Potential of artificial neural network technology for predicting shelf life of processed cheese

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Radial basis (fewer neurons) artificial neural network (ANN) models were developed for predicting the shelf life of processed cheese stored at 7-80 C. Mean square error, root mean square error, coefficient of determination and nash - sutcliffo coefficient were applied in order to compare the prediction ability of the developed models. Soluble nitrogen, pH; standard plate count, yeast & mould count, and spore count were the input parameters, while sensory score was output parameter for the developed model. The developed model showed very good correlation between actual data and predicted data with high coefficient of determination and nash - sutcliffo coefficient besides low root mean square error, suggesting that the developed model is quite efficient in predicting the shelf life of processed cheese.

Keywords*: artificial neural network, artificial intelligence, radial basis (fewer neurons) , processed cheese, shelf life, prediction*

Introduction

Processed cheese is very popular dairy product generally prepared from medium ripened grated Cheddar cheese, and sometimes a part of ripened cheese is replaced by fresh cheese. During its manufacture some amount of water, emulsifiers, extra salt, preservatives, food colorings and spices (optional) are added, and the mixture is heated to 70º C for 10-15 minutes with steam in a cleaned double jacketed stainless steel kettle, which is open, shallow and round-bottomed, with continuous gentle stirring (about 50-60 circular motions per minute) with a flattened ladle in order to get optimum consistency and unique body & texture in the product. An artificial neural

network (ANN), usually called neural network is a mathematical model or computational model that is inspired by the structure and functional aspects of ANN. ANN based computing method is an adaptive system that changes its structure based on external or internal information that flows through the network during the learning phase. In ANN based intelligent computing, simple artificial nodes called "neurons" are connected together to form a network of nodes mimicking the biological neural networks (Wikipedia ANN Website, 2011). A radial basis function network is an ANN that uses radial basis functions as activation functions. It is a linear combination of radial basis functions. They are used in function approximation, time series prediction, and control. Radial basis function network consists of one layer of input nodes, one hidden radial-basis function layer and one output linear layer (Mateo *et al*., 2009). Shelf life studies can provide important information to product developers enabling them to ensure that the consumer gets a high quality product for a significant period of time after production. Since, long time taking shelf life studies do not fit with the speed requirement, hence new accelerated studies have been developed (Medlabs Website, 2011) for many food products. Goyal and Goyal (2011a) implemented brain based artificially intelligent scientific computing models for shelf life detection of cakes stored at 300C. The potential of simulated neural networks for predicting shelf life of soft cakes stored at 100C was highlighted by Goyal and Goyal (2011b). Cascade single and double hidden layer models were developed and compared with each other for predicting the shelf life of Kalakand, a desiccated sweetened dairy product (Goyal and Goyal, 2011c). For forecasting the shelf life of instant coffee drink, artificial intelligence models have been suggested (Goyal and Goyal, 2011d; Goyal and Goyal, 2011e). Artificial intelligent scientific computer engineering models for estimating shelf life of instant coffee sterilized drink were successfully applied by Goyal and Goyal (2011f).ANN for predicting the shelf life of milky white dessert jeweled with pistachio were applied by Goyal and Goyal (2011g). The shelf life of brown milk cakes decorated with almonds was predicted by developing artificial neural network based radial basis (exact fit) and radial basis (fewer neurons) models (Goyal and Goyal, 2011h). Also, the time-delay and linear layer (design) intelligent computing expert system models have been recommended for predicting the shelf life of soft mouth melting milk cakes (Goyal and Goyal, 2011i). Computerized models predicted the shelf life of post-harvest coffee sterilized milk drink (Goyal and Goyal, 2011j).The proposed study aims at developing the radial basis (fewer neurons)

ANN computing model for predicting the shelf life of processed cheese stored at 7-8 ºC, which would be very useful for consumers, manufacturers, retailers, and other concerned agencies.

Materials and method

Experimentally obtained 36 observations for each input and output variables were used for developing the models.

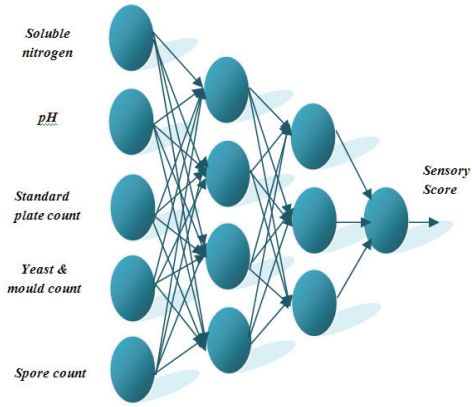

Figure 1. Input and output parameters for ANN models

The dataset was randomly divided into two disjoint subsets, namely, training set having 30 observations (80% for training), and validation set consisting of 6 observations (20% for testing). The input parameters used in developing the ANN model were the experimental data of processed cheese relating to soluble nitrogen, pH; standard plate count, Yeast & mould count, and spore count. The sensory score assigned by the trained panelists was taken as output parameter (Fig.1).

$$MSE = \left[\sum_{1}^{N} \left(\frac{Q_{\exp} - Q_{cal}}{n} \right)^2 \right] \qquad (1)$$

$$RMSE = \sqrt{\frac{1}{n}\left[\sum_{1}^{N}\left(\frac{Q_{\exp} - Q_{cal}}{Q_{\exp}}\right)^2\right]} \qquad (2)$$

$$R^2 = 1 - \left[\sum_{1}^{N}\left(\frac{Q_{\exp} - Q_{cal}}{Q_{\exp}^{\ 2}}\right)^2\right] \qquad (3)$$

$$E^2 = 1 - \left[\sum_{1}^{N}\left(\frac{Q_{\exp} - Q_{cal}}{Q_{\exp} - \overline{Q_{\exp}}}\right)^2\right] \qquad (4)$$

Where,

$Q_{\exp}$ = Observed value; Q_{cal} = Predicted value; $Q_{\exp}$ =Mean predicted value; n = Number of observations in dataset.

Mean Square Error MSE (1), Root Mean Square Error RMSE (2), Coefficient of Determination R2 (3) and Nash - Sutcliffo Coefficient E2 (4) were applied in order to compare the prediction ability of the developed models.

Results and discussion

ANN model's performance matrices for predicting sensory scores are presented in Table 1.

Table 1: Results of Radial Basis (Fewer Neurons) model

Spread Constant	MSE	RMSE	R^2	E^2
10	0.002660019	0.051575367	0.948424633	0.997339981
20	0.002422522	0.04921912	0.95078088	0.997577478
30	0.001958471	0.044254619	0.955745381	0.998041529
40	0.001767319	0.042039494	0.957960506	0.998232681
50	0.002009656	0.04482919	0.95517081	0.997990344
60	1.04864E-05	0.003238266	0.996761734	0.999989514
70	**8.32216E-07**	**0.000912259**	**0.999087741**	**0.999999168**
80	7.6146E-06	0.002759456	0.997240544	0.999992385

90	1.44227E-05	0.003797717	0.996202283	0.999985577
100	2.00537E-05	0.004478131	0.995521869	0.999979946
110	2.48217E-05	0.004982141	0.995017859	0.999975178
120	2.90291E-05	0.005387869	0.994612131	0.999970971
130	3.29264E-05	0.005738157	0.994261843	0.999967074
140	3.66713E-05	0.006055683	0.993944317	0.999963329
150	4.03612E-05	0.006353049	0.993646951	0.999959639
160	2.72909E-05	0.005224066	0.994775934	0.999972709
170	2.44465E-05	0.00494434	0.99505566	0.999975553
180	2.16412E-05	0.004652014	0.995347986	0.999978359
190	1.90509E-05	0.004364729	0.995635271	0.999980949
200	1.67078E-05	0.004087523	0.995912477	0.999983292

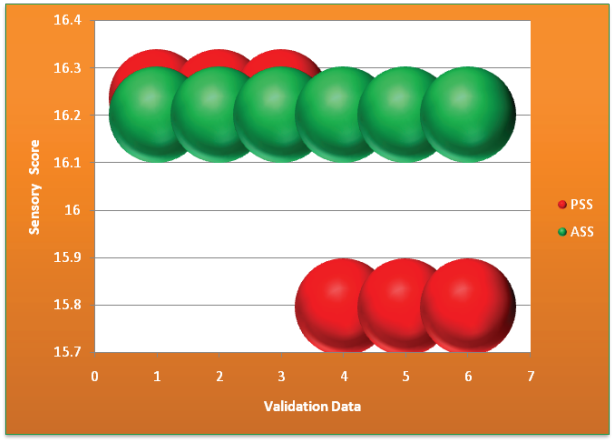

Figure 2. Comparison of ASS and PSS for radial basis (fewer neurons) model

The comparison of Actual Sensory Score (ASS) and Predicted Sensory Score (PSS) for the developed ANN models are illustrated in Figure 2. The reslts showed that the developed model with 70 as spread constant (MSE: 8.32216E-07 ; RMSE : 0.000912259 ; R^2 : 0.999087741 ; E^2 : 0.999999168) got best simulated with a high coefficient of determination and low root mean square error, suggesting that radial basis (fewer neurons) ANN models are useful for predicting the shelf life of processed cheese.

Conclusions

Radial basis (fewer neurons) ANN models were developed for predicting the shelf life of processed cheese stored at 7-80 C. The inputs variables used for developing the ANN model were soluble nitrogen, pH; standard plate count, yeast & mould count, and spore count, while the output variable was sensory score. The experiments results revealed very good correlation between the experimental data and the predicted values, with a high determination coefficient, establishing that the developed ANN models are able to analyze non-linear multivariate data with excellent performance. From the study it is concluded that radial basis (fewer neurons) ANN model is very efficient for predicting the shelf life of processed cheese.

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