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Prediction of surface heat transfer coefficients and mass transfer kinetics of eggplant samples during deep fat frying by artificial neural network

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Introduction: Thermal properties of food during the frying process and mass transfer mechanisms (water and oil) can help in controlling the quality of the fried product (Fiszman et al., 2005). During the frying process, heat was transferred from the oil to the sample surface that it increases the temperature almost to 100 °C, the water evaporates and moved out. The sample surface was covered by bubble layers with various size and distribution. The formation of vapor bubbles on the samples surface have been effective on the micro-flows which is one of the important factor in the coefficient of heat transfer (Sahin et al., 1999). Therefore, knowledge of the relationship between the boundary layer and the surface heat transfer coefficient can determine the thermal behavior and kinetics of the migration of moisture and oil. Eggplant (Solanum Melongena L.) is one of the major agricultural crops of Asian and Mediterranean countries. Iran after China and India has achieved third place in eggplant production, which has made it remarkable, and economical. Eggplant absorbs high amounts of oil during the frying process due to its high moisture content (more than 90%) and high porous structure even if the residual water content is still quite high after frying.

Materials and methods: Fresh eggplants (*Solanum melongena L.* family Solanaceae) were obtained from the local market and stored at 4°C. Eggplant samples were washed with water tap and cut with manual mold into equal and similar cylindrical pieces (2.5×1cm). They were then washed with distilled water and surface water was removed using tissue paper. Finally, the samples were packed by poly-ethylene in order to prevent surface drying. A commercial sunflower oil was purchased from Ladan Factory, Iran.

Eggplant samples were dried at different temperature of hot air drying 40, 70, 100 and 130°C until moisture content 5 and 12 db%. Samples were drawn from the drier after drying, cooled at room temperature (25°C) and deep fat fried.

A domestic deep fat fryer with temperature control of ± 1°C (Seb, France) was used for carrying out frying operations. The fryer was filled with 2.5 l sunflower oil. The eggplant to oil ratio was kept at 1:50 w/v to reduce temperature variation in the oil bath. The frying was performed at 130, 150 and 170 °C for regular interval times 1, 2, 3, 4, 5 and 6 min. The frying oil was changed after 10 h of frying time. The samples were immediately removed from oil and were located on wired plate for draining and remove excess oil on the surface, and allowed to cool at room temperature before analyses. All experiments were performed in triplicates and the presented results are the mean of the obtained values.

Oil and moisture content were determined according to AOAC, 1995.

K type thermocouples (copper-nickel) with accuracy of ±1°C were used to measure the temperatures of samples. Temperature acquisition TC-08, Pico® (Technology Limited, England) with accuracy ±0.5°C and temperature controller PID Rex- D-100® (RKC) were used to data collection and oil temperature control, respectively.

In this study, convective heat transfer coefficient was calculated between surface sample and oil according to Farinu and Baik (2008).

In order to predict surface heat transfer coefficients and mass transfer kinetic eggplant samples during deep frying was used artificial neural networks. Then, the 4 inputs including: frying temperature (130, 150 and 170 °C), frying time (1, 2, 3, 4, 5 and 6 min), 4 pre-treatments drying temperature by hot air (40, 70, 100 and 130 °C) until the two moisture levels (5 and 12 %db) were used and output parameters including moisture and oil content, heat transfer coefficient with two replications which in total of 288 data were used to form the network

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structure.

Results and discussion: Results of this study showed that there is some complicated relationship between convective heat transfer and moisture and oil content. In addition, the convective heat transfer coefficient in up and down surface of the sample showed that oil absorption will be from upper surface. This phenomenon can be attributed to upper surface due to more bubbles of vapor out of the sample. This leads would slower the formation of crust on the upper sample. Finally, channels and cavities of the upper level will be more susceptible to the contact of oil. The results of predictive parameters of heat and mass transfer during deep frying eggplant samples using artificial neural network multilayer perceptron as a non-linear method showed closely relationship with experimental data. It indicates that the proper functioning of this method for modeling and studying the relationship between heat and mass transfer phenomena during deep frying of eggplant samples.

Keywords: Frying, Eggplant, Surface Coefficient of Heat Transfer, Mass Transfer, Artificial Neural Network.