SOFT COMPUTING SINGLE HIDDEN LAYER MODELS FOR SHELF LIFE PREDICTION OF BURFI

Sumit Goyal, Gyanendra Kumar Goyal, Researchers

National Dairy Research Institute, Karnal, India

E-mail: thesumitgoyal@gmail.com, gkg5878@yahoo.com

Received May 6, 2012

ABSTRACT

Burfi is an extremely popular sweetmeat, which is prepared by desiccating the standardized water buffalo milk. Soft computing feedforward single layer models were developed for predicting the shelf life of burfi stored at 30°C. The 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. The results showed excellent agreement between the experimental and the predicted data, suggesting that the developed soft computing model can alternatively be used for predicting the shelf life of burfi.

KEY WORDS

Keeping quality; Forecasting; Instant foods; Layering; Milk; Instantizing; Amino acids; Desserts; Fatty acids.

Artificial Neural Network (ANN) models are mathematical and algorithmic software models inspired by biological neural network. An ANN model is interconnected group of nodes, parallel to the vast network of neurons in the human brain. It consists of interconnected group of artificial neurons and processes information using a connectionist approach to computation. In most cases, ANN model is an adaptive system that changes its structure based on external or internal information that flows through the network during the learning phase. ANN models are non-linear statistical data modelling tools. They can be used to model complex relationships between inputs and outputs or to find patterns inherent in the data. In other words, the application of ANN models is a method of data analysis that is designed to imitate the workings of the human brain. They emulate the way in which arrays of neurons most likely function in biological learning and memory. ANN models differ from classical computer programs in that they “learn” or are “taught” from a set of examples rather than simply being programmed to give a correct answer. Information is encoded in the strength of the network’s “synaptic” connections. It has been established that ANN is fully equipped to predict the shelf stability and safety of food products in general, and dairy products in par-

ticular, as ANN model has the ability to learn from examples and relearn when new data are utilized (Vallejo-Cordoba et al., 1995).

Single layer perceptron network consists of a single layer of output nodes; the inputs are fed directly to the outputs via a series of weights. In this way it can be considered the simplest kind of feed-forward network. The sum of the products of the weights and the inputs is calculated in each node, and if the value is above some threshold (typically 0) the neuron fires and takes the activated value (typically 1); otherwise it takes the deactivated value (typically -1). Neurons with this kind of activation function are also called artificial neurons or linear threshold units. In the literature the term perceptron often refers to networks consisting of just one of these units. A similar neuron was described by Warren McCulloch and Walter Pitts in the 1940s (Wikipedia ANN Website, 2011).

In Indian subcontinent burfi is extremely popular milk based sweetmeat, which is prepared by desiccating standardized water buffalo milk. Its importance can be gauged from the fact that no festival, get-together, marriage or birthday party is considered complete unless it is served. Several varieties of burfi such as coconut burfi, chocolate burfi, cashew nut burfi, almond 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 upper surface of the burfi pieces are essentially coated with an edible thin metallic silver leaf for the main reason of making the product more attractive, besides therapeutic value of silver.

Shelf life studies provide useful information to the product developers and manufacturers enabling them to ensure that the consumer will get a high quality product for a significant period of time after its production. Since the shelf life evaluation of the food products conducted in the laboratory is very expensive, cumbersome, long time taking process, and also do not fit with the speed requirement of the food manufacturing companies, hence accelerated studies have been innovated. The modern food industry has developed and expanded because of its ability to deliver a wide variety of high quality food products to consumers worldwide. This has been possible by building stability into the products through processing, packaging, and additives that enable foods to remain fresh and wholesome throughout the distribution process. Consumer demands for high-quality foods with “fresh-like” characteristics and for convenience such as RTC (ready-to-cook) and RTE (ready-to-eat). This has fueled new innovations in the food product development, packaging and chemical industries, and the widespread desire for products to use in the microwave oven has added further impetus to this effort. As an increasing number of new foods compete for space on supermarket shelves, the words “speed and innovation” have become the watchwords for food companies seeking to become “first to market” with successful products. The overall quality of the product is extremely important in this competitive market and innovation system. How the consumer feels about the product is the ultimate measure of food quality. Therefore, the quality built in during the development and production process must last through the distribution and consumption stages (Medlabs Website, 2011).

ANNs have been applied for predicting the shelf life of the several milk based products: cakes (Goyal and Goyal, 2011a, 2011b), Kalkand (Goyal and Goyal, 2011c), coffee drink (Goyal and Goyal, 2011d, 2011e, 2011f), milky white dessert jeweled with pistachio (Goyal and Goyal, 2011g), brown milk cake decorated with almonds (Goyal and Goyal, 2011h), and soft

mouth melting milk cakes (Goyal and Goyal, 2011i). Doganis et al. (2006) developed a methodology based on ANN models and evolutionary computing for time series sales forecasting for short shelf life food products, and claimed that the methodology is particularly useful for manufacturers of fresh milk, since successful sales forecasting reduces considerably the lost sales and products returns. This study aims to develop soft computing feedforward single layer models for predicting the shelf life of burfi stored at 30°C.

METHOD MATERIAL

For developing the soft computing feedforward single layer model, the experimental data of burfi related to moisture, titratable acidity (TA), free fatty acids (FFA), tyrosine, and peroxide value (PV) were taken as input variables, and the overall acceptability score (OAS) as output variable (Fig.1).

Figure 1 – Input and output variables of ANN model

Mean square error (MSE) (1), root mean square error (RMSE) (2), coefficient of determination (R²) (3) and nash - sutcliffe coefficient (E2) (4) were used in order to compare the shelf life prediction capability of the developed models.

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

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

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

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

Where:

Q_{exp} = Observed value;

Q_{cal} = Predicted value;

Q_{exp} = Mean predicted value;

n = Number of observations in dataset.

RESULTS AND DISCUSSION

The results of the Feedforward single layer soft computing models are displayed in table 1.

Table 1 – Results of feedforward single layer model

Neurons	MSE	RMSE	R2	E2
3	2.96363E-05	0.005443919	0.994556081	0.999970364
4	1.64008E-05	0.004049793	0.995950207	0.999983599
5	5.17191E-07	0.00071916	0.99928084	0.999999483
6	5.22986E-07	0.000723177	0.999276823	0.999999477
7	3.09666E-06	0.001759732	0.998240268	0.999996903
8	1.88275E-07	0.000433906	0.999566094	0.999999812
9	2.02479E-07	0.000449977	0.999550023	0.999999798
10	4.39831E-06	0.002097214	0.997902786	0.999995602
11	7.42676E-05	0.008617864	0.991382136	0.999925732
12	4.28114E-06	0.002069091	0.997930909	0.999995719
13	2.56263E-07	0.000506224	0.999493776	0.999999744
14	2.86094E-06	0.001691432	0.998308568	0.999997139
15	1.83081E-05	0.0042788	0.9957212	0.999981692
16	7.32325E-07	0.00085576	0.99914424	0.999999268
17	6.52134E-07	0.000807548	0.999192452	0.999999348
18	1.53131E-05	0.003913193	0.996086807	0.999984687
19	3.92317E-05	0.00626352	0.99373648	0.999960768
20	3.53538E-06	0.001880261	0.998119739	0.999996465

The comparison of Actual Overall Acceptability Score (AOAS) and Predicted Overall Ac-

ceptability Score (POAS) for the feedforward single layer model is illustrated in Fig. 2.

Figure 2 – Comparison of ASS and PSS for Linear Layer model

Feedforward single layer soft computing model was developed for predicting the shelf life of burfi stored at 30°C. Several experiments were performed in order to reach an optimum result. A perusal of Table 1 indicates that the combination of 5→9→1 resulted in best correlation between the experimental and the predicted values with high R^2 (0.999550023), E^2 (0.999550023) and low RMSE (0.000449977), establishing that the feedforward single layer soft computing models got simulated extremely well, and can be used to predict the shelf life of burfi.

CONCLUSION

In the development of the prediction model for determining the shelf life of burfi stored at

30°C, the experimental 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. Mean square error, root mean square error, coefficient of determination and nash - sutcliffe coefficient were implemented as performance measures for testing the feedforward single layer model's prediction ability. Excellent agreement was found between the training and the validation data. Combination of 5→9→1 gave the best results showing that the developed models can successfully analyze the non – linear multivariate data. From the study, it is concluded that the soft computing feedforward single layer models are very effective in predicting the shelf life of burfi.

REFERENCES

- Doganis, P., Alexandridis, A., Patrinos, P. and Sarimveis, H. (2006). Time series sales forecasting for short shelf-life food products based on artificial neural network models and evolutionary computing. *Journal of Food Engineering*, 75, 196-204.
- Goyal, Sumit, and Goyal, G.K. (2011a). Brain based artificial neural network scientific computing models for shelf life prediction of cakes. *Canadian Journal on Artificial Intelligence, Machine Learning and Pattern Recognition*, 2(6), 73-77.
- Goyal, Sumit, and Goyal, G. K. (2011b). Simulated neural network intelligent computing models for predicting shelf life of soft cakes. *Global Journal of Computer Science and Technology*, 11(14), Version 1.0, 29-33.
- Goyal, Sumit, and Goyal, G.K. (2011c). 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*, 2(5), 292-295.
- Goyal, Sumit, and Goyal, G.K. (2011d). Application of artificial neural engineering and regression models for forecasting shelf life of instant coffee drink. *International Journal of Computer Science Issues*, 8(4), No 1, 320-324.
- Goyal, Sumit, and Goyal, G.K. (2011e). 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*, 2(6), 78-82.
- Goyal, Sumit, and Goyal, G.K. (2011f). 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*, 2(7), 4-12.
- Goyal, Sumit, and Goyal, G.K. (2011g). 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*, 2(9), 1-4.
- Goyal, Sumit, and Goyal, G.K. (2011h). 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*, 2(3), 434-438.
- Goyal, Sumit, and Goyal, G.K. (2011i). Development of intelligent computing expert system models for shelf life prediction of soft mouth melting milk cakes. *International Journal of Computer Applications*, 25(9), 41-44.

Medlabs Website:

http://www.medlabs.com/Downloads/food_product_shelf_life_web.pdf (accessed on 13.2.2011).

Vallejo-Cordoba, B., Arteaga, G.E. and Nakai, S. (1995). Predicting milk shelf-life based on artificial neural networks and head-space gas chromatographic data. Journal of Food Science, 60, 885-888.

Wikipedia Feedforward Website:

http://en.wikipedia.org/wiki/Feedforward_neural_network (accessed on 2.3.2011).