Kinetics of Convective Drying and Quality of Pears Cultivars Conference, Lucas, Abate

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Abstract. The objective of this study is the kinetics process of drying of the pears cv. Conference, cv. Abate and cv. Lucas with a laboratory dryer, in order to identify at which level of humidity the maximum speed of evaporation is achieved and at which level of temperature and humidity pears slices begin to change (colour and shape) and to determine which one of the three tested varieties offers the best properties for drying, which will ensure that the final product is technologically and organoleptically the most acceptable. Drying parameters were the same for all three varieties: 2 hours at air temperature 90°C, 2 hours at air temperature 80°C, 2 hours at air temperature 70°C and 2 hours at air temperature 60°C. The results showed that the sample of the cv. Conference has undergone the least oxidation process, rounded edges and shriveled slices, and samples of the cv Lucas showed the worst results. Following the drying process of all three varieties, it can be concluded that the cultivars Abate and Conference achieved the lower evaporation speed, unlike the cv. Lucas. The cultivars Conference and Abate have attained consistent drying and in this way the technological process was finished with a smaller temperature, resulting in a better quality of the final product.

Keywords: pear, dryer, Conference, Abate, drying process, the kinetics of drying process.

INTRODUCTION

Pears are a valuable food in terms of nutrient that is present in human food throughout the year. Also, pears are a staple in food processing, primarily in the production of juices, nectars, marmalades, jams, stewed and dried fruits. During preservation by drying is necessary technological process aim to achieve an optimum quality end product (Beceanu D. et al., 2011).

Post-harvest losses suffered by vegetables products can be reduced considerably by using adequate drying technologies. The main objective of drying is to reduce the natural moisture content to a level where the activity of microorganisms is stopped without destroying tissues and not depreciate the value of end food products. Generally, fruits are characterized by a high moisture content and sensitivity to high temperatures (color, flavor, texture, nutritional value). The amount of heat required to dehydrate a product depends on several factors such as initial moisture content of the product, desired moisture content after drying, temperature and humidity of drying agent and its speed (Velic D. et. Al, 2007).

In pears, the main of the fruit is pulp, which is 97% of the fruit, while the skin and seeds are 2.5% and 0.5% of the fruit. Pears contain 79 - 87% water, 0.33% minerals, carbohydrates 6.5 to 1.9%, protides 1.2%, lipids1.0%. The chemical composition of fruit depends on climatic conditions, soil, variety and agrotechnical conditions (Drăgănescu E., 2002).

During drying, the product following phenomena occur: external diffusion (water is evaporated from the product surface), internal diffusion (water migrates out of the inner layers due to water evaporation from the surface and the tendency to equalize moisture in product), thermal diffusion of water (Țenu I., Marian Gr, 2006).
MATERIALS AND METHODS

In this study were used pears (Pyrus communis L.) of varieties Conference, Lucas and Abate, fruits were purchased at technological maturity from local market. Dehydration of pears was performed using a vertical laboratory dryer (Figure 1) belonging to Agricultural Mechanization Department of the University of Agricultural Sciences and Veterinary Medicine (Țenu I., R. Rosca, Cărlescu P., 2012). The dryer is equipped with an operator interface "touch screen" that allows control and monitoring parameters of the drying process:
- The temperature of the drying agent;
- The velocity of the drying agent;
- Drying time required.

Heat and mass transfer inside the dryer is achieved by convection, heat agent is represented by air heated by electrical resistance (3 resistance of 1.5 kW). Drying agent is drawn from outside using a fan blowing from the bottom up.

The dryer operates in discontinuous after a cycle according the nature of product, to the following stages: feeding fresh product tray, placement in a uniform layer, and entry into the drying chamber, drying the product by sealing the dryer enclosure, switch on the fan and electrical items, cooling fruit dehydrated product.

The dryer is equipped with its own thermostat that controls the heating temperature and maintain constant. Weight loss due to elimination of water are monitored by electronic balance mounted above the drying chamber.

The fruits are unpeeled, cuts into into slices with thickness 6 mm. On the tray dryer were placed about 500 g of product to be dried. The drying process was conducted in three stages, because each variety was dried separately.

The drying process is a complex process that runs in two stages. In the first hour evaporation is carried with high speed, eliminating free water, then drying speed is reduced gradually in proportion to the product moisture reduction (Guiné R.P.F. et al., 2007).

The experiment was performed to follow the speed drying of pear slices. Drying parameters were the same for all three varieties: 2 hours at 90°C, 2 hours at 80°C air temperature, 2 hours at 70°C and 2 hours at 60°C. Also, another important factor in carrying out the drying process is the speed of the drying agent (atmospheric air). In this study, the
velocity of the air was the same for all three varieties of pears studied it with a value of 1.6 m/s.

The moisture content of each sample was determined by gravimetric method at 60 minutes each tray with product is weighed (Table 1).

Water content was expressed as the percentage of moisture from wet products (w) (Dragana Paunovic et. al, 2010). These values are calculated using the relationship:

\[ w = \frac{m_1 - m_2}{m_2 - m_3} \times 100 \]  \[\text{[1]}\]

where: \( w \) - the percentage of moisture in the wet product (%); \( m_1 \) - is the weight of tray dryer, \( m_2 \) - is the weight trays with product and \( m_3 \) - is the weight tray dried at 105 °C to constant weight.

The amount of water removed from 100 g of pear is calculated with relation 2:

\[ W = G \times (1 - \frac{C_2}{C_1}) \]  \[\text{[2]}\]

Where \( W \) - amount of moisture evaporated (g), \( G \) - initial quantity of fruit (g), \( C_1 \) - solids content before drying (%); \( C_2 \) - dry matter content after drying (%).

RESULTS AND DISCUSSION

Drying kinetics of pear samples was determined by continuously monitoring changes in the mass of product, temperature and humidity profile. Humidity drying agent entry into the dryer ranged from 35 to 40 % and to the output of the dryer ranged between 66 to 71%.

The results obtained from tray weighing products and associated temperatures are shown in Table 1.

<table>
<thead>
<tr>
<th>Timp, [h]</th>
<th>Conference</th>
<th></th>
<th>Lucas</th>
<th></th>
<th>Abate</th>
</tr>
</thead>
<tbody>
<tr>
<td>( T_w ) [°C]</td>
<td>( G_p ) [g]</td>
<td>( T_w ) [°C]</td>
<td>( G_p ) [g]</td>
<td>( T_w ) [°C]</td>
<td>( G_p ) [g]</td>
</tr>
<tr>
<td>1</td>
<td>90</td>
<td>273.4</td>
<td>90</td>
<td>390</td>
<td>90</td>
</tr>
<tr>
<td>2</td>
<td>90</td>
<td>187.7</td>
<td>90</td>
<td>265.8</td>
<td>90</td>
</tr>
<tr>
<td>3</td>
<td>80</td>
<td>119.5</td>
<td>80</td>
<td>152.9</td>
<td>80</td>
</tr>
<tr>
<td>4</td>
<td>80</td>
<td>102.1</td>
<td>80</td>
<td>115</td>
<td>80</td>
</tr>
<tr>
<td>5</td>
<td>70</td>
<td>94.3</td>
<td>70</td>
<td>105.3</td>
<td>70</td>
</tr>
<tr>
<td>6</td>
<td>70</td>
<td>88.6</td>
<td>70</td>
<td>99.6</td>
<td>70</td>
</tr>
<tr>
<td>7</td>
<td>60</td>
<td>84.6</td>
<td>60</td>
<td>96.4</td>
<td>60</td>
</tr>
<tr>
<td>8</td>
<td>60</td>
<td>81.3</td>
<td>60</td>
<td>92.5</td>
<td>60</td>
</tr>
</tbody>
</table>

\( T_w \), \( G_p \) is the temperature of drying agent and weight products.

The results of determination of the humidity content (\( w \)) in the pears during drying and the speed of water evaporation expressed as a decrease in humidity content over time \((\Delta w/\Delta t)\) are shown in Table 2.
Tab. 2

Humidity content in apple slices and speed of water evaporation during drying

<table>
<thead>
<tr>
<th>Temp, h</th>
<th>Conference</th>
<th></th>
<th>Lucas</th>
<th></th>
<th>Abate</th>
</tr>
</thead>
<tbody>
<tr>
<td>w (%)</td>
<td>∆w/∆τ (%/h)</td>
<td>w (%)</td>
<td>∆w/∆τ (%/h)</td>
<td>w (%)</td>
<td>∆w/∆τ (%/h)</td>
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<tr>
<td>0</td>
<td>86.4</td>
<td>0</td>
<td>84.9</td>
<td>0</td>
<td>85.8</td>
</tr>
<tr>
<td>1</td>
<td>75.5</td>
<td>10.9</td>
<td>80.4</td>
<td>4.5</td>
<td>78.0</td>
</tr>
<tr>
<td>2</td>
<td>64.1</td>
<td>11.4</td>
<td>71.3</td>
<td>9.1</td>
<td>66.1</td>
</tr>
<tr>
<td>3</td>
<td>43.7</td>
<td>20.4</td>
<td>50.2</td>
<td>21.1</td>
<td>49.8</td>
</tr>
<tr>
<td>4</td>
<td>34.1</td>
<td>9.6</td>
<td>33.8</td>
<td>16.4</td>
<td>37.7</td>
</tr>
<tr>
<td>5</td>
<td>28.7</td>
<td>5.4</td>
<td>27.7</td>
<td>6.1</td>
<td>29.4</td>
</tr>
<tr>
<td>6</td>
<td>24.1</td>
<td>4.6</td>
<td>23.5</td>
<td>4.2</td>
<td>24.4</td>
</tr>
<tr>
<td>7</td>
<td>20.5</td>
<td>3.6</td>
<td>19.7</td>
<td>3.8</td>
<td>20.0</td>
</tr>
<tr>
<td>8</td>
<td>17.3</td>
<td>3.2</td>
<td>17.7</td>
<td>2.0</td>
<td>17.1</td>
</tr>
</tbody>
</table>

w (%) - humidity content; (∆w/∆τ) (%/h) - speed of water evaporation.

Based on these results, the graphics on speed of drying depending on the current humidity of the pears for each cultivar are given in Figures 2, 3 and 4.

Fig. 2. Drying curve depending on the humidity of product of the variety Conference

Fig. 3. Drying curve depending on the humidity of product of the variety Lucas
Fig. 4. Drying curve depending on the humidity of product of the variety Abate

It is concluded from the figures that the speed of drying increased and the maximum was achieved at the humidity of 43.7% for the variety Conference. For variety Lucas drying speed reached a maximum humidity of 50.2%, and for the variety Abate drying speed was reached at 49.8% moisture content after drying speed decreased. Highest drying rate was recorded for variety Lucas (21.1%/h) to the Conference variety (20.4%/h) and Abate (16.3%/h).

The fresh pears of variety Conference had 15.2% total dry matter and after drying had 82.7% dry matter. The fresh pears of Lucas variety were 16.2% total dry matter and after drying had 82.3%. The fresh pears Abate variety had 15.9% total dry matter and after drying had 82.9% total dry substance.

The amount of evaporated water was determined from 100 g of product. From 100 g of fruit, variety Conference pears have the highest amount of water evaporated during the drying process, that is 81.63 g, 80.32 g of water evaporated during drying for variety Lucas and 80.83 g of water evaporated the variety Abate, according to relation 3:

\[
W = 100 \times \left(1 - \frac{15.2}{82.7}\right) = 81.63 \ g \quad \text{(for cv. Conference)}
\]

\[
W = 100 \times \left(1 - \frac{16.2}{92.4}\right) = 80.32 \ g \quad \text{(for cv. Lucas)}
\]

\[
W = 100 \times \left(1 - \frac{15.8}{82.8}\right) = 80.83 \ g \quad \text{(for cv. Abate)}
\]

Since the drying process lasted 8 hours, this means that the average humidity loss per hour was approximately 10.20 g (cv. Conference), 10.01 g (cv. Lucas) and 10.10 g (cv. Abate).

Because drying parameters (temperature and time) were the same for all three varieties, and the highest percentage of loss of moisture has been the variety Conference and Abate and less for variety Lucas, it can be concluded that the loss of moisture is proportional to the initial moisture content.

Variation of humidity - time for the three varieties of fruit is shown in Figures 5, 6, 7.
Fig. 5. Change in moisture over time for the variety Conference

Fig. 6. Change in moisture over time the variety Lucas

Fig. 7. Change in moisture over time the variety Abate

The pears sample Conference began to brown the moisture content of 64.1% and changed their geometric shape to a moisture content of 43.7% (after 2 - 3 hours of drying, due to high temperature drying agent 90 °C, 80 °C respectively) and during the drying process (drying agent when the temperature was decreased to 60 °C). Sample of the variety Lucas pears start to brown and changed their geometric shape to a moisture content of 71.3% and 50.4%. Browning and changing the geometric shape start to at the humidity content of 49.8%
for Abate. Changes of color and geometric shape of pear slices during the drying process are presented in Figures 8, 9, 10.

Convective drying of pears could be conducted at a temperature of 60 - 70 °C, which would reduce the browning and decreasing moisture content could be higher by increasing airflow velocity. High temperatures or high duration for drying process can cause nutrient losses, reducing color and fragrance products, reducing the rehydration ability of dried (Cháfer M et al., 2011).

CONCLUSIONS

The largest amount of free water evaporated in the first 3 hours of drying. Following the drying kinetics of the pear slices, it can be concluded that the speed of drying increased and achieved its maximum at the humidity of 43,7 % (cv. Conference), 48.9% (cv. Abate) and 50.2% (cv. Lucas), after that the speed of drying decreased.
Because all samples of pears were brown after the first 2 - 3 hours of drying, it can be concluded that the optimum temperature for drying pears can be 60-70 °.

The final content of water for three varieties of pears (Conference, Lucas and Abate) could not reach values lower because the temperature drying of 80° and 90° C increases browning phenomenon (water inside the product not manage to migrate to the outside). To reduce the browning it requires that the temperature be between 65-75 °.

The drying time could be shortened even if the thickness of sliced pears would be reduced from 6 mm to 4 mm. These guidelines will certainly be retested and precise to accurately optimize the conditions of convective drying processes pears.

ACKNOWLEDGMENTS

We would like to thank the Department of Agricultural Mechanization for the material that they put it available and for their support, and not least POSDRU Project 77222.

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