ISSN 2504-5687

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Volume 5(17)
2018

SCIENTIFIC JOURNAL

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CONTENT

OPTIMIZATION OF PRODUCTION PROCESS OF PEELED GRAINS OF WHEAT OF DIFFERENT SOLIDITY

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Abstract

Wheat is a leading agricultural plant with one of most gross grain harvest in the world. It is a valuable raw material for producing the wide assortment of food products. That is why little studied peculiarities of it need specification, and processing technologies – improvement.

The aim of the conducted studies was in specifying of processing regimes of solid and soft wheat grains into peeled ones that allowed to choose rational regimes of water-thermal processing for attaining their maximal output, boiling coefficient and decrease of a preparation duration.

It was proved, that the effect of heat and moisture mostly influences the output of grains and duration of their boiling, despite the solidity. The boiling coefficient depends on the solidity type more.

The optimal mode as to thermal processing at production of peeled grains of soft wheat is is steaming during 10 min with hydration during 10–12 min.

It is rational to steam solid wheat during 10 min with further hydration during 12–13 min at processing.

Keywords: water-thermal processing; peeled grains; boiling coefficient; solidity of grains.

DOI: 10.21303/2504-5695.2018.00718

1. Introduction

Wheat is a main grain culture in the world that is a valuable source of vegetable protein for people. Comparing with rice and corn, wheat is a raw material for many food products, especially bakery ones and peeled grains. It is conditioned by the special structure of wheat protein that is formed of 60–80 % of gliadins and glutenins [1].

Almost 55 % of carbohydrates and 60 % of calories, consumed in the world, are originated by wheat grains [2].

Wheat grains are saturated with macro- and microelements and the use of modern agrotechnological elements allows their effective increase [3].

But despite the wide spread and popularity, wheat proteins can cause an allergic reaction in the human organism that stimulates the work of genetic engineering and selection as to leveling the correspondent negative effect [4, 5].

Today there is fixed the essential increase of the number of varieties and lines of wheat. They have improved technological properties, increased quality, high biological value. So, despite the centuries-old history of using wheat grains, adaption of new varieties to conditions of modern production is urgent.

Under conditions of modern market economy it is prospective to widen the assortment of ready products, especially peeled grains that are very important in the human food ration. It is also effective to decrease energy consumption at processing raw materials, increase of technological efficiency at production enterprises.

2. Analysis of literary data and stating of problem

Grain wheat products together with bakery ones are traditional in the food ration. They have a high culinary and food value. At that last time there was fixed the increase of requirements to safety of wheat grains, especially, the content of microtoxins that favorably differs wheat as a food raw material [6]. Their content in products of child nutrition is especially controlled [7].

The growing popularity is inherent to products with the increased content of food fibers of wheat grains. They are mostly located in peripheral parts of a grain. The presence of food fibers in the ration favors the increase of a satiety feeling at the expanse of decelerating a digestion velocity and absorbing microelements [8].

It is proved that grain products with the high content of food fibers are filled with phytochemical substances, including phenol acids, tanning substances, anthocyans, phytosterols, avenanthramides and polycosanols. But correspondent products have a hard effect on the human digestive tract. That is why their use is recommended within compositional mixtures [9].

"Rules of organization and conduction of the technological process at grain plants", valid in Ukraine, provide complete or partial peeling of wheat grains that conditions the low output of grain products (60–63 %). Taking into account the content of endosperm in wheat grains as 80 %, their essential part becomes a waste at processing.

It is an innovation to use shortened technological schemes of producing peeled grains with the controlled peeling process. It is proved, that at the index of peeling wheat grains as 10–12 %, a grain product with high culinary characteristics may be obtained [10].

Wheat siftings are also a valuable product. Their modification allows to obtain a food supplement that can positively influence the human health and is recommended for subjects with diabetes mellitus type 2 [11].

One of methods of widening the assortment of grain products is the use of grain peeling. Flakes and peeled grains are popular due to the shortened term of preparation and high assimilability. Formation of a flake of wheat peeled grains after a peeling bench and preservation of its form at transporting are attained at the expanse of gelatinization of starch grains of flour endosperm. Starch gelatinization takes place at increased temperatures, attained as a result of hot conditioning (water-thermal processing). Steam production and its transportation to steamers is a complicated, labor-consuming process that essentially increases a prime cost of grain products. But the positive effect of thermal processing on a ready product may be effectively used by the marketing service of a processing enterprise.

It is known, that phytates of ferrum and zinc are contained in wheat grains. They decrease bioavailability of products of grain processing. It was established, that [12], the unessential decrease of phytate (by 11 %) may be achieved as a result of germination of grains (15 ^{o}C, 120 hours). But the use of thermal processing of germinated grains allows to decrease the phytate content by 95 %. Thermal processing of wheat grains favors the bioavailability of zinc from 3 to 27 %, and ferrum from 5 to 37 %.

Water-thermal processing is effectively used for getting arabynoxyl oligosaccharides of wheat siftings [13].

Deoxynivalenol (DON) is the most spread trichothecene in nature that can influence the animal and human health by causing diarrhea, spew, inflammation of the gastrointestinal tract and immune modulation. The partial decrease and transformation of this mitoxen is fixed as a result of water-thermal processing [14].

In Western and Eastern Africa there are used steamers on alternative types of fuel that are in demand. A new steamer is constructed using non-corrosive steel (Inox 304) and set directly on the improved stove, produced of baked bricks. Despite the easiness of construction, these apparatuses have the low duration of water boiling and specific consumption of fuel. The absence of a net of pipelines for conducting steam from a steam-generator to a steamer decreases energy consumption for steam transportation [15].

For intensifying the process of water-thermal processing, there is used preliminary hydration of raw materials, and their germination in separate cases. Processing of prepared raw materials in apparatuses with an increased pressure essentially improves the quality of a ready product [16].

Processes that take place in a grain are studied at the molecular level, and the dynamics of water penetration, microstructural changes in water-thermal processing are established [17].

The question of wheat grain solidity remains little-studied. In whole grain solidity is the ability to destructing starch granules of endosperm under the effect of external forces. There are distinguished two types of wheat by a grain solidity parameter: soft and solid. Technologies of producing peeled wheat grains don't contain recommendations that take into account a type of grain solidity.

So, analyzing modern literary sources, one can make the following conclusions. Wheat is one of leading world agricultural plants. The great attention is paid to its selection, study of its quality, biological value and safety. Technologies of wheat processing in flour and peeled grains have the century-old history and improve dynamically. Today technological properties of wheat grains of different solidity remain insufficiently studied, and technologies of their processing in peeled grains need optimization.

The aim of the conducted studied was in specifying of processing regimes of solid and soft wheat grains into peeled ones that allowed to choose rational regimes of water-thermal processing for attaining their maximal output, boiling coefficient and decrease of a preparation duration.

The following tasks were set for attaining this aim:

– to establish the influence of grain solidity on the output and quality of peeled grains;

– to construct a mathematical model of producing peeled grains of soft ones and to establish optimal values of regimes of water-thermal processing;

– to construct a mathematical model of producing peeled grains of solid ones and to establish optimal values of regimes of water-thermal processing;

3. Materials and methods

3. 1. Raw material

The research object was wheat soft grains, planted at an experimental plot of Uman National University of gardening under conditions of Right-bank forest and steppe region of Ukraine. A precursor – occupied stale. Fertilizers: nitrogen ones– 120 kg/he, phosphorus and potassium – 60 kg/he. Quality parameters: glass-likeness – 95±4 %, nature 720±16 g/l, protein content 11,4±0,6 %.

3. 2. Equipment for researches

Drying of steamed grains was realized in the drying chamber Sadochok (Consumption power – 950 W. Heater type – THE of non-corrosive steel. Speed of heating of an empty chamber to 65 °C – 20 minutes. Maximal temperature of a working chamber – 65+/–5°C.) (**Fig. 1**).

Fig. 1. Drying chamber Sadochok

Fractionating of peeling products was realized at the laboratory sower LSU-1 (**Fig. 2**).

For distributing intermediate products, there were used sieves of the first type with round orifices. The sowing scheme is presented on **Fig. 5.**

Fig. 2. Laboratory sower LSU-1

For studying the hot conditioning process, there was used the laboratory steamer of periodical action, designed and developed at the department of grain processing and storage technology of Uman national University of gardening, Cherkasy region, Ukraine (**Fig. 3**).

The steamer SPA-1 includes heating element 8 with the stably fixed body of apparatus 4. Ball of liquid 7 is placed in the lower part of the body. For preventing losses of steam pressure, collar compaction 5 is provided on regulatory mechanism 6. Studied sample 3 is placed in the lower part of sieve 2, pressurized by cover 1.

The working principle of a steamer of periodical action is that the lower part of the working zone of the apparatus is filled with water to the fixed mark of the maximal level. A handle of the steam supply control is set in a horizontal position that conditions the division of the working zone in two parts. Heating continues till the moment, when the working pressure of saturated steam is set in the lower part of the working chamber. After that, the handle of the controlling mechanism of steam supply is set in the maximally vertical position that conditions the instant equating of pressure in both chambers to 0,2±0,01 MPa.

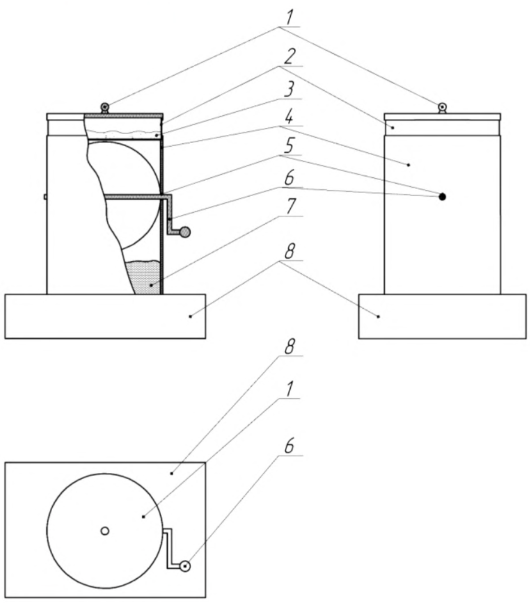

Fig. 3. Laboratory steamer of periodical action SPA-1: 1 – hermetic cover, 2 – sieve, 3 – ball of grain; 4 – steamer body, 5 – collar compaction, 6 – control mechanism of steam supply, 7 – water ball, 8 – heating element

The cylinder with an experimental sample is set in the working position before supplying steam. Steaming time is controlled by an electronic stopwatch with exactness up to 0,5 s. After steaming the cylinder with the hermetic cover is dismantled.

Grains were peeled at the laboratory peeling bench by Marga (Italy) under conditions of the department of technology of grain processing Uman national university of gardening (**Fig. 4**). The essence of improvement was in mechanization of the laboratory setting by installing a drive (electric motor and wedge-belt transmission).

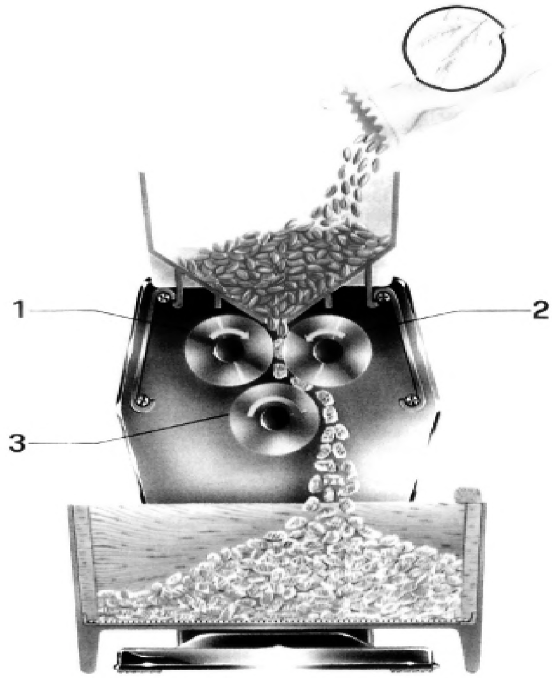

Fig. 4. Laboratory peeling bench by Marga:
1 – low-speed shaft, 2 – high-speed shaft; 3 – shaft for producing flour

The working principle of the peeling machine is in deformation of a raw material by shafts 1 and 2 at orifice 0,5 mm between them. At producing peeled grains, shaft 3 is set in the inoperative position. Power of the electric motor of the bench is 0,75 kW, rotation frequency of the shaft of the electric motor – 25 Hz, transmission type – wedge-belt one, rotation frequency of the high-speed shaft – 2,5 Hz, productivity of the machine is 0,1 kg/min, angle of riffles bend – 8, number of riffles for 1 cm – 10.

The duration of boiling porridge was determined by the electric stopwatch. The output of peeled grain was determined using laboratory scales with measuring exactness 0,01 g.

3. 3. Statistical processing of experimental data

The number of analytic repetitions – is four. The results of the analytical repetitions were processed by the methods of describing statistics using programs Microsoft Excel 2010 and STATISTICA 10. The experiment quality was estimated by the value of coefficient of samples variation, formed of the data of the analytic repetitions. The experiment was considered as reliable at unessential variation of the data of the analytical repetitions. Dependencies between factors were found by the method of dispersion and regression analysis. The choice of optimal processing methods was realized by interpolation of samples of experimental data, constructing a desirability function.

The advantage of using desirable diagrams is a possibility of the complex analysis with deducing reliable tendencies and recommendations. The essence of such analysis is in comparison of all results of statistical processing of regularities between factors and criteria of improvement, construction of a complex function and search for its experimental values.

3. 4. Program of researches and their methodology

At the research there was established the influence of main production parameters of peeled grains (steaming duration, hydration duration) on the output of peeled grains, their boiling coefficient and boiling duration. Steps and levels of varying were identical for solid and soft types of grain (**Table 1**). The technological scheme of getting peeled grains under laboratory conditions is presented on **Fig. 5**.

Grains were peeled before steaming. A peeling index of experimental samples was stable as 10±0,5 %, that conditioned peeled grains of the satisfactory culinary quality.

Porridge was boiled in measuring glass cylinders, placed in the water bath. The boiling coefficient (C_b) was determined by formula:

$$C_b = \frac{V_1}{V}, \quad (1)$$

where V_1 – porridge volume, cm^3; V – peeled grain volume before boiling, cm^3.

The boiling duration was determined by the organoleptic estimation of porridge at its preparation. Estimation intervals were chosen individually for each sample for fix a readiness moment maximally exactly. The first estimation was realized after 5 min of preparing porridge.

Energy consumption was determined by measuring real consumption of electric power of the steamer of periodical action.

Table 1

Steps and levels of varying

Factor name	Minimum value	Center value	Maximum value
Steaming duration ($D_{st.}$), min	5	10	15
Hydration duration ($D_{hyd.}$), min	5	10	15

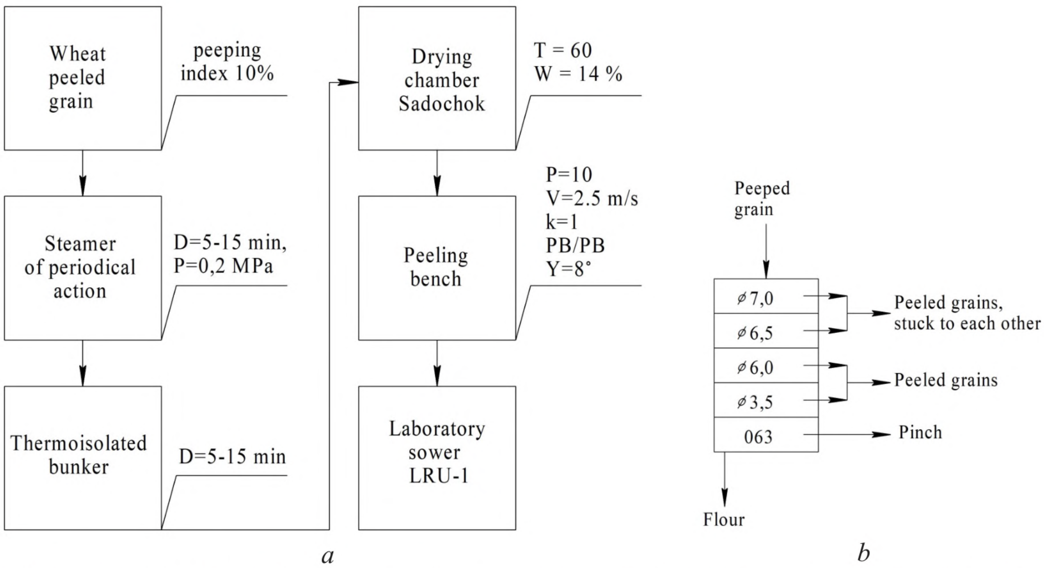

Fig. 5. Conditions of conducted researches: *a* – scheme of laboratory production of peeled grains; *b* – scheme of laboratory sower LSU-1

4. Results and discussion

4. 1. Influence of solidity on the output and quality of peeled grains

It was established, that the output of peeled grain increases with the growth of steaming and hydration duration despite the solidity of raw materials (**Table 2**). So, we can state about such positive influence of hydration and thermal processing on grains of different solidity. But the more output was inherent to samples, produced of soft grains. It is explained by the higher speed of gelatinization of starch granules of soft grains that as a result decreases the amount of obtained flour. Steaming of grains more than 15 minutes was not effective, because the essential number of stuck grains was wasted. Variation of samples of the output of peeled grains, obtained at different processing regimes, was unessential (for soft grain type – 2,98; solid type – 2,90).

There was fixed the essential decrease of boiling duration as a result of increasing steaming and hydration duration despite the solidity of raw materials (Coef.Var.=12,80; 10,90).

The boiling coefficient of peeled grains, analogously to their output, varied unessentially depending on processing parameters, but was higher in samples of the solid grain type.

So, the influence of a raw material type and parameters of its processing on the output and quality of a product is obvious. But it is rather difficult to establish the reliable connection between these factors by the methods of describing, so it needs further mathematical processing.

Table 2

Output and quality of peeled grains depending on raw material types and parameters of their processing

Grain type	$D_{st.}$, min	$D_{hyd.}$, min	Peeled grain output, %	Boiling duration, min	Boiling coefficient
Soft grains	5	5	90,6±0,9	20,0±0,2	7,7±0,2
	5	10	96,9±1,5	19,0±0,2	7,7±0,2
	5	15	95,6±1,1	19,0±0,3	7,8±0,2
	10	5	92,5±1,0	18,0±0,2	7,8±0,2
	10	10	97,8±1,1	17,0±0,2	7,9±0,2
	10	15	96,1±1,2	16,0±0,2	8,0±0,2
	15	5	98,2±0,9	15,0±0,3	7,9±0,2
	15	10	98,5±0,9	14,0±0,2	8,0±0,2
	15	15	97,3±0,7	14,0±0,2	8,1±0,2
	Mean*		95,9	16,9	7,8
	Median*		**96,7**	**17,1**	7,9
	Minimum*		**89,1**	13,7	7,4
	Maximum*		**99,2**	20,2	8,3
	Coef.Var.*		**2,98**	**12,80**	**2,90**
Solid grains	5	5	88,4±1,1	20,0±0,4	7,9±0,2
	5	10	94,7±0,9	20,0±0,3	7,9±0,2
	5	15	93,8±1,4	18,9±0,5	8,0±0,2
	10	5	90,8±0,8	18,0±0,3	8,1±0,2
	10	10	95,6±1,2	16,9±0,3	8,1±0,2
	10	15	94,0±1,4	16,1±0,3	8,2±0,2
	15	5	94,5±1,1	16,1±0,2	8,1±0,2
	15	10	96,6±1,1	15,1±0,2	8,2±0,2
	15	15	95,6±0,7	15,0±0,1	8,2±0,2
	Mean*		93,7	17,3	8,0
	Median*		94,6	17,0	**8,1**
	Minimum*		86,3	14,8	7,5
	Maximum*		97,5	20,2	**8,4**
	Coef.Var.*		2,90	10,90	2,80

Note: The results of describing statistics are based on all values of analytical repetitions

It can be stated with the high reliability that the output of peeled grain and duration of its boiling differed in samples of different grain solidity (**Fig. 6**). But the null hypothesis was confirmed for the boiling duration index (p=0,40).

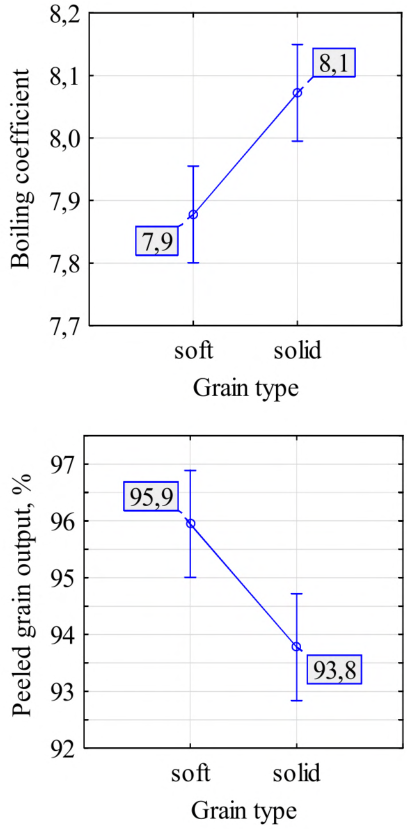

Fig. 6. Peeled grain output and its boiling coefficient depending on grain solidity

At processing wheat of the soft grain type, the output of peeled grain by 2,1 % more can be obtained, but its boiling coefficient is in average by 0,2 un. less.

So, taking into account the reliable influence of the solidity type on parameters of peeled grain production, it is expedient to use this sign at the marketing activity of enterprises. Technical-economic indices of flakes production at processing soft grain type are higher at the expanse of the increased output of a product. It favors the decrease of prime cost of production and obtaining products, available for needy population layers. More consumption at processing solid grain type is compensated by higher organoleptic characteristics.

4. 2. Optimization of processing soft grain type in peeled grains

The peeled grain output depending on boiling and hydration duration can be most exactly described mathematically using the second kind function (R^2=0,74):

$$W = 77{,}28889 + 0{,}38D_{st} + 0{,}02867D_{st}^{2} + 2{,}99333D_{hyd} - 0{,}10733D_{hyd}^{2} - 0{,}059D_{st}D_{hyd}, \quad (2)$$

where W – peeled grain output, %; D_{st} – steaming duration, min.; $D_{hyd.}$ – hydration duration, min.

Analyzing the cogency of regression, it can be stated, that more influence on the output of peeled grains was conditioned by the steaming duration (**Fig. 7**).

The linear dependence is set between the porridge boiling duration, steaming and hydration duration (R^2=0,96):

$$D_{boiling} = 23{,}24167 - 0{,}5D_{st} - 0{,}133333D_{hyd}. \quad (3)$$

The influence of steaming duration on boiling duration was essentially more comparing with the influence of hydration duration (**Fig. 8**).

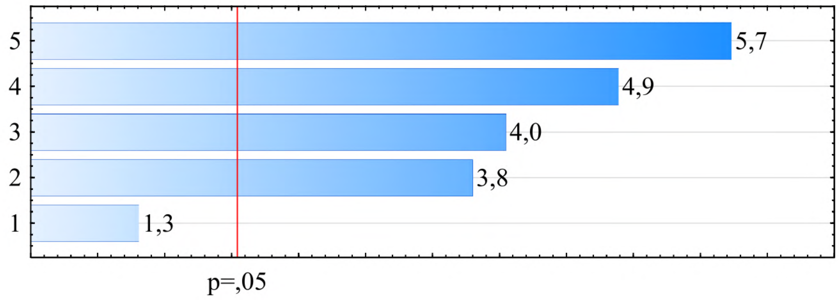

Fig. 7. Pareto diagram of the standardized effect of regression coefficients on the index of soft wheat peeled grain output (absolute value):
1 – D_{st}^{2}; 2 – D_{st} $D_{hyd.}$; 3 – D_{hyd}; 4 – $D_{hydв}^{2}$; 5– D_{st}

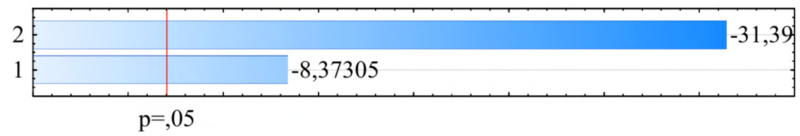

Fig. 8. Pareto diagram of the standardized effect of regression coefficients on the index of soft wheat peeled grain boiling duration (absolute value): D1 – D_{st}; 2 – D_{hyd}

It is impossible to describe mathematically the influence of peeled grain production parameters on the boiling coefficient, because the reliable level of regression coefficients was low (p=0,49–0,91). It testifies to the presence of the reliable connection between parameters of water-thermal processing of soft type grains and correspondent index. Taking into account that boiling coefficient of soft and solid grain types reliably differed, one can make an assumption about the more important influence of raw materials' characteristics on the correspondent index and absence of its change under production conditions.

The choice of optimal parameters of processing soft type wheat grain was realized taking into account the peeled grain output, boiling duration and energy consumption for the steaming process (**Fig. 9**).

In whole the increase of steaming duration raised the peeled grain output and decreased its boiling duration, but energy consumption for its production grew in direct proportion. The excessive hydration duration worsened the peeled grain output, whereas hydration during 10–12 min increased it.

The most abrupt decrease of porridge boiling duration was fixed as a result of hydration duration from 5 to 10 min. The further increase of steaming duration decreased the boiling duration unessentially.

At constructing the desirability function, the product output, least duration of its boiling and energy consumption were in priority. For attaining the set criteria, there were chosen regimes, considered as optimal (steaming duration 10 min, hydration duration 10–12 min). At using the recommended regimes at processing soft type wheat grains, there can be gotten the peeled grain output 97,2 % with boiling duration 16,5 min. Although energy consumption for peeled grains production was calculated at the laboratory production, it is impossible to compare their values with industrial conditions, but the established tendency of their change will be valid.

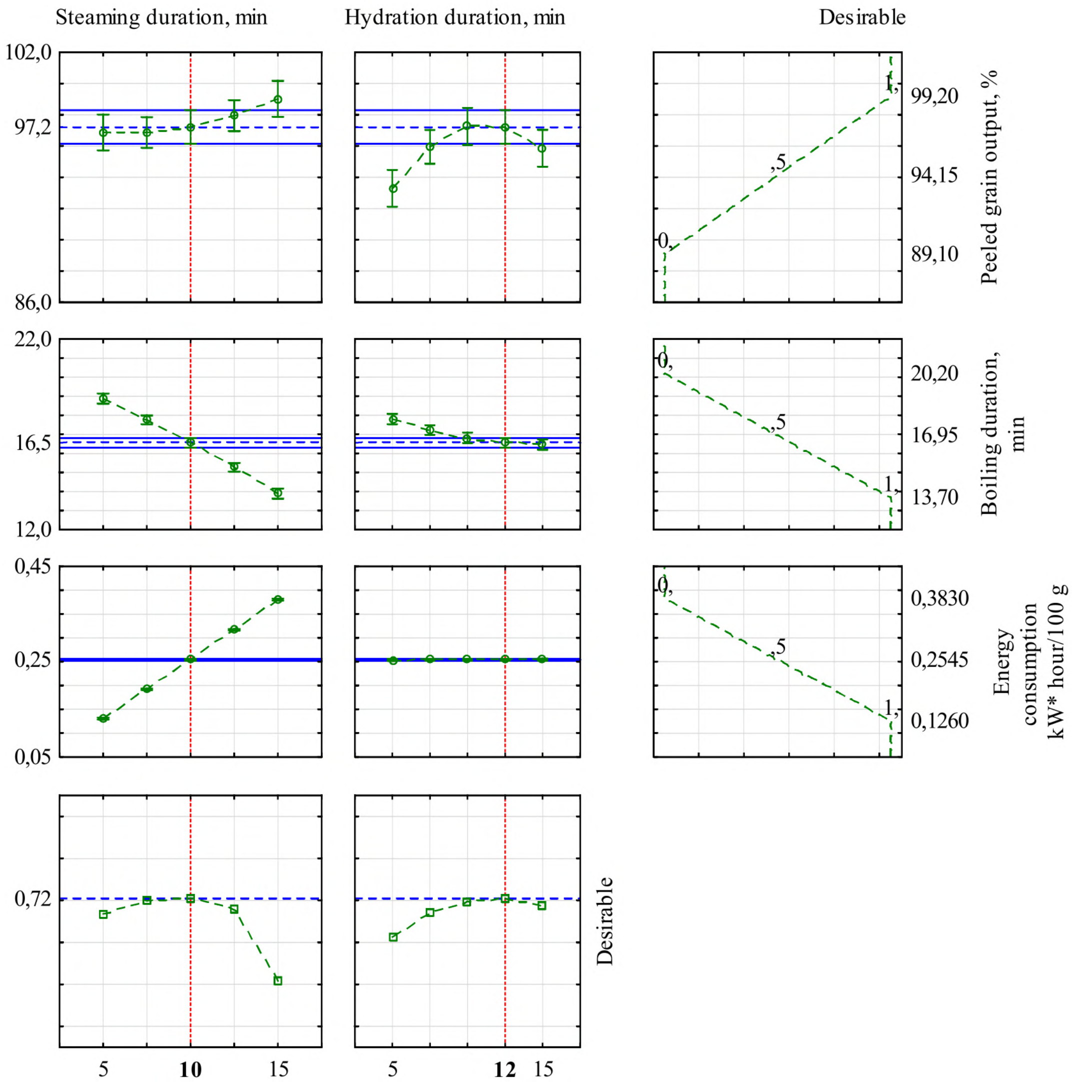

Fig. 9. Profiles of prognosticated values and desirability at processing soft wheat type in peeled grains

4. 3. Optimization of processing solid type grains in peeled grains

The influence of parameters of water-thermal processing on the peeled grain output, its boiling duration and boiling coefficient was similar to the soft one. It can be expressed rather exactly (R^2=0,76–0,93) by equation of the second kind:

$$W = 75,25556 + 0,38333D_{st} + 0,01867D_{st}^2 + 2,98D_{hyd} - 0,11133D_{hyd}^2 - 0,043D_{st}D_{hyd}; \quad (4)$$

$$T_{boil} = 22,88056 - 0,42083T_{st} - 0,13583T_{hyd}. \quad (5)$$

The influence of steaming and hydration duration on the grain output was equivalent, but boiling duration was most influenced by the steaming duration (**Fig. 10, 11**).

The graphic image of functions 3–4 testify that the common zone of optimum of the correspondent functions is in points, similar to the optimum zone of analogous dependences, obtained at processing soft wheat grain (**Fig. 12**). At processing solid grain type wheatб it is rational to steam it during 10 min with the further hydration during 12–13 min.

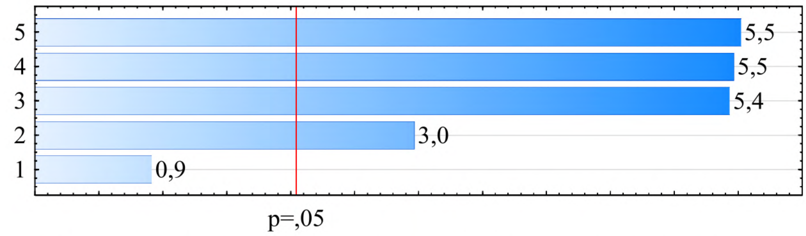

Fig. 10. Pareto diagram of the standardized effect of regression coefficients on the index of solid wheat peeled grain output (absolute value): 1 – D_{st}^{2}; 2 – D_{st} $D_{hyd.}$; 3 – D_{hyd}; 4 – D_{hyd}^{2}; 5– T_{st}

Fig. 11. Pareto diagram of the standardized effect of regression coefficients on the index of solid wheat peeled grain boiling duration (absolute value): 1 – D_{st}; 2 –D_{hyd}

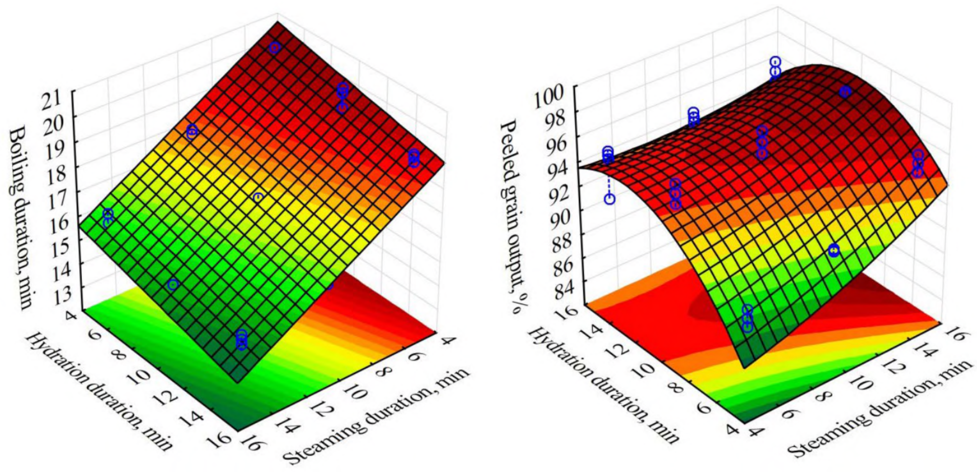

Fig. 12. Influence of parameters of water-thermal processing on the output and boiling duration peeled grain of solid type wheat

As a result of using the offered regimes the peeled grain output of solid type wheat was 95,4 %, and its boiling duration was 16,5 min.

5. Conclusions

The reliable connection between the solidity type of wheat grain and important parameters of peeled grain production (output, boiling coefficient), established as a result of the studies, elucidates new aspects in peeled grains production. The obtained research results can be used for widening the assortment of peeled grain products of traditional wheat at the expanse of using grains of different solidity. The lower output of solid wheat peeled grains can be compensated by their higher cost, whereas soft wheat types are suitable for manufacturing cheaper products. In whole the research results, cited in the article, prove the importance of establishment and further study of the influence of grain solidity on qualitative and quantitative indices of peeled grain production. The article presents real energy consumption for hot conditioning, whereas energy consumption at peeling grain of different solidity type remain unknown that conditions the expedience of further studies.

The output of soft type peeled grains (95,9 %) was more, comparing with the output of solid type peeled grains (93,8 %). Wheat types reliably differed by the boiling coefficient, whereas the boiling duration for soft and solid wheat types was similar.

The optimal regime of water-thermal processing at production peeled grains of the soft type is steaming during 10 min with hydration for 10–12 min.

At processing solid type wheat it is rational to steam it during 10 min with further hydration for 12–13 min.

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INVESTIGATION OF DISINFECTANT'S EFFECTIVENESS AS TO CONTAMINATING MICROFLORA IN SUGAR PRODUCTION

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Abstract

The article presents the results of the studies of the effectiveness of disinfection means, based on chlorinated guanidines, tetradic ammonium salts, dichlorisocyanuric acid, peracetic acid and hydrogen peroxide as to the contaminating microflora of sugar beets. There was investigated the influence of disinfectants on bacteria Bacillus subtilis, Leuconostoc mesenteroides, mycelia fungi Aspergillus niger, Penicillium chrysogenum and yeast Sacharomyses cerevisiae.

It was experimentally established, that the studied means has the high effectiveness as to most microorganisms that cause saccharose losses in the process of its extracting from beet chip and result in worsening a technological quality of semi-products of beet-sugar.

There was established the high effectiveness of modern disinfection means as to inhibiting slime-forming bacteria of Leuconostoc generis. There was proved a possibility of their use at different technological stages of beet-sugar production for preventing the development of mucous bacteriosis.

It was determined that means consumption depends on a type and extent of microbiological contamination of raw materials, semi-products, technological waters at sugar production. There were established concentrations of the studied means as to inhibiting the development of main contaminants of the microflora of raw materials and semi-products in sugar production.

There is offered to use the studied means in industrial beet-sugar production that would favor the decrease of microbial contamination of semi-products and the increase of a sugar output from a raw material unit.

Keywords: sugar beets, disinfectant, dextran, diffusion apparatus, mucous bacteriosis.

DOI: 10.21303/2504-5695.2018.00726

1. Introduction

The course of microbiological process at extracting saccharose of beet chip causes its disintegration, creation of a series of acids, dextran that results in essential losses of saccharose at production, worsening of the white sugar quality and in separate cases – the decrease of productivity of a plant. Microbiological contamination essentially worsens the quality of semi-products and ready sugar, especially as a result of forming organic acids, increase of chromaticity, foaming in juice and so on [1].

The amount of microorganisms in diffusion juice depends on many factors and according to different researchers, can be from 1×10^6 to 1×10^8 CFU in 1 cm^3 [2–4]. The great amount of sporiferous bacteria were found in diffusion juice: *Bacillus subtilis*, *B. mesentericum*, *B. megatherium*, *B. mycoides*, *B. circulans*, *B. stearothermophilus*, which activity is manifested in acid and gas formation, disintegration of saccharose into reducing substances, resulted in complications in the process of purification, filtration and crystallization of saccharose [3, 4].

The most spread type of bacterial diseases of sugar beets is mucous bacteriosis. As a result of injuring edible roots, dextran forms in sugar beet juice, its presence causes not only direct losses of saccharose, but also essential problems at production, so results in financial losses of an enterprise [5]. Dextran is produced by bacteria of *Leuconostoc, Lactobacillus* and *Streptococcus* genera. The most spread type of slime-forming bacteria, occurred at sugar plants, is *Leuconostoc mesenteroides* [6]. Dextran creation by bacteria of *Leuconostoc mesenteroides* generis takes place as a result of saccharose disintegration, analogous to enzymatic inversion save that glucose is polymerized in dextran, and fructose is used for nourishing bacteria [7].

Dextran is a polyglucan, which size changes from the low-molecular (soluble) to high-molecular (insoluble). At the same time its solubility depends on the structural construction of a macromolecule: the higher content of α-(1→6) connections, the more solubility. And vice versa, the higher percent of α-(1→3) connections in a polymer, the less solubility in water [8]. Just the presence of soluble dextran in juices and semi-products causes most technological problems: the effectiveness of juice purification decreases, filtrating-sediment properties of residue worsen, evaporation speed decreases, heat transmission diminishes and so on [9, 10]. It finally results in decelerating the crystallization process, increase of duration of boiling massecuites that causes the decrease of factory capacities [11]. The aforesaid results of microbiological processes at producing sugar testify to the topicality of control and elaboration of arrangements as to their prevention and elimination, and also provision of sanitary conditions of production for ready products according to SSU requirements [12].

For decreasing losses of saccharose from microbiological disintegration, it is expedient to use disinfection means at different production stages, especially: at rinsing roots after washing, for processing juice-chip mixture in the diffusion apparatus, nutritious water and so on. Existent differences in the technological equipment of sugar plants need a differentiated approach to disinfection at separate stages of the technological process, especially: equipment, technological waters, intermediate products.

The aim of the researches was to study the effectiveness of disinfection means, based on different active substances, namely: chlorinated guanidines, tetradic ammonium salts, dichlorisocyanuric acid, peracetic acid and hydrogen peroxide as to inhibiting the vital activity of microorganisms that favor most loses at the stage of getting diffusion juice in sugar-beet production.

2. Materials and Methods

Research objects were: 4 modern biocide means: based on chlorinated guanidine («HSG dez 2»), tetradic ammonium salts («HSG dez 3»), dichlorisocyanuric acid («HSG dez 4»), peracetic acid and hydrogen poroxide («HSG dez 5»).

The studied means belong to III class of moderately dangerous substances by acute toxicity parameters, according to SS 12.1.007. The disinfection means «HSG dez 2» – transparent liquid, colorless or with light opalescence. The active substance of «HSG dez 2» is polyhexamethylenebiguanidine hydrochloride in the amount no less 15 %. The disinfection means «HSG dez 3» – transparent liquid from colorless to light yellow color. The active substance of it is tetradic ammonium compounds in the amount no less 40 %. The disinfection means «HSG dez 4» is a solid substance that looks as tablets, granules or powder. Its active substance is sodium salt of dichlorisocyanuric acid, no less 80,0 %. The disinfection means «HSG dez 5» – transparent liquid from colorless to light yellow color. Its active substance is peracetic acid in the amount no less 12 % and hydrogen peroxide no less 18 %.

There were used the following concentrations of working solutions (by the active substance content): «HSG dez 2» – 0,001, 0,002, 0,003 and 0,004 %, «HSG dez 3» – 0,0005, 0,00075, 0,001, 0,002 and 0,004 %, «HSG dez 4» – 0,0002, 0,0004, 0,0008 and 0,001 %, «HSG dez 5» – 0,001, 0,002, 0,004 and 0,008 %.

The effectiveness of disinfection means was studied on pure cultures of microorganisms. The choice of test-cultures was based on the analysis of the contaminating microflora of raw materials, semi-products and technological waters in sugar production, taking into account the negative influence of products of microbial metabolism on the course of technological processes and white sugar quality.

We established that a series of microorganisms belongs to the contaminating microflora of diffusion juice and technological waters: yeast of *Saccharomyces, Torulopsis genera, bacteria Bacillus subtilis*, *B. mesentericus, B. megatherium, Escherichia coli, Aerobacter aerogenes, Leuconostoc mesenteroides*. At processing raw materials, injured by clamp mould, spores of micromycetes of *Fusarium, Botrytis, Mucor, Penicillium, Aspergillus, Trichotecium, Verticillium* genera, can penetrate diffusion juice.

Thus, the following microorganisms were chosen as test-cultures: ammonifying bacteria *Bacillus subtilis,* slime-forming bacteria *Leuconostoc mesenteroides,* mycelium fungi *Aspergillus niger, Penicillium chrysogenum* and yeast *Sacharomyses cerevisiae*.

The studies were realized under laboratory conditions. For determining the sensitivity of the microflora, typical for diffusion juice and effect of biocide preparations on it, there was used the method of "holes in agar layer" [13]. Cultivation of microorganisms was realized on the following nutrient mediums: a) meat infusion agar (MIA) with inclusion pure cultures of microorganisms (*B. subtilis, L. mesenteroides*), b) medium with wort agar with pure cultures of micromycetes *A. niger, P. chrysogenum* and yeast *S. cerevisiae*. Nutrient mediums with a correspondent culture of microorganisms were poured in sterile Petri dishes. After stiffing the nutrient medium, holes were made at distance 1,5 – 2,0 cm from a dish edge using a sterile drill. Water solutions of antimicrobial preparations with different concentrations were introduced to them.

Conclusions about the effectiveness of disinfectants at a certain solution concentration were made according to the availability of areas of stunted growth of microorganisms. No areas of stunted growth indicates that the studied culture is insensitive to the action of the product at the specified concentration. With the zone diameter of 15 mm we believe that microorganisms have a small degree of sensitivity to the corresponding concentration of the product, with the zone diameter of 15 to 25 mm the average degree of sensitivity is indicated. Availability of the zone with diameter greater than 25 mm indicates a high degree of sensitivity of microorganisms to the concentration of the antimicrobial agent.

3. Results

3. 1. Analysis of effectiveness of disinfection cultures as to test-cultures of microorganisms

The results of studying the effectiveness of disinfection means on separate types of microorganisms, present in feedwater and beet chip, are presented in **Tables 1–4** and on **Fig. 1–3.**

Table 1

Sensitivity level of test-cultures of microorganisms to disinfection means based on chlorinated guanidines «HSG dez 2»

Cultures of microorganisms	Diameter of zone of effect of antimicrobial means, mm			
	Consumption of active substance, g			
	0,001	0,002	0,003	0,004
B. subtilis	20	23	26	32
L. mesenteroides	27	34	40	45
S. cerevisiae	33	38	40	44
A. niger	23	28	34	40

The analysis of the results of the conducted researches (**tables 1–4**) testifies to the high effectiveness of the studied disinfection means «HSG dez 2», «HSG dez 3», «HSG dez 4» and «HSG dez 5» comparing with the bacterial microflora, yeast and micromycetes, present in raw materials, technological water, semi-products of beet-sugar production.

Table 2
Sensitivity level of test-cultures of microorganisms to disinfection means based on tetradic ammonium salts «HSG dez 3»

Cultures of microorganisms	Diameter of zone of effect of antimicrobial means, mm				
	Consumption of active substance, g				
	0,0005	0,00075	0,001	0,002	0,004
B. subtilis	18	23	25	27	30
L. mesenteroides	12	18	21	28	30
S. cerevisiae	19	22	24	26	28
A. niger	9	12	19	23	27

Table 3
Sensitivity level of test-cultures of microorganisms to disinfection means based on dichlorisocyanuric acid «HSG dez 4»

Cultures of microorganisms	Diameter of zone of effect of antimicrobial means, mm			
	Consumption of active substance, g			
	0,0002	0,0004	0,0008	0,001
B. subtilis	16 (28 – growth inhibition)	20 (30 – growth inhibition)	23 (33 – growth inhibition)	25 (34 – growth inhibition)
L. mesenteroides	18	23	28	33
S. cerevisiae	30	5 Colonies	sterile	
A. niger	14	22	2 colonies	sterile

Table 4
Sensitivity level of test-cultures of microorganisms to disinfection means based on peracetic acid and hydrogen peroxide «HSG dez 5»

Cultures of microorganisms	Diameter of zone of effect of antimicrobial means, mm			
	Consumption of active substance, g			
	0,001	0,002	0,004	0,008
B. subtilis	34	46	48	sterile
L. mesenteroides	15	20	26	34
S. cerevisiae	18	20	29	36
A. niger	13	17	21	26

At to the means «HSG dez 2», based on chlorinated guanidines, it is active as to different groups of microorganisms, including micromycetes and slime-forming bacteria at consumption 0,001…0,002 %.

There must be noted the high effectiveness of the presented means as to slime-forming bacteria (**Tables 1–4, Fig. 3, *b***). Thus, at consuming disinfection means «HSG dez 2» and «HSG dez 3» in 0,001…0,002 % the zone, delaying the growth of slime-forming bacteria *Leuconostoc mesenteroides* is 27…34 mm and 21…28 mm, respectively, that testifies to their high effectiveness. Means, based on peracetic acid and hydrogen peroxide, are also effective as to slime-forming bacteria. At consuming disinfection means «HSG dez 5» 0,004…0,008 % the zone, delaying the growth is 26…34 mm.

The analysis of the results of the conducted researches (**Table 3**) testifies to the high effectiveness of the chosen means as to the bacterial microflora of beet-sugar production. The nature of the poisoning effect of chemical compounds, based on active chlorine, is connected with oxidation processes in the protoplasm of a microbial cell that results in its death. Thus, at using disinfection means «HSG dez 4» in diapason of active substance consumption 0,0002…0,0004 % there is observed death of vegetative forms of mesophilic sporiferous bacteria *B. subtilis,* and also yeast *S. cerevisiae.* For attaining the analogous effect of decontamination as to slime-forming bacteria *Leuconostoc mesenteroides* and micromycetes *A. Niger,* consumption of the active substance must be increased to 0,0004…0,0008 %.

Thus, according to the results of the conducted experimental studies, it is necessary to note the high effectiveness of the chosen means «HSG dez 2», «HSG dez 3», «HSG dez 4» and «HSG dez 5» as to the wide spectrum of microorganisms. At that these means are effective as to inhibiting the development of slime-forming bacteria of *Leuconostoc* generis.

According to the results of the conducted studies, it was established, that the effective dose of a disinfectant is determined by the type of contaminating microflora of raw materials and semi-products of sugar production. Although, under industrial conditions raw materials contain the wide spectrum of micromycetes and bacteria, average rational doses that provide decontamination as 80-90 % are used at disinfection.

Taking into account the results of the studies of the effect of the means as main contaminants of beet-sugar production, it was established, that rational concentrations in average correspond to:

– «HSG dez 2» – 0,002…0,003 %;
– «HSG dez 3» – 0,001…0,002 %;
– «HSG dez 4» – 0,0004…0,0008 %;
– «HSG dez 5» – 0,004…0,006 %.

Fig. 1–3 graphically illustrate the results of disinfection effect of the means, based on: dichlorisocyanuric acid (**Fig. 1**), chlorinated guanidines (**Fig. 2**), peracetic acid and hydrogen peroxide (**Fig. 3**).

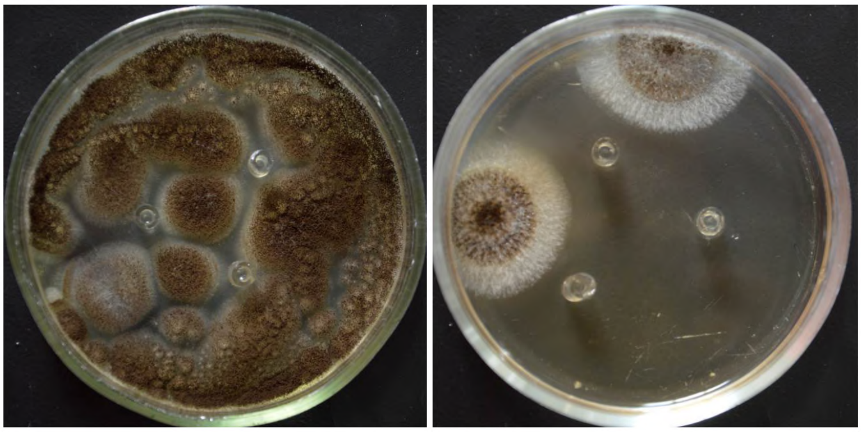
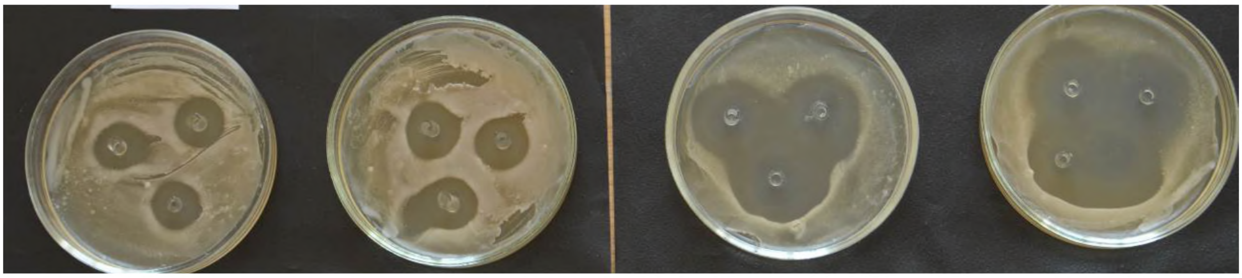


Fig. 1. Effect of the mean «HSG dez 4» with concentrations 0,0002 and 0,0008 % on micromycetes *A. niger*

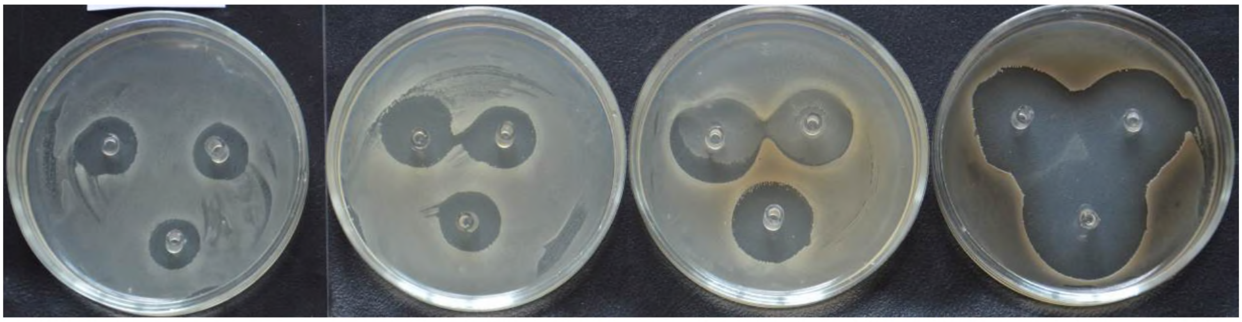
It must be noted that at using «HSG dez 4» there were observed not only distinctly separated zones, delaying the microorganisms' growth, but also inhibition of the growth of cultures along the whole dish. Eucaryotes (micromycetes and yeasts) demonstrated the higher sensitivity to the effect of this means than bacterial cultures that can be explained by differences of the structure of a cellular wall and mechanism of the influence of chlorine compounds on microbial cells.

The presence of the high bactericide effect allows to recommend the studied means for processing transport-washing water, water for rinsing edible roots, for processing juice-chip mixture at extracting saccharose of beet chip and at other production stages that need disinfection.

Fig. 2. Effect of the means «HSG dez 2» with concentrations 0,005 and 0,02 % on micromycetes *A. niger*



a



b

Fig. 3. Effect of the means «HSG dez 5» with concentrations 0,001, 0,002, 0,004 and 0,008 % on microorganisms: *a* – effect on *S. cerevisiae; b* – effect on *L. mesenteroides*

4. Conclusions

The conducted studies demonstrated the high effectiveness of using modern biocide means, namely – based on chlorinated guanidines («HSG dez 2»), tetradic ammonium salts («HSG dez 3»), dichlorisocyanuric acid («HSG dez 4»), peracetic acid and hydrogen peroxide («HSG dez 5»), for decreasing microbial contamination at sugar production.

It was established, that the studied means have the high effectiveness as to most microorganisms that cause losses of saccharose in the process of its extracting from beet chip and result in worsening a technological quality of semi-products of beet-sugar. There was established the high effectiveness of modern disinfection means as to inhibiting slime-forming bacteria.

The practical value of the conducted studies is in establishing the rational concentrations of the studied means as to inhibiting the development of main contaminants, based on which there are elaborated technological regulations of introducing the studied disinfectants in sugar production.

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INVESTIGATION OF TECHNOLOGICAL PROPERTIES OF POWDER OF EGGPLANTS

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Abstract

The aim of the article is to study and to generalize technological properties of eggplant powder, produced by infrared drying at temperatures 50–60 ºC. The results of the conducted complex of studies reflect main technological and consumption properties of the received puree that plays an important role at creating new culinary products.

So, for studying technological properties of food eggplant powder, there was considered the complex of base functional-technological properties of powder, produced by infrared drying.

For finding optimal conditions of rehydration of eggplant powders, there was studied the influence of such technological factors as: swelling ability; liquid; powder ratio; influence of the solvent temperature on renovation; renovation duration; degree of comminution of powders.

Main parameters that influence the renovation ability of dried eggplants are investigated and studied in the article. The results of the studies of technological properties of eggplant powders prove their high rehydration properties. It gives a possibility to use powders at producing different culinary products not only for enriching them with functional ingredients, but also for giving them new technological properties.

Based on the obtained results, there was elaborated and presented the new technological scheme of using renewed powders in food compositions.

Keywords: vegetable powders, eggplant powders, renovation ability, water-retaining ability, rheological parameters.

DOI: 10.21303/2504-5695.2018.00723

1. Introduction

Eggplants are rather valuable raw material, but a season one [1–3]. One of ways of conservation of vegetable raw materials is drying in powders [4, 5]. The drying process allows to avoid a season character of eggplants consumption, to simplify operations for their culinary processing, to shorten a duration of the technological process of preparing dishes and to widen their assortment, to decrease areas of warehouses and production rooms, to create correspondent sanitary-hygienic conditions. Due to infrared drying, the time of thermal processing of the product shortens and maximal conservation of the nutrient composition is attained. Taking it into account, eggplant powder is a rather promising raw material for being used at enterprises of restaurant economy and food industry.

Eggplant powder is a new raw material, so it is necessary to establish main technological properties for further modeling new culinary products.

Eggplant powder corresponds to requirements, set to this type of raw materials by the content of toxic elements and by microbiological parameters [4, 6].

It must be noted, that the developed powder doesn't need additional conditions of storage, which term is 12 months.

At developing and manufacturing restaurant economy products, it is necessary to know main technological properties of raw materials [7, 8]. So it is very important to study main characteristics of powders. One of criteria of estimating their quality is the rehydration ability. The renovation characteristic of a material depends on many factors, first of all, chemical composition of a raw material, its structure, physical-chemical properties and degree of changes, undergone by a product at drying, and influences the ready product's quality. The incorrect renovation can result in losses of valuable food materials, contained in powder as dry substances. The powder quality depends on an initial raw material, regimes of technological processing, conditions of storage and renovation.

The renovation ability of a material is characterized by a value of the swelling coefficient C_s that indicates the relative decrease of a product mass after swelling and determines the ability to renew initial properties of a material at dehydration [7].

For determining optimal rehydration conditions for eggplant powders, there was studied the influence of the following technological factors:

1) Liquid:powder ratio;
2) Solvent temperature;
3) Renovation duration;
4) Powders comminution degree.

So, the aim of this work is to study and to generalize technological properties of eggplant powder, produced by infrared drying. The obtained experimental material allows to calculate the necessary amount of powder as a food supplement at creating recipes and fast food products and to determine time for preparing dishes.

2. Materials and methods

The research object of this work is a food powder of eggplants, received by infrared drying. For producing it, there was chosen the middle-ripe variety of eggplants Diamond, technically ripe, planted in Bilozersky district (Kherson region, Veliky Kopany region, Ukraine). Fruits are characterized by high good parameters, flesh is light-green, with the dense consistence, without the expressed bitterness. Due to its good characteristics it is the most spread crop in the South of Ukraine.

For studying technological properties of eggplant food powder, obtained by infrared drying, there were determined the dispersibility of powders; swelling ability; influence of the solvent temperature on renovation; rheological parameters.

The comminution degree of eggplant powders was determined by sifting a product batch through a sieve and weighting a residue on it [8, 9]. The amount of bound water was determined by the indicator refractometric method (**Fig. 1, *a***) [10]. Rheological characteristics of eggplant powder were determined on Ostwald viscometers (**Fig. 1, *b***) [11]. The density of the studied samples was determined volumetrically – by weighing [12, 13]. The renovation ability of eggplant powders was determined by the method of B. V. Zozulevich [8, 9]. Optimal regimes for powders renovation were chosen using the method of mathematical planning of an experiment [7–9].

a

b

Fig. 1. Devices for the studies: *a* –digital refractometer Rudolph J157 (USA); *b* – Oswald viscometer (China)

2. 1. Experiments

The ratio between liquid and powder was established by the method of selection of optimal compositions [9].

There was studied the renovation degree of powders in water before thermal processing. For getting puree, powders were renewed by the method of B.V. Zozulevich in interval $3{,}0 \cdot 10^2 \ldots 1{,}8 \cdot 10^3$ with different hydromodules [8, 9]. During the experiment there was studied the liquid and powder ratio in proportions 1:1,1:2,1:3,1:4,1:5,1:6. Puree of boiled eggplants was taken as a control.

For determining the solvent temperature influence of eggplant powder renovation, there was taken the liquid-powder ratio in proportions 1:2, 1:3, 1:4, 1:5, 1:6, renovation duration 10 min, water temperature 20 ,40 , 60, 80, 100 ºC, in all cases the dry powder mass was 10g. Dry soluble substances were determined by centrifuging. The research results are presented in table 1.

The water-retaining ability of eggplant powders was determined by the centrifuging method that provides hydration of the batch at the determined temperature and dispersity. The residue is centrifuged and dried. The ratio of evaporated water to the solid residue mass gives the value of water-retaining dependence. The time of the previous wetting, temperature, speed and time of centrifuging doesn't essentially influence the value of water-retaining ability.

3. Results

One of criteria of estimating the quality of dry products is the ability to swelling that depends on the chemical composition and water-retaining ability of powder. It was established, that dispersity influences the value of the water-retaining ability. At dispersity >0,315 mm=80 %, >0,25 mm=60 %, 0,16 mm=56 %. Despite the obtained data, it is most optimal to study powders with dispersity 0,25 mm.

Optimal conditions of powder renovation were chosen depending on such parameters as rehydration duration, hydromodule (1:2, 1:3, 1:4, 1:5, 1:6), solvent temperature (20, 40, 60, 80, 100 ºC) (**Fig. 2**).

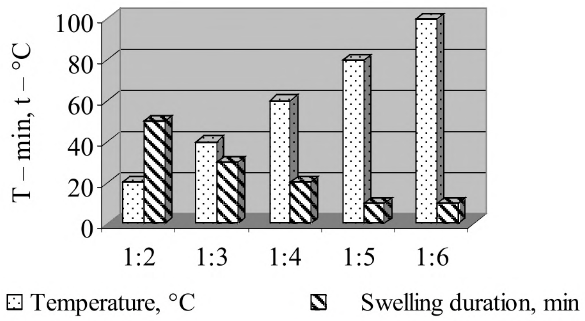

Fig. 2. Dependence of temperature and dissolution duration of eggplant powders

The important role at powders renovation is played by the temperature of water, taken for hydration. It was established that the powder has the high swelling and renovation ability, and the speed depends on the water temperature and dispersity.

It was experimentally established, that powder with sizes of particles less 0,25 mm has a puree-like mass, like in the control. Powders of different fractions were left for 24 hours for watering, as a result the amount of water, taken by dry eggplants with different comminution degrees, was practically equal.

It was established, that at the beginning of the process the water-absorbing ability is higher than in a certain time interval after the beginning. In first $3 \cdot 10^2 \ldots 6 \cdot 10^2$ s a certain amount of water is absorbed by powders with the further decrease of the absorption speed. Losses of soluble substances reach maximum in $6{,}0 \cdot 10^2$–$9{,}0 \cdot 10^2$ s the further increase of the rehydration duration (to $1{,}8 \cdot 10^3$ s) is accompanied by the increase of the water-absorbing ability of powders and it becomes the same as at the beginning in first $3{,}0 \cdot 10^2$–$6{,}0 \cdot 10^2$ s. At the same time diffusion processes finish, and there is no increment of the amount of extracted substances. There is observed its decrease at the expanse of absorption by swelled powder particles.

The essential increase of the rehydration ability in powders is observed at temperatures less 60 °C, at the further water temperature increase it remains practically the same (**Table 1**).

Table 1

Influence of solvent temperature on renovation of eggplant powders

Hydromodule/temperature , °C	Swelling coefficient, %	Dry soluble substances, %	Renovation ability, %
1:2			
20	2,7±0,13	7,2±0,36	36,7±1,84
40	3,5±0,17	7,9±0,40	63,2±3,16
60	3,8±0,18	8,3±0,42	86,0±4,30
80	3,8±0,18	8,5±0,43	86,2±4,31
100	3,8±0,18	8,5±0,43	86,3±4,32
1:3			
20	3,4±0,17	7,8±0,39	42,0±2,10
40	4,0±0,20	8,5±0,43	78,4±3,93
60	4,5±0,23	9,5±0,48	94,0±4,70
80	4,7±0,24	9,6±0,48	94,5±4,73
100	4,8±0,24	9,6±0,48	94,5±4,73
1:4			
20	3,8±0,18	7,6±0,38	39,8±1,99
40	4,0±0,20	8,6±0,43	64,9±3,25
60	4,7±0,23	9,6±0,48	92,9±4,65
80	4,7±0,23	9,5±0,48	93,1±4,65
100	4,7±0,23	9,5±0,48	92,9±4,65
1:5			
20	3,8±0,18	7,4±0,37	38,0±1,90
40	4,1±0,20	8,2±0,42	62,5±3,13
60	4,7±0,23	8,6±0,43	83,0±4,15
80	4,7±0,23	8,7±0,43	83,1±4,16
100	4,7±0,23	8,6±0,43	83,1±4,16
1:6			
20	3,4±0,17	7,2±0,36	36,4±1,82
40	3,8±0,18	8,1±0,41	65,6±3,23
60	4,4±0,22	8,6±0,43	82,3±4,12
80	4,3±0,22	8,5±0,43	82,4±4,12
100	4,2±0,21	8,5±0,43	82,3±4,12

*Note: * – Difference is reliable, p<0,05*

The analysis of the obtained data demonstrated that the swelling coefficient of eggplant powders at temperature 20 °C in the experiments with equal renovation durations has a tendency to the growth with increasing the water-powder ratio.

It was established (**Table 2**), that at the powder-water ratio as 1:2 the swelling coefficient was 2,7 %, and at 1:4 and 1:5 – 3,8 %.

At the temperature increase to 40 °C and 60 °C there is traced the same regularity. Namely: at 1:2 – 3,5 % and 3,8 % and at 1:5 – 4,1 % and 4,7 %.

At the rehydration duration increase from $3{,}0\cdot10^2$ s to $1{,}8\cdot10^3$ s and water temperature increase to 60 °C the water-retaining ability of eggplant powder puree increases, that is testified by the ability of restored powder to retain moisture after centrifuging. At the renovation water temperature increase to 80 °C, the powder ability to retain moisture decreases.

Table 2

Changes of rheological characteristics of renewed eggplant powders depending on rehydration duration

Thermal processing duration, 10^2 s	Viscosity, Pa·s	Fluidity 10^2 Pa·s^{-1}	Dynamic limit of fluidity Pa·s
$3{,}0\cdot10^2$	1,80±0,7	7,60±0,7	5,10±0,8
$6{,}0\cdot10^2$	2,48±0,9	8,0±0,6	4,7±0,8
$12{,}0\cdot10^2$	2,48±0,9	8,2±0,4	4,7±0,7
$18{,}0\cdot10^2$	3,1±0,7	8,3±0,4	4,3±0,7

*Note: * Difference is reliable, p<0,05*

At powders renovation there takes place extraction of soluble substances, mainly due to diffusion. In all cases losses of soluble substances reach maximum at $6{,}0…9{,}0\cdot10^2$ s. The further rehydration duration increase to $1{,}8\cdot10^3$ s and more results in the water-absorbing ability decrease.

The most important parameter is a rehydration duration. As far as viscosity gains its maximal value at 60 °C, for studying the influence of the swelling duration on powders renovation, just these samples with hydromodules 1:3, 1:4, 1:5, 1:6 were taken. Renovation was realized during $3{,}0–18{,}0\cdot10^2$ s. It was established, that the viscosity increase is observed in first $6{,}0…9{,}0\cdot10^2$ s. The swelling time increase to $1{,}8\cdot10^3$ s doesn't essentially influence the viscosity of obtained puree and reaches its maximal value at the temperature from 45°C to 60 °C and at hydromodule 1:3. It was established, that the viscosity increase takes place during $9{,}0\cdot10^2$ s, the essential amount of pectins results in gelatinization of obtained puree with hydromodules 1:4, 1:3. As a result of renovation there forms gel that gives the correspondent consistence to puree of powders. The rational conditions for rehydration is the liquid temperature less 60 °C, swelling duration $6{,}0…9{,}0\cdot10^2$ s, with powder-liquid ratio 1:3, 1:4.

For the quality estimation of restored powder, there were determined rheological properties in the prepared samples (viscosity, fluidity, dynamic limit of fluidity, taking into account the fact that puree is a disperse system (**Table 3**).

Table 3

Rheological parameters of restored eggplants powders

Parameters	Puree of eggplants	Puree of eggplant powder (hydromodule)					
		1:1	1:2	1:3	1:4	1:5	1:6
Dynamic viscosity, Pa·s	13,60	18,40	15,60	12,70	11,98	8,62	5,25
Dynamic limit of fluidity, 10^2Pa	4,66	7,20	5,25	4,70	4,44	1,92	1,80
Fluidity, 10^2Pa·s^{-1}	7,91	4,60	6,49	8,20	9,36	12,81	16,73
Plastic viscosity, Pa·s	3,20	0,78	1,44	2,48	3,30	4,83	6,06
Plasticity coefficient	0,97	0,60	0,73	0,89	0,92	1,27	2,03

At powder-water ratio 1:1 the dynamic viscosity of prepared powder is rather high – 18,4 Pa·s, that is by 26 % more than one of the control sample. The hydromodule increase to 1:3 brings the dynamic viscosity of restored powders close to indices of fresh puree. So, the dynamic viscosity of obtained renewed powder is by 6 % less than the control at the hydromodule 1: 3.

At the further hydromodule increase to 1:5 and 1:6 the dynamic viscosity index decreases by 36 % and 61 % respectively. The analogous changes take place also with other rheological indices of restored powders.

The obtained data testify to high rehydration properties of developed powder that is an important factor at creating culinary products.

Based on the obtained data, there was elaborated the general scheme of eggplant powders renovation (**Fig. 3**).

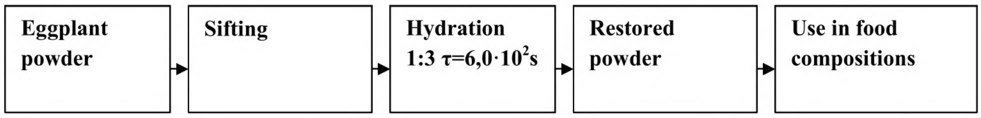

Fig. 3. General technological scheme of using restored eggplant powders in food compositions

The advantage of developed powders is the high renovation level, comfort use, long storage life without special conditions. Their use gives a possibility to create biologically active complexes for providing physiologically full value dishes that allow to influence organoleptic parameters, structural-mechanical properties of ready products essentially.

The perspective of further studies is to define ways of further use of eggplant powders and creation of culinary products, based on them. Determination and study of their influence on structural-mechanical properties and chemical composition of developed products defines a way of further studies.

4. Conclusions

1. The methods and methodologies for studying technological properties of eggplant powders were determined.

2. The optimal conditions for powders rehydration as liquid temperature less 60 °C, swelling duration 6,0…9,0·10^2 s, with liquid-powder ratio 1:3, 1:4 were determined.

3. Based on the obtained results, the general technological scheme of using eggplant restored powders in food compositions was elaborated.

4. The research results demonstrated the high degree of powders renovation. It gives a possibility to use powders at producing different culinary products as a functional supplement not only for enriching them with functional ingredients, but also for giving them new technological properties. They are able to improve structural-mechanical properties and outlook of ready products.

5. Scientific studies as to possibilities of using eggplant powders in technologies of culinary dishes and the influence of the offered supplements on the food and biological value of products on their base are expedient.

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METHODS OF DETERMINATION OF PARAMETERS OF FERMENTED WHEY-MALTY MIXTURES

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Abstract

The article presents main methods of studying restored whey-malty mixtures after fermentation by lactose-fermenting yeast and saccharomyces for getting a beverage of the kvass type.

The methods of accumulation of yeast cells Kluyveromyces lactis 469 and their percent with glycogen from the general concentration at fermentation of wort of the restored mixture at different ratios of dry malt and whey are offered and results are obtained. According to the obtained data, it was established, that yeast cells actively developed in the period from 4 to 16 fermentation hour at the ratio of malt and whey in the restored mixture as 1:1,5 and 1:2. The increment of cells with glycogen in mixtures with the ratio – malt:whey as 1,5:1 and 2:1 was intensive. Thus, at 36 hour of fermentation the amount of yeast was 67,2 and 68,9 % respectively from the total number of cells.

The generative capacity of yeast allowed to specify the fermentation temperature of wort of restored mixtures, cultivated by different races. It was established, that for Kluyveromyces lactis 469 the maximal accumulation of yeast (67…69 mln cell/cm^3 of wort) is observed at fermentation temperature – 30…32 °C, for Saccharomyces cerevisiae P-87 and Saccharomyces cerevisiae M-5 – 30…34 °C.

The gasochromatographic method allowed to identify side products of fermentation of fermented whey-malty wort by both lactose fermenting yeast and saccharomyces. The presented information is enough for the objective assessment of the qualitative composition of fermentation products as a result of the effect of different yeast races. The use of Saccharomyces cerevisiae P-87 for fermentation of whey-malty wort positively influences metabolism of a producer, stimulating biosynthesis or transformation of aromatic substances of the nutritive medium. The obtained research results indicate objective possibilities for the effective functioning of the aforesaid yeast race for fermentation of restored whey-malty wort in production systems.

Keywords: dry whey and malt, side fermentation products, gasochromatographic method, fermentation, whey-malty wort.

DOI: 10.21303/2504-5695.2018.00710

1. Introduction

It is expedient to introduce technologies of products, based on whey, that don't need essential technical re-equipping of an enterprise and establishing of new lines, in production [1, 2]. One of simplest technological ways of processing whey is beverage production.

Whey is a product with a natural set of nutritive and biologically full-value components. The qualitative composition and number of macro- and microelements of whey products essentially exceed traditional refreshing beverages. Whey contains all irreplaceable amino acids. 90 % of carbohydrates are presented by disaccharide – lactose. The content of glucose in whey of sour-milk cheese – 0,7…1,8 %. It is conditioned by hydrolysis of lactose at processing. Among other carbohydrates, arabinose, lactulose and amyloid are present [3]. Fat- and water-soluble milk vitamins are transformed in whey; the latter ones almost completely. At the same time cheese whey contains much more of them than one of sour-milk cheese.

Whey drying is the most popular way of processing for prolonging the storage life. It provides conservation of all nutrients of the raw material. According to the literary data, dry milk whey has the following chemical composition, the mass share in %: moisture – 3…5, carbohydrates – 66,7…73,6, proteins – 12,5…14,0, fats – 0,7…1,5, mineral substances – 4,45…7,90, milk acids – 1,2…2,2 [4, 5].

Dry whey contains almost all milk components and has the low energetic value, can be considerably used for manufacturing products with the combined composition, for example, ice-cream, yogurt, confectionary products and so on. The high biological value of whey is conditioned by protein substances, and also vitamins, hormones, organic acids, immune bodies, microelements. Dry whey on the organoleptic level is combined with different vegetable ingredients, for example, wheat sifting, cellulose, extrudates and grain malts and so on. It is possible to use dry rye malt with mass share (8,0±0,25) % in mixtures with dry whey [6]. Solubility is an important parameter for using dry whey in the composition of such substances for restoring. This parameter for dry whey doesn't exceed 0,8 cm^3 of a damp residue [7]. The existent method of determining this parameter is general and suitable for the objective assessment of dry malt [8, 9].

Fermented beverages, based on whey, of the kvass type combines value components of the main raw material and products of metabolism of microorganisms, created at fermentation (ethyl alcohol, volatile acids, enzymes, different aromatic compounds and so on) [10].

All types of whey beverages have limited storage terms. Prolongation of suitableness and convenience of using this assortment both in production conditions and for the wide circle of consumers needs development of correspondent technologies. Malt with rusks is contained by recipes of dry concentrates of kvass for restoring in water [11]. The use of dry concentrates, based on whey and rye malt, as a base of kvass is possible.

Problems that need a scientific substantiation include identification of such side fermentation products as higher alcohols (propyl, isoamyl, isobutyl and so on) with a typical smell and ability to create esters that essentially influence a fragrance of a fermented beverage [12, 13].

The aim of the work is determination of effective methods of studying restored whey-malty mixtures after fermentation for developing dry concentrates and selection of yeast that allows to improve the technology of fermented beverages.

2. Materials and Methods

Whey-malty mixtures were prepared on the base of dry whey and rye malt. Physical-chemical parameters of dry whey, according to SSU 4552:2006 (European analogue – «Sweet whey powder» ISO 9001; ISO 14001; FSSC 22000) are presented in **Table 1**.

Table 1

Physical-chemical parameters of dry whey

Parameter	Value
Mass share, %	
moisture	5,0±0,33
lactose	50,0±2,5
fat	2,0±0,05
Titrated acidity of whey, restored to mass share of dry substances 6,5 %, cm^3 of damp residue	0,8±0,04

Physical-chemical parameters of dry rye malt according to SS 29272-92 “Malt for bread and kvass” (European analogue – «Barley Malt Powder» ISO 9001, ISO 9000, ISO 14001, ISO 14000, ISO 20000) are presented in **Table 2**.

Table 2

Physical-chemical parameters of dry rye malt

Parameter	Value
Mass share, %	
moisture	8,0±0,25
Extract in the dry substance of malt	42±2,1
Sodium hydroxide with concentration 0,1 mol/dm^3 for 100 g of the dry substance of malt, cm^3	35±1,75
Iodine solution with concentration 1 mol/dm^3 for 100 g of the dry substance of malt, cm^3	17±0,85

At the first stage of the experimental studies there were prepared the dry mixtures with different ratios of malt and whey 1:1,5; 1:2; 1,5:1; 2:1 by mixing. The choice of proportions was conditioned by organoleptic parameters of the restored mixtures. At the second stage there was produced whey-malty wort with introducing dry substance 10 %, restored at temperature 35…45 °C, intensively mixing, the temperature was increased to 75...80 °C for transforming extract substances into the solution (reducing sugars, soluble pentosans, nitrogen-containing compounds and so on). Then the mixture, cooled to 25…30 °C, was set for decanting for eliminating residues of denatured proteins of whey to the malt residue. For malt fermentation there were used lacto-fermenting yeast *Kluyveromyces lactis 469* with amount 40 mln cell/cm^3 of wort. The effectiveness of aforesaid yeast in whey was proved by the previous studies [14, 15]. Fermentation was realized to temperature 30 °C during 36 hours.

Yeast cultures, used in the work, were received from the "Collection of strains of microorganisms and lines of plants for food and agricultural biotechnology" SI "Institute of food biotechnology and genomics" NAS of Ukraine.

Correspondent races of lactose-fermenting yeast and saccharomyces were selected by methods that objectively estimate the effectiveness of fermentation.

The physiological condition of yeast was estimated by the general number of cells with glycogen with coloration by Lugol solution. The amount of yeast in 1 cm^3 was determined by the direct calculation in Goryaev chamber [16–18].

According to the literary data [19], normal yeast contains no more 10 % of dead cells. The high content of such cells causes decelerated fermentation, favors the development of side microflora and autolysis of yeast. For functioning normally, yeast must contain 70…75 % of cells with glycogen. Less number characterizes insufficient nutrition of yeast, starvation. Such yeast multiply slower, lag-phase is longer, fermentation process is decelerated.

The following stage was the study of fermentation activity of different yeast races in whey-malty wort and suitableness for getting fermentative beverages with the standardized content of ethyl alcohol. The raw material – is a restored mixture of dry whey and rye fermented malt.

The control parameters of yeast biochemical activity were the amount of accumulated ethyl alcohol, depth of sugars utilization in the process of cultivation by the content of reducing substances for the final term of fermentation. The research objects were selected as yeast *Saccharomyces casei*, *Saccharomyces cerevisiae M-5*, *Kluyveromyces lactis 2452*, *Kluyveromyces lactis 469*, *Saccharomyces lactis 95*. The control – wort, based on water and malt, produced according to the classic technology using yeast *Saccharomyces cerevisiae-P-87.*

Then there was estimated the ability to development in different races of yeast in fermented whey-malt wort. For comparing the ability to accumulation at different variations, there was selected the monoculture *Saccharomyces cerevisiae P-87* [16]. Such yeast is not able to metabolize lactose independently or to stimulate the development of lactose-fermenting yeast. There was also studied the consistent cultivation of *Saccharomyces cerevisiae P-87* with lactose-fermenting yeast *Saccharomyces lactis 95* on the nutritive medium – restored mixture of whey and malt. During the experiment there was determined the number of yeast cells at fermenting wort of the restored mixture (ratio of malt to whey– 1:2). The process was fixed during 36 hours.

Specification of the temperature of wort fermentation was realized in samples, cultivated by different yeast races at temperatures 24…36 °C with interval 2 °C.

At the fermentation process the amount of emitted carbon dioxide was controlled by the weight method. Mature mash was distilled for determining the mass share of alcohol in the distillate. The image of the laboratory device for extracting ethyl alcohol is presented on **Fig. 1**.

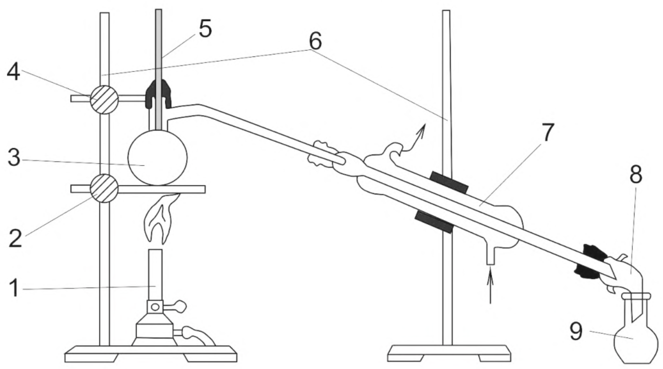

Fig. 1. Device for simple distillation of liquid substances: 1 – Bunsen burner; 2 – ring with clutch and asbestos net; 3 – distillatory flask (Wurtz flask); 4 – claw with clutch; 5 – thermometer; 6 – supports; 7 – Libich refrigerator; 8 – allonge; 9 – receiving flask

The content of reducing substances in whey-malty wort was determined by the iodometric method (this index before fermentation was 5,24 %). The main parameter of the intensity of this process is the amount of emitted carbonic acid in the time unit, so fermentation continued up to the stop of emission of carbon dioxide [16].

Identification of side fermentation products of fermented whey-malty wort.

The characteristic of the smell of higher alcohols and esters depending on construction is presented in **Table 3** [12].

Table 3
Characteristic of smells of alcohols depending on molecular construction

Fermentation product	Structural formula	Smell
Methanol	$H{-}CH_2OH$	Wine
Ethanol	$CH_3{-}CH_2OH$	–
n-propanol	$CH_3{-}CH_3{-}CH_2OH$	Unpleasant, sharp, more pleasant at dilution
Isoamyl alcohol	$(CH_3)_2-CH-CH_2-CH_2CH$ $\vert$ CH_3 $\vert$ $CH_3-CH_2-CH-CH_2OH$	Fusel tone
Acetaldehyde	$CH_3{-}COH$	Sharp, specific, unpleasant bouquet
Propion aldehyde	$CH_3{-}CH_2{-}COH$	Sharp, specific, unpleasant bouquet
Methyl acetate	$CH_3{-}COO{-}CH_3$	Sweet, ether aroma
Ethyl acetate	$CH_3{-}COO{-}CH_2{-}CH_3$	Acetic-sour tone, fruit smell
Methyl propionate	$CH_3{-}CH_2{-}COO{-}CH_3$	Weak aromatic smell with sour tint
Isobutanol	$CH_3-CH-CH_2CH$ $\vert$ CH_3	Fusel tone

Identification of side fermentation products in the distillate of fermented whey-malty wort was realized by the gasochromatographic method by determining higher alcohols C_1–C_5 [20]. Conditions of the chromatographic analysis of determination of volatile substances are presented in **Table 4**.

Table 4
Conditions of the chromatographic analysis of determination of volatile substances

Conditions of analysis	Value
Chromatography column (d/L)	D-mannit with solid carrier of chromosorbs W 80…100 mesh (1,5 mm/2 m)
Gas-carrier	nitrogen
Temperature of column, °C	90
Temperature of injector, °C	150
Temperature of detector, °C	200
Consumption of gas-carrier, cm^3/min	33
Type of detector	Flame-ionization, sprayer with internal diameter 0,25 mm
Consumption of hydrogen, cm^3/min	33
Consumption of air, cm^3/min	330
Volume of sample	0,2

The image of the laboratory equipment Chrom 5 (plant "Laboratory devices" Czechia) for the gasochromatographic analysis is presented on **Fig. 2**.

Fig. 2. Gasochromatographic equipment Chrom 5

Determination of quantitative ratios of higher alcohols, aldehydes and esters in the distillates was realized by the method of internal normalization using "Chromprocessor" software [21].

3. Experimental procedures

The results of the experimental studies of accumulation of yeast cells *Kluyveromyces lactis 469* and their percent with glycogen from the general concentration at fermentation of wort of the restored mixture at different ratios of dry malt and whey are presented in **Table 5**.

Table 5

Dynamics of accumulation of yeast cells and their percent with glycogen from the general concentration

Ratio of malt and whey	Fermentation duration, hour									
	0	4	8	12	16	20	24	28	32	36
Concentration of yeast cells, mln/cm³										
2:1	30	37	45	58	65	66,8	67,2	68,4	69	69,3
1,5:1	30	39	49,5	60	66,3	67,9	68,2	69	70	70,9
1:1,5	30	43	50	63	72	72,3	73,1	73,5	74	74,5
1:2	30	40	52	65	72,5	73	73,6	74	74,5	74,9
% of cells with glycogen from the general concentration										
2:1	71	70,8	70,1	70	69,8	69,8	69,5	69,4	69,1	68,9
1,5:1	69,7	69,5	69,5	69,2	68,9	68,2	68,1	67,8	67,5	67,2
1:1,5	68	66,8	66,7	66,4	63,4	63,1	62,7	60,8	59,1	59
1:2	65,1	63,8	60,1	58,4	57,9	57,2	56,8	55,4	54,8	54,1

The most increment of cells *Kluyveromyces lactis 469* is observed in the restored mixture of malt to whey as 1:1,5 and 1:2 from 4 to 16 hour of fermentation. Indices are an evidence of the effectiveness of utilization of lactose by yeast.

The increment of cells with glycogen (table 5) was more intensive in samples with the other ratio of malt to whey – 1,5:1 and 2:1. Thus, at 36 hour of fermentation the general amount of yeast *Kluyveromyces lactis 469* was 67,2 and 68,9 % respectively.

Taking into account the fact that the concentration of yeast cells at 36 hour of fermentation was maximal at level 74,9 mln/cm^3, wort of the dry mixture with malt: whey ratio as 1:2 was selected for studying fermentation activity.

The method of distillation of wort, fermented by yeast races allowed to get distillates with different contents of ethyl alcohol. The quantity of ethanol, accumulated in wort, fermented by yeast of race *Saccharomyces casei* – 1,8 %, *Saccharomyces cerevisiae M-5* – 1,5 %, *Saccharomyces cerevisiae P-87* – 1,3 %, *Saccharomyces lactis 95* – 1,2 % *Kluyveromyces lactis 469* – 0,5 %, *Kluyveromyces lactis 2452* – 0,3 %. The content of reducing substances was determined by the iodometric method. The lowest index was fixed in wort, fermented by *Saccharomyces lactis 95* – 0,8 %, that characterizes almost finished process of fermentation and utilization of carbohydrates. The higher indices were fixed in worst, fermented by the other types of yeast: *Saccharomyces casei* – 3,77 %, *Saccharomyces cerevisiae M-5* – 3,75 %, *Saccharomyces cerevisiae P-87* – 3,43 %, *Kluyveromyces lactis 469* – 3,56 %, *Kluyveromyces lactis 2452* – 4,19 %.

Specification of the temperature of wort fermentation was realized in samples, cultivated by different yeast races at temperatures 24…36 °C with interval 2 °C, fermentation duration 36 hours. The initial concentration of yeast cells in all samples was 40 mln/cm^3 of wort. The dependence of accumulation of yeast cells on the cultivation temperature is presented on **Fig. 3**.

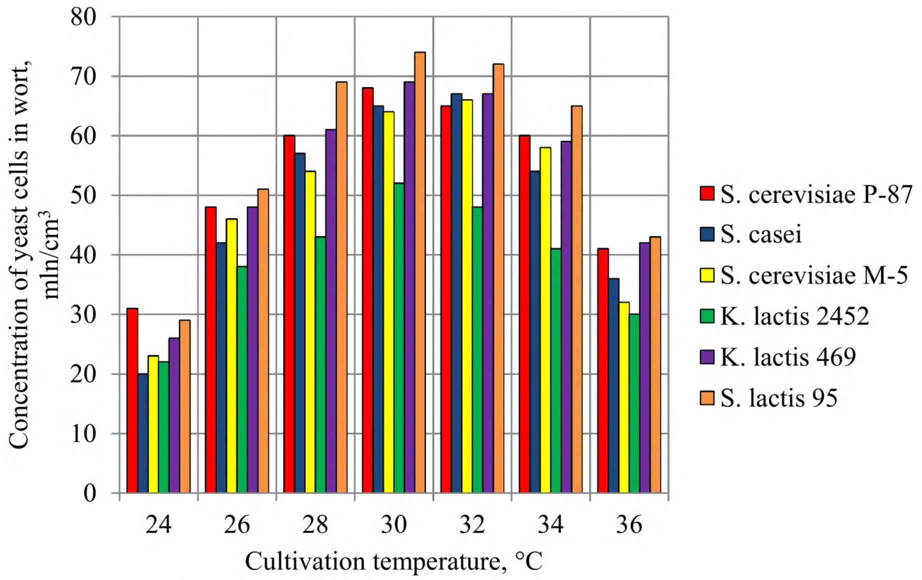

Fig. 3. Dependence of accumulation of yeast cells on the cultivation temperature

The data of fig. 3 testify that the active growth of yeast cells of all races takes place at the temperature from 28 to 32 °C. For *Kluyveromyces lactis 469* the maximal yeast accumulation (67…69 mln cell/cm^3 of wort) is observed at fermentation temperature – 30…32 °C, for *Saccharomyces cerevisiae P-87* and *Saccharomyces cerevisiae M-5* – 30…34 °C.

According to the results, in further studies by the aforesaid methodologies it is possible to use lactose fermenting microorganisms and saccharomyces, although lactose fermenting yeast demonstrated the lower result. Their dynamics of biomass accumulation is enough, so it is expedient to use them for fermentation of restored whey-malt wort. According to generative capacity, the following yeast races were selected for fermentation: *Saccharomyces cerevisiae P-87, Kluyveromyces lactis 469* and *Saccharomyces lactis 95.*

As to the studies by the gaschromatographic method of side fermentation products of whey-malt wort, fermented by *Saccharomyces cerevisiae P-87,* there were fixed values of methyl acetate concentration at level (11,72±0,59) mg/dm³ and ethyla cetate (92,17±4,61) mg/dm³. Such indices are optimal for forming a harmonious smell [9]. According to organoleptic parameters, wort is an opaque dense liquid of the dark-brown color, sour-sweet, malty taste without an expressed bitterness. Its smell is harmonious malty with fruit and flower tones.

Wort, fermented by yeast *Kluyveromyces lactis 469*, has the analogous taste, but with the more expressed bitterness. There are observed lower concentrations of methyl acetate (8,03±0,40) mg/dm³) comparing with the limit one, ethyl acetate ones are essentially higher. At the same type there is observed the malty smell with weakly expressed fruit and sharp sour tones.

Taking into account the aforesaid, wort, fermented by yeast *Saccharomyces cerevisiae P-87,* is suitable by the content of higher alcohols and aldehydes . The content of side fermentation products, in mg/dm³: n-propanol – 9,89±0,50, isobutanol – 27,39±1,40, acetaldehyde – 32,05±1,60, 2-methyl-1-butanol – 52,29±2,61 and 3-methyl-1-butanol – 207,19±10,36. Wort, fermented by yeast *Kluyveromyces lactis 469*, is characterized with higher concentrations of volatile components that influence formation of the general smell of the fermented beverage.

4. Conclusions

Determination of fermentative activity of yeast by the concentration of yeast cells (mln/cm³) and their percent with glycogen of the general number is effective at selecting yeast races for fermenting restored whey-malty mixtures.

The results of the gasochromatographic studies of determining side fermentation products of whey-malty wort allows to estimate their qualitative composition objectively as a result of the effect of *Saccharomyces cerevisiae P-87.* Presence of this yeast race in the nutritive medium positively influences metabolism of a producer, stimulating biosynthesis or transformation of aromatic substances of the nutritive medium. The use of such lactose fermenting yeast for fermentation at temperature 30...34 ºC of restored whey-malty wort indicate objective possibilities for the effective use in production systems.

The given information is recommended to be used for substantiating parameters in the technology of fermented whey-malty beverages of the kvass type.

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INVESTIGATION OF FUNCTIONAL-TECHNOLOGICAL PROPERTIES OF SOYA PROTEIN

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Abstract

There was offered and grounded the use of functional technological properties of the soya protein isolate in the technology of oil pasts. It will allows to increase the balance of the oil past composition additionally and will favor the decrease of extracting moisture during the storage term.

There was studied the dynamics of a gradient of the limit stress of soya protein: hydrated soya protein, hydrated soya protein with the temperature processing, hydrated soya protein with the preliminary keeping during 24 h, hydrated soya protein with the preliminary keeping during 24 h and temperature processing during 5 min, hydrated soya protein with the preliminary keeping during 24 h and temperature processing during 10 min; hydrated soya protein with the preliminary keeping during 24 h and temperature processing during 15 min.

It was established, that the hydrated isolate of soya protein is a plastic system, has enough strength.

The limit stress parameter at the variable velocity of deformation of model samples determines optimal technological parameters of preparing the soya isolate: hydromodule – 1:8, temperature processing – (82±2) °C, process duration 10 min with preliminary keeping during 24 hours.

As a result of the studies, there were demonstrated technological parameters of preparing the soya protein isolate for obtaining the oil past by the direct mixing with the oil base.

Keywords: soya protein isolate; stress gradient; oil past structure stabilization; oil past.

DOI: 10.21303/2504-5695.2018.00716

1. Introduction

One of prospective directions in food industry is the development of the technology of low-cal food products. These products include oil pasts, which fat mass share is from 40,0 to 49,9 %. Obligatory components of recipes of such products are ones, retaining moisture, providing formation of the structure, homogeneity and stability of emulsion. The products of milk processing are used for this aim – dry skimmed milk, caseinates, concentrate of whey proteins, gelatin and also polysaccharides (gum, carrageenan) and vegetable proteins [1, 2]. Due to the use of different stabilizers, the oil pasts consistence may be from past-like to analogous to classic cream butter.

In this direction it is prospective to use the soya protein isolate. Soya proteins [3] are remarkable for the unique amino acid composition that is practically not inferior to ones of the animal origin. Soya proteins contain practically all irreplaceable amino acids, are available and rather profitable component, so the interest to soya processing products grows at world markets of food ingredients.

Soya glycerine that is the main component of soya protein favors the decrease of cholesterol in blood.

Soya is a valuable source of vitamins, especially ones of groups B, D and E, micro- and macroelements, among which it is especially important the presence of digestible ferrum, calcium, potassium and phosphorus and unique complex of other important biologically active components [4, 5]. Today soya protein is recommended for products of dietary and special nutrition, particularly, nutrition of sportsmen.

Soya protein found its wide use in production of different food products due to the high water-binding and fat-retaining capacities that allow to obtain products with the stable quality, to decrease losses at their production and storage.

The soya protein isolate is a refined protein product comparing with a concentrate. Thus, the protein content in textured soya products reaches 70 %, and in isolates – 92 %.

The isolate has practically no admixtures – insoluble polysaccharides and other nitrogen-free compounds, and also has a rather neutral taste and smell that essentially widens possibilities of its use.

The isolate doesn't contain anti-nutritive substances (inhibitors of trypsin), naturally contained in soya, so the assimilability degree of such protein is near 95 %, whereas for native soya protein – near 85 % [6, 7]. Thus, the purposeful combination of vegetable and milk raw materials allows to save raw material resources and also to obtain oil pasts with the more balanced composition, taking into account the protein deficit in the ration of modern people.

Soya proteins are characterized by high functional-technological properties, concentrates and isolates are able to absorb fat and to retain it at thermal processing [8, 9].

Soya proteins also demonstrate the emulsifying capacity. They favor the formation of emulsions such as "fat in water" with their further stabilization [10–12].

Thus, the aim of the study is to investigate the isolate of soya proteins in the composition of recipes of oil pasts as a functional-technological and enriching ingredient.

2. Materials and Methods

Model samples of the oil past with the soya protein isolate were prepared by mixing with the further mechanical processing during 5…10 min to the even distribution of phases, obtaining a product with the homogenous consistence.

For the studies there was used cream butter with fat mass share 72,5 %, moisture – 25 % and soya protein isolate, with mass share of dry substances 95 %. Skimmed milk was used as a normalizing component (fat mass share 0,05 %, protein 3,2 %, acidity 20±1 °T).

Based on literary data [1, 2] and own preliminary studies, there was determined the ratio between the soya milk isolate and hydrating medium – skimmed milk as 1:6. The less value of hydromodule was inexpedient because of the additional evaporation of moisture at further thermal processing. That is why swelling was realized at the temperature in accommodation (18±2) °C. Model samples were prepared in the ratio of the soya protein isolate : skimmed milk as 1:6, 1:8 and 1:10. As far as time is needed for restoring the protein space structure as a result of its hydration, a model sample were also prepared with preliminary keeping during 24 hours at temperature (6±2) °C. Hydration was realized under conditions of lower temperatures to avoid the side microflora and, as a result, the acidity of the sample increased.

Hydrated protein isolates were subjected to thermal processing at temperature (82±2) °C with process duration 5, 10 and 15 min that provided the microbiological safety of a normalizing component. In further the samples were cooled to (20±2) °C for avoiding fat rendering at mixing with a fatty base. If the further storage of the mixture is necessary, it was cooled to temperature (6±2) °C. Before using it was heated to (20±2) °C, because mixing of the cooled mixture with the fatty base resulted in its hardening that complicated the mixing process.

Rheological properties of the model samples were determined on the rotational viscometer «Rheotest 2» (GRANAT, Russia) with the measuring system cylinder – cylinder S/N by removing curves of deformation (current) kinetics.

Measurements were realized at temperature 20 °C. A measuring cylinder (rotor) N was chosen for a gradient layer is distributed along the whole thickness of a product, placed in a ring gap of a measuring device of the viscometer. The measuring of a bias stress θ (Pa) was realized by 12 values of a bias gradient rate γ in the diapason from 0 to 100 s^{-1} at the direct and reverse movement. For that, indications α were taken at the maximal deflection angle at the device scale [10].

The bias stress (Pa) was calculated by the formula:

$$\theta = Z \cdot \alpha,$$

where Z – cylinder constant, Pa; α – measured parameter, number of points on the device scale.

3. Results

At mixing the dry isolate of soya protein with skimmed milk, there formed a rather dense plastic mass that is conditioned by protein hydration. For the effective use of water-retaining properties of a protein component, it is necessary to determine the hydromodule value, at which protein particles are maximally hydrated. The effectiveness of this process may be indirectly demonstrated by changing values of a stress gradient at different values of a deformation rate.

As it can be seen on figure 1, the type of a dependence of a stress gradient on a deformation rate is similar for all samples.

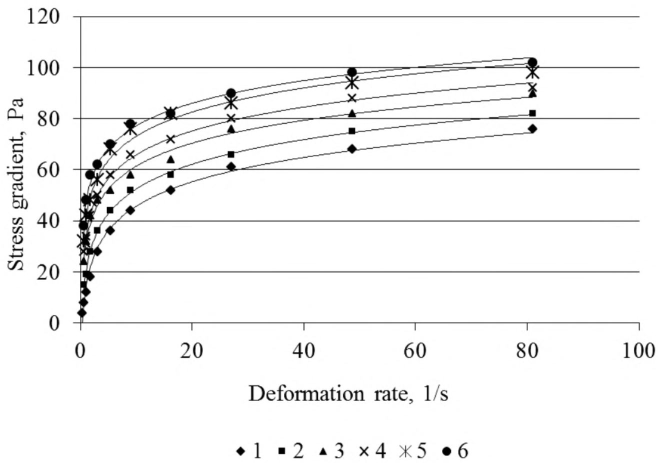

Fig. 1. Dependence of stress gradient on deformation rate for model samples as hydromodule 1:6: 1 – hydrated soya protein; 2 – hydrated soya protein with temperature processing; 3 – hydrated soya protein with preliminary keeping during 24 hours; 4 – hydrated soya protein with preliminary keeping during 24 hours and temperature processing during 5 min; 5 – hydrated soya protein with preliminary keeping during 24 hours and temperature processing during 10 min; 6 – hydrated soya protein with preliminary keeping during 24 hours and temperature processing during 15 min

Moreover, the stress gradient value was higher for the sample, prepared with preliminary swelling during 24 hours.

The value grows for thermally processed samples, moreover, the thermal processing during 10 and 15 minutes gave the unessential increase of the gradient. Thus, it is inexpedient to conduct the thermal processing more than 10 min.

At the following stage, there were specified hydromodule values for the maximal use of functional-technological possibilities of the studied component. The obtained results are given in **Table 1.**

Based on the analysis of the data from **Table 1**, we can make a conclusion that hydromodule value 1:8 provides proper conditions for protein hydration. The hydromodule increase to 1:10 results in decreasing the stress gradient that testifies to the presence of free moisture, not engaged in protein hydration.

Table 1

Stress gradient of model samples at the stable deformation rate of different hydromodule values

Sample, No.	Stress gradient, Pa							
	Deformation rate, 1/s							
	20		40		60		80	
	Hydromodule							
	1:8	1:10	1:8	1:10	1:8	1:10	1:8	1:10
1	60	50	68	68	76	72	82	80
2	62	52	70	68	80	78	84	80
3	64	58	76	70	84	80	88	82
4	66	60	78	70	84	80	88	84
5	72	62	86	72	88	82	96	86
6	78	64	86	72	90	86	96	88

There were studied a possibility of introducing the soya protein isolate in the fatty base, and also the maximally expedient amount of it.

The amount of the isolate, added to the fatty base, varied from 1,0 to 5,0 % with interval 0,5 %. The soya protein isolate was prepared in the aforesaid way.

It was established, that the increase of the isolate amount to 2,0 % didn't cause essential changes, a weak fresh taste, typical for soya, was felt. At increasing the added isolate amount to 3,0 %, the taste became more expressed, the consistence remained homogenous, but at chewing process there appeared the felling of heterogeneity of the sample, the feeling of softness and plasticity decreased.

It is obvious, that such amount of the soya protein isolate is not enough for obtaining oil pasts with the stable consistence and needs the additional use of water-binding components. It is expedient to create complex stabilizing systems with using components-active structure-creators.

4. Conclusions

There was grounded the choice of the soya protein isolate as a vegetable component for stabilizing the oil past structure.

There were determined optimal technological parameters of preparing the soya protein isolate hydromodule – 1:8, temperature processing – (82±2) °C, process duration 10 min with the preliminary keeping for 24 hours.

There was proved a possibility of using the soya protein isolate in recipes of oil pasts in the amount up to 2,0 % without changing organoleptic parameters of the product.

The obtained results are the base for further studies for creating effective functional complexes, based on the soya protein isolate, for the purposeful formation of the oil pasts structure, because obligatory components of such products are ones, providing the structure formation.

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DEVELOPMENT OF COTTAGE CHEESE TECHNOLOGY USING WHEY BROTH OF LINDER FLOWERS

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Abstract

The article presents research results of determining the rational amount of whey broth of linden flowers that favored the increase of the goat cottage cheese quality after adding to cheese seeds.

It was established, that under the influence of the rational amount of 10–20 % of broth, introduced to cheese seeds of development batches (D 1, D 2) of the products at its setting (instead of the same amount of eliminated cheese whey), there took place the increase of the protein content by 0,3, 0,5 % and moisture by 0,6, 1,7 %, comparing with the control.

The use of the rational amount of broth in development batches favored the increase of the product output of 100 kg of skimmed milk by 0,6, 0,8 %, respectively, comparing with the control.

Whey broth of linden flowers also stimulated the development of the healthy microflora, which amount in development batches of the product (D 1–D 2) was higher in 2,5 and 2,8 times, comparing with an analogous result in the control.

It maximally bring commodity parameters of development batches of cottage cheese to requirements of the product, manufactured of cow milk, and increases the number of consumers of goat milk products.

Keywords: water-thermal processing; peeled grains; boiling coefficient; solidity of grains.

DOI: 10.21303/2504-5695.2018.00712

1. Introduction

Sour milk beverages, pasteurized, condensed milk, ice-cream and also soap, lotions and sweets are produced of goat and ovine milk throughout the world together with popular cheeses and yoghurts. At that the increase of production volumes of products of goat and ovine milk is restrained by the existent problem: presence of the "goaty" and "ovine" smell in them, correspondingly [1].

Manifestations of the typical goaty flavor are considered as a qualitative sign only in several types of goat cheeses. Specific peculiarities of organoleptic parameters of milk restrain consumption of products of goat milk by most consumers of milk products [2].

That is why efforts of scientists and specialists of milk-processing enterprises are directed on searching for ways that allow to decrease manifestations of the smack and smell of goat suint in fermented milk products, including, cottage cheese.

The technology of goat yearning cheese is the closest to solving the problem of increasing the quality of goat milk cheese [3].

The aim of the aforesaid study was to select optimal types of leavens and their combinative associations for decreasing the smack and smell of goat suint in a product. The most effective decrease of manifestations of specific peculiarities of goat milk at producing yearning cheese was attained by the traditional leaven, used for producing yearning cheeses – «CMC», of acidophilic and propionic acid bacteria in ratio: 55:25:20 %.

Shortcomings of this way include the necessity of preparing three leaven types – separately. And then to form leavening associations of them. It needs not only additional consumption of milk raw materials and bacterial preparations, but also efforts and time. The aforesaid testifies that the presence of the aforesaid shortcomings of the biotechnology of the aforesaid cheese types needs searching for new biotechnological approaches [3].

For increasing the quality of cheese of goat milk, extracts of five spices and herbs were introduced to its composition. There was studied the antibacterial effectiveness of five spices and herbal extracts (cinnamon stick, oregano, cloves, pomegranate and grape skin) against Listeria monocytogenes, Staphylococcus aureus and Salmonella enterica in cheese, kept at room temperature (~ 23 °C).

The results demonstrated that all five vegetable extracts are effective against three food pathogens in cheese. The enrichment with these extracts increased the stability of cheese to lipid oxidation. Cloves demonstrated the high antibacterial and antioxidant activity. The decrease of the number of pathogens that contain food and braking of lipids oxidation in cheese demonstrated that extracts of these plants (especially cloves) have the potential as food preservatives with natural food products [4].

There were conducted the researches for estimating the influence of the extract of cranberry fruits on the chemical composition, ripening parameters, oxidative stabilities and microbiological and also organoleptic properties of goat cottage cheese during the storage period during 8 weeks at temperature 5±2 °C with adding different concentrations of the red bilberry extract powder (500, 750 and 1000 m.p./ 1 t of milk). The use of the cranberry extract at the concentration less than 750 m.p. for 1 t of milk had the essential influence on the increase of the leaving microflora amount. Fresh and stored cheese, processed by the cranberry extract, contained much less amount of psychotropic, enterococcus, proteolytic, lipolytic bacteria and also amount of yeast and mould fungi, than control cheese.

But the shortcoming of the method is the increase of cheese titrated acidity, cranberry smack, color tints in cheese samples of development batches of the product [5].

The studies concentrated on the development of a new type of cottage cheese that contains spices with acceptable sensor properties, increased biological value and long storage term. There were produced thirty types of cheese with adding fresh or dry parsley, dill, pepper, garlic and rosemary. There was estimated the characteristic of phenol compounds, antioxidant capacity and antibacterial activity of the spices and cheese samples [6].

Cheese that contains fresh pepper and fresh and dry herbs demonstrated perfect organoleptic properties. The best results were obtained with fresh sweet pepper.

The highest antioxidant and antibacterial activity was inherent to dry rosemary. That is why its composition included the high mass share of organic acids and also flavonoids and phenol diterpenes. The plant extracts, studied under the laboratory and production conditions, influenced the decrease of the amount of food pathogens, such as *Salmonella Typhimurium*, colon bacillus, golden staphylococcus and Listeria. The aforesaid testifies to the presence of the potential of vegetable extracts as natural food preservatives and antioxidants [6]. But a shortcoming of enriching goat cottage cheese with spices and vegetables is the acquired smack of herbs and vegetables, color tints, not inherent to cottage cheese of goat milk.

For estimating food properties, minerals and content of heavy metals, there were studied ten most popular and known varieties of plants of Lamiaceae generis, used in production of local cheese.

This research revealed essential changes in the content of minerals among the studied types of plants.

The composition of most studied plants included such mineral compounds as Fe, Cu, Ca, K, Mn and Zn, well-known for their important for health support. The highest concentration of toxic heavy metals, including chrome (1,72 mg kg^{-1}) was revealed in *Mentha longifolia*. The highest cobalt content (1,14 mg kg^{-1}) was inherent to *Ziziphora capitata*. The results of this study allow to assume that the use of these types of plants at producing cheese doesn't favor the increase of toxicity of heavy metals, but may be useful at treating the deficit of microelements [7].

The set contains 58 samples of Polish medical herbal materials: samples of herbs, flowers and bark; there were determined concentrations of total nitrogen and phosphorus in both aforesaid dry samples and in their water extracts. Taking into account the dry weight of samples, the total content of nitrogen included values from 4,69 to 27,42 mg/g in plants, from 11,10to 40,67 mg/g – in flowers and from 5,92 to 9,77 mg/g – in bark samples. The total content of phosphorus was revealed within 2,70 – 10,19 mg/g in herbs: from 2,15 to 8,82 mg/g – in flowers and from 0,46 to 1,30 mg/g – in bark. In average nitrate nitrogen was a share from 2,6 % (in flowers), to 15,1 % (in bark) from the total amount of nitrogen. Whereas, inorganic phosphate phosphorus was from 28,3 % (in herbs) to 60,2 % (in bark) from the total amount of this element. The comparison of potentially bio-accessible inorganic forms of nitrogen and phosphorus with food norms of WHO/FAO and RDA testifies that samples of vegetable materials can deliver to people essential amounts of N and P [8].

The biological activity of many dry medical herbs, including thyme, is described, but mainly connected with its essential oils and used in folk medicine for preparing broth in home conditions. But information about studies on determining the biological activity in its broth is extremely limited. That is why scientists conducted additional studies on determining manifestations of antioxidant and antibacterial properties of thyme broth and its water-alcohol extracts [9]. The content of phenol compounds was also determined.

Thyme broth demonstrated the highest concentration of phenol compounds (phenol acids or flavonoids), comparing with the water-alcohol extract.

In general, all samples of preparations of broth and water-alcohol extracts were effective against gram-positive (Staphylococcus aureus and Staphylococcus epidermidis) and gram-negative (Escherichia coli, Klebsiella spp., Pseudomonas aeruginosa, Enterococcus aerogenes, Proteus vulgaris та Enterobacter sakazakii). But the most expressed effect of inhibiting pathogenic microorganisms took place under the effect of thyme broth [9].

There were conducted the studies of determining the biological activity of Matricaria recutita L. (chamomile) broth. It was established, that camomile broth has antioxidant activity: inhibits peroxide oxidation of lipids. It also prevents the development of enteric bacteria and fungi.

Herbal broth is used at producing sour-milk cheese. The food composition, color and antioxidant activity of all cheese samples were estimated during the storage time. Camomile broth (natural biologically active ingredient) didn't essentially change profiles of lipids and fatty acids in cheese, but increased the antioxidant potential of the product at storage. Moreover, it increased its storage term, because only after 14 days of storage there were fixed degradation signs of only control samples. The development of this new functional milk product gives grounds for widening the assortment of milk products with medical herbs for preventing their spoilage [10].

There is a global tendency to healthy food products, mainly including natural biologically active ingredients that replace synthetic supplements.

Previous studies discovered that extracts of Foeniculum vulgare Mill. (fennel) and Matricaria recutita L. (camomile) retained saturated properties and increased antioxidant activity of sour-milk cheese. At that the effect was limited by 7 days.

Correspondingly, water extracts of these plants were microcapsulated in alginates and included in cheese for attaining the increased biological activity.

Ordinary cheese and one, functionalized by the direct addition of free broth were prepared and compared.

Despite plant types, "functionalization" factor had no essential influence on food parameters that is also proved by the linear discriminant analysis, where these parameters were not chosen as discriminant variables. At the same time models, functionalized by microcapsulated extracts, demonstrated the higher antioxidant activity after 7-th day, in such a way demonstrating that the main aim of this experimental work was attained [11].

Information about demonstration of antibacterial properties by many dry herbs, extracts of herbs and vegetables and broth of them, attracted our attention to linden flowers.

Linder flowers are distributed by drugstore nets because of their medical properties.

The pleasant smell and a bit yellow color of linden flowers are, from our point of view, the most suitable material for preparing whey broth of them and its introduction in the process of manufacturing goat cottage cheese.

The aim of the work is the development of the cottage cheese technology using linden flower broth, directed on increasing the cottage cheese quality (increase of the density of cheese seeds and product output of 100 kg of skimmed milk, decrease of the content of low-molecular fatty acids, responsible for the goat suint smell and taste, without changing the traditional white color of cottage cheese).

The following tasks were set for attaining this aim:

– to increase the cheese seeds density and to decrease losses of its components with cheese whey;

– to increase the product output of 100 kg of goat milk;

– to increase the amount of healthy leavening microflora in the composition of development batches of the product;

– to decrease the number of low-molecular fatty acids that favor elimination of the goat suint taste and smell.

2. Materials and methods of studying goat milk, control and three development batches of cottage cheese

2. 1. Selection of samples of milk of milked goats and methods of conducting physical-chemical and biochemical studies

The milk raw material (goat milk) was processed into cottage cheese. At preparing goat cottage cheese, it was subjected to the laboratory control.

All four batches of cottage cheese (control and three development ones) of the product were prepared according to existent normative-technical documents [12].

Goat milk in the amount of 10 kg for each product batch was used as a milk raw material for producing cheese of the control and three development batches.

A start culture at producing control and development batches of goat cottage cheese was the leaven «CMC», produced at the state research enterprise of bacterial leavens, placed on the territory of the "Institute of food resources" in city Kyiv, Ukraine, and is used for producing cow milk cottage cheese.

Technologies of the development batches of cottage cheese (D 1–D 3) differed from the control one by the change of whey, created at setting cheese seeds, for whey broth of linden flowers in amount 10, 20 and 25 %. The concentration of linden flowers was determined experimentally, based on comparative data of organoleptic estimation of control and development samples of cottage cheese.

For determining physical-chemical and biochemical parameters of goat milk, there were formed groups of animals of 10 heads.

Goats of the second and third lactations were kept at the goat farm of the "Learning-scientific center" of Kharkiv State Zooveterinary Academy. The goat farm is situated in Mala Danylivka, Dergachivsky district, Kharkiv region, Ukraine. Goats of Zaanenska and Local breed were clinically healthy.

Goat milk samples were taken at the farm proportionally to the day yield for 2 adjacent days of each aforesaid experimental animal.

The taken milk samples were filtered at the farm, cooled to temperature 6±2 °C. They were delivered for the study at the probationary center of the Institute of livestock of NAASU in Kulinichy, Kharkiv, Ukraine, accredited according to requirements of SSU ISO/EC 17025:2006 (ISO/IES 17025:2005, accreditation certificate No. 2T621 at the National agency of accreditation of Ukraine).

Determination of a mass share (m. s.) of fat, protein, lactose, density and dry substances in milk samples, taken from the groups of goats and cows from the aforesaid regions of Ukraine, was conducted according to requirements of ISO 9001: 2000 instrumentally on the device «Bentley-150» (USA).

Goat milk was separated at the usual separator – cream-separator of the open type of OCE trademark, produced at the machine-building plant “Smychka”, Russia, placed in the accommodation of the laboratory of the department.

The principle of cream-separator’s action is based on the effect of centrifugal forces, created in its main part – drum. As a lighter milk part, cream is eliminated from the separator’s drum through the upper horn, and skimmed milk – to the low one, as a heaviest one.

One of main technical parameters that characterize the separator’s work is a temperature of heating milk. That is why for conducting the effective process of separating goat milk, it was heated to 43±2 ^{o}C.

Skimmed milk, obtained at the separation process, is directed for processing in cottage cheese. Cream – for producing sour cream.

Physical-chemical parameters of samples of milk products were determined according to requirements, presented in the following normative documents:

– selection of samples of milk products was realized according to SSU 4834:2007 «Milk and milk products. Rules of reception, taking and preparation of samples for controlling» and SSU ISO 707:2002 «Milk and milk products. Instructions of taking samples”;

– an outlook, consistence and color of the product were estimated visually, a smack and smell – organoleptically;

– a temperature was determined by SSU 6066:2008 «Milk and milk products. Methods of determination of temperature and mass-netto»;

– the calculation of somatic cells was conducted on the device of the combined model Somacount 150 and Bentley (USA) (Certificate IDA 0001461-1 of 16.12.2004 SCC);

– a density was determined by SS 3625-84 «Milk and milk products. Methods of determination of density”;

– a titrated acidity was determined by SS 3624-92 «Milk and milk products. Titrimetic methods of determination of acidity”;

– a mass share of moisture and dry substance in cheese – by SS 3626-73 «Milk and milk products. Methods of determination of moisture and dry substances”.

Biomechanical parameters of research objects were determined according to requirements, presented in the following normative documents, including on certified devices:

– M. s. of fat was determined – by SS 5867-90 «Milk and milk products. Methods of determination of fat” and SSU ISO 1211:2002 «Milk. Gravimetric method of determination of fat content” (Control method);

– Determination of the content of free fatty acids was conducted using the fatty-acid analyzer chromatograph “Chrome-5» (country-producer USA) by SS 30418-96 «Vegetable oils. Methods of determination of fatty-acid composition”;

– M. s. of total protein was determined y Kjeldahl method according to requirements of SSU ISO 8968-1 and SSU ISO 8968-5;

– Determination of the amino acid composition of the control and development batches of cottage cheese of goat milk was conducted on the automatic analyzer of amino acids AAA 339 M (Prague).

2. 2. Sanitary-bacteriological research methods

Sanitary-bacteriological parameters of research objects were determined according to requirements, presented in the following normative documents and methods using certified devices:

– preparations of samples and dilutions for the microbiological studies were realized by SSU IDF 122C:2003 «Milk and milk products. Preparation of samples and dilutions for microbiological studies”;

– the total number of sour-milk bacteria and separate representatives – by SS 10444.11-89 «Food products. Methods of determining microorganisms" and by SSU IDF 149A:2003 «Cultures of sour-milk leavens. Determination of type composition".

Pollution of milk and milk products by the side microflora:

– determination of the number of microorganisms – by SSU IDF 100B:2003 «Milk and milk products. Methods of determination of microorganisms' number. Method of calculation of colonies at temperature 30 °C»;

– bacteria of colon bacillus group (BCBG) were determined by SSU 7140:2009 «Milk and milk products. Methods of calculation of coliforms and colon bacillus (*E-coli*) by plates;

– pathogenic microorganisms, including bacteria of Salmonella generis – according to SSU IDF 93A; Staphylococcus aureus in 1 g of cheese – according to requirements SS 30347 «Milk and milk products. Methods of determination of Staphylococcus aureus»; Listeria monocytogenes in 1 g of cheese – according to requirements of SSU ISO 11290-1:2003 «Microbiology of food products and forages for animals. Horizontal method of revelation and calculation of Listeria monocytogenes. Part 1. Method of revelation», SSU ISO 11290-2:2003 «Microbiology of food products and forages for animals. Horizontal method of revelation and calculation of Listeria monocytogenes. Part 2. Method of calculation".

At determining the cheese output, the milk raw material was normalized according to parameters of m.s. of fat and protein in the initial milk raw material.

Fig. 1 presents the device for determination of somatic cells of the physical-chemical composition of goat milk «Bentley Somacount 150» and «Bentley Instrumenis» (country – producer USA).

Fig. 1. device for determination of somatic cells «Bentley Somacount 150» (on the left) and for determination of physical-chemical composition of goat milk «Bentley Instrumenis» (on the right) (USA)

Fig. 2, 3 present photos of the devices, used for determining the physical-chemical composition of goat milk cheese.

Fig. 2. Device for determination of the amino acid composition of the control and development batches of cottage cheese of goat milk – automatic analyzer of amino acids AAA 339 M (Prague)

Fig. 3. Device chromatograph "Chrome-5» for determination of fatty-acid composition of the control and development batches of sour cottage cheese of goat milk (USA)

3. Research results of physical-chemical, biochemical and sanitary-bacteriological parameters of soft grainy cheese of goat milk

For producing cottage cheese, there was used goat milk of goats, kept at the "Learning-scientific center" of Kharkiv State Zooveterinary Academy. After separation, milk was set for producing cottage (grainy cheese).

Table 1 presents physical-chemical characteristics of goat milk, used for separation and transformation in cottage cheese.

The data, presented in table 1, demonstrate that physical-chemical parameters of goat milk correspond to requirements of the existent State standard of Ukraine for stored goat milk (SSU 7006:2009 «Goat milk raw material. Technical conditions" that corresponds to ISO 707:2008 «Milk and milk products – Guidance for taking samples».

The control and development batches of cheese were produced according to SSU 7518:2014 Soft cheese of goat milk. General technical conditions. [Valid of 2015-02-01] and technological instruction to it.

Table 1
Physical-chemical composition of goat milk, used for cottage cheese and skimmed milk

Parameters	Values
M. s. of dry substances, %	11,2
M. s. of protein, %	2,9
M. s. of fat, %	3,7
Titrated acidity, °T	15
Density	
SC number, thousand/cm^3	50
Density in, A^o	28
Skimmed milk	
M. s. of fat, %	0,05
Density in, A^o	30
M. s. of protein, %	3,0
Titrated acidity, °T	17

Note: M.s. – mass share. SC – number of somatic cells

Preparation of whey broth of linden flowers was realized in the following way: 250 grams of linden flowers were placed in a thermostable chamber, poured with 9750–9900 cm^3 of fat sour cheese whey, and the mixture was boiled during 5–7 min.

Thermal processing of broth was stopped after appearance of residue of whey proteins. After that linden broth was cooled, filtered (defecated) and kept before using during no more than 24 hours at temperature 8 ^{o}C.

At the end of the process of setting cheese seeds (mixing of a clot with the synchronous and successive increase of the temperature in cheese bathes to 38–40 ^{o}C) that lasted during 20–25 min, the share of formed cheese whey was eliminated. Especially 10, 20 and 25 % of whey, formed in a bath during the aforesaid technological operation were eliminated from the development batches of cheese D 1, D 2 and D 3, respectively. Instead of eliminated whey, there were introduced 10, 20 and 25 % of broth, mixing during 10–15 min. Then whey in the control cheese batch and the mixture of whey with broth in the development batches of the product was eliminated. Cottage cheese was unloaded from cheese bathes, packed in consumption packages and sent to a refrigerator chamber for cooling to 2-4^o C.

There was realized the determination of physical-chemical parameters of the control (C) and development D 1-D 3) batches of cottage cheese with adding different amounts of linden broth. The research results are presented in **Table 2**.

The data of **Table 2** demonstrate that introduction of whey broth of linden flowers in amount 10 and 20 % to the composition of the development batches (D 1 and D 2) of goat cottage cheese favored the increase of protein m.s. by 0,3, 0,5 % and 0,6 %; moisture by 0,6,1,7 and 4,9; titrated acidity by 3, 5 and 11 °T comparing with the control.

The absence of the reliable difference in indices of the mass share of protein and moisture between the development batch of the product D 2 and D 3 testifies to the inexpedience of increasing the broth amount to 25 %. At the same time the use of this amount of broth increased the titrated acidity of the development batch of cheese D 3 to 80 °T that caused the sourish taste of it. The use of broth in amount 10, 20 and 25 % favored the decrease of consumption of goat skimmed milk at processing of 100 kg of goat milk in cottage cheese, correspondingly less by 0,42, 0,82 and 0,92 kg, comparing with the control. It conditioned the increase of the output of the development batches (D 1–D 3) of cheese of 100 g of skimmed milk, correspondingly, by 0,6, 0,8 and 0,9 kg.

Table 2
Physical-chemical parameters of three batches of cottage linden cheese

Parameters	Research results			
	C	D.1	D.2	D.3
*Amount of linden broth, %	–	10 %	20 %	25 %
M.s. of fat in dry substance of cheese, %	20,0±1,0	21,0±1,0	21,5±1,0	21,7±1,0
M.s. of protein, %	16,9±0,2	17,2±0,2	17,4±0,2	17,5±0,2
M.s. of moisture, %	78,3±0,3	78,9±0,3	80,±0,3	82,5±0,3
Titrated acidity, °T	69,0±3,45	72±3,25	74±3,25	80±3,25
Consumption of the mixture of skimmed milk (DSMR 8,9 %) for 100 kg of cheese, in t	10,42±0,52	9,80±0,47	9,60±0,47	9,50±0,47
Output of cheese of 100 kg of skimmed milk, kg	9,6±0,53	10,2	10,4	10,5

*Note: M.s. – mass share; C, D. 1 – D.3 – control and development batches of goat cottage cheese; *Dose of herbal broth, introduced to the cheese mass instead of eliminated whey, %*

So, the rational dose of using broth of linden flowers is 10–20 % of the mass of whey, separated at producing cottage cheese. The results of the researches on determining the change of the fatty acid composition of the development batches of cheese (D1, D 2 and D 3) of cottage goat cheese, took place under the effect of broth of linden flowers, are presented on **Fig. 4.**

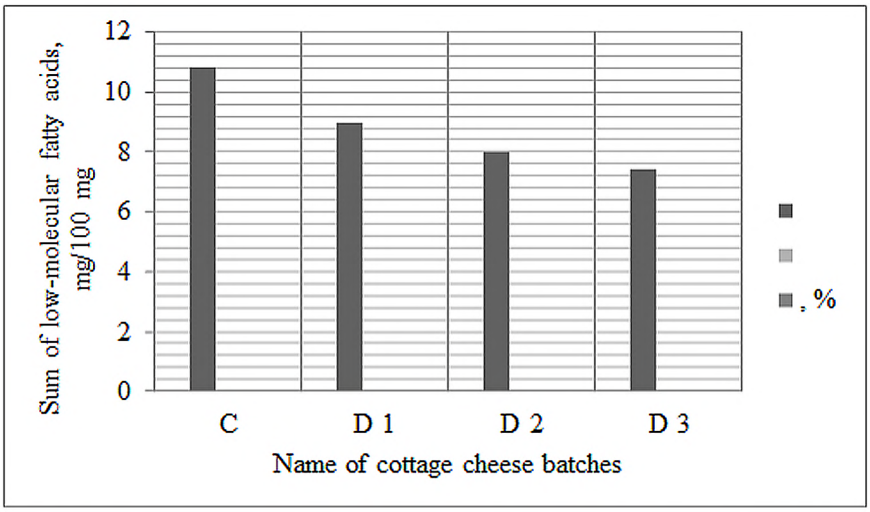

Fig. 4. Changes of the content of low-molecular fatty acids in the development batches of cottage cheese (D 1, D 2 and D3) that took place under the effect of broth of linden flowers

The graph on **Fig. 4** demonstrates that the development batches of cottage cheese (D 1, D 2 and D 3) under the effect of broth of linden flowers in amount 10, 20 and 25 % of the mass of whey, separated at processing of a clot (its cut in blocks) and setting of cheese seeds, underwent the decrease of the content of low-molecular fatty acids by 1,8, 2,8 and 3,4 %, comparing with the control (C) .

The organoleptic estimation of the development batches (D 1–D 3) of cheese demonstrated that instead of the smack and smell of goat suint, they acquired a bit noticeable smack and smell of linden flowers. Cheese seeds became denser than in the control. At that their color in cottage cheese remained the same.

The same characteristic of cheese seeds of cottage cheese is maximally approximated to parameters of the product, manufactured of cow milk.

There were determined microbiological parameters of the control (C) and development batches (D 1–D 3) of cottage cheese (**Table 3**).

Table 3

Microbiological parameters of three samples of cheese

Parameter name	Cheese batch		
	Control (C)	Development (D.1)	Development (D.2)
Bacteria of the group of colon bacillus (coliforms) in 0,01 of cheese	Not revealed		
Pathogenc microorganisms, including Salmonella generus, in 25 g of the prodct	Not revealed		
Staphylococcus aureus, in 1 g of cheese	$1{,}0\times10^2$		$1{,}0\times10^2$
Listeria monocytogenes in 1 g of cheese	Not revealed		
Number of lactobacteria, NCU in cm ^{3}, no less than	$1{,}0\times10^7$	$2{,}5\times10^7$	$2{,}8\times10^7$

The data of **Table 3** demonstrates that the inclusion of linden flower whey broth in the technological process of the development batches (D 1 and D 2) of goat cottage cheese provided formation of the microflora, healthy for the human organism, in 2,5 and 2,8 times more respectively comparing with the control.

4. Conclusions

There was determined the rational amount of linden flower broth, introduced in the process of producing the development batches in amount (10–20 %) of whey, separated at setting cheese seeds, that allows:

– to increase the density of cheese seeds and to decrease losses of their components with cheese whey;

– to increase the product output of 100 kg of skimmed milk by 0,6–0,8 %;

– to increase the biological value in the development batches of goat cheese D 1 and D 2 at the expanse of increasing the population of leavening microflora in 2,5 and 2,8 times, respectively, comparing with the control;

– to decrease the number of low-molecular fatty acids by 1,8, 2,8 %, comparing with the control (C).

It allows to increase organoleptic parameters of development batches of cottage cheese, especially to eliminate the smack and smell of goat suint in them. Although, it remains the white color of cheese dough, typical for cottage cheese, without changes.

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THE STUDY OF TECHNOLOGICAL PROPERTIES OF WAXY WHEAT FLOUR AND ITS INFLUENCE ON REFINED SUGAR-FREE HARDTACK`S DOUGH

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Abstract

There was grounded the choice of ingredients for developing floury confectionary products without sugar and prospects of using amylose-free flour of waxy wheat and sunroot powder for their production. There were determined quality parameters of used flour, conditioned by the state of the protein-proteinase complex.

Based on studying technological properties of flour of waxy wheat, there was demonstrated the expedience of its use in the technology of products of yeasty dough, especially hardtacks, at replacing sugar for sunroot powder. There was offered to introduce sunroot powder at producing hardtacks with the decreased sugar content in equal shares at the stage of kneading liquid fermented dough and ready one.

There was determined the influence of using amylase-free flour of waxy-wheat and inulin-containing raw material on structural-mechanical and surface properties of dough for sugar-free hardtacks. It was demonstrated, that combined introduction of waxy wheat flour and inulin-containing raw material positively influences quality parameters of semi-products of yeasty dough at complete exclusion of sugar from their recipes. The replacement of bakery wheat flour by amylase-free one allows to get dough with sunroot powder for sugar-free hardtacks with less firmness, elasticity and tendency to adhesion.

Keywords: flour force, dough for hardtacks, decreased sugar capacity, sunroot powder, waxy wheat flour.

DOI: 10.21303/2504-5695.2018.00721

1. Introduction

For the last time the urgent direction at developing new types of floury confectionary products is a search and use of recipe components, allowing to decrease a sugar content and energetic value of manufactured products [1]. It is conditioned by the growing demand for food products with healthy effect, dietary properties on the background of raising the level of consumers' awareness of the necessity of observing rational nutrition principles. At the same time the necessity of such studies is connected with the increasing number of people with the disturbed carbohydrate metabolism – diabetes mellitus, obesity and so on [2].

The conducted analysis of literary sources testifies that the special interest is awaken by inulin-containing raw materials, in particular, sunroot powder (SP) as ingredients that may be used for replacing saccharose. Together with the positive influence on the human organism due to its physiological properties, sunroot powder is characterized by a series of technological advantages – easiness in use high hydrophilic capacity; improvement of organoleptic and physical-chemical characteristics of ready products at its optimal dosage and so on [3]. Further studies of characteristics of this raw material may favor its wider use in different branches of food industry, including for bakery.

It must be noted, that producers of floury confectionary products without sugar or with its decreased content often face the problem of worsening the products' quality [4]. This tendency is conditioned by important technological functions of sugar as a recipe ingredient, and its essential influence on the production process and characteristics of ready products [5].

It is probably possible to provide intensification of the fermentation process of yeasty semi-products at excluding sugar from recipes due to the use of waxy wheat flour (WWF) for their production. Flour of such wheat type, found for the first time by Japan selectors, is characterized by the absence of amylase in the composition of its starch and also its high pliability to the effect of amylolytic enzymes [6, 7]. The replacement of bakery wheat flour (BWF) by amylase-free waxy wheat one obviously allows to stabilize the quality of semi-products for hardtacks, prepared with introducing sunroot powder instead of sugar.

The aim of the work is to determine technological properties of waxy wheat flour and structural-mechanical characteristics of sugar-free dough for hardtacks, based on the joint use of WWF and SP. Obtained results allow to estimate a possibility of processing and formation of the studied yeasty semi-products on the existent equipment and to prognosticate the quality of obtained products.

2. Materials and Methods

The experimental part of the work is conducted in the laboratories of the Department of bakery, confectionary, pasta and food concentrates technology, problem scientific-research laboratory of Odesa national academy of food technologies (Ukraine).

The research object – technological properties of WWF, conditioned by the state of the protein-proteinase complex; structural-mechanical and surface properties of dough for sugar-free hardtacks.

The research subject was wheat flour of waxy sort Sofiyka, yeasty dough for hardtacks with the decreased sugar capacity and control samples. Sunroot powder "Interest" (CFN "Malva", Ukraine) (**Fig. 1**) was used as a sugar-replacing ingredient [8].

Fig. 1. Sunroot powder

2. 1. Experimental procedures

Determination of the rough gluten content was realized by the method presented in [9]. For this aim 25 g of flour and 14 cm^3 of drinking water with temperature from 18 to 20 °C were taken from the middle sample. Dough was kneaded on the dough-kneading machine У1-ЕТК («UKRMACHIND», Ukraine), with preliminary pouring of a necessary amount of water in a pan for kneading by a doser. Then the prepared flour batch is transferred there. The pan is set in the body of the kneading machine, and dough is kneaded. After ending of kneading, the pan is taken off and dough is taken from it. Pins and pan are accurately cleaned from dough remains, which are transferred to the total mass. Dough is rolled in a ball, put in a dish, closed by glass for preventing chapping and left for 20 min for swelling of flour ingredients.

After 20 min lying dough is started to be washed under a light water filament with the temperature from 18 to 20 °C above a sieve No. 27. At the beginning it is washed carefully, by wrinkling by fingers for preventing tearing off pieces of dough or gluten together with starch. When the more part of starch and surfaces is eliminated, dough is washed more energetically. Pieces of gluten, torn away, are accurately collected from the sieve and added to the total mass.

Washing is considered as finished, when starch marks are absent in water, squeezed out from the gluten ball. The iodine solution with the concentration near 0,001 mol/dm^3 is used for its determination.

Washed gluten is squeezed from excessive water by pressing. Gluten squeezed in such a way is weighed on technical scales. After the first weighing, gluten is washed under the water filament one more time during 3-5 min, after which squeezed again and weighed. If the difference between two weighing doesn't exceed 0,1 g, washing is considered as finished.

The amount of raw gluten G_{raw}, % is calculated by the formula:

$$G_{raw} = \frac{m_{gl} \cdot 100}{T_f}, \tag{1}$$

where m_{gl} – mass of raw gluten, g, m_f – mass of flour batch, g.

GDM device is designed for determining the gluten quality group, its elasticity, estimated by the value of its deformation under the load effect [10]. For that two batches of 4 g are separated from washed, squeezed and weighed gluten, and balls with the smooth surface without breaks and cracks are formed of it. A gluten ball with mass 4 g is put in a glass with water with temperature 18...20 °C for 15 minutes for lying, eliminating internal stresses. After lying a gluten ball is placed in the center of a support table of the device and a die that compresses gluten during 30 seconds with the force near 1,2 N is let off. The results of measuring the gluten elasticity are expressed in conventional units of the device scale. Depending on the value of measuring results, gluten is related to the correspondent quality group.

The hydration ability of gluten is determined, using the wet value of gluten and calculated by the formula:

$$H = \frac{W_{gl} \cdot 100}{100 - W_{gl}}, \qquad (2)$$

where H – hydration ability of gluten, % of the dry gluten mass, W_{gl} – gluten wet.

For determining the gluten elasticity, its pieces are stretched by three fingers of both hands above a ruler approximately by 2 cm and left. After removal of a stress, there are estimated the degree and speed of restoring the initial length or form of gluten.

Determination of the gluten stretchability above the ruler is conducted by the following way. Pieces with mass 4 g are taken from gluten, squeezed, weighed on the technical scales. Balls are formed from these pieces, then they are immersed in the dish with water with the temperature from 18 to 20 °C for 15 min for relaxing a stress, after that the studies are conducted.

For determining the stretchability, a gluten ball, lied in water, is taken by three fingers and evenly stretched above the ruler with millimeter points till breaking. At that the length that gluten is stretched till the braking moment to is noted.

During the work on the farinograph, made by Brabender (ГGermany) **(Fig. 2)** there were studied structural-mechanical properties of dough at kneading.

Fig. 2. Farinograph by Brabender

The studies were conducted according to the method, described in SSU 4111.1-2002/ISO 5530-1:1997 [9].

The extensograph by Brabender (Germany) (**Fig. 3**) is designed for determining physical properties of dough by its resistance to stretching efforts.

Fig. 3. Extensograph by Brabender

The elasticity and energy of wheat flour dough at deformation of the one-axis stretch were determined by the method AACC 54-10 [11].

Determination of the limit shear stress (τ, Pa) for semi-products was conducted on the penetrometer AP-4/1 (VEB Feinmess, Germany) just by the penetration method, using a metallic cone as an indenter. Penetration is a method of determining structural-mechanical properties of semi-products and ready products by determining penetration of an immersion body in them.

The results of the penetration studies are objective characteristics that reflect the resistance of the material to compression and shear. The main value, obtained at penetration is a limit shear stress, which index can be determined by Rebinger formula:

$$\tau = C\alpha \cdot P/h^2, \quad (3)$$

where h – depth of cone immersion, m; Cα – cone constant (at α=30° Cα=0,959); P – penetration effort, N, equal to the weight of the cone, bush and immersion system.

AP-4/1 penetrometer (**Fig. 4**) was used at the studies.

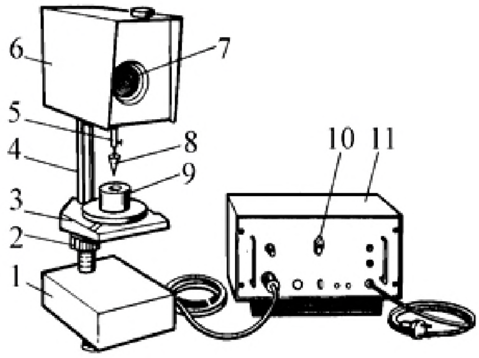

Fig. 4. Penetrometer AP-4/1: 1 – seating, 2 – screw, 3 – measuring table, 4 – upright posture, 5 – sleeve, 6 – measuring head, 7 – microscale for counting determinations, 8 – immersion body – indenter, 9 – glass

On upright posture 4, combining measuring head 6 with seating 1, is measuring **Table 3**, with glass 9, containing dough. The table shifts by screw 2. Measuring head 6 contains the supplying system from sleeve 5 with a replaceable clamping element and microscales for counting immersion of it. Cone 8 is used as an immersion body. A sample for dough is placed on table glass 9, lifted till the surface of a dough sample touches the immersion body. Penetration of the immersion body in dough takes place during some time. After that indications are fixed by the penetrometer.

The specific work of the elastic force of dough was studied on the penetrometer AP-4/1 using a metallic plate-disk (**Fig. 4**) [12]. At determining elastic properties of dough, the cone was replaced by a disk with mass 15 g, diameter 50 mm. A cylindric dough sample is put on the bottom to same overturned glass 9. Glass 9 with the sample is set in device table 3 and lifted till the dough surface touches the disk. A load of 245 g is put on the disk and the device with an immersion body with total mass 300 is switched on. Initial indications are fixed on the device scale. Then the load is removed, and the device is switched on again. At that the value of residual deformation is noted on the scale.

The specific work of elastic forces of dough (A, D/kg) is calculated by the formula:

$$A = \frac{m \cdot g(I_a - I_b)}{m_{av} \cdot 10^7}, \quad (4)$$

where m – mass of removed load, kg, I_a – initial device indications, I_b – final device indications, m_{av} – average mass of dough samples, g.

Adhesion is understood as sticking of materials, different by structure, with formation of an adhesion connection. An adhesion stress is determined by the method of normal separation of a plate from the structured body (dough for hardtacks) on the setting, developed in ONAFT (**Fig. 5**) [12].

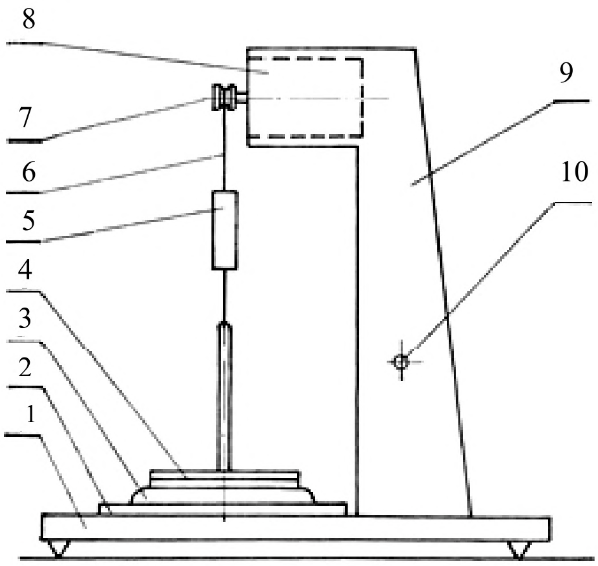

Fig. 5. Device for determining the adhesion stress: 1 – device table; 2 – device chamber; 3 – studied sample; 4 – detachable plate; 5 – dynamometer; 6 – thread; 7 – sheave electric motor; 8 – electric motor; 9 – stand; 10 – tumbler of switching on and reversing of the motor

An adhesion characteristic is the detachment force – P (N), related to the contact area – S (m^2). It is called otherwise an adhesion stress – T (Pa).

The adhesion stress was determined by the dependence:

$$T = \frac{P}{S}. \quad (5)$$

For determining the adhesion as a protecting contact surface, there were used plates of steel. The working order of the device is the following: dough with thickness 0,01 m is placed to the chamber of device 2, plate 4 is lowered on the surface of mass 3, where a load with mass 400 g is set. A stopwatch measures the contact duration (120 s), then the load is removed. Tumbler 10 switches electric motor 8. The plate rises vertically up and is torn away from the mass. The detachment effort is determined by indicators of dynamometer 5. The type of detachment must be adhesion. A result of cohesion detachment is not fixed.

3. Results

At the first stage there was grounded the expedience of using sunroot powder instead of sugar in hardtacks recipes. Its introduction increases a share of non-starch polysaccharides, mineral substances and vitamins and doesn't need essential changes of the technological process [13]. Waxy wheat flour (WWF) due to its high gas-creating capacity [14], allows to intensify the process of fermentation and maturing of yeasty semi-products, which deceleration is observed at excluding sugar from hardtacks recipes.

For producing most types of floury confectionary products, as opposite to bakery ones, it was recommended to use flour with gluten of the weak or middle gluten quality. That is why it is important to study technological properties of flour, conditioned by the protein-poteinase complex.

The comparative analysis of waxy wheat flour and bakery wheat flour (BWF) by quantitative and qualitative parameters of gluten testified that WWF is characterized by the lower content of raw gluten. Gluten, washed of waxy wheat flour, differs by the higher (in 1,7 times) hydration ability, more stretchability and less elasticity comparing with bakery flour.

It's more objective to study technological properties of flour by determining structural-mechanical properties of dough, made of it, on the correspondent devices. The study of the dough-forming process on the farinograph demonstrated that dough of amylase-free flour is characterized by less stability and more liquefaction. Stretchability and elasticity of WWF dough, determined on the extensograph after 135 min of its fermentation were 2 and 3 times less comparing with the control, respectively. According to complex parameters of the flour force (**Fig. 6**) – energy and valometric number (VN), amylase-free flour may be considered as one of the weak force.

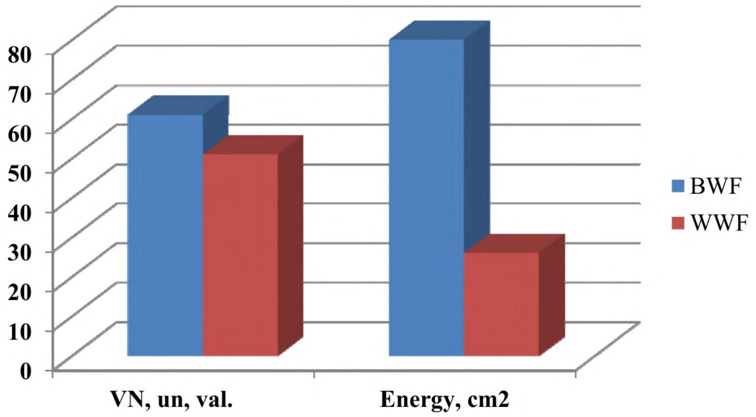

Fig. 6. Results of determination of the flour force by structural-mechanical properties of dough

For substantiating the expedience of using waxy wheat flour at preparing confectionary yeasty dough with replacing sugar by sunroot powder, there were studied structural-mechanical and surface properties of dough for hardtacks. Sunroot powder was introduced in equal shares at kneading fermented liquid dough and ready dough. Characteristics of dough masses were determined on the penetrometer after their lying-keeping and rolling (in 150 min after kneading) before forming workpieces.

It was established, that at preparing dough of bakery flour, the replacement of sugar for sunroot powder is accompanied by increasing its limit shear stress, adhesion properties of semi-products decrease (**Fig. 7, 8**). So, there is observed denser and harder distended dough. As a result, such increase of the density of hardtack dough gives products with inessentially increased porosity.

The use of waxy wheat flour for kneading dough for hardtacks, prepared with sunroot powder instead of sugar (WWF+SP), is accompanied by decreasing the limit shear stress, elasticity of semi-products (**Fig. 7).**

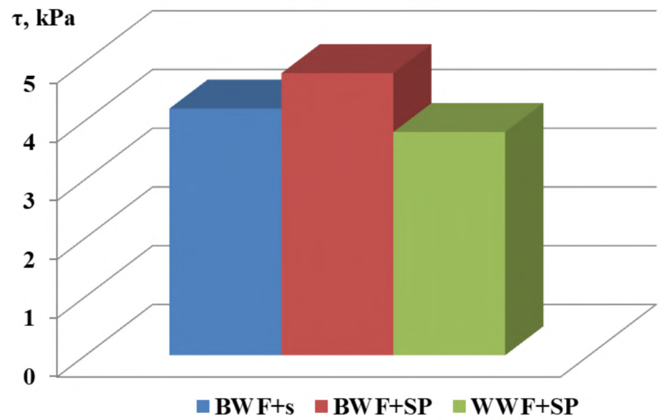

Fig. 7. Strength properties of hardtack dough

At that this tendency is observed comparing with both control sample with sugar (BWF+s) and a sample of bakery wheat flour (BWF+SP) without it. The obtained dependence is probably conditioned by more intensive gas formation at lying -keeping semi-products of WWF. At the same time less resistance of gluten of amylase-free flour as weaker by force allows the protein matrix to stretch more under the effect of carbon dioxide. It helps to get dough with less elasticity and more distended structure (**Fig. 8**).

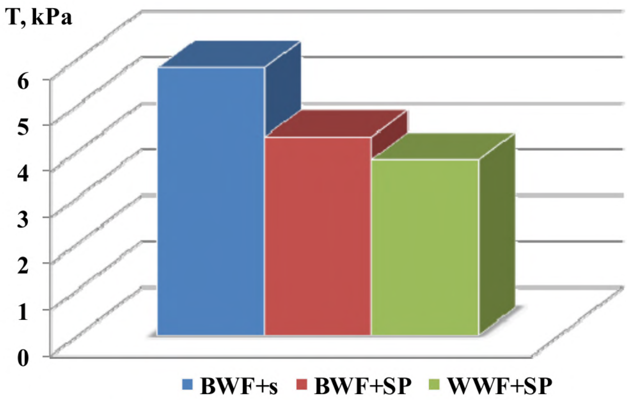

Fig. 8. Adhesion stress of hardtack dough

The decrease of dough adhesion stress at the joint use of BWF and sunroot powder (**Fig. 8**) testifies to the decrease of risk of its sticking to working bodies that favorably influences the currency of the technological process.

4. Conclusions

Based on the analysis of technological properties of waxy wheat flour, there was established the expedience of its use in the technology of yeasty sugar-free confectionary products. It was demonstrated, that this flour differs by the content of less elastic gluten comparing with bakery one and is weak by force. The use of sunroot powder instead of sugar in hardtacks recipe allow to get products with the increased food value and higher content of food fibers, to widen the assortment of floury products with the decreased sugar content.

It was established, that amylose-free flour allows to obtain dough for sugar-free hardtacks with introducing sunroot powder with less adhesion to working surfaces of the equipment. The given samples of dough masses were characterized with less expression of elastic properties and lower firmness that testifies to their better looseness at fermentation-lying. The elasticity decrease of semi-products, based on waxy wheat flour, allows to reduce the duration of lying of sugar-free hardtack dough and to avoid deformation of dough workpieces at forming.

The obtained results give a possibility to state that the joint use of waxy wheat flour and sunroot powder will allow provision of the uninterrupted work of aided and current lines for producing hardtacks, set at enterprises.

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IINFLUENCE OF MAIN TECHNOLOGICAL PARAMETERS OF DRYING ON QUALITY OF BAGASSE FROM CARROT AND BEET

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Abstract

The work studies the drying process of vegetable bagasse, namely of carrot and beet. There is studied the moisture content kinetics of vegetable bagasse and determined the dependence of the process duration on main technological parameters in the work of a vibration vacuum dryer, namely, an amplitude and frequency. There were studied quality parameters of obtained concentrated products, namely the colorimetric estimation of dried bagasse of carrot and beet. Based on obtained results of the study, it was established, that the use of vibration in the process of drying bagasse favors conservation and formation of colorimetric characteristics of a dried product. Determined color characteristics gave a possibility to establish, that at thermal processing it is very important to decrease the drying process duration and temperature. Research data proved prospects of producing concentrated products, namely, dried bagasse of carrot and beet by the offered method. It allows to regulate quality parameters of a ready product: color, brightness, consistence, viscosity and physical-chemical properties. Obtained concentrated products are characterized with high organoleptic indices, food value. This product may be used in the wide spectrum of food industry, such as, for example: juice supplement, stuff for confectionary mass, filling for confectionary products, as biological supplement for healthy nutrition.

Keywords: drying modes, concentrated products, vibration driers, colorimetric estimation, vegetable bagasse.

DOI: 10.21303/2504-5695.2018.00732

1. Introduction

The solution of problems of developing new processing technologies for vegetable raw materials is inseparably connected with the improvement of the apparatus design and creation of new apparatuses that reach the high intensity of the heat and mass exchange process [1].

The aim of work [2] was to study the influence of drying conditions on red beet in the aspect of betaine dispersion and polyphenol, change of the microstructure. The strong thermal shock, provided by convection at 60 °C, then microwave power 315 W/9 min result in better conservation of the bioactive compounds content, comparing with convection at 50, 60 and 70 °C. The results demonstrated that combined drying methods resulted in the essential conservation of the phytochemical content, comparing with traditional methods, but need the essential development in the practical realization of the offered drying methods.

Work [3] presents the results of studying pectin-containing vegetable raw materials. The optimal parameters of a drying agent that guarantee the high conservation degree of pectin and biological substances were established. But the influence of drying parameters on the outlook of products was not studied.

Work [4] determines the kinetics of vacuum drying, thermal history and quality kinetics of vegetable composition. A set of parameters was established for each formulation, and satisfactory experimental data were obtained. As a result of the conducted studies, there was recommended vacuum drying at 70 °C. The degradation mode of ascorbic acid was determined, depending on the tray temperature that is not exact, because the degradation process takes place within a product layer, and heating – through a tray wall, so a crust forms on the surface that decelerates the dehydration process.

Work [5] elaborated the system approach for choosing correspondent drying parameters. This approach can provide simple and comprehensive instructions for choosing suitable working parameters for any drying machine with a pseudo-liquefied layer with a possibility of the maximal permeability for drying vegetable raw materials with the high level of admixtures. These studies are directed on choosing drying parameters, based on the process duration, but don't include the study of a ready product's quality.

Work [6] formulates the conceptual principle of creation of the effective drying method and equipment for its realization. Beet bagasse drying at different modes was substantiated.

Work [7] studies carrot bagasse drying at infrared energy supply. Carrot bagasse without preliminary processing, carrot bassage from raw materials after preliminary thermal processing – blanching by water during 10 minutes at 80–83 °C and blanching by acute steam during 3–5 min were used as samples. Curves of bagasse drying kinetics were formed by the series of conducted studies.

For realizing the raw material drying process, there was used the equipment applying the vacuum technology that allows to increase the boiling temperature in a drying chamber essentially (to 45 °C), that gives a possibility to conserve thermolabile substances and as a result to increase the quality and food value of obtained products. At the same time for intensifying the dehydration process, there is offered to use low-frequency vibrations of trays that a product is placed on.

The aim of the work is to study the influence of technological parameters of the drying process of vegetable bagasse on quality characteristics of a dried product that allows to regulate the main organoleptic parameters of it, namely color, taste, structure (plasticity, solidity, porosity and so on).

2. Materials and methods of studying mass exchange and determining colorimetric characteristics of obtained concentrated products

2. 1. Materials, used in the study

The main material, used in the studies, was bagasse, obtained after dividing the raw materials (carrot, beet) in liquid (juice) and solid (bagasse) phases. The moisture content in bagasse, depending on the division method, varied within 55 … 60 %. In the drying process the final content of moisture in dried bagasse was equal to 10 %. The carrot variety "Carrotel" and beet "Bordo 237" were chosen for the experiments. Completely ripe fruits were chosen. Bagasse sizes after division varied in the diapason from 0,01 m to 0,03 m, and dried from 0,002 m to 0,005 m.

2. 2. Method of studying the process of vibro-vacuum drying of vegetable bagasse

For providing the continuous uninterrupted processing of vegetable bagasse and also for improving the quality of ready products, there was developed a vibration vacuum drier of uninterrupted action. The method of the study is described in work [8]. Drying is realized as following: bagasse is uploaded by rations through a measuring pocket on perforated trays, fixed on a shaft, connected to a generator of vibration, and a dried product accumulates up to the given mass and is taken out through the measuring pocket. Dried bagasse is weighed on measuring scales.

For choosing optimal modes of vibro-processing, there was calculated the working mode coefficient C [9] that indicates the ratio of vertical acceleration, transmitted by vibration to a particle, to the gravity force acceleration. The calculated coefficient gives a possibility to choose an amplitude and frequency of vibrations, solving energy saving problems, so they are chosen in such a way that the material shifts, but the state doesn't transform in vibro-flowing one ($C>3$). The directed shift of the material is created only at $C>1$, and at $1<C<3$ the dispersed system transforms in the vibro-boiling state (particles tear off from each other at shifting).

2. 3. Method of determining colorimetric characteristics of dried carrot and beet bagasse

One of problems at storage and processing of food products of natural raw materials is a change of quality properties, first of all, color. It conditions a necessity of analyzing methods of determining color properties of raw materials for searching a cheaper express-method [10].

Color characteristics of samples were determined by CIE *XYZ* method, based on a tricolorimetric model of color. Blue, green and red are base colors, other ones form by mixing the base colors in correspondent ratios, determined by color coordinates x, y z. If the sum is 1: $x+y+z=1$, the color is white. At that the color surface is perceived in its specific color due to reflection of the light with a certain length, all last waves are absorbed. Using this method, we can get reflection spectrums for opaque substances and materials by measuring the spectrum coefficient of diffusion reflection R_{λ} [11].

3. 1. Study of kinetics of moisture content depending on drying parameters of vegetable bagasse

For determining the influence of main drying technological parameters, namely, an amplitude and frequency of vibration and also a pressure in the apparatus on a speed of the process, there were conducted the experiments of kinetics of the moisture content of dried vegetable bogasse.

The results of the experimental studies of kinetics of the moisture content at drying vegetable bogasse depending on drying parameters are presented on **Fig. 2**, **3**, the experiments were conducted under conditions of different technological drying parameters, indicated in **Table 1**, chosen by the described methods in section 2.2.

Table 1
Drying modes for vegetable bogasse

Name	Amplitude, m	Frequency, Hz	Pressure, MPa
Mode 1	0	0	0,09
Mode 2	0,005	6	0,09
Mode 3	0,005	8	0,09

Fig. 1. presents the results of the experiment of kinetics of the moisture content at drying carrot bogasse at different drying parameters. Thus, drying bogasse at mode 3 continues 82 min and at mode 2 it continues 96 min, but its duration at mode 1 is 118 min that is by 45 % more than at mode 3.

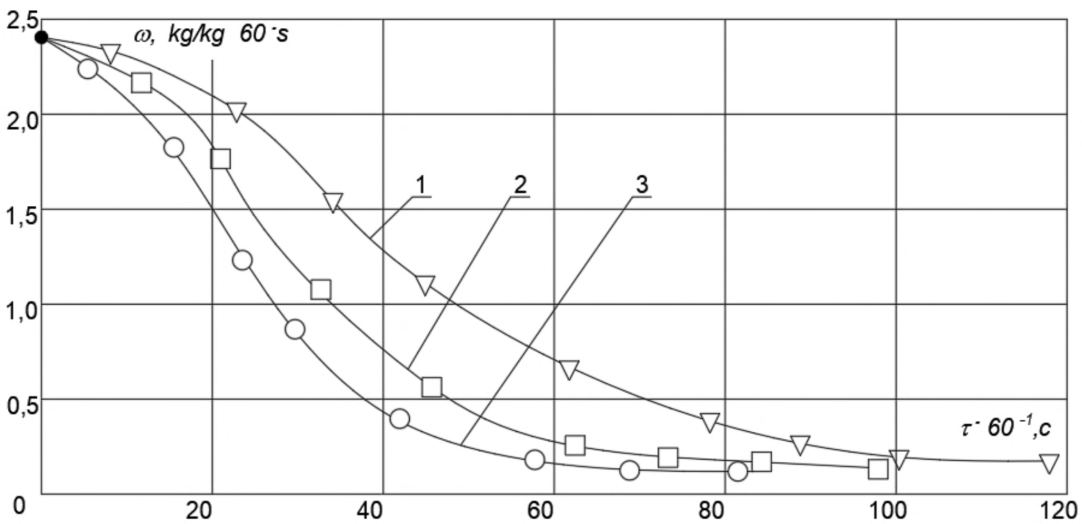

Fig. 1. Kinetics of moisture content at drying carrot bogasse: 1 – mode 1; 2 – mode 2; 3 – mode 3

Fig.2. presents the results of the experiment of kinetics of the moisture content at drying beet bogasse at different drying parameters. Thus, drying bogasse at mode 3 continues 104 min and at mode 2 it continues 112 min, but its duration at mode 1 is 146 min that is by 40 % more than at mode 3.

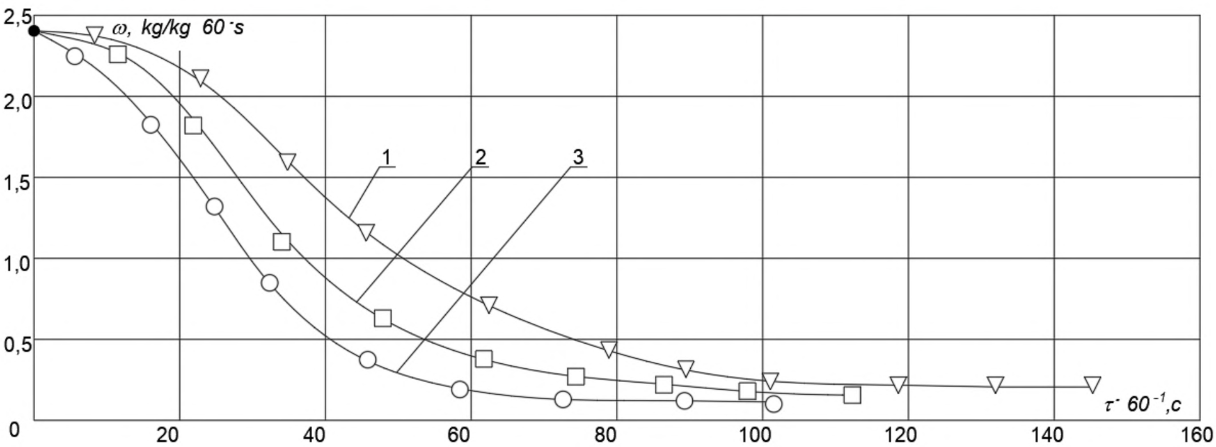

Fig. 2. Kinetics of moisture content at drying beet bogasse: 1 – mode 1; 2 – mode 2; 3 – mode 3

The conducted studies of kinetics of moisture content allowed to confirm the effectiveness of using vibration in drying processes of vegetable raw materials.

The analysis of a moisture content change with the time flow under conditions of different modes of drying bogasse proves the effectiveness of using vibration at realizing the process.

It must be also noted, that beet bossage at equal drying parameters are dried by 26 % longer that is characterized by the physical-chemical composition of the raw material, namely by the content of pectin in beet that influences the process and binds moisture in the product.

3. 2. Study of colorimetric characteristics of obtained dried bogasse

In all experiments the temperature in the working chamber was kept equal (heater temperature 106 °C, vacuum in the working chamber 0,09 MPa), and the amplitude and frequency of vibration change corresponding to the experiments plan.

The research results, namely reflection spectrums depending on drying modes (**Table 1**) are presented on **Fig. 3** (carrot bogasse) and **Fig. 4** (beet bogasse).

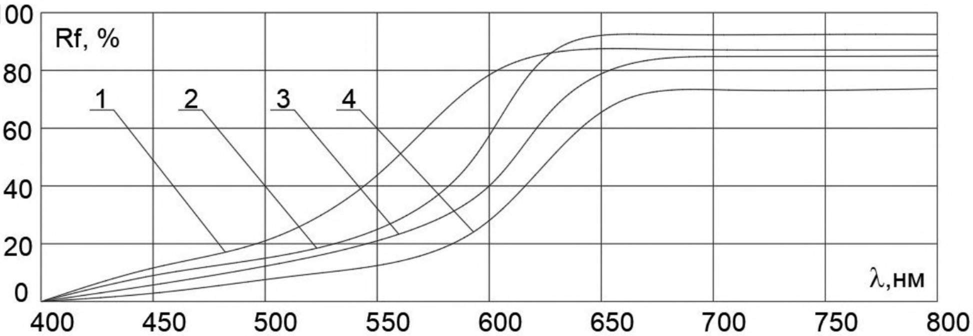

Fig. 3. Reflection spectrums of carrot bogasse depending on drying modes:
1 – mode 3; 2 – mode 2; 3 – mode 1; 4 – bogasse after drying

The calculations, realized according to the research results, are presented in **Table 2.**

Analyzing the data of reflection spectrums, curve 1 has the little intensity in the diapason from 400 to 500 nm, in the diapason from 500 to 600 nm the intensity grows that is characterized by the yellow-orange color, and curve 4 has another dynamics, thus, for example, the intensity grows in the diapason from 600 to 650 mn that is characterized by the red-orange color. The results of curves 2 and 3 also demonstrated that in the diapason from 400 to 550 nm the intensity is minimal, and in the diapason from 550 to 650 nm it grows that is characterized by the orange color of samples.

Table 2

Colorimetric estimation of the quality of carrot bogasse depending on drying technological parameters

Raw material	Carrot bogasse before drying	Dried carrot bogasse at mode No. 1	Dried carrot bogasse at mode No. 2	Dried carrot bogasse at mode No. 3
Dominating wave length, nm	581,6	575,2	579,4	580,3
Tone pureness	85,67	76,97	80,31	83,84
Brightness	45,8689	43,5827	44,4144	44,9401
Spectral color (dominating tone)	Red-orange	Yellow	Yellow-orange	Orange

The growth of reflection intensity in the red-orange area of the visible spectrum characterizes its growth in the red component of light.

The dynamics of the wave length in the orange area of the visible spectrum is increased, and the color share grows that indicates the growth of the contribution of the orange component of the spectrum. Thus, mode 3 is optimal according to the obtained results.

The data of reflection spectrums are presented on **Fig. 4** Curve 1 has a little intensity in the diapason from 400 to 450 nm, and in one from 450 to 650 nm the intensity grows that is characterized by the yellow-red color. Thus, the results of curves 2 and 3 demonstrated that in the diapason from 550 to 700 nm the intensity grows that is characterized by the red-orange color of samples. Curve 4 has another dynamics, thus, for example, the intensity is minimal in the diapason from 400 to 650 nm, and grows in one from 650 to 750 nm that is characterized by the saturated red color of samples.

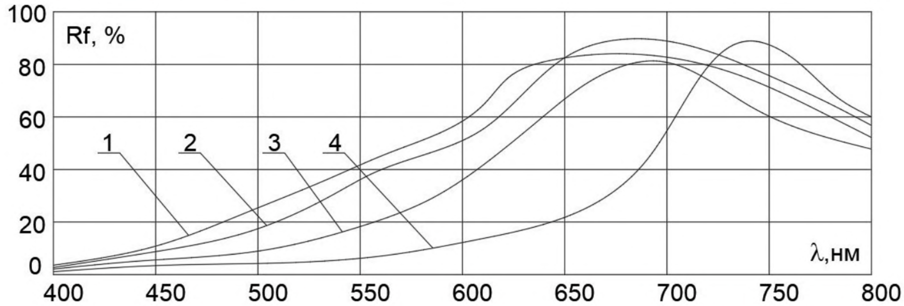

Fig. 4. Reflection spectrums of beet bogasse depending on drying modes:
1 – mode 3; 2 – mode 2; 3 – mode 1, 4 – bogasse before drying

The calculations, realized according to the research results of **Fig. 4,** are presented in **Table 3**.

Table 3
Colorimetric estimation of the quality of beet bogasse depending on drying technological parameters

Raw material	Beet bogasse before drying	Dried Beet bogasse at mode No. 1	Dried Beet bogasse at mode No. 2	Dried Beet bogasse at mode No. 3
Dominating wave length, nm	619,6	591,3	599,4	607,2
Tone pureness	58,10	69,58	76,11	86,11
Brightness	30,19	40,65	42,68	46,92
Spectral color (dominating tone)	Red	Yellow-orange	Orange	Red-orange

The reflection intensity growth in the red area of the visible spectrum characterizes its growth in the red component of light. The dynamics of the wave length in the red area of the visible spectrum is increased (from 650 nm to 800 nm), and the color share grows that indicates the growth of the contribution of the red component of the spectrum. Thus, mode 3 is optimal according to the obtained results.

It proves that qualitative, namely colorometric, characteristics of dried bossage depend on drying parameters, and the use of vibration at the drying process increases the main qualitative characteristics of obtained concentrates, namely, the tone saturation and color pureness.

3. 3. Results of studying the influence of main technological drying parameters on the quality of dried bogasse

Fig. 5, 6 demonstrate, how the processing duration and drying modes influence organoleptic parameters of the obtained dried bogasse. Photos are presented in two variants, samples with the best outlook and ones with the worst one.

As a result of the conducted theoretical and experimental studies, it was proved, that drying parameters essentially influence the process duration and quality parameters of the obtained concentrated products.

The optimal vibration mode for vibration-vacuum drying is established at pressure in the working chamber 0,09 MPa: vibration amplitude A=0,005 m, vibration frequency f=8 Hz. At that the drying duration is 82 min and 104 min for carrot and beet bogasse, respectively.

a *b*

Fig. 5. Carrot bogasse, dried at different drying modes: *a* – mode 1; *b* – mode 3.

a *b*

Fig. 6. Beet bogasse, dried at different drying modes: *a* – mode 1; *b* – mode 3

7. Conclusions

As a result of the conducted work, there were studied quality characteristics of dried carrot and beet bogasse that allowed to determine the dependence between color parameters of a dried product (tone saturation, color pureness) on working modes of the vibration vacuum drier (amplitude, frequency). Based on the result of studying colorimetric characteristics, obtained by reflection spectroscopy, it was proved that the use of vibration in the drying process essentially shortens the dehydration process duration that favors conservation of quality characteristics. It was established, that modes of technological processing influence deviation of values of a dominating wave length and brightness of dried bogasse from ones of these parameters for control samples. The determined color characteristics gave a possibility to establish that at thermal processing it is very important to decrease the raw material processing duration and temperature.

A shortcoming of the studies of quality parameters may be their narrow diapason. The quality of products of vegetable raw materials may be studied in the direction of determining vitamins and macroelements.

The further development of studies of the influence of technological parameters of the drier's work on the ready product's quality may be in changing a heater in the vibration vacuum drier, for example, for ir-heaters and in investigating their influence on quality parameters of processed products, establishing connections between certain quality criteria and processing regimes.

Thus, the offered method of drying bogasse in the developed drier allows to improve the quality of obtained dried product essentially and to use them as improvers of culinary, bakery, confectionary products and for healthy nutrition.

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