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Feedforward Models Predicting Shelf Life of Buffalo Milk Burfi

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Abstract – In this paper the Artificial Neural Network (ANN) feedforward multilayer model is proposed for predicting the shelf life of burfi stored at 4°C. Buffalo milk burfi is very popular confection in Indian subcontinent**.** Input variables for the ANNs were experimental data of the product related to moisture, titratable acidity, free fatty acids, tyrosine, and peroxide value; and overall acceptability score output variable. The results exhibited excellent agreement between the actual and the predicted values, thus confirming the suitability of ANN model for predicting the shelf life of burfi.

Keywords-Artificial Neural Networks; Feedforward algorithm; Burfi; Artificial Intelligence; Soft Computing

1. Introduction

The prediction capability of Artificial Neural Networks (ANN) as a shelf life monitoring tool has been playing an increasingly significant role in analysing food quality. It has been applied by food researchers particularly for monitoring quality of the food products. The study aims to develop feedforward multilayer ANN models for predicting the shelf life of buffalo milk burfi stored at 4°C. Burfi is very popular sweet confection prepared by desiccating the water buffalo milk. In Indian subcontinent it is essentially and customarily served and consumed on all festive occasions and also during social gatherings. Though, several verities of burfi such as almond burfi, cashew nut burfi, chocolate burfi, coconut burfi, pistachio burfi, cardamom burfi and plain burfi are sold in the market, but the latter variety is most popular which contains milk solids and sugar. The pieces of burfi are coated with an edible thin metallic silver leaf, which makes the product more attractive and also adds to the therapeutic value.

ANNs are inspired by the early models of sensory processing by the brain. An ANN can be created by simulating a network of model neurons in a computer. By applying algorithms that mimic the processes of real neurons, one can make the network 'learn' to solve many types of problems. A model neuron is referred to as a threshold unit. It receives input from a number of other units or external sources, weighs each input and adds them up. If the total input is above a threshold, the output of the unit is one; otherwise it is zero. Therefore, the output changes from 0 to 1 when the total weighted sum of inputs is equal to the threshold. The points in input space satisfying this condition define a so called hyperplane. In two dimensions, a hyperplane is a line, whereas in three dimensions, it is a normal plane. Points on one side of the hyperplane are classified as 0 and those on the other side as 1. Thus, a classification problem can be solved by a threshold unit if the two classes can be separated by a hyperplane [1]. Multiple layers of computational units, usually interconnected in a feed-forward way are call as multilayer ANN models. Each neuron in one layer has directed connections to the neurons of the subsequent layer. In many applications the units of these networks apply a *sigmoid* function as an activation function. Multilayer networks use a variety of learning techniques, the most popular being back-propagation. Here, the output values are compared with the correct answer to compute the value of some predefined error-function. By various techniques, the error is then fed back through the network. Using this information, the algorithm adjusts the weights of each connection in order to reduce the value of the error function by some small amount. After repeating this process for a sufficiently large number of training cycles, the network usually converge to some state where the error of the calculations is small [2]. Shelf life can be defined as the length of time that a product is acceptable and meets the consumer's expectations regarding food quality. Shelf life dating is one of the most difficult tasks in food engineering. Market pressure has led to the implementation of shelf life by sensory analyses, which may not reflect the full quality spectra. The consumer demands foods under the legal standards, at low cost, high standards of nutritional, sensory, and health benefits [3]. The prediction of shelf life of burfi in the laboratory is very cumbersome, expensive and time consuming. Hence, the results of this investigation using ANN technique, which is simple, reliable, fast and low cost, would be very beneficial for burfi manufactures, consumers, wholesalers, retailers, regulatory authorities, food researchers and academicians.

2. Prediction using ANNs in foods

2.1 Performance predication of milk ultrafiltration

ANN models were tested in order to the dynamic prediction of permeate flux (JP), total hydraulic resistance

(RT) and the solutes rejection for the crossflow ultrafiltration of milk at different transmembrane pressure (TMP) and temperature (T). This process has complex non-linear dependencies on the operating conditions, thus it provides demanding test of the neural network approach to the process variables prediction. Two neural network models with single hidden layer were constructed to predict the time dependent rate of JP/ RT and rejections from a limited number of training data. The modelling results showed excellent agreement between the experimental data and predicted values, with average errors less than 1%. The experimental results revealed that the RT and solutes rejection (except for protein) increased greatly with time at each value of TMP and T, whereas the JP decreased significantly for the same conditions. Increasing TMP at constant T led to an increase in the JP, RT and solutes rejection, but increasing T at constant TMP had no significant effect on the JP, RT and rejection of components [4].

2.2 Kiwifruit

ANN was implemented to predict the mass transfer kinetics and colour changes of osmotically dehydrated kiwifruit slices. Kiwifruits were dehydrated implementing four different sucrose concentrations, at three processing temperatures and during four osmotic time periods. A multilayer ANN was developed by using the operation conditions as inputs to estimate water loss, solid gain, and colour changes. It was found that ANN with 16 neurons in hidden layer gives the best fitting with the experimental data, which made it possible to predict solid gain, water loss, and colour changes with acceptable mean-squared errors (1.005, 2.312, and 2.137, respectively). The results suggested that ANN could potentially be used to estimate the mass transfer kinetics and colour changes of dehydrated kiwifruit [5].

2.3 Sliced cooked meat products

An ANN based predictive model for Leuconostoc mesenteroides growth in response to temperature, pH, sodium chloride and sodium nitrite developed by Garcia-Gimeno *et al.* [6] was validated on vacuum packed, sliced, cooked meat products and applied to shelf-life determination [7]. Lag-time (Lag), growth rate (Gr), and maximum population density (yEnd) of L. mesenteroides, estimated by the ANN model, were compared to those observed in vacuum-packed cooked ham, turkey breast meat, and chicken breast meat stored at 10.5°C, 13.5°C and 17.7°C, using bias and accuracy factors. The ANN model provided reliable estimates for the three kinetic parameters studied; with a bias factor of 1.09; 0.73 and 1.00 for Lag, Gr and yEnd, respectively and an accuracy factor of 1.26; 1.58 and 1.13 for Lag, Gr and yEnd, respectively. From the three kinetic parameters obtained by the ANN model, commercial shelf-life were estimated for each temperature and compared with the tasting panel evaluation. The commercial shelf life estimated microbiologically, *i.e.*, times to reach 106.5 cfu/g, was shorter than the period estimated using sensory methods.

2.4 Dessert and Kalakand

ANNs were applied for shelf life determination of milky white dessert jeweled with pistachio. From the results, researchers concluded that ANN can predict the shelf life of the product [8]. The shelf life of kalakand stored at 6^{o}C was predicted by cascade backpropagation ANN models [9].

2.5 Cakes

The shelf life of cakes stored at 30^o C was successfully estimated through ANN models. In this study the input variables were the experimental data of the product related to moisture, titratable acidity, free fatty acids, peroxide value, and tyrosine; and overall acceptability score as the output. The results showed that ANN models adequately predicted the shelf life of cakes [10]. Elman and self organizing simulated neural network (SNN) models were developed to predict the shelf life of soft cakes stored at 10^{o}C. In this experiment the lab data of the product relating to moisture, titratable acidity, free fatty acids, tyrosine, and peroxide value were used as input variables; and the overall acceptability score as output variable. *Tangent sigmoid* was transfer function for hidden layers, while for the output layer it was pure *linear*. The results indicated brilliant correlation between the actual data and the predicted values, confirming that SNNs are useful in predicting the shelf life of soft cakes [11]. Radial basis ANN models for shelf life prediction of brown milk cakes decorated with almonds were suggested [12].The models predicted the shelf life of the product exceedingly well. In another study [13] Time-delay and linear layer (design) ANN models were proposed for shelf life estimation of soft mouth melting milk cakes.

2.6 Coffee Drink

Radial basis and multiple linear regression (MLR) models for forecasting the shelf life of instant coffee drink were studied. In this research colour and appearance, flavour, viscosity and sediment of the product were input variables and overall acceptability score as the output. The results revealed that the MLR model was better to radial basis model [14]. Cascade & feedforward backpropagation ANN models [15], and Elman & generalized regression ANN models [16] for predicting the sensory quality of the instant coffee flavoured sterilized drink were proposed.

2.7 Processed Cheese

Processed cheese is very popular variety of cheese. Generally it is prepared from 4 to 6 months old ripened grated Cheddar cheese. Often a part of ripened cheese is replaced by fresh cheese. During its manufacture required amount of water, emulsifiers, extra salt, preservatives, food colourings 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 unique body &

texture and desirable consistency in the product. Several ANN techniques have been applied for predicting shelf life of processed cheese [17, 18, 19, 20, 21, 22].

3. Method Material

In order to develop ANN models, moisture, titratable acidity (TA), free fatty acids (FFA), tyrosine, and peroxide value (PV) were used as input variables and overall acceptability score (OAS) as the output (Fig.1).

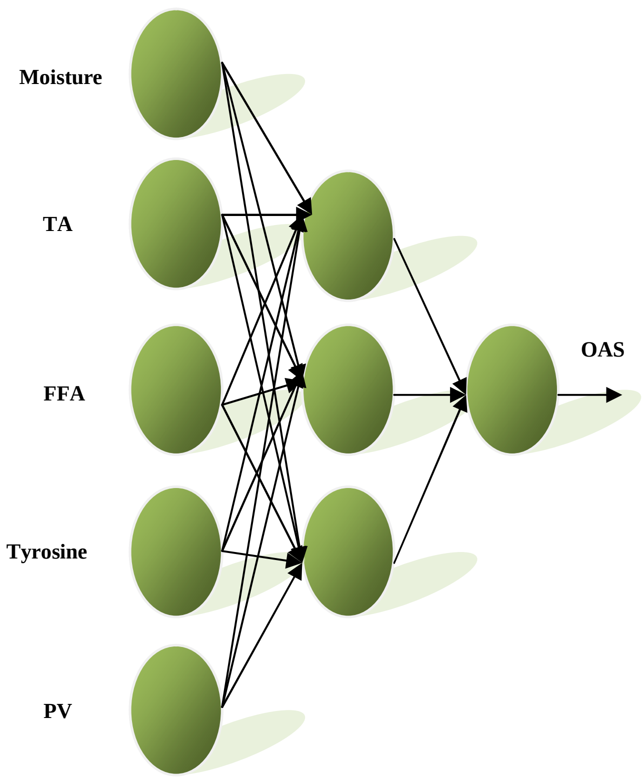

Fig. 1 Input and output variables

Several variants of the backpropagation algorithm were tried like Powell–Beale restarts conjugate gradient algorithm (*TRAINCGB*), BFG quasi-Newton algorithm *(TRAINBFG)*, Bayesian regularization *(TRAINBR)*, Fletcher–Reeves update conjugate gradient algorithm *(TRAINCGF* and Levenberg–Marquardt algorithm (*TRAINLM*). Bayesian regularization gave most promising results; therefore it was selected as training function.

3.1 Measures of Prediction Performance

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

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

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

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

Where,

$Q_{\exp}$ = Observed value;

Q_{cal} = Predicted value;

$\overline{Q}_{\exp}$ =Mean predicted value;

n = Number of observations in dataset.

Mean square error MSE (1), root mean square error RMSE (2), coefficient of determination R^2 (3) and Nash - sutcliffo coefficient E^2 (4) were used as prediction performance measures.

4. Results and Discussion

ANN feedforward multilayer model's performance matrices are presented in Table 1.

The comparison of Actual Overall Acceptability Score (AOAS) and Predicted Overall Acceptability Score (POAS) for ANN models are illustrated in Fig.2.

TABLE 1. Results of multilayer ANN model

MSE	**RMSE**	**R^2**	**E^2**
0.024691358	0.15713484	0.84286516	0.975308642

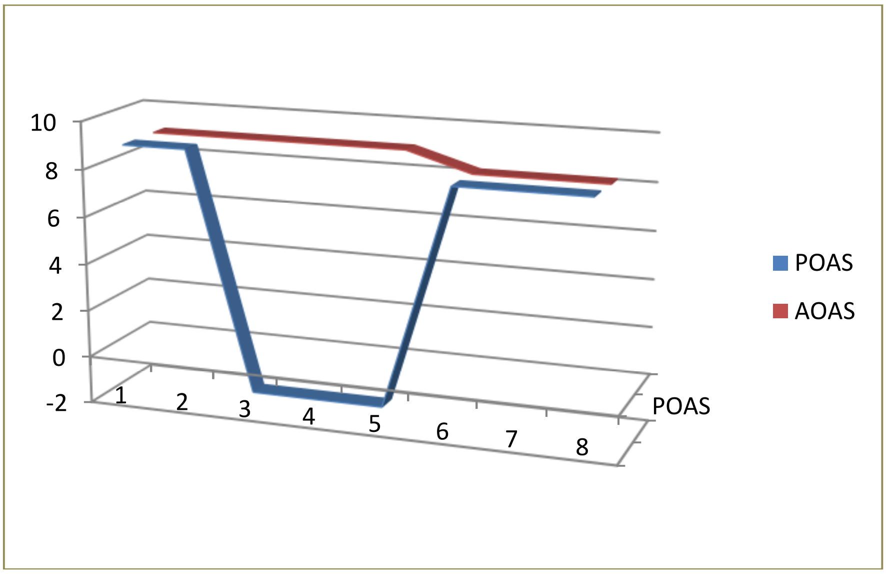

Fig.2. Comparison of AOAS and POAS

Feedforward ANN multilayer model was developed for predicting the shelf life of burfi stored at 4^o C. The modeling results suggested that there was good agreement between the experimental and predicted values (Table 1), with a high determination coefficient (R^2 = 0.84286516) and Nash - sutcliffo coefficient (E^2 = 0.975308642) showing that the ANN model was able to analyze nonlinear multivariate data very well. The investigation thus revealed that multilayer feedforward ANN model can be an alternative way to traditional laboratory shelf life testing of burfi.

5. Conclusion

In Indian subcontinent burfi is very popular sweet confection prepared by desiccating water buffalo milk. Artificial neural network feedforward multilayer model was developed for predicting the shelf life of burfi stored at 4^{o}C. The lab data of the product relating to moisture, titratable acidity, free fatty acids, tyrosine, and peroxide value were taken as input variables, and overall acceptability score as the output. Mean square error, root mean square error, coefficient of determination and Nash - sutcliffo coefficient were used as performance measures. Experimental results showed high coefficient of determination (0.84286516) and Nash - sutcliffo coefficient (0.975308642) suggesting that model might be an alternative method for predicting the expiration date of burfi. The proposed method is a fast and interesting procedure for monitoring authenticity of the product [23 - 26].

References

[1] A. Krogh, “What are artificial neural networks?” *Nature Biotechnology*, vol.26, no.2, pp.195-197, 2008.

[2] http://en.wikipedia.org/wiki/Feedforward_neural_network (accessed on 21.1.2011)

[3] http://www.computerworld.com/s/article/57545/Artificial_Neural_Networks (accessed on 7.1.2011).

[4] S.M.A .Razavi, S.M. Mousavi and S.A. Mortazavi, “Dynamic predication of milk ultrafiltration performance,” *Chemical Engineering Science*, vol.58, pp.4185-4195, 2004.

[5] M. Fathi, M. Mohebbi and S.M.A. Razavi,”Application of image analysis and artificial neural network to predict mass transfer kinetics and color changes of osmotically dehydrated kiwifruit”, *Food Bioprocess Technology*, vol. 4, no.8, pp.1357-1366, 2009.

[6] R.M. García-Gimeno, C. Hervás-Martínez, R. Rodríguez-Pérez and G. Zurera-Cosano,” Modelling the growth of Leuconostoc mesenteroides by Artificial Neural Networks”, International Journal of Food Microbiology,Vol.105, Issue 3, pp. 317–332, 2005.

[7] G.Zurera-Cosano, R.M. García-Gimeno, M.R. Rodríguez-Pérez and C. Hervás-Martínez, “Validating an artificial neural network model of Leuconostoc mesenteroides in vacuum packaged sliced cooked meat products for shelf-life estimation”, European Food Research and Technology, vol.221, no.5, pp.717-724, 2005.

[8] Sumit Goyal and G.K. Goyal, “A new scientific approach of intelligent artificial neural network engineering for predicting shelf life of milky white dessert jeweled with pistachio”, International Journal of Scientific and Engineering Research, vol. 2, no.9, pp.1-4, 2011.

[9] Sumit Goyal and G.K. Goyal, “Advanced computing research on cascade single and double hidden layers for detecting shelf life of kalakand: An artificial neural network approach”, International Journal of Computer Science & Emerging Technologies, vol.2, no.5, pp.292-295, 2011.

[10] Sumit Goyal and G.K. Goyal, “Brain based artificial neural network scientific computing models for shelf life prediction of cakes”, Canadian Journal on Artificial Intelligence, Machine Learning and Pattern Recognition, vol.2, no.6, pp.73-77, 2011.

[11] Sumit Goyal and G.K. Goyal, “Simulated neural network intelligent computing models for predicting shelf life of soft cakes”, Global Journal of Computer Science and Technology, vol.11, no.14, version 1.0, pp.29-33, 2011.

[12] Sumit Goyal and G.K. Goyal, “Radial basis artificial neural network computer engineering approach for predicting shelf life of brown milk cakes decorated with almonds”, International Journal of Latest Trends in Computing, vol.2, no.3, pp.434-438, 2011.

[13] Sumit Goyal and G.K. Goyal, “Development of intelligent computing expert system models for shelf life prediction of

soft mouth melting milk cakes", International Journal of Computer Applications, vol.25, no.9, pp. 41-44, 2011.

[14] Sumit Goyal and G.K. Goyal, "Application of artificial neural engineering and regression models for forecasting shelf life of instant coffee drink", International Journal of Computer Science Issues, vol.8(4), no.1, pp.320-324, 2011.

[15] Sumit Goyal and G.K. Goyal, "Cascade and feedforward backpropagation artificial neural networks models for prediction of sensory quality of instant coffee flavoured sterilized drink", Canadian Journal on Artificial Intelligence, Machine Learning and Pattern Recognition, vol.2, no.6, pp. 78-82, 2011.

[16] Sumit Goyal and G.K. Goyal, "Development of neuron based artificial intelligent scientific computer engineering models for estimating shelf life of instant coffee sterilized drink", International Journal of Computational Intelligence and Information Security, vol.2, no.7, pp.4-12, 2011.

[17] Sumit Goyal and G.K. Goyal, "Performance of generalized regression, radial basis (fewer neurons), and linear layer (design) computational ANN techniques for shelf life prediction of processed cheese", International Journal of Artificial Intelligence and Knowledge Discovery, vol.1, no.4, pp.12-15, 2011.

[18] Sumit Goyal and G.K. Goyal, "Artificial neural expert computing models for determining shelf life of processed cheese", International Journal of Electrical and Computer Engineering, vol.2, no.3, pp.31-36, 2012.

[19] Sumit Goyal and G.K. Goyal, "Shelf life estimation of processed cheese by artificial neural network expert systems", Journal of Advanced Computer Science & Technology, vol.1, no.1, pp.32-41, 2012.

[20] Sumit Goyal and G.K. Goyal, "Time-delay artificial neural network computing models for predicting shelf life of processed cheese", BRAIN. Broad Research in Artificial Intelligence and Neuroscience, vol.3, no.1, pp.63-70, 2012.

[21] Sumit Goyal and G.K. Goyal, "Linear layer and generalized regression computational intelligence models for predicting shelf life of processed cheese", Russian Journal of Agricultural and Socio-Economic Sciences, vol.3, no.3, pp.28-32, 2012.

[22] Sumit Goyal and G.K. Goyal, "Radial basis (exact fit) and linear layer (design) ANN models for shelf life prediction of processed cheese", International Journal of u- and e-Service, Science and Technology, vol.5, no.1, pp.63-69, 2012.

[23] Sumit Goyal and G.K. Goyal, "Artificial Neural Networks for Dairy Industry: A Review", Journal of Advanced Computer Science & Technology, vol.1, no.3, pp.101-115, 2012.

[24] Sumit Goyal and G.K. Goyal, "Elman backpropagation single hidden layer models for estimating shelf life of kalakand", Advances in Information Technology and Management, vol.1, no.3, pp.127-131, 2012.

[25] Sumit Goyal and G.K. Goyal, "Shelf life determination of kalakand using soft computing technique", Advances in Computational Mathematics and its Applications, vol.1, no.3, pp.131-135, 2012.

[26] Sumit Goyal and G.K. Goyal, "Computerized model for estimating shelf life of roasted coffee sterilized milk drink", Advances in Computer Science and its Applications, vol.1, no.3, pp.185-188, 2012.