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Investigating the Influence of Drying Temperature and Air Flow Velocity on Some Qualitative Specifications of the Sliced Pear During Drying and Employment of Image Processing Technique

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Abstract
Drying of agricultural and horticultural crops is one of the most important processes for their long term storage. Therefore, in this study, the influence of drying temperature and air flow velocity on the variation of color, shrinkage and pH were investigated during the drying process of thin-sliced Dargazi pear varieties. Drying air temperature varied in four levels of 50, 60, 70 and 80 °C and the air flow velocity at three levels of 0.5, 1 and 1.5 m/s. The image processing results indicated that maximum variation of the sample' color (30.78) occurred at drying temperature of 80°C and air velocity of 1.5 m/s. In contrast, the minimum variation of the color (14.38) occurred at drying temperature of 50 °C and air velocity of 0.5 m/s. The results indicated that PH of the examined samples increases during the drying process. The maximum value of pH (4.49) was obtained at drying temperature of 50 °C and air velocity of 0.5 m/s, whereas the minimum value (3.93) was measured at 80 °C and air velocity of 1.5 m/s. Given the overall results obtained in this study, minimum drying time with minimum variation of qualitative specifications occurred at drying temperature of 70 °C and air flow velocity of 0.5 m/s; therefore, this condition could be suggested as the best combination for drying of thin-sliced pears.

Keywords: Discoloration, Image Processing, Pear, pH, Shrinkage

Introduction
Drying agricultural products is one of the most important processes for long term storage of these products. Many biological and chemical activities without water or with low water content are stops or slows. Therefore, in this study, influence of different drying temperatures and hot air flow velocity on qualitative properties and color variation of thin slices of Dargazi pear variety was evaluated with the help of real-time imaging (simultaneous imaging by drying) using the image analysis software (Image J, version1.46r). Finally the optimum combination of drying temperature, drying time and air flow velocity that does not adversely affect the product quality, is determined.

Materials and methods
In this study, a type of convective hot-air dryer was used. The dryer was consisted of a centrifugal fan to create airflow, a dimmer to control the air flow rate, four heaters with total power of 2000 W to heat the incoming air into the drying chamber, and several

temperature and humidity sensors. In the experiments, the influence of temperature and air velocity on color change, shrinkage and pH of thin slices with a diameter of 60 mm and a thickness of 5 mm were studied. Drying air temperature and inlet air flow velocity varied in four levels of 50, 60, 70 and 80 °C, and three levels of 0.5, 1 and 1.5 m/s, respectively.

Results and discussion

The results indicated that in the early hours of drying, brightness of dried samples over time (L*) and yellow/below color parameter (b*) were increased. Alignment of brightness parameter L* with b* color parameter is not far-fetched, because the increase in yellow color tone of the fruit tissue reflect more light and the fruit surface becomes more clear, yielding increase of surface brightness. The presented results show that a* color parameter is reduced during the drying process (increased green color tone). These changes were more severe at higher drying temperatures, e.g., at 80 °C.

The results of image analysis shows that the greatest color change (30.78) is for drying temperature of 80 °C and air flow velocity of 1.5 m/s, whereas the lowest color variation (14.38) is for drying temperature and air flow velocity of 80 °C and 1.5 m/s, respectively. The obtained results showed that pH of samples was reduced during drying. The greatest pH value of dried samples (4.49) were observed at drying temperature of 50 °C and air speed of 0.5 m/s, whereas the lowest pH value (3.93) were observed at drying temperature of 80 °C and air speed of 1.5 m/s. During drying, pH of samples reduces due to the loss of amine groups as well as the production of organic acids. According to the results, the shrinkage of pears increased with increasing drying time and reducing the moisture content. In the early stages of drying, the sample's moisture content removes out faster, which is suffered the highest percentage of shrinkage. In this period, i.e., in the first moments of drying, upward concave of the shrinkage curve is detectable. Then variation of shrinkage increased linearly with time and in the end stages of drying, shrinkage concave curve shifted downwards and the rate of shrinkage was reduced.

Conclusion

In this research, color variation, shrinkage and pH of thin slices of Dargazi pear variety was studied in a convective hot-air dryer under the influence of different drying temperatures and input air flow velocities. The results of this study showed that the highest decrease in pH was for drying temperature of 80 °C and air flow velocity of 1.5 m/s. Also according to the results of image analysis, drying temperature of 80 °C is not recommended for drying of pear slices due to the intense color change and a significant decrease in pH of dried samples. The overall color variation index (ΔE) was higher at 60 °C in compare to the drying temperature of 70 °C. Meanwhile the difference between the percentage of shrinkage in drying temperature 60 and 70 °C were not significant; therefore drying temperature of 60 °C was removed from comparison of optimum drying conditions. Percentage change in pH, shrinkage and the overall color variation (ΔE) was significantly lower at drying temperature of 50 °C in compare to that of drying temperature of 70 °C, so in this sense the drying temperature of 50 °C is preferred. On the other hand, total drying time at 50 °C and air velocity of 5.0 m/s was equal to 408.33 min, in compare to total drying time of 180 min at drying temperature of 70 °C and air velocity of 0.5 m/s; which the difference between total drying times was very noticeable.

Given the overall results obtained in this study, minimum drying time with minimum variation of qualititative specifications occurred at drying temperature of 70 °C and air flow velocity of 0.5 m/s; therefore this condition could be suggested as the best combination for drying of thin-sliced pears.