ABSTRACT

Analytical solution for the freezing time prediction of food are difficult and prone to error primarily due to the influence of sharp variation of thermo-physical properties with the lowering of temperature and incomplete knowledge on the estimation of surface heat transfer coefficient .In the current research work, two analytical models (Method 1 and 2) has been developed for predicting the freezing times of finite slab, finite cylinder and sphere shaped shrimp. Method 1 divides the whole freezing process into three time periods, viz., (i) precooling (ii) phase change and (iii) subcooling; while the Method 2 divided the process into two: one which ends when the core of the sample reaches the initial freezing point and the second ends when the core of the food reaches a predetermined final temperature. A finite difference method using Crank-Nicolson scheme was developed to predict the time-temperature relation at any point inside a finite slab shaped food, which was then used to predict the freezing time of the finite slab shaped shrimp. The developed methods were compared with three other analytical models viz., (i) Modified Plank (ii) Cleland et al. (iii) Pham method. Numerical method was compared with the other methods for freezing time prediction of slab shaped shrimp. A laboratory scale experimental set-up was designed to check the reliability of the developed analytical and numerical methods in actual operating conditions. The time-temperature profiles generated through numerical method were also compared with the experimental values at three different locations inside the finite slab shaped food.

Computed freezing time by different methods and errors associated with them showed that (i) Finite Difference and Modified Plank's method are better for finite slab shaped food (ii) Cleland et al. method is the best for finite cylindrical shaped food and (iii) Method 1, Method 2 and Pham method show the better agreement for prediction of freezing time of spherical shaped food. The error limit of the three developed methods for freezing time prediction ranged within 10 % for all the three shapes of food.

Key words: Cryogenic freezing, Freezing time, Analytical and numerical method