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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 type a 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 presented second order polynomial

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

where k is the number of factors in the statistical model; b_{ij} 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.

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. 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

$$x_i = (z_i - z_0) / \Delta z$$

z_{imax} is the maximum value of the real factor in the experiment; z_{imin} 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

number	Factor - amount, % by weight of oil		Response function - mass fraction of phospholipids, % (y)	
	coding(x)	Real (z)	exprence (y _i)	Result(\hat{y}_i)
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

We are looking for the identification of the connection between the factor and the response function in the form of a polynomial of the second degree (parabola)

$$\hat{y} = b_0 + b_1x + b_2x^2$$

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



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

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

To simplify the calculations, the values of the factor are used in dimensionless coordinate system, i.e. $-1 \leq x \leq +1$. Using the values of y_i and x_i given in Table 4.5, we solve the system equations and find the coefficients of the equations b_j :

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

$$4b_0 + 2b_1 + 0b_2 = -0,15;$$

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

Substitute the value of the coefficients b_j into the parabola equation

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

where \hat{y} is the calculated value of the response function; x is the coded value of the factor.

We can calculate and compare the experimental y_i and calculated \hat{y}_i values of the response function. These values are shown in Table 4.5.

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

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

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

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

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

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

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 j , 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

$$y = 0,200 - 0,075x + 0,195x^2$$

differentiating and equating the derivative to zero, we obtain

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

from here

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

Substituting the obtained values into the original equation, we have

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

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

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

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

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

from 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.



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