STUDIES REGARDING ENERGY CONSUMPTION VARIATION AND DRYING TIME FOR CORN SEED IN LABORATORY CONDITIONS

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Abstract

The drying process for grain seeds ensures optimal conditions for storage and stops microbiological processes. In order to improve the drying process of corn seeds an was installation designed and built, aiming for the dehydration of cereal seeds in laboratory conditions. The purpose of this study was to determine the optimal operating parameters of the drying process in order to maximize the technological effect, namely to minimize the drying time and the energy consumption. To achieve this goal, corn seeds with humidities between 16-25% were subjected successively to be dried, in three adjoining cells with 50 mm thickness each. During the research the structural and functional parameters for the dehydration rig were modified, namely the velocity and temperature of the drying agent, until the corn moisture reached 14%, aiming to assess their influence over the duration and energy consumption per product unit. The experimental research displayed variations between 0.006 and 0.03 kWh/kg for energy consumption, and between 2 and 150 minutes for the drying time. A total number of 80 experimental variants were studied during the research, the lowest values of the drying time being recorded at a speed of the drying agent of 2.5 m/s with a temperature of 80 °C and the minimum values of energy consumption at the speed of 2 m/s with a temperature of 80 °C. The research proved that the functional and technical parameters have a major influence over the process duration and energy consumption.

Key words: drying, corn seed, energy consumption

After the drying process, grain seeds for human consumption or for animal feeding may be stored and respond properly to processing and handling. Generally, the energy consumption of these facilities is relatively high.

In the past efforts were made to experimentally study the drying process of corn seed. So far, the studies were focused on the analysis of the fluidized bed drying process, microwave-assisted foam drying, and extractability of salt-soluble protein.

A batch type fluidized bed dryer was designed and constructed (Özahi E., Demir H., 2014) in order to investigate the drying performance (energy and exergy efficiencie) of a batch type fluidized bed drying equipment for corn and unshelled pistachio nut. A series of experiments were carried out for this purpose; the temperature of the drying agent was ranged between 50 and 75 °C and its speed was between 6.87 m/s and 10.86 m/s.

Drying characteristics of shelled corn with an initial moisture content of 26% dry basis (db) were studied in a fluidized bed dryer assisted by microwave heating (Momenzadeh L. et al., 2009). Four air temperatures (30, 40, 50 and 60 °C) and five microwave powers (180, 360, 540, 720 and 900 W) were taken into account. The results showed that increasing the drying air temperature resulted in up to 5% decrease in drying time, while in the microwave-assisted fluidized bed system, the drying time decreased dramatically up to 50%. It was concluded that addition of microwave energy to the fluidized bed drying is recommended to enhance the drying rate of shelled corn.

The purpose of the present paper was to establish the optimal operating parameters of the drying process in order to maximize the technological effect, namely to minimize the drying time and the energy consumption.

For the experiments corn seeds with four initial moisture contents (25, 22, 19 and 16 %) were submitted to dehydration in three adjoining cells (50 mm thickness each); the equipment was operated at five temperatures of the drying agent (40, 50, 60, 70, 80 °C) and four speeds (1, 1.5, 2, 2.5 m/s).

MATERIAL AND METHOD

The experimental investigations were conducted in the laboratory of Food industry and

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agricultural mechanization of the University of Agricultural Sciences and Veterinary Medicine “Ion Ionescu de la Brad”, Iaşi.

The research plan was aimed to conduct the drying process of corn seed in order to optimize the operating process.

Heat penetrating into the mass of cereal seeds starts the mass transfer of water from the inside of the product to its surface; the water vapors are then carried by the drying agent.

The mass transfer passes through different stages during the dehydrating process. The water moves under the influence of capillary forces and due to shrinkage of the product during dehydration; when the water reaches the surface, the evaporation phenomenon takes place with ease. Towards the end of the dehydration process the water transfer is slower because of the dried layer formed on the surface of the product.

The experiments were performed using a laboratory dryer for agricultural products (*figure 1*).

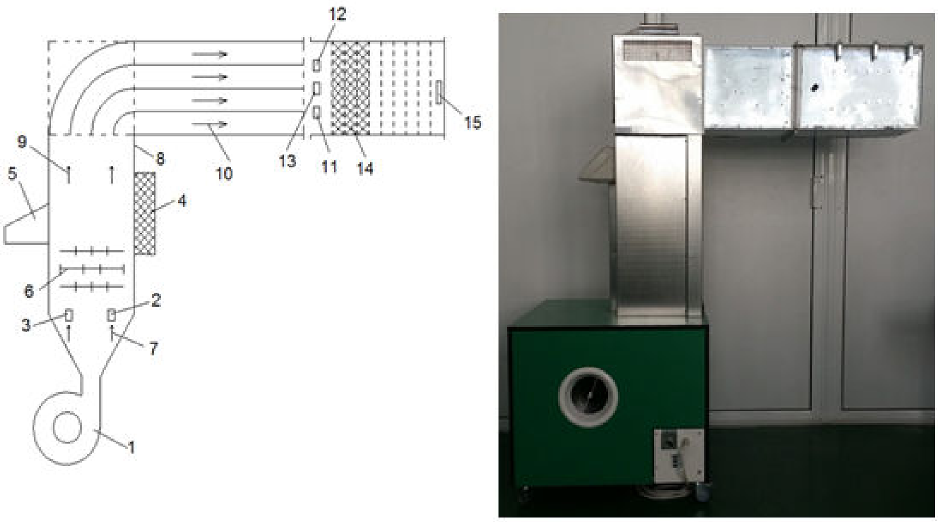

Figure 1 **Laboratory dryer schematics and photo**:
1 – fan; 2, 11 – temperature sensors; 3, 13 – speed sensors; 4 – insulating layer; 5 – control panel; 6 – electrical resistors 7 – cold air; 8 – body; 9 – hot air; 10 – drying agent; 12, 15 – moisture sensors; 14 – drying cells.

The laboratory dryer is equipped with an electronic interface which allows the control and monitoring of the drying process. Heat and mass transfer inside the dryer are achieved by the means of convective heating; the drying agent is represented by the air heated by electric resistors (three resistors of 1.5 kW each).

The humidity of the drying agent is monitored using moisture sensors (12, 15) mounted in two positions: before the cereal layer and at the air exit. The drying process was stopped when humidity reached 14% in the third layer.

The speed of the drying agent is controlled by the automation system, by varying fan speed. The automation system of the dryer allows the recording and visualization (on the LCD screen) of the operating parameters: temperature, humidity and speed of the drying agent.

A view of the box for cereal seed dehydration is presented in *Figure 2*; it consists of eight cells (50 mm wide each), delimited by nine stainless steel sieves.

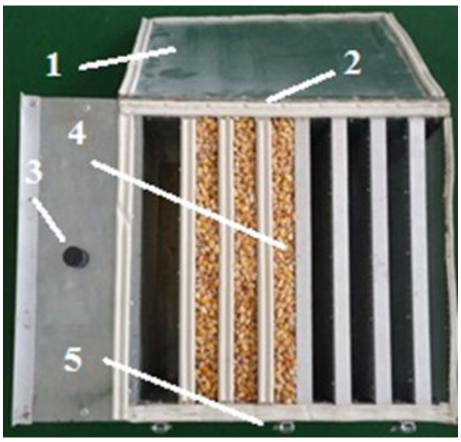

Figure 2 **Cereal seed drying box**:
1 – cover; 2 – seals; 3 – hole for introducing measuring probes;
4 – drying cells separated by steel sieves; 5 – sealing cap system.

RESULTS AND DISCUSSION

The drying time depends on the relative humidity of the air in the system; a lower humidity will lead to the achievement of a shorter drying time.

The relative humidity of air decreases when the air temperature in the dryer increases; as a result the drying agent can carry higher amounts of water vapor.

In order to achieve the goals of the study, the corn seeds were placed in the three adjacent cells, in order to be dried, starting from four initial moistures: 25, 22, 19 and 16%. Taking also into account the speed of the drying agent (between 1 and 2.5 m/s) and its temperature (between 40 and 80° C) a final number of 80 experimental variants was obtained. The experimental results are summarized in *table 1*.

Table 1

Experimental results for the drying of corn seeds

No.	Drying agent temperature (^{o}C)	Drying agent velocity (m/s)	Specific energy consumption (kWh/kg)			
			initial moisture 25%	initial moisture 22%	initial moisture 19%	initial moisture 16%
1.	40	1.0	0.0300	0.0280	0.0270	0.0272
2.		1.5	0.0280	0.0210	0.0190	0.0185
3.		2.0	0.0160	0.0150	0.0120	0.0111
4.		2.5	0.0110	0.0090	0.0086	0.0083
5.	50	1.0	0.0270	0.0260	0.0250	0.0225
6.		1.5	0.0170	0.0210	0.0170	0.0147
7.		2.0	0.0110	0.0100	0.0090	0.0090
8.		2.5	0.0150	0.0098	0.0086	0.0085
9.	60	1.0	0.0260	0.0250	0.0240	0.0190
10.		1.5	0.0140	0.0120	0.0120	0.0125
11.		2.0	0.0120	0.0092	0.0089	0.0088
12.		2.5	0.0230	0.0190	0.0086	0.0121
13.	70	1.0	0.0190	0.0180	0.0167	0.0158
14.		1.5	0.0160	0.0120	0.0121	0.0118
15.		2.0	0.0110	0.0090	0.0079	0.0079
16.		2.5	0.0175	0.0150	0.0086	0.0097
17.	80	1.0	0.0176	0.0150	0.0143	0.0141
18.		1.5	0.0174	0.0130	0.0120	0.0117
19.		2.0	0.0103	0.0080	0.0069	0.0066
20.		2.5	0.0141	0.0110	0.0086	0.0086

The results for the experimental variants with the initial moisture content of 25% presented in *figure 3* show that the specific energy consumption was comprised between 0.010 and 0.030 kWh/kg. Depending on the speed of the drying agent, the higher values of the specific energy consumption were obtained for the speeds of 1 and 2.5 m/s; lower values were obtained for higher temperatures of the drying agent. The minimum energy consumption was recorded for a speed of the drying agent of 2 m/s and the temperature of 80^{o}C; the maximum energy consumption was recorded at the speed of 1 m/s and the temperature of 40° C (due to the longer drying time).

For the process of drying corn seeds with the initial moisture content of 22% (*figure 4*), the energy consumption values were comprised between 0.0080 and 0.0280 kWh/kg. The minimum amount of energy consumption per unit mass was also obtained at the speed of 2 m/s and the temperature of 80 °C. Unlike other tested speeds, at 2.5 m/s the energy consumption did not decrease when the temperature was increased, recording a maximum value of 0.0190 kWh/kg for the temperature of 60 ^{o}C

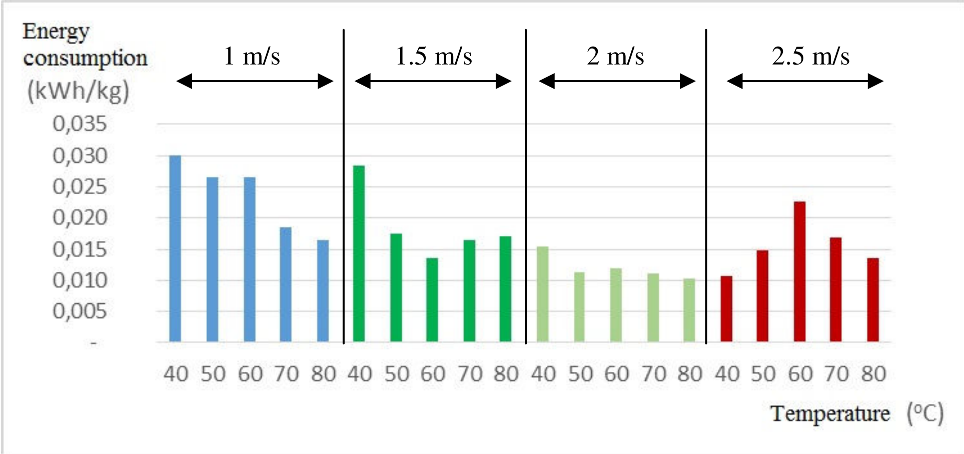

Figure 3 **Changes in energy consumption for the initial moisture content of 25%**

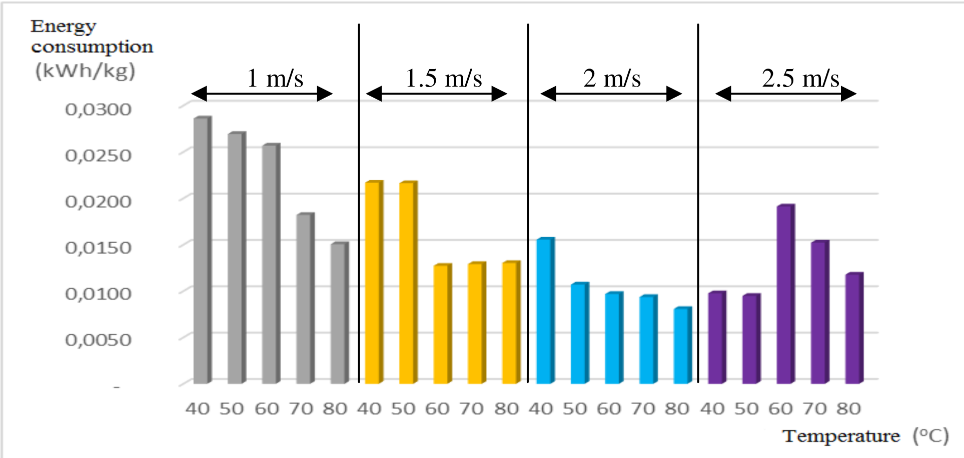

Figure 4 **Changes in energy consumption for the initial moisture content of 22%**

CONCLUSIONS

A total of 80 experimental variants were taken into account when investigating the process of drying corn seeds at different drying agent speeds and temperature and different initial moistures of the grains. During the experiments the following parameters were recorded: drying time and the final moisture content of each seed layer, the active power consumption, energy consumption per unit mass and the final mass for each layer.

The lowest humidity of the first layer (6%) was achieved for a speed of the drying agent of 2.5 m/s and a temperature of 80 °C.

The energy consumption per unit mass recorded values between 0.0066 and 0.030 kWh/kg.

Depending on the speed, the highest values for the energy consumption were obtained for air velocities of 1 and 2.5 m/s; lower values were obtained for higher temperatures. The minimum consumption was recorded for a velocity of the drying agent of 2 m/s and a temperature of 80 °C.

For velocity profile the final humidity decreased when temperature increased.

Values of the drying time higher than the average were recorded for velocities of 1 and 1.5 m/s and for temperatures of 40 and 50 °C. Otherwise the drying time decreased when temperature and velocity of the drying agent were increased.

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