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Review Article

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Application of Artificial Neural Networks in Dairy Products and Biosensors in Drying Products

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Abstract

Undoubtedly, one of the perishable groups in food science classification is dairy products. Dairy group foods provide nutrients that are vital for the health and maintenance of the body. Moreover, agriculture products with the lowest waste are strategist products for all the countries. Artificial neural networks (ANNs) are used in almost all industries such as science, technology, medicine and engineering due to their optimal efficiency. They have been used in analysis as well as the possibility of predicting shelf life in food industries. This article analyzes the available information and articles related to the use of ANNs in predicting the shelf life of dairy products such as milk, yogurt, butter, and cheese, which can be useful from the point of view of consumers, regulatory organizations, researchers, and academics be very productive. The objective of this review was to highlight the application of ANNs in food science technology on deliberated for usual dairy products in food market. The collected results in this research indicated that this computing system followed mathematical models and these methods are always used in food science technologies as input and output in algorithms.

Keywords

Artificial neural network, Shelf life, Dairy product, Mathematical models

Introduction

ANNs in simpler language, are neural networks of new computing systems and methods for learning machine, display of knowledge and at the end applying the obtained knowledge to predict the output responses of complex systems. ANNs are practical instruments for food science technology analyses, which include mathematical of microbial growth and from this predicting food safety, interpreting spectroscopic data, and predicting physical, chemical, functional and sensory evaluations of various food products during processing and distribution [1]. The main idea such networks are somewhat inspired by the way the biological nervous system works to process data and information in order to learn and create knowledge is inspired [2]. The key element of this idea is to create new structures for the information processing system [3]. This system of a lot of highly interconnected processing elements called neurons are formed that work together to solve a problem and are formed by synapses (electromagnetic communications) transmitting information. In these networks, if one cell is damaged, the rest of the cells can be lost compensated and contribute to its reconstruction. These networks can learn, for example, by applying irritation to touch nerve cells, the cells learn not to go to the hot object and with this algorithm teaches the system to correct its error.

Learning in these systems is done adaptively, that is, by using examples, the weight of synapses is changed in such a way that the system produces a correct response when new inputs are given [4]. There is no exact agreement on the definition of neural network among researchers; but most of them agree that the neural network consists of a network of elements. It is simple processing (neurons), which can show a general complex behavior determined by the relationship between processing elements and element parameters. Using computer programming knowledge, you can design a data structure that acts like a neuron [5]. Then by creating a network of these interconnected artificial neurons, creating a training algorithm for the network, and applying this algorithm to the network, trained it. This network for estimation and approximation have shown a very high efficiency and the range of application of these mathematical models derived from the functioning of the human brain is very wide that as a few small examples, this mathematical tool can be used in the mentioned the processing of biological, telecommunication and electronic signals to help in astronomy and space travel. If a network is equivalent to a graph as we know, the network training process will determine the weight of each edge and the initial error [4.5].

Mathematical Modules and Structure of ANN

Although neural networks are used to solve multidimensional and complex problems, they have a relatively simple structure that brings the unique characteristics of neural networks. Of course, like any other modeling method, the proper use of neural networks also has its own rules and framework. Neural networks have various applications in a wide range of industries from speech and face recognition to process control and product quality control. In addition, one of the fields of applied neural network is the prediction of time series which is very useful in agriculture and related industries such as food industry. It is worth noting that in each neural network, the number of neurons in the input and output layers is determined by the input and output data [6, 7]. One of the most common transfer functions used in simple neural networks is the sigmoid transfer function, which is shown in equations (1 and 2) and figure 1.

$$f(x) = 1/\left(1 + e^{(-x)}\right) \quad (1)$$

$$y = f(wx + b) \quad (2)$$

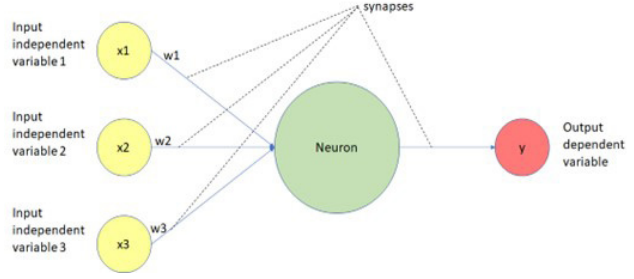

Figure 1: An illustration of mathematical neural network.

ANNs in Predicting Shelf-life of Dairy Products

Shelf-life studies provide important information for manufacturers to ensure quality within a certain period after production. Here, the shelf-life evaluation in the laboratory is a time-consuming process and makes it unsuitable for the practical needs of the industry, which requires a short time [2]. Therefore, more rapid prediction methods have recently been invented, and the quality of food products is the most important principle in the competitive arena of the world market is success. The consumer's feeling towards the product is the most important indicator of the quality of the food product, and hence its primary quality. It should be preserved in the stages of distribution and consumption [8]. In the dairy industry, like the rest of the food industry, almost all the steps from milking, breed of animals, location, and environmental conditions of animal breeding to milk processing and pasteurization and even packaging of the final product have a significant impact on its quality, from ANNs in the fields. Various dairy industries, including production processes in the farm, industrial production processes (pasteurization, cheese production, whey proteins, etc.), performance prediction of profitable products, product quality prediction, economic modeling and improvement of sensor and control issues have been used [9].

Milk

The effectiveness of ANNs in predicting the shelf-life of milk using the method of multivariate interpretation of gas chromatography profiles and the durability related to the sensory properties was compared with the principal component regression method, the result of which was the superiority of neural networks in such a way that an error equal to 2 days that existed in the principal component regression method was not seen in this method [10]. This especially played a significant role in predicting the shelf-life of fresh milk, because the market's negative reaction to corruption caused premature expiration and losses caused by the return of reduced milk. Moreover, combination of ANNs with E-nose was reliable method to prediction of total bacteria count in milk [11]. Nevertheless, ANNs analysis the addition of whey to milk fraud. The Garson method was applied in this research to determine. Moreover, results applied with ANNs showed that concentration of some components affects the fat content and density [12].

Yogurt

Expiry date control

Physical, chemical, and microbial structural changes in yogurt will determine its shelf-life. In a microbial count report, pH was recorded on days 1, 7, and 14. At the same time, the process of filming is also done using the MVS device to record the changes. The color of the yogurt was recorded during the storage period, and the data was collected using neural computing models of the shelf-life of high-fat yogurt. It was modeled as low-fat and lumpy. The input variables of the network included pH, aerobic count, yeast, fungus, and coliform and color analysis read by MVS device. The output variable was the storage time of yogurt, the result of which showed a high coef-

ficient of determination, which is called as proposed a modern forecasting method in promoting food health and safety [13].

Determination of the qualification of low-fat yogurt

With the increasing consumption of low-fat yogurt, the importance of verifying the health and qualification of this product becomes more significant. Fat experiments, despite their simplicity and speed, require the use of dangerous reagents such as sulfuric acid to break protein and fat bonds. In addition, its waste disposal requires care. Using ANNs using simple tools with variables inputs such as pH, color, and hardness were proposed as output variables for the classification of commercial types of low-fat yogurt. A database was formed from these data and the neural model built with Levenberg-Marquardt algorithm was built and accurate using the neural network toolbox of MATLAB software. The result of the analysis was 100% accurate. Considering that there is no need for sample preparation like the old chemical test and no waste, this method was suggested as a new and effective method in predicting the qualification of product [14].

Determination of the yogurt proteins

Recently, a new method has been developed using the specific absorption of protein in the region of a wave spectrum of 1500 - 1800 cm^{-1} by means of Fourier transform infrared spectroscopy and chemometry. Since this method does not require sample preparation and has a suitable accuracy, it was suggested as a new way to measure yogurt protein [15].

Butter

The changes of butter fatty acids were investigated in three different seasons in a 12-month study in a certain grazing area. Fatty acids were analyzed by FID gas chromatography and then evaluated by computer neural network. Butter produced from summer cream compared to butter from spring and autumn cream has a better proportion in the ratio of saturated and unsaturated fatty acids, the percentage of fatty acids. It had less saturation, and a higher percentage of mono- and poly-unsaturated fatty acids, while vaccinic acid was less in spring and more in winter. Based on this, neural networks can determine the production season of creams used in butter and classify them based on (animal feed) [14].

Swiss cheese

The researchers observed that the three-layer neural network model is more accurate in predicting the properties than the regression equation method. They have the feeling of Swiss cheese based on its composition. Researchers stated that moisture prediction of Swiss cheese produced on a commercial scale using neural networks can also be used in research on production variables and their complex reactions with each other as well as cheese moisture prediction [16]. Processed cheeses linear layer models and general regression models for predicting shelf life of processed cheeses at 7 to 8 °C have been maintained and invented [17]. The obtained information related to dissolved nitrogen, pH, standard plate count, fungi and yeast and spores were used as input variables [18]. The output variable was the sensory score to create intelligent computational models was used. Various studies showed the effectiveness of these smart models in predicting the shelf life of cheese [19]. Nevertheless, texture profile analysis in some dairy products such as cheese is the most important part in quality control. Utilization of ANN to predict hardness of cheese during the ripening process, and their work allowed verifying that it had slightly better method to prediction when compared to partial least squares regression models.

Application of Biosensors in Agriculture

Olfactory sensor or electronic nose (E-nose) is also one of the widely used areas of classification algorithms such as neural networks. In research to design an odor sensor for tomato juice product, comparing several methods including network. However, pointing out that these methods require a lot of marked data and providing this amount of data requires spending a lot of time, money and manpower, the researchers suggested a semi-supervised method [20]. Moreover, determination in shelf-life of the product, one of the effective factors is respiration or oxygen absorption after harvesting agricultural products. Researchers stated that using near-infrared spectroscopy in 11 wavelengths from 645 to 979 nm method to relatively fast and appropriate accuracy for predicting the physiological behavior of tomatoes [21]. Another example of the chemical component that was chosen as a natural ingredient is lycopene pigment that is so important in agriculture and the food industry. Red fruits and vegetables, especially tomatoes variety, watermelons, pink grapefruits, apricots, and pink guavas, contain lycopene. Lycopene is a linear carotenoid found mostly in tomato and related products such as tomato paste and ketchup that has been antioxidant activities. In a literature, researchers investigated the stability and resistance of lycopene in 4 types of tomato juice, 3 types of ketchup and 3 types of other sauces [22]. Radial-Basis Network was used to simulate the kinetics of lycopene decomposition. The difference between this network and the usual networks is the type of its transfer function.

In general, lycopene natural pigment is always measured by chemistry analytical technique such as high-performance liquid chromatography, that is almost expensive and needed to time to accuracy of the result.

ANN in Drying Industry

Scientists in the study of thin onion sheets in a laboratory bed dryer with three different temperatures and speeds. Investigated different air in constant air humidity and modeled its drying kinetics from ANN and they used the mean square error of 0.00003938 and the correlation coefficient of 0.999. According to the investigation, the neural network with 1-5-2 arrangement was presented as the best neural model [23].

In research, ANN modeling of mass transfer during osmotic dehydration of kefir lemon peel was investigated. The results showed that the best network was obtained by using a hidden layer with 5 neurons and using Lunberg-Margot algorithm as a learning algorithm. In this process, the goal was to predict the absorption of solids and the reduction of sample water [24].

Scientists applied a neural network model to estimate sugar absorption and water excretion in the process. They used

osmotic drying of apples. In this research, the optimal conditions of the neural network included a hidden layer with 4 neurons, and the neural network model obtained in a wide range of process variables was able to estimate water excretion and sugar absorption in the test phase, respectively, with a mean square error of 13.9 and 4.4 moreover, a regression coefficient was 0.86, 0.96 [25].

Conclusion

Dairy products are one of the crucial sources of portions in the food nutrition pyramid. These products had great ability to spoilage by all of source of microorganisms. The use of neural networks in predicting the durability in food science technology is a new and effective method. The reason for inventing this method was the difficulty, cost and time-consuming methods of sensory evaluation tests used in durability prediction. While sensitive, reliable neural networks, they are fast, simple, and inexpensive to determine the eligibility of food products and the safety of consumers.

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None.

Conflict of Interest

None.

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