Artificial Neural Network Simulated Elman Models for Predicting Shelf Life of Processed Cheese

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ABSTRACT

Elman artificial neural network models with single and multilayer for predicting shelf life of processed cheese stored at 7-8ºC were developed. Input parameters were: Body & texture, aroma & flavour, moisture, and free fatty acid, while sensory score was output parameter. Bayesian regularization was training algorithm for the models. The network was trained up to 100 epochs, and neurons in each hidden layers varied from 1 to 20. Transfer function for hidden layer was tangent sigmoid, while for the output layer it was pure linear function. Mean Square Error, Root Mean Square Error, Coefficient of Determination and Nash - Sutcliffo Coefficient were used for comparing the prediction ability of the developed models. Elman model with combination of 4-17-17-1 performed significantly well for predicting the shelf life of processed cheese stored at 7-8º C.

Keywords: *Artificial Intelligence, Artificial Neural Network (ANN), Elman, Prediction, Processed Cheese, Shelf Life*

INTRODUCTION

The aim of this research is to develop Elman Artificial Neural Network (ANN) models with single layer and multilayer, and to compare them with each other for predicting shelf life of processed cheese stored at 7-8ºC. Elman models are two layered backpropagation networks, with the addition of a feedback connection from the output of the hidden layer to its input. This feedback path allows Elman model to learn to recognize and generate temporal patterns, as well as spatial patterns. The Elman ANN model has *tansig* neurons in its hidden layer, and *purelin* neurons in its output layer. This combination is special in that two layered networks with these transfer functions can approximate any function (with a finite number of discontinuities) with arbitrary accuracy. The only requirement is that the hidden layer must have enough neurons. More hidden neurons are needed as the function being fitted increases in complexity. Elman model differs from conventional two layer networks in that

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the first layer has a recurrent connection. The delay in this connection stores values from the previous time step, which can be used in the current time step. Therefore, even if two Elman models, with the same weights and biases, are given identical inputs at a given time step, their outputs can be different because of different feedback states. Because the network can store information for future reference, it is able to learn temporal patterns as well as spatial patterns. The Elman models can be trained to respond to, and to generate, both kinds of patterns (Demuth *et al.*, 2009).

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 technique, which is fully equipped to predict the shelf life of food products, should be employed for processed cheese as well. Hence, a study was planned for developing Elman artificial neural network models with single and multilayer for predicting shelf life of processed cheese stored at 7-8ºC. The results of this investigation would be very useful for consumers, dairy factories manufacturing processed cheese, wholesalers, retailers, regulatory authorities, food researchers and academicians.

LITERATURE REVIEW

Artificial Neural Network

An artificial neural network (ANN), usually called neural network is a mathematical model or computational model that is inspired by the structure and functional aspects of ANN. ANN based computing method is an adaptive system that changes its structure based on external or internal information that flows through the network during the learning phase. In ANN based intelligent computing, simple artificial nodes, variously called "neurons," "neurodes," "processing elements," or "units," are connected together to form a network of nodes mimicking the biological neural networks — hence the term "ANN." Generally, ANN involves a network of simple processing elements that exhibit complex global behavior determined by connections between processing elements and element parameters. While an ANN does not have to be adaptive, its practical use comes with algorithms designed to alter the weights of the connections in the network to produce a desired signal flow (Artificial Neural Network) (Wikipedia, n.d.). An electrostatic potential difference is maintained across the cell membrane, with the inside of the membrane being negatively charged. Ions diffuse through the membrane to maintain this potential difference. Inhibitory or excitatory signals from other neurons are transmitted to a neuron at its dendrites' synapses. The magnitude of the signal received by a neuron from another neuron depends on the efficiency of the synaptic transmission, and can be thought of as the strength of the connection between the neurons. The cell membrane becomes electrically active when sufficiently excited by the neurons making synapses onto this neuron. A neuron will fire, *i.e.,* send an output impulse of about 100mV down its axon, if sufficient signals from other neurons fall upon its dendrites in a short period of time, called the