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# Time of exposure to grain processing disinfection in strong electric fields

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A b s t r a c t. A prototype installation is presented developed at the Department of Electric and Electro Technology of the National University of Life and Environmental Sciences of Ukraine, in which, with appropriate electric field intensity in air inclusions partial grain mass discharges are occurring and, accordingly, throughout the volume of products ozone is formed, the concentration of which is governed by the electric field. The results of investigation of barley moisture effect on ozone concentration in the grain mass under the action of a strong electric field are discussed and a nomogram is developed for determining the time required for an effective dose of antiseptic treatment of barley.

K e y w o r d s: Strong electric field decontamination processing, grain weight, nomogram, treatment dose, ozone treatment exposure, humidity.

## INTRODUCTION

The purpose of grain microflora disinfection can be attained by chemical, biological and physical methods. Nowadays grain processing is carried out mainly by chemical means. But along with the achievement of positive results, the use of chemicals has several negative consequences, including environmental pollution by pesticides and their accumulation in soil and in plant products that pose a threat to human and animal health, as well as the complexity of the performance of work [1, 2]. There are also a number of diseases against which chemicals cannot provide the proper effect. This primarily refers to Fusarial diseases and mold fungi that develop during storage. Besides, chemical methods cannot be used in the processing of food supply of grains.

Given these circumstances, in the advanced countries of the world environmentally clean agricultural production is actively developed, by reducing the use of pesticides and alternative methods of plant processing. First of all, it focuses on electrical methods, providing electromagnetic, ionizing, light, ultraviolet, laser, and other seed processing [3, 4, 5]. However, these methods do not have industrial use because of the insufficient clear reproducibility of the results and low efficiency in the fight against disease-causing agents of seeds, some of them being very energy-intensive.

One promising trend developing in the recent years has been the use of strong electric fields for preseeding processing of seed crops in order to stimulate growth processes and processing of the crop during storage in order to neutralize surface microflora [6, 7].

Therefore, the development of a method for determining operating parameters for decontamination processing of grain in the electric field of high voltage for use in a production environment is an urgent task.

## MATERIALS AND METHODS

In recent years, at the Department of Electric and Electro Technology at the National University of Life and

**Fig. 1.** Appearance settings for the processing of cereals in the electric field of high intensity

Environmental Sciences of Ukraine research has been carried out on the application of strong electric fields for preseeding stimulation of seeds and grain handling disinfecting storage [8, 9, 10]. The research resulted a prototype installation, the look of which is shown in Fig. 1.

At the developed installation the grain mass is poured into the processing chamber where it is between high voltage electrodes. The appearance of the treatment chamber is shown in Fig. 2.

**Fig. 2.** Appearance of camera processing

At a corresponding electric field in the volume of products partial discharges occur in air inclusions where the uneven distribution electric field intensity is the maximum [11, 12]. With the increase of the applied voltage, ionization occurs in large amounts of air inclusions, and the momentum of the discharge of air inclusions in the following will be more than in the previous ones.

It will also increase the intensity of the ionization in the inclusions where it started at a lower intensity. With the passage of the ionization processes, in the whole volume of production ozone forms, which is known for its bactericidal properties [13, 14, 15, 16, 17]. The concentration of ozone depends on the electric field and moisture of the grain mass [18].

## RESULTS AND DISCUSSION

As a result of experimental studies an effective dose has been found of disinfecting treatment [19], which is dependent on exposure time and ozone concentration. Determination of the ozone concentration in grain mass involves the time necessary to obtain the effective dose. In a production environment the problem of determining the dose is complicated, since it needs the measurements of ozone complex and laborious processes requiring additional equipment. Therefore, it became necessary to develop an alternative and easy way to determine the dose of grain processing, depending on the known parameters of the crop, such as humidity.

Moisture determines the dielectric properties of grain mass, which significantly affect the discharge processes in it under an electric field of high intensity, and hence the concentration of ozone.

To investigate the influence of humidity on the concentration of ozone, barley variety «Don'ts» was used of the moisture ranging from 12.2% to 17.2%. In the studies dielectric plate of polyethylene was used with the thickness of 0.5 mm, the distance between the electrodes was 3 cm, height mixture of barley 6 cm [20]. The voltage at the electrodes was 16 kV. The results are shown in Table 1.

**Table 1.** Studies of dependence of ozone concentration in the grain weight of its moisture

| № п/п | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|
| W, % | 12,2 | 13,5 | 14 | 14,5 | 15,9 | 16,7 | 17,2 |
| K, мг/м$^3$ | 101,4 | 592,8 | 697,4 | 644,3 | 487,5 | 362,1 | 217,3 |

The analysis of experimental studies presented in Table. 1. shows that the maximum of ozone concentration is achieved with conditioned grain moisture 14-14,5%. This can be explained by the ability of grain mass to move from the state of the insulator to the conductor, depending on humidity. So, at 12% moisture corn is in the state of an insulator and the number of ions in the interstitial fluid is very small. In this state, the grain mass partial discharges occur infrequently and therefore ozone concentration is low. With increasing humidity, the number of ions in the intercellular fluid of grains increases, which contributes to the formation of the electric field in the air inclusions and thus the passage of intense bit processes. Therefore, there is a growth of ozone concentration to moisture content 14.5%. With further increase in moisture, content of ions continues to grow, conduction current begins to flow through the grain mass, which prevents the accumulation of charge in the air inclusions. The intensity of partial discharges is reduced. Thus after humidity of 15%, a gradual reducing of the ozone concentration is observed.

As a result of the research the mathematical dependence $K_o=f(W)$ is described. Analytical expression $K_o=f(W)$ obtained on a PC using software is represented by the expression:

$$K_o = \mathrm{a} + b \cdot W - c \cdot W^2 + d \cdot W^3, \quad (1)$$

where: a = -52834; b = 9891; c = 600; d = 11,88 - coefficients for barley grain mass.

Also to construct a nomogram it was necessary to establish the dependence for determining the exposure time at various concentrations of ozone, which is necessary to ensure processing of 2940 doses (mg·m$^3$)/min, providing 90% neutralization of harmful microorganisms. [19] The dependence is established given in Fig. 3. Parameters are defined for the developed setup, with 3 cm distance between electrodes, dielectric plates of polyethylene thickness of 0.5 mm and the voltage across electrodes 16 kV.

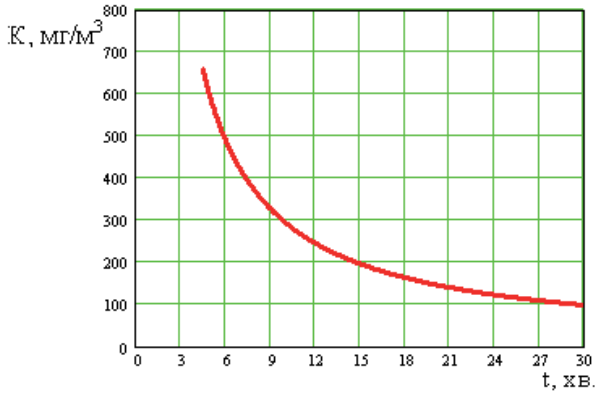


**Fig. 3.** The dependence of time of exposure at various concentrations of ozone, which is necessary to ensure 2940 mg dose processing of m3/min

Using the above relationship (Fig. 3) and the mathematical dependency of ozone concentration in the grain mass at the field strength 5.3 kV / cm from the moisture content (1), a nomogram was constructed , which is presented in Fig. 4.

For a given nomogram we can determine the time required to ensure an effective dose of decontamination during the processing of barley grain mass at a certain value of its moisture.

## CONCLUSIONS

The effective disinfection of grain in the electric field of high intensity, with the necessary dose of processing, depends on the ozone concentration and exposure time. Measurement of ozone concentration is a difficult and time-consuming process requiring additional equipment. Therefore, a nomogram was developed, using which it is possible to determine the exposure time that is necessary to ensure the effective dose of antiseptic processing of barley grain mass (2940 (mg·m$^3$)/min) with relation to the barley humidity.

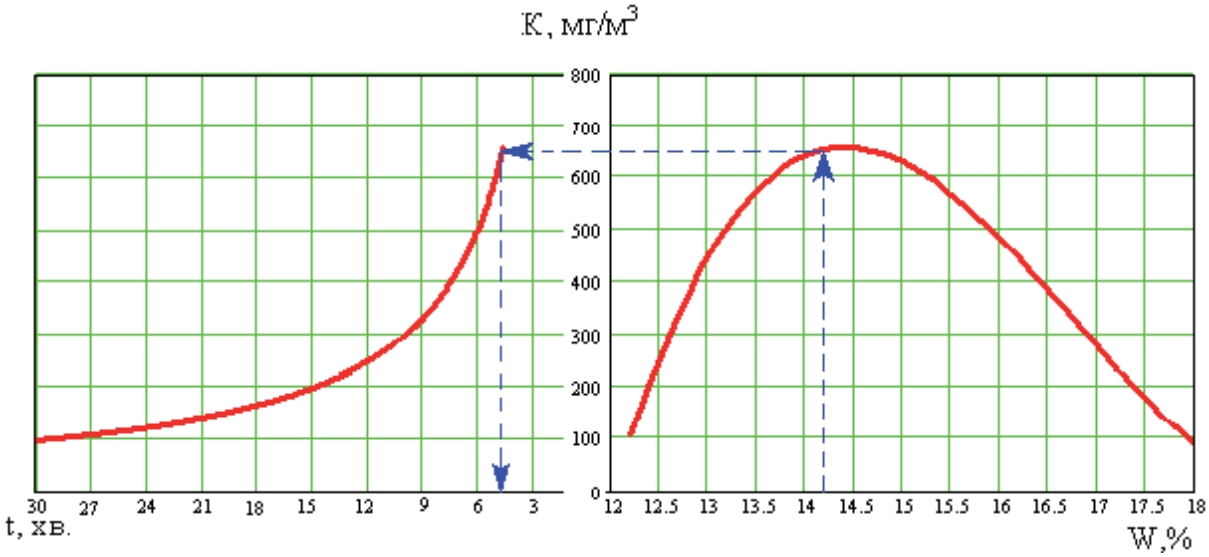


**Fig. 4.** Nomogram for determining exposure time of barley grain in a production environment

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