes: aqueous enzymatic extraction and previous enzymatic processing of oilseeds before the stage of mechanical pressing. These methods may have some advantages compared to conventional technology of oil extracting. The first method allows simultaneously removing oil and restored proteins [12]. But using of such technological operations results

in the risk of a colloidal solution creation, which in turn may be the cause of a stable emulsion and reduce the release of oils [1].

Enzymatic hydrolysis of cell wall is considered as an alternative pretreatment of oilseeds [14]. During the enzymatic pretreatment processing enzymes only facilitate hydrolysis of seed cell walls, so the system does not form a colloidal solution. The destruction of complex lipoproteins and lipopolysaccharides molecules allows removing of additional oil quantity in process of pressing [15]. Enzymatic pressing technology can be used as an alternative to the traditional cold pressing to increase not only the release of oil, but also improve the functional quality of the resulting cake [16, 17, 18, 19]. The enzymes processing using does not change the quality parameters of oil and improves the nutritional value of cake compared to the control samples, obtained without the use of enzymes [13, 19, 20].

Research findings confirm the need for further study and improvement of enzymatic technology for processing of plant material. The aim of this study was to increase the yield of oil from rapeseeds using enzymes in the process of seeds pressing and to investigate the oil quality. In this work we have used enzymes of complex action for rape seed pretreatment.

Materials and methods

Materials

Rape seeds of the low glucosinolates varieties were used in this study. The seeds were cleaned and crushed before using. The following enzyme preparations with broad range activities were used: Protolad (protease from Bacilus subtilis, 70 units/g, Enzyme, Ukraine) and Celulad (cellulase from Bacilus subtilis, 300 units/g, Enzyme, Ukraine).

Chemicals and reagents

Petroleum ether, ethyl alcohol, potassium iodide and other chemicals used in the experiments were supplied by "Ximlaborreaktyv" (Kiev, Ukraine).

Stages of experiments

The ground seeds were incubated with each of the two enzyme preparations (Protolad and Celulad) at a concentration of 0,4–1,4% (by seed weight) for 2–4 hour at (42 ± 0,2 °C) while retaining 50–53% moisture contents. Then, the enzymes were inactivated at temperature of 100 °C and the moisture level readjusted as high as 4–12% by seed weight by drying the enzyme-treated material in an oven at 100 °C prior to pressing. A laboratory screw press (L5–PSH, Ukraine) was used for pressing and oil recovery purposes at process temperature 75–85 °C. A control oil samples were also prepared by pressing the seed material using the same moisture and heat pretreatment and conditions but without the enzyme treatment.

Methods

Sample preparation

Selected average sample of rape seeds were cleaned and used for analysis. Seed moisture was determined by drying to constant weight. Fatty acid composition was investigated by gas-liquid chromatography on a gas chromatography 4000m using capillary

column ZB-WAX 30 m long with an internal diameter of 0,32 mm and a thickness of 0,5 microns stationary phase under the following conditions: the flow rate of gas-media – 10 cm^3/min, flow rate division – 1:100, the evaporation temperature of – 230 °C, the temperature of detector – 250 °C, temperature control column – the gradual heating from 50 to 220 °C. Registration and processing of chromatogram was carried out using a personal computer equipped with software NetChrom v2.1.

Determine the acid number

Acid number was determined taking about 5 g of oil, dissolving in the solvent mixture (diethyl ether: ethanol 1:2) and titration of free fatty acids by aqueous solution of sodium hydroxide.

Determine the peroxide number

Peroxide numbers of pressed oils were determined by iodometric method taking about 1 g of oil.

Determine the residual cake oil content

Determination of the residual cake oil content was conducted in the Soxhlet apparatus using petroleum ether as a solvent. Extraction time was about 8 hours.

Determine the degree of destruction of cell membranes

The method of instant shaking was used for determination of cell integrity. This method allows to determine the content of the so-called "free oil". The content of cells exposed on this method as follows. Sample oil materail about 10 grams are placed in a conical flask is poured 200 ml of petroleum ether and the flask contents were stirred for 3 sec (exactly), then the flask was left alone for 10 sec (exactly), after which the ether oil was quickly and carefully poured into another conical flask. The solution thus obtained is filtered through a filter into a weighed conical flask. After the filter was washed with several portions of ether, the ether from a weighted bulb distilled off and the oil dried to constant weight. Amount of oil, expressed as a percentage, corresponds to the number the so-called "free oil". In another test portion of the oil materail samples simultaneously determine the oil content of the conventional method to Soxhlet extraction.

Statistical analysis

Each measurement was performed three times. Variants of technological parameters of enzymatic pre-treatment before pressing were chosen under planning matrix of three factorial experiments. Enzyme concentration, moisture content of the material before pressing oil and duration of the enzymatic hydrolysis were input parameters of experiment design and oil yield was the output function. The obtaining regression equation was tested for variance homogeneity by Cochran criterion. The coefficients of obtained equation were tested for significance by Student's test. The adequacy of the regression equation was estimated by Fischer criterion.

Results and discussion

Hydrolysis temperature is a critical parameter for enzymatic processes. At higher temperatures the enzymes may be subject to recovery or inactivation. In the first case the enzymes affect the process, having a positive effect, while the second – do not show their activity. Regarding hydrolysis, equally important factor is the ratio of water to the solid substrate in the system. On the other hand, enzymatic treatment with high water content (moisture) may be more effective due to increased enzyme activity. In addition, high seed moisture during processing is an unfavorable factor from an economic point of view. This is due to the need to dry before the next stage of processing.

The main consequence of cellulase and protease pretreatment of oil material is the destruction of cell integrity of seeds. The obtained results of influence of technological parameters of enzymatic pre-treatment of seeds on quantitative yield of pressed oils are shown in Table 1. According to Table 1, the amount of oil yield depends on the final moisture of rapeseed before pressing, the concentration of enzyme and duration of pretreatment.

Table 1

Effect of prior enzymatic treatment parameters on quantitative yield of rapeseed oil

Sample N	The concentration of enzyme , % by weight of seeds	Processing time , h	Moisture content before pressing, %	Amount obtained oil, % by weight of seed
1	1,4	2	4	43,4
2	1,4	4	4	42,9
3	1,4	2	12	40,4
4	0,4	2	4	43,1
5	0,4	2	12	32,2
6	1,4	4	12	37,6
7	0,4	4	4	45,9
8	0,4	4	12	42,2

The best results were obtained in the samples of rape seed that had moisture content of 4%. Enzymatic treatment of oil material during two hours is sufficient to obtain a high quantitative output of oil compared with the control sample that was processed by the same method with the only difference – the lack of enzyme, residual oil content in the meal decreased from 24.4% to 9.4%. The 0.4% of the enzyme preparation to weight of seeds lets to achieve efficient removal of oil.

Enzymatic treatment in compression technology is a very effective method for increasing the amount of oil removed, which is characterized by higher quality of the finished products for final consumption, and the process requires less investment than traditional solvent extraction. The data on quality parameters of rapeseed oil are shown in Table 2. According to the results obtained acid number of samples N7 and N4 were the smallest, and the concentration of enzyme was on the lower level − 0.4%.

Quality parameters of rapeseed oil

Sample N	Acid number, mg КOH/g	Peroxide number, mmol ½O/kg
1	4,7	5,6
2	4,4	9,8
3	3,9	12,8
4	3,2	4,7
5	4,2	11,1
6	3,9	6,6
7	3,0	6,6
8	3,9	6,5

There were no direct dependence between time of enzyme pretreatment, enzyme concentration and final material moisture and peroxide numbers of oils. They were in a range from 5.6 to 12.8 mmol ½O/kg and samples N 1, 7 and 8 had the lowest values.

Analysis of fatty acid composition of rapeseed oil sample after enzymatic extraction have revealed increase of linoleic and oleic acids about 3 % and linolenic – more than 1 % in comparison to the control. The content of other fatty acids revealed no significant differences (Table 3).

Table 3

Composition of fatty acids in rapeseed oil samples

N	Fatty acid	Content of fatty acid, % of the total content	
		Oil after enzymatic treatment	Control oil sample
1	C 16:0	6,0	7,7
2	cis-9–C 16:1	0,2	0,4
3	C18:0	1,1	2,0
4	C 18:1	59,2	56,7
5	cis, cis-9,12–C 18:2	21,5	18,5
6	cis, cis, cis-9,12,15–C 18:3	6,2	4,8
7	C20:0	0,6	0,2
8	cis-11–C 20:2	0,3	0,5
9	C22:0	0,2	0,0
10	cis-13–C 22:1	0,1	0,2
11	C23:0	0,7	0,8

We have calculated a regression equation for the dependence of oil yield from enzyme concentration, moisture content of the material before pressing oil and time of the enzymatic hydrolysis on the basis of experimental data:

$$y = 49,04 - 0,72x_2 + 1,19x_3 - 1,01x_1x_3 - 0,15x_1x_2x_3.$$

In this equation input parameters that most influence the process of pre-processing and extracting oil: x_1 – the amount of enzyme,%; x_2 – moisture content before pressing,%; x_3 – duration extraction process (h). The level of statistical significance is a = 0.05. The intervals within which this equation is adequate given in the Table 4.

The range of variation of each factor

Name of levels variation	x_1, %	x_2, %	x_3, h
Higher level	1,4	12	4
Zero level	0,9	8	3
Lower level	0,4	4	2

The coefficients of obtained equation were significant according to Student test and regression equation was adequate according to Fisher test.

Increasing the number of removed oil from rapeseed samples that were previously processed by enzyme preparations of complex action shows that the enzymatic hydrolysis is very effective method of material pretreatment to the pressing. Adding the enzyme is possible in an aqueous solution, It is necessary to minimize the moisture oilseed material during enzymatic hydrolysis, as the next stage of processing is the drying. The effect of enzymes depends on the time and therefore the production process. Duration of treatment may be decreased depending on the chosen enzyme. The increase in peroxide and acid numbers in the two studied samples may be due to prolonged drying step before pressing. It should also examine the degree of denaturation of the protein component of rapeseed meal and the remaining amount of enzyme in the resulting oil.

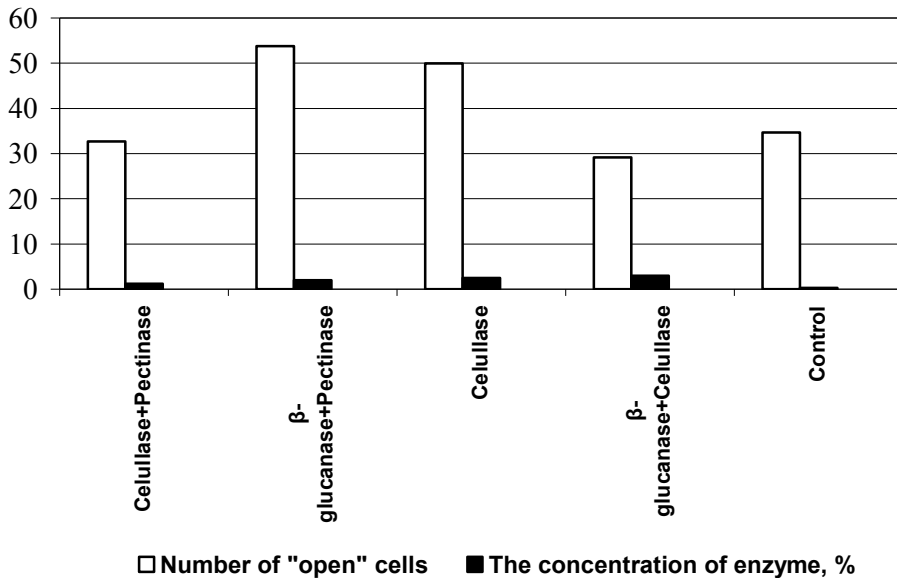The results determine the number of free cells of different samples shown in Figure 1.

Figure 1. Determining the average number of "open" cells in rapeseed
by method of instant shaking

Conclusions

Previous enzymatic processing of rapeseed makes it possible to increase the yeild of the pressed oil. The process of mechanical extraction of oil is affected by a significant number of factors, which in turn depend on processing parameters of oil material. The optimal humidity parameters of the oil material before pressing and duration of the enzymatic treatment are determined. The fatty acid composition of samples and their quality indicators, including peroxidation and acid number are analyzed. The main tasks of further research are to study the effect of cellulase and pectinase enzymes for rapeseed, to select the optimal ratio of substrate and biocatalyst, to determine the impact of technology on the quality of the oil.

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Refinement of technology of macaroni products enriched with whortleberry

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Abstract

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Introduction. Using of whortleberry powder in macaroni production from bread flour was researched that is actual for the quality improving and increasing of macaroni nutritional value.

Materials and methods. Macaroni products were made from wheat baking flour and whortleberry powder. The quality of macaroni products was estimated by means of complex quality index, that includes sensorial, physical, chemical indexes as well as nutritional value. Structural and mechanical properties of dough were determined at Brabender faringograph. Optimal technological parameters were determined by Box-Wilson method.

Results and discussion. The quality of macaroni products with addition of 5–10% whortleberry powder to the weight of flour have got violet color, improved cooking properties. The increasing of whortleberry dosage till 15% effects more acidity of macaroni and lower durability on 30%. Whortleberry powder causes decreasing of gluten content and its hydration. It is explained by fact that components of whortleberry effect dehydration of macaroni dough and prevent biopolymers wheat flour to form a dough. In this case gluten has got more elastic properties. Whortleberry powder encourages forming of small friability dough that fasten pressing of products. The optimal technological parameters have been determined, such as dosage of whortleberry powder – 4% to the weight of flour, temperature of water for the dough kneading – 37 °C. Such dosage fortifies macaroni products with this nutrient in 2,3 mh/100 g (consumption of 100 grams of macaroni products ensures daily requirement for vitamin C by 2.56%).

Conclusion. Researched results are recommended to varying of the assortment of macaroni products from baking flour and for dietary, vegetarian and children's nutrition and in case of using of flour with enhanced ability to darkening.

Introduction

Macaroni products are produced at specialized food enterprises, at the restaurants by equipment of small capacity and at home. The popularity of macaroni products in restaurant enterprises increases last time due to widening of Italian cuisine in the world.

Macaroni products have a non-balanced chemical composition (oversaturated of carbohydrates, low content of macro- and micro-elements, absence of fat-soluble vitamins A and E). It causes the search of ways for enriching of macaroni products with essential nutrients [1, 2, 3, 4, 5]. Investigations of scientists concerning applying of wild raw materials (barbaris, hawthorn, blackberry, rowan, whortleberry) in the technology of nutrition appears last years [6, 7]. Wild raw material is the source of valuable bioactive nutrients – vitamins, macro- and micro-elements, food fibers that give the functional properties to the products. The wild fruits are not processed by the chemical matters in the growth period as cultivated raw materials [6].

On author opinion, using of whortleberry powder is a perspective way in increasing of nutritional value of macaroni products. Whortleberry (*Vaccinium myrtillus L.*) in dry matters contain of food fibers 12,6 g/100 g, β-carotene – 9 mg/100 g, vitamin C – 57,14 mg/100 g, macro-element Ca –91,4mg/100 g, K – 291,4 mg/100 g, Fe – 40 mg/100 g [8]. These components are limited in macaroni products made from wheat flour. Applying of whortleberry powder in macaroni producing has not been investigated. Research of technological processes and proving of technological regimes of macaroni products with whortleberry powder producing will provide enriching of macaroni with bioactive substances and varying of assortment of macaroni made by wheat baking flour.

Methods of research

The wheat baking flour of higher grade is used as the main raw material for producing the macaroni products. The quality of the flour was characterized by the following parameters: moisture 12.5–13.0%, content of gluten 25–27% of average quality. Whortleberry powder was obtained by grinding of dried whortleberry at the laboratory pulverizer with further scattering onto the metal sieve with sizes of opening 1 mm. Whortleberry powder had homogenic texture, dark violet colour, moisture content $12 \pm 0.5\%$, acidity $4.2 \pm 0,2$ degree, ash assay $2.3 \pm 0,1\%$.

Raw macaroni products were shaped as noodles and twisted goods with 100 g mass by extrusion of pressed dough via die with inserts of cuprum matrix without teflon coating at laboratory press by 10 kg/hour capacity. Dough with moisture content 33–35% was kneaded during 10 minutes, warm kneading with water of 40–60 °C was used. Whortleberry powder was added in dry kind and in mixture with water in proportions of 5%, 10% and 15% per weight of flour. Raw macaroni products were laid on nylon sieve cassettes and ware dried at laboratory condition with temperature 20 ± 2 °C.

Macaroni products were analyzed in 6–14 days after producing. Each series of the experiments was triplicated. By measuring the basic quality factors of semi-finished and finished products, a sample sufficient for statistical processing was identified.

The organoleptic and cooking properties of the macaroni products were determined, as well as its physical and chemical quality characteristics, including moisture content, acidity and strength. Structural and mechanical characteristics of dough were determined by means of Brabender faringraph.

The structure (crumbliness) of macaroni dough samples was studied by scattering the batch onto the system of metal sieves (No. 7, 5, 3, 1) and by determining the mass of dough

fractions different in size according to the methodology developed by prof. Yurchak V.G. The amount of crumbs of each dough fraction was proportioned in percentage per batch. The speed of macaroni extrusion (mm/s) was determined by measuring the length of the raw product extruded within 30 seconds. The productivity of press, kg/h, was determined by weighting the product.

The quality estimation of macaroni products was implemented by complex index [9]. This index includes estimation of organoleptic, cooking properties, physical and chemical characteristics, nutritional value of macaroni products and is calculated by 100 balls range.

For the installing of optimal technological parameters of macaroni with whortleberry powder producing the method of experimental and statistical analysis of the results has been used, including the identification of errors, calculation of regression coefficients of the mathematical model, assessment of the significance of mathematical model and verification its adequacy. The optimization of the process was performed using the Box-Wilson complex method by plan of full factor experiment 2^2 [10].

The chemical content, biological value by aminoacid content and nutritional value of macaroni products were calculated by means of integral score [11].

Results and discussions

Firstly, the effect of whortleberry powder (5%) to the quality of macaroni products has been investigated (Table 1). It has been installed that macaroni products with whortleberry powder get light violet colour, pleasant taste and better cooking properties: mass and volume of cooked products increases. But, passing of dry matter into cooking water increases by 0.5%. Obviously, due to saccharides that solve in cooking water.

Totally, macaroni products with whortleberry powder had higher quality on 3 balls by complex index comparing to the products without additional raw materials.

At the further step the dosage of 10 and 15% of whortleberry powder to the mass of flour has been investigated with the aim of maximum fortification of macaroni products with valuable bioactive substances. It was important to save the acceptable quality of macaroni products.

It has been installed (Table 2), that products with 10, 15% of whortleberry powder get strong violet colour and whortleberry taste, that do not worst the taste properties of products. However, micro-cracks appear in the structure of products and strength decreases to the 30%. This indicates that whortleberry powder does not ensure the formation of structure products.

The increasing of acidity of products has been installed, in case of dosage whortleberry powder 15 % this index increases triply.

Cooking properties of products get worst, namely, products have less volume after cooking, the amount of dry matter passed in cooking water increases. As a result, complex quality index of macaroni products decreases.

However, acceptable quality of macaroni products is characterized in case of dosage 5% of whortleberry powder. Further increasing of dosage has a negative effect to the quality of macaroni products – acidity increases; cooking properties are getting worst, strength decreases.

The quality of gluten, structural and mechanical processes, friability of macaroni dough and parameters of pressing have been researched to prove the mechanism of influence of additional raw materials to the processes of dough and products forming, structure of dough.

Table 1

Effect of whortleberry powder on the quality of macaroni products

Quality indexes	Characteristics of products with the addition of whortleberry powder	
	Control (without whortleberry powder)	Whortleberry powder, 5% to the weight of flour
Organoleptic characteristics		
Colour	White	light violet
Surface	Smooth, small number of cracks	
Micro-cracks	Absent	
Fracture	Glassy	
Physical and chemical characteristics		
Moisture,%	13 ± 0.5	12 ± 0.5
Acidity, degree	2.2 ± 0.2	2.5 ± 0.2
Strength, H	5.5 ± 0.2	5.2 ± 0.2
Cooking properties		
Cooking time, min.	18 ± 1	18 ± 1
Mass increase index, M_i	1.4 ± 0.1	1.5 ± 0.2
Volume increase index, V_i	1.5 ± 0.2	1.6 ± 0.1
The amount of dry matter passed in cooking water,%	7.0 ± 0.2	7.5 ± 0.3
Stickiness, shape	Retain their shape, stick in some way	Retain their shape, do not stick
Taste and odour	typical for the kind of the product	light whortleberry, free of foreign
Complex quality index	**89 ± 1**	**92 ± 1**

The gluten research was implemented with dosage of whortleberry powder 5 and 10 % to the weight of flour (Table 3). It was found that whortleberry powder provides a reduction of gluten and its dehydration ability. This gluten reveals more elastic properties in terms of extensibility and compression device DDG-1. Obviously, whortleberry powder and flour proteins compete for water absorption in the dough. As a result of more coarse dispersiveness fiber whortleberry powder prevents swelling protein wheat flour for gluten formation.

The study of structural and mechanical properties of the dough carried on with whortleberry powder in dry form in an amount of 5 and 10% by weight of flour.

Results of farynohrams (Figure 1, Table 4) show that the addition of whortleberry powder practically has no influence on the water absorbing ability of dough.

The duration of formation dough, in other words, time during which the value of consistency investigated dough reaches its maximum, increases with the addition of whortleberry powder.

Sustainability (stability) of dough, which characterizes the duration of preservation macaroni the maximum level of consistency in the mixing, not typical for all samples. However, the degree of dilution of dough, which is characterized by the difference between the maximum reached during mixing texture and consistency in the final mixing time, increases with increasing dosage of whortleberry powder. Evaluation based on farinogram reduced. This indicates that the components of whortleberry powder detect dehydrating effect in the macaroni products dough and prevent biopolymers wheat flour to form a dough.

Table 2

Effect of whortleberry powder dosage on the quality of macaroni products

Quality indexes	Characteristics of products with the addition of whortleberry powder, to the weight of flour		
	Control sample	10 %	15 %
Organoleptic characteristics			
Colour	white	intense violet	
Surface	smooth	small number of cracks	
Micro-crack	absent		
Fracture	glassy		
Physical and chemical characteristics			
Moisture,%	12 ± 0,2	12 ± 0,5	13 ± 0,5
Acidity, degree	2.2 ± 0,2	4.8 ± 0,2	6.5 ± 0,2
Strength, H	5.4 ± 0,3	4.2 ± 0,2	3.9 ± 0,3
Cooking properties			
Cooking time, min.	17 ± 1	13 ± 1	10 ± 1
Mass increase index, M_i	1.4 ± 0,2	1.3 ± 0,1	1.1 ± 0,1
Volume increase index, V_i	1.5 ± 0,2	1.4 ± 0,2	1.2 ± 0,2
The amount of dry matter passed in cooking water,%	7.0 ± 0,1	7.7 ± 0,1	8.0 ± 0,2
Stickiness, shape	Some stick together, form is not lost		
Taste and odour	typical for the kind of the product	light whortleberry, free of foreign	
Complex quality index	**89 ± 1**	**88 ± 1**	**85 ± 1**

Table 3

Effect of whortleberry powder to the quality indexes of gluten

Indexes	Dosage of whortleberry powder		
	Control sample	5%	10%
Content of raw gluten,% to the weight of flour	25.4 ± 0,2	24.6 ± 0,2	21.2 ± 0,2
Content of dry gluten, %	8.4 ± 0,1	8.6 ± 0,2	7.9 ± 0,1
Humidity of gluten, %	67.0 ± 0,5	64.8 ± 0,5	62.6 ± 0,5
Hydrating ability of gluten,% the weight of dry gluten	203 ± 2	184 ± 2	167 ± 2
Colour	Light	dark, violet	dark, violet
Extensibility, cm	19 ± 1	17 ± 1	16 ± 1
Elasticity	Extensible	extensible	extensible
Elasticity of gluten, unit of device DDK	73,6 ± 0,2	64,7 ± 0,3	45,8 ± 0,2

Table 4

Farinogram indexes of dough with whortleberry powder

Indexes	Without additional raw materials	With 5% whortleberry powder	With 10% whortleberry powder
Watersorbing capacity, sm³/100 g	59.6–56.4	59.8–56.6	59.4–56.2
Time of dough forming, min.	2.5	3	5
Stability, min.	0	1	0
Rarefaction for mixing, unit of device	35	165	180
Evaluation based on farinogram, units of device	52	42	48

a

b

c
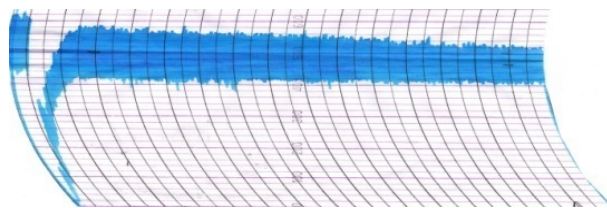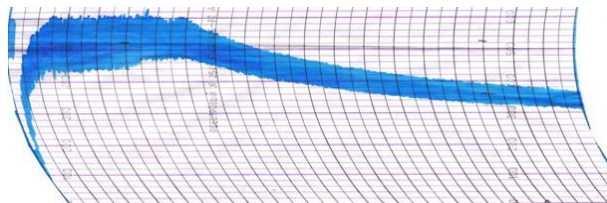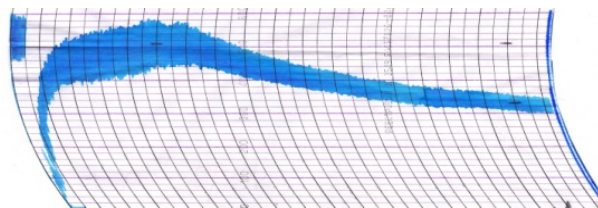
Figure 1. Farynohrams of macaroni products dough:
a – no additional material (control); *b* – adding of a 5% whortleberry powder;
c – adding of 10% whortleberry powder

Results of studying of friability of macaroni products dough established (Figure 2), that whortleberry powder provides formation more small friability dough: increasing mass fractions of crumbs with size of 3–5 mm and greater than 1 mm, and weight decreased of largest fraction in case of increasing the dosage of whortleberry powder.

Growth of pressing parameters of macaroni dough with whortleberry powder has been established (Figure 3). Thus, adding of whortleberry powder in an amount of 5–10% by weight of flour increases the speed and productivity of extrusion press due to the formation dough with crumbs to the size that best fill the screw turns. This is positive as it allows to get more production per unit of time.
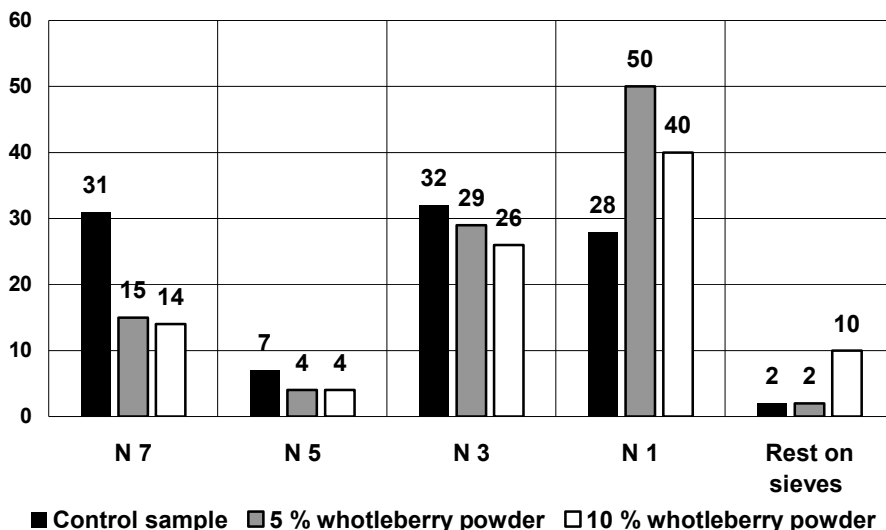

Figure 2. Effect of whortleberry powder to the macaroni products dough friability
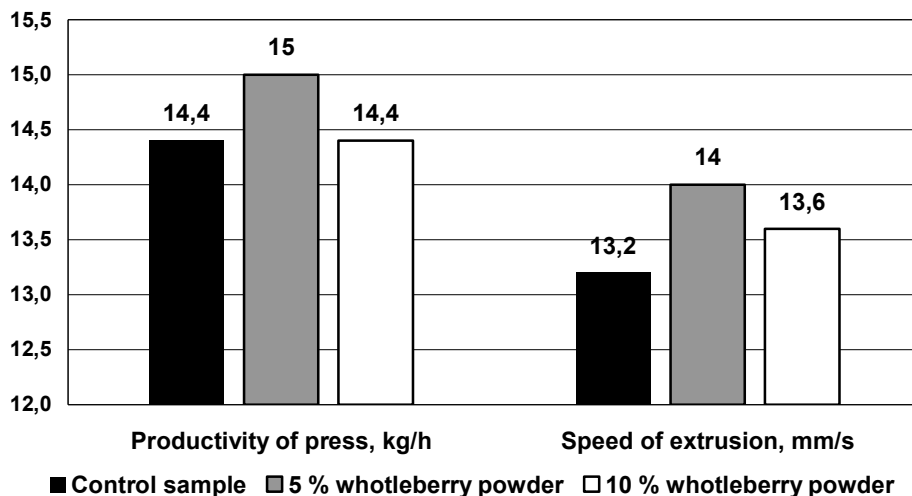

Figure 3. Effect of whortleberry powder extrusion parameters macaroni products

The full factorial experiment FFE 2^2 has been implemented for studying the compatible influence of technological factors on the quality of semi-finished and finished products and determining of optimal process parameters of macaroni dough producing.

The dosage of whortleberry powder, which has found in one factor experiment, requires clarification of the interaction of other technological factors. Therefore, quantity of whortleberry powder and water temperature for dough kneading were selected as the factors for optimization of products. Quantity of whortleberry powder changed in the range of 4 – 12%, water temperature – from 33 till 55 °C based on obtained preliminary results. Complex quality of macaroni products index has chosen as an optimality criterion.

Processing of experimental data using correlation regression analysis allowed getting the regression equation in a coded expression (1), which describes the dependence of the original function of the studied variables:

$$Y = 89,25 - 1,8 \cdot X_1 + (-2,37 \cdot X_2) \tag{1}$$

where X_1 – adding of whortleberry powder; X_2 – temperature of water mixture.

The analysis of mathematical dependences for complex quality in coded form allows to conclude that the effect of the studied variables on the original function and to quantify this impact. Reduction of whortleberry powder dosage and temperature of water increases the complex quality.

Processing of experimental data has been performed using FFE 2^n, which was created in programming environment Borland Delphi v 6.0. Materiality regression coefficients have been estimated by Student's test, the adequacy of the resulting mathematical model has evaluated by Fisher criterion, the estimated value of which was 5.9.

The optimal values of technological parameters: whortleberry powder dosing – 4%, the water temperature for kneading – 37 °C, providing maximum value complex quality – 94.5 points have been installed as a result of building the program "steep climb" and the implementing of experiment. These parameters were the basis for developing of technological instructions and recipes for making of macaroni products with whortleberry powder.

According to calculations, the nutritional value of macaroni products found that growth of macronutrients content compared to products without additional materials is negligible increases in fiber and carbohydrates. However, carbohydrates of whortleberry are presented by mono- and disaccharide that is digestible carbohydrates. As a result, the energy value of macaroni products is falling.

Analyzing mineral composition of macaroni products found that they increased with potassium, calcium, phosphorus and iron. Iron contained in whortleberries, is better absorbed due to content of ascorbic acid in whortleberries [12].

Taking to the attention fact that macaroni products without additional raw does not content vitamin C, products with 4% whortleberry powder fortified with this nutrient in 2,3mh/100 g, which the consumption of 100 grams of macaroni products daily requirement for vitamin C is ensured by 2.56%.

Conclusion

The feasibility of using whortleberry powder in producing of macaroni products has been installed based on experimental data.

Adding of powdered whortleberries has positive effect on the quality of macaroni products in particular 5% whortleberry powder become violet, cooking properties improve,

such as the weight and volume increases, except of it, products with whortleberry powder with higher integral index for mineral and vitamins.

The increasing of dosage of whortleberry powder – 10 and 15% by weight of flour has been investigated. Deterioration of quality of macaroni products with 15% whortleberry powder for organoleptic and cooking properties has been established.

The effect of additional raw materials to the quality of gluten and structural and mechanical properties of dough found that whortleberry powder components detect dehydrating effect on the structure of the macaroni products dough and prevent biopolymers flour to form a dough.

Whortleberry powder promotes formation of small friability of dough that encourages growth of pressing parameters of macaroni products.

Optimal parameters of macaroni making with whortleberry powder, namely the amount of powder – 4% by weight of flour, water temperature for the dough – 37 °C have been set on experimental and statistical modeling. The resulting figures have been included to technical and technological documentation for macaroni products with whortleberry powder.

As the whortleberry powder gives the product purple colour, so it should be used for production of flour with enhanced ability to darkening.

So increasing of nutritional value of macaroni products using whortleberry powder has a social effect. These products are made from domestic raw materials, indicating the stability of raw materials. This will help diversify domestic macaroni products, especially dessert group, and enhance their competitiveness. Such products can be offered in the diet, vegetarian, children's menu at the restaurant establishments.

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Drying of the composite phytoestrogen materials

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Abstract

Introduction. Compositions from phytoestrogens include components which differ from mono-raw-materials by the high protein and the presence of a significant percentage of lipids. During the processing of raw materials makes sense to develop a mode of the preparing of soybean with inactivation non-food components and drying with maximum preservation of biologically active substances.

Materials and methods. During the research methods used by modern means of measuring parameters of drying, such as the time of the experiment , coolant temperature and reduce the weight of the material. To assess the quality of functional products was used standard research methods with using spectroscopy methods.

Results and discussion. Developed preparing soybean in which almost completely inactivated trypsin inhibitor – is 4%, or tracks within the error, and increases protein digestibility of 25%. We used the songs: soybeans – carrots (hydro-thermal processed) and carrot-rapeseed (without hydro-thermal processing). To prevent lipid soy and rapeseed them combined with vegetables. The drying process is a binary mixture in the second period. Drying material mode coolant 120 °C reduced by almost half compared to the duration of the process at 70 °C. Acid number increases to 5 – 8%, material at a temperature of 100 °C. Drying Rape-carrot mixture is in a period of falling drying rate of the previous warming material. In drying mode t = 70 °C; V = 3,5 m/s; δ = 10 mm maximum speed of drying is 11.5 %/min. The final temperature of the mixture 78 °C. To prevent melayidynovoyi reactions that occur during drying material with protein with high carbohydrate content specified maximum temperature threshold 60–70 °C. With increasing temperature of the coolant increases acid number (at 70 °C to a critical level of 4.2 – 4.5%, and at 100 °C rising to unacceptable values of 9 – 11%).

Conclusions. Created floral compositions in which the most basic food components are stored. Developed preparing regimes soybean and rapeseed to create compositions with drying. As a result, studies were first obtained phytoestrogenic products based on soy and vegetables, canola and vegetables.

Introduction

Soya is considered a rich source of proteins, lipids and contains other biologically active compounds such as isoflavones, saponins and phytosterols. This diversity compounds is complicating the process determine the beneficial biological function for one connection after eating products based on soy (tofu, soy milk). For example, lowering cholesterol is associated with the consumption of soy protein, saponins, isoflavones, fytosterynov [1,2]. It is therefore important to use in food processed soy with shell, not individual products beans.

Phytoestrogens – substances which are contained in small amounts in almost any plant foods but in varying amounts. These substances on its structure resemble human hormone estradiol – the most active form of estrogen [2]. It is known that estrogen plays a role in reproductive function and bone health women's , and believe that it protects women from heart disease with the onset of menopause. For these reasons phytoestrogens are regarded as potentially important substance for the prevention of a variety of human diseases, including heart disease and some forms of cancer[2,3].

Soy-based products are a major source of isoflavones. Isoflavones found in almost all vegetables, but their main source are seed of soy and oilseed rape, dried peas [4].

The high fat content reduces the shelf life of crushed soybeans, the oxidation of fat which leads to the destruction of other nutrients. To prevent oxidation of fat, soybeans was combined with carrots, red beets and onions.

During processing under the influence of moisture and temperature is swelling globules soy protein that promotes physical replacement and release of oil globules from cytoplasmic matrix soybeans and their interaction with vegetables [Patent of Ukraine 29892 MPK A23 L1/20, A23 V7/02. Sposib oderzhannia soievo-morkvianoho poroshku].

Thanks to colloidal capillary-porous structure of raw-material, moisture of ingredients (soy beans 12...14% and vegetables 88...90% humidity) with careful mixing redistributed and equalized.Carotene substances of vegetables partially soluble in soybean and rapeseed oils, that protects carotene molecule from contact with the oxidant and save them from destruction [3–4].

During technology processing of soybean is necessary to adjust the depth denaturation of the protein. On the one hand, the minimum denaturation retains biological food-value of protein , and the second – more stringent regimes for hygro-heat treatment are required for inactivation of undesirable enzymes and proteins-trypsin inhibitors (Patent of Ukraine 29891, A method for producing a powder from a soy and pumpkin).

For soy exsist typical components that reduce the nutritional quality of protein products. These components include the substance of protein nature and non-protein character. The components of protein origin are soyin, trypsin inhibitors, some hygroma-lytic enzymes (protease, urease) and redox enzymes (lipoxygenase).

Products of processing soybeans have a specific odor, whose need to get rid of. Already in the early stages of processing (soaking) disappears odor.

Materials and methods

For conducting research were used soy, canola, carrot chips, onions, squash, table beet and functional compositions of them. Drying of raw-materials was performed on experimental drying booth in a wide range of operational parameters, the temperature varied in the range of 60...100ºC, air speed 2.0...3.5 m/s, the moisture content of the coolant

7...15 g/kg, layer thickness of 2...20 mm., with continuous automatic collection and processing of information took place with the help of the developed application "Sooshka".

Drying soybean and rape was conducted at 70 ºC coolant, air speed of 2 – 3,5 m/s, carrier of moisture 10 g/kg evaporated moisture, the material layer thickness of 2...20 mm. Quality control of finite raw-materials was performed defining the final material change in acid number.

Physical – chemical studies to assess the quality of plant raw-materials and received from it phytoestrogen powders were performed by standard methods.

Standard and official analytical methods – consuming and sometimes non-specific and require a lot of time – include pretreatment of samples using complex chemical, physical and biochemical reactions. Many of these methods are not sufficiently selective, complex, or require expensive equipment, and hazardous chemicals. Therefore there is an urgent need for methods with high sensitivity and in a standardized, internationally recognized methods, including combined.

Before carrying out any analytical study at determine the chemical composition of the plant material must extract these components. In each case, determine which solvent to use for this rawmaterial, and further we are working by the standard method.

Results and discussion

Studied the effect of preliminary preparation phytoestrogenic raw materials on reduce anti food components and changes in chemical composition.

Developed modes preparing of soy beans which include: soaking full beans within an hourhour at a temperature of medium 50ºC. Washing them after soaking, cooking for 20 minutes. After this, to prevent oxidation of lipids, soybeans combined with raw materials containing carotene.

During hygro-termal processing (cooking soybeans for 20 min.) happens inactivation of enzymes, including lipoxygenases complex and partial loss of light volatile and insoluble in water decomposition products. At the same the concentration is decreases: of 2–butanol (2.5 times), n-butanol (1.8 times), izopentanola (3.2 times), n-hexanol (in 5.0 times) [3].

In the process of the study was determined the chemical composition of soybeans before and after hygro-termal processing and changes of quality in previous stages humid-heat treatment [4].

Quality soybean hygro-termal processing for processing, nitrogenous substances – 35%, lipids – 16% carbohydrates – 27% digestibility – 55%, trypsin inhibitor – 50%.

Quality soybean hygro-termal processing after treatment, nitrogenous substances – 32%, lipids – 16% carbohydrates – 22% digestibility – 80%, trypsin inhibitor – 4%.

The quality of raw materials and finished products was evaluated by the content of dry substances, mass fraction of total nitrogen, sugars, lipids, digestibility proteins. After hygro-thermal process, increases digestibility of protein by 25% and is almost completelyinactivated trypsin inhibitor.

Compared with untreated soybeans – beans,which was processed lose a small amount to 5% of soluble protein that goes into the water, fats remain unchanged. Occurs a partial loss (10%) of soluble carbohydrates losses due oligosaccharides that are not digested by the human body, which is a positive.

To investigate material with phytoestrogen was chosen combination soybean-carrot with hygro-thermal treatment and rapeseed-carrot without hygro-thermal treatment. To prevent lipid soy and rapeseed them were combined with vegetables.

Dehydration of plant materials, as has been emphasized – one of the most important stages of the technology process, which greatly determines the quality of finished products. Soy-vegetable compositions as drying objects are complex in structure, physico-chemical and biochemical composition. They combine the properties of soy and vegetables with rich mineral and vitamin content and high nutritional value of vegetable protein. The content of vegetable protein gives them special properties that require a more thorough study of the processes of dehydration [5,6].

With this aim were conducted experimental studies on drying soy-carrot combination in the temperature diapason of the 70 to 120 °C (Figure 1) [4].
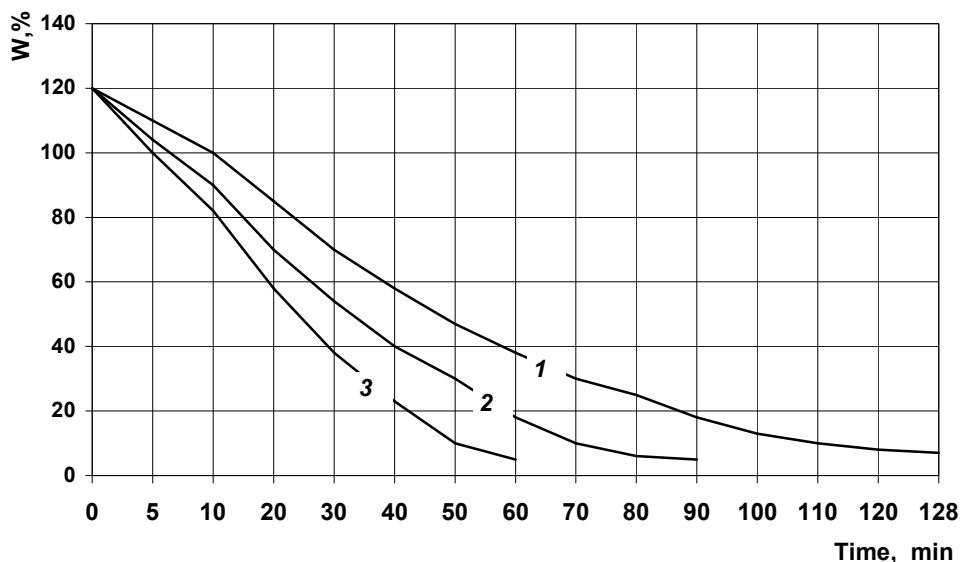
Figure 1. The influence of coolant temperature on drying up composition of soy-carrot
V = 2 m/sec; d = 10 h/kg dry product:
1 – 70 °C, 2 – 100 °C, 3 – 120 °C.

Combined analysis of the data showed that the drying process of binary mixture is passes in the second period. With the deepening of evaporation area into the material the temperature is increased, and the speed of recoil of moisture reduced. Curves of drying rate show that with increasing of temperature heat carrier intensity – the intensity of dehydration the increases. Mode drying material heat carrier 120 °C reduced by almost half compared to the duration of the process at 70 °C.

The influence of temperature, speed of heat carrier and layer oilseed rape-carrot mixture on the kinetics of the drying process shown in Figure 3, 4, 5.

From increasing the temperature of heat carrier the drying period decreases in the temperature range from 60 to 70 ºC reduced by 8%, and during a further increase in temperature from 70 to 80 ºC reduces by 25%, and from 80 to 100 °C – 16% (Figure 2) [4].

The increase in heat carrier temperature more than 80ºC leads to oxidation of lipid and partial destruction of carotenoid as was considered earlier [3]. That's why, the impact speed and the quality of the material dried raw explore 70 ºC heat carrier temperature (Figure 3) [4].
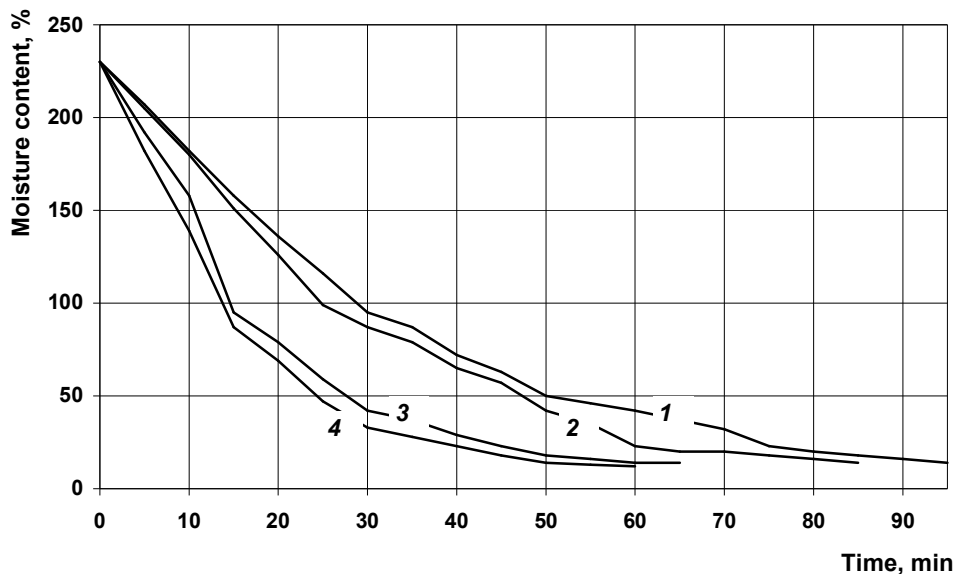
Figure 2. Influence of coolant temperature on drying kinetics composition of rape – carrot (1:2)
δ = 10mm (c) at V =3,5 m/s; W= 8%; d = 10 g/kg dry product;
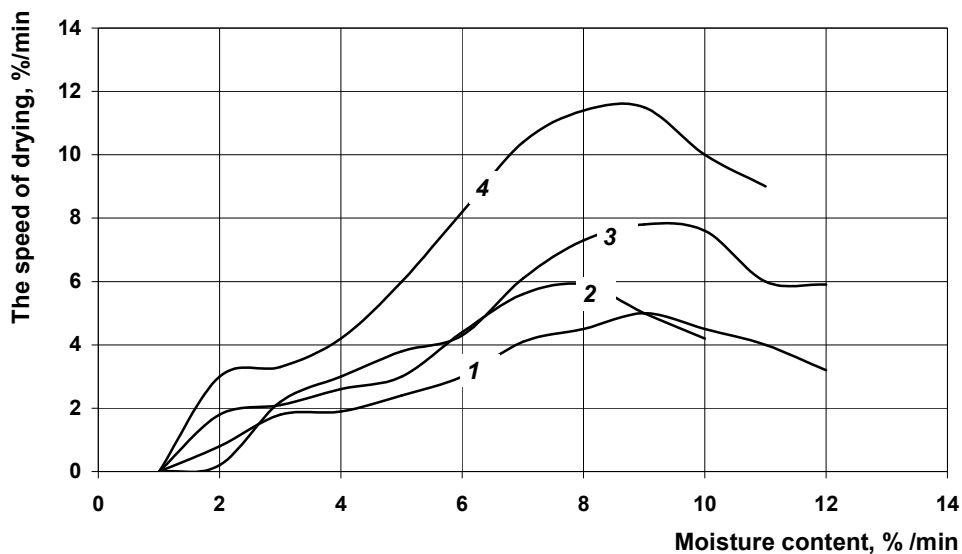1 – 60 ºC, 2 – 70 °C, 3 – 80 ºC, 4 –100 ºC.

**Figure 3. Influence of heat carrier temperature on the rate of drying composition
rape – carrot (1:2)**
δ = 10mm (c) at V =3,5 m/s; W =8%; d =10 g/kg dry product:
1 – 60 ºC, 2 – 70 °C, 3 -80 °C, 4 – 100 ºC.

Drying mixture of oilseed rape – carrot is happens in a period of falling drying speed of previous with warmed material. In drying mode t = 70 ℃; V = 3,5m/sec; δ = 10 mm maximum speed of drying is 11.5 %/min. The final temperature of the mixture 78 ℃.

The study of phytoestrogenic material showed that the greatest impact on drying kinetics and quality of the material comes from the heat carrier temperature [8,9].

Changing the temperature in the middle layer of 10 mm, as shown in Figure 4, occurs more slowly with the mode of drying 60,70 ℃ and more noticeable growth observed with temperature increases to 80 – 100 ℃ [4].
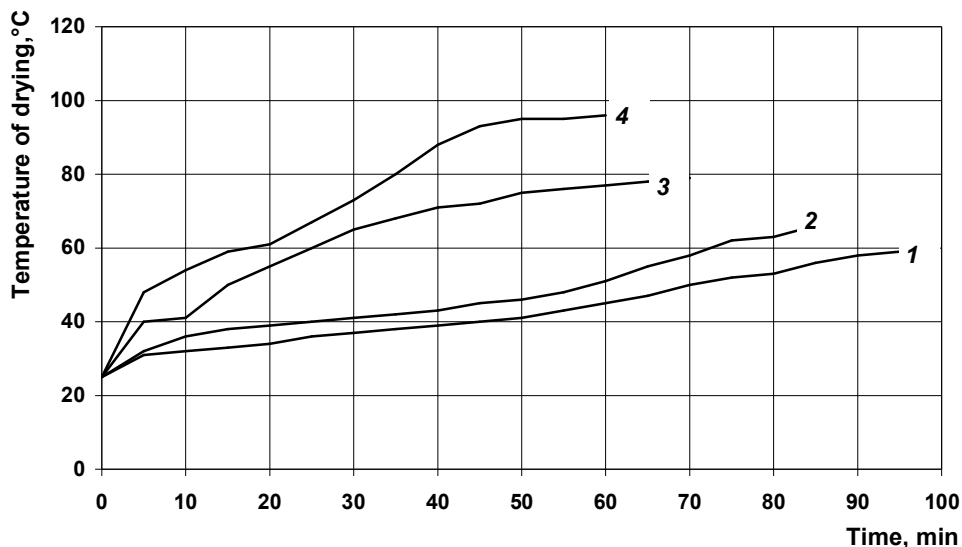
Figure 4. Effect of temperature heat carrier on to temperature change inside layer of the rape – carrot composition (c)
δ = 10mm (c) at V = 3,5m/s; W = 8%; d =10g/kg dry product:
1 – 60℃, 2 – 70 °C, 3 – 80℃, 4 – 100℃.

When considering research quality of phytoestrogenic material we chose a combination of soy – carrot which was hygro-thermal treatment, oilseed rape, carrots without hygro-thermal treatment. Also we are studied composition with soy-based pre-processing hygro-thermal such as soybeans – beets, soybeans – onions, soybeans – pumpkins, soybeans crushed. This raw material contains a large amount of fat 20–40%, which are oxidized during processing and in turn destroy biologically active substances. Therefore, the influence heat carrier in the processing investigated in determining acid number change [4].

In entire oilseed rape and soya beans during drying from the temperature of heat carrier practically no happens change in acid number. Shredded soy and oilseed rape have another characteristics during heat treatment [6,7].

Acid number is raised to 5–8% at the temperature of material the 100 ℃. The entire membrane around the seeds of soybean and rapeseed protects fats from the effects of temperature and therefore the process of oxidation fats not happens. In the crushed soybeans and oilseed rape this process is happens intense. With increasing temperature of the material in crushed soy and oilseed rape is increased acid number. At a temperature of

70 ºC of the crushed material the acid number rises to a critical level 4.2 – 4.5% and at the temperature 100 ºC increases to values of 9 – 11%, which is already unacceptable. At the earlier researching of paste, which consist caroten, were shown that at 5% of the acid number happens the destruction of carotenoids are to 63%, and also happens the loss of other biologically active substances [3]. Also partial hydration of fats during drying rapeseed – carrot, soy – vegetable compositions. Creation of compositiia based on soy, rapeseed with vegetables made it possible to maximum to preserve the lipids from oxidation and offer drying modes phytoestrogenic raw-material with temperature of the heat carrier the 70 ºC [7,11].

Optimum temperature of heat carrier at the drying fitoesrohennoyi raw material, with pretreatment or without her, is the 70 ºC.

Conclusions

Advance preparation phytoestrogenic raw materials allowed completely inactivate the nonfood components of soybeans, increase the digestibility of proteins. Creating compositions of soybeans – vegetables, rapeseed – vegetables allowed prevented lipid oxidation during processing.

Was determined the optimum temperature of the coolant during drying phytoestrogens raw materials, it is 70 ºC.

The suggested regimes allowed to obtain a new product from soy, raps and vegetables. Absence, in time the preparation of the material to drying, chemicals and other foreign ingredients allowed to obtain high-quality environmentally friendly products while preserving in concentrated form all the substances that make up the output feedstock.

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Cutting speed value during plant material grinding in food industry

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Abstract

Introduction. The influence of cutting speed factor on elastic and frictional properties of plant materials is investigated and justified. The dependence of cutting force on cutting speed is determined. The choice of rational parameters of the process is justified by the qualitative indicator of the ground product.

Materials and methods. The elastic properties of vegetables have been studied by the standard method of sample compression between two plane-parallel plates. Compression force has been recorded. Frictional properties were measured on the setup of disk type: the test material was in contact with a rotating steel disk, the friction force was recorded. Cutting forces were measured by the tensometric method during plate blade penetration into the material layer. The cutting speed varied within the range of 0.4–2.5 m/s.

Results and discussion. With the increase of cutting speed the elastic properties of the material appear to a lesser degree, due to the spread of elastic deformations in the layer. Within the cutting speeds range from 0.4 m/s to 2.5 m/s the elasticity modulus is reduced by a factor of 1.2.

Frictional properties that are characterized by a friction coefficient are reduced by a factor of 1.2–1.5 with the increase of sliding speed of friction pairs from 0.75 to 2.66 m/s. The nature of these changes depends on the structural configuration of the material, the moisture content, contact surfaces quality, the pressing force of friction pairs.

Cutting forces of plant materials depend on their structural and mechanical properties. The increase of cutting speed within the ranges under study will contribute to their reduction by a factor of 1.4–2, depending on the product type. In this regard, it is appropriate to use higher cutting speeds of plant materials for vegetable cutting equipment in order to reduce specific cutting forces.

To get high quality cutting it is necessary to consider the influence of cutting speed, cutting thickness, structural characteristics of the products to be ground.

Conclusion. Taking into account the factor of speed influence on cutting forces of plant materials, the optimal and the recommended range of circumferential cutting speeds for the products under research is from 300 to 600 rev/min.

Introduction

The task of this article is to study the cutting speed factor influence on elastic and frictional properties of plant materials; to define the dependence of cutting force on the speed of blade cutting edge penetration into viscoelastic product; as well as to justify the expediency of high cutting speeds use with qualitative indicator of the ground product.

Cutting force of food material is a major energy component of the cutting process. The effectiveness and the expediency of the chosen grinding method will depend on this indicator value. Reducing the value of cutting force is a priority for the intensification of this process.

In this article, we raised the issue of grinding food products of plant origin (vegetables), which are classified as viscoelastic materials.

At the enterprises of restaurant business vegetable cutting machines of disk type are most widely used when grinding vegetables. In these machines, the product is cut with a rotating blade installed in the working chamber of the machine on a special supporting disk. Depending on the configuration of blade cutting edge the cut shape may change [1].

The conducted analysis of technical and operational performance of vegetable cutting equipment has shown that in machines of different models the grinding speed ranges from 0,4 up to 2.5 m/s [2]. The analysis of the literature reference revealed no data on speed factor influence on the cutting process of viscoelastic plant materials in the indicated range. Besides, the factor of cutting speed influence on quality indicators of the ground product has not been studied yet.

Cutting force in vegetable cutting machines of disk type depends on geometrical parameters of the cutting tool (blade thickness, blade sharpening angle, surface roughness of the cutting edge), technical and operational parameters of the machine (cutting speed), and on the structural and mechanical properties of the product being ground, namely – coefficient of product friction on the surface of blade cutting edge, and elasticity modulus [1].

The influence of geometrical parameters of blades on the cutting force is described in works [1, 3, 4, 11]. Structural and mechanical properties of viscoelastic materials are given in works [5–8]. Data on the influence of cutting speed on structural and mechanical properties of the plant material in the indicated range of cutting speeds are not systematic.

Materials and methods

The experiments were carried out with vegetables having a relatively uniform structure: potatoes, onions, carrots, beets, eggplants, zucchini, cucumbers.

The study of elastic properties of plant materials was carried out by compressing the product sample between two plane-parallel plates according to standard methods [1, 3, 7]. During the experiment the sample compressing force was recorded.

A linear relationship between compression stress and relative deformation has been assumed in determining the numerical values of elasticity modulus [6, 8, 9].

To conduct the studies of frictional properties of plant materials the experimental setup of disc type has been developed [10, 11, 12]. The setup design allows to study the influence of sliding speed on frictional properties of the product in conditions most closely resembling the actual manufacturing process. The setup consists of a head section, disk of 150 mm in diameter which rotates in a horizontal plane (disk is made of polished food stainless steel), the vertical beam with tensoresistors placed on it, at the lower end of which

the box with the product sample is mounted, the amplifier, the analog-digital converter, PC and the package of licensed LGraph software.

Product sample is pre-set the desired geometric dimensions. For each subsequent measurement a new sample of the product in a freshly cut form was used which eliminates the possibility of juice loss. The required speed limit is set with the speed regulator. During disc rotating the product sample is carried away with friction force and bends the measuring beam. Devices record friction force value which is displayed on a monitor in a form of oscillograms in real-time mode. The friction coefficient is defined as the ratio of frictional force to the weight of the sample under research.

Specific efforts of plant materials cutting were determined by measuring the cutting force during plate blade penetration into the sample layer. The research was carried out at a linear cutting speed of 0.005, 0.1, 0.47, 0.75, 1 and 1.25 m/s.

The experimental setup similar to vegetable cutting machine of disk type at food plants was used to study the influence of cutting speed limits on the quality of vegetables cutting. The setup allows to change the circumferential blade speed from 150 to 2000 rev/min. The product portion of 1 kg weight was ground at a predetermined cutting speed, and then the cutting quality was analyzed and the number of substandard particles in the total mass was defined.

The measurement and organoleptic methods were used to evaluate the product quality indicators. The product was sliced 1, 4 and 6 mm thick. Grading was determined in percentage correlation to the total amount of the product to be cut.

Results and discussion

Cutting speed influence on elastic properties of plant materials. Experimental studies allowed to prove the reduction of elastic properties of plant materials pulp with the increase of influence speed on the sample product under research. This is due to the development of slow elastic deformation in the product. Initially, when loading a viscoelastic material, there occur instantaneous and delayed elastic deformations. Instantaneous elastic deformation is developed quite fast, it is almost impossible to be fixed experimentally, that is why it is designated arbitrarily and is assumed to be zero in practice. Delayed elastic deformation is the value that can be numerically determined. The distribution of delayed elastic deformation depends directly on the loading speed.

The increase of deformation speed leads to the fact that viscoelastic stresses in the product sample hardly relax, tensile strength occurs immediately after the yield point, plastic deformation does not occur and brittle fracture is observed. The total deformation work of the product will decrease.

The dependence of elastic modulus E of viscoelastic plant materials on the deformation speed ε in the indicated speed range is of linear character (Figure 1) and is described by the equation (1):

$$E = k_1 \cdot \dot{e}^n , \qquad (1)$$

where k_1 and n are the coefficients which are defined by experiment.
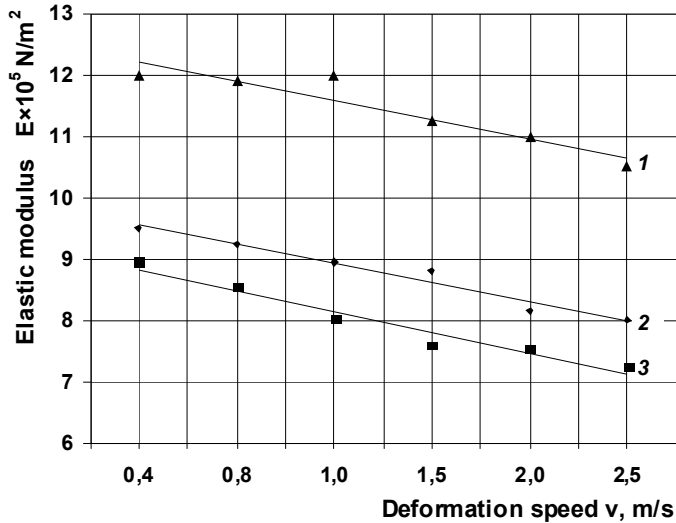
**Figure 1. The dependence of elastic modulus
on the deformation speed for some vegetables:**
1 – potato; 2 – carrot; 3 – onion.

The dynamics of elastic modulus change from the deformation speed is somewhat different for different kinds of vegetables, which is associated with the structural configuration of the products under study, and their moisture content.

Summarizing the results of the experiment, we should point out that for the investigated plant materials within the range of loading speeds of 0.4–2.5 m/s, the elasticity modulus is decreased by a factor of 1.2.

The influence of cutting speed on frictional properties of plant materials. Frictional properties of plant materials are normally described with friction coefficient. According to the results of experimental studies, the change of friction coefficient from the sliding speed has linear function (2):

$$f = k'' \cdot v + C'', \tag{2}$$

where f is a friction coefficient ;

v is sliding speed, m/s;

k'', C'' are the coefficients which are defined by experiment.

With the increase of the sliding speed from 0.75 to 2.66 m/s we may observe the friction coefficients of the vegetables under study decrease by a factor of 1.2–1.5 at average (Figure 2).
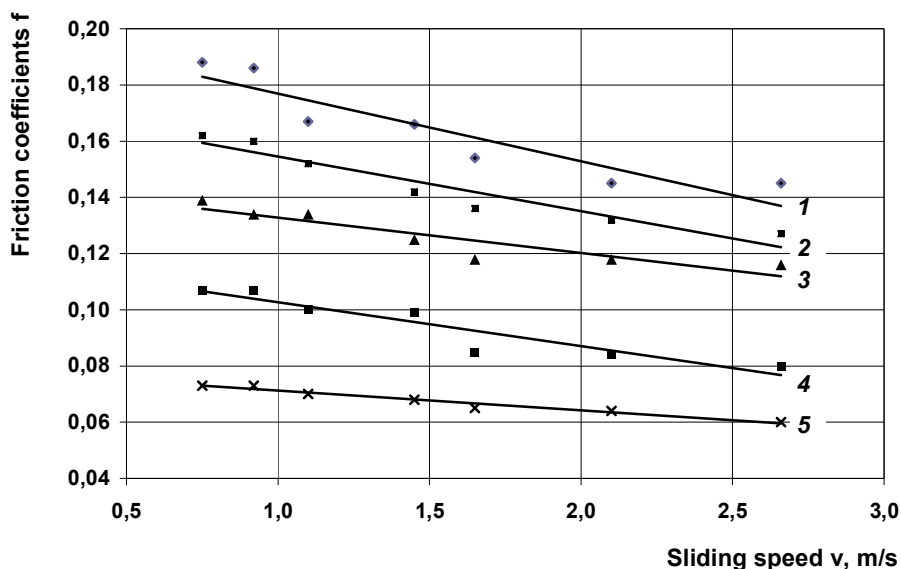
Figure 2. The influence of sliding speed on friction coefficients of vegetables:
1 – beet; 2 – potato; 3 – carrot; 4 – cucumber; 5 – zuccini

The decrease of friction coefficients value with the increase of sliding speed is associated with the change of roughness of contacting surfaces. When two solid bodies contact there occurs a discrete contact, which causes the constant change of the individual elementary contact points. In addition, each elementary contact has three stages of evolution: interaction, change, and destruction [10, 11]. The lifetime of elementary contact depends on the rate of relative movement of the friction pair, physical and mechanical properties of the contacting materials, and the conditions of the sliding surfaces.

Upon elastic contact the individual surface projections have significantly greater roughness in tangential direction than in normal one. With the enlarging of adjacent material areas they are deformed. Under the influence of elastic forces the projection is rectified and, oscillating, collides with other projections. Upon imperfect contact elasticity with the increasing sliding speed the time between two impulses is no longer sufficient to fully rectify the projection. This leads to the change of surface roughness. As the actual contact area grows in time, then with sliding speed increase the contact time is decreased, and respectively, the contact area is reduced. This leads to friction coefficient decrease.

Since the increase of cutting speed will help to reduce the influence of frictional properties of plant materials on the cutting forces, then it is economically feasible to use higher cutting speeds.

The influence of cutting speed on specific cutting forces. According to experimental studies, the dependence of specific cutting force on the cutting speed is described by the exponential function (3):

$$q_{sp} = kv^{-m},$$ (3)

where q_{sp} is specific cutting force, N/m;
v is the cutting speed, m/s;
k and m are the coefficients which are defined by experiment.

Figure 3 shows the diagrams of specific cutting force change within the cutting speeds range from 0,005 to 1,25 m/s.
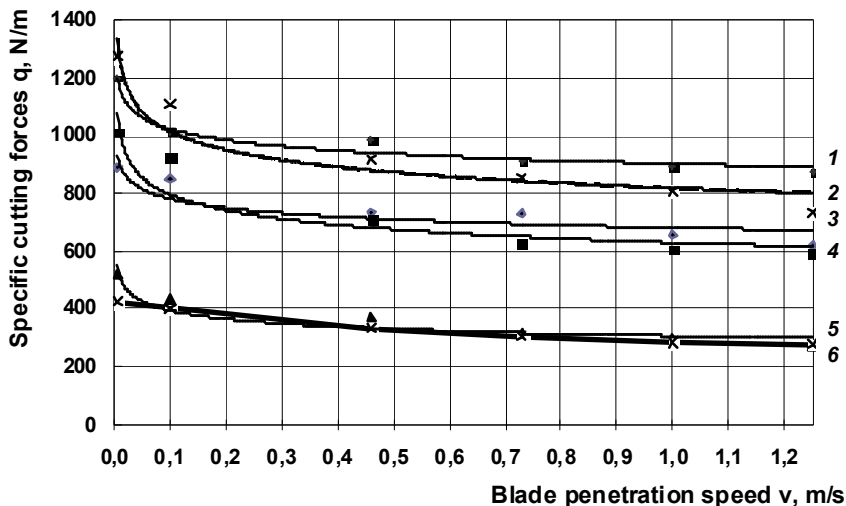
Figure 3. The dependence of specific cutting forces of vegetables on blade penetration speed:
1 – beet; 2 – eggplant; 3 – potato; 4 – carrot; 5 – cucumber; 6 – zuccini

In the speeds range under study there is a decrease of specific cutting force of vegetable raw materials by the factor of 1.4 – 2. The most significant decrease of q_{sp} value is observed within the speeds range from 0.005 to 0.2 m/s, after which the curve has a smooth flow. The decrease of specific cutting force with the increase of cutting speed is associated with the influence on the process of frictional and rheological properties of the product sample to be ground. Thus, we consider the dependence $R_{cut} = f(v)$ as a change of some physical and mechanical property of the product, since it is a proven fact that the speed of the working tool influences the nature of the plant material properties change.

Statistical studies, corresponding the minimum cutting speeds, show that the grinding of plant materials under such conditions is not economically feasible. With the increase of cutting speed exceeding 1.5 m/s there are difficulties with rapid removal of the ground product from the cutting area and its excessive deformation due to the increase of centrifugal forces effect. This has a significant impact on the quality of cutting as a whole and reduces the competitiveness of the equipment.

Analyzing the above-mentioned experimental results, we can conclude the feasibility of using high cutting speeds to reduce the specific cutting forces and, accordingly, reduce the energy component of the process.

The influence of cutting speed on the ground product quality. It should be noted that the quality of manufacturing operation is an important indicator when grinding plant materials in food industry. The quality of the ground product is determined by the cut smoothness, slice thickness constancy, the amount of defective products, juice losses etc.

Figure 4 shows the thickness influence of the products being cut on the cutting quality at circumferential cutting speed of 1250 rev/min.
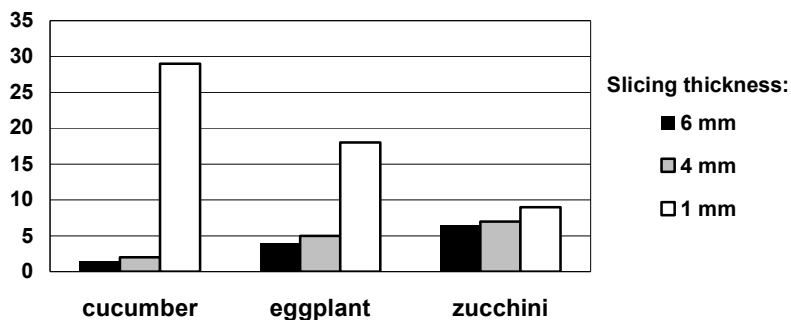
**Figure 4. The histogram of grading amount change from
vegetables slicing thickness at the grinding speed of 1250 rev/min**

The experiment was conducted only for those products, the grading amount of which was the largest. With the increase of cutting thickness from 1 to 4 mm the number of substandard product particles is significantly reduced and reaches optimal performance. With the increase of cutting thickness up to 4 mm the grading amount for eggplants decreased by a factor of 3.6, for cucumbers – by a factor of 15.5, zucchini – by a factor of 1.3. The increase of cutting thickness up to 6 mm has no significant influence on the number of substandard particles. Consequently, with the thickness increase of the slices being cut the product breaks up less on impact with the structural elements of the machine; and the presence of chips in the volume under study largely depends on the structural features of the blade, the discharging device, and the degree to which the product is pressed to the blade at the cutting moment. For such products as eggplants and cucumbers with shallow cutting thickness, it is advisable to use cutting speeds up to 350 rev/min.

Figure 5 shows a histogram describing the change of the substandard products amount when cutting certain types of vegetables in slices with the increase of cutting speed from 280 to 2000 rev/min. The cutting thickness in this experiment was 1 mm.
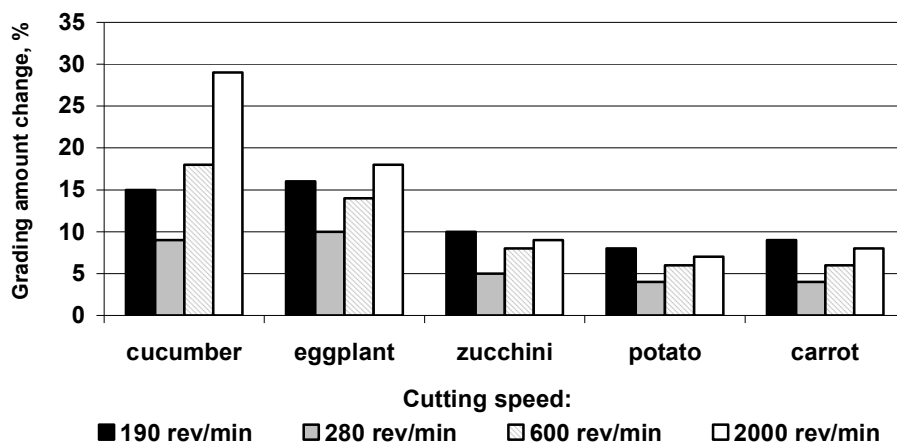
**Figure 5. The histogram of grading amount change with the increase
of cutting speed**

According to Figure 5 and the results of the experiment as a whole, we conclude that at the cutting speed of less than 280 rev/min the cutting quality of the vegetables under study is deteriorating. The integrity of the end surfaces of the slices is disturbed, which is manifested in the formation of fractures and cracks, which impair the product appearance and lead to excessive juice loss. Low cutting speeds are not recommended for the products that are cut with the peel, especially if the peel elasticity is significantly different from the core elasticity (eggplant, zucchini, some varieties of cucumber). When cutting such vegetables the peel cutting force is much larger, and when cutting at low speeds there is an excessive crushing of the product layers under the peel. This significantly reduces the cutting quality. Cutting speeds under 280 rev/min are recommended for grinding the boiled vegetables.

At cutting speed above 1000 rev/min, we can observe the increase of the grading amount in the total volume of the ground mass. This is caused by the destruction of the product on impact with the walls of the discharging device of the vegetable cutting machine at the time of discharge. Such cutting speeds significantly degrade the cutting quality and they are not recommended for the grinding of brittle and juicy products with thickness of the slice being cut of less than 4 mm.

When cutting brittle vegetables of 1–2 mm thick it is necessary to select the cutting mode more carefully. These vegetables are more susceptible to deformation upon contact with structural elements of the equipment and the ground mass. When cutting vegetables into slices over 4 mm thick it is allowed the use higher cutting speeds (over 600 rev/min). It should be taken into account that the increase of cutting speed leads to additional juice loss when cutting products with high moisture content.

Conclusions

Experimental research has allowed to study the influence of speed factor on the process of viscoelastic plant materials cutting within the range of cutting speeds used in modern vegetable cutting equipment.

It has been found out that with the increase of cutting speed the elastic properties of the material appear to a lesser degree, due to the spread of elastic deformations in the layer. Within the cutting speeds range from 0.4 to 2.5 m/s the elasticity modulus is decreased by a factor of 1.2.

Frictional properties that are characterized by a friction coefficient of the material under study are decreased by a factor of 1.2–1.5 with the increase of sliding speed of friction pairs from 0.75 to 2.66 m/s. The structural configuration of the material under study, its moisture content, contact surfaces quality, as well as the pressing force will additionally influence the nature of these properties change.

Cutting forces of plant materials largely depend on its structural and mechanical properties. Therefore, the increase of cutting speed in the ranges under study will contribute to their decrease, as studies have shown, by a factor of 1.4–2, depending on product type. Therefore, basing on research results, we can conclude about the expediency to use higher cutting speeds of plant materials in vegetable cutting equipment in order to reduce the specific cutting forces.

To obtain products of high-quality cutting with a minimum amount of substandard particles it is essential to select the speed mode more carefully. The cutting speed has significant influence on cutting quality of brittle materials and materials having the most heterogeneous structure (presence of peel, seeds etc). Here, the product cutting thickness is an important factor that determines this or that mode. Taking into account all the above-

mentioned factors, the optimal and the recommended range of circumferential cutting speeds for using in vegetable cutting machines of disc type will be 300–600 rev/min. Under this condition, the ratio of "cut quality – grading" remains optimal.

Experimental research data and the relations obtained are valid only for the specified cutting conditions. When changing the cutting speed range the rheological properties of plant materials can vary significantly.

Thus, considering the factor of speed influence on the structural and mechanical properties of the plant materials and, as a result, cutting force, the optimal and the recommended range of circumferential cutting speeds for the products assortment under research is from 300 to 600 rev/min.

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Simulation of liquid dough mixing in the machine with the rotor unit

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Abstract

Introduction. The work describes the analytical method of changing the kinematic parameters intensive rotary periodical mixer for making liquid semimanufactured goods of baking industry and defined power necessary for such process.

Materials and methods. The process of mixing the liquid components of wheat dough humidity of 65 % using a rotary periodical mixer. Using the analytical method determined kinematic and dynamic parameters of the mixer using the differential equations of the medium movement which written in cylindrical coordinates, ignoring the convective members and by gravity.

Results and discussion. The work proposes analytic output model of rotary mixer, namely energy balance for defining its drive unit power. Found power used on rotation of the rotor in liquid flour dough, as well as power required on punching flour dough through channels cylindrical rotor. Comparison of these two components has led to the conclusion that 40 % of the total power consumed on the rotor rotation in product volume and 60 % on punching product through the rotor channels.

Comparing required power from the rotor sizes, indicates that the rotation rate of 100 s^{-1} rotor size 1/3D spends 3.62 times more energy than the rotor size 1/4D, while the rotor 1/2D spending has in 8,49 times more energy per rotor size 1/4D. By increasing the speed to 300 s^{-1} this ratio is 4.14 and 9.28 times respectively. The reason is that increasing the rotor size increases its contact area with the processed product, which entails an increase in product resistivity rotating rotor.

As an analytically determined product velocity flow, torques arising on the rotor shaft, the productivity for the finished product and the required pressure head at a given productivity.

An analytic formula of drive power components allows us to analyze its numerical value depending on changes in structural and mechanical characteristics of the dough, the geometric dimensions of the driven element and its kinematic characteristics.

Conclusions. The work shows the general analytical model of the process of mixing liquid dough in original designed rotary periodical mixer. The advantage of the proposed model is it reckons in the rheological properties of the product, which makes it more accurately describes these processes.

Introduction

The process of making liquid dough based on periodic mixer is economically beneficial, but its implementation is related to the complexity of determination a mode processing, a mixing parameters and a geometry of working. Currently, the matching all these parameters is performed experimentally that requires considerable investments.

There are many researches related to mixing process (homogenization) of bakery semimanufactured goods [1, 2, 3, 4], mainly because this process is responsible for the quality of the finished product and most correctly can be described by classical equations of conservation of mass, momentum and energy.

To study the problems of hydromechanics used three main approaches, namely acquiring analytic solutions; physical experiment and numerical methods or use of simulation(CFD).

Analytical solutions up to this date received only for the simplest tasks. They are also used in numerical simulations to describe some aspects of the problem. The physical experiment is mostly used as a criterion of correctness acquired numerical solutions. Numerical methods are used to simulate fluid flow by means of computer technology. Numerical simulation of fluid flow in the last decade becoming more widespread due to intensive growth of computer performance [6, 7, 8, 9].

To solve this problem and design of a mixing equipment, becomes important mathematical or analytical modeling of mixing process, which allows it to make more informed choice of a geometry of working and processing modes that provide the appropriate quality. Analytical modeling can also significantly reduce the amount of experimental research and to reduce the cost of design work.

Mathematical studies of non-Newtonian fluids motion equations, especially viscoelastic fluids, are quite complex. Right now, we obtain only few significant results in this area. This can be explained by the following factors: first, even the mathematical theory of Newtonian fluids and Navier-Stokes equations are not complete and contains a large number of unresolved issues; second, many of the non-Newtonian fluids motion equations, including viscoelastic, significantly harder Navier-Stokes' equations and cannot always be studied by the same methods; third, defining relations for many non-Newtonian fluids were relatively new and little known among mathematicians. [10].

More complex models and solved by numerical methods and aimed at determining the total shear strain, which is one of the indicators of quality of processing. However, the quality of processing, on the other hand, can be measured by the intensity of dissipation, which associated with mixing.

The vast majority of real flow that occur in nature and technology is turbulent. In this case, speed, pressure, temperature and other hydrodynamic quantities pulsate erratically, varying in space and time. Laminar flows are quiet, smooth and is a very rare exception. Turbulent flow, as opposed to laminar, have a much greater ability to transfer momentum, turbulent environment has a high effective viscosity. Turbulent flow has increased ability to transfer heat and passive impurity, to the spread of chemical reactions [11].

It should be noted that the transition from laminar to turbulent flow leads to a significant increase in energy losses compared to laminar, if it occurred at the same average speed.

Attempts to describe the origin and development of turbulent has great history and are in detail described in the literature. Basically, it refers to shear turbulence that appears due to the layers sliding. There are complex models containing dozens of settings and can describe subtle experimental results. However, because of their bulkiness they are difficult

to implement. On the other hand, simple models have only a few options and limited in usage. In real situations there are always a choice to make between generality and complexity on the one hand, and simplicity and ease of implementation the other.

Many analytical models neglect viscosity which can significantly change the flow picture by tightening its development over time. But do flow fully steady viscosity cannot.

Materials and methods

The process of mixing the liquid components of wheat dough with humidity of 65% using the originally designed periodical mixer.

Dough mixed from the highest quality wheat flour, flour humidity was $13,9 \pm 0,2\%$. The temperature of the dough was within 28 ± 1 °C. Dough's volume in all cases amounted to $0,006$ m^3, the density of the dough $\rho = 1066$ kg/m^3.

Viscosity of dough was recived previously [12] and is described by power law:

$$\eta = 4,71n^{-0,42},$$

where n – the number of revolutions of the rotor, sec^{-1}.

Limit yield stress dough was obtained [13] with rotational viscometer was under $\tau_0 = 2,5$ Pa.

The device relates to the baking industry, namely to a periodic mixer. It intensifies the mixing of liquid semimanufactured goods such as dough (Y.Y. Dolomakin, I.M. Litovchenko, Patent 103656 Ukraine, Device for mixing of liquid semifinished products, publ. 25.12.2015). To understand the process is shown a diagram of the device (Figure 1).
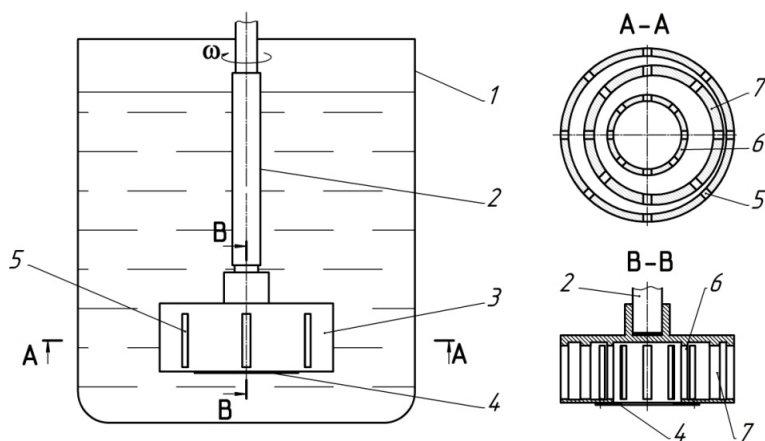
Figure 1. Mixing device

The liquid and dry ingredients are loaded into the working capacity of the mixer 1 with outer diameter D, wherein using the cylindrical rotor 3, outer radius R_1, untwisted and discarded by the centrifugal force to the periphery of the container. Due to the supply of mechanical energy, within the rotor is occurring the pressure drop, which in turn creates a massive suction of the product inside the rotor, while the hydraulic entrance 4 resistance in

the rotor is minimal. Entering through the lower hole of the rotor and passing across the through channels 5 of the first cylinder with radius 0,2–0,25D, the processed product is expose an intensive mixing, dispersing and deformation of dispersed particles, whereas the inner cylinder 7 designed with eccentricity and a diameter in the range of 0,35–0,4D creates semi-vibration, pulsation, cavitation and other hydrodynamic effects. The intensification of the mixing process in the machine caused by multifactorial effects on the treated liquid heterogeneous medium, consisting in the pressure pulsations and liquid flow rate, developed turbulence in the local volume of the rotor. The device allows to achieve greater densities of hydrodynamic and hydroacoustic energy.

In order to adjust the intensity of product processing, a diameter of the entrance hole of the rotor can be changed with removable washers of different diameters.

This design has a low energy consumption due to a fact, that the processed product is both the source and the object of hydro-mechanical fluctuations, the kinetic energy is converted directly into the turbulent energy.

Using the analytical method determined kinematic and dynamic parameters of the mixer element, using the differential equations of the medium movement, which are written in cylindrical coordinates, ignoring the convective members and by gravity.

For theoretical studies are used equations written in cylindrical coordinates $r\varphi z$. The equations were written under the assumption of axial symmetry of the flow, the flow characteristics regardless of the coordinate z, is incompressible and isotropic medium, constancy of its temperature and the ambient pressure [14].

In continuum mechanics most widely used Euler method, in aim of producing the equations of media motion and received data analysis, gave the efficient use of the well-developed methods of vector analysis and the theory of vector and scalar fields.

The object of examination in continuum mechanics are bodies consisting of a large number of individual particles which fill a certain volume. According to the continuity hypothesis, a similar body is viewed as medium that fills the space of the continuous manner (continuum or continuous medium).

Results and discussion

Determination of the capacity of power drive unit carried out by the experimental setup of a cylindrical cup with internal diameter D = 260 mm. Dimensions of driven elements (outer diameter) were depended on the internal diameter of the bowl D, and were respectively 1/2, 1/3 and 1/4 of its parts, which in absolute terms amounted to 130, 86 and 65 mm.

Next is derived an analytical model of the rotor mixer. The energy balance for determining the drive power of the rotor mixer will look like:

$$P = P_1 + P_2 \tag{1}$$

where P_1 – power, expended on the rotor rotation in the product volume, W; P_2 – power, expended to get sourdough through the rotor, W.

Next, we shall find the power spent on the rotor rotation in the liquid sourdough. By transforming Genki equations through adding the equations linking the components of the tensor's tension with the components of the tensor's deformation rates and assuming that the flow of the medium is flat and axially symmetric, we obtain the simplified equations in cylindrical coordinates r, z, φ with the z axis along the axis of the rotor:

$$-\frac{v_\varphi^2}{r} = \frac{1}{\rho}\left(\frac{\partial \tau_{rr}}{\partial r} + \frac{\tau_{rr} - \tau_{\varphi\varphi}}{r}\right)$$

$$\frac{1}{\rho}\left(\frac{\partial \tau_{\varphi r}}{\partial r} + \frac{2\tau_{\varphi r}}{r}\right) = 0,$$

(2)

$$\tau = \frac{1}{2}\sqrt{\left(\tau_{rr} - \tau_{\varphi\varphi}\right)^2 + 4\tau_{\varphi r}^2} = \tau_0 + \left|\frac{\partial v_\varphi}{\partial r} - \frac{v_\varphi}{r}\right|,$$

$$\left(\tau_{rr} - \tau_{\varphi\varphi}\right)\left(\frac{\partial v_\varphi}{\partial r} - \frac{v_\varphi}{r}\right) = 0.$$

Then solving system with the following boundary conditions $r = R_1$: $v_\varphi = \omega_1 R_1$, $r = R_2$: $v_\varphi = 0$, as in our case $\omega_2 = 0$ (fixed cup)
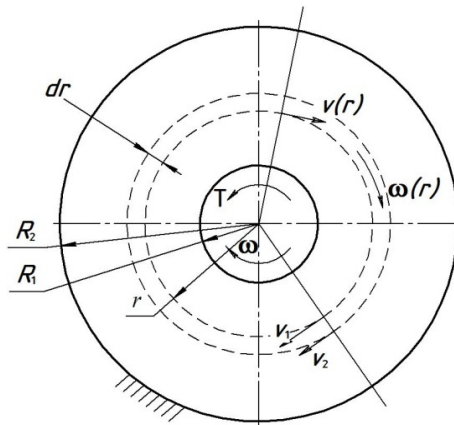
Figure 2. Calculation scheme

From the third equation of the system (2) we shall find the circular speed v_φ. In order to do this, first we put in it the value of the shear stress $\tau_{\varphi r}$ (which found from the second equation). After integrating it by the coordinate r (the limits of integration from R_1 to R_2) finding the speed of the medium points:

$$v_\varphi = \frac{\omega\left(R_2^2 - R_1^2\right)}{(R_2^2 / R_1^2)R_1} + \frac{\tau_0}{2}\frac{R_2^2 \ln(R_2^2 / R_1^2) + R_1^2\ln\dfrac{1}{(R_2^2 / R_1^2)} - (R_2^2 / R_1^2)R_1 \ln(R_2^2 / R_1^2)}{(R_2^2 / R_1^2)R_1}$$

Making such changes:

$$b = R_2^2 / R_1^2,$$

$$a = R_2^2 - R_1^2,$$

$$\frac{\tau_0}{\eta\omega} = Sen$$

where *Sen* – the number of Sen-Venant-Ilyushin, a ratio measure of forces to the plasticity of inertia forces. Finally, we get:

$$v_\varphi = \frac{Sen}{bR_1}\left(a\,Sen^{-1} + (a - bR_1)\ln\sqrt{b}\right)$$

Assuming that the area of the shear flow is distributed by the whole space between the rotor and the cup, a moment of resistance forces from the liquid sourdough is given by:

$$T_1 = 2\pi\omega\frac{hR_2^2}{(R_2^2/R_1^2)-1} + \tau_0\frac{hR_2^2}{(R_2^2/R_1^2)-1}\ln(R_2^2/R_1^2)$$

making the change $b = R_2^2/R_1^2$ and relegate the expression over brackets $\dfrac{2\tau_0 hR_2^2}{b-1}$, at the same time replacing $\dfrac{\eta\omega}{\tau_0} = Sen^{-1}$ having the final expression:

$$T_1 = \frac{2\tau_0 hR_2^2}{b-1}(\pi Sen^{-1} + \ln\sqrt{b})$$

Power, expended on the rotor rotation in the product volume:

$$P_1 = T_1 \times \omega = \frac{2\omega\tau_0 hR_2^2}{b-1}(\pi\,Sen^{-1} + \ln\sqrt{b})$$
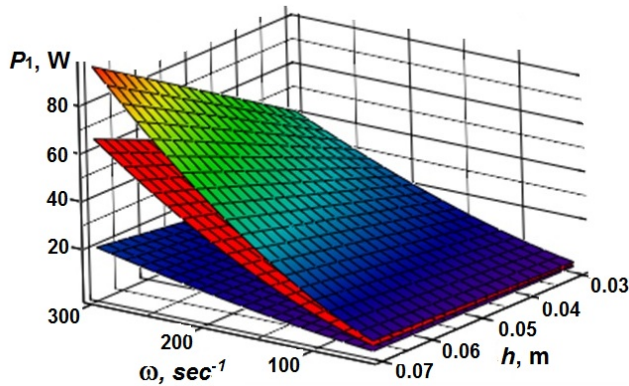
Figure 3. Power required for the rotor rotation in the product volume, P$_1$
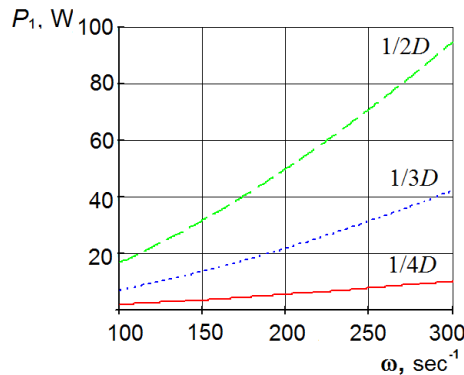
Figure 4. Power required for the rotor rotation in the product volume, P1 from its rotation frequency

Next, we find the necessary power to get liquid sourdough through the cylindrical rotor channels (Figure 5). We apply the differential equations of the medium motion, received in cylindrical coordinates (r, z, φ) with the z axis along the axis of the rotor, ignoring the convective terms and the forces of gravity, due to the high viscometric properties of liquid wheat sourdough:

$$
\left.
\begin{aligned}
\frac{\partial P}{\partial r} &= \frac{1}{r}\left[\frac{\partial}{\partial r}(r\sigma_r) + \frac{\partial \tau_{r\varphi}}{\partial \varphi} - \sigma_\varphi + r\frac{\partial \tau_{rz}}{\partial z}\right] \\
\frac{1}{r}\frac{\partial P}{\partial \varphi} &= \frac{1}{r}\left[\frac{1}{r}\frac{\partial}{\partial r}(r^2\tau_{r\varphi}) + \frac{\partial \sigma_\varphi}{\partial \varphi} + r\frac{\partial \tau_{\varphi r}}{\partial z}\right] \\
\frac{1}{r}\frac{\partial P}{\partial z} &= \frac{1}{r}\left[\frac{\partial}{\partial r}(r\tau_{rz}) + \frac{\partial \tau_{\varphi z}}{\partial \varphi} + r\frac{\partial \sigma_z}{\partial z}\right]
\end{aligned}
\right\}
$$

Assuming (quite arbitrarily) that the mass is homogeneous, incompressible, and medium flow – flat, insulated and axially symmetric, the equation of motion in terms of tension take the form of:

$$
\frac{\partial \tau_{rz}}{\partial z} = \frac{\partial P}{\partial r};
$$

$$
r^2\frac{\partial r^2\tau_{r\varphi}}{\partial r} + \frac{\partial \tau_{\varphi r}}{\partial z} = 0;
$$

$$
\frac{1}{r}\frac{\partial(r\tau_{rz})}{\partial r} = 0.
$$
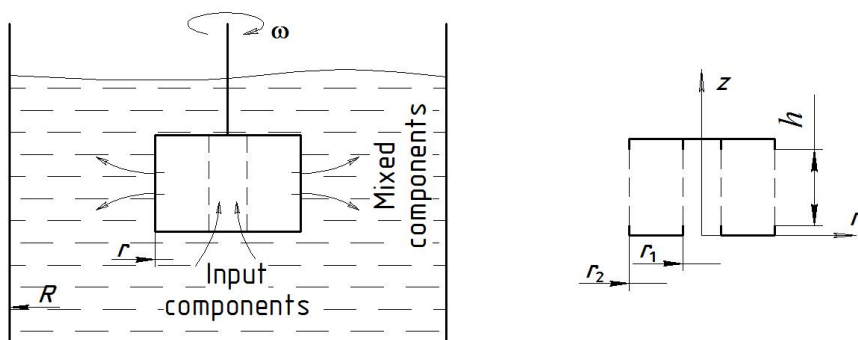
Figure 5. Calculation scheme of liquid dough motion through rotary mixer channels

The tangential product's speed in the flow is determined by the following relationship:

$$
v_\varphi = \omega r; \quad \frac{\partial v_\varphi}{\partial z} = r\frac{\partial \omega}{\partial z}
$$

Knowing the physical and mechanical properties of the liquid sourdough and expressing them in terms of the second invariant of the tensor's deformation rate, get:

$$
K\left[\left(\frac{\partial v_r}{\partial z}\right)^2 + \left(\frac{r}{h}\right)^2\right]^{(n-1)/2}\frac{\partial v_r}{\partial z} = -r\frac{\partial P}{\partial r}
$$

knowing that: $\dfrac{\partial v_r}{\partial z} \ll \dfrac{r}{h}$ and substituting in the previous expression, we have:

$$\frac{\partial v_r}{\partial z} = -\frac{\partial p}{\partial r}\frac{r^{2-n}}{K(\omega/h)^{n-1}}$$

from the boundary conditions $v_r = 0$ at $z = h$ get:

$$v_r = \frac{r^{2-n}h^{n+1}}{K(/h)^{n-1}}\frac{\partial p}{\partial r}(h-z) = \frac{r^{2-n}h^{2n}}{K^{n-1}}\frac{\partial p}{\partial r}(h-z)$$

The performance of the final product will be determined by the equalization:

$$Q = 8\int_0^h 0,1rv_r dz = \frac{0,8r^{3-n}\omega^{1-n}h^{2n+1}}{K}\frac{\partial p}{\partial r}$$

Required pressure at a given performance:

$$p = \frac{QK^{n-1}}{\pi h^{2n+1}(n+4)}(r_2^{n+4} - r_1^{n+4})$$

Shaft torque which arises from the pumping effect:

$$T_2 = 2\int_{r_1}^{r_2}\tau_{\varphi z}\, 2\pi r^2 dr,$$

integrating, get:

$$T_2 = \frac{2\pi K}{(n+3)}\left(\frac{\omega}{h}\right)^n\left(r_2^{n+3} - r_1^{n+3}\right)$$

Power, spent on getting product's volume through the rotor:

$$P_2 = T_2 \times \omega = \frac{2\pi K^n}{(n+3)h^n}\left(r_2^{n+3} - r_1^{n+3}\right)$$

Finding the values of two power capacities, substitute them into the equation (1) of the energy balance of the rotary mixer's power drive:

$$P = P_1 + P_2 = \frac{2\omega\tau_0 hR_2^2}{b-1}(\pi Sen^{-1} + \ln\sqrt{b}) + \frac{2\pi K^n}{(n+3)h^n}\left(r_2^{n+3} - r_1^{n+3}\right)$$
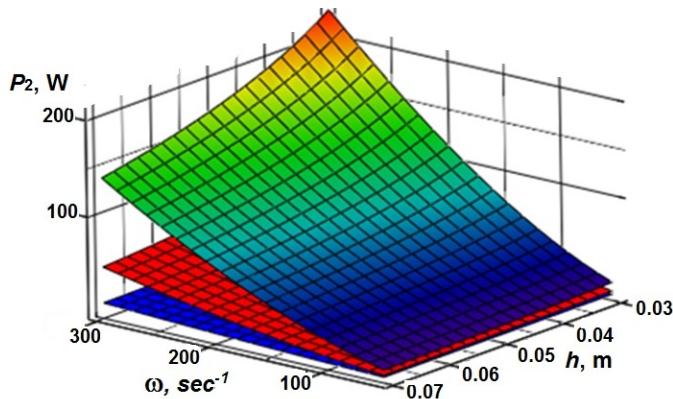
Figure 6. Power needed to push the dough through the channels of the rotor, P_2
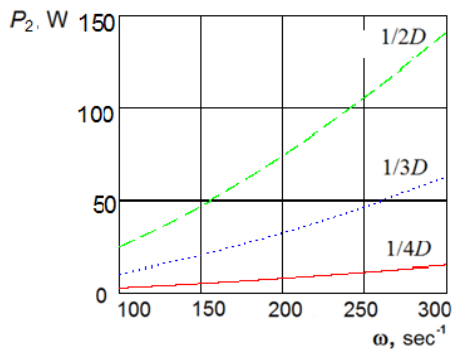
Figure 7. Power needed to push the dough through the channels of the rotor, P_2 from its rotation frequency
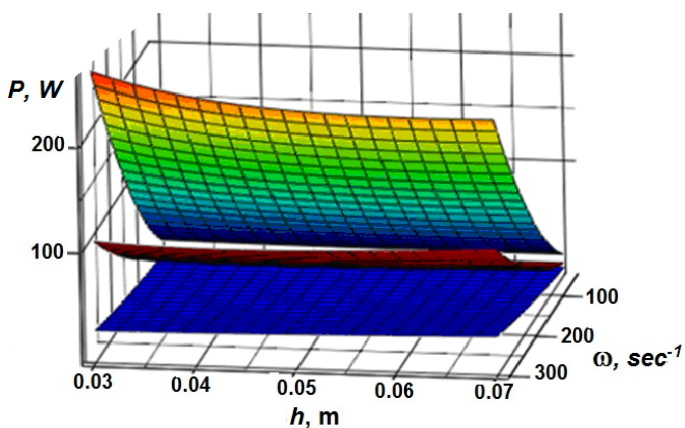
Figure 8. Total power capacity for mixing sourdough, P
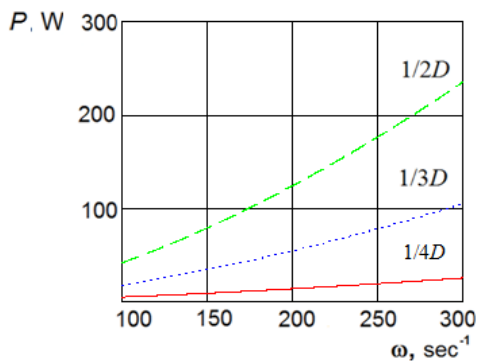
Figure 9. Total power capacity for mixing sourdough, P from its rotation frequency

It can be assumed, that the total power to the rotor shaft in all cases depends on the geometrical dimensions of the rotor and its rotational speed and the structural and mechanical properties of dough.

After separately analyzing of the power components, we conclude that the power spent on the rotor in addition to its size and the speed of rotation depends on the boundary shift τ_0 tension and viscosity η dough. While used power for pumping dough through channels, except its rotor geometry and speed of rotation, also depends on the consistency K and the flow rate n dough.

If we compare the two components of power among themselves, in a different rotor speed range and at its various geometrical sizes, in all cases, we obtain 40% of the power consumed in the rotor rotation in dough volume, and 60 % – to push the dough through the channels of the rotor.

Comparing the expended power on the size of the rotor, notes that the rotation rate of 100 s^{-1}, rotor with size $1/3D$ spends 3.62 times more energy than the rotor size $1/4D$, while the rotor $1/2D$ spends 8 49 times more energy from the rotor size $1/4D$. By increasing the speed to 300 s^{-1} this ratio is 4.14 and 9.28 times respectively.

Conclusions

Usage of a new generation equipment of stirring liquid media is the perspective direction and it is possible both by using (1) swirling flow and vortex motion, which creates centrifugal forces that greatly exceed the gravitational, and (2) application of elastic waves, which create cavitation, acoustic pressure, pulsating microflows etc. The most effective of these aspects combined in rotary machines.

The work presents the general analytic mixing model of liquid dough with a rotary pereodic mixer. It is noted that the mixing process depends on the combination of other processes (rotor volume of the product and forcing it through the rotor channels). The proposed approach to the mixing process description as one of important influenced procces on the quality of the finished product allows to organize its making modes. For example, one of the advantages of this model is to taking into account structural and mechanical characteristics of the product being processed.

Received analytical model includes geometric, kinematic and structural and mechanical characteristics allows to optimize the process and serve as a basis for future project calculations.

Model allows to determine the following parameters:

1. The rate of medium dots in the volume of dough and inside the rotor;
2. The distribution of section modulus of the liquid dough;
3. The performance rotor on the finished product and the required head pressure of performance.
4. The power required for the mixing process.

The developed model allows under certain design parameters to get the rotor for different speeds, mechanical and power characteristics, the optimum combination of a cylinder of radius values, speed and load torque, ensuring maximum utilization of energy of the rotor.

In the case where the kinematic and dynamic parameters of the process are represented by analytical functions, convenient to use the theory of optimization of functions of several variables, and can also be used in the mathematical formalism of calculus of variations and optimal control theory.

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Mathematical modeling of nonlinear regression function at the central compositional design of experiment with any number of factors

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Abstract

Introduction. We are going to consider the task of building a multi nonlinear regression functions to any number of factors when using a central composite design of experiments.

Materials and methods. The methods of mathematical statistics use for find the total (by factors) algorithm for calculating the coefficients of the regression multivariate functions of the second order with the use method of minimum squares and methods of linear algebra for finding the solution of sparse systems of linear algebraic equations with.

Results and discussion. In most cases, for processing the results of experiments useing orthogonal scheme of the central compositional design of experiment. For m-factors the number of experiments of full factorial experiment is 2^m. This number of experiments is insufficient to use nonlinear models of multivariate regression of the full form. It is therefore proposed to use the rotatable scheme of central compositional design. The number of experiments without repetitions is ($2^m + 2m$). More points allows to find a greater number of coefficients of a nonlinear regression function.

Construction of nonlinear models of multivariate regression for an arbitrary number of factors requires special mathematical tools. For processing the results of experiments we use nonlinear model of multivariate regression. Coefficients of regression functions by the method of minimum squares is the problem of finding solutions of a system of algebraic equations. To solve the system of equations, it is necessary to calculate the appropriate number of determinants. Recurrence and direct formulas for computing sparse determinants of a special type of of *n*-th order were obtained for solving this problem. The main result is the general formulas coefficients of regression function of the second order that take into account the number of factors and the number of experiments.

Conclusions. The results of mathematical modeling of nonlinear multivariate regression functions are recommended for use in determining the recipe of raw materials, for example, when optimizing the recipe of confectionery products. Formulas for calculating coefficients of multivariate regression functions of the second order can be used for any number of *m*-factors when applying rotatable central composite design of experiment with the appropriate number research.

Introduction

The central composite design of experiment (CCD) is the famous and convenient way of research that to create a mathematical model to find the optimal solution – aggregate value of certain factors that provide best value of investigational effective rate. But depending on the number of factors and the number of experiments the algorithms for the calculation of the regression functions may be different. Can be used various schemes of CCD: orthogonal and rotatable [1–5].

In general, m – factor central composite design of experiment for the studing of the links between several variable factors and their impact on certain qualitative characteristics of the studied process it is used multiple regression equation the first, the second and less – the third order, which parameters are evaluated according to a certain number of experiments. We consider the task of calculating of the coefficients of the regression function of the second-order factor m- rotatable experiment for any number m.

Materials and methods

Methods of mathematical statistics (correlation theory) and methods of linear algebra (finding solutions of systems of linear equations) are used for mathematical modeling studies of multi central composite experimental design. Moreover, the method of mathematical induction was used for finding recurrent recurrent formulas of calculating determinants special kind of arbitrary (sustainable) order.

Results and discussion

The multiple regression equation of the first order (linear) has the form

$$y = b_0 + b_1 x_1 + b_2 x_2 + ... + b_m x_m , \tag{1}$$

where m – number of factors. Estimation of the parameters of this equation – coefficients $b_0, b_1, b_2, ... b_m$ is done according to the sampling (the results of N experiments) according by the method of minimum squares. In general, the coefficients of the regression equation (1) calculate according by the formula in matrix form [4]:

$$\bar{b} = \left(X^T X \right)^{-1} \cdot X^T \cdot \bar{y} , \tag{2}$$

where $\bar{b} = (b_0, b_1, b_2, ... b_m)^T$ – vector of parameter estimates-coefficients,

$\bar{y} = (y_1, y_2, ... y_N)^T$ – vector of criterion values in the N experiments,

$$X = \begin{pmatrix} 1 & x_{11} & x_{12} & ... & x_{1m} \\ 1 & x_{21} & x_{22} & ... & x_{2m} \\ ... & ... & ... & ... & ... \\ 1 & x_{N1} & x_{N2} & ... & x_{Nm} \end{pmatrix} \text{ – matrix, which has size } N \times (m+1) . \tag{3}$$

The function of the second order regression in full form for m factors is:

$$y = b_0 + b_1 x_1 + b_2 x_2 + ... + + b_m x_m + b_{12} x_1 x_2 + ... + b_{(m-1)m} x_{m-1} x_m + b_{11} x_1^2 + ... + b_{mm} x_m^2 , \tag{4}$$

where x_i - variable of i-th factor, $i = \overline{1, m}$; $b_0, b_1, ..., b_m, b_{12}, ..., b_{(m-1)m}, b_{11}, ..., b_{mm}$ — the coefficients of the regression equation, which otherwise can be described as: b_0, b_i, b_{ik}, $i = \overline{1, m}$, $k = \overline{1, m}$, $i \leq k$ $(b_{ik} = b_{ki})$.

The nonlinear mathematical model (4) can be reduced to linear models (1). For this the variables in (4) of degree higher than the first are replace by other variables (new) in the first degree, provide their independence. After the change mathematical model obtained from the model (4) can be considered as linear with r variables:

$$y = \alpha_0 + \alpha_1 \cdot z_1 + ... + \alpha_m \cdot z_m + \alpha_{m+1} \cdot z_{m+1} + ... + \alpha_r \cdot z_r = \alpha_0 + \sum_{j=1}^{r} \alpha_j \cdot z_j, \qquad (5)$$

where α_j — unknown coefficients. The number of new variables r is:

$$r = m + \frac{m(m-1)}{2} + m = 2m + \frac{m^2}{2} - \frac{m}{2} = \frac{m^2 + 3m}{2}.$$

We can use the formula (2) to find the coefficients of the obtained regression function (5).

The described method can be used in the case of the rotatable central design of experiment, for the case of two factors is show in Fig.1. Due of the results of point with "star shoulder" a are achieve the independence of the variables of second order. In the case of two-factor of rotatable central composite design of experiment with the size of the "star shoulder" α, when experiments can be done at the points 1–8 (Figure 1), matrix coordinates X in coded form has the form:

$$X = \begin{pmatrix} 1 & -1 & -1 \\ 1 & +1 & -1 \\ 1 & +1 & +1 \\ 1 & -1 & +1 \\ 1 & 0 & -\alpha \\ 1 & \alpha & 0 \\ 1 & 0 & \alpha \\ 1 & -\alpha & 0 \end{pmatrix}$$
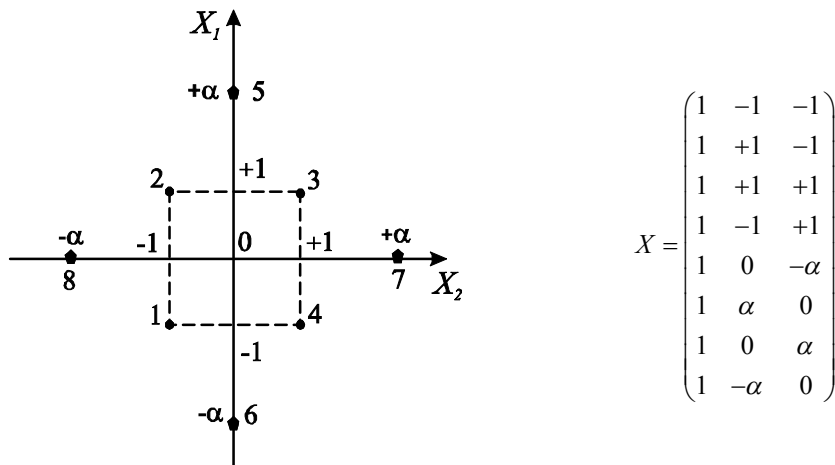
Figure 1. Scheme two-factor of rotatable central design of

If the experiments N values of quality characteristics of studied process $y_k, k = 1...N$ were obtained, to find the coefficients of the function (5), we can apply the method of minimum squares:

$$Q = \sum_{k=1}^{N} \left[y_k - \left(\alpha_0 + \sum_{j=1}^{r} \alpha_j \cdot z_{kj} \right) \right]^2 \rightarrow \min. \qquad (6)$$

Coefficients of the function (5) are the solutions of the system of equations:

$$\begin{cases} \dfrac{\partial Q}{\partial \alpha_0} = 2\sum_{k=1}^{N}\left[y_k - \left(\alpha_0 + \sum_{j=1}^{r}\alpha_j \cdot z_{kj}\right)\right]\cdot(-1) = 0; \\[3mm] \dfrac{\partial Q}{\partial \alpha_l} = 2\sum_{k=1}^{N}\left[y_k - \left(\alpha_0 + \sum_{j=1}^{r}\alpha_j \cdot z_{kj}\right)\right]\cdot z_{kl} = 0; \end{cases}$$

$$\begin{cases} N\alpha_0 + \sum_{k=1}^{N}\sum_{j=1}^{r}\alpha_j \cdot z_{kl} = 0; \\[3mm] \sum_{k=1}^{N} y_k z_{kl} = \sum_{k=1}^{N}\left(\alpha_0 + \sum_{j=1}^{r}\alpha_j \cdot z_{kj}\right)\cdot z_{kl}, \end{cases} \qquad l = \overline{1,r}. \qquad (7)$$

For the solution of the system (7) by Cramer's rule, we need to calculate the appropriate amount of determinants. To solve this problem formulas were obtained to calculate determinants special type of n-th order.

Let's consider some of the important determinants of square matrices of general dimension n.

1. Determinant I_n has n rows and n columns :

$$I_n = \begin{pmatrix} 1 & 1 & 1 & \ldots & 1 & 1 \\ -1 & 0 & 0 & \ldots & 0 & 0 \\ 0 & -1 & 0 & \ldots & 0 & 0 \\ \ldots & \ldots & \ldots & \ldots & \ldots & \ldots \\ 0 & 0 & 0 & \ldots & 0 & 0 \\ 0 & 0 & 0 & \ldots & -1 & 0 \end{pmatrix}$$

$I_1 = 1;$

$$I_2 = \begin{vmatrix} 1 & 1 \\ -1 & 0 \end{vmatrix} = 1; \quad I_3 = \begin{vmatrix} 1 & 1 & 1 \\ -1 & 0 & 0 \\ 0 & -1 & 0 \end{vmatrix} = 1; \quad \ldots$$

$$I_n = (-1)^{n+1}\cdot(-1)^{n-1} = 1.$$

By the method of mathematical induction we calculate several determinants of lower orders (n =1,2,3), make assumptions about determinant order (n -1) and calculate the determinant of order n.

2.

$$J_n = \begin{pmatrix} 1 & 1 & 1 & \ldots & 1 & 1 \\ 1 & -1 & 0 & \ldots & 0 & 0 \\ 1 & 0 & -1 & \ldots & 0 & 0 \\ \ldots & \ldots & \ldots & \ldots & \ldots & \ldots \\ 1 & 0 & 0 & \ldots & -1 & 0 \\ 1 & 0 & 0 & \ldots & 0 & -1 \end{pmatrix}$$

$J_1 = 1;$

$$I_2 = \begin{vmatrix} 1 & 1 \\ 1 & -1 \end{vmatrix} = -2; \quad I_3 = \begin{vmatrix} 1 & 1 & 1 \\ 1 & -1 & 0 \\ 1 & 0 & -1 \end{vmatrix};$$

$$I_3 = (-1)^{3+1}\begin{vmatrix} 1 & 1 \\ -1 & 0 \end{vmatrix} + (-1)(-1)^{3+3}\cdot\begin{vmatrix} 1 & 1 \\ 1 & -1 \end{vmatrix} = I_2 - J_2;$$

Recurrent formula for calculating determinants J_n has the form:

$$J_n = (-1)^{n+1}\cdot I_n + (-1)(-1)^{n+n}J_{n-1} = (-1)^{n+1} - J_{n-1} \quad \text{або} \quad J_n = (-1)^{n+1}\cdot n.$$

3.

$$A_n = \begin{pmatrix} a & 1 & 1 & \ldots & 1 & 1 \\ 1 & -1 & 0 & \ldots & 0 & 0 \\ 1 & 0 & -1 & \ldots & 0 & 0 \\ \ldots & \ldots & \ldots & \ldots & \ldots & \ldots \\ 1 & 0 & 0 & \ldots & -1 & 0 \\ 1 & 0 & 0 & \ldots & 0 & -1 \end{pmatrix}$$

$$A_1 = a; \quad A_2 = \begin{vmatrix} a & 1 \\ 1 & -1 \end{vmatrix} = -a - 1; \quad A_3 = \begin{vmatrix} a & 1 & 1 \\ 1 & -1 & 0 \\ 1 & 0 & -1 \end{vmatrix};$$

$$A_3 = (-1)^{3+1} \begin{vmatrix} 1 & 1 \\ -1 & 0 \end{vmatrix} + (-1)(-1)^{3+3} \cdot \begin{vmatrix} a & 1 \\ 1 & -1 \end{vmatrix} = I_2 - A_2;$$

Recurrent formula for calculating determinants A_n has the form:

$$A_n = (-1)^{n+1} \cdot I_n + (-1)(-1)^{n+n} A_{n-1} = (-1)^{n+1} - A_{n-1}.$$

We can prove that $A_n = (-1)^{n+1} \cdot (n - 1 + a)$.

4.

$$B_n = \begin{pmatrix} b_1 & 1 & 1 & \ldots & 1 & 1 \\ b_2 & -1 & 0 & \ldots & 0 & 0 \\ b_3 & 0 & -1 & \ldots & 0 & 0 \\ \ldots & \ldots & \ldots & \ldots & \ldots & \ldots \\ b_{n-1} & 0 & 0 & \ldots & -1 & 0 \\ b_n & 0 & 0 & \ldots & 0 & -1 \end{pmatrix}$$

$$B_1 = b_1; \quad B_2 = \begin{vmatrix} b_1 & 1 \\ b_2 & -1 \end{vmatrix} = -b_1 - b_2;$$

$$B_3 = \begin{vmatrix} b_1 & 1 & 1 \\ b_2 & -1 & 0 \\ b_3 & 0 & -1 \end{vmatrix};$$

$$B_3 = b_3 \cdot (-1)^{3+1} \begin{vmatrix} 1 & 1 \\ -1 & 0 \end{vmatrix} + (-1)(-1)^{3+3} \cdot \begin{vmatrix} b_1 & 1 \\ b_2 & -1 \end{vmatrix} = I_2 - B_2;$$

Recurrent formula for calculating determinants B_n has the form:

$$B_n = b_n \cdot (-1)^{n+1} \cdot I_n + (-1)(-1)^{n+n} B_{n-1} = b_n \cdot (-1)^{n+1} - B_{n-1}.$$

We can prove that $B_n = (-1)^{n+1} \cdot (b_1 + b_2 + \ldots + b_n)$.

5.

$$E_n = \begin{pmatrix} 1 & 1 & 1 & \ldots & 1 & e_1 \\ -1 & 0 & 0 & \ldots & 0 & e_2 \\ 0 & -1 & 0 & \ldots & 0 & e_3 \\ \ldots & \ldots & \ldots & \ldots & \ldots & \ldots \\ 0 & 0 & 0 & \ldots & 0 & e_{n-1} \\ 0 & 0 & 0 & \ldots & -1 & e_n \end{pmatrix}$$

$$E_1 = e_1; \quad E_2 = \begin{vmatrix} 1 & e_1 \\ -1 & e_2 \end{vmatrix} = e_1 + e_2; \quad E_3 = \begin{vmatrix} 1 & 1 & e_1 \\ -1 & 0 & e_2 \\ 0 & -1 & e_3 \end{vmatrix};$$

$$E_3 = e_3 \cdot (-1)^{3+3} \begin{vmatrix} 1 & 1 \\ -1 & 0 \end{vmatrix} + (-1)(-1)^{3+2} \cdot \begin{vmatrix} 1 & e_1 \\ -1 & e_2 \end{vmatrix} = e_1 + e_2 + e_3$$

Recurrent formula for calculating determinants E_n have the form:

$$E_n = E_{n-1} + e_n(-1)^n(-1)^{n-2} = E_{n-1} + e_n = e_1 + e_2 + \ldots + e_n.$$

With the help of determinants of the special form considered above, we can solve the system (7) and obtain the formulas of finding the coefficients of the regression functions of the second order for an arbitrary number of factors.

Formulas for calculating the coefficients of the regression function (4) can be obtained by solving the system of equations (7):

$$\begin{cases} b_i = \dfrac{1}{v} \cdot I_i, \ i = \overline{1,m}\,; \\[2mm] b_0 = I_0 \cdot \dfrac{2 \cdot \alpha^4 + m \cdot 2^m}{R} - \dfrac{v}{R} \cdot S; \\[2mm] b_{ii} = I_0 \cdot \left(-\dfrac{v}{R} \right) + \dfrac{v^2 - m2^m}{2\alpha^4 \cdot R} \cdot S + \dfrac{1}{2\alpha^4} \cdot I_{ii}; \\[2mm] b_{ij} = \dfrac{1}{2^m} \cdot I_{ij}\,, i < j, \end{cases} \quad (8)$$

where $\ I_0 = \sum\limits_{k=1}^{N} y_k;\ \ I_i = \sum\limits_{k=1}^{N} y_k \cdot x_{ik};$

$v = 2^m + 2\alpha^2;\ \ R = M\left(2\alpha^4 + m \cdot 2^m\right) - m \cdot v^2, v = 2^m + 2\alpha^2;$

$R = M\left(2\alpha^4 + m \cdot 2^m\right) - m \cdot v^2, v = 2^m + 2\alpha^2;$

$R = M\left(2\alpha^4 + m \cdot 2^m\right) - m \cdot v^2, v = 2^m + 2\alpha^2;\ \ R = M\left(2\alpha^4 + m \cdot 2^m\right) - m \cdot v^2,$

$i, j = \overline{1,m}\,;\ m\ -$ are numbers of factors.

Conclusions

We have considered the problem of calculation of the coefficients of regression function of the second order for multivariate rotatable of experiment with an arbitrary number of factors. As a result we got formulas for calculating determinants of a special type, which significantly simplify the solution of systems of linear equations − coefficients of multivariate function regression of the second order.

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Method of human factor minimization in expert judgement for occupational risk assessment and decision making

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Abstract

Introduction. The purpose of research – to minimize the subjectivity of expert methodology in occupational risk management by the use of impartial risk-relevant information and theoretically substantiated decision-making.

Materials and methods. The health and safety management system in the tobacco manufacturing factory is being observed during 6 years. The modified risk matrix method has been advanced up to the component method of risk-relevant information assessment. Method of multi-criterial decision analysis for risk reduction was strengthened with the application of Hurwitz criterion in terms of uncertainty.

Results and discussion. The survey of the health and safety management system at the tobacco factory (2009–2016) has demonstrated the difference between traumatic factors highly ranked by experts (exposed to or contact with a harmful substance", including noise and dust in the working area) and factors that caused lost time accidents at the site (moving parts of machinery, fell from height). This difference is caused primarily by the subjective component in the expert assessment. To minimize the human failure in judgment the following risk assessment scheme was proposed: 1. The risk-relevant impartial information available at the site was taken into account. It included in addition to the modified matrix method outcomes, the external and internal audit recommendations, near misses, the manufacturing statistics of lost time injuries and fatalities. 2. The information was reduced to common denominators – 18 traumatic events, and an averaging mass risk distribution within risk-relevant components was calculated. 3.The risks ranked as unacceptable and intermediate are to be managed using hierarchy of risk reduction, for this purpose and health and safety professionals have prepared an array of measures for the each step of hierarchy. 4. The expert group has judged them using 5 criteria and the weighting factors, and the Hurwitz criterion was used to overcome the uncertainty. 5. The highly ranked substantiated measures were chosen by them to be a basis of a planning process at the site health and safety management system. The information analysis computer system is used to facilitate the practical implementation.

Conclusions. It is recommended to use the advanced expert system with the suppressed human factor for risk management in the occupational health and safety management systems in food and tobacco manufacturing.

Introduction

One of the key factors determining the economic success of industrial companies is an ability to maintain an advantage in an increasingly competitive global market. Insufficient organization of work, poor working conditions, high level of hazards in human interaction with equipment are factors that negatively impact on production efficiency. These factors lead to accidents and set the manufacturing as one of the dangerous industries in frequency of accidents at work [1]. The number of accidents can be reduced if enterprises enhance the safety of working environment. In order to minimize the possibility of adverse consequences in the workspace the risk assessment process is used. Companies, which introduced the health and safety management systems, have better performance both in safety and productivity than those that do not have such systems [2]. But in its functioning often the imperfection of risk assessment is observed as the basis of a management system. It is caused by the limited capacity of certain risk assessment methods, incorrect application, poor correlation between the of risk assessment results and subsequent management decisions [3, 4, 5]. Using widespread methods and common approaches to the risk assessment the distinctive features of enterprises are not taken into account, that leads to the inadequate outcomes. One of the biggest impacts in risk assessment provides the factor of human subjectivity in expert estimation, which reduces the reliability [6, 7]. It potentially can point the wrong direction for the risk reduction preventive measures and cause the unavailing spending of resources. This is particularly evident for industrial companies that tend to follow the requirements of health and safety management standards, and engage a lot of workers for measuring the risk level with insufficient experience and poor training. Although such engagement rises the right attitude of workers to risk perception, it also increases the subjectivity in risk score calculation and therefore doubtful risk reduction activities. In order to reduce the subjectivity in risk assessment some researches propose to take into account the unaffected reliable information, that can be quantitatively measured [8, 9].

The purpose of research is to minimize the subjectivity of expert methodology in occupational risk management by the use of impartial risk-relevant information and scientifically substantiated decision making. It is reasonable to make such advancement in quantitative risk assessment techniques. As they are the most applicable and widespread techniques (65,63%) comparing to qualitative (27,68%) and hybrid (6,70%), on the assumption of their scientific studies [10]. But the existing methodological approaches cannot be considered as universal for different sites, and their choice depends largely on the context of risk management. Thus, the external and internal conditions of organizations should be considered as much as it is possible, when selecting the risk assessment methods. The factor of subjectivity has an impact on risk assessment where the experts conduct their judgment groundlessly and without full information. Usually the expert's opinion is enlisted at the stage of risk assessment method implementation and the risk reduction measure choosing.

The proposed method is intended to improve the reliability of the risk assessment outcomes by quantitate treating all available risk-relevant information at the site. It will create the more grounded basis for further risk reduction with the use of multi-criterial decision analysis. Using the advanced expert system the risk assessment performance of the site can be improved.

Materials and methods

Health and safety management system in the tobacco manufacturing factory is being observed during 6 years. The survey of the health and safety management system at the tobacco factory (2009–2016) has demonstrated the 6–time reduction of accidents number comparing to previous 10 years. Although it showed the difference between traumatic factors with the highest risk score assessed by the experts using the modified risk matrix method and factors leading to real injuries at the site. The modified risk matrix method calculates the risk as the product of four multipliers:

$$R = P \cdot F \cdot S \cdot N, \tag{1}$$

where R – the occupational risk (risk); P – the possibility of an accident (likelihood); F – frequency of hazard appearance (frequency); S – the extent of possible damage (severity), N – the number of people exposed to the hazard (number of people). This is the improved method in comparison with the original technique of "consequence/probability matrix" and H. Rafaat risk calculator, where 3 factors are used and other similar methods [11]. Each factor has its point scale, the expert group conducts the risk assessment evaluating jobs, professions, processes, equipment etc. The evaluation defines the type of the traumatic event that could potentially happen, and the risk level – from unacceptable to insignificant. To increase the reliability of the outcomes and to suppress the human failure in evaluation it was proposed to take into account the risk-relevant impartial information available at the cite.

To characterize the context of risk management at the site it is proposed to operate the concept of "risk-relevant information". It is a reliable quantitative data obtained empirically, that characterizes the probability of consequences of traumatic events. The principle of selection risk-relevant quantitate information from different time periods (future, present and past) can be considered as an attempt to reflect the dynamic of working environment:

1. Future threats of the working environment (forecasting, modeling, design). It can include the significant risk factors identified by current risk assessment methods adopted at the site (matrix method, HAZOP, HACCP, project and machinery risk assessment, specific risks identification like fire hazard, hazardous substances etc.). Typically, methods of risk assessment are elected by the organization among the 31 methods described in the standard ISO/IEC 31010:2009 «Risk management – Risk assessment techniques»: creative methods, methods of analysis scenarios, methods of analysis indicators, methods of functional analysis, statistical curves. The most widespread of the standard methods is the "consequence/probability matrix", where the risk is the product of the likelihood of accidents and the severity of the consequences.

2. Current hazards to health present at the site. They can be identified during internal and external audits, inspections and survey reports made by health and safety authorities or trade union representatives. It is advisable to include the near misses reported by employees based on the theory of safety triangle [12], split by causes.

3. Past experience of the working environment (the injury statistics). The information is represented by the statistics of more than 3 days lost time accidents and separately fatality statistics. If the site has an unrepresentative statistics, it is advisable to use the well-maintained statistics of similar enterprises, industry, business group etc.

All this information for further processing should be spread out on types of traumatic events that could potentially happen. Thus, a massive data array of the risk-relevant information is formed. It consists of data that characterize different time periods and cover the context of risk management. The number of components can be increased or decreased depending on the data available at the site. The more risk-relevant data can be taken into account, the more adequate risk assessment process is performed.

In this case study for the tobacco manufacturing site the risk-relevant information includes the risk assessment outcomes with high rating assessed by the modified matrix method, the external and internal audit recommendations, near misses information, the industry statistics of lost-time injuries and fatalities. The risk-relevant information was reduced to the common denominators – 18 traumatic events, and it was processed by determination of the risk of traumatic events based on averaging mass risk distribution within risk-relevant components. Hence the modified risk matrix method has been developed into the quantitative method of risk-relevant components assessment – the component risk assessment method. The risks ranked as unacceptable and intermediate are to be managed using hierarchy of risk reduction, for this purpose and health and safety experts have prepared an array of risk reduction measures for the each step of hierarchy. And the expert group of 4 experts has judged them using 5 criterion and the weight ratio for each of them. The Routh–Hurwitz stability criterion was used to overcome the uncertainty. In such way the theoretically substantiated measures with high score were chosen to be a basis of the planning process in the site health and safety management system. The information analysis computer system is used to facilitate the practical implementation.

Results and discussion

It is assumed that the risk assessment, based on inclusion of larger range of risk-relevant information, leads to the increased accuracy of evaluation, and thus, to more effective risk reduction. In the experiment the following risk-relevant information, consisting of different data from 2009–2015 period have been analyzed:
– 544 lost time work-related accidents resulted in temporary disability for 3 days and more in the manufacturing group of tobacco sites,
– 9 cases of fatal work-related injuries including contractors injured in the premises of the manufacturing group of tobacco sites,
– 247 notifications from the site employees on potentially dangerous incidents that could lead to injury – near misses,
– 26 non-conformities that could lead to traumatic events, found during internal and external audits by health and safety experts,
– 48 hazards identified by the modified risk matrix method and ranged as a high risk level of the traumatic events occurrence.

The risk-relevant information was reduced to the common denominators – 18 traumatic events, and it was processed by determination of the risk of traumatic events based on averaging mass risk distribution within risk-relevant components. The data array is a table where the horizontal are 18 traumatic events, vertically – of risk-relevant components, in cross-cells – the number of traumatic events recorded for each component. The sum of events for each component is calculated as the sum of line items:

$$R_j = \sum_{i=1}^{n} R_{ij} \ , \tag{2}$$

where m – number of traumatic events, n – number of risk-relevant components.

The shared risk distribution is calculated as the ratio of each traumatic event to the total number of traumatic events for each risk-relevant component, taken as a percentage:

$$R_i' = \frac{R_{ij}}{R_j} \cdot 100\% \ ,$$ (3)

For each type of traumatic events the arithmetic mean of risk distribution is calculated for each risk-significant component, as a percentage:

$$\overline{R}_i = \frac{1}{n} \sum_{j=1}^{m} R_{ij}$$ (4)

The maximum risk is calculated:

$$R_{ij}^{\max} = \max_i(\overline{R}_i) .$$ (5)

Thus, the results of risk assessment are shown in a table outlining the risk of traumatic events in percentage (Table 1, 2). Types of traumatic events are shown across, the risk-relevant components are in vertical format.

Analyzing the data it is evident that the risk distribution for different components of risk-relevant information diverges. Thus, according to the statistics of lost time accidents that led to temporary disability for more than 3 days (n1), the most traumatic events were road traffic injuries whilst travelling to/from work (23,53%); according to the statistics of fatal accidents (n2) – fell from height and road traffic injuries whilst at work (by 44.4%). With regards of the near misses registration provided by employees (n3) the most traumatic possible events are slipping, tripping and falling at the same level (17,81%). According to the nonconformities registration during audits (n4) and risk assessment results obtained by the modified matrix method (n5) – the contact with hazardous substances is considered as the most traumatic (15,38% and 33,33%, respectively). Thus, the overall risk of the enterprise will be incomplete if only one component of the risk-relevant information is taken into account.

And other way, the compilation reflects real risks at the site, as it is based on the and quantitative method (the modified matrix method) and all available countable risk-relevant information. With an accumulation, processing and comparison of risk-relevant information the existing modified risk matrix method has been improved to the component risk assessment method. The comparison and analysis of risk-relevant components leads to the identification of the most probable traumatic events, and hence allows to conduct more dedicated risk reduction.

Figure 1 shows a comparison the mass distribution of causes of injuries at the site (63 lost-time accidents with temporary disability for 3 days or more, 1999–2015), with the risk assessment results of traumatic events likelihood, conducted by 2 methods – the modified risk matrix method and the component method of the risk-relevant information assessment, proposed in this work.

Determination the risk of traumatic events based on averaging risk share distribution in terms of risk-relevant information

Types of traumatic events	Risk-relevant information										$\overline{R}_i$
	n1		n2		n3		n4		n5		
	No	%	No	%	No	%	No	%	No	%	
m1	102	18,75	0	0	34	13,77	3	11,54	3	6,25	**10,06**
m2	41	7,54	0	0	21	8,50	1	3,85	4	8,33	**5,64**
m3	22	4,04	1	11,11	8	3,24	2	7,69	7	14,58	**8,13**
m4	25	4,60	0	00	26	10,53	1	3,85	1	2,08	**4,21**
m5	63	11,58	0	0	8	3,24	0	0	1	2,08	**3,38**
m6	48	8,82	0	0	44	17,81	2	7,69	2	4,17	**7,70**
m7	12	2,21	4	44,44	4	1,62	2	7,69	1	2,08	**11,61**
m8	4	0,74	0	0	1	0,4	0	0		0	**0,23**
m9	53	9,74	0	0	5	2,02	3	11,54	0	0	**4,66**
m10	2	0,37	0	0	26	10,53	4	15,38	16	33,33	**11,92**
m11	4	0,74	0	0	31	12,55	6	23,08	1	2,08	**7,69**
m12	0	0	0	0	6	2,43	0	0	2	4,17	**1,32**
m13	0	0	0	0	21	8,50	1	3,85	3	6,25	**3,72**
m14	13	2,39	0	0	1	0,40	1	3,85	1	2,08	**1,74**
m15	5	0,92	0	0	0	0	0	0		0	**0,18**
m16	16	2,94	0	0	8	3,24	0	0	1	2,08	**1,65**
m17	6	1,10	4	44,44	1	0,4	0	0	4	8,33	**10,86**
m18	128	23,53	0	0	2	0,81	0	0	1	2,08	**5,28**
Σ	**544**		**9**		**247**		**26**		**48**		

Table 2

The description of traumatic events (m) risk-relevant information (n)

Code	Type of traumatic events	Code	Components of risk-relevant information
m1	Contact by moving machinery or material being machined	n1	Number of > 3 days lost-time work-related accidents (the manufacturing group statistics)
m2	Hit by a moving, flying or falling object		
m3	Hit by a moving vehicle	n2	Number of work-related accidents resulted in fatalities (the manufacturing group statistics)
m4	Hit something fixed or stationary		
m5	Injured while handling, lifting or carrying	n3	Number of near misses registered by employees (the site data)
m6	Slipped, tripped of fell on the same level		
m7	Fell from a height	n4	Number of nonconformities, which can lead to traumatic events, and found during internal and external audits (the site data)
m8	Trapped by something collapsing		
m9	Contact with machines at rest		
m10	Exposed to or contact with a harmful substance	n5	Number of hazards with a high risk level identified by the modified risk matrix method (the site data)
m11	Exposed to fire or contact with hot substance or surface		
m12	Exposed to an explosion		
m13	Contact with electricity or an electrical discharge		
m14	Using portable power or hand tools		
m15	Physically assaulted by a person		
m16	Another kind of accident		
m17	Road traffic injuries whilst at work		
m18	Road traffic injuries whilst travelling to/from work		

Comparing the risk distribution data obtained by the modified matrix and the component method it is evident that the last one leads to obtaining the risk data distributed more evenly, and closer to the real causes of injuries. Also the impact of the subjectivity is reduced, as it was shown in the example m10 "Exposed to or contact with a harmful substance", that had the highest risk of occurrence of traumatic events identified by the modified matrix method. Indeed, the staff has recognized the harmful substances, including noise, dust and presence of chemicals in the working area, as the most dangerous risk factor, as they have affected the psycho-emotional state of humans. But according to the statistics data the harmful substances at the site did not cause any injuries or occupational diseases. Conversely, traumatic events with serious consequences, such as m1 "Contact by

moving machinery or material being machined", m 6 "Slipped, tripped of fell on the same level", m7 "Fell from height" are underestimated during the risk assessment, as those that have a few opportunities to be realized. Using the component method of risk assessment the influence of factors caused fatalities was increased, such as m7 "Fell from height" and m17 "Road traffic accidents whilst at work", which almost were not reflected in the risk matrix method outcomes. So, the component method of risk-relevant information assessment is more objective due to the larger number of components, and it allows to highlight real risks and spend resources effectively and purposefully.
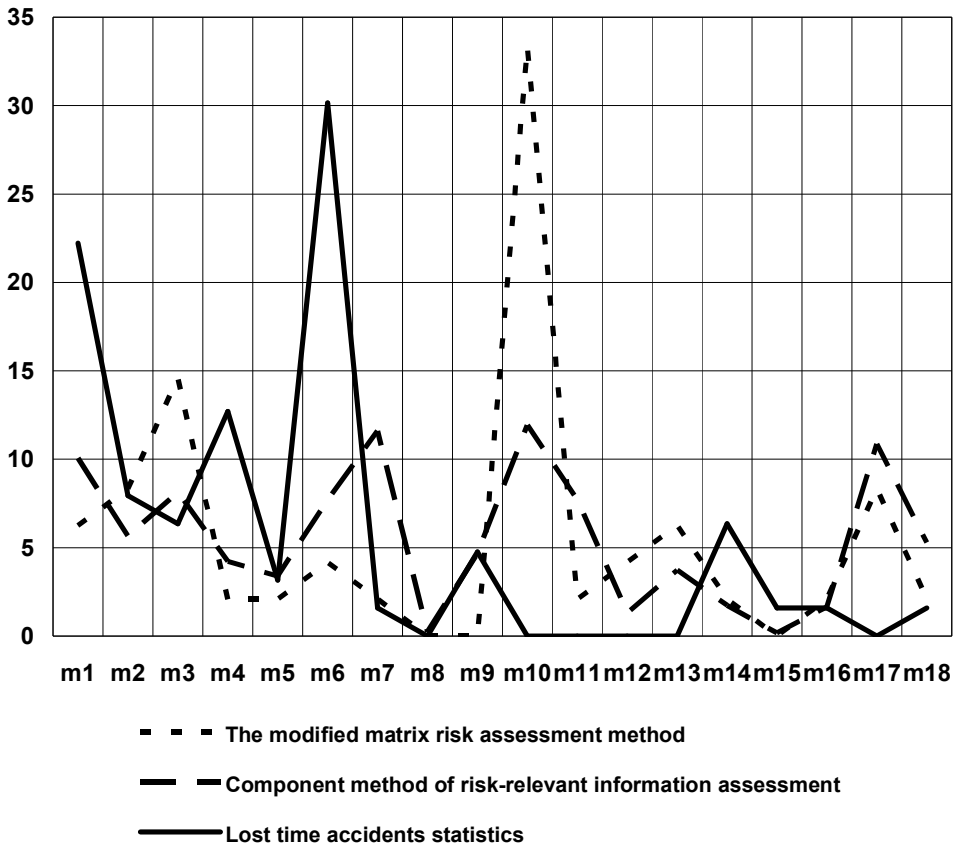
Figure 1. Comparison the real lost time accident causes with the mass risk distribution of traumatic events occurrence, obtained by the modified matrix and the component methods of risk assessment

Choosing the management measures the constant priority is to determine the frames of risk acceptability. In accordance with the general risk management approach, the risk levels are divided into few groups. In the component method it is proposed to divide the resulting scale percentage value of the risk level of traumatic events occurrence $[0...R_{ij}^{max}]$ into 3 equal parts:

1. The highest, an unacceptable risk level of traumatic events occurrence, where the risk management is essential regardless of benefits from risk taking and costs $[\frac{2}{3} \cdot R_{ij}^{max} ... R_{ij}^{max}]$; This includes the risk of traumatic events occurrence: m10 (11,9 %) , m7 (11,6%) , m17 (10,8%) , m1 (10,1%) m3 (8,1%) .

2. Intermediate risk level, for which costs and benefits of risk-taking can be considered in relation to costs $- [\frac{1}{3} \cdot R_{ij}^{max} ... \frac{2}{3} \cdot R_{ij}^{max})$; m6 (7,7%) , m11 (7,7%) , m2 (5,6 %), m18 (5,3%) , m9 (4,7%) , m4 (4,2%) .

3. Acceptable level of risk is negligible, which does not reduction, as the cost of reducing the risk exceeds the benefits, the risk is reduced as much as reasonably possible – $[0...\frac{1}{3} \cdot R_{ij}^{max})$. Specifically, m13 (3,7%), m5 (3,4%), m14 (1,7%), m16 (1,7%) , m12 (1,3%), m8 (0,2 %) , m5 (0,2%) .

For intermediate and unacceptable risk levels the management measures should be introduced. The terms for risk reduction is to follow the sequence of the risk reduction hierarchy, as it is specified in the BS OHSAS 18001 Occupational Health and Safety Management standard, in order of decreasing: elimination, substitution, engineering controls, administrative controls, protection. For unacceptable risk level the application of the three higher levels of the hierarchy are strongly required as the most effective. If the level of risk is related to acceptable, the application of measures for its reduction is not necessary until changes in working environment or risk assessment conditions have been made, etc.

The next step is planning measures for risks reduction. The formalized statement of the problem lies in deciding justification of choosing the optimal alternative set of management decisions by applying the criteria. The search of the optimal solution is to maximize (minimize) the criterion value calculated for multiple alternatives. For the formation the array of alternatives (risk reduction measures) it is proposed to engage the occupational health, safety and technical professionals. Each measure in each stage of hierarchy, created for all traumatic events of unacceptable and intermediate level of occurrence will be evaluated by the group of competent experts (55 measures in total for 5 unacceptable and 6 intermediate risks of traumatic events in this case study). With the aim of their subjectivity reduction the evaluating criteria and weighting factor are to be used.

The expert group should apply the criteria via point scale ratings and weighting factors for each criterion to evaluate each measure on its reliability in risk reduction. 5 criteria are proposed for choosing proper measures k_{ij} , they are to be evaluated on a scale from 0 (low) to 1 (high):

1. The performance index of the measure: the level of ensuring the risk reduction of traumatic event's occurrence.
2. Stability of the result: the level of ensuring the sustained permanent positive result.
3. The efficiency of the measure: reasonability of cost and human resources required for the realization of the measure.
4. Rate of implementation: the velocity of the measure implementation.
5. The easiness of implementation: needlessly of complex technical solutions, design, interruption of the production process, special permits, etc.

Each expert has determined the relative weighting factor for each criterion under condition that the sum of the relative weights exhibited by j-th expert (v_s) equal to unity:

$$\sum_{j=1}^{n} v_s = 1, \tag{6}$$

where v_s – the relative weight of the s-*th* criterion, exhibited by j-*th* expert; s = 1, …, 5,

$j = 1, ..., n$ – the serial number of the expert in the group.

The score calculation for evaluated measures according to the criteria and weighting factors done by the expert group is the following:

$$b_i = \sum_{j=1}^{n} v_s \cdot k_{ij} \cdot \overline{R}_i \tag{7}$$

where b_i - the rank of the *i-th* measure, estimated by *j*-th expert,

k_{ij} - the value of the *i-th* criterion, estimated by *j-th* expert,

$\overline{R}_i$ - the arithmetic mean of the risk distribution for the *i-th* component of risk-relevant information (calculated using the formula 4).

The sum of ranks for each measure: (b_i) is an a criterion for ranking measures in ascending sort for compiling the list of risk reduction activities.

The level of accordance the expert evaluation was checked using the Kendall tau rank correlation coefficient [13]. In case of accordance the finalized list of risk reduction measures can be compiled and sorted in descending order of preferences, defined by the sum of ranks.

To solve the management issues in health and safety it is also appropriate to apply the Routh–Hurwitz stability criterion (Hurwitz criterion) [14]. Applying the criterion of Hurwitz the decision-making manager assumes that the environment may be in the most favorable condition for the site management with probability α, and in the disadvantaged condition – with a probability $1 - \alpha$. Obviously, there are two limiting cases of this criterion: pessimistic (the value α is assumed to be 0), and optimistic (the value α is assumed to be 1). Thus, the result of Hurwitz criterion use is largely dependent on the correct choice of a confidence factor ($0 \le \alpha \le 1$). This value is proportional to the degree of the decision-maker confidence in occurrence of the favorable state of the environment. As the practice shows, the choice of values for the confidence factor can be poor grounded.

So, summarizing the above considerations, it can be stated that Hurwitz criterion is the most versatile. For its effective application, it is offered to calculate the confidence factor based on a mathematical model that establishes the dependence of occupational risk from multiple influencing factors. This model with a glance of formula (1) is the following:

$$R = R(P, F, S, N) \tag{8}$$

In order to determine the confidence factor it is proposed to use the normalized rated indicator, which is calculated as follows:

$$\alpha \in [0;\ 1] \alpha \in [0;\ 1], \tag{9}$$

where R_r – the rated value of the occupational risk; $R^{\min} R^{\min}$ – at its maximum and minimum possible value of indicator.

For the case when the occupational risk assessment is carried out in a range $[0; 1]$, that is $R^{\min} = 0$, $R^{\max} = 1$, formula (9) becomes:

$$\alpha = 1 - R_r \qquad (10)$$

Thus, the confidence factor is inversely proportional to the value of the calculated occupational risk. The use of Hurwitz criterion allows taking into account the risk assessment results for decision making in terms of uncertainty.

As an example, let us solve the task of planning risk reduction measures for m3 traumatic event "Hit by a moving vehicle", ranked as unacceptable.

Traumatic Event: Hit by a moving vehicle.

Hazard: Movement of people inside the manufacturing area where there is a possible hit by a moving electrical vehicle. The movement in the territory outside, where there is a possible hit by collision with a truck or an automobile.

Conditions of developing risk reduction measures: the use of risk reduction hierarchy.

The set of possible states of the environment:

z_1 – the prognosticated market growth for the finished goods produced by the enterprise, the increasing of production;

z_2 – the forecast on stable demand for the finished goods of the enterprise, the production remains unchanged;

z_3 – the negative forecast on decreasing demand for enterprise's products, the production is reduced;

The calculated levels of the risk of traumatic events occurrence:

$R_r = 8,1\%$ – The possibility of occurrence of a traumatic event "Hit by a moving vehicle" (risk is unacceptable);

$R^{\max} = 11,9\%$ – The possibility of occurrence of a traumatic event " Exposed to or contact with a harmful substance" (the risk is unacceptable);

$R^{\min} = 0,2\%$ – The possibility of occurrence of a traumatic event " Physically assaulted by a person" (the risk is acceptable);

Decision-making criterion: the criterion of Hurwitz, the confidence factor calculated using the formula (9) is 0,32.

The set of alternatives for the occupational risk reduction measures, expert evaluation results of the alternatives, and the estimated values of Hurwitz criterion are performed in the table 3.

Therefore the results presented in the column "Criterion value" show that the optimum in this case is an Alternative $a3$, which corresponds to the biggest rated value of criterion.

The proposed algorithm of decision-making is based on the expert method that was enhanced by suppressing the subjectivity. It allows to ground risk management decisions ranging the alternatives using indicators both quantitative and qualitative nature in terms of uncertainty. For provision of the automated calculation and maintenance of risk-relevant database, as well as the visualization of risk assessment results the computer information system has been developed. The software is based on the proposed algorithm of the component risk assessment method and decision making, and it can be practically applicable in the food and tobacco manufacturing enterprises.

Substantiation the occupational risk reduction measures using Hurwitz criterion

Alternative occupational risk reduction measures	Expected results of the alternatives			Criterion value
	z_1	z_2	z_3	
a1. Elimination of hazards (segregation of ways for moving vehicle and the pedestrians by installing physical barriers where it is possible)	0,87	0,53	0,32	0,50
a2. Substitution of hazards (automatic conveyors and pipelines for materials and products transportation instead of moving vehicles)	0,55	0,32	0,21	0,32
a3. Engineering controls (installation of traffic lights, spherical mirrors above crossroads, technical speed limit devices, light and sound signals for reverse movement of vehicle)	0,91	0,47	0,38	0,55
a4. Signage/warnings and/or administrative controls (warning signs, markings on the floor walkways, training for drivers and all employees)	0,52	0,39	0,24	0,33
a5. Personal protective equipment (shoes with metal protection, light-reflecting jackets for employees and visitors)	0,54	0,31	0,18	0,30

Conclusions

The component method of risk assessment is based on the evaluation of full range of the risk-relevant information with further substantiated decision making was implemented at the tobacco manufacturing factory. And is allowed to make some conclusions:

1. Human factor is expressed in risk assessment whilst an expert judgment. Such parameters of working environment as noise, dust, temperature, chemicals even in small dozes has an impact on psycho-emotional human state and hence distract the evaluation from real causes of injuries. It does not mean that the conditions of working environment can should be neglected, but focusing on severe injuries should be kept.

2. To reach the comprehensiveness of risk assessment all risk-relevant information available at the site should be taken into account. The simple average of risk distribution between the statistics of lost time injuries and fatalities, near misses information and results of internal and external audits, in addition to the standard risk assessment method results can be calculated. It will help to estimate the risk of traumatic events occurrence, and minimize the influence of subjectivity factor on risk assessment outcomes.

3. The risk-relevant information should reflect different time periods, so the attempt to recreate the dynamics of working environment has been done from the risk assessment standpoint.

4. The method stimulates the regular collection of risk-relevant information, increases engagement, awareness and knowledge of the site personnel in risk assessment.
5. Comparison the risk assessment results conducted by the modified matrix method and by the component method with the accident statistics has demonstrated the relevance of the latter method to real hazards specific to the working environment.
6. Making reasonable management decisions for occupational risk reduction based on multi-criterial approach and using Hurwitz criterion in terms of full or partial uncertainty will rise the effectiveness of resource allocation in health and safety, and it will enhance the safety performance of manufacturing enterprises.

Therefore, the minimization of human factor in expert judgement for occupational risk assessment and decision making is a practical tool for avoiding incorrect choice of management solutions, prevention significant material losses, and above all keeping safe working environment and human wellbeing.

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Evaluation of the working items of hotel-restaurant complex stability structures

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Abstract

Introduction. The institutions of the hotel and restaurant industry for its activity specific is not high-risk object, but the adverse or unusual situations, which should be classified as dangerous, can be created during its functioning. These situations include explosions and fires, which take place in the process of activities of the institution and could affect on the production staff, staff and/or visitors.

Materials and methods. To assess the stability of structures manufacturing objects of the hotel and restaurant complex to the effects of negative factors there was making explore using a method that establishes the procedure for calculating the value of the overpressure, which may be created during the combustion of gas-steam-air mixtures in production buildings of above mentioned institutions.

Results and discussion. To calculate the values of the explosive fire risk criteria in case the combustion of gas-vapor-air mixture choose the most unfavorable variant of the accident (emergency), when at the building receives the maximum quantity of dangerous substances (mixtures). Number of substances which fall within the buildings and may form explosive and flammable gas-air and steam-air mixtures and their hybrids are defined under the following conditions: – there is estimated accident (emergencies) one of the devices; – the entire amount of the dangerous mixture contained in the unit enters the building; – all amounts of pipeline substance considering the time to disconnect.

The research method of calculating the overpressure, what may be formed during combustion gas mixture was occurred with the following conditions: in a typical building of the hotel-restaurant institution with normal conditions of working environment, free volume 200 m^3, laid a pipeline with a bore diameter 50 mm, which is transported propane C_3H_8 with maximum consumption 5×10^{-3} m^3/s, and the maximum pressure 150 kPa.

Calculations were made for cases with pipeline equipped with automatic shut-off system timing eventually 2 s; Automation system failure probability no more than 0.000001 a year and did not provide emergency reservation of items, off time – 120 s; at manual disconnection system off time – 300 s.

Conclusions. The proposed method of calculation of the overpressure size, which can be created by the burning of gas-vapor-air mixture in the buildings of institutions of hotel-restaurant complex allows determine in advance the consequences of possible adverse or unusual situations and take timely structural and technical measures for preventing or minimizing it.

Introduction

The institutions of the hotel and restaurant industry for its activity specific is not high-risk object, but the adverse or unusual situations, which should be classified as dangerous, can be created during its functioning. These situations include explosions and fires, which take place in the process of activities of the institution and could affect on the production staff, staff and/or visitors.

To provide the safety of visitors, staff and production staff, minimizing the possible effects in the event of adverse or unusual situations, it is necessary to carry out the sustainability assessment of the structures manufacturing objects of hotel and restaurant complex. Based on the results is determining the suitability of structure of the building (building) of institution of the hotel and restaurant industry to norms of the flammability and explosive dangerous standards.

The aim of the work is to develop a method for calculating the value of the overpressure, which may be created during the combustion of gas-steam-air mixture in the buildings of the hotel and restaurant complex.

Materials and methods

To evaluate the stability of structures of the manufacturing facilities of the hotel and restaurant complex for the effects of damaging overpressure factors of the blast wave was carried the following researches stages:

• analyzed the conditions and factors what determine the degree of manufacturing danger for facilities of hotel and restaurant complex.

• the existing methods of modeling the actions of the air blast on the elements of design and process equipment of manufacturing facilities was analyzed.

• experimental research of parameters of the stability elements of process equipment from the effects of the air blast wave overpressure and substantiated findings was made.

• was evaluated scale and consequences of possible explosions facilities of hotel and restaurant complex.

During the research is applied method of analysis of the process deviations during the substantiation of the dangers that may arise in case of violation of the technical specifications for manufacturing facilities of hotel and restaurant complex; method of failure analysis process equipment of hotel and restaurant complex while research the effects of the failure of individual units, systems and devices.

Evaluating of fire and explosion danger of the technological process was determined experimentally and analytically the following:

- overpressure, which is formed during the combustion of gas-steam-air mixture in the manufacturing premises;

- size of zones what limited of Lower Explosive or Flammable Limit (LEL/LFL) of gas and steam;

- damaging factors that arise in the destruction of process equipment due to the impact on it center of fire;

- the intensity of evaporation of flammable liquids and liquefied gases in open area and in the industrial premises;

- other indexes of fire and explosion danger of the technological process that is necessary for analysis of its dangers.

Results and discussion

In common life people very often found the adverse domestic, non-standard situations: accident, accidents, mining of buildings, terrorism and so on. Such situations could have a negative impact both on the production staff and visitors of hotel and restaurant institutions (complex).

For safety designs, the right choice of material, quality of production, construction, installation, repair and technical diagnostics, as well as compliance with the object to the facility regulations consistent to enterprise organization (regardless of ownership and departmental affiliation), which performs the appropriate operation. The accommodation of buildings and their interconnection should create the necessary hygiene and fire safety conditions [1–3, 7].

By the term "unfavorable" or "nonstandard situation" in the restaurant and hotel institutions include situations arising in the building, which have no acquired the scale of the emergency, but creating the threat for people`s lives and health or causing of material damage. These situations include explosions or fires, what threaten both the production staff and visitors [4, 6].

Explosion and fire danger of hotel and restaurant institutions occursed, when using vessels, which are working under the pressure (cylinders with combustible gases for gas cookers; cylinders of beersplate installation and saturators; piping with natural gas or other agent) in production, auxiliary, or other buildings. Also this danger occursing, when the concentration of dust or gas meets the conditions to achieve of Lower Explosive or Flammable Limit (LEL/LFL) of dust, gases or their hybrids what can explode (burst) able under certain conditions (by exceeded the level of gas concentration in buildings and boiler buildings, where the pipelines natural gas are or natural gas is used as fuel, ammonia refrigeration compressors in cooling chambers are, renovations using varnish-and-paint materials are, etc.) [6–8].

Therefore, for each institution of hotel and restaurant complex is developing the documentation regarding the stability of buildings for the effects of an explosion or fire; actions of staff in case of non-standard (unfavorable) situations.

To calculate the values of the explosive fire risk criteria in case the combustion of gas-vapor-air mixture choose the most unfavorable variant of the accident (emergency), when at the building receives the maximum quantity of dangerous substances (mixtures) [5, 8].

Number of substances which fall within the buildings and may form explosive and flammable gas-air and steam-air mixtures and their hybrids are defined under the following conditions:
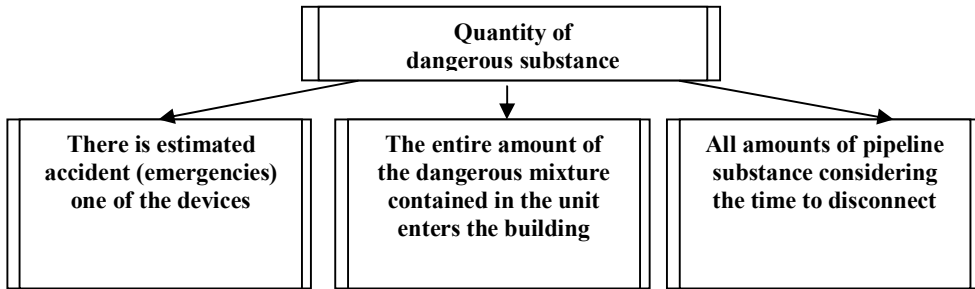
```
┌─────────────────────────────────┐
│         Quantity of             │
│     dangerous substance         │
└─────────────────────────────────┘
```

| There is estimated accident (emergencies) one of the devices | The entire amount of the dangerous mixture contained in the unit enters the building | All amounts of pipeline substance considering the time to disconnect |

Figure 1. Conditions, which counted to determine the amount hazardous substances

Time of disconnection of the pipelines is determined for each accident, based on the actual cases. It should be minimal considering the technical characteristics of safety devices and the kind of the process.

Calculated time of emergency shutdown of the pipelines

time operation of automatic shutdown system pipiline that meets the technical characteristics of the device if the probability of system failure does not exceed 0.000001 per year or provided emergency backup its elements (no more than 120s)

120 s, if the probability of system failure automatic over 0.000001 year and did not provide emergency backup its elements

300 s with manual disconnection system

Figure 2. The determine limits of the estimated time of emergency shutdown of the pipelines

Using the technical means with off time exaggerates hover above mentioned are unacceptable.

Excess pressure Δp, kPa, for individual combustible substances, which consist of atoms of C, H, O, N, Cl, Br, I, F, is calculated by formula:

$$\Delta p = (p_{max} - p_0) \cdot \frac{mZ}{V_{bil}\rho_{g,s}} \cdot \frac{100}{S_c} \cdot \frac{1}{C_a} , \qquad (1)$$

where p_{max} – maximal pressure, which generated during combustion or stoichiometric gas-steam or steam-air mixture in a closed volume, kPa; P_0 – initial pressure of gas-air or steam-air mixture, kPa; m – mass of combustible gas or vapor flammable and combustible liquids,

which have got into the building with an accident, kg; Z – number of rate of combustible substances during combustion gas-air mixture (allowed to accept 0–1, depending on the type of combustible material); V_{bil} – free building volume, m^3; $\rho_{g,s.}$ – the density of steam or gas explosion at an initial temperature, kg/m^3; S_c – stoichiometric concentration of the gas-steam or steam-air mixture; C_a – coefficient accounting for facilities and leaks non adiabatic processes of burning. It is supposed to take $C_a = 3$. Leaks in buildings due to constantly open windows or other apertures in the technological envelope.

Free volume of production building or any other building of the hotel-restaurant complex is calculated as the difference between total volume and its volume, what is busy processing equipment or interior (the objective of equipment filling, furniture and other design objects). If the free volume production facilities can`t be determined, it is accepting conditionally, equal to 80% from the total volume of the building.

The density of gas or steam ($\rho_{g.s}$) at the settlement temperature t_s, kg/m^3, is given by:

$$\rho_{g,s} = \frac{M}{V_0(1+0.00367 t_s)}, \tag{2}$$

where M – molar mass of gas or steam, kg/kmol; V_0 – molar volume of gas or steam is 22.413 m^3/kmol; t_s – settlement temperature, °C.

Calculation of stoichiometric concentration of combustible gases or steam of the flammable substances and combustible substances, S_c, % (vol.), is given by:

$$S_c = \frac{100}{1+4,84\beta}, \tag{3}$$

where $\beta = n_C + \frac{n_H - n_X}{4} - \frac{n_O}{2}$ – stoichiometric coefficient of oxygen in the combustion reaction; n_c, n_H, n_o, n_x – number of atoms of C, H, O in the molecule.

Calculation Δp, kPa, for individual substances and mixtures can be made by the equation:

$$\Delta p = \frac{m H_m p_0 Z}{V_{bil} \rho_a C_a T_0} \cdot \frac{1}{C_a} \tag{4}$$

where H_m – the heat of combustion, J/kg; ρ_a – the air density with the initial temperature T_0, kg/m^3; C_a – the heat capacity of air, J/(kg×K); T_0 – the initial temperature, K.

Mass of gas m, which entering the workplace in case of the accident, kg:

$$t = (V_a + V_p)\, \rho_g, \tag{5}$$

where V_a – volume of gas that came from the apparatus, m^3; V_p – volume of gas, that came out of the pipeline, m^3.

With:

$$V_a = 0,01\, p_1 V, \tag{6}$$

where p_1 – the pressure in the apparatus, kPa; V – volume of apparatus, m^3.

$$V_t = V_{1t} + V_{2t} \tag{7}$$

where V_{1t} – the volume of gas, that came out of the pipeline before turn it off, m^3; V_{2t} – the

volume of gas, that came out of the pipeline after shutdown it, m^3.

$$V_{1t} = q_t, \qquad (8)$$

where q – cost of gas determined in accordance with the technological regulations depending on the pressure in the pipeline, its diameter, temperature of gas environment and others, m^3/s; t – time, s.

$$V_{2t} = 0,01\pi p_2 (r_1^2 l_1 + r_2^2 l_2 +, ..., + r_n^2 l_n), \qquad (9)$$

where p_2 – the maximum pressure in the pipeline with the technical regulations kPa; $r_{1,2,...n}$ – internal radius of pipeline, m; $l_{1,2,...n}$ – the length from the pipeline system to the catches, m.

Mass of liquid vapor *m*, what falls in production buildings in the presence of few sources of evaporation (surface liquid spilled, freshly painted surface, open containers, etc.), is:

$$m = m_l + m_{vol} + m_{fr.paint.}, \qquad (10)$$

where m_l – mass of liquid, which evaporates from the spill surface, kg; m_{vol} – mass of the liquid, which evaporates from the open containers, kg; $m_{fr.paint.}$ – mass of the liquid, what evaporates from the freshly painted surface, kg.

Thus, each component of the formula 10 is defined as:

$$t = WS_{vp.}T \qquad (11)$$

where W – intensity of evaporation, kg/(m^2×s); $S_{ev.}$ – evaporation area, m^2.

The research method of calculating the overpressure, what may be formed during combustion gas mixture was occurred with the following conditions: in a typical building of the hotel-restaurant institution with normal conditions of working environment, free volume V_{fv} = 200 m^3, laid a pipeline with a bore diameter $d_{pip.}$ = 50 mm, which is transported propane C_3H_8 with maximum consumption q = 5×10^{-3} m^3/s, and the maximum pressure P_{max} = 150 kPa.

Calculations were made for cases with pipeline equipped with automatic shut-off system timing eventually 2 s; Automation system failure probability no more than 0.000001 a year and did not provide emergency reservation of items, off time – 120 s; – 300 s with manual disconnection system off time – 300 s.

The results are shown in Table 1.

Table 1

Calculated value of overpressure Δp, kPa

$V_{fv.}$ free volume of building, m^3	$l_p.$ the length of pipeline that cut off, m	q maximum consumption of dangerous substance, m^3/s	The presence of the automatic shutdown system (time of processing, s)	Value of overpressure Δp, kPa
200	10	5×10^{-3}	2	0,04
			120	8,06
			300	19,6

These calculations are used for determining the stability of structures, scope and degree of destruction of buildings and the number of possible victims. Therefore in the design of new or renovation of old buildings should take into account all possible risks.

In the case of redevelopment of premises, change their functional purpose, technical rearmament must adhere to the fire protection requirements of existing regulations of construction and technological design. Not allowed reducing design limits of fire resistance of structures and deteriorating conditions of evacuation of people.

Given the conditions of emergence, spread and effects of negative factors of non-standard situations (fire or explosion) to the location of production conditions put forward the following requirements:

– Engine building of cooling chambers must be located in one unit with refrigerating chambers and have a separate entrance into the corridor. Engine building of freon refrigeration units must be a height no less than 3.5 m, while the gas volume described by compressors piston up to 150 m^3/h – a minimum height 2.6 m.
– Heat points should position usually on the 1st floor of the building adjacent to the outer wall of the water-supply input urban highway network and have output to the corridor and into the street.
– Furnaces of coal, peat or wood cookers should be placed in a separate building.
– Number of automatic fire-detectors determined by the need in detection of fires of all controlled buildings areas (zones).

Conclusions

The proposed method of calculation of the overpressure size, which can be created by the burning of gas-vapor-air mixture in the buildings of institutions of hotel-restaurant complex allows determine in advance the consequences of possible adverse or unusual situations and take timely structural and technical measures for preventing or minimizing it.

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Анотації

Харчові технології

М'ясні продукти для харчування людей з надлишковою вагою тіла – пандемією XXI століття

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Вступ. Для успішного вирішення проблеми надлишкової ваги важливою є розробка таких спеціальних продуктів, які дали б змогу групі людей з надлишковою вагою тіла знизити масу тіла, споживаючи той чи інший продукт. Такого ефекту можна досягти, додаючи або замінюючи певний компонент у рецептурі на інший, з високими функціональними властивостями.

Матеріали і методи. Для дослідження обрано м'ясо цесарки та шинку, збалансовані за амінокислотним і жирно-кислотним складом. Використані методи математичного моделювання рецептур готового продукту, експериментальні методи дослідження хімічного складу, структурно-механічних показників продукту. Амінокислотний склад визначено методом іонообмінної хроматографії на аналізаторі амінокислот типу Т-339. Жирнокислотний склад сировини визначали методом газової хроматографії.

Результати і обговорення. Для нормальної роботи людського організму найкращим співвідношенням основних жирних кислот вважається 1:1:1. Найбільш наближеними за цим показником до ідеального є жир дикої качки та цесарки (1:0,9:0,7 та 1:0,5:1,0 відповідно). Найгіршим за співвідношенням жирних кислот є баранячий жир (1:0,1:1,9). За співвідношенням ПНЖК/НЖК найкращими є свинячий жир (0,27) і жир перепелів (0,21), найгіршими є жир дикої качки (1,27), кінський (0,58) і курячий жир (0,56).

Варено-копчена шинка з м'ясом цесарки має більш збалансований амінокислотний склад порівняно з контрольними зразками. У варено-копченій шинці спостерігається вищий вміст валіну (на 0,6%), лізину (на 0,71%), метіоніну (на 0,20%), треоніну (на 0,69%), аланіну (на 0,59%), аспарагінової кислоти (на 0,69%) та гліцину (на 0,79%) порівняно з контрольним зразком. За вмістом незамінних амінокислот шинка з м'ясом цесарки наближається до білка курячого яйця, а за вмістом таких амінокислот, як валін, ізолейцин, лейцин, лізин, аланін, аргінін, аспарагінова кислота, гліцин, глютамінова кислота і тирозин перевершує його.

Висновки. Варено-копчена шинка з м'ясом цесарки має добре збалансований амінокислотний склад, характеризується високою біологічною цінністю і може бути віднесена до повноцінних продуктів харчування за вмістом незамінних амінокислот.

Ключові слова: *м'ясо, цесарка, шинка, ожиріння, харчування, баланс.*

Дослідження вмісту ароматичних компонентів у вині із сортів винограду, вирощених в Інституті виноградарства і енології (м. Плевен, Болгарія)

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Вступ. Походження ароматичних речовин винограду, мусту і вина визначається: ароматичними речовинами винограду, який переходить у муст і вино; ароматичними речовинами, які є продуктами біохімічних явищ (окиснення, екстракція, гідроліз), що передують ферментації; ароматичними речовинами, які є продуктами діяльності дріжджів і бактерій, що проводять спиртове і яблучно-молочне (малолактичне) бродіння; ароматичними речовинами, які утворюються під час перетворення і є результатом утворення вина; ароматичними речовинами, що утворюються протягом тривалого зберігання чи старіння вин.

Матеріали і методи. Досліджувалися вина з винограду таких видів: Сторгозія, Кайласький рубін, Трапезіца, Рубін і Букет, селектованих в Інституті виноградарства і енології у м. Плевені шляхом внутрішньо- і міжвидової гібридизації. Ці види перероблялися для виробництва сухих червоних вин традиційним шляхом. Визначення ароматичного профілю вин проводилось шляхом газової хроматографії.

Результати і обговорення. Кількість ацетальдегіду в досліджених винах знаходилася у межах норми для червоних сухих вин. Найбільшу кількість ацетальдегіду було виявлено у вині, виготовленому з винограду сорту Кайласький рубін (83,80 мг/дм^3). У винах з винограду сортів Рубін і Сторгозія кількість ацетальдегіду незначна, а у вині з винограду сорту Трапезіца ацетальдегід не зафіксований. Фракції вищих спиртів 2-метил-1-бутанол було виявлено лише у вині з винограду Кайласький рубін (269,80 мг/дм^3). 1-пентанол, який надає приємного квіткового тону винам, виявлено у винах з сортів винограду Букет (71,79 мг/дм^3), Трапезіца (58,20 мг/дм^3), Рубін (29,00 мг/дм^3), тоді як у винах з винограду Піор Нуар його вміст склав лише 15,49 мг/дм^3. З фракції ефірів у всіх винах виявлено етилацетат (13-37 мг/дм^3). Також у всіх винах зафіксовано ізобутилацетат (33,80-86,84 мг/дм^3). Етиловий бутират виявлено лише у вині з винограду сорту Букет (164,60 мг/дм^3). Із групи терпенів визначені гераніол і бета - цитронеллол.

Висновки. Кількість ацетальдегіду в досліджених винах знаходиться в межах норми. Серед вищих спиртів найбільший вміст 1-пентанолу. Домінуючим ефіром є етил бутират. Наявність терпенів менш помітна.

Ключові слова: *виноград, вино, спирт, ефір, терпен, хроматографія.*

Обґрунтування седиментаційної стійкості молочної сироватки після електроіскрового оброблення

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Вступ. Стаття присвячена первинному обробленню молочної сироватки, зокрема перспективам її переробки з використанням електричних розрядів. Доцільність застосування електричного розряду в технології переробки молочної сироватки

підтверджується експериментальними дослідженнями, а також результатами математичного і статистичного аналізу.

Матеріали і методи. На основі математичного моделювання створено раціональний режим електрогідравлічної обробки сироватки, яка супроводжується максимальною дисперсністю часточок осадженого казеїнового пилу.

Результати і обговорення. Було підтверджено, що середній гідродинамічний діаметр частинок молочної сироватки знизився з (1697,5 ± 82,38) нм до (221,34 ± 10,3) нм після обробки електричними розрядами з максимальною напругою 45 кіловольт і кількістю розрядів 25. Індекс полідисперсності при цьому різко впав з 1,0 до 0,35... 0,40, що характеризує систему як монодисперсну.

За напруги 30 і 35 кВ і кількості розрядів 5...15 диспергування частинок було несуттєвим. Середній розмір часток зменшувався тільки на 22...30%. Зі збільшенням напруги і кількості розрядів відзначено зсув піків на кривих розподілу в бік частинок розміром до 500...1000 нм і зниження середнього гідродинамічного діаметра. Кращі результати електрогідравлічної обробки молочної сироватки були досягнуті за напруги 45 кВ і кількості розрядів 25.

Обсяг осаду в обробленій сироватці знизився з 0,9...1,1 до 0,1...0,2 см^3 за напруги 45 кВ і кількості розрядів 25.

Висновки. Запропоновано технологічну схему первинної переробки молочної сироватки з використанням електрогідравлічного методу.

Ключові слова: *сироватка, розряд, дисперсність, седиментація, стійкість.*

Тістоутворювальна здатність сумішей із борошна пшениці та плодів хлібного дерева

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Вступ. Дослідження проведено з метою визначення здатності сумішей пшеничного борошна і борошна з плодів хлібного дерева до утворення тіста для можливого промислового використання.

Матеріали і методи. Плоди хлібного дерева сортувалися, милися, чистилися від шкірки, нарізалися скибками, бланшувалися, охолоджувалися, з них видаляли вологу, сушили у сушильній шафі за температури 650 °C, подрібнювали на борошно і перемішували з пшеничним борошном із таким співвідношеннями пшеничного борошна до плодів хлібного дерева: 100:0, 90:10, 85:15, 80:20, 75:25. Ці композиційні суміші борошна піддавали аналізу щодо здатності до утворення тіста.

Результати і обговорення. Максимальний показник в'язкості для суміші борошна пшениці й плодів хлібного дерева коливався від 193,5 до 270,68 відносних одиниць. Спостерігалися значні (<0,05%) відмінності в значеннях в'язкості для різних зразків. Показник в'язкості показує ймовірність розриву тіста під час приготування. Показник в'язкості, за якого можливий розрив тіста, коливається від 72,92 до 106,08 умовних одиниць. Останній показник в'язкості коливався між 216,67 і 275,75 умовних одиниць, а найвище значення в'язкості отримало борошно плодів хлібного дерева, що вказує на стабільність приготованого тіста. Найнижчі значення коливаються між 96,0 і 111,75 умовних одиниць. Максимальний час

коливається від 4,43 до 4,66 хв для 100% пшеничного борошна, тоді як значення суміші на 15% нижчі. Значні (<0,05%) відмінності помічено для температур утворення тіста з борошна суміші пшениці та хлібного дерева. Температура утворення тіста дає змогу визначити час желатинізацій під час процесу.

Висновки. Збільшення вмісту борошна з плодів хлібного дерева в суміші покращує її тістоутворювальні характеристики.

Ключові слова: *пшениця, хлібне дерево, борошно, тісто.*

Вплив морських водоростей на зміни показників якості вершкового масла

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Вступ. Метою статті є дослідження впливу морських водоростей на зміни показників якості вершкового масла в процесі зберігання.

Матеріали і методи. Об'єктом дослідження є зразки вершкового масла з порошком з ламінарії, фукуса, спіруліни і цистозири; контролем – вершкове масло жирністю 62,5%. Зразки зберігали за температур плюс 3 ± 2 °C і мінус 7 ± 2 °C, визначали зміни органолептичних показників (смаку і запаху), а також первинних продуктів окислення – пероксидів і гідролізу ліпідів на різних термінах.

Результати і обговорення. Використання морських водоростей у складі вершкового масла дозволяє продовжити термін зберігання продукції в два рази. Так, динаміка органолептичних показників вершкового масла з водоростями характеризувалася зниженням балів у контрольних зразках в процесі зберігання при плюс 3 ± 2 °C до 45 діб на 4 бали, з водоростями – на 2 бали; під час зберігання в умовах мінус 7 ± 2 °C до 65 діб – на 5 балів в контрольному зразку і на 2 бали – з морськими водоростями. Під час зберігання зразків в умовах температури плюс 3 ± 2 °C зміни комплексу показників проходить більш інтенсивно порівняно зі зберіганням при мінус 7 ± 2 °C, що пояснюється впливом низьких температур. Пероксидне число жиру контрольного зразка вершкового масла після 30 діб становило 4,9; з морськими водоростями – від 3,2 до 3,5 ½ О ммоль/кг відповідно. Аналогічна залежність установлена під час вивчення гідролізу жиру: всі види морських водоростей вдвічі уповільнюють процеси накопичення вільних жирних кислот. Можна припустити, що спостережуваний нами ефект обумовлений наявністю в морських водоростях селену, пігментів, біофлавоноїдів, а також формуванням полісахаридно-ліпідних комплексів на поверхні нанозерен, які захищають жирову фазу від окислення й гідролізу.

Висновки. Збагачення вершкового масла морськими водоростями уповільнює погіршення органолептичних показників, а також процеси окислення й гідролізу жиру під час зберігання як за плюсової, так і мінусової температури.

Ключові слова: *вершки, масло, ламінарія, фукус, спіруліна, цистозіра, зберігання.*

Оцінка якості порошку з овочів, отриманих способом змішаного теплопідведення

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Вступ. Розширення асортименту продуктів переробки плодоовочевої продукції за рахунок збільшення частки і різноманітності асортименту сушених плодів і овочів на сьогодні є доцільним і перспективним.

Матеріал і методи. Для дослідження використовувався порошок із капусти, отриманої висушуванням із змішаним теплопідведенням. Структурні і регідратаційні властивості порошку з капусти вивчались з використанням оптичного (МВІ-15) мікроскопа з «просвічуванням» світлом, дериватографа Pauli-Erden Q-1500D та приладу Догадкіна, що працює за принципом сполучуваних судин. Під час аналізу ізотерм адсорбції парів води овочевих порошків встановлено, що дослідні зразки ЗТП-сушіння за адсорбційною структурою однакові.

Результати і обговорення. Порошок з капусти, отриманий способом змішаного теплопідведення (ЗТП-сушіння), за температур процесу 50 та 70°C, що обрано як умовно «граничні», досліджено на розміри пор за допомогою установки Мак-Бена.

Аналіз знімків мікроструктури відновлених частинок порошку з капусти дає змогу констатувати, що на процес регідратації впливають вид і температура середовища. Так, на представлених знімках мікроструктури видно, що за температури 20 °C у різних середовищах на поверхні клітин тканин овоча між складовими компонентами порошку та молекулами води формуються сольватні комплекси і на знімках добре видно шар адсорбційно зв'язаної вологи.

Визначено коефіцієнт водопоглинання порошків з капусти, кабачків і топінамбуру в обраних полярних середовищах. Результати досліджень вказують, що використання методу ЗТП-сушіння сприяє формуванню регідратаційних властивостей порошку з капусти, що відрізняються в 1,5 раза більшою здатністю зв'язувати вологу порівняно з конвективним сушінням.

Висновки. Отримано порошок з капусти методом сушіння зі змішаним тепловідведенням за температур 50 та 70 °C. Більша в 1,5 раза поверхня адсорбції порошку з капусти (70 °C) дозволяє констатувати, що поглинання вологи у даного зразка порошку буде, відповідно, більшим.

Ключові слова: *якість, порошок, овочі, регідратація, мікроструктура.*

Вплив екструдування на мікробіологічні показники кормових сумішей

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Вступ. З метою визначення якості кормових сумішей, що містять лляний екстракт на основі сироватки, досліджено мікробіологічні показники кормових сумішей після екструдування різного рецептурного складу під час зберігання.

Матеріали і методи. Досліджувалися кормові суміші із зерна пшениці, кукурудзи та лляного екстракту на основі сироватки у різній відсотковій кількості. Лляний екстракт отримували шляхом екстракції в пульсаційних диспергаторах з

активною діафрагмою. Суміш змішували й екструдували за температури 110–120 °C, тиску 2–4 МПа, що дозволяє майже повністю її знезаразити.

Досліджували зміну мікробіологічних показників кормових сумішей під час зберігання. Дослідні зразки поміщали в тканинні мішки і зберігали впродовж 2 місяців за температури 0 °C (холодильник), +20 °C, (термостат) і відносній вологості повітря 45%.

Результати і обговорення. Вологість зернових сумішей до екструдування в зразках знаходилась в межах 16,8 – 17,6%, після екструдування від 13,3 до 13,5%, протягом терміну зберігання не змінювалась. За температури + 20 °C і відносній вологості повітря 45% вологість зразків змінюється в процесі зберігання від 13,3…13,5% до 15,3…16,1%.

Зміна вологості екструдованих кормових сумішей значною мірою залежить від температури зберігання, а не від кількості введеного лляного екстракту на основі сироватки до складу суміші.

На початку та в кінці зберігання екструдованих кормових сумішей характерний досить низький рівень мікробіологічного обсіменіння. Не були виявлені такі групи мікроорганізмів, як бактерії групи кишкової палички (БГКП), патогенні мікроорганізми. Загальна кількість мезофільних аеробних і факультативно анаеробних мікроорганізмів (МАФАМ) у всіх зразках сумішей знаходиться в допустимих межах (не більше $5 \cdot 10^5$ КУО/г).

Аналіз колоній мезофільних аеробних мікроорганізмів на м'ясопептинному агарі виявив, що вони характеризуються великими, малими і середніми розмірами, білим і жовтим забарвленням, рівними і нерівними краями. Основна частина мікроорганізмів - це кокові бактерії, клітини яких розміщуються поодиноко або скупченнями. Основними морфотипами бактерій, виділених із кормових екструдатів, є аеробні бактерії.

Висновок. Рекомендується використовувати процес екструдування як ефективний спосіб підвищення санітарної якості екструдованих кормових сумішей, оскільки він дозволяє отримати майже стерильний продукт.

Ключові слова: *корм, льон, екстракт, мікробіологія, коки.*

Зміни мікронутрієнтного складу біофортифікованих овочів під час заморожування і зберігання

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Вступ. Досліджено зміни мікронутрієнтного складу біофортифікованих шляхом застосування добрива "Ріверм" овочів під час заморожування і зберігання.

Матеріали і методи. Матеріали – свіжі і заморожені зразки біофортифікованого перцю солодкого і гарбузів. Для визначення вмісту мікронутрієнтів використано методи інверсійної вольтамперометрії, рідинної хроматографії, а також колориметричний і титрометричний методи.

Результати і обговорення. Зразки біофортифікованих плодів перцю і гарбузів є більш цінними за вмістом заліза (на 7,4–14,6%), цинку (на 2,7–6,7%), міді (на 2,1–

6,6%), вітамінів B$_1$ (на 20,9–44,7%), B$_2$ (на 18–34,3%), C (на 28–29%), каротиноїдів (на 11,6–22,8%) порівняно з контролем.

Зменшення кількості заліза в заморожених біофортифікованих овочах за 6 місяців зберігання складає 4,5–5,4%, міді – 2,6–2,7%, цинку – 2,1–2,3%. За час заморожування і зберігання біофортифіковані гарбузи сорту Олешківський втратили 22,4% вітаміну C (контроль – 36,9%), 15,7% каротиноїдів (контроль – 23,7%), 15% вітаміну B$_1$ (контроль – 32,4%), 13,8% вітаміну B$_2$ (контроль – 26,2%). Протягом зберігання замороженого біофортфікованого перцю солодкого сорту Золото скіфів теж відбулося зменшення вмісту вітамінів: вітаміну B$_2$ – на 13,8% (контроль – на 14,9%), вітаміну B$_1$ – на 12,8% (контроль – на 14,1%), вітаміну C – на 12,7% (контроль – на 13,2%), каротиноїдів – на 5,3% (контроль – на 6,0%). Найбільшу кількість вітамінів дослідні зразки овочів втратили безпосередньо під час заморожування. Контрольні зразки заморожених овочів на всіх етапах дослідження містили у своєму складі меншу кількість мікроелементів і вітамінів.

Висновки. Заморожування і зберігання біофортифікованих (вирощених із застосуванням органічного добрива "Ріверм") плодів перцю і гарбузів призводять до зниження в них вмісту мікронутрієнтів, але ці зміни відбуваються не так інтенсивно, як у контрольних зразках. Найбільші втрати вітамінів припадають на процес заморожування.

Ключові слова: *заморожування, мікронутрієнт, біофортифікація, овоч, Ріверм.*

Показники якості кондитерських напівфабрикатів з порошком із банану та моркви

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Вступ. Проведено дослідження технологічних властивостей порошків з моркви і банану, отриманих холодним розпилювальним сушінням, з метою визначення впливу рослинної сировини на показники якості кондитерського напівфабрикату.

Матеріали і методи. Визначення дисперсності рослинних порошків проводили шляхом підрахунку розмірів частинок порошків за допомогою окуляр-мікрометра й оптичного мікроскопа зі збільшенням у 400 разів. Дослідження фізико-хімічних показники якості отриманих напівфабрикатів визначали за допомогою стандартних методик.

Результати і обговорення. Визначення дисперсності рослинних порошків мікроскопічним методом показало, що найбільший обсяг часточок у досліджуваних зразках представлений фракцією до 20 мкм, дана фракція у порошку з банану міститься в обсязі 81%, моркви – 78 %. Тобто частинки в готовому виробі не будуть відчуватись органолептично.

Порошок з банану є гомогенним за дрібними фракціями часточок, представлений часточками кулеподібної форми, однорідний за всією масою.

Найкраще утримує жир порошок з банану (0,92 мл/г), який, навпаки, має меншу вологозв'язувальну здатність (6,33%). Аналогічна зворотна тенденція виявляється і для порошку з моркви: за більших водопоглинання і вологоутримання (6,93%) даний порошок має менше значення жироутримувальної здатності (0,89 мл/г).

Під час визначення впливу обраних дозувань досліджуваних порошків на органолептичні властивості кондитерського напівфабрикату як найбільш раціональне було обрано дозування порошку з моркви – 5% та порошку з банану – 18% до рецептурної маси, що дозволяє отримати кондитерський напівфабрикат з високими смаковими властивостями, а саме: однорідної структури, пластичної консистенції, зі смаком і запахом, що притаманні даному фрукту.

Масова частка вологи кондитерського напівфабрикату з порошком моркви становить 12,2%, з порошком з банану – 11,6% . Масова частка жиру - 25% та 18 % відповідно. Вміст редукуючих речовин в отриманих напівфабрикатах складає 4,4% та 4,2%. Розмір кристалів основної фракції становить 10–15 мкм.

Висновки. За результатами досліджень можна рекомендувати використання дрібнодисперсних рослинних порошків у кондитерському виробництві з метою підвищення харчової цінності та розширення асортименту готової продукції.

Ключові слова: *напівфабрикат, порошок, якість, кондитерські вироби, банан, морква.*

Використання ферментів для вилучення ріпакової олії методом пресування

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Вступ. Для вилучення ліпідів, які зберігаються в замкненій структурі насіння, необхідно подолати кілька бар'єрів. Використання гідролітичних ферментів, таких як целюлаза, геміцелюлаза, пектин аза, підвищує проникність такої структури.

Матеріали і методи. Для дослідження використано насіння ріпаку низькоглюкозинолатних сортів. Для попередньої ферментативної обробки обрано ферментні препарати з розширеним спектром дії: Protolad (протеаза, 70 од/г, Ензим, Україна) і Celulad (целлюлаза, 300 од/г, Ензим, Україна). Для оцінки якості одержаної олії використали методи визначення йодного, кислотного та пероксидного чисел. Ефективність дії ферментних препаратів оцінювали методом моментального збовтування, а також за залишковою кількістю олії в макусі.

Результати і обговорення. Найкращі результати були отримані в зразках насіння ріпаку, які мали вміст вологи 4 %. Ферментативна обробка олійного матеріалу протягом двох годин є достатньою умовою для зменшення залишкової олійності макухи з 24,4 % до 9,4 %. Кількість ферментного препарату 0,4 % до маси насіння є оптимальним значенням. Ферментативна обробка в технології пресування є дуже ефективним способом збільшення кількісного виходу олії. Фізико-хімічні показники зразка олії після ферментативної обробки порівняли із зразком пресової ріпакової олії. Результати відповідають вимогам нормативної документації. Аналіз складу жирних кислот зразка ріпакової олії після ферментативної обробки показав збільшення лінолевої і олеїнової кислот (близько 3%) і ліноленової – більш ніж на 1% порівняно з контролем. Вміст інших жирних кислот у зразках ріпакової олії істотних відмінностей не мав. Розраховано рівняння регресії для залежності виходу олії від концентрації ферменту, вмісту вологи в матеріалі перед пресуванням і часом гідролізу на основі експериментальних даних. Збільшення кількості вилученої олії з ріпакового насіння, яке піддавалося попередній ферментативній обробці, показує, що ферментативний гідроліз є дуже ефективним методом попередньої обробки матеріалу перед пресуванням. Додавання ферменту проводиться у водному розчині. Висока

вологість насіння під час обробки є несприятливим фактором з економічної точки зору, тому що наступним етапом обробки є висушування.

Висновки. Основними завданнями дослідження залишається удосконалення методу попередньої обробки насіння ріпаку, а саме: зменшення вологості насіння в процесі ферментативного гідролізу.

Ключові слова: *ріпак, фермент, пресування, олія.*

Удосконалення технології макаронних виробів, збагачених чорницею

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Вступ. Досліджено використання чорниці у технології макаронних виробів з хлібопекарського борошна, що є актуальним для поліпшення харчової цінності й удосконалення асортименту макаронних виробів.

Матеріали і методи. Досліджено макаронні вироби з хлібопекарського борошна, порошок чорниці, отриманий подрібненням висушеної чорниці. Якість макаронних виробів оцінювали за комплексним показником, що включає показники варильних властивостей, органолептичні, фізико-хімічні й харчову цінність. Структурно-механічні властивості тіста оцінювали на фаринографі Брабендера. Оптимальні технологічні параметри встановлювали методом Бокса-Уїлсона.

Результати і обговорення. Макаронні вироби з внесенням чорничного порошку в кількості 5 – 10 % до маси борошна набувають фіолетового кольору, поліпшуються їх варильні властивості. Зростання дозування до 15 % призводить до підвищення кислотності та зниження міцності виробів на 30 %. Чорничний порошок зумовлює зниження вмісту клейковини та її гідратаційної здатності. Це пов'язано тим, що компоненти чорниці виявляють дегідратувальний вплив у макаронному тісті і перешкоджають біополімерам пшеничного борошна утворювати тісто. При цьому клейковина виявляє більш пружні властивості. Чорничний порошок забезпечує утворення дрібнокрихтуватого тіста, що зумовлює певне прискорення випресовування виробів. Встановлені оптимальні технологічні параметри для приготування макаронних виробів з чорничним порошком: дозування порошку чорниці – 4 % до маси борошна, температура води для приготування тіста – 37 °C. Таке дозування забезпечує збагачення виробів вітаміном C у кількості 2,3 мг/100 г (у разі споживання 100 г макаронних виробів денна потреба в цьому вітаміні забезпечується на 2,6 %).

Висновки. Результати досліджень рекомендуються для розширення асортименту макаронних виробів, для дієтичного, вегетаріанського, дитячого харчування, а також у разі перероблення борошна, здатного до потемніння.

Ключові слова: *макарони, чорниця, якість, збагачення.*

Процеси і обладнання харчових виробництв

Сушіння композиційної фітоестрогенної сировини

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Вступ. Фітоестрогенні композиції за своїм вмістом компонентів відрізняються від моносировини високим вмістом білка та наявністю значного відсотка ліпідів. Під час переробки доцільно розробити режими підготовки сої з повною інактивацією антихарчових компонентів і сушіння з максимальним збереженням біологічно активних речовин.

Матеріали і методи. Для проведення досліджень використовували сою, ріпак, стружку моркви, цибулі, гарбуза, столового буряка та функціональні композиції з них. Застосовували експериментальні методи з використанням сучасних засобів вимірювання параметрів сушіння: часу проведення досліду, температури теплоносія та зменшення маси матеріалу. Для оцінки якості функціональних продуктів використані стандартні методи досліджень із застосуванням методів спектроскопії.

Результати і обговорення. Розроблена підготовка сої, за якої майже повністю інактивується інгібітор трипсину – залишається 4%, тобто сліди в межах похибки, та підвищується перетравлюваність білка до 25%. Використовувалися композиції: соя – морква (оброблялася гігротермічно) та ріпак–морква (без гігротермічної обробки). Для запобігання окислення ліпідів сої та ріпаку їх поєднували з овочами. Процес сушіння бінарної суміші проходить у другому періоді. Тривалість сушіння матеріалу в режимі теплоносія 120 °C зменшується майже вдвічі порівняно з тривалістю процесу за 70 °C. Кислотне число збільшується до 5–8% за температури матеріалу 100 °C. Сушіння ріпаково-морквяної суміші відбувається в періоді спадної швидкості сушіння з попереднім прогріванням матеріалу. В режимі сушіння t = 70 °C; V = 3,5 м/с; δ = 10 мм максимальна швидкість сушіння складає 11,5%/хв. Кінцева температура суміші 78 ºC. Для запобігання мелаїдиновій реакції, яка відбувається в процесі сушіння білкововмісної сировини з високим вмістом вуглеводів, визначений максимальний температурний поріг 60–70 ºC. Зі зростанням температури теплоносія збільшується кислотне число (за температури 70 ºC до критичного рівня 4,2 – 4,5%, а за температурі 100 °C зростає до неприйнятних значень 9 – 11%).

Висновок. Створені рослинні композиції, у яких максимально збережені основні харчові компоненти. Розроблені режими підготовки сої та ріпаку до сушіння зі створенням композицій. У результаті досліджень вперше були отримані фітоестрогенні продукти на основі сої та овочів, ріпаку і овочів.

Ключові слова: *соя, ріпак, фітоестроген, сушіння.*

Значення швидкості різання при подрібненні рослинної сировини в харчовій промисловості

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Вступ. Досліджено й обґрунтовано вплив фактора швидкості різання на пружні та фрикційні властивості рослинної сировини. Встановлено залежність зусилля різання від швидкості різання. Раціональні параметри процесу різання обґрунтовані показником якості подрібненої сировини.

Матеріали і методи. Пружні властивості овочів досліджували за стандартними методиками стисканням зразка між двома плоскопаралельними пластинами. Фіксувалося зусилля стискання. Фрикційні властивості визначали на установці дискового типу: матеріал, що досліджувався, контактував з обертальною поверхнею сталевого диску, фіксувалося зусилля тертя. Зусилля різання визначалися тензометричним методом при проходженні пластинчастого ножа через шар матеріалу. Швидкість різання змінювалася у діапазоні 0,4 – 2,5 м/с.

Результати і обговорення. Збільшення швидкості різання призводить до зниження прояву пружних властивостей матеріалів за рахунок поширення у шарі пружних деформацій. Модуль пружності зменшується у 1,2 раза в діапазоні швидкостей різання від 0,4 до 2,5 м/с.

Фрикційні властивості характеризуються коефіцієнтом тертя, який зменшується у 1,2–1,5 раза зі збільшенням швидкості ковзання від 0,75 до 2,66 м/с. Характер зміни цих властивостей залежить від структурної будови матеріалу, вологовмісту, якості поверхні контакту, зусилля притискання пар тертя.

Зусилля різання рослинної сировини залежать від її структурно-механічних властивостей. Збільшення швидкості різання в досліджуваних діапазонах призводить до їх зменшення у 1,4 – 2 рази. Відповідно, для зменшення впливу питомих зусиль різання доцільно застосовувати високі швидкості різання рослинної сировини в овочерізальному устаткуванні.

З метою отримання нарізаної сировини високої якості необхідно враховувати вплив швидкості різання, товщину нарізки, структурні властивості продуктів, що подрібнюються.

Висновки. З урахуванням впливу фактора швидкості на зусилля різання рослинної сировини раціональними рекомендованим до впровадження є діапазон обертових швидкостей різання від 300 до 600 об/хв.

Ключові слова: *різання, овочі, властивості, швидкість, якість.*

Моделювання процесу змішування рідкої опари в апараті з роторним робочим органом

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Вступ. У статті за допомогою аналітичного методу описано зміну кінематичних параметрів інтенсивного роторного змішувача періодичної дії для приготування рідких напівфабрикатів хлібопекарної промисловості та визначено потужність, необхідну для приготування продукту.

Матеріали і методи. Досліджено процес змішування компонентів рідкої пшеничної опари вологістю 65 % за допомогою роторного змішувача періодичної дії. За допомогою аналітичного методу визначено кінематичні та динамічні параметри змішувача, застосовуючи диференційні рівняння руху середовища, записані в циліндричних координатах, і нехтуючи конвективними членами та силами тяжіння.

Результати і обговорення. В статті розроблено аналітичну модель роторного змішувача, а саме: енергетичний баланс для визначення потужності його приводу. Знайдена потужність, яка витрачається на обертання ротора в рідкій опарі, а також потужність, необхідна на продавлювання рідкої опари крізь канали циліндричного ротора. Порівняння цих двох складових засвідчило, що 40 % загальної потужності витрачається на обертання ротора в об'ємі продукту і 60 % – на його продавлювання скрізь канали ротора.

Порівняння витрат потужності від розмірів ротора вказує на те, що за швидкості його обертання 100 сек$^{-1}$ ротор з розмірами 1/3D витрачає у 3,62 раза більше енергії, ніж ротор з розмірами 1/4D, тоді як ротор 1/2D витрачає вже у 8,49 раза більше енергії за ротор з розмірами 1/4D. При збільшенні швидкості до 300 сек$^{-1}$ ці співвідношення складають 4,14 та 9,28 раза відповідно. Це пояснюється тим, що при збільшенні розмірів ротора збільшується площа його контакту з оброблюваним продуктом, що призводить до зростання опору продукту ротору, що обертається.

Аналітично визначені швидкості продукту в потоці, крутні моменти, що виникають на валу ротора, продуктивність за готового продукту і необхідний напір тиску за заданої продуктивності.

Аналітична формула складових потужності приводу дозволяє аналізувати її чисельне значення залежно від зміни структурно-механічних характеристик опари, геометричних розмірів робочого органу і його кінематичних характеристик.

Висновки. Наведено загальну аналітичну модель процесу змішування рідкої опари в роторному змішувачі оригінальної конструкції періодичної дії. Перевага пропонованої моделі полягає в тому, що вона враховує реологічні властивості оброблюваного продукту, що дозволяє вважати її більш точною.

Ключові слова: *опара, тісто, змішування, ротор, модель, потужність.*

Математичне моделювання нелінійних функцій регресії при центральному композиційному плануванні експерименту з довільною кількістю факторів

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Вступ. Розглядається задача побудови багатофакторних нелінійних функцій регресії для довільної кількості факторів *m* із застосуванням центрального композиційного планування експерименту (ЦКП).

Матеріали і методи. Використовуються методи математичної статистики для знаходження загального (по кількості факторів) алгоритму розрахунку коефіцієнтів багатофакторних функцій регресії другого порядку, а також метод мінімальних квадратів і методи лінійної алгебри знаходження розв'язків системи лінійних розріджених алгебраїчних рівнянь.

Результати дослідження. У більшості випадків для обробки результатів експериментів застосовують ортогональну схему центрального композиційного планування експерименту. Для кількості факторів *m* кількість дослідів повного факторного експерименту складає 2^m. Така кількість дослідів є недостатньою для використання нелінійних моделей багатофакторної регресії в повній формі, тому пропонується застосування ротатабельної схеми ЦКП. При цьому кількість дослідів

без повторень складає ($2^m + 2m$). Більша кількість точок дозволяє знайти більшу кількість коефіцієнтів нелінійної функції регресії.

Побудова нелінійних моделей багатофакторної регресії для довільної кількості факторів вимагає створення спеціальних математичних засобів. Коефіцієнти функцій регресії за методом мінімальних квадратів є розв'язками системи алгебраїчних рівнянь. Для розв'язання цієї задачі отримані рекурентні та прямі формули обчислення розріджених визначників спеціального виду $n - $го порядку, які суттєво спрощують знаходження розв'язків систем лінійних рівнянь – коефіцієнтів багатофакторних функцій регресії другого порядку. Основним результатом є загальні формули розрахунку коефіцієнтів функцій регресії другого порядку, які враховують кількість факторів і кількість дослідів.

Висновки. Результати математичного моделювання багатофакторних нелінійних функцій регресії рекомендується застосовувати в задачах визначення рецептури сировини, наприклад, для оптимізації рецептур кондитерських виробів. Формули розрахунку коефіцієнтів багатофакторних функцій регресії другого порядку можна використовувати для будь-якої кількості факторів m із застосуванням центрального ротатабельного композиційного планування експерименту з відповідною кількістю дослідів.

Ключові слова: *експеримент, фактор, множинна регресія, коефіцієнт, визначник.*

Безпека життєдіяльності

Метод мінімізації людського фактора в експертних судженнях з оцінки виробничого ризику і прийняття рішень

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Вступ. Мета дослідження – звести до мінімуму суб'єктивність експертної методології у сфері управління виробничим ризиком шляхом використання неупередженої ризик-значущої інформації і теоретично обґрунтованого прийняття рішень.

Матеріали і методи. Проведені 6-річні спостереження за системою управління охороною праці тютюнової фабрики. Модифікований метод матриці ризиків був удосконалений до компонентного методу оцінки ризик-значущої інформації. Метод багатокритеріального аналізу рішень щодо зниження ризику був посилений застосуванням критерію Гурвіца для умов невизначеності.

Результати і обговорення. Дослідження системи управління безпеки й охорони праці на тютюновій фабриці (2009–2016 рр.) продемонстрували різницю між найбільш травматичними чинниками, визначеними експертами, (зокрема, дія шкідливих речовин, в тому числі підвищений рівень шуму і пилу у робочій зоні), та факторами, які спричинили нещасні випадки на виробництві (рухомі частини обладнання, падіння з висоти). Ця різниця обумовлена суб'єктивною складовою в

експертній оцінці. Щоб звести її до мінімуму, було запропоновано такий алгоритм оцінки ризику: 1. Урахування об'єктивної ризик-значущої інформації, наявної на підприємстві, що включає додатково до результатів оцінки ризику модифікованим матричним методом, рекомендації зовнішнього і внутрішнього аудитів, дані щодо потенційно небезпечних випадків, статистичні дані травматизму. 2. Інформація зводиться до загальних знаменників – 18 травматичних подій, та розраховується середній масовий розподіл ризику за ризиками відповідних компонентів. 3. Ризики, оцінені як неприйнятні та середні, повинні управлятися за допомогою ієрархії зниження ризику, для цього спеціалісти з охорони праці готують масив заходів для кожного ступеня ієрархії. 4. Експертна група обирає заходи за допомогою 5 критеріїв і вагових коефіцієнтів, критерій Гурвіца використовується для подолання невизначеності. 5. Обґрунтовані таким чином заходи стають основою процесу планування в системі управління охороною праці підприємства.

Висновки. Рекомендується використовувати удосконалену експертну систему з мінімізацією впливу людського фактора в системі управління охороною праці в харчовій і тютюновій промисловості.

Ключові слова: *ризик, безпека, життєдіяльність, оцінка, суб'єктивність, експерт.*

Оцінювання стійкості конструкцій виробничих об'єктів готельно-ресторанних комплексів

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Вступ. Заклади готельно-ресторанного господарства за специфікою своєї діяльності не є об'єктами підвищеної небезпеки, але під час їх фуніонування можуть утворюватися несприятливі або нестандартні ситуації, які слід віднести до небезпечних. До таких ситуацій відносяться вибухи і пожежі, що виникають у процесі діяльності закладу і можуть вплинути на виробничий, обслуговуючий персонал та/або на відвідувачів.

Матеріали і методи. Для оцінювання стійкості конструкцій виробничих об'єктів готельно-ресторанного комплексу до впливу негативних факторів було проведено дослідження з використанням методу, який встановлює порядок розрахунку величини надлишкового тиску, що може створюватися під час згоряння газо-паро-повітряних сумішей у виробничих приміщеннях вищезгаданих закладів.

Результати і обговорення. Для розрахунку значень критеріїв вибухо-пожежонебезпеки під час згоряння газо-паро-повітряної суміші обирають найбільш несприятливий варіант розвитку аварії (аварійної ситуації), за якого у приміщення надходить максимальна кількість небезпечних речовин (сумішей).

Кількість речовин, які потрапляють у приміщення і можуть утворювати вибухо-пожежонебезпечні газо-повітряні і паро-повітряні суміші та їх гібриди, визначається за таких умов: відбувається розрахункова аварія (аварійна ситуація) одного з апаратів; вся кількість небезпечної суміші, що міститься в апараті, надходить у приміщення; вся кількість речовин з трубопроводів, враховуючи час на відключення.

Дослідження методу розрахунку надлишкового тиску, який може утворитися під час згоряння газо-повітряної суміші, проводилося за таких умов: у типовому приміщенні закладу готельно-ресторанного господарства з нормальними умовами

виробничого середовища (вільним об'ємом 200 м^3) проходить трубопровід із внутрішнім діаметром 50 мм, по якому транспортується пропан C$_3$H$_8$ з максимальною витратою 5×10^{-3} м^3/с і максимальним тиском 150 кПа.

Розрахунки здійснювалися для випадків: трубопровід оснащений системою автоматичного відключення з часом спрацювання 2 с; імовірність відмови системи автоматики більше 0,000001 на рік і аварійне резервування її елементів не забезпечене, час відключення – 120 с; за ручного відключення системи час відключення – 300 с.

Висновки. Запропонований метод розрахунку величини надлишкового тиску, який може створюватися під час згоряння газо-пароповітряних сумішей у приміщеннях закладів готельно-ресторанних комплексів, дозволяє завчасно визначати наслідки можливих несприятливих або нестандартних ситуацій і своєчасно вживати конструктивно-технічні заходи щодо їх запобігання або мінімізації.

Ключові слова: *тиск, вибух, стійкість, готель, виробництво, безпека.*

Аннотации

Пищевые технологии

Мясные продукты для питания людей с избыточным весом тела – пандемией XXI века

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Введение. Основным решением проблемы избыточного веса является разработка таких специальных продуктов, которые позволили бы группе людей с избыточным весом тела снизить массу тела, потребляя тот или иной продукт. Такого эффекта можно достигнуть, добавляя или заменяя определенный компонент в рецептуре на другой, с высокими функциональными свойствами.

Материалы и методы. Для исследования используется мясо цесарки и ветчина, сбалансированные по аминокислотному и жирно-кислотному составу. Использованы методы математического моделирования рецептур готового продукта, экспериментальные методы исследования химического состава, структурно-механических показателей продукта. Аминокислотный состав определен методом ионообменной хроматографии на анализаторе аминокислот типа Т-339. Жирнокислотный состав сырья определяли методом газовой хроматографии.

Результаты и обсуждение. Для нормальной работы человеческого организма наилучшим соотношением основных жирных кислот считается 1:1:1. Наиболее приближенными по этому показателю к идеальному есть жир дикой утки и цесарки (1:0,9:0,7 и 1:0,5:1,0 соответственно). Наихудшим по соотношению жирных кислот является бараний жир (1:0,1:1,9). По соотношению ПНЖК/НЖК наиболее предпочтительны свиной жир (0,27) и жир перепелов (0,21), а наихудшими являются жир дикой утки (1,27), конский (0,58) и куриный жир (0,56).

Варено-копченая ветчина с мясом цесарки имеет более сбалансированный аминокислотный состав по сравнению с контрольными образцами. В варено-копченой ветчине наблюдается высокое содержание валина (на 0,6%), лизина (на 0,71%), метионина (на 0,20%), треонина (на 0,69%), аланина (на 0,59 %), аспарагиновой кислоты (на 0,69%) и глицина (на 0,79%) по сравнению с контрольным образцом. По содержанию незаменимых аминокислот ветчина с мясом цесарки приближается к белку куриного яйца, а по содержанию таких аминокислот, как валин, изолейцин, лейцин, лизин, аланин, аргинин, аспарагиновая кислота, глицин, глутаминовая кислота и тирозин превосходит его.

Выводы. Это свидетельствует о том, что варено-копченая ветчина с мясом цесарки имеет хорошо сбалансированный аминокислотный состав, обладает высокой биологической ценностью и может быть отнесена к полноценным продуктов питания по содержанию незаменимых аминокислот.

Ключевые слова: *мясо, цесарки, ветчина, ожирение, питание, баланс.*

Исследование содержания ароматических компонентов в вине из сортов винограда, выращенных в Институте виноградарства и энологии (г. Плевен, Болгария)

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Введение. Происхождение ароматических веществ винограда, муста и вина определяется: ароматическими веществами винограда, который переходит в муст и вино; ароматическими веществами, которые являются продуктами биохимических явлений (окисление, экстракция, гидролиз), предшествующих ферментации; ароматическими веществами, которые являются продуктами деятельности дрожжей и бактерий, которые проводят спиртовое и яблочно-молочное брожение; ароматическими веществами, которые образуются во время преобразования и являются результатом образования вина; ароматическими веществами, которые образуются при длительном хранения или старении вин.

Материалы и методы. Были исследованы вина из винограда следующих сортов: Сторгозия, Кайлашский рубин, Трапезица, Рубин и Букет, селектированных в Институте виноградарства и энологии в г. Плевене путем внутренней и межвидовой гибридизации. Данные виды перерабатывались для производства сухих красных вин традиционным путем. Определение ароматического профиля вин проводилось путем газовой хроматографии.

Результаты и обсуждение. Количество ацетальдегида в исследованных винах находилось в пределах нормы для красных сухих вин. Наибольшее количество ацетальдегида было обнаружено в вине, изготовленном из винограда сорта Kaylashky Rubin (83,80 мг/дм^3). В винах из винограда сортов Рубин и Сторгозия количество ацетальдегида незначительное, а в вине из винограда сорта Трапезица последний не найден. Из фракций высших спиртов 2-метил-1-бутанол был найден только в вине из винограда Кайлашский рубин (269,80 мг/дм^3). 1-пентанол, обеспечивающий приятный цветочный тон вина, был обнаружен в винах из сортов винограда Букет (71,79 мг/дм^3), Трапезица (58,20 мг/дм^3), Рубин (29,00 мг/дм^3), тогда как в винах из винограда Пиоро Нуар его содержание составило лишь 15,49 мг/дм^3. Из фракции эфиров во всех винах найден этилацетат (13-37 мг/дм^3). Также во всех винах присутствует изобутилацетат (33.80- 86.84 мг/дм^3). Этиловый бутират был найден только в вине из винограда сорта Букет (164,60 мг/дм^3). Из группы терпенов были определены гераниол и бета-цитронеллол.

Выводы. Количество ацетальдегида в исследованных винах находилось в пределах нормы. Среди высших спиртов наибольшее содержание 1-пентанола. Доминирующим эфиром являлся этил бутират. Присутствие терпенов менее заметно.

Ключевые слова: *виноград, вино, спирт, эфир, терпен, хроматография.*

Обоснование седиментационной устойчивости молочной сыворотки после электроискровой обработки

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Введение. Статья посвящена первичной обработке молочной сыворотки, в частности перспективам ее переработки с использованием электрических разрядов. Целесообразность применения электрического разряда в технологии переработки молочной сыворотки подтверждается экспериментальными исследованиями, а также результатами математического и статистического анализа.

Материалы и методы. На основе математического моделирования подобран рациональный режим электрогидравлической обработки сыворотки, который сопровождается максимальной дисперсностью частиц осажденной казеиновой пыли.

Результаты и обсуждение. Было подтверждено, что средний гидродинамический диаметр частиц молочной сыворотки снизился с (1697,5 ± 82,38) нм до (221,34 ± 10,3) нм после обработки электрическими разрядами с максимальным напряжением 45 киловольт и количеством разрядов 25. Индекс полидисперсности при этом резко упал с 1,0 до 0,35…0,40, что характеризует систему как монодисперсную.

При напряжении 30 и 35 кВ и количестве разрядов 5...15 диспергирование частиц было несущественным. Средний размер частиц уменьшался только на 22... 30%. С увеличением напряжения и количества разрядов отмечено смещение пиков на кривых распределения в сторону частиц размером до 500...1000 нм и снижение среднего гидродинамического диаметра. Лучшие результаты при электрогидравлической обработки молочной сыворотки были достигнуты при напряжении 45 кВ и количестве разрядов 25.

Объем осадка в обработанной сыворотке снизился с 0,9...1,1 до 0,1...0,2 см^3 при напряжении 45 кВ и количестве разрядов 25.

Выводы. Предложена технологическая схема первичной переработки молочной сыворотки с использованием электрогидравлического метода.

Ключевые слова: *сыворотка, разряд, дисперсность, седиментация, устойчивость.*

Тестообразующая способность смесей из муки пшеницы и плодов хлебного дерева

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Введение. Исследование проведено с целью определения способности смесей пшеничной муки и муки из плодов хлебного дерева к образованию теста для возможного промышленного использования.

Материалы и методы. Плоды хлебного дерева сортировались, мылись, чистились от кожуры, нарезались ломтями, бланшировались, охлаждались, из них удаляли влагу, сушили в сушильном шкафу при температуре 650 °С, измельчали на муку и смешивали с пшеничной мукой со следующими отношениями пшеничной муки к муке плодов хлебного дерева: 100:0, 90:10, 85:15, 80:20, 75:25. Эти композиционные смеси муки анализировались на способность к образованию теста.

Результаты и обсуждение. Максимальный показатель вязкости для смеси муки пшеницы и плодов хлебного дерева колебался от 193,5 до 270,68 относительных единиц. Наблюдались значительные (<0,05%) различия в значениях вязкости для различных образцов. Показатель вязкости показывает вероятность разрыва теста при приготовлении. Показатель вязкости, при котором возможен разрыв теста, колеблется от 72,92 до 106,08 условных единиц. Последний показатель вязкости колебался между 216,67 и 275,75 условных единиц, а наивысшее значение вязкости получила мука из плодов хлебного дерева, что указывает на стабильность приготовленного теста. Самые низкие значения колеблются между 96,0 и 111,75 условных единиц. Максимальное время колеблется от 4,43 до 4,66 минут для 100% пшеничной муки, в то время как смесь получила значения на 15% ниже. Значительные (<0,05%) различия замечено для температур образования теста из муки смеси пшеницы и хлебного дерева. Температура образования теста позволяет определить время желатинизации во время процесса.

Выводы. Увеличение содержания муки из плодов хлебного дерева в смеси улучшает ее тестообразующие характеристики.

Ключевые слова: *пшеница, хлебное дерево, мука, тесто.*

Влияние морских водорослей на изменения показателей качества сливочного масла

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Введение. Целью работы является исследование влияния морских водорослей на изменения показателей качества сливочного масла в процессе хранения.

Материалы и методы. Объектом исследования служили образцы сливочного масла с порошком из ламинарии, фукуса, спирулины и цистозиры; контролем – сливочное масло жирностью 62,5 %. Образцы хранили при температурах плюс 3 ± 2 °С и минус 7 ± 2 °С и определяли изменения органолептических показателей (вкуса и запаха), а также первичных продуктов окисления – пероксидов и гидролиза липидов на различных сроках.

Результаты и обсуждение. Использование морских водорослей в составе сливочного масла позволяет продлить срок хранения продукции в два раза. Так, динамика органолептических показателей сливочного масла с водорослями характеризовалась снижением баллов в контрольных образцах в процессе хранения при плюс 3 ± 2 °С к 45 суткам на 4 балла, с водорослями – на 2 балла; при хранении в условиях минус 7 ± 2 °С к 65 суткам – на 5 баллов в контрольном образце и на 2 балла – с морскими водорослями. При хранении образцов в условиях температуры плюс 3 ± 2 °С изменения комплекса показателей проходит интенсивнее по сравнению с хранением при минус 7 ± 2°С, что объясняется влиянием низких температур. Пероксидное число жира контрольного образца сливочного масла после 30 суток составляло 4,9; с морскими водорослями – от 3,2 до 3,5 ½ О ммоль/кг, соответственно. Аналогичная зависимость установлена при изучении гидролиза жира: все виды морских водорослей замедляют в два раза процессы накопления свободных жирных кислот. Можно предположить, что наблюдаемый нами эффект

обусловлен присутствием в морских водорослях селена, пигментов, биофлавоноидов, а также формированием полисахаридно-липидных комплексов на поверхности нанозерен, которые защищают жировую фазу от окисления и гидролиза.

Выводы. Обогащение сливочного масла морскими водорослями замедляет ухудшение органолептических показателей, а также процессы окисления и гидролиза жира при хранении как при плюсовой, так и минусовой температуре.

Ключевые слова: *сливки, масло, ламинария, фукус, спирулина, цистозира, хранение.*

Оценка качества порошка из овощей, полученного способом смешанного теплоотвода

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Введение. Расширение ассортимента продуктов переработки плодоовощной продукции за счет увеличения доли и разнообразия ассортимента сушеных плодов и овощей на сегодняшний день является целесообразным и перспективным.

Материалы и методы. В работе исследовался порошок с капусты, полученной сушкой со смешанным теплоподводом. Структурные и регидратационные свойства порошка из капусты изучались с использованием оптического (МВI-15) микроскопа с «проходящем» светом, дериватографа Pauli-Erden Q-1500D и прибора Догадкина, который построен по принципу сообщающихся сосудов. При анализе изотерм адсорбции паров воды овощных порошков установлено, что опытные образцы ЗТП-сушки с адсорбционной структуре одинаковы.

Результаты и обсуждение. Порошок из капусты, полученный способом со смешанным теплоподводом (СТП-сушка) при температурах процесса 50 и 70 °C, выбранного в качестве условно «предельного». Размеры пор исследованы с помощью установки Мак-Бена.

Анализ снимков микроструктуры восстановленных частиц порошка из капусты позволил констатировать, что на процесс регидратации влияют вид и температура среды. Так, на представленных снимках микроструктуры видно, что при температуре 20 °C в различных средах на поверхности клеток тканей овоща между составляющими компонентами порошка и молекулами воды формируются сольватные комплексы, на снимках хорошо видно слой адсорбционно связанной влаги.

Определен коэффициент водопоглощения порошков из капусты, кабачков и топинамбура в избранных полярных сред. Результаты исследований указывают, что использование метода ЗТП-сушки способствует формированию регидратационных свойств порошка из капусты, отличающегося в 1,5 раза большей способностью связывать влагу прочными связями по сравнению с конвективной сушкой.

Выводы. Методом сушки со смешанным теплоподводом при температурах 50 и 70 °C получен порошок из капусты. Больше в 1,5 раза поверхность адсорбции порошка из капусты (70 °C) позволяет констатировать, что поглощение влаги у данного образца будет, соответственно, большим.

Ключевые слова: *качество, порошок, капуста, регидратация, микроструктура.*

Влияние экструдирования на микробиологические показатели кормовых смесей

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Введение. С целью определения качества кормовых смесей, содержащих льняной экстракт на основе сыворотки, были исследованы микробиологические показатели кормовых смесей после экструдирования разного рецептурного состава при хранении.

Материалы и методы. Исследовались кормовые смеси из зерна пшеницы, кукурузы и льняного экстракта на основе сыворотки в разном процентном соотношении. Льняной экстракт получали путем экстракции в пульсационных диспергаторах с активной диафрагмой Смесь смешивали и экструдировали при температуре 110 – 120 °C, давлении 2 – 4 МПа, что позволяет почти полностью ее обеззаразить.

Исследовали изменение микробиологических показателей кормовых смесей при хранении. Опытные образцы помещали в тканевые мешки и хранили в течение 2 месяцев при температуре 0 °C (холодильник), + 20 °C, (термостат) и относительной влажности воздуха 45%.

Результаты и обсуждение. Влажность зерновых смесей до экструдирования в образцах находилась в пределах 16,8 – 17,6%, после экструдирования - от 13,3 до 13,5%, и в течение срока хранения без изменений. При температуре 20 °C и относительной влажности воздуха 45% влажность образцов изменяется в процессе хранения от 13,3...13,5% до 15,3...16,1%.

Изменение влажности экструдированных кормовых смесей в значительной степени зависит от температуры хранения, а не от количества введенного льняного экстракта на основе сыворотки в состав смеси.

В начале и в конце хранения экструдированных кормосмесей характерен достаточно низкий уровень микробиологического обсеменения. Такие группы микроорганизмов, как бактерии группы кишечной палочки (БГКП), патогенные микроорганизмы в смесях не обнаружены. Общее количество мезофильных аэробных и факультативно анаэробных микроорганизмов (МАФАМ) во всех образцах смесей находится в допустимых пределах (не более $5 \cdot 105$ КОЕ/г).

Анализ колоний мезофильных аэробных микроорганизмов на мясопептинном агаре показал, что они характеризуются большими, малыми и средними размерами, белым и желтым окрасом, равными и неравными краями. Основная часть микроорганизмов - коковые бактерии, клетки которых размещаются одиночно или скоплениями. Основными морфотипами бактерий, выделенных из кормовых экструдатов, являются аэробные бактерии.

Вывод. Рекомендуется использовать процесс экструдирования как эффективный способ повышения санитарного качества экструдированных кормовых смесей, поскольку он позволяет получить почти стерильный продукт.

Ключевые слова: *корм, лен, экстракт, микробиология, коки.*

Изменение микронутриентного состава биофортифицированных овощей при замораживании и хранении

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Введение. Исследовано изменение микронутриентного состава биофортифицированных с помощью удобрения "Риверм" овощей при замораживании и хранении.

Материалы и методы. Материалы – свежие и замороженные образцы биофортифицированного перца сладкого и тыкв. Для определения содержания микронутриентов использованы методы инверсионной вольтамперометрии, жидкостной хроматографии, а также колориметрический и титрометрический методы.

Результаты и обсуждение. Образцы биофортифицированного перца и тыкв являются более ценными по содержанию железа (на 7,4–14,6%), цинка (на 2,7–6,7%), меди (на 2,1–6,6%), витаминов B_1 (на 20,9–44,7%), B_2 (на 18–34,3%), С (на 28–29%), каротиноидов (на 11,6–22,8%) по сравнению с контролем.

Уменьшение количества железа в замороженных биофортифицированных овощах за 6 месяцев хранения составляет 4,5–5,4%, меди – 2,6–2,7%, цинка – 2,1–2,3%. При замораживании и хранении биофортифицированная тыква сорта Олешкивский потеряла 22,4% витамина С (контроль – 36,9%), 15,7% каротиноидов (контроль – 23,7%), 15% витамина B_1 (контроль – 32,4%), 13,8% витамина B_2 (контроль – 26,2%). При хранении замороженного биофортифицированного перца сладкого сорта Золото скифов также произошло уменьшение содержания витаминов: витамина B_2 – на 13,8% (контроль – на 14,9%), витамина B_1 – на 12,8% (контроль – на 14,1%), витамина С – на 12,7% (контроль – на 13,2%), каротиноидов – на 5,3% (контроль – на 6,0%). Больше всего витаминов опытные образцы овощей потеряли непосредственно в процессе замораживания. Контрольные образцы замороженных овощей на всех этапах исследования содержали в своем составе меньше микроэлементов и витаминов.

Выводы. Замораживание и хранение биофортифицированных (выращенных с применением органического удобрения "Риверм") плодов перца и тыкв приводят к снижению в них содержания микронутриентов, но эти изменения происходят в них менее интенсивно по сравнению с контрольными образцами. Самые большие потери витаминов происходят при замораживании.

Ключевые слова: *замораживание, микронутриент, биофортификация, овощи, "Риверм".*

Показатели качества кондитерских полуфабрикатов с порошками из банана и моркови

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Введение. Проведено исследование технологических свойств порошков из моркови и банана, полученных холодной распылительной сушкой с целью определения влияния растительного сырья на показатели качества кондитерского полуфабриката.

Материалы и методы. Определения дисперсности растительных порошков проводили путем подсчета размеров частиц порошков с помощью окуляр-микрометра и оптического микроскопа при увеличении в 400 раз. Исследование физико-химических показателей качества полученных полуфабрикатов определяли с помощью стандартных методик.

Результаты и обсуждение. Определения дисперсности растительных порошков микроскопическим методом показало, что наибольший объем частиц в исследуемых образцах представлен фракцией до 20 мкм, данная фракция в порошке из банана содержится в объеме 81%, моркови – 78%. То есть частицы в готовом изделии не будут ощущаться органолептически.

Порошок из банана является гомогенным за мелкими фракциями частиц, представленный дольками шарообразной формы, однородный по всей массе.

Лучше удерживает жир порошок с банана (0,92 мл/г), который, наоборот, имеет меньшую водосвязывающую способность (6,33%). Аналогичная обратная тенденция проявляется и для порошка из моркови: при большем водопоглощении и влагоудержании (6,93%) данный порошок имеет меньшее значение жироудерживающей способности (0,89 мл/г).

При определении влияния выбранных дозировок исследуемых порошков на органолептические свойства кондитерского полуфабриката как наиболее рациональная была избрана дозировка порошка из моркови – 5% и порошка из банана – 18% к рецептурной массы, что позволяет получить кондитерский полуфабрикат с высокими вкусовыми свойствами, а именно: однородной структуры, пластичной консистенции, со вкусом и запахом, присущими данному фрукту.

Массовая доля влаги кондитерского полуфабриката с порошком моркови составляет 12,2%, с порошком из банана – 11,6%. Массовая доля жира - 25% и 18% соответственно. Содержание редуцирующих веществ в полученных полуфабрикатах почти равны 4,4% и 4,2%. Размер кристаллов основной фракции составляет 10–15 мкм.

Выводы. По результатам исследований можно рекомендовать использование мелкодисперсных растительных порошков в кондитерском производстве с целью повышения пищевой ценности и расширения ассортимента готовой продукции.

Ключевые слова: *полуфабрикат, порошок, качество, кондитерское изделие, банан, морковь.*

Использование ферментов для извлечения рапсового масла методом прессования

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Введение. Для извлечения липидов, которые хранятся в замкнутой структуре семян, необходимо преодолеть несколько барьеров. Использование гидролитических

ферментов, таких как целлюлаза, гемицелюллазы, пектиназа, повышает проницаемость такой структуры.

Материалы и методы. Для исследования использовались семена низкоглюкозинолатных сортов. Для предварительной ферментативной обработки использованы следующие ферментные препараты с расширенным спектром действия: Protolad (протеаза, 70 ед/г, Энзим, Украина) и Celulad (целлюлаза, 300 ед/г, Энзим, Украина). Для оценки качества полученного масла использовали методы определения йодного, кислотного и перекисного чисел. Эффективность действия ферментных препаратов оценивали методом моментального взбалтывания, а также за остаточным количеством масла в жмыхе.

Результаты и обсуждение. Наилучшие результаты были получены в образцах семян, которые имели содержание влаги 4%. Ферментативная обработка масляного материала в течение двух часов является достаточным условием для уменьшения остаточной масличности жмыха с 24,4% до 9,4%. Количество ферментного препарата 0,4% к массе семян является оптимальным значением. Ферментативная обработка в технологии прессования является очень эффективным способом увеличения количественного выхода масла. Физико-химические показатели образца масла после ферментативной обработки сравнили с образцом прессового рапсового масла. Результаты соответствуют требованиям нормативной документации. Анализ жирных кислот образца рапсового масла после ферментативной обработки показал увеличение линолевой и олеиновой кислот (около 3%) и линоленовой – более чем на 1 % по сравнению с контролем. В содержании других жирных кислот в образцах рапсового масла существенных различий не было. Рассчитано уравнение регрессии для зависимости выхода масла от концентрации фермента, содержания влаги в материале перед прессованием и времени гидролиза на основе экспериментальных данных. Увеличение количества извлеченного масла с семян рапса, которое подвергалось предыдущий ферментативной обработке, показывает, что ферментативный гидролиз является очень эффективным методом предварительной обработки материала перед прессованием. Добавление фермента проводится в водном растворе. Высокая влажность семян при обработке является неблагоприятным фактором с экономической точки зрения, так как следующим этапом обработки является высушивание.

Выводы. Основными задачами исследования остается усовершенствование метода предварительной обработки семян, а именно: уменьшение влажности семян в процессе ферментативного гидролиза.

Ключевые слова: *рапс, фермент, прессование, масло.*

Усовершенствование технологии макаронных изделий, обогащенных черникой

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Вступление. Исследовано использование черники в технологии макаронных изделий из хлебопекарной муки, что является актуальным для повышения пищевой ценности и усовершенствования ассортимента макаронных изделий.

Материалы и методы. В работе исследованы макаронные изделия из хлебопекарной муки, порошок черники, полученный измельчением высушенной

черники. Качество макаронных изделий оценивали по комплексному показателю, который включает показатели варочных свойств, органолептическиие, физико-химические показатели и пищевую ценность. Структурно-механические свойства теста определяли на фаринографе Брабендера. Оптимальные технологические параметры определяли методом Бокса-Уилсона.

Результаты и обсуждение. Макаронные изделия с внесением порошка черники в количестве 5 – 10 % к массе муки приобретают фиолетовый цвет, улучшаются их варочные свойства. Увеличение дозировки порошка черники до 15 % приводит к повышению кислотности и снижению прочности изделий на 30 %. Черничный порошок приводит к снижению содержания клейковины и ее гидратационной способности. Это объясняется тем, что компоненты черники проявляют дегидратирующее действие в макаронном тесте и препятствуют биополимерам пшеничной муки образовывать тесто. При этом клейковина проявляет более упругие свойства. Черничный порошок обеспечивает образование мелкокрошковатого теста, что способствует некоторому ускорению выпрессовывания изделий. Установлены оптимальные технологические параметры для приготовления макаронных изделий с черничным порошком: дозировка порошка черники – 4 % к массе муки, температура воды для приготовления теста – 37 °C. Такая дозировка обеспечивает обогащение изделий витамином C в количестве 2,3 мг/100 г (в случае потребления 100 г макаронных изделий суточная потребность в этом витамине покрывается на 2,6 %).

Выводы. Результаты исследований рекомендуются для расширения ассортимента макаронных изделий, для диетического, вегетарианского, детского питания, а также в случае использования муки, способной к потемнению.

Ключевые слова: *макароны, черника, качество, обогащение.*

Процессы и оборудование пищевых производств

Сушка композиционного фитоэстрогенного сырья

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Введение. Фитоэстрогенные композиции по своему содержанию компонентов отличаются от моносырья высоким содержанием белка и наличием значительного процента липидов. При переработке целесообразно разработать режимы подготовки сои с полной инактивацией антипищевых компонентов и сушки с максимальным сохранением биологически активных веществ.

Материалы и методы. При проведении исследований использовали экспериментальные методы с использованием современных средств измерения параметров сушки: времени проведения опыта, температуры теплоносителя и уменьшения массы материала. Для оценки качества функциональных продуктов использованы стандартные методы исследований с применением методов спектроскопии.

Результаты и обсуждение. Разработана подготовка сои, при которой почти полностью инактивируется ингибитор трипсина – остается 4%, то есть следы в пределах погрешности, и повышается перевариваемость белка до 25 %. Использовались композиции: соя – морковь (обрабатывалась гигротермически) и

рапс-морковь (без гигротермической обработки). Для предотвращения окисления липидов сои и рапса их объединяли с овощами. Процесс сушки бинарной смеси проходит во втором периоде. Продолжительность сушки материала в режиме теплоносителя 120°C уменьшается почти вдвое по сравнению с продолжительностью процесса при 70 °C. Кислотное число увеличивается до 5 – 8% при температуре материала 100 °C. Сушка рапсового-морковной смеси происходит в периоде падающей скорости сушки с предыдущим прогревом материала. В режиме сушки t = 70 ºC; V = 3,5 м/с; δ = 10 мм максимальная скорость сушки составляет 11,5 %/мин. Конечная температура смеси 78ºC. Для предотвращения мелаидиновой реакции, которая происходит в процессе сушки белковосодержащего сырья с высоким содержанием углеводов, определен максимальный температурный порог 60–70 ºC. С ростом температуры теплоносителя увеличивается кислотное число (при температуре 70 ºC до критического уровня 4,2 – 4,5%, а при 100 °C возрастает до неприемлемых значений 9 – 11 %).

Вывод. Созданы растительные композиции, в которых максимально сохранены основные пищевые компоненты. Разработаны режимы подготовки сои и рапса к сушке с созданием композиций. В результате исследований впервые были получены фитоэстрогенные продукты на основе сои и овощей, рапса и овощей.

Ключевые слова: *соя, рапс, фитоэстроген, сушка.*

Значение скорости резания при измельчении растительных материалов в пищевой промышленности

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Введение. Исследовано и обосновано влияние фактора скорости резания на упругие и фрикционные свойства растительных материалов. Установлена зависимость усилия резания от скорости резания. Выбор рациональных параметров процесса обоснован качественным показателем измельченного продукта.

Материалы и методы. Упругие свойства овощей изучались по стандартной методике сжатием образца между двумя плоскопараллельными пластинами. Фиксировалось усилие сжатия. Фрикционные свойства определялись на установке дискового типа: исследуемый материал контактировал с вращающимся стальным диском, фиксировалось усилие трения. Усилия резания определялись тензометрическим способом при внедрении пластинчатого ножа в слой материала. Скорость резания варьировалась в диапазоне 0,4 – 2,5 м/с.

Результаты и обсуждение. С увеличением скорости резания упругие свойства материала проявляются в меньшей степени, что обусловлено распространением в слое упругих деформаций. В диапазоне скоростей резания от 0,4 м/с до 2,5 м/с модуль упругости уменьшается в 1,2 раза.

Фрикционные свойства, характеризуемые коэффициентом трения, снижаются в 1,2…1,5 раза при увеличении скорости скольжения пар трения от 0,75 до 2,66 м/с. Характер изменения этих свойств зависит от структурного строения материала, влагосодержания, качества поверхностей контакта, усилия прижатия пар трения.

Усилия резания растительных материалов зависят от их структурно-механических свойств. Увеличение скорости резания в исследуемых диапазонах будет способствовать их снижению в 1,4 – 2 раза в зависимости от вида продукта. В связи с этим целесообразно использовать более высокие скорости резания растительных материалов в овощерезательном оборудовании с целью снижения удельных усилий резания.

Для получения нарезки высокого качества необходимо учитывать влияние скорости резания, толщины нарезки, структурных особенностей измельчаемых продуктов.

Выводы. С учетом влияние фактора скорости на усилия резания растительных материалов оптимальным и рекомендуемым для исследуемой продукции является диапазон окружных скоростей резания от 300 до 600 об/мин.

Ключевые слова: *резание, овощи, свойства, скорость, качество.*

Моделирование процесса смешивания жидкой опары в аппарате с роторным рабочим органом

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Введение. В работе с помощью аналитического метода описано изменение кинематических параметров интенсивного роторного смесителя периодического действия для приготовления жидких полуфабрикатов хлебопекарной промышленности и определена мощность, необходимая для приготовления продукта.

Материалы и методы. Исследован процесс смешивания компонентов жидкой пшеничной опары влажностью 65% с помощью роторного смесителя периодического действия. С помощью аналитического метода определены кинематические и динамические параметры смесителя, применяя дифференциальные уравнения движения среды, записанные в цилиндрических координатах, и пренебрегая конвективными членами и силами притяжения.

Результаты и обсуждение. В работе предложен вывод аналитической модели роторного смесителя, а именно: энергетический баланс для определения мощности его привода. Найдена мощность, расходуемая на вращение ротора в жидкой опаре, а также мощность, необходимая на продавливание жидкой опары сквозь каналы цилиндрического ротора. Сравнение этих двух составляющих привело к выводу о том, что 40 % общей мощности расходуется на вращение ротора в объеме продукта и 60 % — на его продавливание сквозь каналы ротора.

Сравнение затрат мощности от размеров ротора указывает на то, что при скорости его вращения 100 сек$^{-1}$ ротор с размерами 1/3D тратит в 3,62 раза больше энергии, чем ротор с размерами 1/4D, тогда как ротор 1/2D тратит уже в 8,49 раза больше энергии, чем ротор с размерами 1/4D. При увеличении скорости до 300 сек$^{-1}$ эти соотношения составляют 4,14 и 9,28 раза соответственно. Объясняется это тем, что при увеличении размеров ротора увеличивается площадь его контакта с обрабатываемым продуктом, что влечет за собой возрастание сопротивления продукта вращающемуся ротору.

Также аналитически определены скорости продукта в потоке, крутящие моменты, возникающие на валу ротора, продуктивность по готовому продукту и необходимый напор давления при заданной продуктивности.

—— *Abstracts* ——

Аналитическая формула составляющих мощности привода позволяет анализировать её численное значение в зависимости от изменения структурно-механических характеристик опары, геометрических размеров рабочего органа и его кинематических характеристик.

Выводы. Приведена общая аналитическая модель процесса смешивания жидкой опары в роторном смесителе оригинальной конструкции периодического действия. Преимущество предлагаемой модели состоит в том, что она учитывает реологические свойства обрабатываемого продукта, что позволяет считать её более точно описывающей подобные процессы.

Ключевые слова: *опара, тесто, смешивание, ротор, модель, мощность.*

Математическое моделирование нелинейных функций регрессии при центральном композиционном планировании экспериментов с произвольным количеством факторов.

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Введение. Рассматривается задача построения многофакторных нелинейных функций регрессии для произвольного количества факторов m при использовании центрального композиционного планирования эксперимента (ЦКП).

Материалы и методы. Для системы центрального ротатабельного композиционного планирования эксперимента используются методы математической статистики для построения обобщенного (по количеству факторов) алгоритма расчета коэффициентов многофакторных функций регрессии второго порядка, а также метод минимальных квадратов и методы линейной алгебры нахождения решений системы линейных разреженных алгебраических уравнений.

Результаты. В большинстве случав для обработки результатов экспериментов используют ортогональную схему центрального композиционного планирования. Для количества факторов m количество опытов полного факторного эксперимента составляет 2^m. Такое количество опытов является недостаточным для использования нелинейных моделей многофакторной регрессии в полной форме. Предлагается использовать ротатабельную схему ЦКП. При этом количество опытов без повторений составляет ($2^m + 2m$). Большее количество точек позволяет найти большее количество коэффициентов нелинейной функции регрессии.

Построение нелинейных моделей многофакторной регрессии для произвольного количества факторов требует создания специальных математичних средств. Коэффициенты функций регрессии по методу минимальных квадратов определяются решением системы алгебраических уравнений. Для решения этой задачи получены рекуррентные и прямые формулы вычисления розреженных определителей специального вида n – го порядка, которые существенно упрощают задачу нахождения решений систем линейных уравнений – коэффициентов многофакторных функций регрессии второго порядка. Основным результатом являются обобщенные формулы вычисления коэффициентов функций регрессии второго порядка, в которых учитываются количество факторов и количество опытов.

Выводы. Результаты математического моделирования многофакторных нелинейных функций регрессии рекомендуется использовать в задачах определения рецептуры сырья, например, для оптимизации рецептур кондитерских изделий.

Формулы вычисления коэффициентов многофакторных функций регрессии второго порядка можно использовать для произвольного количества факторов m при использовании центрального ротатабельного композиционного планирования эксперимента (ЦРКП) с соответственным количеством опытов.

Ключевые слова: *экспериент, фактор, множественная регрессия, коэффициент, определитель.*

Безопасность жизнедеятельности

Метод минимизации человеческого фактора в экспертных суждениях по оценке производственного риска и принятия решений

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Введение. Цель исследования – свести к минимуму субъективность экспертной методологии в области управления производственным риском путем использования непредвзятой риск-значимой информации и теоретически обоснованного принятия решений.

Материалы и методы. Проведены 6-летние наблюдения за системой управления охраной труда табачной фабрики. Модифицированный метод матрицы рисков был усовершенствован до компонентного метода оценки риск-значимой информации. Метод многокритериального анализа решений по снижению риска был усилен применением критерия Гурвица для условий неопределенности.

Результаты и обсуждение. Исследование системы управления безопасности и охраны труда на табачной фабрике (2009–2016 гг.) продемонстрировали разницу между наиболее травматическими факторами, определенными экспертами с использованием модифицированного матричного метода оценки рисков (в частности, содержание вредных веществ, в том числе уровень шума и пыли в рабочей зоне), и факторами, которые вызвали несчастные случаи на производстве (движущиеся части оборудования, падение с высоты). Эта разница обусловлена субъективной составляющей в экспертной оценке. Чтобы свести ее к минимуму, был предложен следующий алгоритм оценки риска: 1. Количественный учет объективной риск-значимой информации, доступной на предприятии: в дополнение к результатам оценки риска модифицированным матричным методом, она включает рекомендации внешнего и внутреннего аудита, данные о потенциально опасных случаях, статистические данные травматизма. 2. Информация была сведена к общему знаменателю – 18 травматическим событиям, и рассчитано среднее массовое распределение риска по соответствующим компонентам. 3. Риски, ранжированные как неприемлемые и средние, должны управляться с помощью иерархии снижения риска, для чего эксперты в области охраны труда готовят массив мероприятий для

каждой ступени иерархии. 4. Экспертная группа избирает меры с помощью 5 критериев и весовых коэффициентов, критерий Гурвица используется для преодоления неопределенности. 5. Обоснованные таким образом мероприятия становятся основой процесса планирования в системе управления охраной труда предприятия.

Выводы. Рекомендуется использовать усовершенствованную экспертную систему с минимизацией влияния человеческого фактора в системе управления охраной труда в пищевой и табачной промышленности.

Ключевые слова: *риск, оценка, безопасность, жизнедеятельность, субъективность, эксперт.*

Оценка устойчивости конструкций производственных объектов гостинично-ресторанных комплексов

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Введение. Заведения гостинично-ресторанного хозяйства по специфике своей деятельности не являются объектами повышенной опасности, но при фунционировании таких заведений могут образовываться неблагоприятные или нестандартные ситуации, которые следует отнести к опасным. К таким ситуациям относятся взрывы и пожары, возникающие в процессе деятельности учреждений, которые могут повлиять на производственный, обслуживающий персонал и / или посетителей.

Материалы и методы. Для оценки устойчивости конструкций производственных объектов гостинично-ресторанного комплекса к воздействию негативных факторов было проведено исследование с использованием метода, который устанавливает порядок расчета величины избыточного давления, который может создаваться при сгорании газо-паро-воздушных смесей в производственных помещениях вышеупомянутых заведений.

Результаты и обсуждение. Для расчета значений критериев взрыво-пожароопасности при сгорании газо-паро-воздушной смеси выбирают наиболее неблагоприятный вариант развития аварии (аварийной ситуации), при котором в помещение поступает максимальное количество опасных веществ (смесей).

Количество веществ, которые попадают в помещение и могут образовывать взрыво-пожароопасные газо-воздушные и паро-воздушные смеси и их гибриды, определяется при следующих условиях: происходит расчетная авария (аварийная ситуация) одного из аппаратов; все количество опасной смеси, которое содержится в аппарате, поступает в помещение; все количество веществ из трубопроводов, учитывая время на отключение.

Исследование метода расчета избыточного давления, который может образоваться при сгорании газо-воздушной смеси, проводилось при следующих условиях: в типовом помещении заведения гостинично-ресторанного хозяйства с нормальными условиями производственной среды (свободным объемом 200 м^3) проходит трубопровод с внутренним диаметром 50 мм, по которому транспортируется пропан C_3H_8 с максимальным расходом 5×10^{-3} м^3/с и с максимальным давлением 150 кПа.

Расчеты проводились для случаев: трубопровод оснащен системой автоматического отключения со временем срабатывания 2 с; вероятность отказа системы автоматики больше 0,000001 в год, аварийное резервирование ее элементов не обеспечено, время отключения – 120 с; при ручном отключении системы время отключения – 300 с.

Выводы. Предложенный метод расчета величины избыточного давления, который может создаваться при сгорании газо-паровоздушных смесей в помещениях заведений гостинично-ресторанных комплексов, позволяет заранее определять последствия возможных неблагоприятных или нестандартных ситуаций и своевременно принимать конструктивно-технические мероприятия по их предупреждению или минимизации.

Ключевые слова: *давление, взрыв, устойчивость, отель, производство, безопасность.*

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Автори (рік видання), Назва статті, *Назва журналу (курсивом)*, том (номер), сторінки.
Всі елементи після року видання розділяються **комами**.

Приклади:

1. Yannick Fayolle, Sylvie Gillot, Arnaud Cockx, Laetitia Bensimhon, Michel Roustan, Alain Heduit (2010), In situ characterization of local hydrodynamic parameters in closed-loop aeration tanks, *Chemical Engineering Journal*, 158(2), pp. 207–212.
2. Carlo Tocchi, Ermanno Federici, Laura Fidati, Rodolfo Manzi, Vittorio Vincigurerra, Maurizio Petruccioli (2012), Aerobic treatment of dairy wastewater in an industrial three-reactor plant: Effect of aeration regime on performances and on protozoan and bacterial communities, *Water Research*, 46(10), pp. 3334–3344.

Приклад оформлення статті, оригінал якої українською мовою:

1. Pyroh T.P., Konon A.D., Skochko A.B. (2011), Vykorystannia mikrobnykh poverkhnevo-aktyvnykh rechovyn u biolohii ta medytsyni*, Biotekhnolohiia*, 4(2), pp. 24–38.

За бажання після транслітерованої назви статті або журналу в {фігурних дужках можна дати переклад англійською мовою}.

Посилання на книгу

Автори (рік), *Назва книги (курсивом)*, Видавництво, Місто.
Всі елементи після року видання розділяються комами.

Приклади:

1. Harris L. (1991), *Money theory*, McGraw-Hill Companies, Hardcover
2. Rob Steele (2004), *Understanding and measuring the shelf-life of food*, CRC Press.

Приклад оформлення статті, оригінал якої українською або російською мовою:

1. Donchenko L.V. (2000), Tekhnologiya pektina i pektinoproduktov, Deli, Moscow
2. Kirianova H.A. (2008), Udoskonalennia tekhnolohii termostabilnykh zheleinykh nachynok shliakhom ratsionalnoho vykorystannia hidrokoloidiv roslynnoho ta mikrobnoho pokhodzhennia: PhD tethis, NUHT, Kyiv.
3. Zalutskyi I.R., Tsymbaliuk V.M., Shevchenko C. H. (2009), Planuvannia i diahnostyka diialnosti pidpryiemstva, Novyi svit, Lviv.

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Приклад посилання на статтю із електронного видання:

1. Barbara Chmielewska. (2012), Differentiation of the standard of living of families in countries of the European Union, *Ukrainian Food Journal*, 2(2), pp. 230–241, available at:
   http://ufj.ho.ua/Archiv/UKRAINIAN%20FOOD%20JOURNAL%202013%20V.2%20 Is.2.pdf
2. (2013), *Svitovi naukovometrychni bazy*, available at:
   http://www1.nas.gov.ua/publications/q_a/Pages/scopus.aspx