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RESEARCH ARTICLE

OPTIMIZATION OF ENZYMATIC PROCESSING OF RAPESEED.

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Abstract

The problem of extracting oil from rapeseed is discussed. The optimal enzymatic processing before pressing is studied. The nonlinear model of rape oil extraction after enzymatic treatment was built. Moreover, obtained the parameters in which the local maximum of rape oil volume is reached.

Introduction:-

Traditionally, oil is extracted from oilseeds by pressing or extraction methods. The forging oil has a best quality in terms of environmental safety. Oil extraction technology that combines previous pressing and extraction is most effective. Therefore, it is often used in manufacturing. But, organic solvent that used in the extraction process is very valuable and quality of extracted oil is low. Therefore, the development of alternative technologies extract oil that can compete with the method of extraction is an important practical task. Using the previous enzymatic treatment step before pressing we reach the high-quality products and reducing the manufacturing cost.

To extract the lipids from the structure of seeds we must overcome several barriers. In (Latif and Anwar, 2009; Latif at al., 2007a, 2011) studied the hydrolytic enzymes such as cellulase, hemicellulase, pectinase for destroying the cell walls. Since enzymes are mostly specific to a particular type of communication, we need to use a mixture of enzymes with different types of activity (Soto at al., 2007; Ricochon and Muniglia, 2010).The rewiev of enzymatic mixtures, stages of the process and the conditions under which the enzymatic treatment must be carried out we can seen in (Latif at al., 2007b). Increasing the efficiency of oil extraction using enzymatic treatment in the process of compaction compared to the control is associated with better solubilization of the cell wall, that leads to the release of a higher quantity of oil (Latif at al., 2007b).The process depends not only on the pH, temperature, amount of time, but also from the technological procedures before and after hydrolysis seed. The effectiveness of the enzymes will also be different from the chosen materials (seeds, cake, finely core) (Kolpak at al., 2012; Cherstva at al., 2016).

According to the results the enzymatic treatment does not alter the oil quality indicators and improves the nutritional value of cake compared to the control samples, obtained without the use of enzymes. As a result, is received a first grade rapeseed oil (Cherstva at al., 2016).

Materials and methods:-

The rapeseed meal was collected in laboratory, Ukraine. The following enzyme preparations with broad range activities were employed: Protolad (protease from Bacillus subtilis, 70 units/g, Enzyme, Ukraine) and Cellulad (cellulase from Bacillus subtilis, 300 units/g, Enzyme, Ukraine).

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The ground seed material was incubated with each of the two enzyme preparations (Protolad and Cellulad) at a concentration of 0,2–1,3% (by seed weight) for 60-195 min (41,8-42,2°C) while retaining 50–53% moisture contents.

Then, the inactivation of enzymes made. Before pressing, the level of moisture of seed was adjusted to 3,5-4% (drying at 100°C). Next, the manual laboratory hydraulic press (L5-PSH, Ukraine) was used (at 75-85°C). The pressing of seeds material was continued for 20 min with the pressure between 30-49 MPa. The technological process shown on Figure 1.

A control oil sample was also prepared by pressing the seed material under the specified conditions but without the enzyme treatment. The results are compared in Table 1.

To receive the mathematical model of oil extraction process was used the module of nonlinear estimation in STATISTICA program. To find the optimal process parameters used program Mathcad.

Results and Discussion:-

Modelling and Optimization. We have supposed that there was some relation between yield of oil and two parameters (time processing and concentration of enzyme). The experimental data for the regression model are presented in Table 2 .For further analysis was applied variables transformation Table 2 too.
Unsatisfactory results were obtained using Multiple Regression module, but cases numbers 8, 11 were excluded from the analysis as outlier.

Thus, we used the Nonlinear Estimation module. Nonlinear Estimation is a general fitting procedure that will estimate any kind of relationship between a dependent, and a list of independent variables. In general, all regression models can be stated as: $y = f(x_1, x_2, \ldots, x_n)$. In most general terms, we are interested how a dependent variable is related to a list of independent variables. Generalized Linear/Nonlinear Models (GLZ) module includes efficient algorithms for fitting. We can write any type of regression equation, which STATISTICA will then fit to our data. Levenberg-Marquardt method was used for estimation of the model parameters. Polynomial model (1)

$$z = -229,44 + 144,932x + 0,728yx - 1,555y^2 - 29,98x^2 + 0,221y^3 + 2,04x^3 \qquad (1)$$

shown on Figure 2, explains 97.3% of data variation. Therefore, the model approximates well the available data. The Levenberg-Marquardt algorithm is an improvement of the classic Gauss-Newton method for solving nonlinear least-squares regression problems. It is the recommended method for nonlinear regression problems, where it is more efficient than other more general optimization algorithms such as the Quasi-Newton, or Simplex methods. Also seen that all coefficients of model (1) are statistically significant at $\alpha = 0.05$ from Figure 2.

Next, using the Mathcad-function Maximize, we obtain the point, where the maximum of z in (1) is reached (Figure 3). This is $(x_{\max}, y_{\max}) = (4.551, 1.636)$, and $z_{\max} = 3.724$. Finally, using the inverse transformation (2) we find an optimal parameters of enzymatic processing

$$t_{\max} = \exp(x_{\max}) = 94.722; \quad c_{\max} = \ln(y_{\max}) = 0.492, \qquad (2)$$

and the local maximum quantity of oil is $q_{\max} = \exp(z_{\max}) = 41.434$.

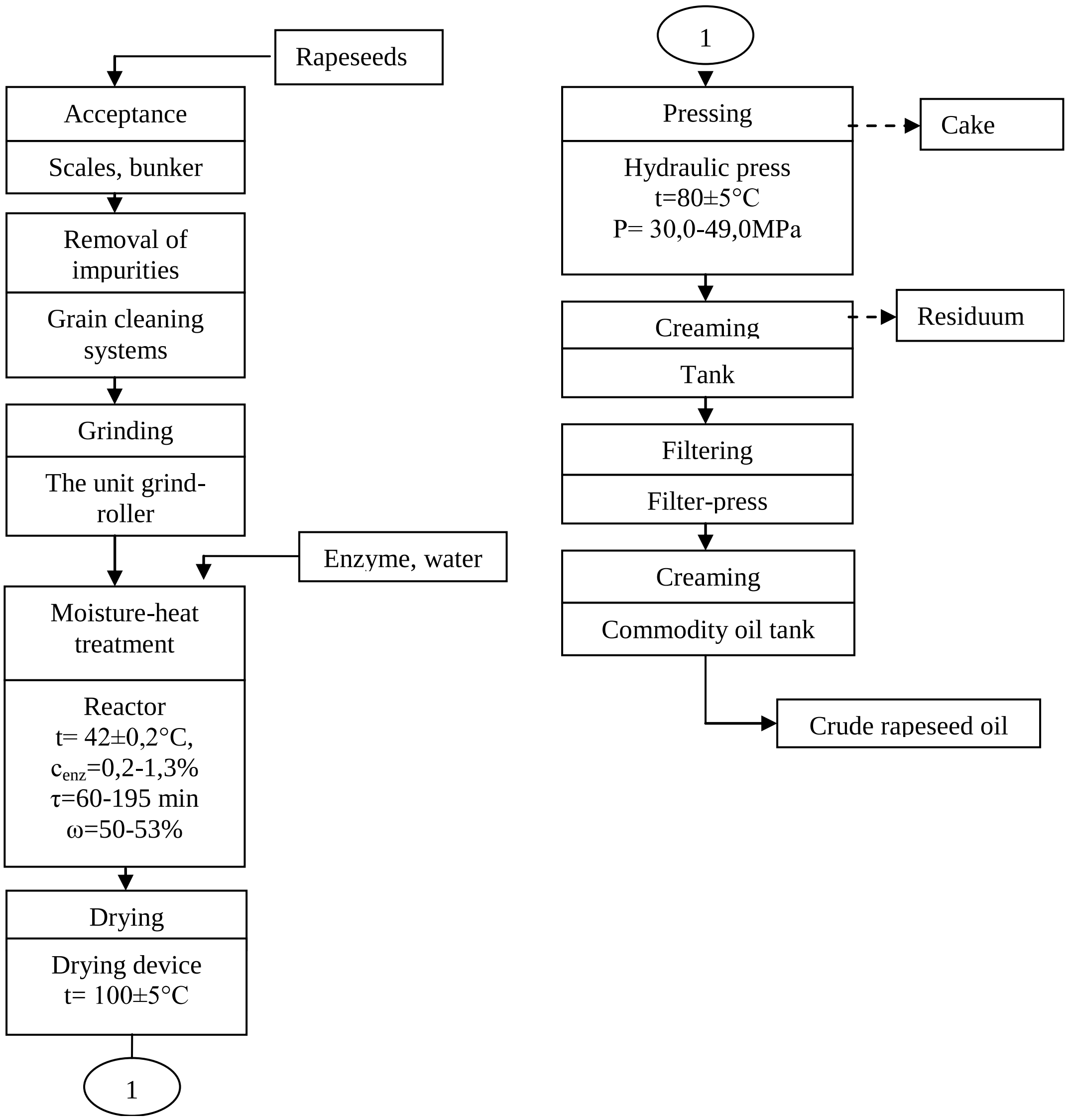

Figure 1 :-Technological block-diagram technology of enzymatic treatment rape prior to pressing

Table 1:- Composition of fatty acids in rapeseed oil samples.

№	**Fatty acid**	**Content of fatty acid, % of the total content**	
		Oil after enzymatic treatment	**Control oil sample**
1	C 16:0	6,0	7,7
2	cis-9-C 16:1	0,2	0,4
3	C18:0	1,1	2,0
4	C 18:1	59,2	56,7
5	cis, cis-9,12-C 18:2	21,5	18,5
6	cis, cis, cis-9,12,15-C 18:3	6,2	4,8
7	C20:0	0,6	0,2
8	cis-11-C 20:2	0,3	0,5
9	C22:0	0,2	0,0
10	cis-13-C 22:1	0,1	0,2
11	C23:0	0,7	0,8

Table 2:- Experimental and transformed data.

	Experimental Data			Transformed Data		
N	**Time processing (t, min)**	**Concentration of enzyme (c, %)**	**Oil output (q, %)**	**x=ln(t)**	**y=exp(c)**	**z=ln(q)**
1	60	0,2	22,7	4,09434456	1,22140276	3,12236492
2	120	0,4	35,8	4,78749174	1,4918247	3,57794789
3	150	0,5	29,9	5,01063529	1,64872127	3,39785848
4	165	0,6	36,2	5,10594547	1,8221188	3,58905912
5	180	0,7	32,3	5,19295685	2,01375271	3,47506723
6	195	0,8	33,4	5,27299956	2,22554093	3,5085559
7	80	0,8	32,5	4,38202663	2,22554093	3,48124009
8	100	0,7	10,7	4,60517019	2,01375271	2,37024374
9	120	0,5	35,3	4,78749174	1,64872127	3,56388296
10	60	0,9	13,3	4,09434456	2,45960311	2,58776404
11	60	2,5	33,3	4,09434456	12,182494	3,5055574
12	90	1,3	34,6	4,49980967	3,66929667	3,54385368
13	150	1,2	41,8	5,01063529	3,32011692	3,73289634

Model is: z=b0+b2*x+b3*y*x+b4*y^2+b5*x^2+b8*y^3+b9*x^3 (
Dep. Var. : z
Level of confidence: 95.0% (alpha=0.050)
Exclude cases: 8;11

	Estimate	Standard error	t-value df = 4	p-level	Lo. Conf Limit	Up. Conf Limit
b0	-229,441	68,27370	-3,36061	0,028289	-419,000	-39,8832
b2	144,932	44,14195	3,28332	0,030406	22,374	267,4899
b3	0,728	0,16714	4,35826	0,012079	0,264	1,1925
b4	-1,555	0,32113	-4,84217	0,008387	-2,447	-0,6634
b5	-29,980	9,47307	-3,16476	0,034028	-56,281	-3,6786
b8	0,221	0,04328	5,10385	0,006964	0,101	0,3411
b9	2,040	0,67464	3,02354	0,039027	0,167	3,9129

Figure 2:- Polynomial model (nonlinear estimation results)

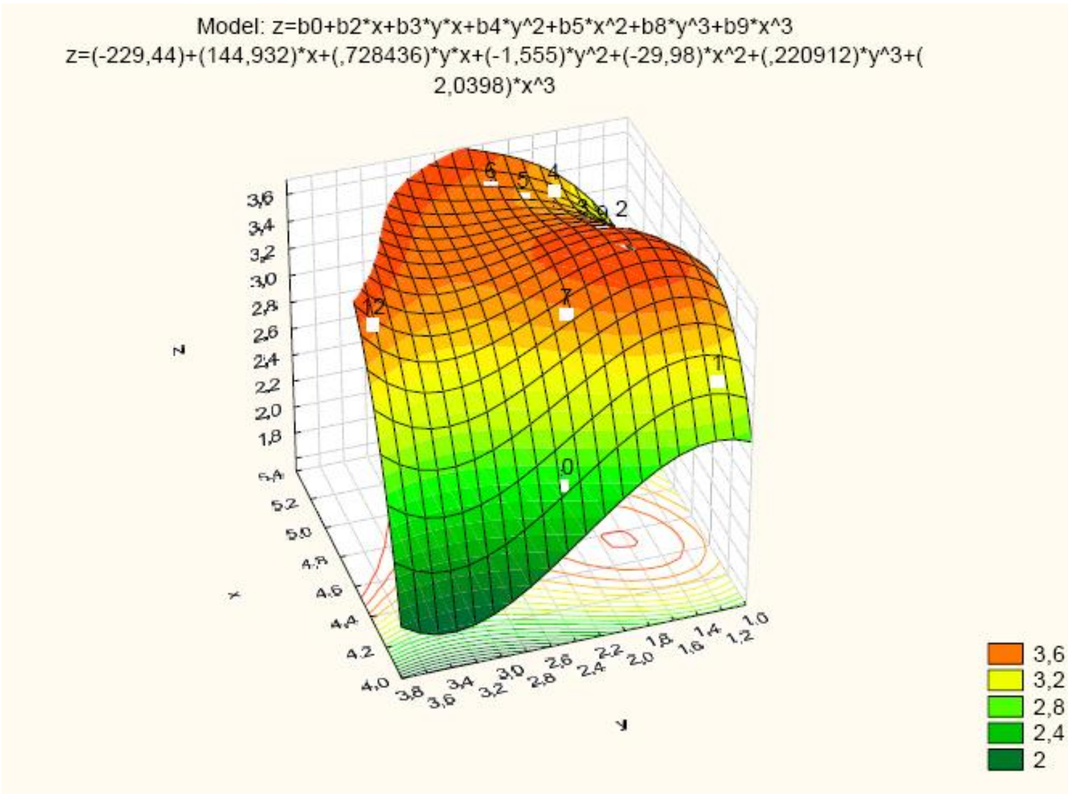

Figure 3 :- Graphic (response surface) with local maximum

Conclusion:-

The results obtained in this paper allow one to see the impact of complex action of enzymes during pretreatment rape seeds to increase oil output by breaking down cell walls and membranes. We built the polynomial regression model of enzymatic processing. Using obtained surface we find the optimal parameters to take maximum rape oil volume. Future research will be devoted to study similar processes with an arbitrary seeds.

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