Radial Basis (Exact Fit) and Linear Layer (Design) ANN Models for Shelf Life Prediction of Processed Cheese

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Abstract

Radial Basis (Exact Fit) and Linear Layer (Design)ANN models were developed for predicting the shelf life of processed cheese stored at 30^o C. Processed cheese is protein rich food, and is a comparable supplement to meat protein. Soluble nitrogen, pH, standard plate count, yeast & mould count, and spore count were taken as input parameters, and sensory score as output parameter for developing models. ANN model predicted the shelf life of processed cheese as 28.54 days which is close to experimental shelf life of 30 days.

Keywords: *ANN, Artificial Intelligence, Radial Basis (Exact Fit), Linear Layer (Design), MATLAB, Processed Cheese, Shelf Life, Prediction*

1. Introduction

This paper highlights the significance of Artificial Neural Network (ANN) models for predicting shelf life of processed cheese stored at 30^o C. Processed cheese is protein rich food, and is a comparable supplement to meat protein. Processed cheese has several advantages over unprocessed cheese, including extended shelf-life, resistance to separation of milk fat when cooked, and uniformity of product. Its production also enjoys significant economic advantages over traditional cheese making processes, most often through the ability to incorporate any of a wide variety of less expensive ingredients [1]. 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 [2]. Linear layers are single layers of linear neurons. They may be static, with input delays of 0, or dynamic, with input delays greater than 0. They can be trained on simple linear time series problems, but often are used adaptively to continue learning while deployed, so they can adjust to changes in the relationship between inputs and outputs while being used [3]. Shelf life is the length of time given before a product is considered unsuitable for sale, use, or consumption. In most of the regions, a 'best before', 'use by' or freshness date is required on packaged perishable foods [4].Elman and Self-Organizing simulated neural network models detected shelf life of soft cakes stored at 10^{o}C as 20.57 days, against 21 days experimental shelf life [5]. Goyal and Goyal [6] applied artificial neural engineering and regression models for forecasting the shelf life of instant coffee drink. The predicted shelf life was found to be 37.29 days, which was well within the experimentally obtained shelf life of 45 days.

ANN Generalized Regression and Linear Layer (Train) models successfully predicted the shelf life of milky white dessert jeweled with pistachio. The predicted shelf life was 20.15 days as against experimentally obtained shelf life of 21 days, suggesting that ANN based Linear Layer (Train) models are very effective in predicting the shelf life of milky white desserts jeweled with pistachio [7].Neuron based artificial intelligent scientific computer engineering models for predicting shelf life of instant coffee sterilized drink have been developed [8].

Goyal and Goyal [9] implemented Linear Layer (Design) and Time - Delay methods of intelligent computing expert system for shelf life detection of soft mouth melting milk cakes stored at 6°C. They compared performance of the models with each other, and observed that Linear Layer (Design) model exhibited better results. The models predicted the shelf life as 49.54 days, which was very near to experimentally obtained shelf life of 50 days. The main aim of the present study is to develop a computing model for predicting the shelf life of processed cheese stored at 30° C, which would be less expensive and less time consuming than the determination of shelf life in the laboratory.

2. Method and Material

The experimental data consisted of 36 observations, out of which 30 were taken for training the ANN network, and 6 for validation. Soluble nitrogen, pH; standard plate count, yeast & mould count, and spore count were taken as input variables, while sensory score as output variable for developing the ANN models (Figure 1).

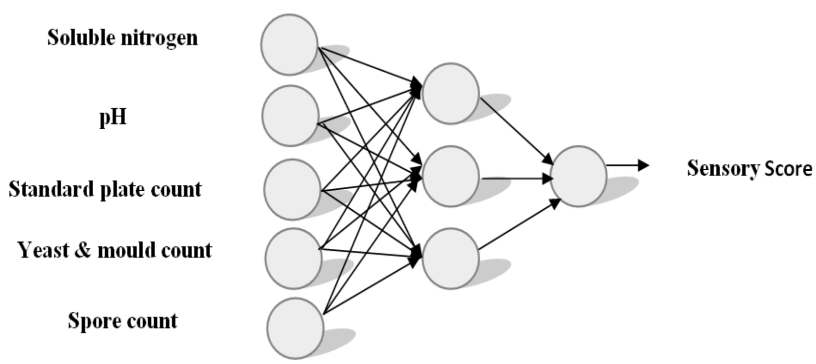

Figure 1. Input and Output Variables of ANN Models

Neural Network Toolbox under MATLAB software was used for developing the models. Training pattern of ANN models is presented in Figure 2. Mean Square Error: MSE (1), Root Mean Square Error: RMSE (2), Coefficient of Determination: R^2 (3) and Nash - Sutcliffo Coefficient :E^2 (4) were used in order to compare the prediction ability of the developed models. Where $Q_{\exp}$ = Observed value; Q_{cal} = Predicted value; $Q_{\exp}$ =Mean predicted value; n= Number of observations in dataset.

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

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

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

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

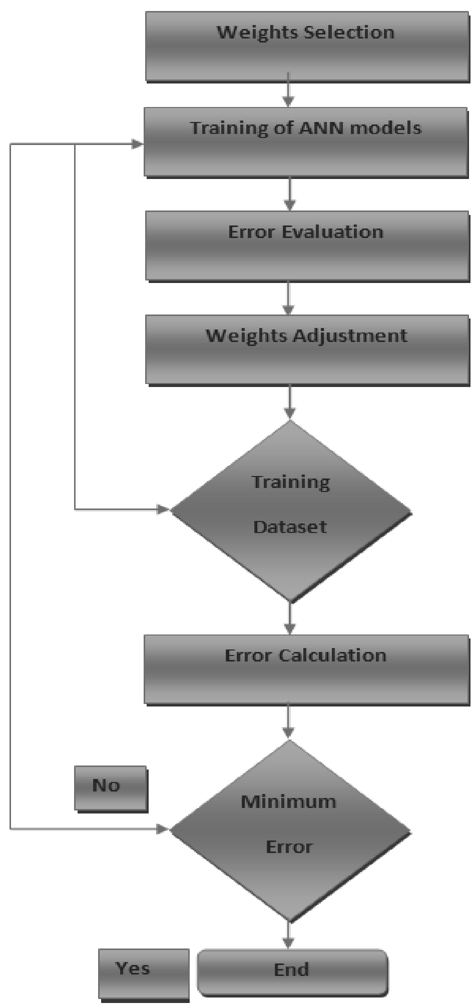

Figure 2. Training pattern of ANN

3. Results and Discussion

Table 1. Results of Radial Basis (Exact Fit) Model

Neurons	Spread Constant	MSE	RMSE	R^2	E^2
30	5	0.133891044	0.365911252	0.634088748	0.866108956
30	**20**	**1.81045E-06**	**0.001345528**	**0.998654472**	**0.99999819**
30	30	2.8501E-05	0.005338631	0.994661369	0.999971499
30	50	0.000472988	0.02174828	0.97825172	0.999527012
30	75	0.000844794	0.029065346	0.970934654	0.999155206
30	100	0.000985283	0.031389221	0.968610779	0.999014717
30	118	0.001000201	0.031625956	0.968374044	0.998999799
30	137	0.000983313	0.031357817	0.968642183	0.999016687
30	150	0.000964166	0.031051027	0.968948973	0.999035834
30	200	0.006069247	0.077905369	0.922094631	0.993930753

Table 2. Results of Linear Layer (Design) Model

MSE	RMSE	R^2	E^2
8.6721E-05	**0.009312409**	**0.990687591**	**0.999913279**

Radial Basis (Exact Fit) and Linear Layer (Design) models were developed for predicting shelf life of processed cheese stored at 30^{o}C. Several experiments were carried out in order to get to good results. The best results were observed for Radial Basis (Exact fit) model with 30 neurons and spread constant as 20 (MSE: 1.81045E-06, RMSE: 0.001345528, R^2 : 0.998654472, E^2: 0.99999819), and best results for Linear Layer (Design) were MSE: 8.6721E-05, RMSE: 0.009312409, R^2 : 0.990687591, E^2: 0.999913279).After comparing both the models, it was observed that Radial Basis (Exact fit) model is better. Therefore, it was selected for predicting the shelf life of processed cheese. The comparison of Actual Sensory Score (ASS) and Predicted Sensory Score (PSS) for Radial Basis (Exact Fit) and Linear Layer (Design) models are illustrated in Figure 3 and Figure 4.

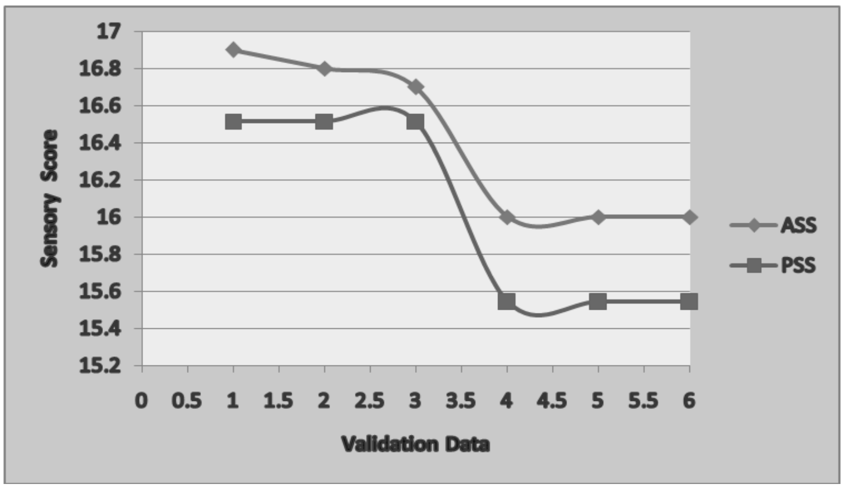

Figure 3. Comparison of ASS and PSS for Radial Basis (Exact Fit) Model

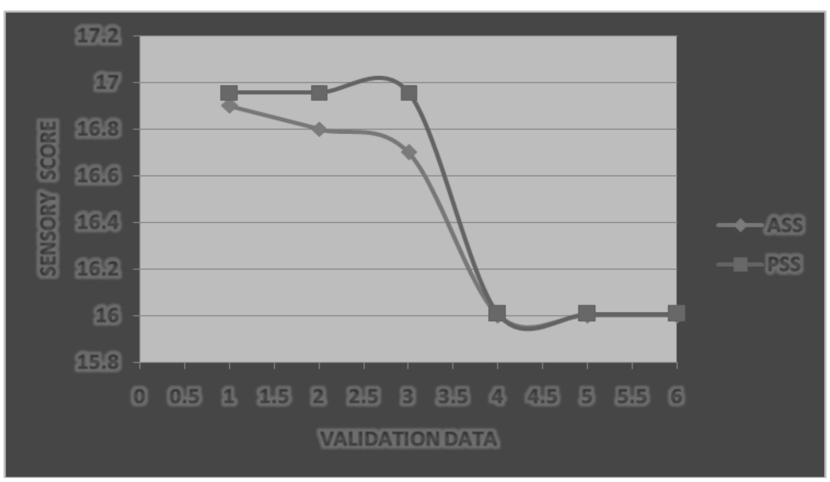

Figure 4. Comparison of ASS and PSS for Linear Layer (Design) Model

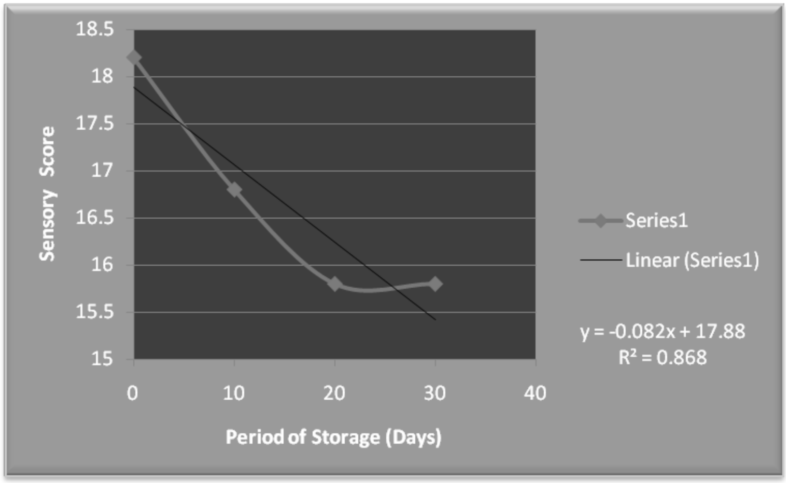

Figure 5. Sensory Score and Period of Storage (days) for Processed Cheese

R^2 was found to be 86.8 percent of the total variation as explained by sensory scores. Period of storage (days) for which the processed cheese has been in the shelf can be determined based on sensory score (Figure 5). The shelf life is computed by subtracting the obtained value of days from experimentally determined shelf life, which was found to be 28.54 days as against 30 days experimentally obtained shelf life.

4. Conclusion

Radial Basis (Exact Fit) and Linear Layer (Design) ANN models were developed for predicting the shelf life of processed cheese stored at 30^o C. Soluble nitrogen, pH; standard plate count, yeast & mould count, and spore count were taken as input variables and sensory score was taken as output variable. 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. Several experiments were carried out and it was observed that Radial Basis (Exact Fit) model with 30 neurons and spread constant as 20 performed the best, hence it was selected for predicting the shelf life of processed cheese, which came out as 28.54 days vis-à-vis 30 days experimental shelf life. From the study it is concluded that the developed computing model is quite efficient in predicting the shelf life of processed cheese.

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