PERFORMANCE ASSESSMENTS AND THE EFFECT ON BARLEY SEED QUALITY REGARDING A NEW DEVELOPED GRAIN DRYER

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Abstract

Convective dryers are widely used in various fields, such as for drying pasta, fruit, vegetables, agricultural plant seeds etc. Several variants of dryers have been designed so far, such as: dryers with intermediate heating of the drying agent, dryers with partial recirculation of the drying agent, closed circuit dryers and those ones with combined technical solutions. None of the above solves the problem regarding the drying agent flow uniformity. In the case of existing world-wide tower dryers, drying is more intense towards the end of the drying agent mixing chamber.
To overcome this shortcoming, an innovative cylindrical tower dryer was conceived, which evens the drying agent parameters. The dryer contains a conical device mounted inside the perforated cylinder above the burner. This device is based on the *Coandă* effect according to which, a fluid jet has the tendency to stay attached to a convex surface.
The device has been designed after Computational Fluid Dynamics simulations (CFD), after which optimum setting adjustments have been made to achieve uniformity of the speed and temperature profiles across the entire interior surface of the perforated cylinder, regardless the porosity of the seed layer. Experiments were conducted using barley seeds with three initial moisture contents, five air temperatures (40ºC to 80ºC) and four fan speeds (1 m/s to 2.5 m/s).
The obtained results showed a reduction of protein loss of up to 1.77%, a reduction of germination capacity loss of up to 9.87%, a decrease of the energy consumption of up to 10-15% and a decrease of the drying time of up to 20%, compared to the results obtained with a conventional tower dryer. The advantages of using the new developed dryer are: drying process uniformity, energy consumption and drying time reduction, seed quality improvement, construction cost reduction and material economy.

Key words: tower dryer, seed dehydration, protein content, germination capacity

Phenomena under physiological processes, which are carried out with different intensities during seed storage, mostly undesirable and with particularly severe consequences, are due to the high moisture content of the preserved seeds.

There are many seed storage systems, but dry storage is currently the most widely used system, irrespective of the destination, since under these conditions the physiological processes are inhibited, the microorganisms do not find development conditions, this storage system being therefore efficient and economic (Jidko V.I., 1982).

Increasing seed moisture by only 2 to 3% above the conservation limit intensifies the breathing 10 to 12 times and creates conditions for the development of microorganisms.

At the same time starch losses occur, leaving heat, carbon dioxide and water (Bîlteanu G. *et al*, 1991).

As the temperature rises, breathing increases and the degenerative process increases. (Murariu O.C. *et al*, 2014).

By condensing water on the surface of the seeds there is a self-heating, the unpleasant smell becoming more and more persistent. These conditions favor the development of microorganisms, which can degrade seed components.

In addition to reducing the carbohydrate and protein content, fat degradation also occurs, increasing in particular the content of unsaturated fatty acids.

The process of self-heating of seeds (burping) takes place in two phases:

- the incipient phase when the seed temperature is about 30 °C, the predominant processes being breathing and fermentation;
- the seed alteration phase, which starts at 45 °C to 50 °C, with a pronounced change of color and taste, accompanied by a strong and unpleasant smell (Brătucu G., 1999).

To prevent these phenomena, cereal grains and technical plants are dehydrated by various processes: artificial drying; solarization, which

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consists in the use of solar energy, being simple and easy to practice; active aeration, which is used as a temporary storage medium until dry or final conditioning (wheat, barley, corn).

The aeration consists of introducing atmospheric air into the seed mass, using different types of air intake in the seed mass.

The higher the seed humidity, the greater the amount of air required to feed the seed mass.

Currently, for drying the seeds of agricultural plants, convective dryers are used, which do not solve the problem of the air distribution's uniformity of temperature and velocity in the drying seed layer, leading to high energy demands.

In order to overcome this drawback and to reduce the negative effect, an innovative cylindrical drying unit was built.

The main objective of the paper was to determine the influence of the physical parameters on the dehydrated barley seeds and to what extent the innovative baffled drying unit influences the energy consumption and the quality of seeds after the drying process.

MATERIAL AND METHOD

The laboratory dryer (*fig. 1)* allows control and monitoring of the drying process parameters that can be chosen by the user before or during the drying process.

Mathematical modelling was used in design, in the operational and optimization work. The mathematical model of the convective drying process is based on the theory of fluid dynamics, mass balance and energy.

The experiments were conducted by varying and monitoring the operating parameters of velocity and temperature of the warm air (1-2.5 m/s, respectively 40-80°C) and using barley seeds with three initial moisture contents 21, 19 and 17%.

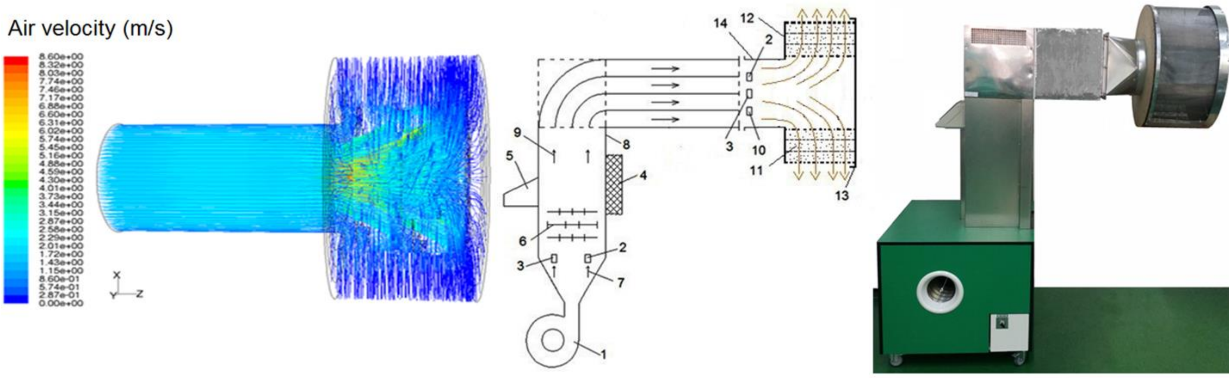
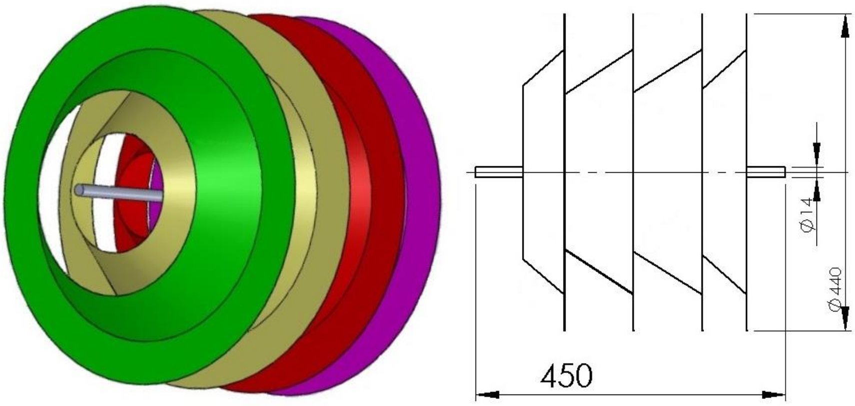


Figure 1 **Laboratory cylindrical dryer scheme and simulation**

The conical drying unit was designed by simulation, fluid dynamics calculations (CFD), after which optimum setting arrangements were made to achieve the uniformity of the speed and temperature profile across the entire interior surface of the perforated cylinder in which it is included.

The components design of the drying unit was done using the Solid Works software (*fig. 2*).



a. **b.**

Figure 2 **Three-dimensional projection of the cylindrical baffled unit**
a. design of the conical baffle
b. baffle construction scheme

RESULTS AND DISCUSSIONS

After drying, the protein content and germination capacity of the seeds were determined to see to what extent they were affected by the working parameters of the laboratory drying plant.

It was found that after the drying of barley seeds with an initial humidity of 21%, there were no significant differences for the drying process speed of 2.5 m/s for the duration of the drying process, between the conventional drying and the cylindrical casing provided with a deflector.

Drying times (*fig. 3*) vary almost directly in proportion to the decrease in temperatures and the speeds of the thermal agent.

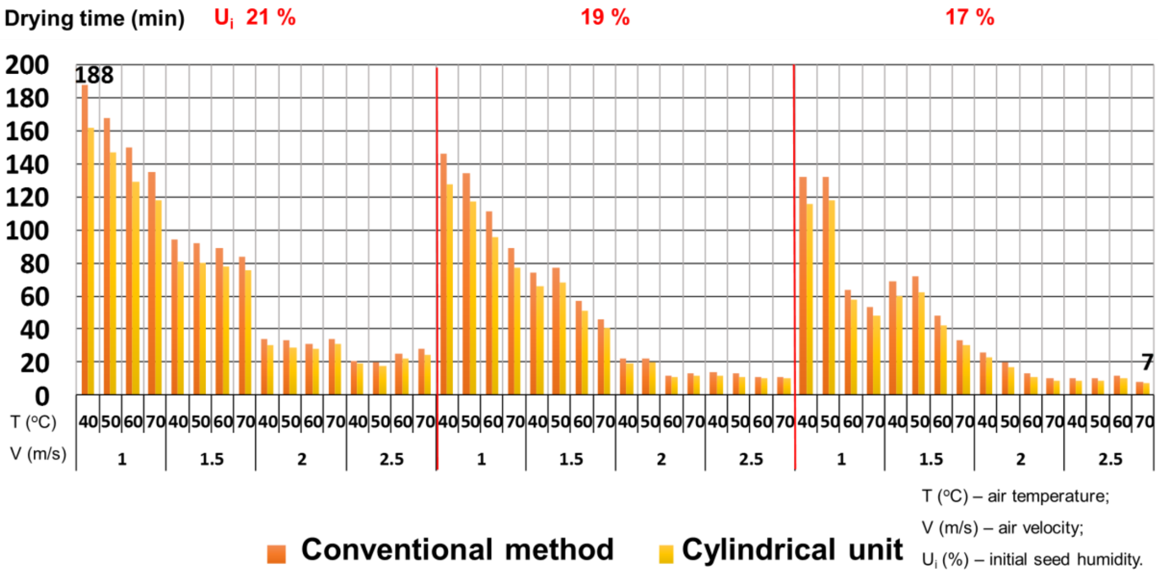


Figure 3 **Drying time**

The energy consumption per barley seed meal unit, irrespective of the initial humidity, varied inversely with the speed and temperature of the drying agent, except for the drying speeds of 1.5 m/s at temperatures of 40°C, 50°C, 60°C.

Both the protein content (*fig. 4*) and germination capacity of the seeds were most severely affected at 80 ° C generally.

The minimum values obtained for these, respectively 11.06% protein and 10% germination capacity, were recorded for the thermal velocity of 1 m/s.

The germination capacity is easily affected at the temperature of the 60°C drying agent, then drastically decreases.

It can be said that seed germination values vary inversely with air temperature and directly proportional to air velocity.

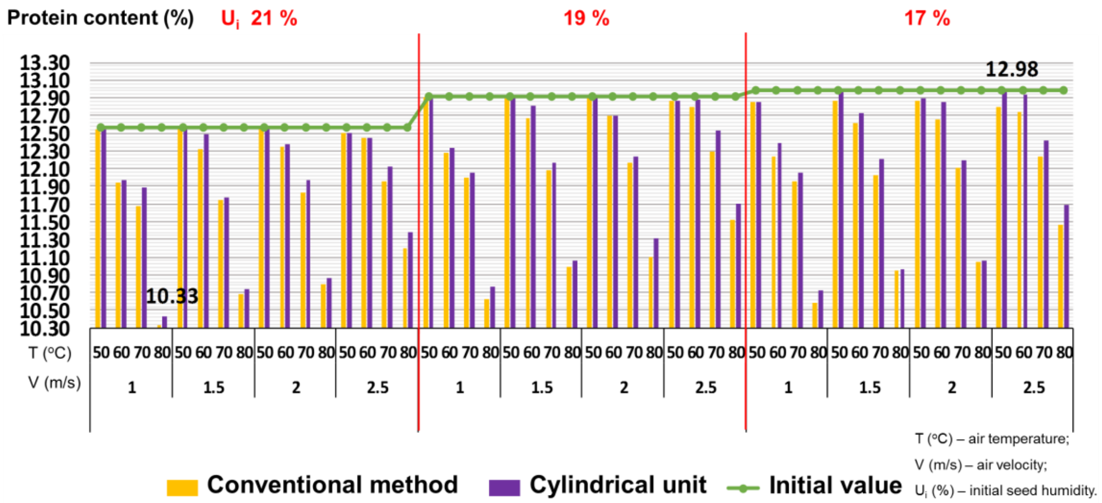


Figure 4 **Protein content**

There were no differences between the two drying methods for the temperatures of the thermal agent of 40 °C and 50 °C. At high temperatures, the seed germination capacity has been superior for the baflled drying unit. By drying with the conical unit of barley seeds with an initial moisture content of 15%, an increase in protein content of up to 1.77% and germination capacity by up to 9.87% compared to the conventional method was obtained.

CONCLUSIONS

After having dried barley seeds with an initial humidity of 21%, one could notice that for a thermal agent velocity of 2.5 m/s there were not recorded significant differences for the drying process time between the conventional drying and the one using the new cylindrical unit, provided with a deflector.

The energy consumption per mass unit has recorded values between 0.0027 and 0.0506 kWh/kg. According to the thermal agent velocity the highest values of the energy consumption were obtained for the velocity of 1 and 2.5 m/s. The low values were obtained at high temperatures. The minimum consumption was recorded at the drying agent velocity of 1.5 m/s and at its temperature of 80ºC, the maximum value being recorded for 1.5 m/s velocity and 40ºC temperature, this also being due to the long drying time.

High values for the drying time have been recorded for 1 and 1.5 m/s velocity. It is also evident that there is a decrease tendency of drying times at the same time with the increase of the thermal agent velocity values and of the working temperatures.

When getting in, the humidity of the drying agent varies inversely proportional to its temperature. When getting out, the humidity initially has an increase tendency, followed by a decrease, due to the water removal from the product. Up to the half drying period, the humidity keeps staying constant, then it starts decreasing as the temperature increases.

For each velocity of the drying agent the final humidities decrease at the same time with the increase of the temperatures, this being also evident in the case of the other studied seeds.

One can state that the values of the germination power of seeds vary inversely proportional to the air temperature and directly proportional to the air speed.

Generally, both the protein content and the germination power of the seeds were the most severely affected at the temperature of 80ºC.

The research demonstrated that the increases of the studied parameter value by using the cylindrical unit were minimum for the barley seeds with an initial humidity of 15%, but unlike the other humidities or the other studied seeds, there were recorded low increases of the studied parameter values also for drying at 40ºC and 50ºC temperatures, when the protein content and the germination power of the seeds are not highly affected.

After the statistical analysis, significant differences for the protein content and the germination capacity of dried barley seeds, in both drying cases, were obtained for both the air temperature variation and the air velocity variation.

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