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Ion-ozone-cavitation treated barley "Baysheshek"

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***Abstract*:** *The paper presents mathematical models of ion-ozone treatment without and with cavitation, describing changes in seed properties and technological qualities of barley "Baysheshek". To improve the quality of barley seed and products of its processing during storage, electrophysical processing methods were used on a universal experimental installation. Technologies and technologies of ion-ozone and ion-ozone-cavitation installation for processing grain crops are optimized. As a result of the research, regression and optimal models were developed describing the interrelationships of the regime parameters with the parameters of grain properties and quality, and also the optimal technological regimes of ion-ozone and ion-ozone cavitation treatment are established in preparation for sowing, levels of quality and quality of cereals.*

Keywords: *ion, ozone, cavitation, grain, barley.*

1. Introduction

At the basis of increasing the biological value of processed seed and food grains and obtaining the effect, structural and functional changes in the membrane formations of cells and intracellular organelles, which in our understanding are the targets of ion-ozone-cavitation [1-2].

As a result of this interaction, a physico-chemical basis is created to change the metabolic processes associated with the transfer of protons and electrons in the cell membranes, and on this basis, successive nonspecific reactions of the cell and the organism as a whole arise. Differences exist only in the biophysical subtleties of the interaction of ion-ozone-cavitation and biotissues [3].

The regulated effect on the biological environment of the ion-air-ion mixture with the use of ion-ozone-cavitation allows intensive bubbling with activation and stimulation of biological media of crop production, as well as inhibiting viruses, bacteria, spore formations with the retention of physiological and physicochemical processes in them, suppression of their infectious activity.

To increase seed, productivity and technological properties of the grain at the short and long-term storage is effective ion-ozone processing of grain products in the flow of electrically charged particles, which allows to use the potential of biological and ecological resources [4].

In order to increase the efficiency of the use of crop production, Alamty technological university scientists developed various electrophysical methods for processing, storing and processing crop production: ion-ozone, ion-ozone-cavitation processing of crop production, which contribute to improving the quality and conservation of grain [5-6].

2. Methods

Experimental studies were carried out in accordance with the plan of full-factor experiments at room temperature 18-23 ° C. In the ion-ozone treatment, the crops are loaded into an ion-ozone-cavitation unit pre-filled with an ion-ozone mixture with an ozone concentration of 0.5 mg/dm3 to 4 mg/dm3 and the content of molecular ions in the range from 500 to 60000 unit/cm3. The ratio of ion concentration (U/cm3) to ozone concentration (mg/cm3) Ci/o is (1-15)*106 units/mg, i.e. 1-15 million units / mg. Further, for 10-20 minutes, ion-ozone ventilation of grains.

As factors influencing the properties and quality indicators of the barley, the following:

– the ratio of the ion concentration (ppm/cm3) to the ozone concentration (mg/cm3) million units / mg;

- overpressure (for cavitation treatment) P, ati;

- humidity of samples before treatment w,%;

- processing time $\tau 1$, min.

On the basis of the least squares studies performed, algorithms and programs of sequential regression analysis developed in the Odessa Technological Institute of Food Industry [7, 8] obtained regression equations, adequately (by the Fisher criterion) describing the dependencies of the above indices of the quality of the processed grain crops, respectively, on the conditions and regimes of their ion-ozone-cavitation and ion-cavitation treatment.

The analysis of technological properties of grain crops was carried out in accordance with the following normative documents: GOST 12041-82 - Seeds of agricultural crops. Method for humidity determination; GOST 10968-88 - Grain. Methods for determining germination energy and germination capacity; GOST 10846-91 - Grain and derivative products. Method for protein determination; ST RK GOST R 51411-2006 - Grain and derivative products. Ash determination; GOST 12042-84 - Mass of 1000 grains; ISO 5529: 1992 – Green Index; GOST 10845-98 - Grain and derivative products. Method for starch determination.

3. Main Part

Ozone and molecular ions contribute to oxidation-reduction processes in biological media. Transition of negative and positive ions from one substance to another means oxidation of the first and restoration of the second, which is accompanied by the acquisition or loss of energy potential. Oxidation-reduction abilities of ozone and ions contribute to metabolism. Including all the variety of reactions occurring in a living organism: oxidation, reduction, cleavage, integration of molecules, intermolecular transfer, etc. for the development of the cellular system [9-10].

The use of molecular ions has a positive effect on the germination, growth, productivity, preservation of a number of plants during presowing cultivation, growing, storage, including in greenhouses at any time of the year. In this paper, we present the results of studies on the use of ion-zone and ion-ozone-cavitation seedbed seed treatment in the field of cavitation with the aim of increasing the productivity, the viability of seeds and the technological properties of grain crops for the production of environmentally friendly products of processing.

In experimental studies, two methods of processing grain crops were studied:

1. Ion-ozone treatment of grain crops;

2. Ion-ozone-cavitation processing of grain crops.

The experiments were carried out under normal processing conditions - at room temperature 18-25 ° C.

Quality indicators of control (unprocessed) cereal crops are given in Table 1. The matrices for planning experiments with the experimental conditions and the results of determining the quality indicators of the treated crops are given in Tables 2,3.

The regression equations obtained on the basis of processing the results of the experiments are given below in the corresponding mathematical models used in optimizing the processing regimes of the cultures studied. All the equations obtained adequately describe the experimental data.

TABLE I: Quality indicators of control (unprocessed) samples of barley "Baysheshek"

Samples (cultivars) of crops	Seed properties			Technological properties						
				Physical				Biochemical		
	Germination energy for 3 days,%	Growth capacity for 5 days, %	Germination for 7 days,%	Moisture before treatment, %	Nature, g / l	Density, g / cm^3	Weight of 1000 grains, g	Mass fraction of protein, %	Starch, %	Green Index, ml
	Function Indicators									
	y_1	y_2	y_3	y_4	y_5	y_6	y_7	y_8	y_9	y_{10}
Barley «Baishes hek»	97	98	100	12,66	642	1,12	49	9,59	65,03	32,12
	97	98	98	18,94	614	1,11	52	5,57	57,87	29,81

TABLE II: Conditions and results of full-factorial experiments of FFE-23 on ion-ozone treatment of barley "Baysheshek"

Experiment Numbers	Ratio of ion concentrations to ozone, million units / mg	Moisture before processing, %	Processing time, min	Seed properties			Technological properties						
							Physical				Biochemical		
				Germination energy for 3 days,%	Growth capacity for 5 days, %	Germination for 7 days, %	Moisture before treatment,%	Nature, g / l	Density, g / cm^3	Weight of 1000 grains, g	Mass fraction of protein, %	Starch, %	Green Index, ml
	Experimental conditions			Quality indicators									
	$C_{i/o}$, mln. units/mg	w, %	τ, min.	y_1	y_2	y_3	y_4	y_5	y_6	y_7	y_8	y_9	y_{10}
1	15	20	20	89	89	90	16,68	627	1,11	60	8,88	61,34	32,24
2	1	20	20	86	88	89	17,32	622	1,12	62	8,15	61,05	32,54
3	15	20	20	85	99	99	12,75	634	1,11	52	9,82	63,96	33,48
4	1	20	20	89	99	99	12,72	638	1,09	46	9,60	64,24	33,27
5	15	13	20	84	87	88	17,11	621	1,09	58	8,42	60,98	32,74
6	1	13	20	86	87	89	17,47	614	1,11	60	8,78	61,34	33,15
7	15	13	20	95	99	99	12,72	638	1,12	53	9,83	64,29	32,63
8	1	13	20	92	99	99	12,64	635	1,09	46	9,85	64,19	34,03

TABLE III: Conditions and results of full-factorial experiments of FFE-2^4 on the ion-ozone-cavitation processing of barley "Baysheshek"

Experiment Numbers	Ratio of ion concentrations to ozone, million units / mg	Overpressure (cavitation), ati	Moisture before processing, %	Processing time, min	Seed properties			Technological properties						
								Physical				Biochemical		
					Germination energy for 3 days, %	Growth capacity for 5 days, %	Germination for 7 days, %	Moisture before treatment,%	Nature, g / l	Density, g / cm^3	Weight of 1000 grains, g	Mass fraction of protein, %	Starch, %	Green Index, ml
	Experimental conditions				Quality indicators									
	$C_{i/o}$, mln. units/ mg	*P*, atm.	*w*, %	τ, min.	y_1	y_2	y_3	y_4	y_5	y_6	y_7	y_8	y_9	y_{10}
1	15	4	20	20	92	93	93	17,57	615	1,11	57	8,10	61,19	35,42
2	1	4	20	20	88	92	92	17,04	625	1,11	60	7,75	60,37	33,10
3	15	1	20	20	85	87	89	17,44	615	1,11	56	8,03	61,15	33,53
4	1	1	20	20	90	91	92	17,27	622	1,11	61	8,77	61,19	36,96
5	15	4	13	20	98	98	99	12,64	635	1,11	49	9,41	64,15	34,45
6	1	4	13	20	96	98	98	12,48	639	1,11	50	9,00	64,55	33,28
7	15	1	13	20	98	99	99	12,75	632	1,11	48	9,26	63,83	35,89
8	1	1	13	20	98	100	100	12,72	639	1,11	48	9,58	63,85	34,28
9	15	4	20	10	91	91	91	17,51	618	1,11	60	8,26	60,64	35,76
10	1	4	20	10	94	95	95	17,18	616	1,12	54	8,55	61,56	34,76
11	15	1	20	10	97	98	98	17,43	621	1,11	53	8,33	60,83	33,27
12	1	1	20	10	93	94	94	17,22	622	1,12	53	8,19	61,18	34,51
13	15	4	13	10	96	97	97	12,8	634	1,11	49	9,19	63,74	32,52
14	1	4	13	10	98	100	100	12,77	637	1,11	50	9,70	63,85	34,58
15	15	1	13	10	98	99	99	12,77	631	1,11	50	9,59	64,27	33,49
16	1	1	13	10	100	100	100	12,78	636	1,09	51	9,62	63,57	34,29

Restrictions on the range of variation in the regime parameters of ion-ozone treatment of all the investigated cereal crops were as follows:

1 mln. unit/mg $\leq C_{i/o} \leq$ 15 mln.unit/mg; 13 % $\leq w \leq$ 20 %; 10 min$\leq \tau_1 \leq$ 20 min.

The mathematical model for optimizing the modes of ion-ozone treatment of barley of the barley «Baysheshek» has this form:

Seed properties:

– objective function:

$80 \leq y_1 = 132{,}50 - 2{,}50 \cdot w - 2{,}32 \cdot \tau + 0{,}129 \cdot w \cdot \tau, \% \leq 100 \rightarrow max;$

– restrictions on quality indicators:

$85 \leq y_2 = 119{,}89 + 1{,}61 \cdot w, \% \leq 100;$

$85 \leq y_3 = 117{,}57 - 1{,}43 \cdot w, \% \leq 100.$

Physical properties:

– objective function

$1{,}0 \leq y_6 = 1{,}105, g/cm^3 \leq 1{,}2 \rightarrow max;$

– restrictions on quality indicators:

$12{,}0 \leq y_4 = 4{,}47 + 0{,}634 \cdot w, \% \leq 22{,}0;$

$600 \leq y_5 = (62{,}86)\cdot 10$ g/l ≤ 650;
$45{,}0 \leq y_7 = 16{,}55 + 1{,}59\cdot C_{и/о} + 2{,}23\cdot w - 0{,}0867\cdot C_{i/o}\cdot w$, g $\leq 65{,}0$;
Biochemical properties:
– objective function
$5{,}5 \leq y_8 = 12{,}04 - 0{,}174\cdot w$, % $\leq 10{,}0 \rightarrow max$;
– restrictions on quality indicators:
$56{,}0 \leq y_9 = 62{,}67$, % $\leq 75{,}0$;
$28{,}0 \leq y_{10} = 33{,}01$, % $\leq 35{,}0$.

The nature of the dependence of the energy of barley germination "Baysheshek" on the factors w and τ is shown in Figure 1. The remaining dependencies of objective functions on the investigated factors, as follows from mathematical models, do not need a graphical representation.

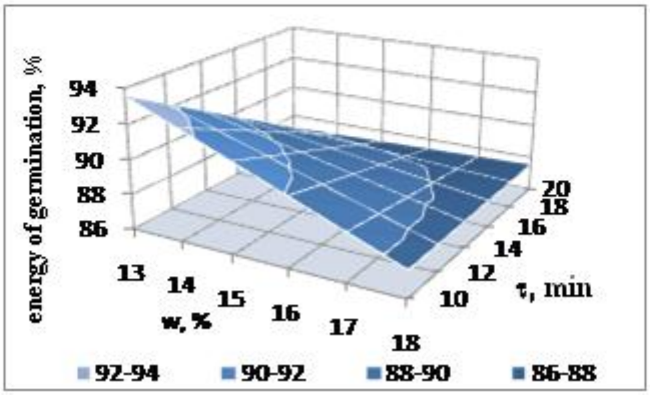

Fig. 1: Surfaces of the response of the dependence of the energy of barley germination "Baysheshek" on the factors w and τ

The mathematical model for optimizing the modes of ion-ozone-cavitation processing of barley of the barley «Baysheshek» has this form:
Seed properties:
– objective function
$84 \leq y_1 = 113{,}95 - 0{,}929\cdot w - 0{,}275\cdot \tau$, % $\leq 100 \rightarrow max$;
– restrictions on quality indicators:
$86 \leq y_2 = 113{,}48 - 0{,}893\cdot w - 0{,}200\cdot \tau$, % ≤ 100;
$88 \leq y_3 = 98{,}25 + 0{,}769\cdot \tau - 0{,}0557\cdot w\cdot \tau$, % ≤ 100.
Physical properties:
– objective function
$1{,}0 \leq y_6 = 1{,}11$, g/cm$^3 \leq 1{,}14 \rightarrow max$;
– restrictions on quality indicators:
$12{,}0 \leq y_4 = 4{,}14 + 0{,}660\cdot w$, % $\leq 18{,}0$;
$600 \leq y_5 = 627{,}3$, g/l ≤ 650;
$47{,}0 \leq y_7 = 35{,}68 + 1{,}05\cdot w$, г $\leq 62{,}0$;
Biochemical properties:
– objective function
$7{,}0 \leq y_8 = 11{,}59 - 0{,}167\cdot w$, % $\leq 11{,}0 \rightarrow max$;
– restrictions on quality indicators:
$55{,}0 \leq y_9 = 62{,}49$, % $\leq 67{,}0$;
$28 \leq y_{10} = 33{,}78 - 0{,}121\cdot C_{i/o} + 0{,}127\cdot \tau + 0{,}0434\cdot C_{i/o}\cdot P - 0{,}0321\cdot P\cdot \tau$, % ≤ 38.

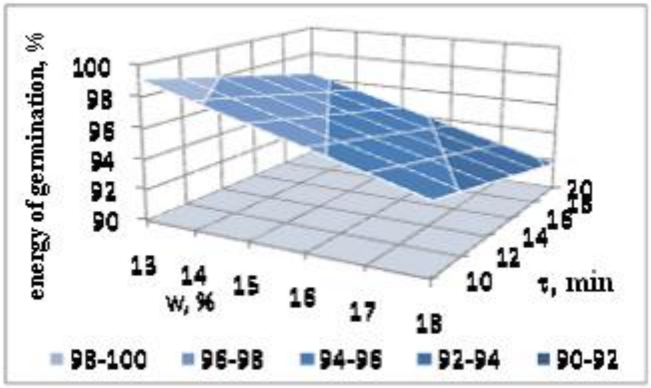

Fig. 2: Surfaces of the response of the dependence of the energy of barley germination "Baysheshek" on the factors w and τ

From the mathematical models it can be seen that all the objective functions of barley have a simple character - the germination energy depends only on two factors (grain moisture and processing time), the density of barley grain does not change statistically (constant), and the mass fraction of the birch depends only on the moisture content of the grain. Therefore, the graphical dependence is presented only for the germination energy (Figure 2). It is seen that it inversely decreases inversely with increasing barley moisture and the duration of its treatment.

To compare the quality of control (unprocessed) samples of the studied cultures and the optimal parameters obtained after their ion-ozone (IO) and ion-ozone-cavitation (IOC) treatment.

Analysis of these tables showed that the optimum regimes of ion-ozone and ion-ozone-cavitation treatment to improve the considered seed, physical, biochemical, flour-milling properties and the state of preservation of grain are the same – optimal results were obtained when processing wet grain (20%). For seed, physical, biochemical, flour-milling and state of preservation, the best results were obtained when processing dry grain (13%).

The analysis of the obtained results also showed that the ratio of ion concentration to ozone concentration for practically all treatment regimes is 1 million units / mg.

The pressure of cavitation and the duration of treatment for different properties affect differently.

Thus, the conducted studies have shown that applying ion-ozone and ion-ozone-cavitation processing of grain can purposefully change (improve) its properties depending on the purpose.

4. Conclusion

We have developed mathematical models describing changes in the seed and technological properties of barley seeds "Baysheshek". As a result, 156 regression models were obtained on the basis of 23 and 24 full-factor experiments.. Full-factorial planning of the 23rd and 24th-degree experiments allowed obtaining regression equations, describing changes in the seminal, physico-biochemical and physiological parameters of barley "Baysheshek" and identify the priority grain indicators for compiling a model of linear and non-linear programming, specifying the target and restrictive functions. Complex programming optimization models for the Baisheshek barley grades allowed to establish optimal processing regimes for processing.

5. References

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