Complex Research of Using Microwave in Processing Grains and Plants Materials for Agriculture

Maksim Moskovskiy
Department of Technologies and Equipment of Processing Agricultural Products, Don State Technical University (DSTU), Rostov-on-Don, Rostov Region 344000, Russia

Received: May 13, 2013 / Accepted: July 17, 2013 / Published: August 30, 2013

Abstract: It is observed contamination and subsequent growth of various types of mycotoxins in the production and processing of grain and non-grain crops. The contamination of grain and non-grain cereals crops harvest was analyzed. The aim of this research is using of microwave energy to disinfect grains of harvest and giving new properties to the grains and plants materials. The author has presented researches of the grains disinfection, during seedbed preparation and post processing. Rational parameters of heating rates of different biological objects were identified, revealed their dependence and impact on infection pathogens, through using of microwave energy technology. The author found a reduction of the number of pathogenic microbes and organisms at the various stages of processing agricultural products during using of microwave energy, and found new qualitative indicators of the products properties.

Key words: Microwave, processing grains and plants materials, mycotoxins, disinfection.

1. Introduction

It is observed a growth of various types of mycotoxins in grain and non-grain parts of the harvest during its production and processing. Their subsequent processing increases infections concentrations [1].

Processing of the infected part of the harvest will help to spread different types of toxins, and introduction into the final products of crops processing and into other objects susceptible to infection, as shown in Fig. 1.

Analysis of contamination of grains harvest part showed the presence in the grain various mycotoxins, harmful for humans and for animals, as shown in Table 1.

Active growth of mitotoxins is connected with the storage time of grain crops, as shown in Table 2 and Fig. 2.

Existing disinfection methods of grain are not sufficiently effective and very costly. The disinfections methodology is based on the using liquid reagents by their dispersion spray.

Also after the grain harvest, a significant amount of non-grain part (straw material) was used in poultry and animal husbandry as a bedding material. The increasing of mycotoxins, microscopic mushrooms (mostly native Aspergillus—the causative agent of aspergillos is birds) in bedding material in poultry and livestock during keeping animals and birds on deep litter also is seen [2].

This is due to the high density planting of birds. Also conveyor technology facilitates continuous pass aging of natural microorganisms, and increased virulence properties.

Large number of pathogenic microorganisms is concentrated in birds buildings. The level of air pollution greatly increased by the time of expiration of poultry breeding. Enteropathogenic strains of E. coli, Salmonella and other microorganisms are presented in
The author has proposed a methodology for disinfection of grains and straws harvest parts through the using of new technologies based on the microwave power effects. The aim of this research is the using of microwave energy to disinfect grains and straw material and giving new properties to grain and plant materials.
2. Materials and Methods

For research, such materials were taken: pre-sowing seeds, grain and straw after harvesting. Harvesting was carried harvesting combine “Klaas”.

For the study crop wheat variety Bezostaya1 was selected. This grade (v. lutescens) launched in the Krasnodar Research Institute of Agriculture (Agricultural Research Institute). This sort of crop has such agricultural particular qualities: germinations is average; seasons resistance is average for winter hardiness and drought; this sort is resistant to shattering. Sort of crop is very responsive to fertilizer and irrigation. Grain has good baking qualities. This sort is high-yielding.

Three grains samples measures at pre-sowing and post-harvest stages were carried out. The wheat straw after combine treatment with a size of 50 mm in length and a diameter of Ø 2-3 mm was used.

According to method of experimental planning, program of experimental studies was developed [3]. The number of repeated experiments was determined, which provides a relatively random error indicators.

The samples were processed by the electromagnetic waves of microwave treatment using radiation for installation over high frequencies with a priori information collected. Microwave installation provided generate pulses of plane-polarized electromagnetic radiation with the following parameters: frequency of 2450 MHz radiation, pulse power 1.49 MW microwave pulse duration 60 s, pulse repetition frequency 375 Hz [4]. Microwave installation was located in an open area, the dimensions of which excluded the effect of the reflected microwave radiation to the surroundings at the samples. The plant placed the samples studied. Tightness excludes the impact of external factors (mainly temperature and humidity).

Analysis for mycotoxins and fungi performed in a specialized laboratory of North Caucasus Scientific Research Institutes of mechanization and electrification of agriculture (Russian Academy of Sciences).

The method of test columns OCHRASCAN® and AFLASCAN® were used for determining the mycotoxins in grains.

Test AFLASCAN® column used for rapid determination of aflatoxins B1, B2, G1, G2 and OCHRASCAN®, respectively, for the rapid determination of ochratoxin A in samples of food grains, feed and food products.

Guidelines for the using of the test columns AFLASCAN® and OCHRASCAN® were approved by the Veterinary Office of the Federal Agency for Agriculture Ministry of Agriculture of Russia.

The treated samples were tested in a standardized equipment, which have been certified calibration, and actively used both in training and in research activities.

The samples of straw was determined and adapted research method based on atomic-force method of scanning probe microscopy. The device provides a scanning probe microscope studies NanoEducator. NanoEducator allows for different methods of measuring the tunnel and “semicontact” atomic force microscopy in studies of the physics and technology of micro-and nanostructures, materials science, catalysis, physics and chemistry of polymers, tribology, cytology, etc. [5].

3. Results and Analysis

3.1 Processing Seeds at the Pre-sowing Stage

Chemical, biological and electro-physical methods of the seeds processing are used for intensification of seeds indicators during disinfection in the period pre-sowing preparation.

These effects give a certain action, but not sufficiently stable (increase yields from 0 to 15%).

During the microwave treatment, local heating occurs on the wetted surface of seeds due to its high dielectric properties and depth of micro-organisms was seen. In this case, it occurs simultaneous drying of seeds and electromagnetic activation their
pre-sowing properties due to the influence of microwave energy on the activity of amylolytic enzymes. According to preliminary field-laboratory evaluation, seeds germination can be increased by an average of 10%-12%, as compared with the control and depending on the original. Number of surviving plants for harvesting is more than 15%-20%, and yield increase to 20%-30%. This energy and using materials can be reduced by 3-5 times in the proposed technology, as shown in Tables 3 and 4.

3.2 Processing Grain after Combine Harvesting

The effect of heating rate of microwave energy to different types of pathogens has been studied, the rational parameters of heating rates to different biological objects were identified. Their dependence and impact on pathogens with using of microwave energy technology were revealed. An example of the identified dependencies is shown in Fig. 3 and Table 5. Nowadays, infrared (IR) heating is used for high-intensity heat treatment on grain products. However, this technology requires to organize the grain layer with the depth in one grain. Also the author needs to organize double-sided heating from infrared emitters or in one-sided heating organize grains mixing. All this complicates and increases the cost of construction.

| No. samples | Samples name      | Energy of growth (%) | Repeated experiments | Average |
|-------------|-------------------|----------------------|----------------------|---------|
| 1           | Microwave treatment | 91, 89, 88, 90       | 89.5                 |
| 2           | Disinfection      | 84, 85, 83, 85       | 84.3                 |
| 3           | Stainingseeds    | 89, 76, 83, 87       | 83.4                 |
| 4           | Without treatment | 86, 80, 83, 84       | 81.3                 |

Table 3 Comparative analysis of seeds growth energy at the model farm.

| No. samples | Samples name      | Seed germination (%) | Repeated experiments | Average |
|-------------|-------------------|----------------------|----------------------|---------|
| 1           | Microwave treatment | 94, 95, 94, 95       | 94.5                 |
| 2           | Disinfection      | 91, 88, 91, 91       | 90.8                 |
| 3           | Stainingseeds    | 93, 86, 91, 93       | 90.0                 |
| 4           | Without treatment | 93, 92, 90, 94       | 89.1                 |

Table 4 Comparative analysis of seed germination.

Fig. 3 Impact of microwave heating speed on infestation wheat bran pathogens (type Fusarium).
### Table 5  Impact microwave energy on infestation of products of grain processing by pathogens (type Fusarium).

| Variant number | Treatment mode | Temperature, t (°C) | Infestation CFU/g × 10³ |
|----------------|----------------|---------------------|------------------------|
|                | Time (sec)    | Heating speed (°C/sec) | Wheat bran | Flour 1 sort | Flour high sort |
| 1              | 90            | 0.8                  | 80          | 0            | 0              |
| 2              | 90            | 0.4                  | 60          | 10           | 3              |
| 3              | 30            | 0.8                  | 45          | 22           | 10             |
| 4              | 30            | 0.4                  | 30          | 22           | 11             |
| 5              | 60            | 0.8                  | 70          | 0            | 0              |
| 6              | 60            | 0.4                  | 50          | 17           | 8              |
| 7              | 90            | 0.6                  | 68          | 0            | 0              |
| 8              | 30            | 0.6                  | 48          | 18           | 9              |
| 9              | 60            | 0.6                  | 65          | 0            | 0              |
| 10             | Control       |                      | 21          | 12           | 8              |

Using of microwave energy allow to avoids the main drawbacks of the infrared heating in the high-intensity heat treatment of cereal products. This provided the necessary moisture-temperature mode, high-quality properties of the final product (the degree of starch dextrinization more than 50%, increase major tenderization in 5-10 times) and reduced specific energy consumption in 1.5 times compared to similar.

The optimum moisture of the original grain material is 10%-14% and corresponds to the usual moisture of stored grain.

### 3.3 Processing of the Straw by Microwave

The author has also conducted research on disinfection of the straw material with changes of the structural properties for use as a floor bedding in poultry. Comparative analysis of the microscopic fungi showed a slower growth in the straw bedding processed by standard methods and by microwave energy technology, as shown in Fig. 4.

It was found that the number of microscopic fungi reduced from 52 million units to 187 units CFU in 1 g in the process of microwave energy disinfection of bedding material. Body weight of chickens increased to 3.17%, and healthy of keeping chickens increased to 4.75%.

The author has been conducted studies on the structural changes in the straw material surface. In the study sized portions of straw 50 × 50, 23 × 23, 12 × 12 microns were isolated [6, 7]. Results of these researches are shown in Figs. 5 and 6.

Plot of the straw with the size 23 × 23 microns shown on Fig. 6a, where more than approximately uniform visible surface and its relative smoothness on the raw material are seen. 3-D model of the treated material shows a significant qualitative change in the surface of the material.

The lateral surface of the original and processed samples had been studied, as shown in Fig. 7. An initial mathematical analysis of the samples surfaces was conducted, based on the graphic representation of the distribution of heights along the axis 0Z and 0X (Fig. 7). A relationship was established $y = f(x)$ height of the surface area distribution and quadratic functions defined distribution of heights:

It is given in the area of 0-4 microns in integrating Eq. (1). Prior to treatment $S_{y_1} = 26.25$ microns² and after to treatment $S_{y_2} = 129.74$ microns² were determined by surface contact.

\[
\int_{0}^{4} y_1 dx = -0.0119 \int_{0}^{4} x^2 dx + 1.3622 \int_{0}^{4} dx + 3.990 \int_{0}^{4} dx,
\]
\[
\int_{0}^{4} y_2 dx = -0.004 \int_{0}^{4} x^2 dx + 0.425 \int_{0}^{4} dx + 31.60 \int_{0}^{4} dx
\]
Fig. 5  2-D and 3-D surface model of the straw material measuring 50 × 50 microns: (a) original; (b) treated.

Fig. 6  2-D and 3-D surface model of the straw material measuring 23 × 23 microns: (a) original; (b) treated.
Complex Research of Using Microwave in Processing Grains and Plants Materials for Agriculture

4. Conclusion

Complex using of microwave energy in processing of grain and non-grain harvest parts allow to reduce infection by pathogenic microbes and organisms in various stages of processing of agricultural products.

References

[1] M.E. Tumbleson, V. Singh, K.D. Rausch, D.B. Johnston, D.F. Kendra, G.L. Meerdink, et al., Mycotoxin control during grain processing, in: ASABE Annual Meeting St. Joseph, Michigan, USA, 2006.

[2] I.P. Saleeva, Technological methods and techniques to improve production efficiency of broiler meat, Ph.D. Thesis, VNibTIP, Sergiev Posad, 2007.

[3] A.P. Adler, Planning Experiment with Optimal Conditions, Moscow Science, 1976.

[4] A.I. Pakhomov, A.A. Paraponov, Problems and prospects of implementation of powerful sources of microwave energy in agricultural production, in: Status and Prospects of Modern Agricultural Machinery, 13th International Scientific and Practical Conference, Rostov-on-Don, Russia, 2010.

[5] V.L. Mironov, Fundamentals of the Scanning Probe Microscopy, Technosphere, Russia, 2004.

[6] M.N. Moskovskiy, V.I. Pakhomov, A.A. Gulyaev, Analysis of the surface the straw litter processed microwave, International Conference of Agricultural Engineering, 2012, http://www.cigr.agenga2012.org/images/fotosg/tabla_137_C0442.pdf.

[7] M.N. Moskovskiy, A.A. Gulyaev, A device for grinding and disinfection the straw, RU Patent 114826 (2012).