INFLUENCE OF TEMPERATURE AND GEOMETRY IN THE KINETICS OF DRYING PEARS

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Abstract

Pears are very perishable fruit because of its high moisture content (77 – 89%). Drying is one of the practices used in the food industry to maintain quality of the final product for a period of time. The purpose of this research was to study the drying process parameters of Rochas pears variety regarding the way of partitions (slices, cubes, rings) and drying agent temperatures. Research has been carried out, with the help of a drying plant for different working conditions. The parameters of drying agent was 60° C and 70° C, the initial air humidity was 40 – 45 %, the time being set so that at the end of the drying process, the moisture content had the value of 12 to 15 %. Drying data were determined using a vertical laboratory dryer for the horticultural products and adjusted with a mathematical model. The results showed that the dividing method of pears influenced the drying process and its duration. Pears divided as cubes and dried at 70° C, reached 14 % humidity earlier than divided into slices.

Key words: pears, drying kinetics, dryer

Pears are very appreciated by the consumers for fresh consumption and as raw material for processing. Pear is a very old culture, written references dates back to the year 300 bc (*Teofrast*). The origin of pear is not very secure (*Pirus communis*), apparently originated in Europe and Asia, *Pirus sinensis* being native from the Orient (Hui Y.H, 2006).

Regarding the range of existing varieties, it is possible that pears can be consumed fresh between 8 to 9 months a year, but with little variety in the winter.

Pears are appreciated for their richness in carbohydrates 8 – 15%, organic acids 0.2%, 0.5% albumin, 4.3% cellulose, 0.5% pectic substances, tannin, vitamins A, B1, B2, PP, C, mineral ions: phosphorus, sodium, calcium, magnesium, iron, iodine, etc. Fruits are consumed fresh or processed into various products (sauce, jam, dried fruit) (Sârbu Roxana, 2006). Taste qualities and shelf life of fruits depend very much on the time and conditions of harvest. Because their perishability, summer pears are harvested from 7 to 10 days before the maturity, when it reaches typical size and color, the shaded varieties are changing from green to yellow.

The presence of water or moisture products is a factor that determines the development and multiplication of microorganisms and, therefore appears the necessity of eliminate water products content. Dehydration is one of the earliest methods of food preservation known. Modern processes of dehydration enables the production of food from which water was removed, being still kept most of the nutritional value (Shafiur-Rafman M., 2007).

Without moisture, the microorganisms cannot develop, and the dehydrated product can be kept for a long time. Dehydration process is conditioned by a number of factors: the quality of raw material, temperature, humidity, speed drying agent, type of installation, etc. (Grivu P., M. Mihalcea, Temocico Georgeta, 2001). Evaporation rate of water is the factor that determines the duration of dehydration.

The percentage of water content for fresh pears can reach up to 78 – 88% of volume and by dehydration is gaining a lot of space and eliminates the risk of rapid degradation due either microorganisms or oxidation reactions (Țenu I. Marian Gr, 2009). The advantages offered by the dehydration are low volume in storage (not required cold stores) and are ready for consumption by rehydration.

MATERIALS AND METHODS

Experimental investigations were conducted in Department of Agriculture Mechanization of "Ion Ionescu de la Brad" Agricultural Sciences and Veterinary Medicine University. For this study we used pears (*Pyrus communis L.*) of variety *Rochas*, divided into different types: rings, slices and cubes (*Fig. 1a, 1b, 1c*). Laboratory experiments were conducted with the help of an installation for drying different horticultural products (vegetables, fruits) (*fig. 2*). The transfer of heat in the drying plant is done by convection, the heat being represented by air heated by an electrical resistance.

a b c

Figure 1 **The raw material for dehydration**
(a - rings, b - cubes, c - slices)

"Dried pears" product marketed on the market presents significant variability in terms of texture and color characteristics. These two parameters are heavily influenced by the drying temperature and the drying time.

In order to optimize the process of dehydration have determined the factors which lead to increasing productivity of dehydration:

- raw materials and the finished product (physical and chemical);

- the dehydration process parameters – temperature, relative humidity and air speed, the actual dehydration, loading capacity of the plant, drying time.

Productivity of a dehydration plant is determined by many factors. The installation technical parameters, the physico-chemical material and the quantity of raw materials brought from dehydrated have direct influence of dehydration (Ţenu I., 2012).

Figure 2 **The experimental drying plant for horticultural products**

Modeling processes is fundamental for the selection and optimization of drying process (Andrea Rush, et. al., 2010). The model (the relationship 1) is widely used to simulate drying curves for plant products:

$$\frac{X_t - X_\infty}{X_0 - X_\infty} = \exp\left(-kt^n\right) \qquad [1]$$

where X_0, X_t and X_∞ are the initial moisture humidity at time *t* and steady humidity, *k* and *n* are constants of the mathematical model, and *t* is the drying time (minutes).

Therefore, the objectives of this study were to exanimate the influence of division type and temperature for the drying process in obtaining a product pears dehydrated with 14% humidity in the shortest time possible.

Pears were purchased from the local market (supermarkets Carrefour, Kaufland, Auchan), and were stored under special conditions (4 – 10^o C. RH 60 – 65%) until were introduced in the drying process. In order to obtain a dried product, pears were observed following technological steps:

- Quantitative and qualitative reception;

-Packaging raw material (sorting, washing);

-The processing of the raw material (division);

-Dehydration;

-Cooling;

-Storage.

Fruit for processing have been selected according to appearance (color, size, and maturity), washed (for removing the remainder of the plant and a significant part of contaminants), cleaned to remove the peduncle and the seminal house (Yadollahinia.A.R., 2008). The division was made in the form of slices, cubes and rings. The division was manually done. The pears were placed in divided tray dryer, uniform layer, so that the average load was about 600 grams per drying process. To determine the optimum parameters of the technological process, determinations were carried out every hour of operation, monitoring the values of the following parameters: temperature in dehydration chamber, the temperature in the drying fruit, fruit weight variation, relative air humidity from entering and leaving from the dehydration. Sketch of the drying facility are presented in *Figure 3*.

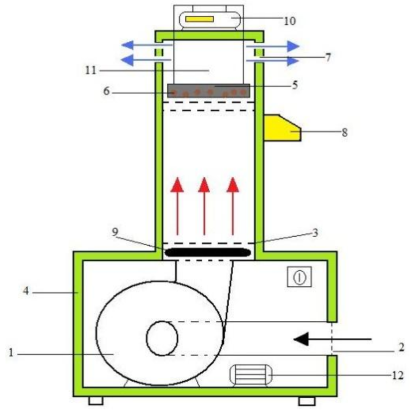

Figure 3 **Functional scheme of drying plant**

(1-fan; 2-air inlet connection; 3 – grill; 4-thermal insulation; 5-tray for products; 6 – products subject to drying; 7 – exhaust the drying agent; 8 – touch-screen user interface; 9 – electrical heating elements of air; 10-electronic balance; 11-drying chamber; 12 – electric motor)

The drying agent temperature needed for carrying out the experiments was 60° C and 70° C, with a speed drying agent of 1.5 m/s per each experiment. The number of experiments for each mode of partitions (rings, slices, cubes) and temperature was 4 (*Tab. 1*). The intake of the drying agent in installation was performed using a centrifugal fan that draws air from the outside and then it escapes into the drying chamber. The electrical resistances inside the plant allowing air heating of the temperature process. The plant is equipped with a thermostat that controls heat and maintain temperature constant (Tenu I., Rosca, R., Cârlescu P., 2012). The temperature of drying agent from dryer entering and leaving holes was monitored using a thermometer with thermocouple type K. the humidity drying agent was monitored with moisture sensors, included in the installation designed. The reducing of the moisture content was determined by measuring the weight of the fruit throughout the drying process (every hour). Determination of the content for the initial and final water was achieved by oven drying (104.5° C, 4½ hours). The speed of the drying process is expressed as the amount of evaporated water over time (Velic D., et. al., 2007):

$$\frac{\Delta w}{\Delta t} = \frac{w_t - w_{t-\Delta t}}{dt} \qquad [2]$$

where *Δw/Δt* is the rate of drying (%/h); w_t - humidity at time t (%); $w_{t-\Delta t}$ - humidity at time t - Δt (%); *dt* - time (minutes).

Table 1

Drying parameters

No. crt.	Drying agent temperature (^oC)	Drying agent velocity (m/s)	Presentation	Number of repetition	Initial moisture content (%)	Final moisture content (%)
1	70	1,5	Rings	4	*82.60*	*13.84*
			Slices	4	*82.74*	*14.23*
			Cubes	4	*82.56*	*12.84*
2	60	1,5	Rings	4	*82.36*	*13.91*
			Slices	4	*82.71*	*23.05*
			Cubes	4	*82.45*	*13.14*

RESULTS AND DISCUSSION

This study has been illustrated the behavior of fruit divided in various forms and dehydrated at two different temperatures (60° C and 70^o C). The results recorded during the drying process after weighing the samples are shown below (*tab. 2*).

It was found that increasing the temperature of drying agent leads to shortened drying up to 20%. For a better view of plants behavior in the drying process were done drying curves, by the moisture content of drying agent temperature for 70^o C and 60^o C, in different forms of division : pears - rings, slices, cubes (*Fig. 4 and 5*).

The temperature of drying agent have influence on the process kinetics, because the higher values of this parameter results in a decrease in moisture and, therefore, the drying time is being reduced.

Table 2

Results of pears drying at temperature of 60° C and 70° C, speed drying agent 1.5 m/s

Time (h)	Rings				Slices				Cubes			
	70°C		60°C		70°C		60°C		70°C		60°C	
	w (%)	*Δw/Δt (%/h)*	*w (%)*	*Δw/Δt (%/h)*	*w (%)*	*Δw/Δt (%/h)*	*w (%)*	*Δw/Δt (%/h)*	*w (%)*	*Δw/Δt (%/h)*	*w (%)*	*Δw/Δt (%/h)*
0	*82.60*	0	*82.36*	0	*82.74*	0	*82.71*	0	*82.56*	0	*82.45*	0
1	74.36	8.24	75.29	7.31	72.34	10.40	72.36	10.35	65.65	16.91	65.29	17.16
2	61.80	12.56	63.68	11.91	61.20	11.14	62.50	11.14	45.97	19.68	51.65	13.64
3	47.68	14.12	50.70	12.98	50.94	10.26	55.52	11.55	31.95	14.02	41.20	10.45
4	32.73	14.95	36.79	13.91	42.18	8.76	48.56	8.24	20.26	11.72	30.33	10.87
5	24.87	7.86	30.44	6.35	34.07	8.11	39.83	7.54	*12.84*	7.42	20.86	7.47
6	18.44	6.43	24.33	6.11	28.75	5.32	34.43	5.78			16.71	6.15
7	15.25	3.19	18.71	5.62	23.86	4.89	30.08	4.15			*13.14*	3.57
8	*13.84*	1.41	15.54	3.17	21.75	2.11	27.86	3.24				
9			*13.91*	1.63	19.66	2.09	26.21	1.98				
10					17.75	1.91	25.08	1.49				
11					15.96	1.79	24.11	1.24				
12					*14.23*	1.73	*23.05*	1.24				

w (%) – moisture content; *Δw/Δt – speed drying;*

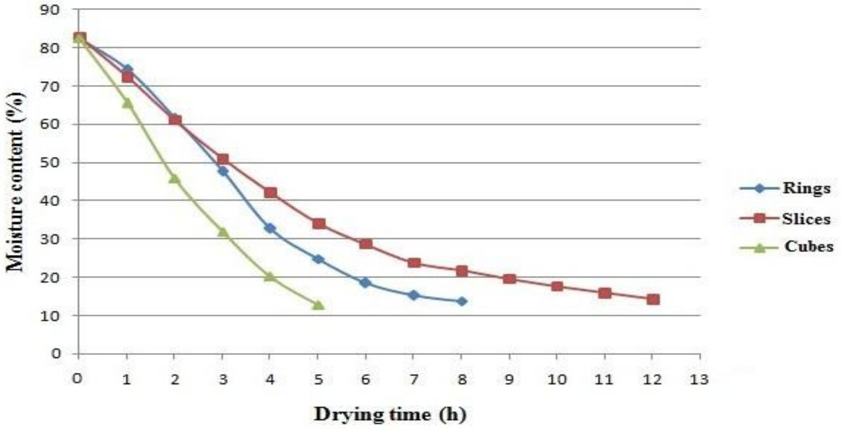

Figure 4 **Evolution of moisture over time (temperature 70° C, air velocity 1.5 m/s)**

At 70° C, there was a rapid decrease in moisture in the first 30 minutes, this behavior being not seen at 60° C, observing that the drying agent temperature is an important factor in the drying process. The contact area of the sample with drying agent (hot air) is a determining factor for the drying process. Thus, the final humidity of pears in the form of cubes (13%) was reached after 5 hours (temperature of 70° C) and 7 hours of operation (drying agent temperature 60° C). the evaporation of water from food is influenced by various phenomena, such as water related forms of food and water migration from the inside out. The pears division method (rings, slices, cubes) enhanced evaporation due to larger contact area, reducing the drying time for reaching an equilibrium. In order to achieve the value of 14% moisture content, at drying agent temperature of 70° C and speed of 1.5 m/s, drying time was 8 hours in the case of pears dried in slices; and 9 hours at a temperature of 60° C.

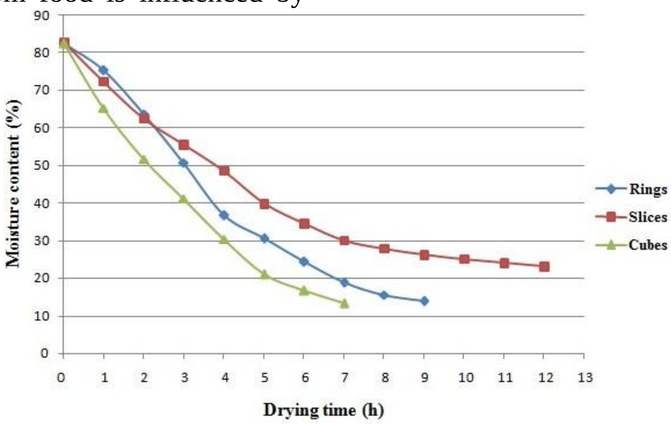

Figure 5 **Evolution of moisture over time (temperature 60° C, air velocity 1.5 m/s)**

The final product obtained - dried pears (*fig. 6*) - in appearance and from sensorial point of view has proven superior quality observing the following:

Figure 6 **The finished product – „Dried Pears**

- *The shape of the finished product* is specific to the product before drying (rings, slices, cubes), being subject to the phenomenon of shriveling due to the removal of water and of the tissue contraction.
- *Color* – the color degradation is in function of temperature and drying time, having a reddish color.
- *The taste and aroma* – in the case of drying products with hot air occurs stripping steam specific flavors, keeping the product taste and flavor.
- *The decrease volume* – is the result of contracting effect and water removal from fruits (Hui Y. H., 2010).

CONCLUSIONS

Fruit size is particularly important on the drying kinetics. The research shows the drying speed significantly increase when the pears are divided in cubes.

How to divide fruit showed great influences in the drying process.

At 70° C was a rapid decrease in moisture in the first 30 minutes, this behavior being not seen in 60° C, observing that the drying agent temperature is an important factor in the drying process.

Pears divided in different forms (rings, slices and cubes) and dried at 70° C with a speed of drying agent (hot air) at 1.5 m/s, reached the final moisture in a shorter time than those dried at 60° C (5, 8, 12 hours of drying to 7, 9, 13 hours).

The final product obtained (dried pears) in appearance and sensorial point of view proved to be superior quality.

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