Libyan Agriculture Research Center Journal International 2 (6): 274-278, 2011
ISSN 2219-4304

Computerized Models for Shelf Life Prediction of Post-Harvest Coffee Sterilized Milk Drink

[1]Sumit Goyal and [2]Gyanendra Kumar Goyal

[1]Senior Research Fellow, Dairy Technology Division,
National Dairy Research Institute, Karnal, 132001, India
[2]Emeritus Scientist, Dairy Technology Division,
National Dairy Research Institute, Karnal, 132001, India

Abstract: For centuries, coffee has been brewed and consumed in households, hot shops and restaurants. Coffee is the second most important product in the international market in terms of volume trade and the most important in terms of value. In today's highly competitive market consumers look for healthy and delightful food products. To attain good quality of food products, prediction of shelf life is necessary. Computerized models were developed for shelf life prediction of coffee sterilized milk drink. Colour and appearance, flavour, viscosity and sediment were taken as input parameters. The Overall acceptability was used as output parameter for developing the Artificial Neural Networks (ANN) models. The dataset was randomly divided into two disjoint subsets, namely, training set consisting of 40 observations (80% of total observations) and testing set comprising of 10 observations (20% of total observations). Number of neurons in each hidden layer varied from 1 to 30. The network was trained with 500 epochs. MSE, RMSE, R^2 and E^2 were used in order to compare the prediction performance of the developed computerized artificial intelligence models. The ANN models predicted 37.80 days shelf life which is within the experimentally determined shelf life of 45 days, suggesting that the product is acceptable.

Key words: Coffee % ANN % Artificial Intelligence % Elman % Radial Basis % Prediction % Shelf Life

INTRODUCTION

According to a coffee history legend, an Arabian shepherd named *Kaldi* found his goats dancing joyously around a dark green leafed shrub with bright red cherries in the southern tip of the Arabian Peninsula. *Kaldi* soon determined that it was the bright red cherries on the shrub that were causing the peculiar euphoria and after trying the cherries himself, he learned of their powerful effect. The stimulating effect was then exploited by monks at a local monastery to stay awake during extended hours of prayer and distributed to other monasteries around the world. Coffee was born [1]. Coffee is the second most important product in the international market in terms of volume trade and the most important in terms of value. Presently flavoured milks are very popular as they contain rich nutrients compared to soft drinks. They are prepared by using natural and synthetic flavours, while the coffee sterilized milk drink is made by heating the mixture of milk, sugar and coffee brew to high temperature (121°C) with 15 m holding time so that it remains fit for human consumption for longer time at room temperature. Artificial Neural Network (ANN) consists of an interconnected group of artificial neurons and processes information using an artificial approach to computation as represented in Fig. 1.

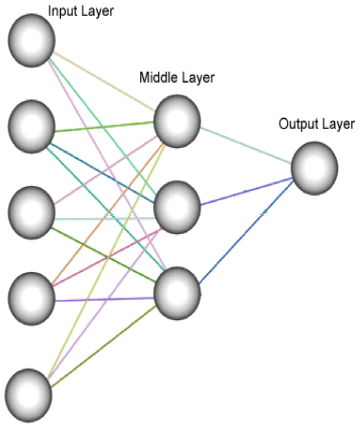

Fig.1. Artificial Neural Network

Corresponding Author: Sumit Goyal, National Dairy Research Institute, Karnal, 132 001, India.

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. In more practical terms, 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 data. ANN model is an interconnected group of nodes, parallel to the vast network of neurons in the human brain [2]. ANNs have been applied for predicting shelf life of Kalakand [3], milky white dessert jeweled with pistachio [4], instant coffee flavoured sterilized drink [5, 6]. Time-Delay and Linear Layer ANN models were developed for predicting shelf life of soft mouth melting milk cakes [7] and soft cakes [8]. Radial Basis models were successfully applied for predicting shelf life of Brown milk cakes [9]. Till date, there has been no published report based on ANN on the prediction of shelf life of roasted coffee sterilized drink. The objective of this research is to apply artificial neural network engineering approach for predicting the shelf life of roasted coffee sterilized cow milk drink.

MATERIALS AND METHODS

The data consisted of experimentally developed 50 observations. Colour and appearance, flavour, viscosity and sediment were taken as input parameters. The Overall acceptability was used as output parameter for developing the ANN models (Fig. 2).

ANN Training: The data was randomly divided into two disjoint subsets, namely, training set containing 40 observations (80% of total observations) an testing set comprising of 10 observations (20% of total observations). Number of neurons in each hidden layer varied from 1 to 30. The network was trained with 500 epochs and transfer function for each hidden layer was tangent sigmoid while for the output layer, it was linear function. Different algorithms were tried like BFG quasi-Newton algorithm, gradient descent algorithm with adaptive learning rate, Levenberg–Marquardt algorithm, Fletcher–Reeves update conjugate gradient algorithm, Powell–Beale restarts conjugate gradient algorithm and Bayesian regularization. Bayesian regularization gave good outputs; hence it was selected as training function. The training pattern is presented in Fig. 3.

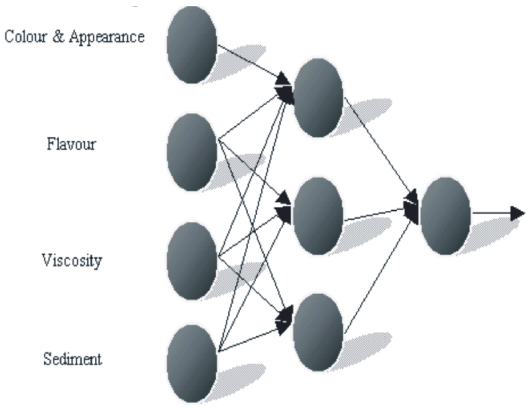

Fig. 2: Input and output parameters for models

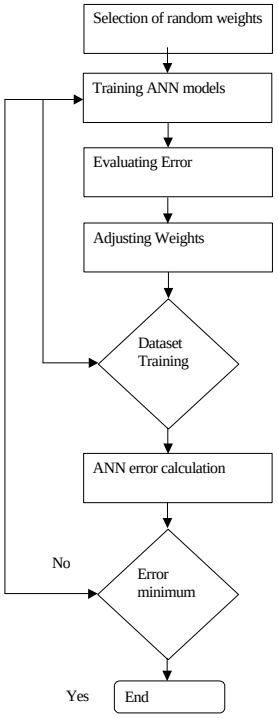

Fig. 3: ANN models training pattern

Prediction Performance Measures:

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

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

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

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

Where,

Q_{exp} = Observed value;
$\bar{Q}_{cal}$ = Predicted value;
Q_{exp} = Mean predicted value;
n = Number of observations in dataset.

MSE (1), RMSE (2), R^2 (3) and E^2 (4) were used in order to compare the prediction performance of the developed artificial intelligence models.

RESULTS AND DISCUSSION

Elman and Radial Basis ANN models were developed for predicting shelf life of roasted coffee sterilized cow milk drink. Several experiments were carried with single as well as double hidden layers for both the models as shown in Table 1, 2 and 3, respectively. Different topologies were tried and tested. The number of neurons increased as the time of training. For testing efficiency of ANN models four different prediction performance measures MSE, RMSE, R^2 and E^2 were used. It was observed that Elman model with single hidden layer having eighteen neurons gave the best result (MSE: 9.97756E-07, RMSE: 0.000998877, R^2: 0.999990022 , E^2: 0.999996211); for double hidden layer Elman model having seven neurons in the first layer and five neurons in the second layer (MSE: 8.48661E-06, RMSE: 0.002913179, R^2: 0.999915134, E^2: 0.999999923). Radial Basis model was also developed and its best performance was with 100 spread constants (MSE : 4.1554E-05 , RMSE: 0.006446238 , R^2: 0.99958446, E^2: 0.999951677).

Comparison of Elman and Radial Basis Models: The relationship between Actual Overall Acceptability Score (AOAS) and Predicted Overall Acceptability Score (POAS) is presented in Fig. 4, 5 and 6 (Y Axis=*AOAS,POAS* :X Axis =*Scale*) respectively.

Table 1: Elman Model with single hidden layer

Neurons in Hidden Layer	MSE	RMSE	R^2	E^2
5	2.5625	0.00506	0.99974	0.99997803
6	6.6577	0.00815	0.99933	0.99999721
7	4.9947	0.00706	0.99950	0.99999760
9	4.3418	0.00208	0.99995	0.99999885
10	2.5436	0.00504	0.99974	0.99999182
12	4.6925	0.00685	0.99953	0.99999999
14	1.8932	0.00137	0.99998	0.99999994
18	9.9775	0.00099	0.99999	0.99999621
25	0.0001	0.01329	0.99823	0.99998055
30	0.0001	0.01061	0.99887	0.99997534

Table 2: Elman model with double hidden layer

Neurons in Hidden Layer	MSE	RMSE	R^2	E^2
5:5	4.3782	2.09243	0.99999	0.99999
6:6	0.0002	0.01563	0.99755	0.99997
7:7	0.1285	0.35855	-0.28560	-0.0645
4:3	6.7148	0.00259	0.99993	0.99999
7:5	8.4866	0.00291	0.99991	0.99999
3:9	5.5710	0.00746	0.99944	0.99998
11:11	0.0003	0.01973	0.99610	0.99999

Table 3: Radial Basis Model

Spread Constant	MSE	RMSE	R^2	E^2
2	4.7587	0.00689	0.99952	0.99996
10	4.8936	0.00699	0.99951	0.99996
20	4.3208	0.00657	0.99956	0.99995
30	4.2301	0.00650	0.99957	0.99995
50	4.1727	0.00645	0.99958	0.99995
100	4.1554	0.00644	0.99958	0.99995

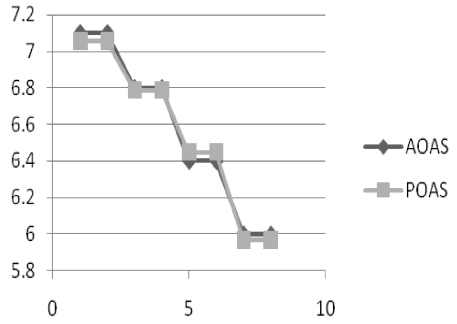

Fig. 4: Comparison of actual and predicted sensory score for Elman single layer model

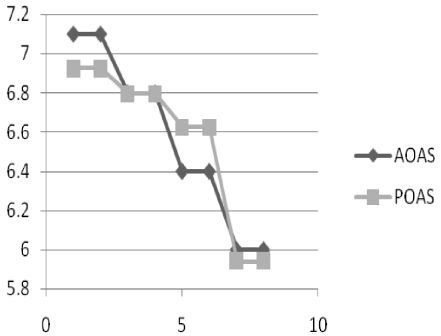

Fig. 5: Comparison of actual and predicted sensory score for Elman double layer model

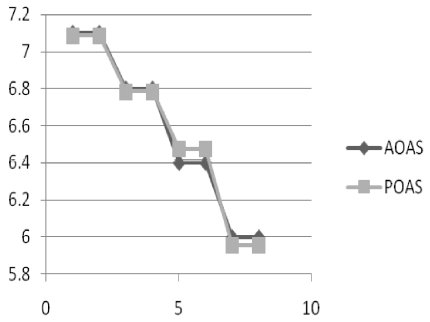

Fig. 6: Comparison of actual and predicted sensory score for Radial Basis Model

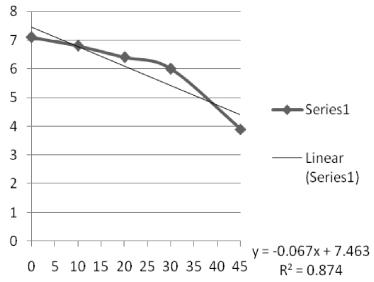

Fig. 7: Shelf life prediction of cow milk roasted coffee sterilized drink

Shelf Life Prediction for Cow Milk Roasted Coffee Sterilized Drink: The regression equations were developed to estimate shelf life of the roasted coffee sterilized cow milk drink, *i.e.*, in days for which product has been in the shelf, based on overall acceptability score. The product was stored at 30°C taking storage intervals (in days) as dependent variable and overall acceptability score as independent variable (Y Axis= *OAS*,X Axis = Days *i.e.*, Period of Storage) in Fig. 7.

R^2 was found to be 87.4 percent of the total variation as explained by overall acceptability scores. Time period (in days) for which the product has been in the shelf can be predicted based on overall acceptability score for roasted coffee sterilized cow milk drink stored at 30°C. The shelf life is computed by subtracting the obtained value of days from experimentally determined shelf life, which was found to be 37.80 days. The predicted value is within the experimentally obtained shelf life of 45 days, hence the product is acceptable.

CONCLUSION

Shelf life is the amount of time till a product retains its natural taste, quality and can be stored. In today's highly competitive market consumers look for healthy and delightful food products. To attain good quality of food products, prediction of shelf life is necessary. Hence, artificial intelligence neural network Elman model was developed for predicting shelf life of roasted coffee sterilized cow milk drink stored at 30°C. To compare prediction potential Radial Basis model was also developed. The final results of both the models were compared with each other. The Elman model with single hidden layer having eighteen neurons gave the best fit (MSE: 9.97756E-07, RMSE: 0.000998877, $R^{2:}$ 0.999990022, $E^{2:}$ 0.999996211), followed by Elman model with two hidden layers having seven neurons in the first layer and 5 neurons in the second layer (MSE: 8.48661E-06 , RMSE : 0.002913179, R^2: 0.999915134, E^2: 0.999999923) and Radial Basis model with spread constant as 100 (MSE : 4.1554E-05 , RMSE: 0.006446238 , R^2 : 0.99958446, E^2 : 0.999951677). Regression equations were developed to estimate shelf life of the roasted coffee sterilized cow milk drink. The shelf life was computed by subtracting the obtained value of days from experimentally determined shelf life, which was found to be 37.80 days. The predicted value is within the experimentally obtained shelf life of 45 days, hence the product is acceptable. Therefore, from the study it can be concluded that artificial intelligence models are good in predicting shelf life of roasted coffee sterilized cow milk drink stored at 30°C.

REFERENCES

1. http://www.coffeeresearch.org/coffee/history.htm (accessed on 30.8.2011)
2. http://en.wikipedia.org/wiki/Artificial_neural_network (accessed on 1.8.2011)
3. Goyal, Sumit and G.K. Goyal, 2011. Advanced Computing Research on Cascade Single and Double Hidden Layers for Detecting Shelf Life of Kalakand: An Artificial Neural Network Approach. International J. Computer Science & Emerging Technologies, 2(5): 292-295.
4. Goyal Sumit and G.K. Goyal, 2011. A New Scientific Approach of Intelligent Artificial Neural Network Engineering for Predicting Shelf Life of Milky White Dessert Jeweled with Pistachio. International J. Scientific and Engineering Research, 2(9): 1-4.
5. Goyal Sumit and G.K. Goyal, 2011. Cascade and Feedforward backpropagation artificial neural networks models for prediction of sensory quality of instant coffee flavoured sterilized drink. Canadian J. Artificial Intelligence, Machine Learning and Pattern Recognition, 2(6): 78-82.

6. Goyal Sumit and G.K. Goyal, 2011. Application of artificial neural engineering and regression models for forecasting shelf life of instant coffee drink. International J. Computer Science Issues, 8(4): 320-324.
7. Goyal Sumit and G.K. Goyal, 2011. Development of Intelligent Computing Expert System Models for Shelf Life Prediction of Soft Mouth Melting Milk Cakes. International J. Computer Applications, 25(9): 41-44.
8. Goyal Sumit and G.K. Goyal, 2011. Simulated Neural Network Intelligent Computing Models for Predicting Shelf Life of Soft Cakes. Global J. Computer Science and Technol., 11(14): version1.0: 29-33.
9. Goyal, Sumit and G.K. Goyal, 2011. Radial Basis Artificial Neural Network Computer Engineering Approach for Predicting Shelf Life of Brown Milk Cakes Decorated with Almonds. International J. Latest Trends in Computing, 2(3): 434-438.