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Short communication

Analyzing shelf life of processed cheese by soft computing

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A B S T R A C T

Feedforward soft computing multilayer models were developed for analyzing shelf life of processed cheese. The models were trained with 80% of total observations and validated with 20% of the remaining data. Mean Square Error, Root Mean Square Error, Coefficient of Determination and Nash - Sutcliffo Coefficient were used in order to compare the prediction ability of the developed models. From the study, it is concluded that feedforward multilayer models are good in predicting the shelf life of processed cheese stored at 7-8^{o}C.

1. Introduction

Processed cheese is a dairy product made from medium ripened (up to six months old) Cheddar cheese, and sometimes a part of ripened cheese is replaced by fresh cheese. During its manufacture emulsifiers, extra salt, preservatives, food colorings and spices (if desired) 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 in the product. Different varieties of processed cheese with many flavours, colors, and textures are available in the world market. Processed cheese has advantages over unprocessed cheese, *viz.,* pleasing taste, extended shelf life, and the use of emulsifiers in processed cheese preparation results in cheese that melts smoothly when heated. Processed cheeses are normally very smooth, medium-firm, velvety, and highly regarded by the cheese lovers. The determination of shelf life of processed cheese in the laboratory is very costly affair and takes a very long time to give results. It is alarming need of the day that artificial neural network(ANN) technique, which is fully equipped to predict the shelf life of food products be employed for processed cheese as well (Goyal and Goyal, 2012a).

The term “feedforward” describes how neural network processes and recalls patterns. In a feedforward neural network, neurons are only connected forward. Each layer of the neural network contains connections to the next layer, but there are no connections back. “Backpropagation” type of neural network involves supervised training in which the network is provided with both sample inputs and anticipated outputs, which are compared with the actual outputs for given input. Using the anticipated outputs, the backpropagation training algorithm then takes a calculated error and adjusts the weights of the various layers backwards from the output layer to the input layer. The backpropagation and feedforward algorithms are often used together. It is permissible to create a neural network that uses the feedforward algorithm to determine its output and does not use the backpropagation training algorithm (Heatonsearch Website, 2011). Martins *et al.* (2008) defined shelf life as the length of time that a product is acceptable and meets the consumer’s expectations regarding food quality. It is the result of the conjunction of all services in production, distribution, and consumption. Shelf life dating is one of the most difficult tasks in food engineering.

Soft computing techniques have been effectively applied for predicting the shelf life of several dairy products, *viz.*, milk (Vallejo-Cordoba *et al.,*1995); yogurt (Ainscough and Aronson, 1999); soya milk (Ko *et al.,* 2000); sensory attributes of noodles (Tulbek *et al.,* 2003), burfi (Goyal and Goyal, 2012b,2012c,2012d,2012e,2012f), coffee (Goyal and Goyal, 2012g); kalakand(Goyal and Goyal, 2012h, 2012i); milk cakes (2012j); cakes (Goyal and Goyal , 2011) and processed cheese (Goyal and Goyal, 2012k,2012l,2012m,2012n,2012o,2012p). The main aim of this research is to develop feedforward multilayer soft computing models for analyzing shelf life of processed cheese stored at 7-8º C.

2. Materials and methods

The input parameters for developing soft computing models were the data of the product pertaining to body and texture, aroma & flavour, moisture, and free fatty acids, while sensory score was the output parameter (Fig. 1).Numerous combinations of internal parameters, *i.e.*, data preprocessing, data partitioning approaches, number of hidden layers, number of neurons in each hidden layer, transfer function, error goal, *etc.* were tried in order to optimize the prediction performance. Different algorithms, *viz.,* Gradient Descent algorithm with adaptive learning rate, Bayesian regularization, Levenberg Marquardt algorithm and Powell Beale restarts conjugate gradient algorithm were explored. Bayesian regularization algorithm gave better results than other algorithms, hence it was selected for conducting further experiments.

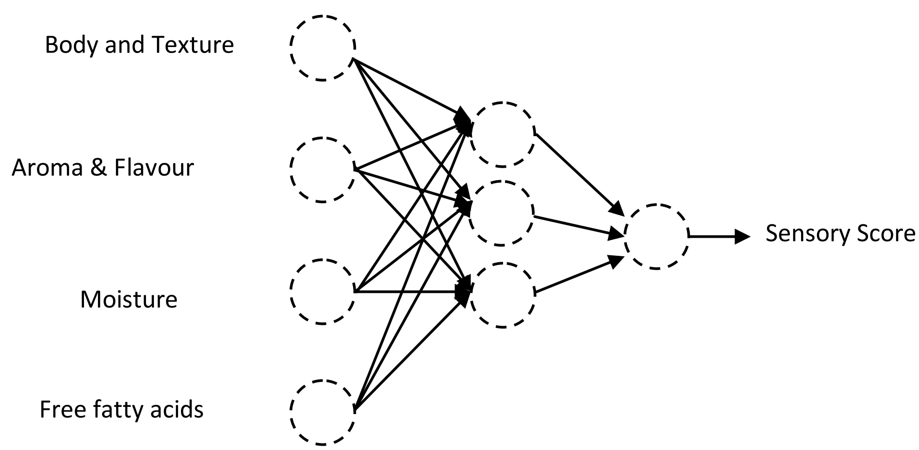

Fig. 1. Input and output parameters of feedforward model.

The data used in this study consisted of 36 observations, which were divided into two subsets, *i.e.*, 30 for training (80% of total observations) and 6 for validation (20% of total observations) (Fig. 2).

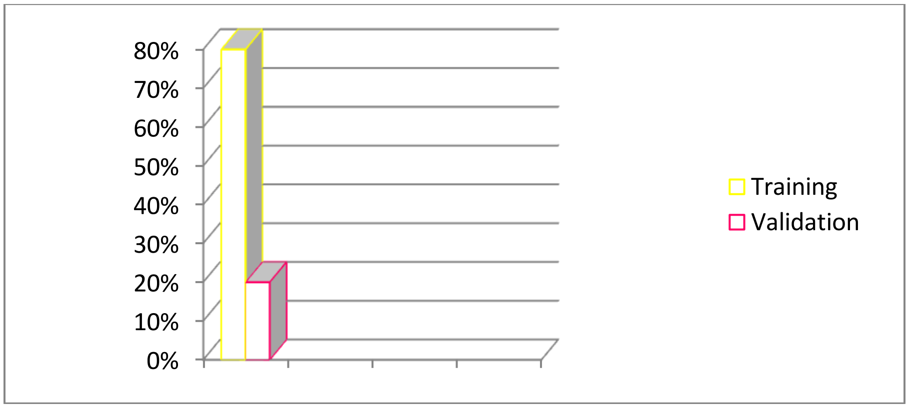

Fig. 2. Training and validation of data.

The network was trained with 100 epochs, and neurons in each hidden layers varied from 3:3 to 20:20. MALTAB software was used for performing the experiments.

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

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

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

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

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 in order to compare the prediction ability of the developed models. Training pattern of soft computing models is illustrated in Fig. 3.

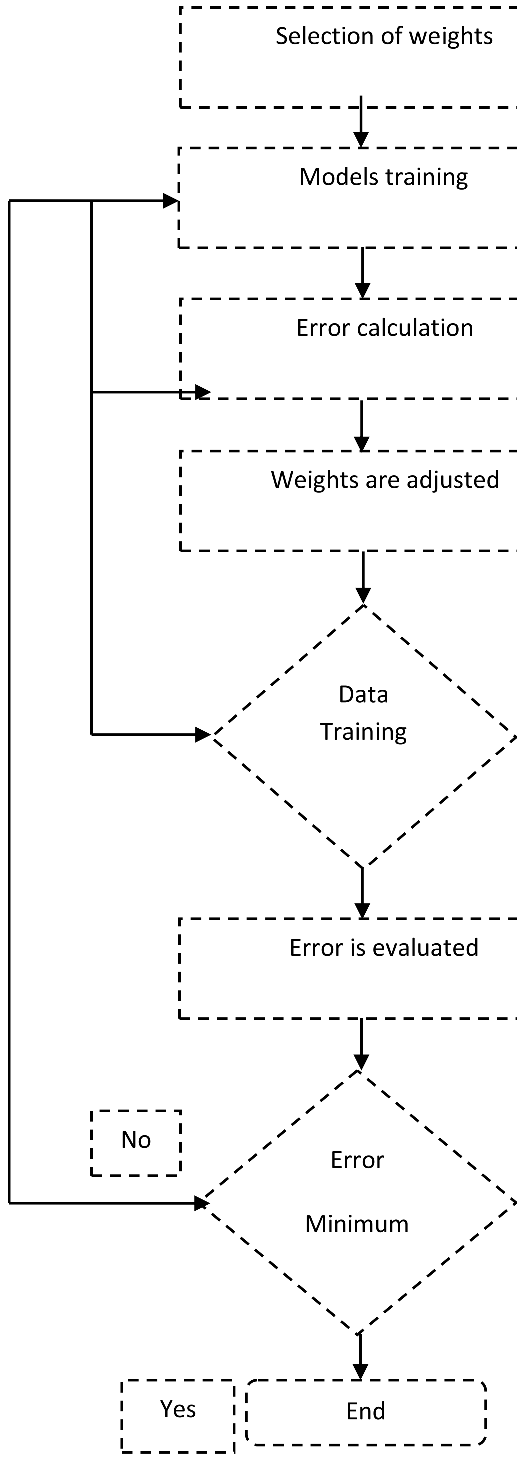

Fig. 3. Training pattern of the models.

3. Results and discussion

Performance matrices for predicting sensory scores are presented in Table 1. The comparison of Actual Sensory Score (ASS) and Predicted Sensory Score (PSS) for multilayer soft computing models is illustrated in Fig. 4.
The supervised training showed very encouraging results. Combination of 4→11→11→1(MSE: 6.22428E-08; RMSE: 0.000249485; R^2: 0.999750515; E^2: 0.999999938) gave the best results. The models got very well simulated with the data (Table 1; Fig.4). Goyal and Goyal (2012a) developed Elman single and multilayer soft computing models for predicting the shelf life of processed cheese and observed that multilayer models performed better compared to single layer models for predicting the shelf life of processed cheese. Our findings are in harmony with the observations of Goyal and Goyal (2012a) that multilayer soft computing models are efficient in predicting the shelf life of processed cheese.

Table 1
Results of feedforward multilayer model

Neurons	MSE	RMSE	R^2	E^2
3:3	0.00025543	0.015982165	0.984017835	0.99974457
4:4	0.000160358	0.012663257	0.987336743	0.999839642
5:5	0.000320768	0.017910004	0.982089996	0.999679232
6:6	1.18848E-05	0.00344743	0.99655257	0.999988115
7:7	0.000309761	0.017600037	0.982399963	0.999690239
8:8	1.35556E-05	0.003681795	0.996318205	0.999986444
9:9	0.000325116	0.018030966	0.981969034	0.999674884
10:10	0.000662148	0.025732243	0.974267757	0.999337852
11:11	**6.22428E-08**	**0.000249485**	**0.999750515**	**0.999999938**
12:12	0.000468058	0.021634639	0.978365361	0.999531942
13:13	0.000319776	0.017882283	0.982117717	0.999680224
14:14	0.000177986	0.013341151	0.986658849	0.999822014
15:15	0.000287042	0.016942304	0.983057696	0.999712958
16:16	0.00025038	0.015823401	0.984176599	0.99974962
17:17	1.38729E-05	0.003724636	0.996275364	0.999986127
18:18	0.004910868	0.070077583	0.929922417	0.995089132
19:19	8.76941E-05	0.00936451	0.99063549	0.999912306
20:20	0.000268315	0.016380333	0.983619667	0.999731685

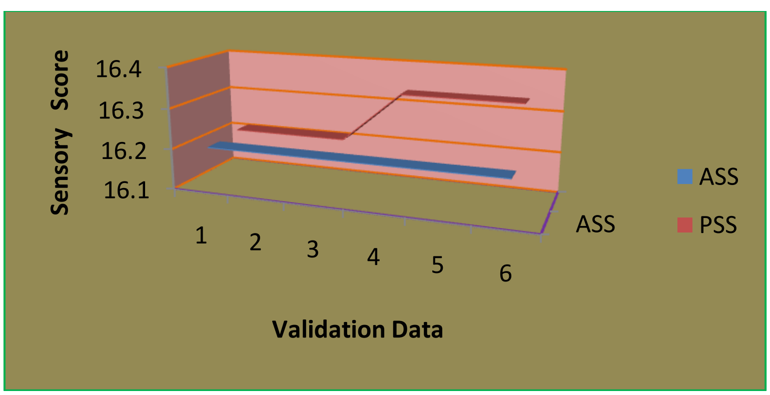

Fig. 4. Comparison of ASS and PSS for multilayer model.

4. Conclusion

Feedforward soft computing multilayer models were developed for predicting the shelf life of processed cheese stored at 7-8^{o}C. The data of the product relating to body and texture, aroma & flavour, moisture, and free fatty acids were taken as input parameters and sensory score as the output. The models were trained with 80% of the total observations and validated with 20% of the remaining data. Bayesian regularization was selected with combination of TANSIG→TRAINBR→PURELIN as threshold function. Multilayer model with a combination of 4→11→11→1 gave the best results. Therefore, from the study it can be concluded that multilayer feedforward models are very effective in predicting the shelf life of processed cheese.

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