

The Effect of Biopreservatives on the Chemical Properties of Tomato Paste and Predicting Results with Artificial Neural Networks

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Research Article

Keywords: tomato paste, biopreservative, artificial neural network, self-organizing map

Posted Date: May 18th, 2022

DOI: <https://doi.org/10.21203/rs.3.rs-1643130/v1>

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Abstract

This study aimed to develop a tomato paste using biopreservatives as substitutes for chemical preservatives. Fennel seed (*Foeniculum vulgare* Mill) (FSE) and *Ziziphora clinopodioides* Lam. extract (ZCE) were used as biopreservatives. Physico-chemical properties of tomato paste such as pH, titratable acidity and total soluble solid (brix) were measured during five weeks of storage at 4°C. The results showed that the incorporation of different concentrations of FSE and ZCE significantly ($p < 0.05$) caused to decreasing in pH and increasing in acidity of tomato pastes. Increasing the extracts level in tomato paste samples significantly ($p < 0.05$) resulted in increased brix during storage. Overall it can be concluded that utilization of 2 or 3% FSE as biopreservative resulted in the desirable physicochemical in tomato paste. Finally, the self-organizing map (SOM) showed that the winner neuron which has the most data is neuron 31. Input data to perceptron artificial neural network are concentration, and during different weeks (time) is considered as output. The values of the correlation coefficient (R^2) and the mean of squared errors (MSE) used to evaluate the perceptron artificial neural network with 1 hidden layers and 31 neurons are 0.99301, 0.99288, 0.000016499, and 0.0085227, respectively, indicating the high accuracy of the network

1. Introduction

Now, using chemical preservatives is the most common way to maintain food safety during its storage period. In addition to damage to the health of the consumer, rotten foods harm the manufacturer economically. Lack of consumer trust in the safety of food products containing synthetic preservatives and the obtained reports from toxic effects of these preservatives on the body [1], have led people to use natural foods which are without these chemical preservatives, are made from natural products or combinations of them as substitutive preservatives and at the same time have the storage capability at the desired period of time [2, 3]. Using natural antioxidants from plant sources in various sectors of the food industry as an effective factor in delaying chemical and oxidative changes and increasing shelf life of products has been established. The composition, structure and functional groups of essential oils and extracts have an important role in the antimicrobial and antioxidant activities and compounds containing phenolic groups are usually more influential. Saluty [4], investigated garlic as a preservative in the tomato paste industries. In this research, fresh garlic and garlic extract with concentrations 0.125%, 0.25%, 0.5%, 0.75%, 1%, 1.5%, 2%, 2.5% and 3% were used. The results of this study showed that the minimal inhibitory concentration of fresh garlic and garlic extract in tomato paste was 3 and 0.5%, respectively. In terms of the effect of garlic on chemical and physical properties and taste of tomato paste, results showed that minimum inhibitory concentration of fresh garlic and garlic extract had no significant effect on the chemical and physical properties of tomato paste, but changes in the taste of tomato paste depending on the personal tastes of the people were considered as favorable or unfavorable. Amir [5], studied the quality and mineral contents of *Moringa oleifera* root-based tomato sauce. Their results showed that roots of *M. oleifera* are highly enriched with essential nutrients including minerals, and vitamins specifically vitamin C. Moreover, the tomato sauce supplemented with moringa roots is an effective remedy of malnutrition.

In a study by Hassan [6], they evaluated the effects of pre-heating and concentration temperatures on the physicochemical and microbiological quality attributes of semi-concentrated tomato paste. TSS, titratable acidity, pH, lycopene, vitamin C, and viscosity were determined using standard methods. According to the obtained results, increased breaking temperature and concentration temperatures significantly ($p < 0.05$) increased TSS, viscosity, and lycopene content, but reduced significantly ($p < 0.05$) vitamin C content. Processing conditions had also a great influence on the overall quality of the final product. Shatta [7], investigated the impact of processing steps on physicochemical and rheological properties of tomato paste. The results showed that, the rheological values, pectin fractions, lycopene and beta-carotene contents were increased significantly during concentration of tomato juice to paste. Lycopene and total carotenoids contents were well correlated with Hunter color parameters ($= 0.80-0.93$). During concentration process, the studied rheological properties of tomato juice had positive correlations with total and pectin fractions contents. In a study, Mokhtarian [8], used artificial neural network (ANN) and genetic algorithm (GA) to predict tomato drying kinetics. To this end, four mathematical models were taken from the literatures, then they were matched with the empirical data. Final step was choosing the best fitting model for tomato drying curves. Their results revealed that the model proposed by Aghbashlo et al (Agh-m) had great performance in predicting the moisture ratio of the dried tomato slices. Finally, the results of comparison of the findings observed in ANN and GA models showed that the GA model offers higher accuracy for predicting the moisture ratio of dried tomato. Velioglu [9] investigated performance of an artificial neural network (ANN) integrated computerized inspection system (CIS) in determining of visual quality of tomato paste. Their results indicated that in the color evaluation of the tomato paste, strong correlations (R) were found between the results estimated from ANN-integrated CIS and those obtained from colorimeter. Overall, this study showed that the ANN-integrated CIS had good determination and measurement capability. Dolatabadi [10], investigated modeling of the lycopene extraction from tomato pulps using ANN. The inputs of this network were the concentration of pectinase and time of incubation, and the outputs were extracted lycopene and the radical scavenging activity. Two different networks were designed for the process under the sonication and without it. For optimal network, networks' transfer functions and different learning algorithms were assessed and the validity of each one was determined. Consequently, the feedforward neural network with function of logarithmic transfer, Levenberg Marquardt algorithm and 4 neurons in the hidden layer with the correlation coefficient of 0.96 and 0.99 were respectively observed for the treatments under sonication and without it. The selected networks could determine the chosen responses, individually and in combined effect of both inputs as well. Concepcion [11], studied implementation of multilayer perceptron neural network on quality assessment of tomato puree in aerobic storage using electronic nose. They used an intelligent electronic nose (eNose) system discriminating the condition of tomato puree using artificial neural network (ANN) based only on ammonia and methane concentrations, and pH level. Multilayer perceptron neural network was implemented using feedforward backpropagation algorithm. The number of hidden layers and artificial neurons were analyzed based on performance of the system computational parameters, i.e., cross-entropy (CE), learning time and regression (R) coefficient. The system classifies the tomato puree sample as not spoiled, partially spoiled, and spoiled. The smellprint of each food condition was generated and the tomato puree-spoilage determinant parameters were characterized. Through 3-layer

perceptron ANN with 120 and 50 artificial neurons on the first and second hidden layers respectively, an accuracy of 93.33% was yielded for tomato puree quality deterioration classification.

The aim of present study is to compare the use of fennel seed extract and *Ziziphora clinopodioides* Lam. extract as a natural preservative in the formulation of tomato paste and to examine their effects on physicochemical, properties of the product. Finally, the obtained laboratory data is predicted with an artificial neural network. First, the winning neuron is identified using the SOM neural network and then the laboratory values are compared with the values predicted by the network using the perceptron neural network.

2. Multilayer Perceptron Network (Mlp)

This network contains an input layer, one or more hidden layers and an output layer. For the training of this network, the back propagation algorithm is usually used. During the training of the multi-layer perceptron (MLP) network using the back propagation (BP) learning algorithm, calculations are first performed from the network input to the network output, and then the calculated error values are propagated to the previous layers. Initially, the output is calculated layer to layer and the output of each layer is the input of the next layer. In post-propagation mode, the output layers are firstly modulated, since for each neuron of the output layer there is a desirable value and it is possible to modulate the weights by them and updating rules. Although the post-propagation algorithm has shown good results in solving problems, it has weak performance in solving some problems due to the long or uncertain learning time, the inappropriate choice of the coefficient of learning, or the random distribution of initial weights. In some cases, because of the local minimum, the learning process is disrupted due to the placement of the solution in smooth sections of the threshold functions. The training steps with the help of this algorithm are Ghahdarijani [12] (a) assigning random weight matrix to each of the connections, (b) selecting the input and output vector fitting it, (c) calculating the output of the neuron in each layer and as a result, calculating the output of the neurons in the output layer, (d) updating the weights by the method of network error propagation to the previous layers that the mentioned error is the difference between the actual output and the calculated output and (e) evaluating the performance of the trained network using some defined indicators such as mean square error (MSE) and correlation coefficient (R^2) [13].

2.1 Training algorithms

To update the artificial neural network weights, the Levenberg-Marquardt (LM) training algorithm was used, which is one of the most widely used algorithms since it performs network training very fast and minimizes the level of error available [14]. In fact, the aim of designing this algorithm is to speed up network learning based on the Hysen matrix. The perceptron neural network used had 1 hidden layer and 31 neurons. The topology made by the network is represented in Fig. 1.

The parameters of nanofluid temperature, different nanoparticle sizes and nanofluid volume concentration were considered as inputs to the SOM neural network to investigate and select the winner

neuron with the most data. It can be argued that in this neural network, the output is not important at all, and only the inputs to the SOM neural network are important to determine the winner neuron [15]. As shown in figure below, a network with 2 inputs and 36 neurons is evaluated.

3. Experiments

3.1. Test methods

3.1.1. Preparation of alcoholic extract of fennel seeds

In this study, dried fennel seeds in the necessary amount were purchased from Indian medicinal plants company, Abhar. After being confirmed by the experts of medicinal herbs, 1 kg of fennel seeds was powdered using a mill with mesh 40 and then 30 gr of this powder was mixed inside a flask with 100 ml of ethanol at 70 ° (1:3). Then this mixture was completely stirred using a magnetic stirrer for 3 days at room temperature (20 ° C). After that, the resulting mixture was filtered by the filter paper Whatman 42 and the obtained solution was put into the vacuum evaporator rotating apparatus (rotary) at a temperature of 50 °C for condensing extract and not mixing with the phenolic compounds in the mill (Fig. 2). Extract was filtered for 1 hour using a syringe 0.25-micron Millipore filter and kept in a dark and sterilized container at the refrigerator temperature until it is applied in the tests [16].

3.1.2. Preparation of alcoholic extract of *Ziziphora clinopodioides* Lam.

Ziziphora clinopodioides Lam. plants was collected in the spring from the mountains of the province of Zanjan, Abhar city and after being identified and confirmed by the herbarium experts in University of Science and Research, Branch of Islamic Azad University of Tehran, were used. The leaves of the plants were washed and rinsed and then completely dried in an oven at 54 ° C for 24 hours. Then the dried leaves were powdered using a mill with mesh 40 and then 30 gr of this powder was mixed inside a flask with 100 ml of ethanol at 70 ° (1:3). Then this mixture was completely stirred using a magnetic stirrer for 3 days at room temperature (20°C). After that, the resulting mixture was filtered by the filter paper Whatman 42 and the obtained solution was put into the vacuum evaporator rotating apparatus (rotary) at a temperature of 50 °C in order to not being mixed with the phenolic compounds in the mill. Extract was filtered for 1 hour using a syringe 0.25-micron Millipore filter and kept in a dark and sterilized container at the refrigerator temperature until it is used in the tests [16].

3.1.3. Physical and chemical analysis of tomato paste containing fennel seed extract and *Ziziphora clinopodioides* Lam. extract

First, 100 gr of pasteurized tomato paste was weighed and then the concentrations of 0.5, 1, 2 and 3% of sterilized extracts of fennel seed and *Ziziphora clinopodioides* Lam. were added into the tomato paste and kept at the incubator temperature 25 ± 0.5 ° C for 5 weeks (35 days). All analyses were performed 3 times .

3-1-3-1 pH measurement

For this purpose, the pH meter device was calibrated with buffers 4 and 7 and then tomato paste sample was placed into the cell of this device and pH of the samples was measured at temperature 20°C [17]. According to maximum pH of tomato paste must be 4.3.

3-1-3-2 Acidity measurement

Tomato paste acidity in terms of citric acid is calculated according to the following formula [17].

Sample weight / (the amount of consumed soda $\times$ 100 $\times$ 0.0064) = acidity

3-1-3-3 Total soluble solid (Brix) measurement

Brix represents the weight percentage of soluble solids in a solution. Refractometer was used for this purpose. The device was first calibrated with distilled water at 20 ° C and then the measurement was performed. To do this, water of tomato paste was taken using the filter paper Whatman and a few drops of it was put into refractometer, and then in order to obtain tomato paste Brix, the device was taken into the light [17] .

4. Results And Discussion

4 – 1 pH variations in tomato paste sample containing extracts of fennel seed and ziziphora clinopodioides Lam.

The results of comparing data obtained from Duncan's multiple range test in terms of pH variations in tomato paste samples containing different percentages of fennel seed and ziziphora clinopodioides Lam. extracts for 5-week storage period are represented in Table 1. As shown in ANOVA table (Table 2), pH variations in various tomato paste samples during the storage period were significantly ($p < 0.05$) dependent on the storage time, extract concentration and the interaction of these two variables (time and extract concentration). The results of this study showed that an increase in the storage time of tomato paste containing different concentrations of the extracts decreased samples pH significantly ($p < 0.05$). Among the various samples, the control samples containing no additives had significantly higher pH ($p < 0.05$) during different storage times. Comparison of pH changes in tomato paste samples containing different percentages of fennel seed and ziziphora clinopodioides Lam. extracts showed that an increase in the percentage of extract (for both extracts) from 0.5–2% reduced pH significantly ($p < 0.05$) but no significant change was observed in pH with an increase in the percentage of extracts from 2–3% ($p < 0.05$), such that at the end of the storage period (5th week), control treatment had the highest pH and treatments 3 (containing 2% fennel seed extract) (3.81) and 7 (containing 2% ziziphora clinopodioides Lam. extract) (3.79) had the lowest pH.

Table 1
pH variations in tomato paste containing different percentages of plant extracts

Sample	First	Second	Third	Forth	Fifth
Control	0.05 ^{aA} ± 4.44	0.02 ^{aA} ± 4.42	0.05 ^{abAB} ± 4.35	0.07 ^{aAB} ± 4.34	0.29 ^{aB} ± 4.24
Treatment 1	0.02 ^{aA} ± 4.41	0.07 ^{abAB} ± 4.34	0.20 ^{bAB} ± 4.32	0.00 ^{cB} ± 4.10	0.03 ^{bcC} ± 3.85
Treatment 2	0.03 ^{aA} ± 4.38	0.00 ^{abA} ± 4.36	0.08 ^{bA} ± 4.33	0.22 ^{aA} ± 4.30	0.01 ^{bcB} ± 3.86
Treatment 3	0.00 ^{abA} ± 4.32	0.00 ^{abA} ± 4.31	0.00 ^{bA} ± 4.27	0.16 ^{abA} ± 4.26	0.02 ^{cB} ± 3.81
Treatment 4	0.00 ^{abA} ± 4.32	0.02 ^{abA} ± 4.31	0.01 ^{bA} ± 4.30	0.00 ^{abA} ± 4.25	0.00 ^{bB} ± 3.86
Treatment 5	0.00 ^{aA} ± 4.42	0.00 ^{aA} ± 4.40	0.00 ^{aA} ± 4.40	0.00 ^{abB} ± 4.28	0.01 ^{bC} ± 3.91
Treatment 6	0.01 ^{aA} ± 4.45	0.00 ^{aA} ± 4.41	0.00 ^{aA} ± 4.41	0.01 ^{bB} ± 4.24	0.01 ^{bC} ± 3.92
Treatment 7	0.01 ^{aA} ± 4.47	0.00 ^{aA} ± 4.42	0.01 ^{aA} ± 4.41	0.01 ^{bB} ± 4.21	0.01 ^{cC} ± 3.79
Treatment 8	0.01 ^{aA} ± 4.44	0.02 ^{aA} ± 4.41	0.01 ^{cB} ± 4.19	0.05 ^{dC} ± 3.86	0.01 ^{bC} ± 3.86
* Different letters a-d represent significant difference at probability level 95% (p < 0.05).					
* Different letters A-C represent significant difference at probability level 95% (p < 0.05).					

Treatment 1 (containing 0.5% fennel seed extract), treatment 2 (containing 1% fennel seed extract), treatment 3 (containing 2% fennel seed extract), treatment 4(containing 3% fennel seed extract), treatment 5 (containing 0.5% ziziphora clinopodioides Lam. extract), treatment 6 (containing 1% ziziphora clinopodioides Lam. extract), treatment 7 (containing 2% ziziphora clinopodioides Lam. extract) and treatment 8 (containing 3% ziziphora clinopodioides Lam. extract).

Table 2
pH variance analysis

Variation source	Degree of freedom	Mean squares	F	P
Storage time (A)	4	0.933	176.039	*0.000
Sample type (B)	8	0.063	11.869	*0.000
Interaction(A ×B)	32	0.043	8.032	*0.000
R-Sq (R ²) 92.1%				

* Significant difference at probability level 5%

4 – 2 Acidity variations in tomato paste sample containing extracts of fennel seed and ziziphora clinopodioides Lam.

The results obtained from Duncan's multiple range test regarding the effects of different percentages of fennel seed and ziziphora clinopodioides Lam. extracts on the acidity of the tomato paste for different storage periods are represented in Table 3. As shown in ANOVA table (Table 4), acidity variations in various tomato paste samples during the storage period depended significantly ($p < 0.05$) on the storage time and extract concentration, but the interaction of these two variables (time and extract concentration) had no significant impact on acidity variations ($p < 0.05$). As shown in Table 3, in general, the acidity of different samples increased with increasing storage time from one week to five weeks significantly ($p < 0.05$). Comparing different treatments in terms of acidity showed that control treatment (without extract) had significantly lower acidity than other treatments ($p < 0.05$). Also comparison of the effects of adding different percentages of fennel seed and ziziphora clinopodioides Lam. extracts to tomato paste showed that by increasing the concentration of each extract, acidity of tomato paste increased significantly ($p < 0.05$), but this increasing trend of acidity was observed up to 2% concentration of both extracts and with increasing the concentrations of fennel seed and ziziphora clinopodioides Lam. extracts from 2–3%, no significant difference was observed in acidity. In the first week, all tomato paste samples showed no significant differences in terms of acidity, but at the end of the storage period (5th week), control treatment had the lowest acidity (0.506) and treatments 3 (containing 2% fennel seed extract) (0.526) and 7 (containing 2% ziziphora clinopodioides Lam. extract) (0.527) had the highest acidity.

Table 3

Acidity variations in tomato paste containing different percentages of extracts during the storage period

Sample	Acidity variations during different weeks				
	first	Second	third	fourth	fifth
Control	0.00 ^{dD} ± 0.400	0.00 ^{eCD} ± 0.406	0.00 ^{eC} ± 0.415	0.02 ^{aB} ± 0.476	0.00 ^{bA} ± 0.506
Treatment 1	0.00 ^{cD} ± 0.415	0.000 ^{dCCD} ± 0.423	0.00 ^{dC} ± 0.433	0.01 ^{cB} ± 0.483	0.01 ^{abA} ± 0.510
Treatment 2	0.00 ^{cE} ± 0.413	0.00 ^{cD} ± 0.446	0.00 ^{cD} ± 0.463	0.01 ^{bB} ± 0.492	0.00 ^{abA} ± 0.510
Treatment 3	0.03 ^{aD} ± 0.470	0.00 ^{aC} ± 0.486	0.00 ^{aBC} ± 0.498	0.04 ^{aAB} ± 0.513	0.00 ^{aA} ± 0.526
Treatment 4	0.01 ^{dD} ± 0.465	0.02 ^{abC} ± 0.474	0.02 ^{abBC} ± 0.488	0.04 ^{aAB} ± 0.509	0.01 ^{aA} ± 0.520
Treatment 5	0.00 ^{cD} ± 0.418	0.00 ^{dCD} ± 0.426	0.00 ^{dC} ± 0.434	0.00 ^{cB} ± 0.480	0.00 ^{abA} ± 0.510
Treatment 6	0.01 ^{bD} ± 0.437	0.00 ^{cCD} ± 0.444	0.00 ^{cC} ± 0.459	0.00 ^{bB} ± 0.490	0.01 ^{abA} ± 0.513
Treatment 7	0.01 ^{aC} ± 0.467	0.00 ^{aBC} ± 0.485	0.00 ^{aB} ± 0.501	0.01 ^{aAB} ± 0.516	0.00 ^{aA} ± 0.527
Treatment 8	0.01 ^{aD} ± 0.464	0.02 ^{abC} ± 0.476	0.02 ^{abBC} ± 0.487	0.01 ^{abAB} ± 0.503	0.01 ^{aA} ± 0.519

* Different letters a-c represent significant difference at probability level 95% ($p < 0.05$).

* Different letters A-E represent significant difference at probability level 95% ($p < 0.05$).

Treatment 1 (containing 0.5% fennel seed extract), treatment 2 (containing 1% fennel seed extract), treatment 3 (containing 2% fennel seed extract), treatment 4 (containing 3% fennel seed extract), treatment 5 (containing 0.5% ziziphora clinopodioides Lam. extract), treatment 6 (containing 1% ziziphora clinopodioides Lam. extract), treatment 7 (containing 2% ziziphora clinopodioides Lam. extract) and treatment 8 (containing 3% ziziphora clinopodioides Lam. extract).

Table 4
Acidity variance analysis

Source variation	Degree of freedom	Mean squares	F	P
Storage time (A)	4	0.051	251.357	*0.000
Sample type (B)	8	0.002	7.701	*0.000
Interaction (A×B)	32	0.000	1.327	0.150
R-Sq (R ²) 92.5%				
* Significant difference at probability level 5%				

4 – 3 Brix variations in tomato paste sample containing extracts of fennel seed and ziziphora clinopodioides Lam.

The results of comparing data obtained from Duncan's multiple range test in terms of Brix variations in tomato paste samples containing different percentages of fennel seed and ziziphora clinopodioides Lam. extracts as natural preservatives are represented in Table 5. According to ANOVA table, Brix variations in tomato paste samples containing different percentages of the extracts during the storage period were significantly ($p < 0.05$) dependent on the storage time, extract concentration and the interaction of these two variables (Table 6). As seen from Table 5, in samples enriched with different percentages of the extracts, depending on the changes in the extract percentage, total soluble solids significantly ($p < 0.05$) increased. On the other hand, Brix of control samples containing no extract and additive increased clearly during the storage period compared to the other treatments. Thus, the results showed that with increasing storage time for treatments containing different percentages of extract, treatments containing lower percentages of extracts had significantly ($p < 0.05$) higher total soluble solids than treatments containing higher concentrations of extracts. Although treatments containing 3% of fennel seed and ziziphora clinopodioides Lam. extracts during the storage period had no significant difference in total soluble solids ($p > 0.05$), but their total soluble solids were significantly ($p < 0.05$) lower compared to the other treatments.

Table 5

Brix variations in tomato paste containing different percentages of extracts during the storage period

Sample	Brix variations during different weeks				
	firth	second	Third	fourth	fifth
Control	0.00 ^{aE} ± 27.50	0.00 ^{aD} ± 27.81	0.01 ^{cC} ± 28.13	0.06 ^{aB} ± 28.50	0.10 ^{aA} ± 27.84
Treatment 1	0.00 ^{bE} ± 27.20	0.13 ^{bD} ± 27.42	0.07 ^{bC} ± 27.62	0.07 ^{bB} ± 27.86	0.05 ^{bA} ± 27.08
Treatment 2	0.11 ^{bDE} ± 27.16	0.10 ^{bcD} ± 27.32	0.17 ^{bC} ± 27.53	0.12 ^{bcB} ± 27.71	0.45 ^{bcA} ± 27.92
Treatment 3	0.01 ^{cD} ± 26.96	0.00 ^{cdC} ± 27.16	0.12 ^{cBC} ± 27.29	0.05 ^{cAB} ± 27.63	0.07 ^{cA} ± 27.81
Treatment 4	0.01 ^{cC} ± 26.94	0.12 ^{dC} ± 27.02	0.06 ^{dC} ± 27.11	0.09 ^{dB} ± 27.38	0.06 ^{dA} ± 27.62
Treatment 5	0.05 ^{bE} ± 27.18	0.10 ^{bD} ± 27.39	0.05 ^{bC} ± 27.64	0.16 ^{bB} ± 27.89	0.02 ^{bA} ± 28.12
Treatment 6	0.15 ^{bE} ± 27.13	0.13 ^{bD} ± 27.34	0.14 ^{bcC} ± 27.56	0.10 ^{bcB} ± 27.74	0.10 ^{bcA} ± 27.96
Treatment 7	0.11 ^{cE} ± 26.92	0.10 ^{cdD} ± 27.18	0.05 ^{cC} ± 27.33	0.03 ^{cB} ± 27.66	0.12 ^{cA} ± 27.85
Treatment 8	0.20 ^{cC} ± 26.95	0.12 ^{dC} ± 27.05	0.11 ^{dC} ± 27.14	0.11 ^{dB} ± 27.41	0.06 ^{dA} ± 27.65
* Different letters a-d represent significant difference at probability level 95% (p < 0.05).					
* Different letters A-E represent significant difference at probability level 95% (p < 0.05).					

Treatment 1 (containing 0.5% fennel seed extract), treatment 2 (containing 1% fennel seed extract), treatment 3 (containing 2% fennel seed extract), treatment 4 (containing 3% fennel seed extract), treatment 5 (containing 0.5% ziziphora clinopodioides Lam. extract), treatment 6 (containing 1% ziziphora clinopodioides Lam. extract), treatment 7 (containing 2% ziziphora clinopodioides Lam. extract) and treatment 8 (containing 3% ziziphora clinopodioides Lam. extract).

Table 6
Brix variance table

Source variation	Degree of freedom	Mean squares	F	P
Storage time (A)	4	1.006	28.846	*0.000
Sample type (B)	8	3.597	103.099	*0.000
Interaction (A×B)	32	0.154	4.414	*0.000
R-Sq (R ²) 92.3%				
* Significant difference at probability level 5%				

In order to predict the acidity and brix data of the tomato paste using the artificial neural network, the winner neuron was first identified by the SOM neural network, and the acidity and brix data were predicted using multilayer perceptron (MLP) artificial neural network. Each input element has 200 data used for the uncontrolled neural network SOM. An uncontrolled neural network topology is seen in Figs. 3 and 4, using a 6*6 and hexagonal structure of 36 neurons. In fact, each of these hexagonal houses is a neuron with neighbors. In Fig. 3, the distance between each neuron and the dependence of each neuron on neighboring neurons is clearly shown. Figure 5 represents the distance between neurons considering the location in real space. The darker the color of each neuron, more distance between the neuron and the neighboring neuron is. For instance, in Fig. 5, the distance between the neurons 25 and 26 is greater than the other neurons, and the distance between the neurons 5 and 6 is lower than the other neurons [18]. In other words, the yellow neurons have the smallest distance with their neighboring neurons. The purpose of the study of Fig. 6) a, b is to determine how much the neurons are excited with inputs such as the concentration, and during different weeks (time). In Fig. 6(a), the range of input of concentration data is in 0.5-3% and contains 200 data. As seen, black neurons 22 and 36 have the least excitability, and the neurons 4, 5, 7, 10, 11 and 28, which are yellow, have a higher excitability. Excitability of neuron 31 is less than that of the other neurons, and the yellow color assigned to the other neurons represents high excitability. Therefore, generally, there is a direct relationship between higher inputs and higher excitability. The higher the number of inputs, the more excitable the neurons are, and the smaller the number of data, the less excitable the neurons are. As shown in Fig. 7, neuron 31 is the most successful ones and the most data assigned to themselves are 40 data. These neurons have covered more points than other neurons. The neurons without data indicate their failure to absorb data. Based on the results of the artificial neural network SOM, the winner neuron is neuron 31 that can be used in the MLP neural network.

In order to show that the predicted data of acidity and Brix are in agreement with experimental data, these data were plotted (Figs. 8 to 9). These graphs, called linear regression graphs, show the agreement between the predicted data and the experimental data, and reveal the results obtained by the network as a straight line crossing the 45-degree line. The closer the resulting line is to the 45 ° line, the better the

agreement between the predicted and experimental results of cyanide removal efficiency will be [19]. All the predicted and experimental results are drawn as points around the 45-degree line. According to Figs. 3 to 6 and the expectations from the selected network of design 2-31-1 (2 inputs and a hidden layer with 31 neurons and one output), the correlation coefficients for the total data are 0.99301 and 0.99288, respectively

In Figs. 10 and 11, the horizontal axis for an artificial neural network with 1 hidden layer and 31 neurons is the number of experimental data (200 data) and the vertical axis of the network is the output values (predicted results) and the target input data (experimental results). As seen in Figs. 10 and 11, there is no peak between the predicted and experimental values, and the data are totally consistent [19].

In Figs. 12 and 13, the number of outputs predicted by the perceptron artificial neural network is represented with a certain difference from the results obtained for the acidity and brix from experiments on potato pasta. Indeed, in Figs. 12 and 13, the horizontal axis indicates the difference between the estimated output and the output obtained from the experiments and the vertical axis represents the number of these outputs. In Fig. 12, better results are obtained and the guessed 200 outputs are at the distance of 0.00017 from the outputs obtained by experiments, indicating a small network error. Under the best circumstances, the predicted values equal the measured value and the MSE value will be zero.

According to Figs. 14 and 15, the best value of the mean square error (MSE) for the designed network is represented by the Best line, and the network training process is correct if the MSE value of the Train curve is less than this value, as well as Validation and Test values close together [20]. Moreover, the best validation for a network with 1 hidden layers and 31 neurons in steps 3 and 2, is 0.000016499 and 0.0085227, respectively.

Conclusion

The aim of this study was to compare the use of fennel seed and ziziphora clinopodioides Lam. extracts as natural preservatives in the formulation of tomato paste and to examine their effects on the physicochemical, of the product. The results of this study showed that using different concentrations of fennel seed and ziziphora clinopodioides Lam. extracts caused significant ($p < 0.05$) decrease in pH and significant increase in acidity during the storage period. Extended storage period for various treatments significantly ($p < 0.05$) resulted in an increase in total soluble solids (Brix). Treatments containing higher percentages of plant extracts had significantly ($p < 0.05$) lower Brix than the other samples. The obtained results showed that there is a good agreement between the predicted and experimental results and the sum of mean square error (MES) and correlation coefficient (R^2) are desirable.

Declarations

Author Contribution

Maryam Mohebbi analyzed the data and wrote the manuscript.

Funding Declaration

The research conducted in this manuscript has no funder.

Data Availability

The datasets generated and/or analyzed during the current study are available from the corresponding author on reasonable request.

Competing Interests

Maryam Mohebbi declares that she has no conflict of interest.

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Figures

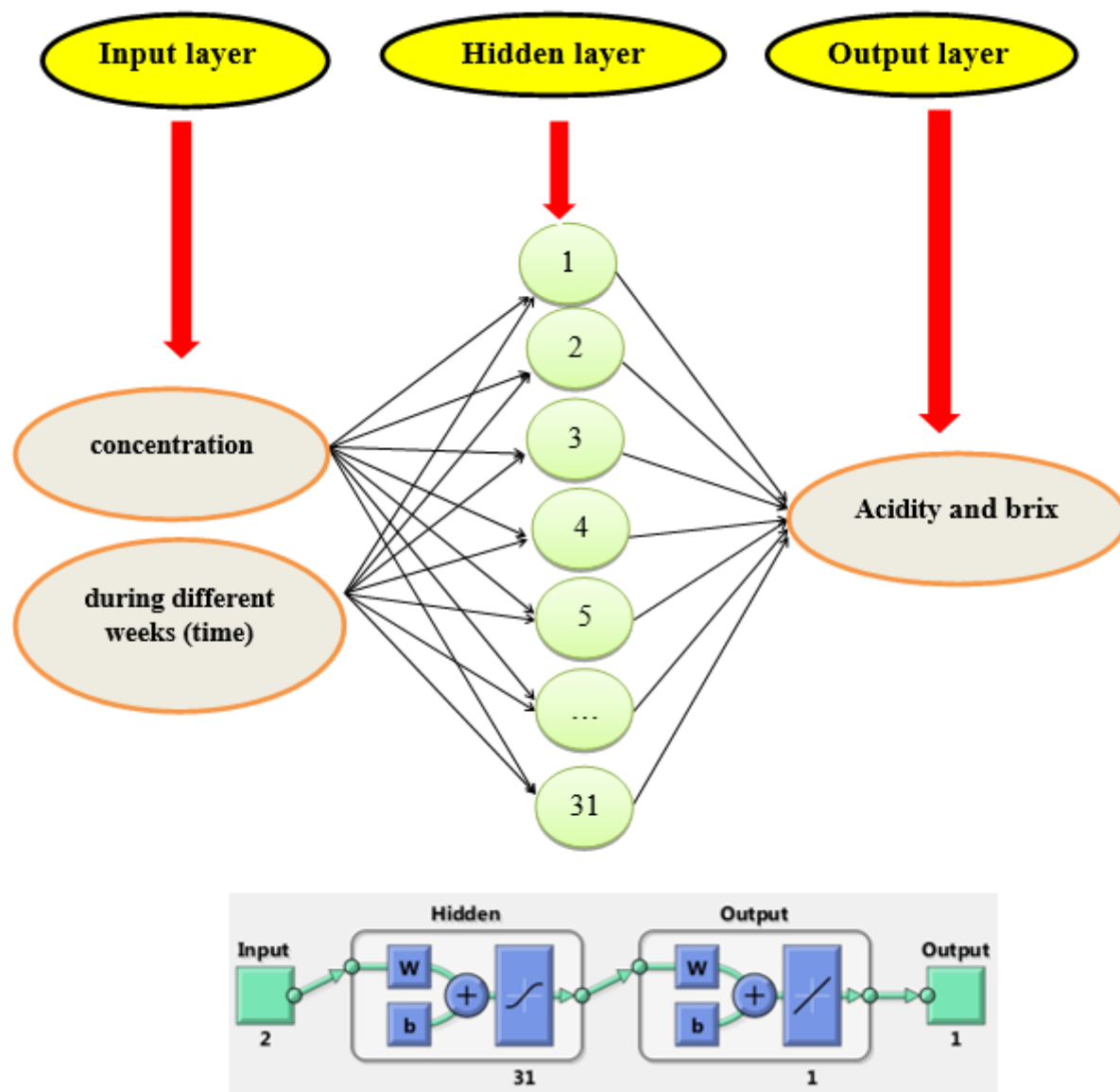


Figure 1

The schematic of multilayer perceptron network used (1 hidden layer and 31 neuron).

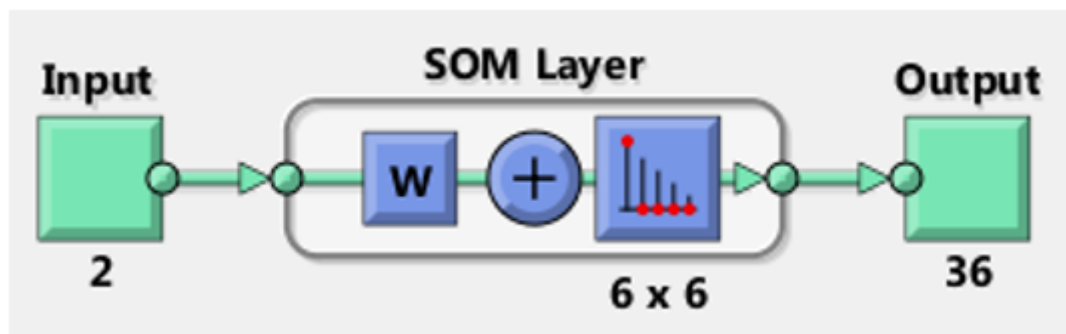


Figure 2

The schematic of used (SOM) neural network

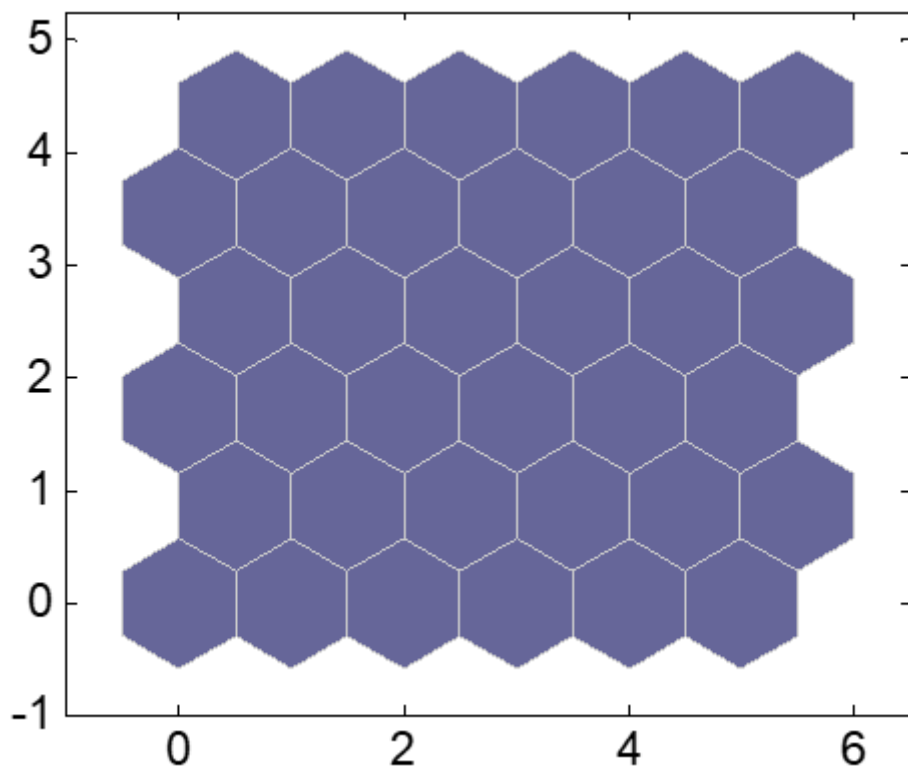


Figure 3

Topology structure of SOM neural network

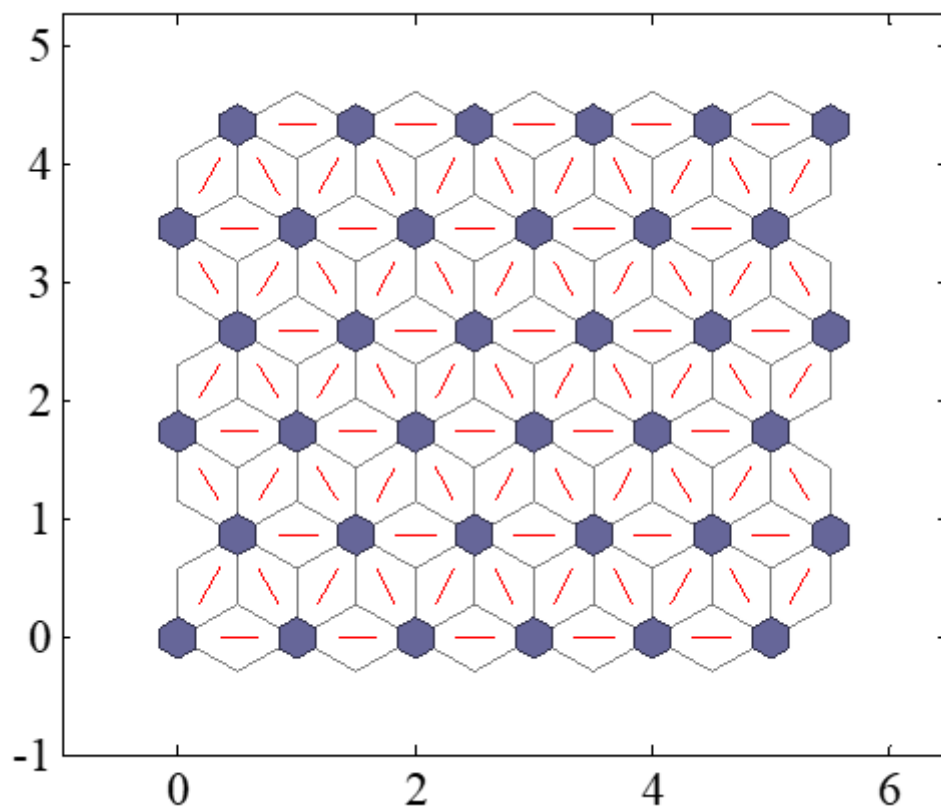


Figure 4

SOM neighbor connection

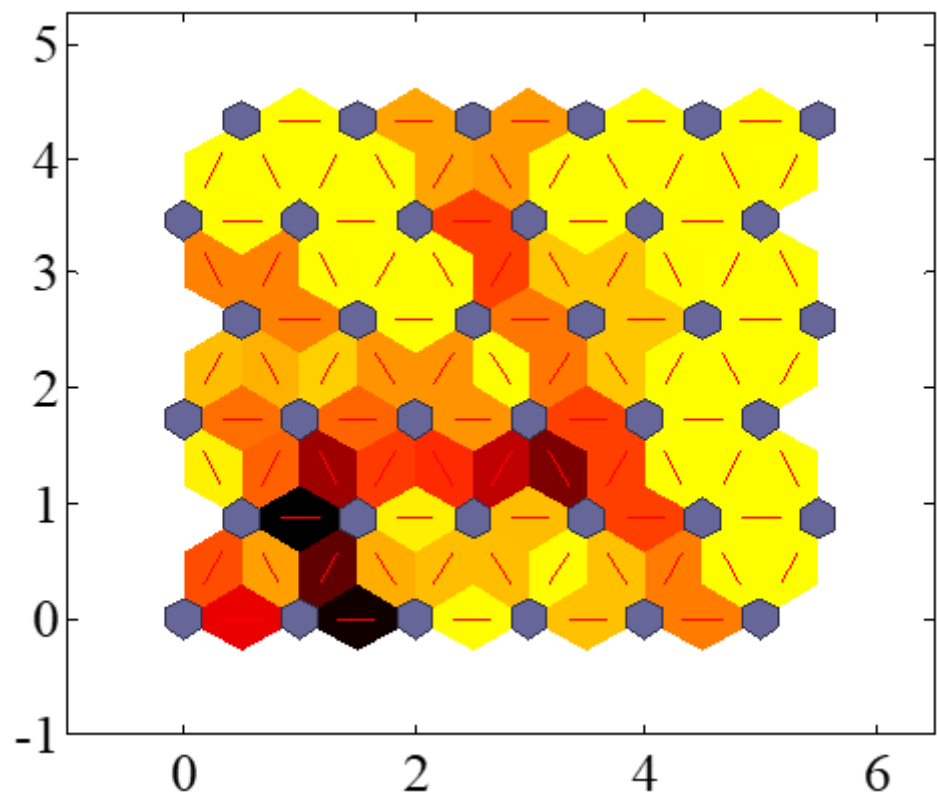


Figure 5

SOM neighbor weight distances

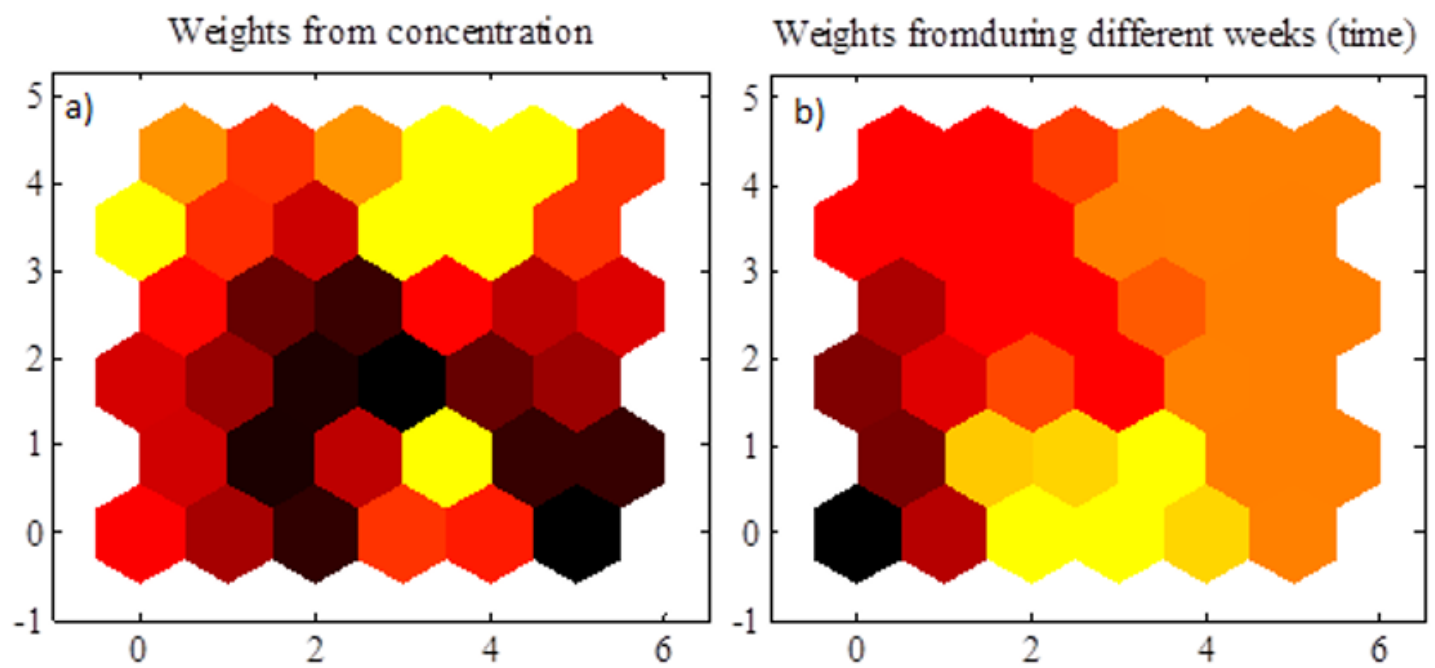


Figure 6

Influence of the input. a) concentration, b) time variables weights on neural network neurons for clustering definition

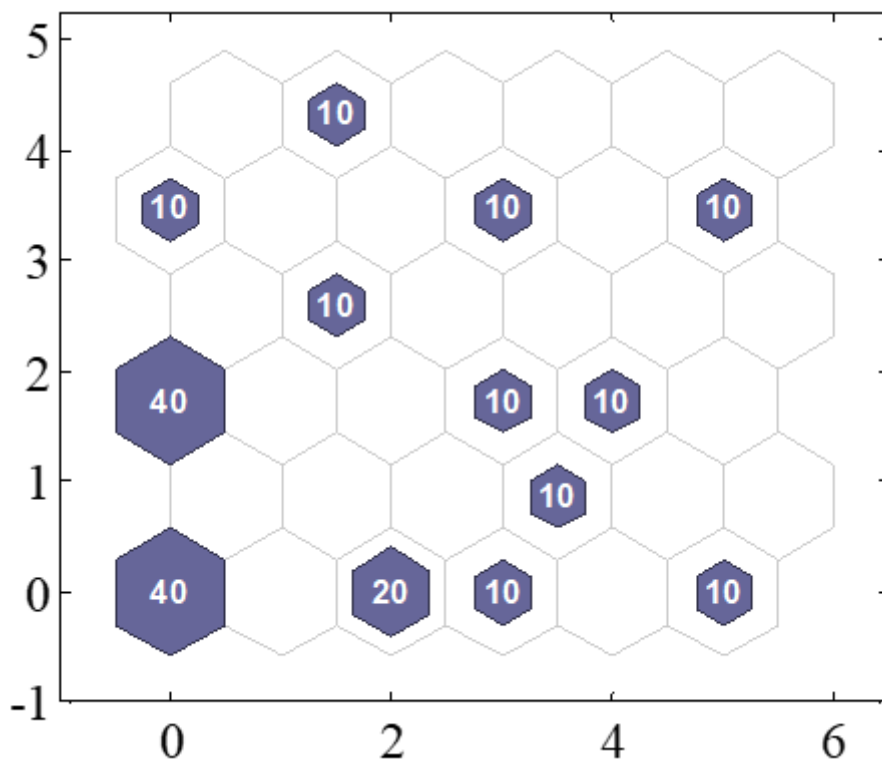


Figure 7

Statistics chart of winning neurons of SOM neural network

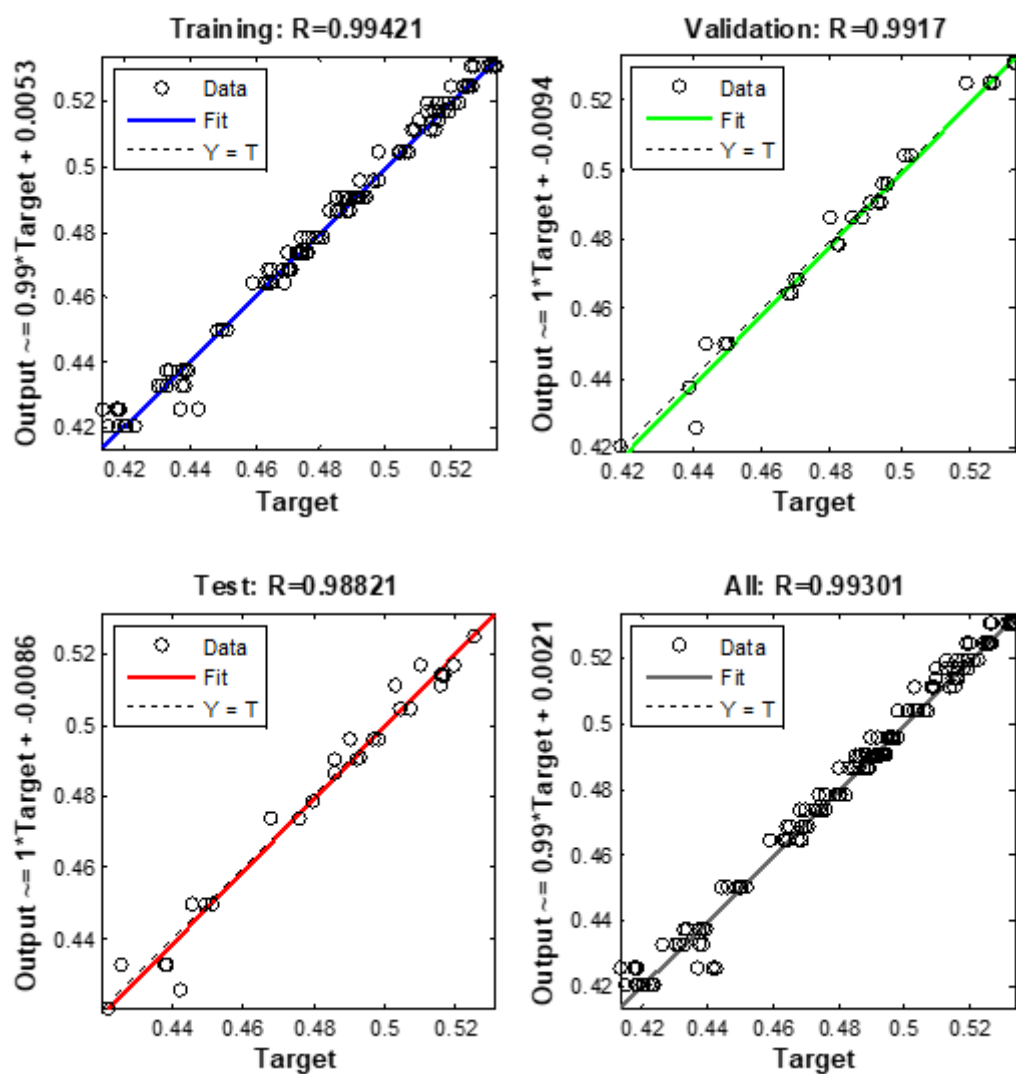


Figure 8

The obtained values of the correlation coefficient(R^2) for training, validation, test and all data from the artificial neural network (acidity)

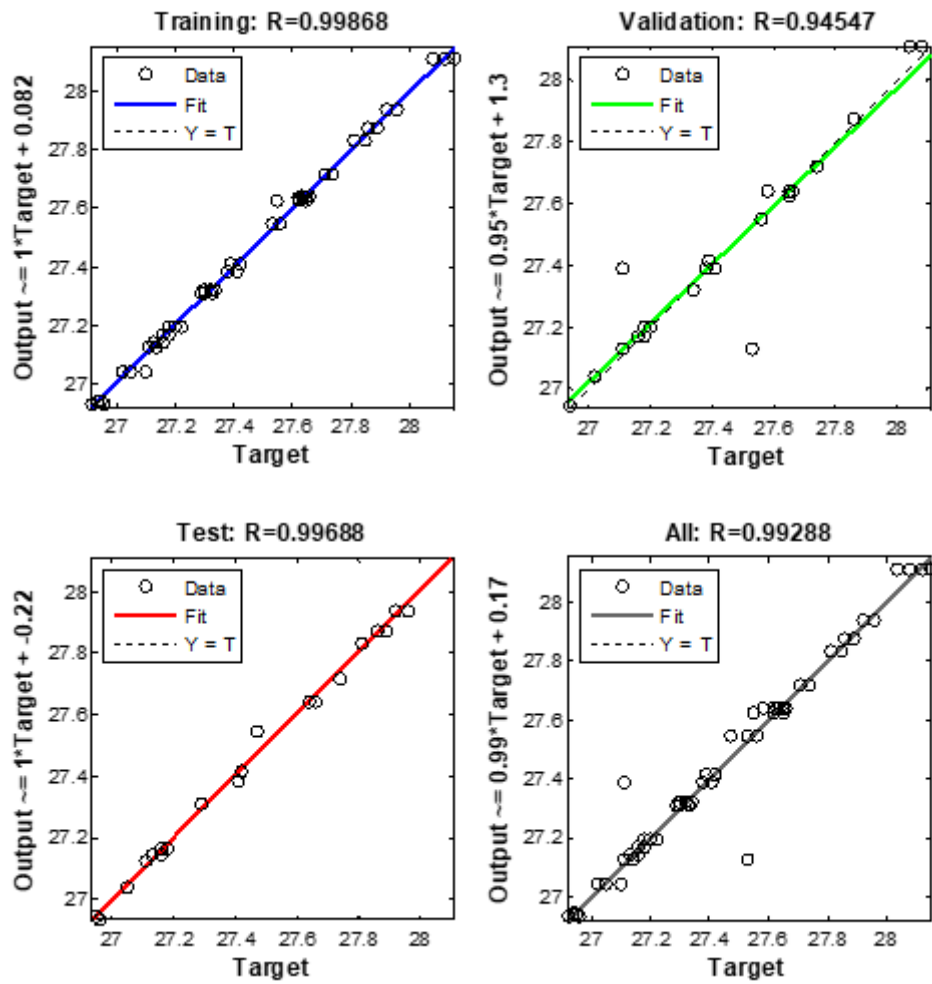


Figure 9

The obtained values of the correlation coefficient(R^2) for training, validation, test and all data from the artificial neural network (brix)

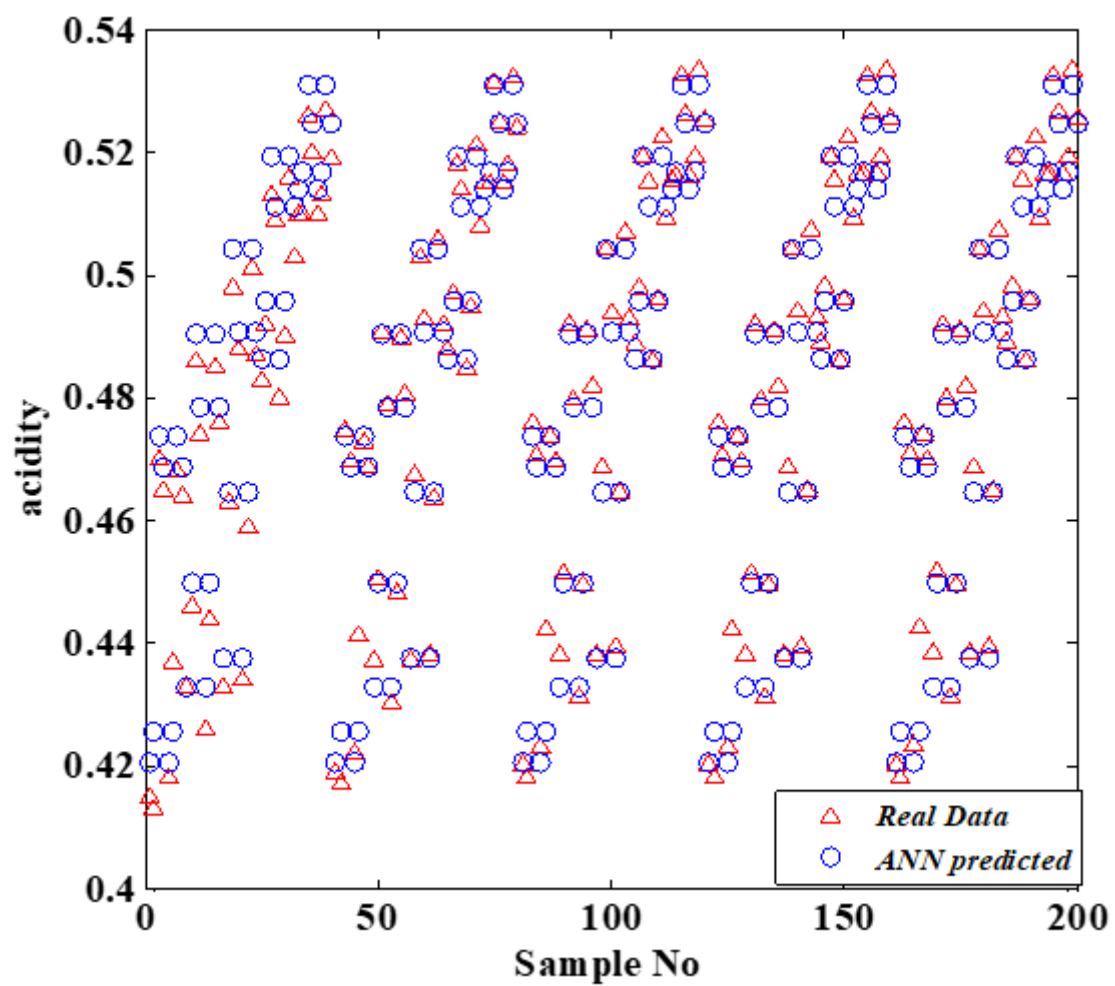


Figure 10

The results of the predicted acidity versus experimental data with number of samples, artificial neural network with 1 hidden layers and 31 neurons

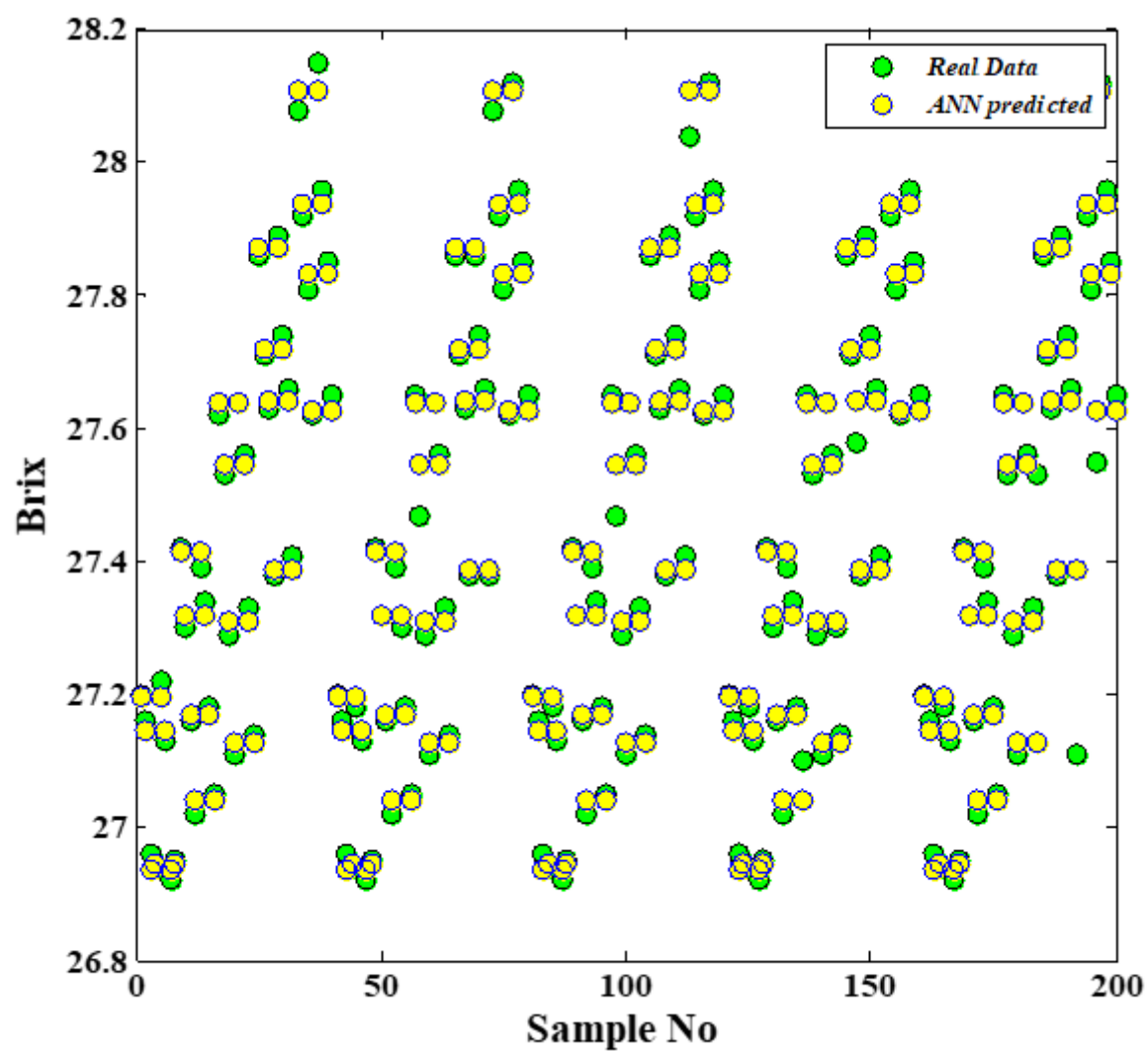


Figure 11

The results of the predicted brix versus experimental data with number of samples, artificial neural network with 1 hidden layers and 31 neurons

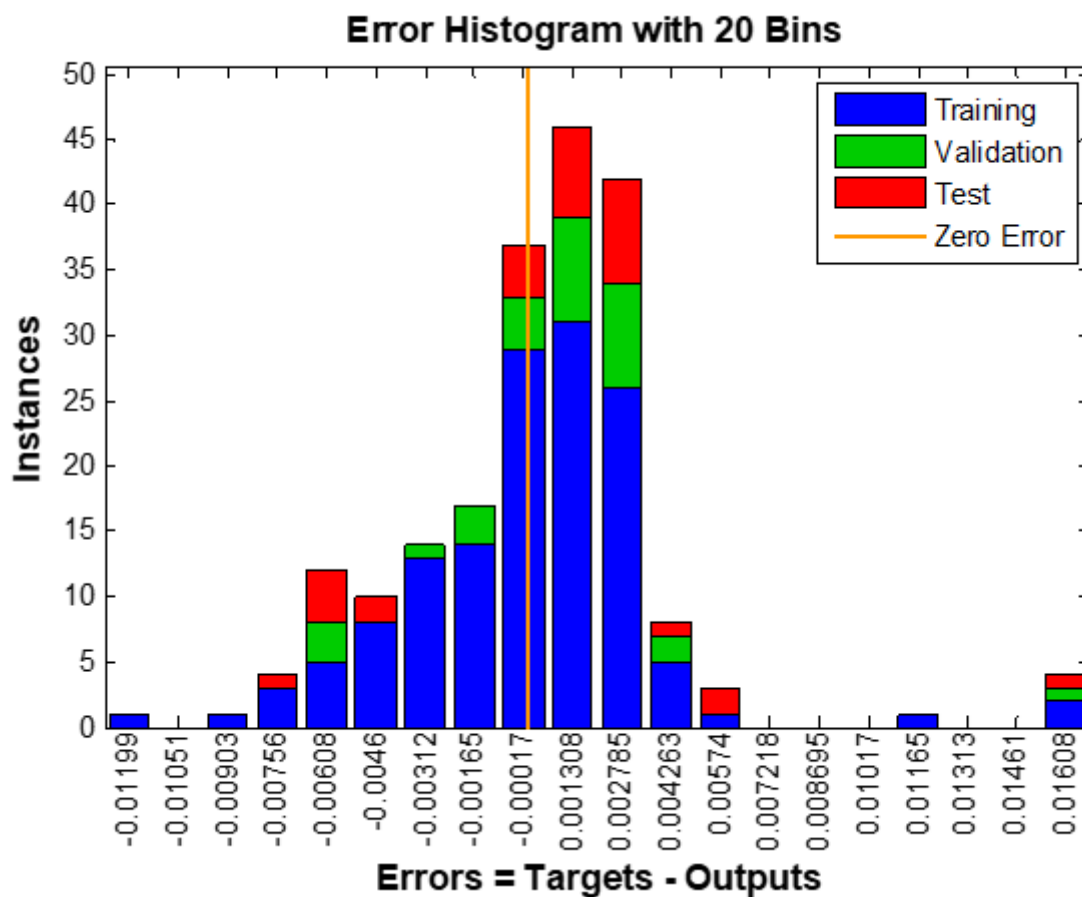


Figure 12

The error resulting from the difference between experimental and predicted values with the number of samples for the neural network with 1 hidden layers and 31 neurons(acidity)

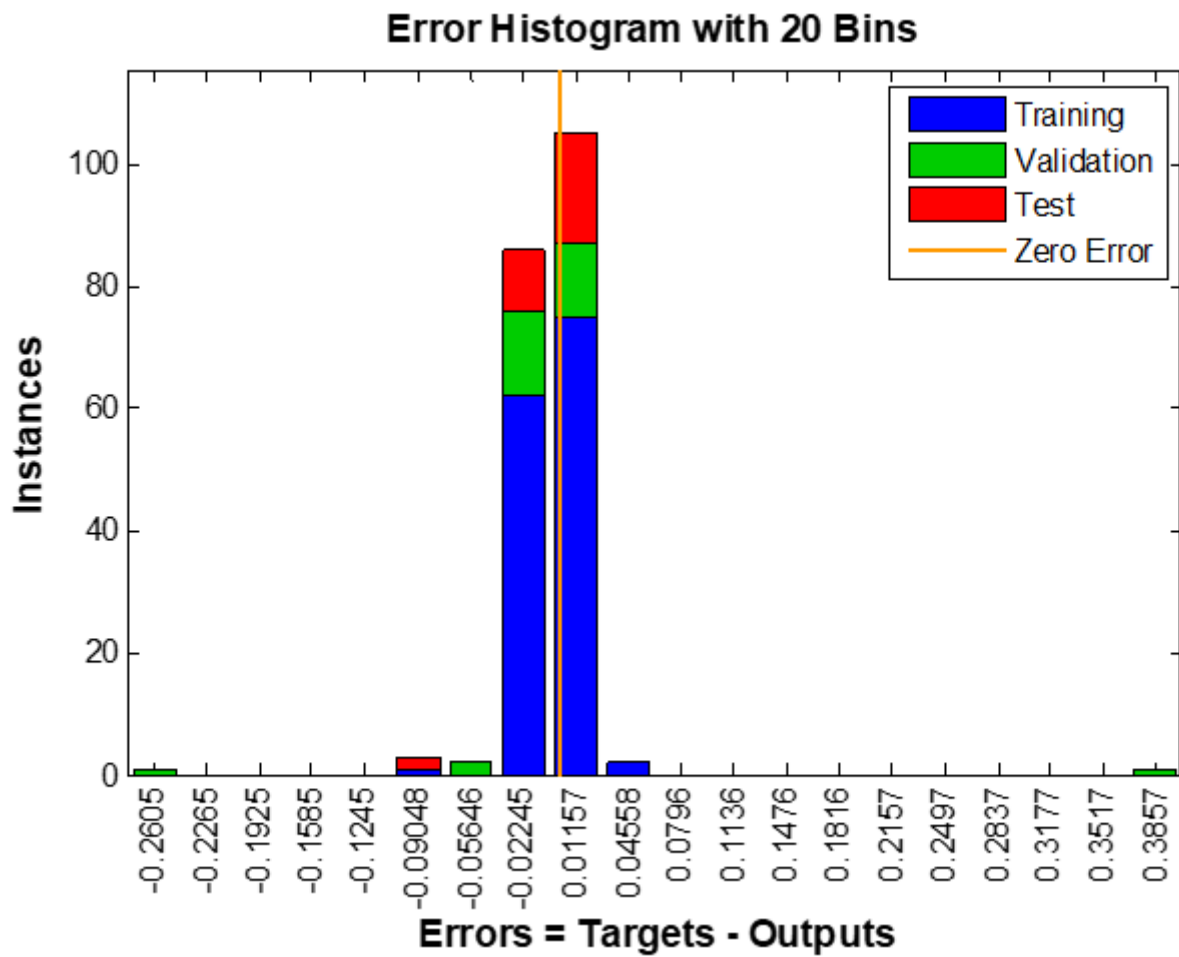


Figure 13

The error resulting from the difference between experimental and predicted values with the number of samples for the neural network with 1 hidden layers and 31 neurons (during different weeks (time))

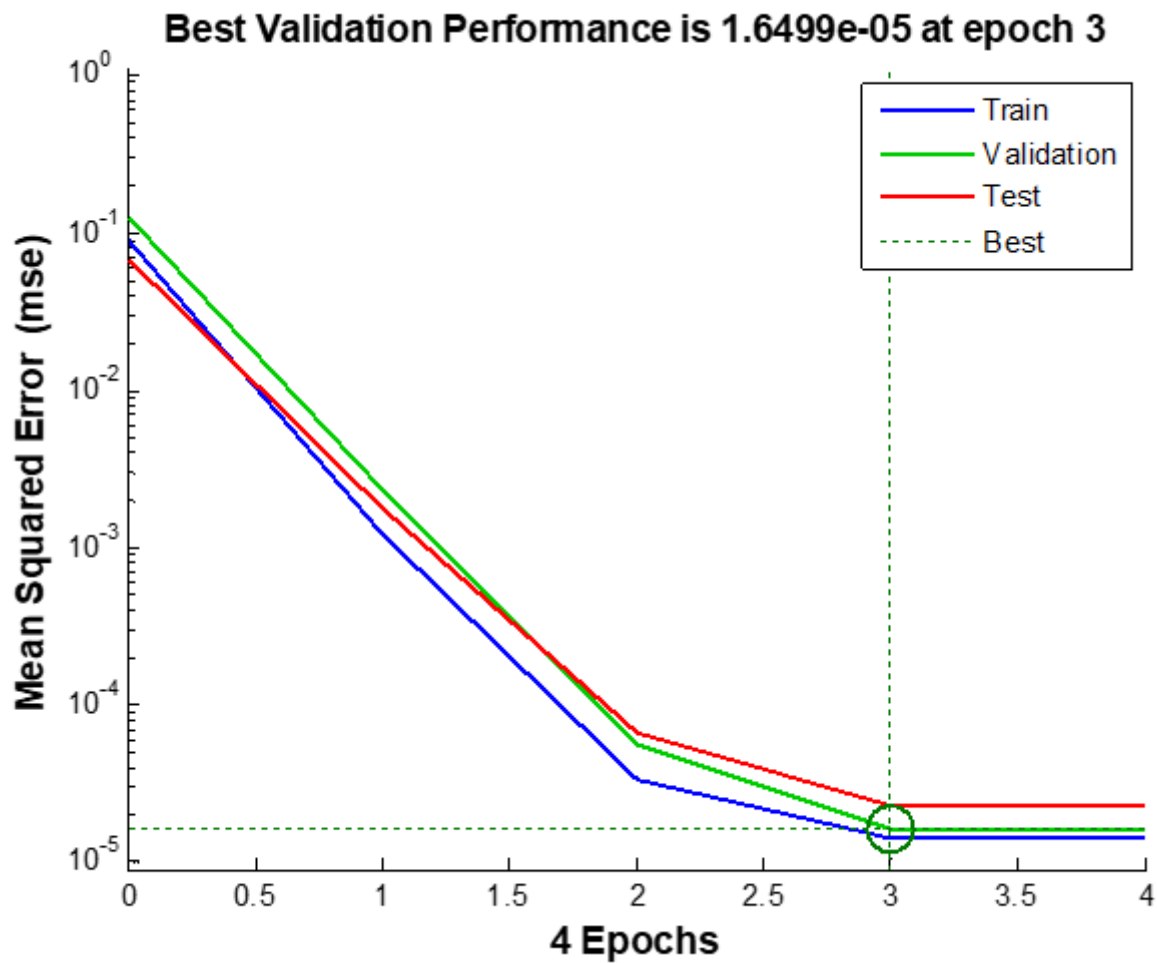


Figure 14

Mean Square Error (MSE) variations during training steps for training, validation and testing for a neural network with 1 hidden layer and 31 neurons (acidity)

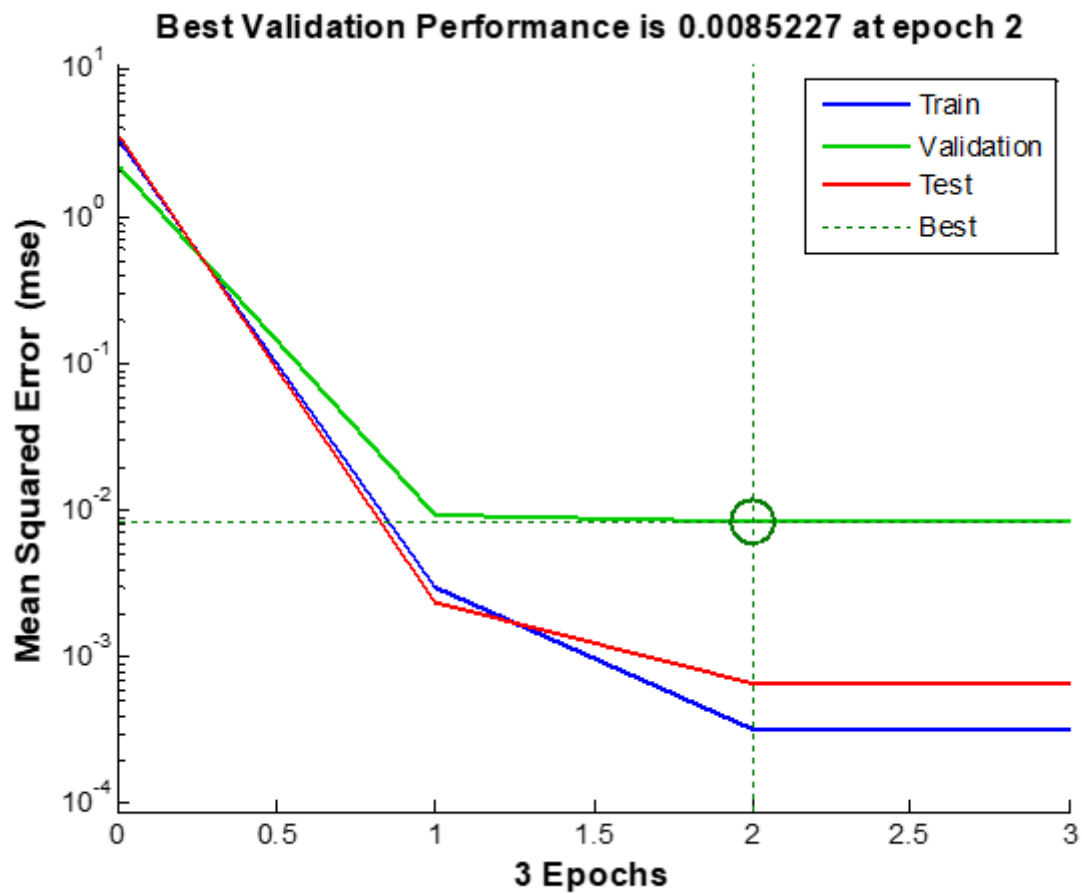


Figure 15

Mean Square Error (MSE) variations during training steps for training, validation and testing for a neural network with 1 hidden layer and 31 neurons (during different weeks (time))