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Shelf life prediction of paneer tikka by artificial neural networks

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ABSTRACT

Artificial Neural Network (ANN) model has been proposed to predict the shelf life of *paneer tikka* using the sample data. The stored samples were evaluated at regular intervals for changes in physico-chemical characteristics, *viz.*, moisture, titratable acidity, free fatty acid and tyrosine content, which were taken as input parameters; while overall acceptability scores (OAS) was output parameter. Experimentally determined 42 observations for each input and output parameters were considered for the modelling. The dataset was randomly divided into two disjoint subsets, *viz.,* training set containing 38 observations, and test set comprising of 4 observations. *Paneer tikka* is an exotic *kebab* of Indian cottage cheese, which is highly rich in proteins, vitamins, minerals, fibre content and sulphur compounds. The ANN model with two hidden layers having twenty five neurons in first hidden layer and twenty five neurons in second hidden layer was found to be the best configuration to predict OAS with root mean square error as 0.094547317 and R^2 as 0.964243219, confirming that the developed model is efficient for predicting the shelf life of *paneer tikka* stored at 3±1°C.

1. Introduction

Artificial neural networks (ANN) have been developed as generalizations of mathematical models of biological nervous systems. A first wave of interest in neural networks emerged after the introduction of simplified neurons, also known as connectionist models, by McCulloch and Pitts. ANN is a network of collections of very simple processors "Neurons", each possibly having a small amount of local memory. The units operate only on their local data and on the inputs they receive via the connections or links which are unidirectional (Abraham, 2006). ANN has three layers in its structure; first layer is input layer, which directly interacts with external worlds; second layer is of hidden unit, where computation is done according to function provided, and the last layer is output layer, from where output is obtained. Knowledge in neural networks is stored as synaptic weights between neurons. The network propagates the input data from layer to layer until the output data is generated. If the networks is multilayer perceptron with backpropagation algorithm and the output is different from the desired output, then an error is calculated and propagated backwards through the network. The synaptic weights are modified as the error is propagated (Nielsen, 2001).

Paneer is very popular acid coagulated Indian variety of soft cheese, which forms base for a variety of culinary dishes, stuffing material for various vegetable dishes, snacks, and sweetmeats. *Tikka* is a general South Asian term meaning marinated barbequed food. *Paneer tikka* is a very popular dish among vegetarians, which is highly rich in proteins, vitamins, minerals, fibre content and sulphur compounds, and is laxative in nature. According to Sinclair (2004) *tikka* means small pieces of meat or poultry marinated in yoghurt and tandoori spice mix, grilled or roasted and served with Indian bread and salad. It is extensively used as fast-food during get-togethers, marriage parties, birthday parties, and also sold in restaurants. *Paneer tikka* requires more than five hours for its preparation. At present, it is consumed immediately after its preparation. However, if stored at ambient temperature, its shelf life is hardly one day, which impedes its proper marketing and distribution. To impart longer shelf life, the product was vacuum packed and stored at 3±1°C. Awareness of modern consumers about quality of the processed foods creates challenge in product development and marketing. Shelf life prediction models could facilitate the manufacturers and also the food quality regulating agencies to critically evaluate the shelf life of such foods.

Vallejo *et al.* (1995) studied the usefulness of ANN models *vis-à-vis* principal components regression (PCR) model for predicting the shelf life of milk and found better predictability of ANN model than the PCR model. Ni and Gunasekaran (1998) observed that a three-layer ANN model was able to predict the rheological properties of Swiss type cheeses on the basis of their composition more accurately than regression equations. Sofu and Ekinci (2007) developed an ANN model using back-propagation learning algorithm for prediction of shelf life of set-type whole-fat and low-fat yoghurts, and found that the ANN model was able to analyse nonlinear multivariate data with very good performance, fewer parameters and shorter calculation time. Goñi *et al.* (2008) trained and validated a cascade ANN model using experimental values of freezing and thawing times of foods and test substances of different geometries, and concluded that ANN model provide a simple and accurate prediction method for freezing and thawing times.

The present study was undertaken to predict the shelf life of *paneer tikka* by developing efficient ANN model, as determination of shelf life in the laboratory is very cumbersome, time consuming and costly affair.

2. Materials and methods

For developing the model experimental data of stored *paneer tikka* relating to quality parameters, *viz.,* moisture, titratable acidity, free fatty acid, and tyrosine content were taken as input parameters, while sensory score as output (Fig. 1). A five-point Hedonic scale was used for evaluation of the sensory score. Experimentally determined 42 observations were considered for developing the model. The dataset was randomly divided into two disjoint subsets, *viz*., training set having 38 observations and test set comprising of 4 observations.

In the development of ANN model for shelf life prediction of *paneer tikka*, different combinations of several internal parameters, *i.e.*, data pre-processing, data partitioning approach, number of hidden layers, number of neurons in each hidden layer, transfer function, error goal, *etc.*, along with backpropagation algorithm based on Bayesian regularisation mechanism as training function, were explored in order to optimise the prediction ability of the model. It is evident from the literature that there is no generalised method to determine the optimum values for these parameters, *i.e.*, number of hidden layers and neurons in each hidden layer, *etc.* Hence, trial and error approach was pursued to decide the optimum architectural parameters.

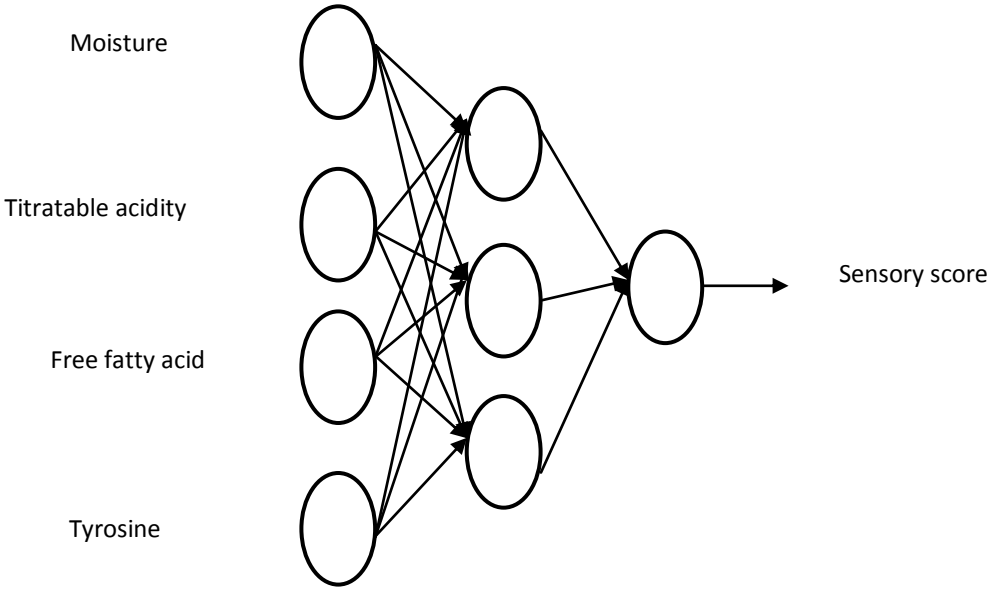

Fig. 1. Input and output parameters of ANN model.

ANN models with single hidden layer as well as with two hidden layers were explored. After finding optimum values for ANN network and preparing training and test datasets, the network was trained with training set. The network was then simulated with the test set as well as with fresh input dataset to validate the proposed ANN model. In backpropagation algorithm for a given set of input to the network, the response to each neuron in the output layer was calculated and compared with corresponding desired output response. The errors associated with desired output response were adjusted in a way that will reduce these errors in each neuron from the output to the input layer. The main problem faced while constructing the ANN model was over fitting, *i.e.*, the error with the training set comes out to be a very small value, but when a new dataset is employed to the network, the error becomes larger (Mittal and Zhang, 2000). To overcome such a problem, a variant of the backpropagation method based on Bayesian regularisation technique was used, which determines the optimal regularization parameters in an automated fashion (Mackay, 1992; Foresee and Hagan, 1997). The number of neurons in each hidden layer varied from 3 to 50 for single hidden layer models and from 3:3 to 25:25 for double hidden layer models. Weights and biases were randomly initialized. The network was trained with 150 epochs. The transfer function for each hidden layer was *tangent sigmoid*, while for the output layer *linear* function. The Neural Network Toolbox under MATLAB software was used for development of the ANN models.

The performance of ANN model was evaluated using Root Mean Square Error (RMSE) technique as follows:

$$RMSE = \sqrt{\frac{1}{N}\left[\sum_{1}^{N}\left(\frac{Q_{\exp} - Q_{cal}}{Q_{\exp}}\right)^2\right]} \times 100 \qquad (1)$$

Where

$Q_{\exp}$ = Observed value,

Q_{cal} = Predicted value and

N = Number of observations in dataset.

3. Results and discussion

Performance matrices of the ANN model for predicting the shelf life of *paneer tikka* are presented in Table 1.

Table 1
Performance of ANN model for predicting shelf life of paneer tikka.

Hidden layers	Neurons		RMSE	R^2
	I	II		
I	3	-	0.218240345	0.809484607
I	4	-	0.181809065	0.867781855
I	7	-	0.176058989	0.876012929
I	9	-	0.171169062	0.882804609
I	10	-	0.197749026	0.843581292
I	12	-	0.228446763	0.791248305
I	14	-	0.184927027	0.863207978
I	16	-	0.247592514	0.754791788
I	20	-	0.146717849	0.913895492
I	30	-	0.172879173	0.880451167
I	40	-	0.242656669	0.764470963
I	50	-	0.218793485	0.808517643
II	3	3	0.176058989	0.876012929
II	5	5	0.210742665	0.822350116
II	6	6	0.134679734	0.927445477
II	8	8	0.195515704	0.847094438
II	10	10	0.203474999	0.834391699
II	12	12	0.176058989	0.876012929
II	15	15	0.200241981	0.839612596
II	18	18	0.176058989	0.876012929
II	20	20	0.148605062	0.911666142
II	25	25	0.094547317	0.964243219

Comparison between the Actual Overall Acceptability Score (AOAS) and Predicted Overall Acceptability Score (POAS) using ANN model is graphically shown in Fig. 2.

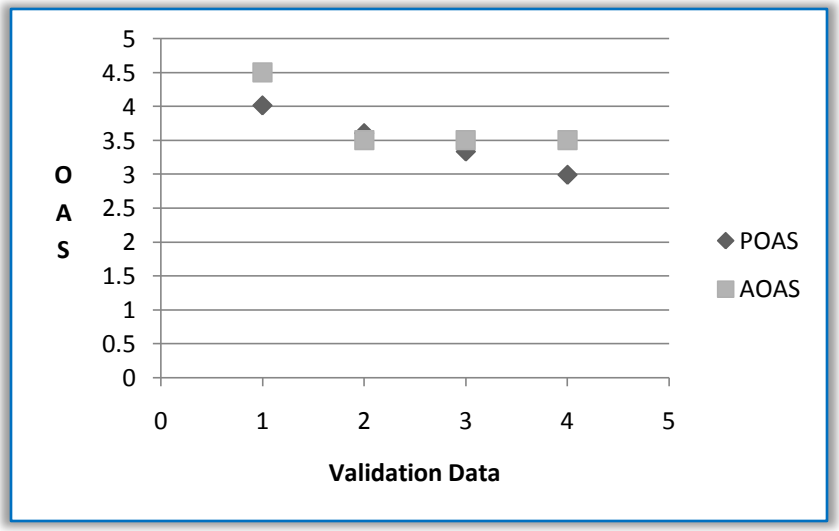

Fig. 2. Comparison of AOAS and POAS.

ANN models were developed with single and double hidden layers for predicting the shelf life of *paneer tikka* based on supervised learning cascade algorithm. It was observed that as the number of hidden layers increased, also the training time. The configuration for the best ANN model to predict OAS for *paneer tikka* included two hidden layers with twenty five neurons in first hidden layer and twenty five neurons in second hidden layer attaining RMSE as 0.094547317 and R^2 as 0.964243219 (Table 1). The modelling results suggested that there is an excellent agreement between the experimental data and the predicted values. Considering the complexity of testing shelf life in the laboratory manually, the proposed ANN model is simple, reliable and fast for predicting the shelf life of *paneer tikka*.

4. Conclusion

ANN models with single and multi layers were developed for predicting the shelf life of *paneer tikka*. The input parameters for the model were moisture, titratable acidity, free fatty acid and tyrosine content, while OAS was the output parameter. The best ANN configuration for prediction of OAS included two hidden layers with twenty five neurons in first hidden layer, and twenty five neurons in second hidden layer, which achieved RMSE as 0.094547317 and R^2 as 0.964243219. The prediction performance of ANN models gave excellent fit. The outcome of the study is that the ANN approach could be used for predicting the shelf life of *paneer tikka.*

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