Hot Air Drying of Quince Slices: Impact of Ethanol Immersion, Citric Acid and Microwave Pretreatment on Drying Characteristics, Thin layer and Artificial Neural Network Modeling, Color and Shrinkage Properties and Energy Consumption

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Abstract:

The current study investigates the effect of ethanol and citric acid immersion, microwave application as a pretreatment on drying characteristics, thin layer (TL) and artificial neural network (ANN) modeling, color and shrinkage properties and energy consumption of hot air-dried quince slices. Briefly, quince slices (4 cm width, 4 mm thickness) were immersed in ethanol (100% for 10 and 20 min) and citric acid (%1 for 2 min) solutions. The samples were coded as ET10, ET20 and CA. Microwave applications were carried out at 800 W power for 30 s and called as MW. The unpretreated samples were regarded as control group and coded as C. All samples were dried at 60 °C and 1 m s^{-1} air velocity in drying oven. Drying times of C, CA, MW, ET10 and ET20 samples were found to be 390, 330, 270, 240 and 210 min, respectively. Additionally, effective moisture diffusion coefficients of C, CA, MW, ET10 and ET20 were calculated as follows: 2.88 x 10^{-10}, 3.32 x 10^{-10}, 3.03 x 10^{-10}, 3.61 x 10^{-10} and 4.14 x 10^{-10} m^2 s^{-1}. The dehydration ability of products for determining optimum drying process is indicated by effective moisture diffusivity. In other words, increasing moisture diffusion indicates an increase in drying rate and decrement in drying time. As a result, pretreatments enhanced the drying rate and reduced the drying time. The highest effect on drying rate and time was observed in ET20. On the other hand, drying curves of the samples were high accurately described by Page and Midilli and Kucuk models. However, ANN modeling gave better performance than thin layer models. The RMSE and R^2 values of the samples were 0.000730741-0.00254425 and 0.9999, respectively. To optimize the drying process, accuracy of modeling has remarkable effects. Color properties of fresh quince slices were 71.87, 10.70 and 33.34 for L*, a* and b*, respectively. The highest losses of L*, a* and b* were observed in C with the values of 43.65, 21.09 and 30.87, respectively ($p<0.05$). The best results in terms of color were obtained from CA with 64.13, 17.32 and 32.31 L*, a* and b* values, respectively ($p<0.05$). Besides, the total color difference (ΔE) values of samples were higher than 5, meaning that non-trained observer can detect color change in the products. The lowest ΔE value was calculated in CA. All samples showed shrinkage tendance in both width and thickness after drying. However, no remarkable change was generally determined among the pretreatments ($p>0.05$). Shrinkage is a key quality parameter in plant products with high water content, as drying can alter their shape, density, and porosity. Therefore, determination of shrinkage is an important process. Moreover, specific moisture extraction rate (SMER) and specific energy consumption (SEC) of the samples were determined. High SMER values indicate efficient moisture removal with less energy, while low SEC values reflect lower energy demand per kilogram of moisture removed. These metrics assess energy consumption and the