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MATHEMATICAL MODELING OF THE TECHNOLOGICAL PROCESS OF PRODUCTION OF THE NEW SOUR-DAIRY PRODUCT

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Abstract. Biotechnologists must be fluent in modern scientific areas in the field of applied biotechnology, the theory of analysis and synthesis of technological systems in objective production conditions. To optimize both individual technological operations and technologies as a whole, a modeling methodology is now widely used as a tool for studying the behavior of an object using its mathematical description.

Keywords: mathematical processing, oatmeal, sensory assessment.

Introduction. The successful industrial enterprise of any profile, including technological, is kept on three basic bases: high-quality raw materials and materials; the modern equipment; the advanced technologies among which the big role is played by management information technologies, allowing operatively and effectively to solve problems on planning, the account and the analysis of activity of the enterprise [1].

The production of traditional foodstuffs is not sufficient to meet the physiological needs of the population, because under current technologies all products are overprocessed and as a result lose most of their biologically active substances. In addition, the requirements of modern humans to the energy and nutritional value of products have changed, which is associated with a decrease in the share of physical labor, environmental degradation, etc. [2].

At the first stage of research and development the scientific and technical literature on the subject of research was studied. Physico-chemical composition, pre-processing parameters and technological properties of used raw materials have been studied and proved. On the basis of analysis of the received data the working hypothesis was formulated.

At the second (experimental) stage researches on development of new products were conducted. The scientifically based recipe and technology of products were developed.

In order to implement the tasks set in the work experimental research was carried out in the laboratories of the Department of "Technology and Standardization" of KazUTB and experiments were conducted in three and five times.

Methods. In order to obtain reliable results of experimental studies, all received data were mathematically processed. The purpose of mathematical processing of experimental results was to estimate the criterion of elimination of gross errors, finding critical values of controlled factors and the range of their variation with their subsequent use in solving optimization tasks. All obtained results were processed in 2 stages.

The results. At the first stage, the experimental data were processed by mathematical statistics. In order to avoid errors and obtain reliable results, the experiments were conducted with 5 multiple repetitions. To exclude the so-called "miss" in the experiment, the criterion of checking for a gross error by the following dependence on the formula (1) was applied.

$$r = \frac{(x_{под} - x)}{R\sqrt{\frac{n-1}{n}}} \qquad (1)$$

где, $x_{под}$- suspicious result;
X – middle;
R- root mean square deviation calculated by the formula (2).

$$R = \sqrt{\frac{\sum_{i=1}^{n}(\Delta x_1)^2}{n(n-1)}} \qquad (2)$$

Where, n- the number of experiments in the experiment.

Discussion. The processing of the results showed the absence of gross errors, which indicates the high correctness of the experiments and high accuracy of the methods used.

To find the critical values of the controlled parameters the results of the experiment were described by the trend equations in different ways. The results of these treatments are presented below. Further optimization tasks aimed at finding optimal parameters of variable factors were solved.

The purpose of the optimization task was to find a function in which, in the presence of technological limitations on the control parameters, obtained as a result of studies, met the conditions of optimality, and the selected criterion reached the extreme values. Levels of variation of factors are presented in Table 1.

To solve optimization problems, the method of mathematical planning of the experiment was applied. Technological modes and the amount of plant component introduction were subjected to optimization. The target function (optimization criterion) was chosen indicator - sensory evaluation of developed products (Table 2).

Table 1 - Variation of factors

Levels	Varying factors			
	X_1	X_2	X_3	X_4
1	12,5	5	4,6	155
2	10	4,5	4,5	140
3	7,5	4	4,4	125
4	5	3,5	4,3	110
5	2,5	3	4,2	95

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Table 2 - Implementation plan for the full-scale experiment

№ experience	Levels				Optimization criterion sensory assessment
	X_1	X_2	X_3	X_4	
1	14	15	16	17	14
2	13	17	16	19	15
3	15	16	18	19	18
4	16	13	18	14	17
5	17	15	13	18	18
6	18	14	19	17	15
7	19	17	20	18	16
8	13	19	14	16	13
9	16	17	18	15	17
10	15	18	13	16	18
11	13	19	14	17	15
12	14	13	15	18	16
13	17	15	18	19	19
14	18	16	17	15	17
15	19	17	18	14	18
16	15	18	17	13	14

We write down equations containing a factor of each level:

$У_1= f_1(C_{1j}) + f_2(C_{2j}) + f_3(C_{3j}) + f_4(C_{4j})$;
$У_2= f_1(C_{1j}) + f_2(C_{2j}) + f_3(C_{3j}) + f_4(C_{4j})$;
$У_3= f_1(C_{1j}) + f_2(C_{2j}) +f_3(C_{3j}) + f_4(C_{4j})$;
$У_4= f_1(C_{1j}) + f_2(C_{2j}) + f_3(C_{3j}) + f_4(C_{4j})$.

We produce a soiled addition of these equations for each level.
We find the average value of the target function by the formula

(3):

$$Y= \frac{1}{N}\sum_{i=1}^{N} Y_u \qquad (3)$$

Determine the average value of the target functioni-factor at the j-level of the formula (3.4).

$$Yij= \frac{k}{N}\sum_{i=1}^{N/k} Y_{u(ij)} \qquad (4)$$

где, *N* – number of experiments;
K – number of factors.

Set the effect of the i-th factor at the j - level, for each factor by the number of levels Эij= Y - Y_u.

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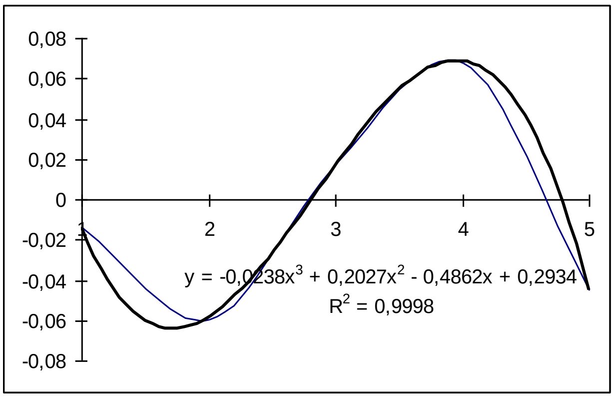
Table 3 - Interfactorial effects of a full-scale experiment plan in the optimization of technological modes of production

Managed Factors	№ levels	Level value	Target functionЭij
X_1 - oatmeal, %	1	12,5	-0,0137
	2	10	-0,0592
	3	7,5	0,0177
	4	5	0,068
	5	2,5	-0,045
X_2 - fermentation time, hour	1	5	0,15
	2	4,5	0,2625
	3	4	0,063
	4	3,5	-0,242
	5	3	-0,192
X_3 - active acidity, pH	1	4,6	0,3223
	2	4,5	0,0165
	3	4,4	0,0258
	4	4,3	-0,396
	5	4,2	-0,0231
X_4- titratable acidity, °T	1	155	0,3223
	2	140	-0,086
	3	125	0,164
	4	110	0,274
	5	95	-0,189

Graphically the dependence of interfactorial effects is shown in the following figure 1.



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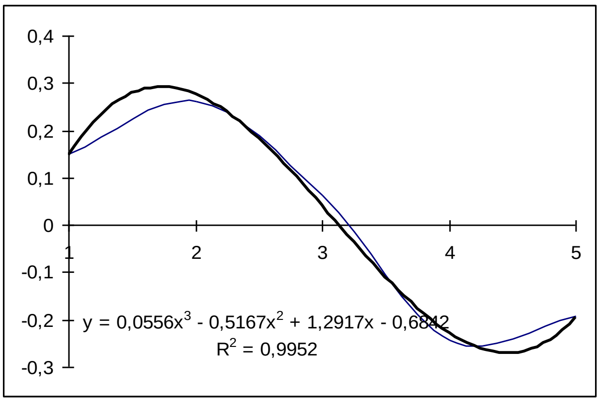

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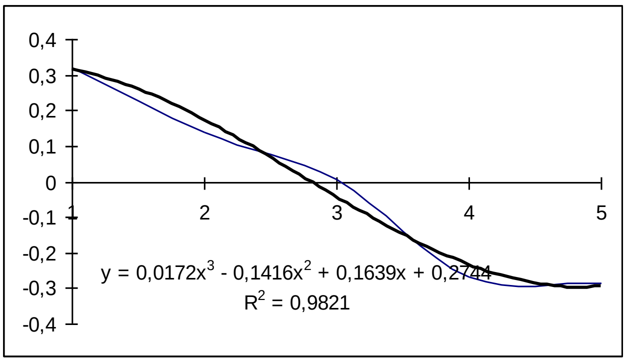

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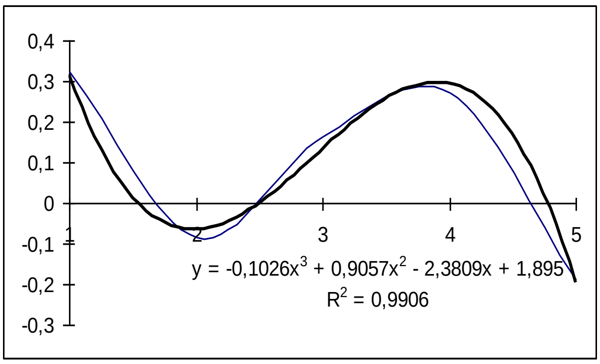

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Fig.1 - Dependence of the interfactorial effect: a) on the amount of phytomyls of oats, %; b) on fermentation, hour; c) on active acidity, pH; d) on titratable acidity, ºT.

Validity of approximation (R2) is close to one that testifies that the received equations adequately describe experimental data and can serve as a basis for search of optimum values of factors of investigated processes.

The general equation of the target function has the following form.

$$F= A \cdot x_1^3 + B \cdot x_2^2 + C \cdot x_3 + D \rightarrow \text{мах}$$

Where, the coefficients are presented in table 4.

Table 4 - Empirical ratios of the regression equation

Controllable factors	Regression coefficients			
	A	B	C	Д
Oatmeal Fiber Quantity, %	0,55	1	0,9455	3
Fermentation time, hour	0,215	0,533	0,78	3
Active acidity, pH	0,594	1	0,888	3
Titratable acidity, ºT	4,25	3,2041	2,581	4

Under the following restrictions on controlled factors:

1)Amount of oatmeal, %:

$Y= 0,5\ x_1^3 + 1\ x_2^2 + 0,9455\ x_3 + 3 \leq\ 5,0083$

2) Fermentation time, hour.:

$Y= 0,215\ x_1^3 + 0,533\ x_2^2 + 0,78\ x_3 + 3 \leq\ 4,000651$

3) Active acidity, pH:

$Y= 0,594\ x_1^3 + 1x_2^2 + 0,888\ x_3 + 3 \leq 4,400832$

4) Titratable acidity, ºT:

$Y= 4,25\ x_1^3 + 3,2041\ x_2^2 + 2,581\ x_3 + 3 \leq 140,0026$

Conclusions. Based on the results, it was found that at the maximum organoleptic assessment, the amount of oatmeal added and the technological parameters of the product will be as follows: the amount of oatmeal-5%; fermentation time -4 hours .; active acidity - 4.4; titratable acidity - 140 ºT.

Thus, as a result of the mathematical development of the data, the optimal values for the introduction of oat flour and technological modes that meet the requirements of the task are obtained.

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