EXPERIMENTAL STUDY OF DRYING BEHAVIOUR OF POTATO

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Abstract

Drying is one of the processes used in the food industry to preserve and maintain the quality of food products for a period of time. The efficiency of drying potatoes depends on the content of dry substance; their initial moisture percentage is between 66-88%. The purpose of this research was to study the drying parameters of the potato, as regards the temperature of the drying and how partitions (slices, cubes) without any pre-treatment. The parameters of drying agent were as follows: temperature of the drying was 50°, 60° and $70\ ^oC$, the initial moisture content of the air was 30 to 35%, the rate of drying agent was kept constant at 2.0 m/s. The time was set so that at the end of the drying the moisture content of the product to have a value of 14%. Data drying was determined experimentally using a vertical laboratory dryer. Experimental results have shown that the temperature of the drying and splitting mode have a high influence on the duration of the drying process. Potatoes in the form of cubes and dried at $70\ ^oC$ were reached at a moisture content of 14% in a shorter time than the products being divided in the form of rings.

Key-words: kinetics of drying, dryer, food products.

Potato is one of the major crops, being ranked second after grain in our country and worldwide. Potato is the staple food for many people and has a high percentage in the economic balance of many countries, considered as the second bread.

In food industry is used to obtain potato flour, flakes, dehydrated potatoes (which are used for purees and bread), chips. Potato is used in starch industry, alcohol or chemical industry. Also potato is used in animal feed as such or as draff from the production of starch and alcohol

The chemical composition of potato (*Table 1*) depends on several factors, including the characteristic of the variety, soil type, climate and growing conditions (fertilization, pesticides, diseases) (Zlatkovic B., M. Rajkovic, 2005).

Potato tuber is a living organism, whose physiological activity does not stop even during storage. Due to its high water content, losses during storage are quite high.

Table 1

Chemical composition / 100 g product

No.	Component	Quantity
1	Water	66 – 88 %
2	Proteins	1.87 g
3	Fats	0.1 g
4	Fibers	1.8 g
5	Carbohydrates	20.13 g
6	Calcium (Ca)	5.0 mg
7	Vitamin C	13.0 mg
8	Iron (Fe)	0.31 mg
9	Potassium (K)	37.9 mg
10	Phosphorus (P)	44.0 mg

Dehydration or drying represents technological operation based on reducing water content, i.e. increased concentration soluble substances to which reach the food storage stability. For vegetables, drying reduces the natural content of water to a level which is hampered the activity and development of microorganisms, without the destruction of tissues or depreciation in value. Drying mechanism is determined by some thermophysical processes which take place inside the particles of the product subject to dehydration (diffusion, thermal diffusion) and simultaneous transfer of heat and mass in the boundary layer that separates the solid surface thermodynamic agent, called drying agent (hot air, flue gas or mixture of gases and air).

The process of drying depends on several factors: the temperature of drying agent, drying agent flow, relative humidity of air, as well as the parameters of the product subject to drying (moisture content, genre, form). The simplest and most common method of drying is drying by

convection: is carried out in the presence of a hot gas which transfers heat to the particles of the product, which is designed to pick up water vapor resulting from the processing of water in the gas phase. The hot air represent thermal agent and entrainment agent of moisture evaporated by the product. Heat and mass transfer during drying is conditioned by drying agent parameters (speed, temperature, relative humidity) and the relationship between humidity and product.

MATERIAL AND METHOD

Biological material to perform experiments was purchased from a private farm in Iasi, and then stored at 4 ° C until the start of experiments.

In order to obtain dried product were followed several technological stages (Luminita Catana et al., 2008):
- Reception quantitative and qualitative;
- Conditioning of raw material (sorting, washing);
- Processing of raw material (division);
- Dehydration;
- Cooling;
- Storage.

Potato drying kinetics was studied using a laboratory vertical dryer (Fig.1.A) belonging Agricultural Mechanization Department at the University of Agricultural Sciences and Veterinary Medicine (Ţenu I., R. Rosca, Cârlescu P., 2012).
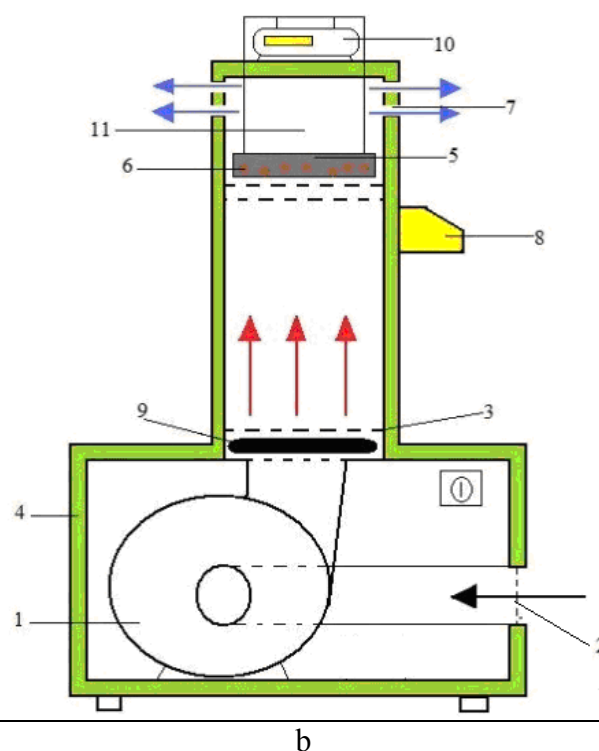

Figure 1 **Installation for drying: a - general view, b - scheme of the installation:**
1 - fan; 2 - the air inlet pipe, 3 - grill, 4 - thermal insulation, 5 - tray product, 6 - products subjected to drying,
7 – exhaust of the drying agent, 8 - Interface touch - screen; 9 - electric heaters of air,
10 - electronic balance; 11 - drying room, 12 - electric motor

The heat transfer inside of the drying plant is achieved by convection, the heating agent being represented by the air heated by electrical resistance. Heated air circulates from the bottom above on top of the product. In order to improve the drying process were determined factors that lead to increased productivity of the drying installation:
- Raw material and final product (physical and chemical composition);
- Drying process parameters - temperature, humidity and velocity of air, the effective area of the drying, the carrying capacity of the system, the time of drying).

At the beginning of each experiment, the potatoes were washed, trimmed and manually peeled and again washed to remove adhered peels on the surface it were cut into slices with dimensions of 0.5 cm (diameter of 5 cm) and cubes of 1.5 cm using a kitchen slicer. The potatoes were not treated in any way before drying.

The drying system consists a tunnel having at one end a mounted axial fan for providing agent; drying agent (air) is heated by electric heating elements. The plant is able to provide and ensure the desired temperature of the drying air in the range of 25 °C to 125 °C and the relative humidity in the range of 10% to 100%. The dryer is

equipped with a thermostat which controls its heat and keep the temperature constant.

The dryer works in batch mode, by respecting the following steps: food tray with fresh products and their arrangement in a uniform thin layer, placing the tray in the drying chamber, drying chamber seal, turn the fan and electrical resistance, dehydration products cooling the dehydrated products.

In order to establish the optimum parameters for the technological process, the measurements were made at every operating hour, monitoring the values of the following parameters:

temperature in the drying area, the change in weight of vegetables, the relative humidity of the air at the entry and exit of dehydration instalation (Zlatkovic B., M. Rajkovic, 2005). Functional scheme of the drying installation shown in figure 1.b. During the experiments, the speed the drying agent (air) to 2.0 m / s speed is controlled and ensured by the fan is checked by means of an anemometer Testo 410 Anemometer (Fig. 3.a). The temperature the drying agent, was to 50°, 60° and 70°C. The temperature at the surface and inside of the product was measured using a Testo 925 thermometer, T/C type K (Figure 3.b).

Figure 2 **Devices for measuring the temperature and velocity the drying agent**
a - anemometer, b - type K thermocouple thermometer

The potato samples were placed in a uniform layer on the surface of the drying tray, the tray with the dimensions of 30 cm x 30 cm.

The moisture content of the of potato during the drying process was determined by the difference in weight resulting from the weighing sample. Weighing the sample was performed using an electronic balance, reducing the moisture content was recorded by measuring weight during the drying process. Determination of initial and final water balance is achieved by thermal method.

The moisture content was expressed as percent wet basis, and then converted to gram water per gram of dry matter. Moisture ratio (MR) of the slices was determined using (Dinrifo R., 2012):

$$MR = \frac{M_x \quad M_e}{M_0 - M_e}$$

where MR is the moisture ratio, M_x - product moisture at time t, M_e - moisture equilibrium; M_0 - initial moisture content of the product.

Drying curve. The moisture content of the samples was found during the drying process using:

$$M_x = \frac{W_x - W_d}{W_d}$$

RESULTS AND DISCUSSIONS

Experiments to determine the kinetics of drying the potato divided in different form: slices (thickness of 5 mm) and cubes (1.5 cm) were taken at various temperatures of the drying agent: 50 °, 60 ° and 70 °C. According to studies on drying potatoes for dehydrating potatoes that optimal speed is 2.0 m / s (American Potato Journal, 1960).

The potato samples were marked as follows:
- B50 - sliced dried at 50 °C;
- B60 - sliced dried at 60 °C;
- B70 – sliced dried at 70 °C;
- C50 - potato cubes dried at 50 °C;
- C60 - potato cubes dried at 60 °C;
- C70 potato cubes dried at 70 °C.

Drying times under experimental conditions are presented below (Table 2).

Table 2

Drying times under experimental conditions

No.	Dimensions (cm)		Air velocity (m/s)	Temperature (^{o}C)	Durata (min)	
	B	**C**			**B**	**C**
1	Diameter: 5			50	420	360
2		1.5	2.0	60	390	330
3	Thickness: 0.5			70	360	300

In order to visualize the behavior of the drying process, and drying curves were made based on the moisture content the drying agent at a temperature of 50 °, 60 ° and 70 °C for different types form of the potatoes – sliced and diced (*fig. 3, 5, 7*).Temperature the drying agent significant influence on the kinetics of the process as higher values of this parameter results in a decrease in humidity and, therefore, reduce drying time or increase the rate of drying.
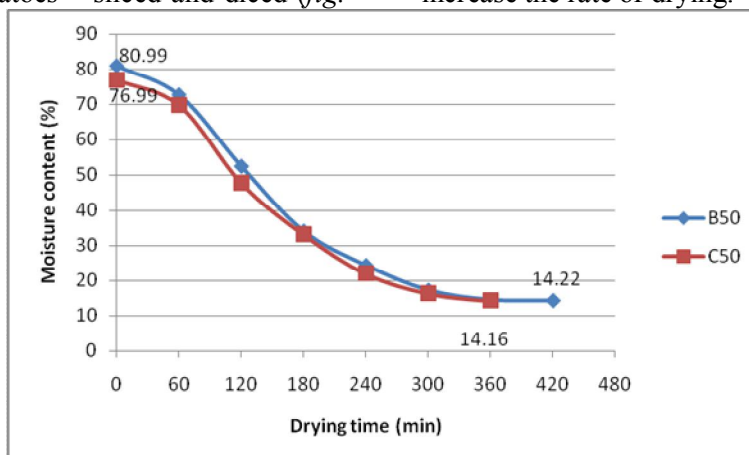
Figure 3 **Evolution of moisture during the drying process at a temperature of 50 °C**
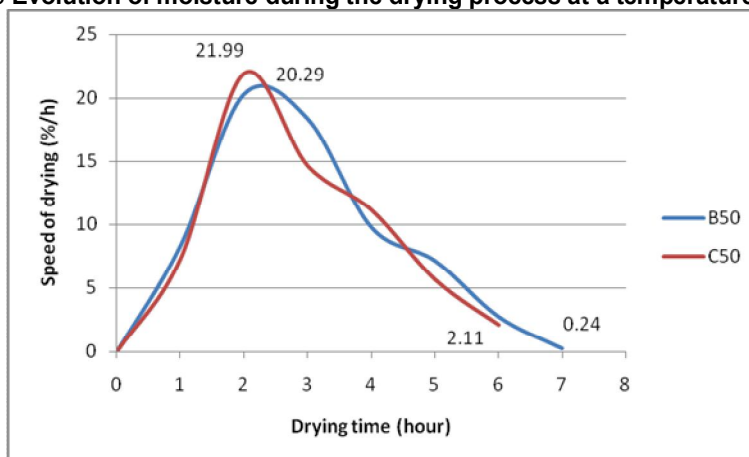
Figure 4 **The speed drying at a temperature of 50 °C.**

Contact area of the sample with drying agent (hot air) is a determining factor for the drying process. Thus, the final moisture of the potato dried at 50 ° c was reached after 420 minutes (for B50), with final humidity of 14.22%; after 360 minutes to C50, with a final water content of 14.16%. The form of product influences the diffusion of water from the inside to the outside, the speed of drying, the highest value is recorded in the first 120 minutes of the process (21.99%/h) in the case of potato cubes (*fig. 4*).
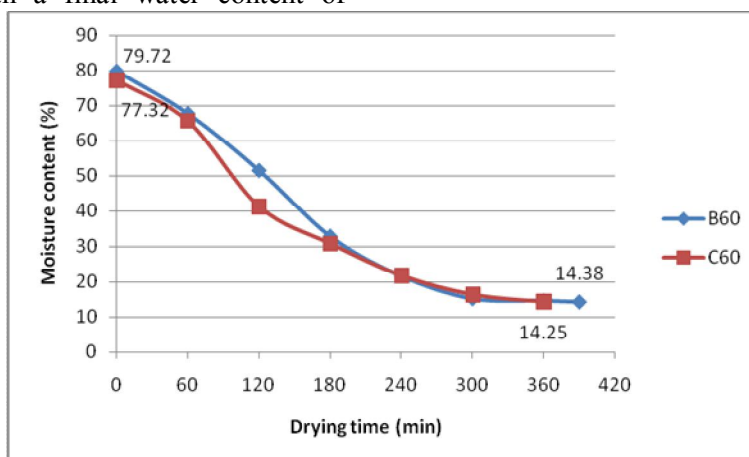
Figure 5 **Evolution of moisture during the drying process at a temperature of 60 °C**
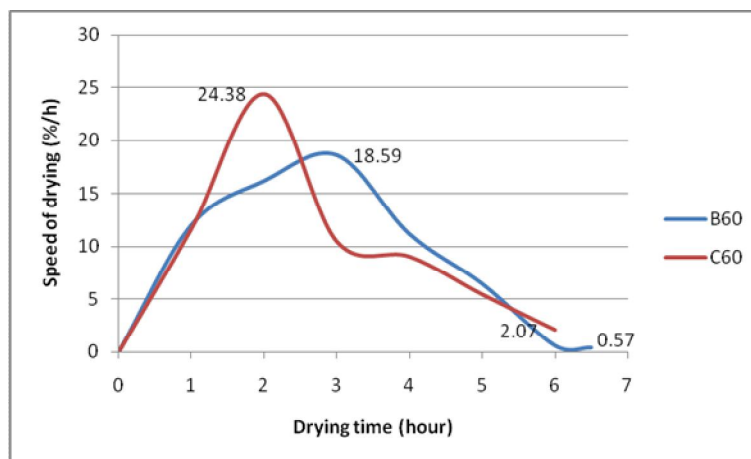
Figure 6 **The speed drying at a temperature of 60 °C.**

Potato samples showed kinetic characteristics very similar, after 300 minutes, leading to a final moisture content of 14.25% (for C60) and 14.38% for B60 (*fig. 5*). The speed of drying the potato at a temperature of 60 °C to the maximum value registers for C60 (24.38%/h) to b60 (18.59%/h) after 120 minutes and 180 minutes from the process (*fig. 6*). At 70 °C, there was a rapid decrease in the moisture in the first 60 minutes, and this behavior was not observed at lower temperatures, the conclusion that the temperature of drying is important in the drying process (*fig. 7*). Changes in the rate of drying when the last value of the water temperature is shown in figure 8. In this case, the speed of drying the potato as cubes was higher and reached the highest value after about 60 minutes (in the case of C70) compared to B70.
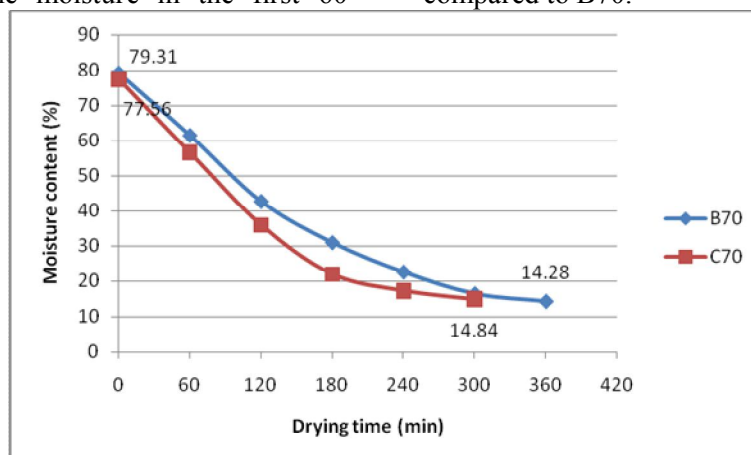

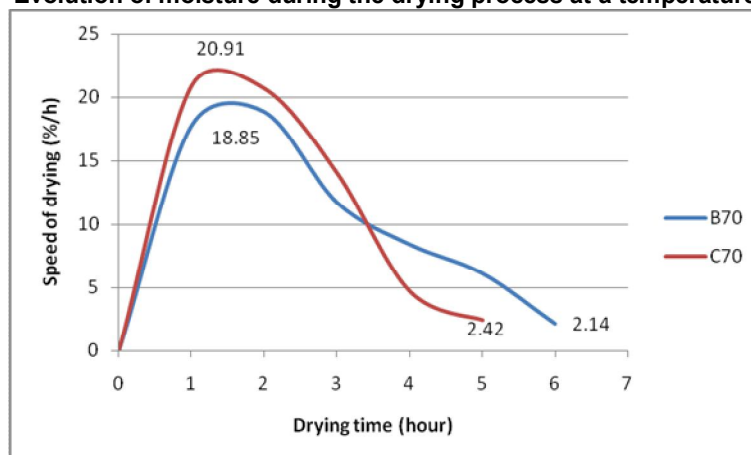Figure 7 **Evolution of moisture during the drying process at a temperature of 70 °C**

Figure 8 **The speed drying at a temperature of 70 °C**

The method of dividing (sliced, diced) favored the evaporation of water because of the larger contact area, reducing the drying time to reach equilibrium. To achieve a 14% moisture at a temperature of 70 °C the drying agent and a speed of 2.0 m/s, the drying time was 360 minutes for

B70 and 300 minutes for C70. Evaporation of water in the food is influenced by various phenomena, such as the form of connection of the water in food, water migration from inside to outside.

CONCLUSIONS

The size of the product is of particular importance on the kinetics drying process.

The form of product shows a large influence in the process of drying . Research shows that the speed of drying significantly increases to the products (potatoes) divided in the form of cubes.

At 70 °C , there was a rapid decrease in the moisture in the first 30 minutes, and this behavior was not observed at lower temperatures, it was concluded that the temperature of drying is important in the drying process.

Potato divided in various forms (sliced, diced) and dried at 70 °C at speed of 2.0 m/s (hot air), reached the final moisture content in a shorter time than those dried at 60 and 50 $^{\circ}$C.

The productivity of an installation for drying is determined by many factors. The technical parameters of the plant, physico - chemical materials and the amount of raw material have direct influence on drying time.

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