PLANNING EXPERIMENTS ON THE DRYING PROCESS OF JERUSALEM ARTICHOKE UNDER THE INFLUENCE OF A PULSED ELECTRIC FIELD

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Abstract . In this article, the factors affecting the drying process of the root crop of the jerusalem artichoke are studied, from which the temperature of the drying process, drying time, and air flow rate are selected. The range of these factors was determined from the studied literature, existing technological regimes, and research results. The output moisture of the product was taken as the input factor for the process. In addition, the dependence of the input factors on the output factor was expressed through mathematical modeling.

Keywords: drying process temperature, drying time, air flow rate inside the dryer, humidity, model, optimal, drying

Introduction. Experimental study of a process is one of the most basic methods of studying a process. To design experiments, all input parameters of the process and system are considered . Input parameters as drying process temperature , drying time , drying device inside air of the flow speed , product thickness , atmosphere pressure reduce through drying process acceleration possible .

But to the process impact indicator all parameters the impact study more complex problems gives birth . Therefore for raw material thickness and atmosphere pressure unchanged without designated in value leave This is possible . at work above seen from factors process for impact provider main three impact provider factors selectively taken : drying process temperature , drying time , drying device inside air of the flow speed .

Physics and mathematician in the model held experience the results by comparison , physics from the model taken the results to the results of the mathematical model suitable coming options find based on Jerusalem artichoke root vegetable drying process optimal values for clear is found .

Material and methods. The drying of agricultural products is a crucial process for preservation and value addition. Conventional drying methods, however, often suffer from drawbacks like long drying times, uneven drying, and potential nutrient degradation. Applying an pulsed electric field during drying is a promising

technique to enhance the process, potentially reducing drying time and improving product quality. This article explores the use of planning, a statistically efficient experimental design, to optimize the drying of jerusalem artichoke under the influence of an pulsed electric field. Influential of factors to the process impact indicator to the point according to qualified , physicist to the model experience transfer for factors selectively received . Selected of factors border values of the process feature and literature analysis based on selectively taken and we see in Table 1 possible .

Table-1. Selection taken values change intervals .

No.	**Impact provider factors**	**Lower border**	**High border**
1	Drying process temperature ; ^{0}C	55	60
2	Drying time ; minute	180	210
3	Drying device inside air of the flow speed ; m/s	1	3

Jerusalem artichoke root vegetable dry process student factor as of the product humidity selectively received .

Jerusalem artichoke root vegetable drying process experiences following plan based on We conducted 3 incoming calls . factor and 1 outgoing to the factor the impact we learned .

Research methods experiments with combined , this very big expenses , power and requires resources , because others unchanged under the circumstances separately independent of variables to change is based on .

Scientific experiments , rule in general , many factorial become it seems and being studied of materials quality optimization , technological processes done increase for acceptable conditions search , equipment further acceptable constructions working exit and others with related will be .

Such research object was systems so much are considered complex , so that they theoretical in terms of own on time study possible not . Implemented scientific and experimental of affairs enough to the amount despite , presumably information based on many conclusions is taken and that's why It is not optimal for .

Several of factors drying during to humidity the impact study for , Jerusalem artichoke root vegetable drying process mathematician model to compose for to the process impact 3 factors that contribute that is drying temperature , drying time and drying in the camera of the air speed exit factor of the product humidity dependence seeing We will go out . The effect of humidity on y (%) doer factors as the following selected :

Z_1 – drying temperature (^{0}C); $Z_1^- = 55, Z_1^+ = 60$;

Z_2 – Jerusalem artichoke root vegetable drying time (min); $Z_2^- = 180, Z_2^+ = 210$

Z_3 – convective drying on the device of the air speed (m/s); $Z_3^- = 1, Z_3^+ = 3$

Factors all mutual the impact into account received without regression equation to compose , to compose comment and created the model adequacy verification required . Full factorial the experiment planning matrix and taken The results are presented in Table 2 .

Table-2. Complete factorial the experiment planning matrix

No.	Learned factors			Experimental results		
	z_1	z_2	z_3	y_1	y_2	y_3
1	1	1	1	7.8	9.2	10.3
2	-1	1	1	8.3	7.4	9.4
3	1	-1	1	6.8	7.3	9.2
4	-1	-1	1	10.6	10.4	10.8
5	1	1	-1	9.2	9.8	9.5
6	-1	1	-1	8.3	7.1	7.8
7	1	-1	-1	9.1	10.2	11.3
8	-1	-1	-1	11.4	8.7	9.3

Every one effect provider factor for we center , change interval and encoded x_i of the variable natural z_i to connection Let's find out .

Each experience for us on average sample the results we calculate :

$$\overline{U}_i = \frac{(y_{1i}+y_{2i}+y_{3i})}{3} \qquad (1)$$

The following expression using regression equation coefficients Let's find out .

$$b_i = \frac{1}{8}\sum_{j=1}^{8} \overline{u}_j \qquad (2)$$

Accuracy for us table we will build , regression equation found coefficients we enter .

Regression equation coefficients

b_0	b_1	b_2	b_3	b_{12}	b_{13}	b_{23}	b_{123}
9.1333	0.0083	-0.4583	-0.1750	0.6167	-0.5333	0.2333	0.2750

Reproductive dispersion find $S^2_{\{y\}}$

$$S^2_{\{y\}} = \frac{1}{n(m-1)}\sum_{j=1}^{n}\sum_{i=1}^{m}(y_{ji}-\overline{y_j})^2 = \frac{1}{n}\sum_{j=1}^{n}\left(\frac{1}{m-1}\sum_{i=1}^{m}(y_{ji}-\overline{y_j})^2\right) = \frac{1}{n}\sum_{j=1}^{n} S_j^2$$

Here internal S_j^2 summaries j- experience according to experience of the

results selection variances (j= 1,… ,n). Convenience For this we present the calculations in the form of Table 3. presented we will .

Table-3. Sample differences calculation

j	y_1	y_2	y_3	$\overline{y}_j$	$(y_{j1}-\overline{y_j})^2$	$(y_{j2}-\overline{y_j})^2$	$(y_{j3}-\overline{y_j})^2$	S_j^2
1	7,800	9,200	10,300	9,100	1.6900	0.0100	1.4400	1.5700
2	8,300	7,400	9,400	8,367	0.0044	0.9344	1.0678	1.0033
3	6,800	7,300	9,200	7,767	0.9344	0.2178	2.0544	1.6033
4	10,600	10,400	10,800	10,600	0.0000	0.0400	0.0400	0.0400
5	9,200	9,800	9,500	9,500	0.0900	0.0900	0.0000	0.0900
6	8,300	7,100	7,800	7,733	0.3211	0.4011	0.0044	0.3633
7	9,100	10,200	11,300	10,200	1.2100	0.0000	1.2100	1.2100
8	11,400	8,700	9,300	9,800	2.5600	1.2100	0.2500	2.0100

Table last column elements generalization :

$$\sum_{j=1}^{n} S_j^2 = 7{,}8900 \qquad (3)$$

From here we get repeatability the difference we get :

$$S_{\{y\}}^2 = \frac{1}{8}\sum_{j=1}^{8} S_j^2 = \frac{1}{8}\cdot 7{,}89 = 0{,}98625 \qquad (4)$$

We are the coefficients standard deviation we define :

$$S_{KOEF} = \sqrt{\frac{S_{\{y\}}^2}{n\cdot m}} = \sqrt{\frac{0{,}98625}{8\cdot 3}} = 0{,}2027 \qquad (5)$$

Student's freedom degrees number according to distribution from the tables n(m-1)=8·2=16 significance at the level α=0.05 $t_{kr.} = 2{,}12$. we find . The coefficient $t_{kr} \times S_{koef.} = 2.12\times 0.2027 = 0.4297$

Received the value compare $t_{kr}.\ S_{coef} \approx 0.4297$ in the table cited regression equation coefficients with S_{coeff} we b except $_{1,2,3}$ all coefficient 0.4297 absolute in value big that We'll see . That's why for $b_1, b_3, b_{23}, b_{1,2,3}$ except all odds important importance Assume the coefficients $b_1, b_3, b_{23}, b_{1,2,3} = 0$. if we do , it is encoded in variables regression equation we get :

$$y = 9.13 - 0.46x_2 + 0.62x_1x_2 - 0.53x_1x_3 \qquad (6)$$

Received The consistency of equation (6) is verified by the Fisher criterion . using We will check . Again working release dispersion previous in the bag found because of , F_{rasch} criterion calculated value determination for . S^2_{res} residue dispersion calculation need .

For this we have taken $\tilde{y}_j$ (j= 1,... , 8) regression from the equation using , studying parameter values to j number according to x_i instead of +1 or -1 putting we find :

S^2_{ocm} From the formula using , leftover dispersion we count ;

$$S^2_{ost} = \frac{3}{8-7}\sum_{j=1}^{8}(\tilde{y}_j - \overline{y_j})^2 = 3{,}85833 \qquad (7)$$

Fisher's criterion calculated value F_{rasch} formula with is determined ;

$$F_{rasch} = \frac{S^2_{ost}}{S^2_{\{y\}}} = \frac{3{,}85833}{0{,}98625} = 3{,}91 \qquad (8)$$

F_{tab} criterion table The value of the Fisher distribution critical points from the tables $k_1 = n - r = 8 - 7 = 1$ and $k_2 = n(m-1) = 8 \cdot 2$ degrees of freedom to the levels corresponding to $\alpha = 0.05$ significance at the level we find . = 16, $F_{tab} = 4.49$

$F_{tab} = 3.91 < F_{tab} = 4.49$ for (3.5) regression equation adequate will be . Obtained the model let's comment

$$y = 9.13 - 0.46x_2 + 0.62x_1x_2 - 0.53x_1x_3 \qquad (9)$$

From the equation visible so that x_3 , x_2 and x_1 factors strong to the effect have , drying temperature , drying time and drying device inside of the air speed because they joint in value the most big to the coefficient has .

Regression Equation (6) in natural variables we write , x_i instead of their expressions z_i through we put , we are the table last from the column we will get

$$y = 9.13 - 0.4\left(\frac{Y-195}{15}\right) + 0.62\left(\frac{X-57.5}{2.5}\right)\left(\frac{Y-195}{15}\right) - 0.53\left(\frac{X-57.5}{2.5}\right)(Z-2)$$

$$y = 176.11 - 0.98133Y + 0.01653XY - 2.8X - 0.212XZ + 12.19Z (3.29)$$

Impulse electric field drying represents a transformative approach to the preservation of agricultural products like jar roots. By accelerating drying, preserving quality, and reducing energy consumption, this technology addresses many limitations of conventional methods. Continued research and development will enable its integration into commercial food processing systems, ensuring sustainable and efficient drying solutions.

Conclusion. It can be said that the dependence of the factors affecting the drying process of Jerusalem artichoke root by treating it with a pulsed electric field was studied. As a result of the research, it was found that when the temperature during the drying process was 60 ^{0}C, the drying time was 210 minutes, and the air velocity in the chamber was 1 m/s, the final moisture content of the Jerusalem artichoke root was 7-8%. An equation of the dependence of the factors affecting the process on the moisture content of the product was constructed. The adequacy of the constructed equation was checked using the Fisher criterion.

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