OPTIMIZATION OF TECHNOLOGICAL PARAMETERS FOR DEODORIZATION OF VEGETABLE OILS

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The purpose of basic laboratory work is to determine the optimal process conditions, maximum product yield, etc.

Therefore, the main attention is paid to the creation of statistical models describing the area close to the optimum in terms of various technological indicators. Limited time for work imposes certain restrictions on the number of experiments, carried out within the framework of a particular work, and for the time spent on obtaining a model and its optimization. By typea plan that can be optimized is a second-order plan for three levels, during the implementation of which models containing quadratic parameters are obtained. The general view of such a model is presentedsecond order polynomial

$$y = b_0 + b_1x_1 + b_2x_2 + \cdots + b_kx_k + b_{12}x_1x_2 + \cdots + b_{k-1}x_{k-1}x_k + b_{11}{x_1}^2 + b_{22}{x_2}^2 + b_{kk}{x_k}^2 \quad (47)$$

where k is the number of factors in the statistical model; bij are the coefficients of the polynomial.

To reduce the number of experiments and save time, rich experimental plans (or close to saturated), i.e., those in which the number of experiments coincides with the number the coefficients of the model (polynomial). Experiment three matrix

factors are given in Table 4.4.

Table 4.4.

N	Factors	Factor levels in coded variables in experiments											Characteristicsoftheplan
											0	1	
1	x1	1				1			1	1			Saturated
	x2	1					1		1		1		Saturated

	x3	1						1		1	1		Saturated
2	x1	1		1		1							Compositional
	x2	1	1					1	1				Compositional
	x3		1	1						1			Compositional

Considering the possibility of using the above plans

experiment to various objects of research, the levels of factors are given in coded form. In this case, 0 is the average value of the factor in the studied interval, -1 is the lower (minimum) value of the factor; 1- upper (maximum) value. V

In this case, the plan step corresponds to the deviation of the factor value from

the center of the interval under study to its boundaries ± 1.

To move from the coded values of the factors to the real ones, we used the formula

xi = (zi - z0) / Δz (48)

where –xi is the coded value of the factor in the interval (–1 ... 1); zi is the real value of the factor;

$$z_0 = \frac{z_i^{max} + z_i^{min}}{2} -;$$

$$\Delta z = \frac{z_i^{max} - z_i^{min}}{2} -;$$

zimax is the maximum value of the real factor in the experiment; zimin minimal

the value of the real factor in the experiment.

Thus, the center of the plan is chosen as the mean

factors, and the plan step is determined by the boundaries of the area in which

the influence of factors on the response function has been studied.

When using compositional designs, the number of experiments is greater than the number of coefficients in the polynomial (equation

regression), which makes it possible to estimate the error of an individual experiment.

After conducting an experiment on deodorization technology using real values of the factor z in four experiments when used to determine

mass fraction of phospholipids in deodorized oil y in the amount of z, the results were entered in

Table 4.5.

Table 4.5.

Results of an experiment on one-factor optimization of the deodorization process

Experiencenumber	Factor - amount,% by weight of oil		Response function - mass fraction of phospholipids,% (y)	
1	-1	1,0	0,47	0,47
2	1	3,0	0,32	0,32
3	0	2,0	0,19	0,20
4	0	2,0	0,21	0,20

$$b_0 4 + b_1 \sum_{i=1}^{4} x_i + b_2 \sum_{i=1}^{4} {x_i}^2 = \sum_{i=1}^{4} y_i \,;$$

$$b_0 \sum_{i=1}^{4} x_i + b_1 \sum_{i=1}^{4} {x_i}^2 + b_2 \sum_{i=1}^{4} {x_i}^3 = \sum_{i=1}^{4} x_i y_i \,; \qquad (49)$$

$$b_0 \sum_{i=1}^{4} {x_i}^2 + b_1 \sum_{i=1}^{4} {x_i}^3 + b_2 \sum_{i=1}^{4} {x_i}^4 = \sum_{i=1}^{4} {x_i}^2 y_i .$$

To simplify the calculations, the values of the factor are used in dimensionless coordinate system, i.e. -1 ≤ x ≤ +1. Using the values of yi and xi given in Table 4.5, we solve the system equations and find the coefficients of the equations bj:

$4b_0 + 0b_1 + 2b_2 = 1{,}19$;

$4b_0 + 2b_1 + 0b_2 = –0{,}15$;

$2b_0 + 0b_1 + 2b_2 = 0{,}79$;

$\hat{y} = 0{,}200 – 0{,}075x + 0{,}195x^2$

where ŷ is the calculated value of the response function; x is the coded value of the factor.

We can calculate and compare the experimental yi and calculated ŷi values of the response function. ThesevaluesareshowninTable 4.5.

To estimate the tightness of the nonlinear connection, we use the correlation ratio θ, determined by the formula (43),

$$\theta = \sqrt{1 - \frac{(4-3)s_{ocm}^2}{(4-1)s_4^2}}$$

$$s_{ocm}^2 = \frac{1}{4-3}[(0{,}47-0{,}47)^2 + (0{,}32-0{,}32)^2 + (0{,}19-0{,}20)^2 + (0{,}21-0{,}19)^2]$$
$$= 0{,}0002$$

$$\hat{y} = \frac{1}{4}(0{,}47 + 0{,}32 + 0{,}19 + 0{,}21) = 0{,}297$$

$$s_y^2 = \frac{1}{4-1}[(0{,}47-0{,}297)^2 + (0{,}32-0{,}297)^2 + (0{,}19-0{,}297)^2 + (0{,}21-0{,}297)^2]$$
$$= 0{,}0165$$

$$\theta = \sqrt{1 - \frac{0{,}0002}{3 \cdot 0{,}165}} = 0{,}998$$

The closeness of the correlation ratio to unity indicated a practically functional relationship between the factor and

response function. Therefore, omitting the estimate of the significance of the coefficients bj, we proceeded to find the factor x that would provide the minimum value of the response function. For this, the gradient method was used, i.e. determined the extremum of the function

$y = 0{,}200 – 0{,}075x + 0{,}195x^2$

$$\frac{\partial y}{\partial x} = -0{,}075 + 2 \cdot 0{,}195x = 0$$

here

$$x_{\min} = \frac{0{,}075}{2 \cdot 0{,}195} = 0{,}192$$

$$y_{\min} = 0{,}200 - 0{,}075 \cdot 0{,}192 + 0{,}195(0{,}192)^2 = 0{,}193\%$$

Thus, the minimum mass fraction of phospholipids in deodorized oil corresponds to 0.19%.

To determine the optimal amount of live steam for deodorization of this oil, we used the formula (47) of the transition from the coded values of the factor to the real ones.

Using the data in Table 4.5, we have

$$z_0 = \frac{3,0 + 1,0}{2} = 2,0\ \%$$

$$\Delta z = \frac{3,0 - 1,0}{2} = 1,0\ \%$$

$$0,192 = \frac{z_i - 2,0}{2}$$

Here

$$z_i = 2,0 + 0,192 = 2,192\ \%$$

Thus, to deodorize the test oil, it is necessary to add 2.19% of live steam to the oil mass. In this case, the minimum mass fraction of phospholipids in the deodorized oil is expected, i.e., the maximum degree of deodorization.