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# Radial Basis (Fewer Neurons) and Statistical Multiple Linear Regression Models for Predicting Shelf of Processed Cheese

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**Abstract**

Processed Cheese is one of the most popular varieties among the types of cheeses. Radial Basis (Fewer Neurons) and Multiple Linear Regression models were developed for predicting the shelf life of processed cheese stored at 7-8º C by taking body & texture, aroma & flavour, moisture, free fatty acids as input parameters, and sensory score as output parameter. Mean square error, root mean square error, coefficient of determination and Nash–Sutcliffe coefficient were used for calculating the prediction capability of the developed models. The comparison of the two developed models revealed that the performance of radial basis (fewer neurons) artificial neural network model is better than that of statistical multiple linear regression model for predicting the shelf life of processed cheese.

**Keywords:** Radial Basis (Fewer Neurons), Multiple Linear Regression, Artificial Intelligence, Artificial Neural Network (ANN), Soft Computing

## 1. Introduction

Processed cheese is one of the most popular varieties among the types of cheeses. It is prepared generally by using medium ripened (up to 6 months old) grated Cheddar cheese by adding water, emulsifiers, salt, and preservatives, followed by heating to 70º C for 10-15 min 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 min) with a flattened ladle in order to get unique body & texture in the product.

The first Artificial Neural Network (ANN) was invented in 1958 by psychologist Frank Rosenblatt. Researchers have since used similar ANNs to study human cognition. An artificial neural network operates by creating connections between many different processing elements, each analogous to a single neuron in a biological brain. These neurons may be physically constructed or simulated by a digital computer. Each neuron takes many input signals, then based on an internal weighting system, produces a single output signal that's typically sent as input to another neuron. The neurons are tightly interconnected and organized into different layers. The input layer receives the input; the output layer produces the final output [1]. A radial basis function network is an ANN that uses radial basis functions as activation functions. It is a linear combination of radial basis functions. They are used in function approximation, time series prediction, and control. Radial basis function network consists of one layer of input nodes, one hidden radial-basis function layer and one output linear layer [2].Multiple linear regression is a technique that allows additional factors to enter the analysis separately so that the effect of each can be estimated. It is valuable for quantifying the impact of various simultaneous influences upon a single dependent variable [3]. Shelf life is defined 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. The food engineers are facing the challenges to monitor, diagnose, and control

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**Table 1: Results of Radial Basis (Fewer Neurons) Model**

| *Neurons* | *MSE* | *RMSE* | $R^2$ | $E^2$ |
|---|---|---|---|---|
| 10 | 0.002520741 | 0.05020698 | 0.94979302 | 0.997479259 |
| 20 | 6.86887E-06 | 0.002620853 | 0.997379147 | 0.999993131 |
| 30 | 0.247948697 | 0.497944472 | 0.502055528 | 0.752051303 |
| 40 | 0.000254223 | 0.015944364 | 0.984055636 | 0.999745777 |
| 50 | 0.003878866 | 0.062280545 | 0.937719455 | 0.996121134 |
| 60 | 0.01445383 | 0.120224081 | 0.879775919 | 0.98554617 |
| 70 | 0.025423077 | 0.159446158 | 0.840553842 | 0.974576923 |
| 80 | 0.034253717 | 0.185077598 | 0.814922402 | 0.965746283 |
| 90 | 0.040769288 | 0.20191406 | 0.79808594 | 0.959230712 |
| 100 | 0.04546772 | 0.21323161 | 0.78676839 | 0.95453228 |
| 110 | 0.048871489 | 0.221068969 | 0.778931031 | 0.951128511 |
| 120 | 0.05137405 | 0.226658443 | 0.773341557 | 0.94862595 |
| 130 | 0.053248353 | 0.230756046 | 0.769243954 | 0.946751647 |
| 140 | 0.054680242 | 0.233838069 | 0.766161931 | 0.945319758 |
| 150 | 0.055794898 | 0.236209437 | 0.763790563 | 0.944205102 |
| 160 | 0.056675761 | 0.238066715 | 0.761933285 | 0.943324239 |
| 170 | 0.057384693 | 0.239551025 | 0.760448975 | 0.942615307 |
| 180 | 0.057960836 | 0.240750569 | 0.759249431 | 0.942039164 |
| 190 | 0.592135802 | 0.0986893 | 0.9013107 | 0.990260422 |
| 200 | 0.058834114 | 0.242557446 | 0.757442554 | 0.941165886 |

the quality and safety of food products. The advent of nanotechnology, multivariate sensors, information systems, and complex systems will revolutionise the way we manage, distribute, and consume foods. The consumer demands foods under the legal standards, at low cost, high standards of nutritional, sensory, and health benefits [4]. ANNs have been successfully applied for predicting the shelf life of milky white dessert jeweled with pistachio [5], Kalakand [6], and instant coffee flavoured sterilized drink [7-8]. Cascade ANN models predicted sensory quality of roasted coffee flavoured sterilized drink [9]. Time-Delay and Linear Layer models predicted shelf life of soft mouth melting milk cakes [10]. Elman and self-organizing models predicted shelf life of soft cakes [11]. Radial Basis models were developed for forecasting shelf lives of brown milk cakes decorated with almonds [12], and cakes [13]. Till date no work has been reported for predicting the shelf life of processed cheese stored at 7-8ºC by employing Radial Basis (Fewer Neurons) and Multiple Linear Regression(MLR) models, hence this investigation. This study would be very beneficial to manufacturers, food researchers and academicians.

## 2. Method Material

The datasets used in this research consisted of 36 observations, which were divided into two subsets, *i.e.*, 30 for training and 6 for testing the developed Radial Basis (Fewer Neurons) and MLR models. The values of body & texture, aroma & flavour, free fatty acids and moisture of processed cheese stored at 7-8º C, were taken as input parameters and sensory score as output parameter for developing ANN models (Figure1).

**Figure 1: Input and Output Parameters**

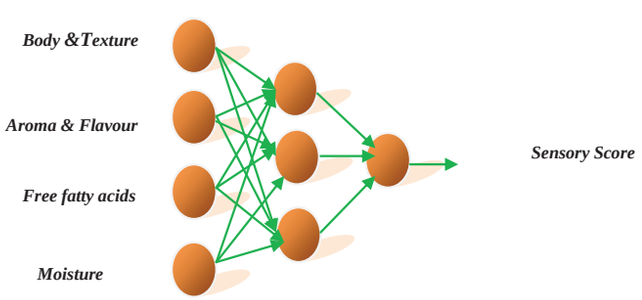


**Figure 2: Comparison of ASS and PSS for Radial Basis (Fewer Neurons) Model**

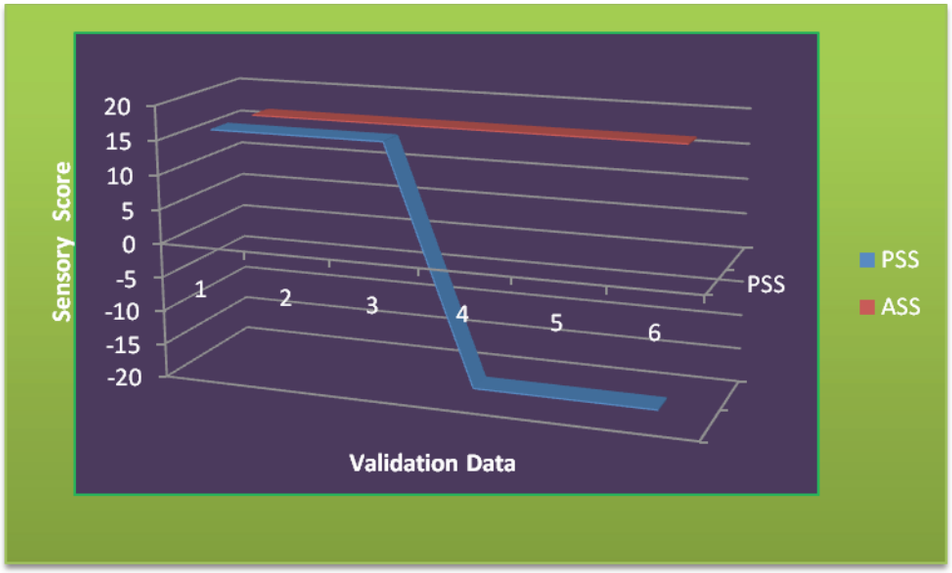
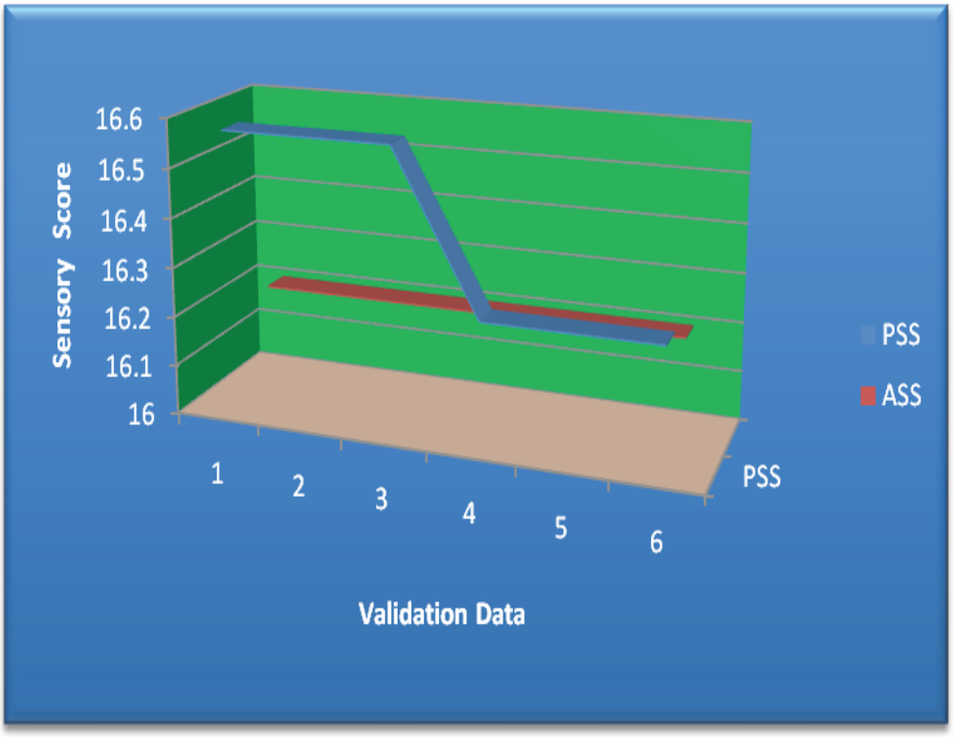



**Figure 3: Comparison of ASS and PSS for MLR Model**




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

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

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

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

Where,

$Q_{\exp}$ = Observed value;

$Q_{cal}$ = Predicted value;

$Q_{\exp}$ = 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–Sutcliffe Coefficient ($E^2$) (4) were used in order to compare the prediction ability of the Radial Basis (Fewer Neurons) and MLR models. The Neural Network Toolbox under MATLAB software was used for performing experiments.

## 3. Results and Discussion

ANN model's performance matrices for predicting sensory scores are presented in Table 1 and Table 2, respectively.

**Table 2: Results of Multiple Linear Regression Model**

| *MSE* | *RMSE* | $R^2$ | $E^2$ |
|---|---|---|---|
| 8.77913E-05 | 0.009369703 | 0.990630297 | 0.999912209 |

The comparison of Actual Sensory Score (ASS) and Predicted Sensory Score (PSS) for Radial Basis (Fewer Neurons) and MLR models are illustrated in Figure2 and Figure3, respectively. Radial Basis (Fewer Neurons) (Table 1) and MLR models (Table 2) were developed and compared with each other for predicting the shelf life of processed cheese. It was observed that Radial Basis (Fewer Neurons) model with spread constant as 20 gave the best results (MSE: 6.86887E-06; RMSE: 0.002620853; $R^2$ : 0.997379147 ; $E^2$ : 0.999993131 ). The comparison of the results of MLR model (MSE: 8.77913E-05; RMSE: 0.009369703; $R^2$: 0.990630297; $E^2$: 0.999912209) with the best results of Radial Basis (Fewer Neurons) model showed that the Radial Basis (Fewer Neurons) ANN model was better than statistical model MLR for predicting the shelf life of processed cheese. However, as per earlier findings [8], MLR model was found to be better than Radial Basis (Fewer Neurons) ANN model in case of predicting the shelf life of instant coffee drink [14-20].

## 4. Conclusion

Body & texture, aroma & flavour, free fatty acids and moisture were taken as input parameters, and sensory score as output parameter for developing Radial Basis (Fewer Neurons) ANN and MLR models for predicting the shelf life of processed cheese stored at 7-8$^{o}$C. The data comprised of 36 observations, which were divided into two sets, *i.e.*, 30 (80% of observations) for training, and 6 (20% of observations) for validation of the developed models. On comparing the two developed models, it was found that the Radial Basis (Fewer Neurons) (RMSE: 0.002620853) and MLR (RMSE: 0.009369703) model performed better. From the study, it is concluded that Radial Basis (Fewer Neurons) ANN models, which proved to be better than MLR model, can be used for predicting the shelf life of processed cheese.

## References


1. http://www.computerworld.com/s/article/57545/Artificial_Neural_Networks (accessed on January 1, 2011).
2. Mateo, F., Gadea, R., Medina, Á., Mateo, R. & Jiménez, M. (2009). Predictive assessment of ochratoxin an accumulation in grape juice based-medium by Aspergillus carbonarius using neural networks. *Journal of Applied Microbiology,* 107(3), 915-927.
3. http://www.law.uchicago.edu/files/files/20.Sykes_.Regression.pdf (accssed on January 1, 2011)
4. Martins, R. C., Lopes, V. V., Vicente, A. A. & Teixeira, J. A. (2008). Computational shelf-life dating: Complex systems approaches to food quality and safety. *Food and Bioprocess Technology,* 1(3), 207-222.
5. Goyal, S. & Goyal, G. K. (2011). 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.
6. Goyal, S. & Goyal, G. K. (2011). 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.
7. Goyal, S. & Goyal, G. K. (2011). 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.

8. Goyal, S. & Goyal, G. K. (2011). Application of artificial neural engineering and regression models for forecasting shelf life of instant coffee drink. *International Journal of Computer Science Issues*, 8(4), 320-324.
9. Goyal, S. & Goyal, G. K. (2012). Study on single and double hidden layers of cascade artificial neural intelligence neurocomputing models for predicting sensory quality of roasted coffee flavoured sterilized drink. *International Journal of Applied Information Systems*,1(3), 1-4.
10. Goyal, S. & Goyal, G. K. (2011). 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.
11. Goyal, S. & Goyal, G. K. (2011). Simulated neural network intelligent computing models for predicting shelf life of soft cakes. *Global Journal of Computer Science and Technology*. 11(14), 29-33.
12. Goyal, S. & Goyal, G. K. (2011). 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.
13. Goyal, S. & Goyal, G. K. (2011). 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.
14. Goyal, S., Sitanshu, K. & Goyal, G. K. (2013). Artificial neural networks for analyzing solubility index of roller dried goat whole milk powder. *International Journal of Mechanical Engineering and Computer Applications*, 1(1), 1-4.
15. Goyal, S. & Goyal, G. K. (2013). Cascade modelling for predicting solubility index of roller dried goat whole milk powder. *Bulletin of Electrical Engineering and Informatics*, 22(1), 19-28.
16. Goyal, S. & Goyal, G. K. (2013). Intelligent artificial neural network computing models for predicting shelf life of processed cheese. *Intelligent Decision Technologies*, 7(2), 107-111.
17. Goyal, G. K. & Goyal, S. (2013). Cascade artificial neural network models for predicting shelf life of processed cheese. *Journal of Advances in Information Technology*, 4(2), 80-83.
18. Goyal, S. & Goyal, G. K. (2013). Artificial vision for estimating shelf life of burfi. *Journal of Nutritional Ecology and Food Research*, 1(2), 1-3.
19. Goyal, S. (2013). Artificial neural networks (ANNs) in food science - A review. *International Journal of Scientific World*, 1(2), 19-28.
20. Goyal, S. (2003). Artificial neural networks in vegetables: A comprehensive review. *Scientific Journal of Crop Science*, 2(7), 75-94.