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Regress models of ion-ozon treatment without and with cavitation, describing changes of indicators for grain crops quality

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Abstract. The effect of ionic, ozone, ion-ozone and ion-ozone cavitation treatment on the safety of such grain crops as spring wheat of "Kazakhstanskaya-10" and "Aray" varieties, "Baisheshek" variety, "Alaman" oats, "Taza Elita" triticale have been studied. Use in the preparation of seeds of cereal crops of the above treatments strengthens their effect on grain cells, increasing the viability of the germinal part in them, which ultimately improves the overall ecological state of the seeds and activates biological processes that increase the seed properties of the grain.

Key words. Ion-ozone treatment, cavitation, grain crops quality.

1. Introduction

Storage is an important stage in the technologies of production and processing of grain, which plays a primary role in ensuring the safety of both the grain itself and the products of its processing [1–3]. To ensure the requirements of environmen-

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tal standards and the safety of grain products from seed preparation in cultivation to transport, primary processing at grain enterprises, storage and further processing with flour, cereals, mixed fodders, bread, pasta, confectionery and other food products, pay attention to the initial quality of the crops used in this chain [4–7]. Our research was carried out in the research laboratory of innovative technologies of food and processing industries of Almaty Technological University. Observations were made that showed that the yield increases when treated with molecular ions [8–9].

2. Methodology

The objects of the research are seeds of grain crops: spring wheat of "Kazakhstanskaya - 10" and "Aray" varieties, "Baisheshek" variety, "Alaman" oat, "Taza Elita" triticale, green plants of these crops in the phase of complete earing. Processing methods: ionic, ozone, ion-ozone and ion-ozone cavitation treatment of presowing material in the field of charged particles of molecular and atomic ions. At the same time all ion-ozone treatments without and with cavitation are carried out in ionizing plants, in which the laths regulating the voltage of electric current and, accordingly, the synthesis of atomic and molecular oxygen ions were installed.

Characterization of the grain mass after the treatment was determined by the parameters: temperature, acidity, respiration rate. The parameters of temperature and acidity were determined by conventional methods. To determine the intensity of breathing, the technique proposed by the All-Union Scientific Research Institute of Grain (VNIIZ), based on the quantitative registration of carbon dioxide released by the grain during respiration, is applied, expressed in milligrams of carbon dioxide released per 100 g of dry matter per day.

3. Results

The analysis of technological properties of grain crops was carried out in accordance with the following normative documents: ST RK GOST R 51411-2006 - Grain and derivative products. Ash determination; GOST 10845-98 - Grain and derivative products. Method for starch determination; GOST 10846-91 - Grain and derivative products. Method for protein determination; GOST 12041-82 - Seeds of agricultural crops. Method for humidity determination; GOST 12042-84 - Mass of 1000 grains; ISO 5529: 1992 – Green Index; GOST 10968-88 - Grain. Methods for determining germination energy and germination capacity. The condition of grain conservation is closely related to the physiological process of breathing during storage. As is known, the general state of the grain mass is mainly determined by humidity and temperature. The intensity of breathing is directly depends on these two parameters. Acidity and carbon dioxide CO_2 emission in % are determined by standard methods at room temperature from $25\,^\circ$ div $25.7\,^\circ$ and grain moisture $W_g = 13.0\,\%$.

The results of full-factorial experimental studies on the dependency determination of ion concentration to ozone concentration x_1 (u/mg), humidity before treatment x_2 (%), and treatment time x_3 (min), are given by the varieties of grain crops in Table 1.

An analysis of the data of Table 1 for varieties of cereal crops shows that the increase in the acidity of the grains is mainly observed in the grain with a moisture content of 20.0 % compared to the initial samples, with a moisture content of 13.0 %, no change occurs. The value of the acidity of wheat grains fluctuated from experiments of 1.46 to 2.4 degrees. By the triticale, the maximum acidity value was in the range from 1.50 to 1.80 degrees. The change in barley acidity was from 1.35 to 1.77 degrees, and oat—from 1.38 to 3.06 degrees.

Analyzes of the data in Table 2 show that in case of ion-ozone cavitation treatment the grain is better prepared and becomes more resistant to storage, in comparison with ion-ozone treatment. This is confirmed by data on the values of acidity and respiration rate for the release of CO_2. This is most typical for "Kazakhstan-10" wheat, as only in one experiment No. 8 the acidity value was equal to 1.54 degrees, and in the remaining cases, with ion-ozone cavitation treatment in comparison with ion-ozone treatment, the acidity value was 1.5 and 2 times lower and ranged from 0.80 to 1.33 degrees. Similar changes are characteristic for all other cereal crops.

Data processing and calculations were carried out using the algorithm developed by Odessa National Academy of Food Technologies and PLAN sequential regression analysis program. Calculations of the coefficients are carried out with respect to matrices in the natural dimension and, accordingly, the equations are obtained in the natural dimension. This is why, after recalculating the remaining significant coefficients, both the values of the coefficients and their errors change.

The general form of the equations for three factors is

$$y = b_0 + b_1x_1 + b_2x_2 + b_3x_3 + b_{12}x_1x_2 + b_{13}x_1x_3 + b_{23}x_2x_3 \,,$$

while the general form of the equations for four factors is

$$y = b_0 + b_1x_1 + b_2x_2 + b_3x_3 + b_4x_4 + b_{12}x_1x_2 + b_{13}x_1x_3 + b_{14}x_1x_4 + \\ + b_{23}x_2x_3 + b_{24}x_2x_4 + b_{34}x_3x_4 \,.$$

In the equations, the factors are denoted in natural notation, since x_1 denotes the coded values of the factors. Then, for three factors the equation has the following form:

$$y = b_0 + b_1C + b_2w + b_3\tau + b_{12}Cw + b_{13}C\tau + b_{23}w\tau \,,$$

and for four factors

$$y = b_0 + b_1C + b_2P + b_3w + b_4\tau + b_{12}CP + b_{13}Cw + b_{14}C\tau + \\ + b_{23}Pw + b_{24}P\tau + b_{34}w\tau \,.$$

Here, b is the regression coefficient, e denotes the confidence intervals for the corresponding coefficients, x_1 stands for the ratio of ion concentration to ozone concentration (units/mg), x_2 denotes the excess pressure (atm), x_3 is the sample humidity (%) and x_4 stands for the treatment time (min).

Table 4. Calculation of regression coefficients by the method of least squares according to the linear plan, taking into account the interfactor interactions, germination for 7 days – 2^4

Name		Form of equation (optimization)	Numerical characteristic			
			Mean value	Mean-square deviation	Crireria	
					Fisher F_c	Student t_{cr}
Wheat	Kaz-10	y_{germ}=86.667 +1.583x_2 +3.6325x_4 –0.255x_3x_4	79.1	s_y = 2.1000, s_i = 8.2929	F_c = 15.59, F_{cr} = 19.41	4.304
	Array	y_{germ}=96.625 +2.286x_4 –0.176x_3x_4	84.165	s_y = 2.2000, s_i = 4.8000	F_c = 4.76, F_{cr} = 19.42	4.304
Triticale	Taza elita	y_{germ}=192.342 +6.417x_2 +8.304x_3 +0.917x_4 –0.492x_2x_4	62.25	s_y = 1.8700, s_i = 6.2208	F_c = 11.07, F_{cr} = 19.40	4.304
Barley	Baisheshek	y_{germ}=98.25 +0.769x_4 –0.0557x_3x_4	95.25	s_y = 0.6000, s_i = 1.8166	F_c = 9.17, F_{cr} = 19.42	4.304
Oats	Alaman	y_{germ}=137.393 –2.982x_3	88.19	s_y = 2.7000, s_i = 7.5469	F_c = 7.81, F_{cr} = 19.42	4.304

Table 2. Calculation of regression coefficients by the method of least squares according to the linear plan, taking into account the interfactor interactions, mass for 7 days – 2^4

Name		Form of equation (optimization)	Numerical characteristic			
			Mean value	Mean-square deviation	Crireria	
					Fisher F_c	Student t_{cr}
Wheat	Kaz-10	y_{mts}=17.583 +3.309x_2 +1.333x_3 –0.1905x_2x_3	39.75	s_y = 0.9000, s_{ag} = 2.3979	F_c = 7.10, F_{cr} = 19.41	4.304
	Array	y_{mts}=20.213 +0.673x_1 –0.583x_2 +1.219x_3 –0.0408x_1x_3	38.875	s_y = 0.7500, s_{ag} = 1.6307	F_c = 4.73, F_{cr} = 19.40	4.304
Triticale	Taza elita	y_{mts}=43.0357 +6.7857x_3	56	s_y = 1.4000, s_{ag} = 2.4349	F_c = 3.027, F_{cr} = 19.42	4.304
Barley	Baisheshek	y_{mts}=35.679 +1.053571x_3	53.06	s_y = 0.8900, s_{ag} = 2.4404	F_c = 3.37, F_{cr} = 19.42	4.304
Oats	Alaman	y_{mts}=23.0403 –1.693x_2 +0.123x_1x_2 –0.01988x_1x_4	35.615	s_y = 0.8900, s_{ag} = 2.9813	F_c = 11.22, F_{cr} = 19.40	4.304

In Tables 1 and 2, s_y and s_i denote the standard deviations of the mean experimental result and inadequacy, respectively. Symbols F_c and F_{cr} stand for the calculated and critical (tabular) values of the F test; all of them adequately describe the experimental data, since $F_c \leq F_{cr}$ (for confidence level 0.05). Finally, t_{cr} is the critical (tabular) value of Student criterion (for the significance level of 0.05).

Table 3. Calculation of regression coefficients by the method of least squares according to the linear plan, taking into account the interfactor interactions, wet gluten – 2^4

Name		Form of equation (optimization)	Numerical characteristic			
			Mean value	Mean-square deviation	Crireria	
					Fisher F_c	Student t_{cr}
Wheat	Kaz-10	y_{wg}=28.483 –0.0988x_1 +0.278x_2 –0.3102x_3	23.265	s_y = 0.3720, s_{ag} = 0.9141	F_c = 6.04, F_{cr} = 19.41	4.304
	Array	y_{wg}=33.212 –0.3770x_3 –0.1199x_4	25.19	s_y = 0.5400, s_{ag} = 1.1909	F_c = 4.86, F_{cr} = 19.42	4.304
Triticale	Taza elita	y_{wg}=20.535 +0.1846x_2	20.995	s_y = 0.2300, s_{ag} = 0.6364	F_c = 7.66, F_{cr} = 19.42	4.304

Table 3. Calculation of regression coefficients by the method of least squares according to the linear plan, taking into account the interfactor interactions, wet gluten – 2^4

Name		Form of equation (optimization)	Numerical characteristic			
			Mean value	Mean-square deviation	Crireria	
					Fisher F_c	Student t_{cr}
Wheat	Kaz-10	y_{ur}=202.542 –1.104x_1 +5.8304x_3	289.9	s_y = 6.2200, s_{ag} = 12.631	F_c = 4.51, F_{cr} = 19.42	4.304
	Array	y_{ur}=347.84875 –1.40325x_4	326.8	s_y = 6.1700, s_{ag} = 13.108	F_c = 4.51, F_{cr} = 19.42	4.304
Triticale	Taza elita	y_{ur}=111.614881 –5.663x_1 +6.0308x_2 +612.5736x_3 –3.973929x_4 +0.407x_1x_4	274.9	s_y = 6.9500, s_{ag} = 24.964	F_c = 12.90, F_{cr} = 19.39	4.304

Parameter x_1 in the experiment planning matrix dimension was reduced 1000 times (unit/g instead of units/mg) in order to make calculations of the coefficients more convenient.

4. Conclusion

The initial seeds of the investigated varieties of cereal crops: wheat, triticale, barley and oats in a dry and medium dry state and a temperature of 18 ° to 25 ° are characterized by sufficient resistance to storage in terms of the respiratory process index.

Ion-ozone treatment of grain seeds of dry and wet conditions promotes the preservation of the resistance to storage of the investigated varieties of wheat, triticale, barley and oats, without increasing acidity and respiration rate.

Table 5. Calculation of regression coefficients by the method of least squares according to the linear plan, taking into account the interfactor interactions, acidity – 2^4

Name		Form of equation (optimization)	Numerical characteristic			
			Mean value	Mean-square deviation	Crireria	
					Fisher F_c	Student t_{cr}
Wheat	Kaz-10	y_{ac}=0.000 +0.0346x_1 –1.335x_2 +0.0414x_3 +0.11156x_4 –0.0025x_1x_4 +0.0098x_2x_3 –0.0051x_3x_4	1.135	s_y = 0.0.0300, s_{ag} = 0.1217	F_c = 16.45, F_{cr} = 19.38	4.304
	Array	y_{ac}=0.000 +0.0598x_3 +0.101x_4 –0.00506x_3x_4	1.310	s_y = 0.0600, s_{ag} = 0.2294	F_c = 14.62, F_{cr} = 19.42	4.304
Triticale	Taza elita	y_{ac}=5.574 –0.04550x_1 –0.344167x_2 –0.238988x_3 –0.1565x_4 +0.0023x_1x_4 +0.0192x_2x_3 +0.008393x_3x_4	1.24	s_y = 0.5000, s_{ag} = 0.1978	F_c = 15.66, F_{cr} = 19.37	4.304
Barley	Baisheshek	y_{ac}=3.35 –0.0172x_1 –0.0834x_3 –0.024125x_4	1.475	s_y = 0.0570, s_{ag} = 0.2460	F_c = 18.627, F_{cr} = 19.41	4.304
Oats	Alaman	y_{ac}=5.2927 +0.9913x_2 –0.222x_3 +0.01054x_1x_2 –0.0032x_1x_4 –0.0042x_2x_3 –0.0355x_2x_4 +0.006122x_3x_4	2.23	s_y = 0.0700, s_{ag} = 0.1972	F_c = 7.94, F_{cr} = 19.37	4.304

Ion-ozone cavitation treatment of grain seeds of dry and wet conditions makes it possible to create more favorable conditions for storage of the investigated varieties of wheat, triticale, barley and oats, in comparison with ion-ozone treatment. We calculated and developed mathematical models describing the changes in seed and technological properties of grain crops seeds under ion-ozone and ion-ozone cavitation preparation of grain seeds, which in the future makes it possible to optimize the technological regimes for IHO and IOC treatment. As a result, 156 regression models were obtained on all grades of cereals based on 23 and 24 full-factor experts for wheat varieties "Kazakhstanskaya-10", "Aray", triticale varieties “Taza Elita”, barley varieties “Baisheshek” and oat varieties “Alaman”.

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