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Scientific Research

The use of adaptive neural-fuzzy inference system (Enfis) in modeling the storage conditions of grapes coated with maltodextrin containing potassium nanocarbonate and Pyracantha extract.

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ABSTRACT

In this research, due to the lack of a study on the modeling of the storage conditions of grape fruits coated with maltodextrin containing potassium nanocarbonate and pyracantha extract using the fuzzy-neural inference system (ANFIS), different storage times (zero to 60 days), concentration Potassium nanocarbonate (zero to 2%) and concentration of pyracantha extract (zero to 1.5%) used in edible coating as input and the amount of Brix, the percentage of dropping berry, the amount of malondialdehyde, the browning of the grapes cluster, aroma and taste of samples were considered as output. Three Gaussian, triangular and trapezoidal membership functions with 2-2-2 and 3-3-3 membership functions were investigated. The results showed that trapezoidal function with 3-3 membership function and Gaussian function with 3-3 membership function were selected as the best model for Brix output variable and percentage of dropping berry, respectively. finally, triangular model with 3-3 membership function was selected for cluster browning and malondialdehyde variables. On the other hand, the results indicated that with the increase in storage time, the amount of Brix, the percentage of dropping berry, malondialdehyde and cluster browning increased in all samples, but the amount of aroma and tast of the samples decreased. the use of coating containing potassium nanocarbonate and pyracantha extract caused the speed of these changes to decrease. In the end, it can be said that the high correlation coefficients between the laboratory results and the model outputs indicate the acceptable accuracy and usability of these models in controlling the storage conditions of grape fruits coated with maltodextrin containing potassium nanocarbonate and pyracantha extract.

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1- Introduction

grape with scientific name (*Vinifera L.*) is a perennial woody shrub that is very popular due to its taste and nutritional value, economically and therapeutically [1]. Grape is an edible fruit with an attractive appearance and rich in various sugars, organic acids, protein, minerals and vitamins. In addition, grape skin contains flavonoids, resveratrol, anthocyanins, various amino acids and physiologically active substances, the use of which reduces fatigue and arteriosclerosis and ultimately increases the body's immunity [2]. Grapes with a cultivated area of 760 million hectares and a yield of more than 6820 million tons are one of the most consumed fruits in the world, and China ranks first in grape production worldwide [3]. However, the high content of sugar and plenty of water and weak skin in grapes make this fruit susceptible to spoilage and short shelf life, which results in severe economic losses during storage, transportation and marketing. Therefore, developing methods to increase the shelf life of this fruit is necessary to solve this problem [4 and 5]. The most common methods of short-term storage of fresh grapes are storage in a fruit basket at room temperature or storage in the refrigerator, but for long-term storage of fresh grapes, the use of chemicals It is inevitable.Household waste from fresh fruits and vegetables in European countries is approximately 50%, and the European Commission has declared that reducing food waste is one of the most important areas in the European economic strategy [6]. Although the use of sulfur dioxide is a widespread and effective method to prevent grape rot, the residual sulfites in grapes cause concerns for consumer health. In addition, sulfur dioxide is very harmful for most fresh products and can also cause an increase in plant diseases such as pods whitening and browning [7]. Therefore, multifunctional food coatings that have antibacterial and antioxidant benefits and have little effect on various food compounds have been widely investigated in recent years, while they can significantly preserve the quality of grapes and extend their shelf life. increase [8]. On the other hand, these edible coatings act as a barrier to the entry of moisture and gas into the fruit and lead to the improvement of their sensory, mechanical and microbial properties and increase the shelf life of these products. Antifungal food coatings containing plant extracts and essential oils have been used to increase the shelf life of various fruits such as avocado, jujube, persimmon, etc. [9]. Due to its low cost, neutral flavor, low viscosity in high concentrations and resistance to oxidation, maltodextrin is one of the most widely used polysaccharide materials as a wall in the microcoating of various materials [10]. Some researchers used edible coatings to increase the shelf life of grapes, which can be attributed to studiesD'Souza Et al(2021) (using edible coatings consisting of alginate, galactomannan, cashew gum and gelatin), Huang et al.In 2023(pectin and epigallocatechin gallate) and Brancomello et al(2018) (nanochitosan extracted from mushrooms) [11, 12 and 13]. Pyracantha is a plant whose main habitat is Southeast Europe and Southeast Asia and has many species. This plant is in the family of plantsrosacea[1] classifying. Its morphological and morphological characteristics are: an evergreen shrub with oval leaves, height 1 to 6 meters, crown diameter 2 to 5 meters, its crown shape is round and vase-shaped and fast-growing, which is planted in sunny or semi-shaded environment and in It flowers in early summer and late spring [14]. The fruits of this plant contain nutrients such as amino acids, phenolic compounds, soluble sugars,

[1] Rosaceae

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vitamins, mineral elements, fatty acids, proteins, starch, pectin and dietary fiber, etc. Its roots, leaves, and fruits all have medicinal and functional values that help strengthen the immune system and spleen. At present, its fruits are used to produce various foods, fruit juice, canned food, and other additives such as pigments and pectin, and it is widely used in the pharmaceutical, food, cosmetic, health and other industries [15]. The fruits of this plant are consumed fresh in the African continent, and these fruits are also used to prepare jelly, sauce and jam. On the other hand, in the studies of some researchers, it has been shown that the fruits of this plant have good nutritional value due to having large amounts of protein, total sugar, vitamins, minerals and bioactive compounds [16 and 17]. Phytochemical compounds, antioxidant and enzyme inhibitory activity of Pyracantha extract were investigated by Sarikorxo and Tepe (2015) and these researchers showed that the ethanolic extract of this plant is rich in phenolics, flavonoids, thickening tannins and saponins and this extract has the ability Inhibition of free radicalsDPPH And it has a high iron ion reducing power and also has a good inhibition on acetylcholinesterase, butyrylcholinesterase, α-amylase, α-glucosidase and tyrosinase enzymes [18]. Antimicrobial compounds used to formulate edible coatings should be considered safe.GRAS(recognized and approved for use as food additives by the US Food and Drug Administration)FDA(or European Food Safety Organization)EFSA) have been confirmed [19]. Food additives are widely used as preservatives for controlpH , taste or qualitative properties of food are used. Among them, various organic and inorganic salts have antimicrobial effect and may be a good alternative to the use of synthetic fungicides. Availability, relatively low cost and high solubility in water are the main advantages of these compounds [20]. Potassium carbonate is a mineral compound (salt) with the formulaK_2CO_3 It is known that this compound is a white salt that easily dissolves in water and other solvents such as dimethyl sulfoxide. Potassium carbonate has diluting properties with a wet appearance. The special characteristics of this salt include high ion content, good thermal stability, non-volatility, non-flammability and low viscosity, which is also used in environmentally friendly polymers [21]. This substance has been added to the list of permitted food additives since 1995, for example, it can be used to create a better color in cocoa, and in Japan, this substance is also used in various foods such as processed fruits [22 and 23]. [. Among all statistical techniques,Fuzzy inference system– applied neurological (ANFIS) It has better performance for modeling, which can be effectively used for complex nonlinear problems such as drying, osmotic dehydration, and extraction of phytochemicals from agricultural products to establish a relationship between input and corresponding responses [24]. From this technique, some researchers likeyou are aliveet al. (2021)and Huang et al. (2012) used to model the storage period of hawthorn and bayberry fruit, respectively [25 and 26].Given that so farThere is no research in the field of using oral coating containing pyracantha extract and potassium nanocarbonate in order to increase Shelf life of grape fruit and its modeling by useFromAnfis systemIt has not been done for this reason in the present researchThe modeling of the use of edible coating containing Pyracantha extract and potassium nanocarbonate in order to increase the storage life of grapes was investigated using Enfis system.

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2- Materials and methods

2-1- Materials

Rish Baba grapes were purchased from Melayer city of Hamadan province and immediately transferred to the laboratory of Melayer university grape and raisin research institute and graded based on uniformity in maturity, size, color and lack of fungal infection or signs of physical damage. For this study, maltodextrin powder (white powder soluble in water with dextrose equivalent less than 20 and 4% moisture) andTrichloroacetic acid (with molecular formulaCCl_3COOH، bulk density 0.900 g/cm3 and melting point 56-54 degrees Celsius)from company German Merck and potassium nanocarbonate (purity grade 99.5 and particle size 100 nm) were obtained from the Nanotechnology Laboratory of Malayer University.

2-2- Extraction of pyracantha extract and preparation of studied coatings

To prepare pyracantha extract, pyracantha fruits are mixed with distilled water (25 g and 100 ml) in a ratio of 1 to 4 at room temperature and after homogenization in an ultrasonic device (*Topsonics*, Latvia) for 6 minutes with a power of 400 W for extraction, and after the smoothing operation, the resulting extract was used in different concentrations to prepare coating solutions. To prepare the maltodextrin solution, after adding its powder to distilled water, stirring was done slowly in laboratory conditions until it was completely dissolved. In order to dehydrate, maltodextrin biopolymer was stirred for 30 minutes after dissolving and finally by adding three different concentrations of Pyracantha aqueous extract (0, 0.75 and 1.5% by weight) and three different concentrations of potassium nanocarbonate (0, 1 and 2 (weight percent) coating solutions were prepared and again subjected to ultrasonic waves with a power of 400 watts for 5 minutes [27 and 28].

2-3- covering operation of grapes

Grape bunches were immersed in each prepared coating solution for 15 minutes until the coating process took place. After placing on drying paper at laboratory temperature and drying, a bunch of these fruits weighing approximately 250 grams were packed in polypropylene containers and transferred to a cold room with a temperature of -1°C and a relative humidity of 90%. Specific time intervals (0 to 60 days) were taken out of the cold storage and in order to simulate sales conditions for 15 minutes at temperatureroomplaced and then checked. The treatments used in this study are listed in Table 1.

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Table 1- Experiment design

Run	storage time (day)	Concentration of potassium nanocarbonate (%)	Concentration of pyracantha extract (%)
1	30	2	0.75
2	30	1	0.75
3	0	0	0
4	30	1	0.75
5	0	1	0.75
6	0	2	1.5
7	0	0	1.5
8	60	1	0.75
9	30	1	0.75
10	30	1	1.5
11	60	0	0
12	30	1	0.75
13	30	1	0
14	30	1	0.75
15	60	2	0
16	30	1	0.75
17	60	2	1.5
18	60	0	1.5
19	30	0	0.75
20	0	2	0

2-4-Measurement of dissolved solids (Brix)

The amount of brix of the samples according to the methodRosh Davoudi et al. (2022)It was measured. For this purpose, 5 kernels were selected and extracted from each sample, and after filtering the extracts prepared by a digital refractometer (Atago, Japan) at a temperature of 20 degrees Celsius, the amount of dissolved solids was determined [29].

5-2- percentage of pill drop

To measure the drop percentage, grape bunches were placed at a distance of 5 cm from the hand, and each bunch was hit three times uniformly, and the number of dropped bunches was counted. Finally, the total bunches of each bunch were counted and the drop percentage was calculated [30]. [.

6-2- Determining the amount of malondialdehyde

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To measure the concentration of malondialdehyde from the method Yui and Yanzhi (2013)was used[31]. According to this method 0.5 grams of TextureThe fruit was ground in a Chinese mortar containing 5 ml of 20% trichloroacetic acid (containing 0.5% thiobarbituric acid) and the resulting extract was boiled for 15 minutes in6000 far offper minute centrifuge (Thermo, Japan). Supernatant solution for 25 minutes in a hot water bath (Memmert, Germany)WithThe temperature was heated to 80°C and after the temperature was immediately reduced with crushed ice for 5 minutes. with the same round as before It was centrifuged. To remove the effect of disturbing compounds,The absorption intensity of this solution first at the wavelength of 600 nmby spectrophotometer (Varian Cary 300, America)reading became open Its absorption amount in Wavelength 532 nm Deducted. Malondialdehyde concentration using extinction coefficient$cm^{-1}m\ mol^{-1}$0.155 andin micromoles per gram of wet weight Sample Calculated and reported.

7-2- Evaluation of browning of clusters

In this study, the grading method of Crisosto et al. (2001) and according to Table 2 was used to evaluate the degree of browning of grape bunches [32].

Table 2- Scores the color of grape cluster

Cluster color	Green	Brownish green	Light brown	Medium brown	Dark brown
Score	5	4	3	2	1

8-2- Flavor of the samples

In order to check the aroma and taste of grape samples, the taste test and 5-point hedonic method were used and scoring was done based on very good (score 5) to very bad (score 1). The number of panelists was considered 12 people in 3 repetitions [33].

9-2- Modeling using Anfis

In the training of Enfis structure, a hybrid method was used, which is a combination of the least squares method and the backpropagation method, and the error limit, which is used to create a training stop criterion, was set to zero. To optimize the model, different types and numbers of membership functions were used to determine the optimal number and type. Storage time (days), concentration of potassium nanocarbonate (percentage) and concentration of Pyracantha extract (percentage) were determined as inputs and the amount of Brix, bean drop, malondialdehyde, cluster browning and flavor of the samples were determined as outputs in Enfis model. In this study, Sogno type fuzzy inference system was used and in order to find the optimal model, triangular, trapezoidal and Gaussian membership functions were investigated and considering the three-variable input of the model with 2-2-2 and 3-3-3 membership functions. and the efficiency of the obtained models by the values of the correlation coefficient (R^2) and mean squared error (MSR) which are determined using relations 1 and 2, respectively, were evaluated [34].

$$R^2 = 1 - \frac{\sum_{i=1}^{N} \left(X_{pi} - X_{no}\right)^2}{\sum_{i=1}^{N} \left(X_{pi} - \underline{X}\right)^2}$$

$$MSE = \frac{1}{N}\sum_{i=1}^{N} \left(X_{pi} - X_{no}\right)^2$$

In these equationsX_{pi} The variable predicted by the networkX_{no} The actual value resulting from the tests and$\underline{X}$ The mean of laboratory values and N is the total number of observations.

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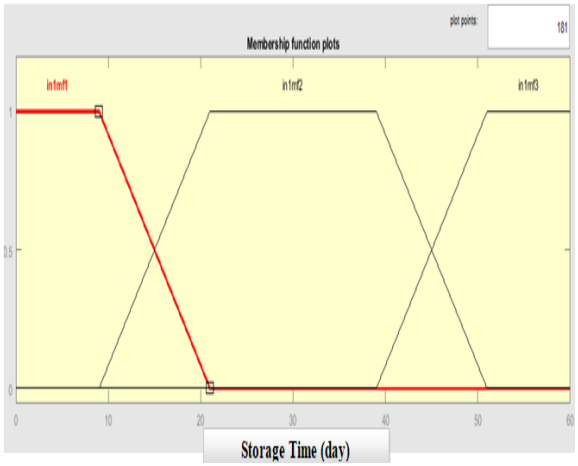
In this research, MATLAB software was used for modeling. In this software, it is possible to design the desired types and number of membership functions. In Figure 1 (a) the trapezoidal membership function with three functions for the retention time variable, Figure 1 (b) the trapezoidal membership function with three functions for the potassium nanocarbonate concentration variable and finally Figure 1 (c) the trapezoidal membership function with three functions as an example of The functions used in this research are displayed.



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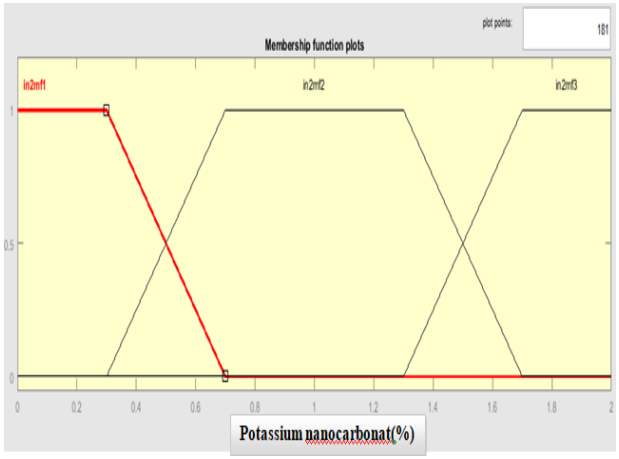

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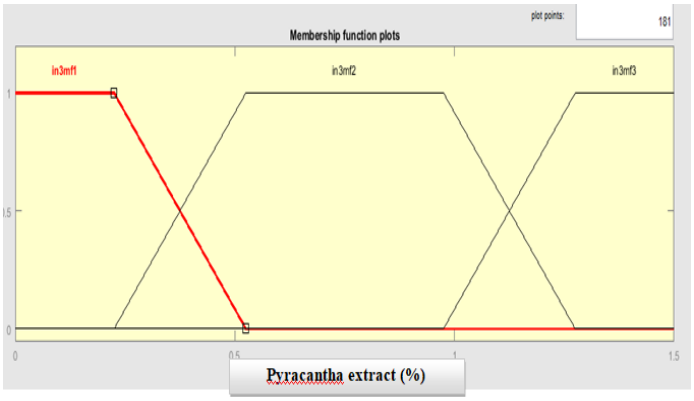

c)

Figure 1- The trapezoidal membership function with 3 functions for storage time (a), potassium nanocarbonate (b) and Pyracantha extract concentration(c)

In Figure 2, it is also shown as a structural example of Enfis model with three inputs and three membership functions, which are used to determine the number of rules and connections of membership functions. As shown in this figure, each Enfis network consists of 5 layers, which include inputs, membership functions related to inputs, rules, membership functions related to outputs, and outputs.

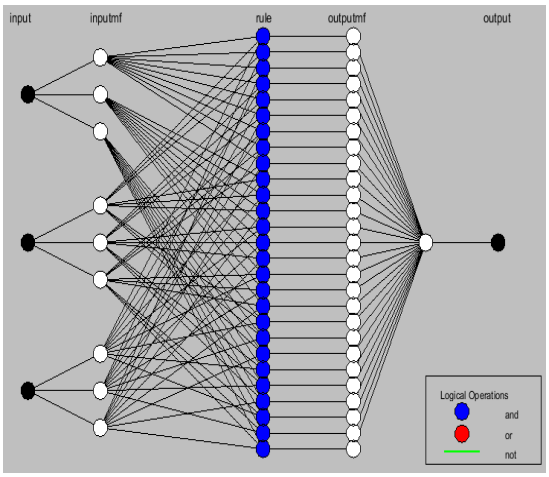

Figure 2-Structure of ANFIS model sample with 3 inputs and 3 membership functions for each input

3. Results and Discussion

3-1- Breaks

According to the results given in Table 3 and the values of correlation coefficient and mean squared error, the trapezoidal function with 3-3 membership function was selected as the optimal model for the BRICS output variable. The results indicated that with increasing storage time, the amountSoluble solids (brix)It increased in all samplesIn the control sample, Brix value had a faster increasing trend than the coated samples. This effect can be due to the loss of water and the increase in the concentration of soluble solids in the fruit during the cold storage period. However, the coating containing potassium nanocarbonate and pyracantha extract prevented the decrease in the moisture content of the grape fruit and the increase in Brix during the storage period (Figure 3). brix It depends on many factors, including the amount of fruit sugar, acidity and soluble pectins in the fruit. Soluble solids in this study have taken an increasing trend The main reason for the increase in the amount of soluble solids during fruit storage is the loss of juice, high respiration, ethylene production, and as a result, the high aging speed in these samples, which leads to the breakdown of polysaccharides in the cell wall and membrane and causes an increase in substances The solids are dissolved. Any factor that prevents or reduces the breaking of cell walls will prevent the abnormal increase of Brix [35]. In coated samples, the trend of increase is milder, which is justified by reducing the diameter of the pores on the surface of the fruit by coating, and as a result, reducing the amount of water loss and respiration. In line with these results, Aishe et al. (2022) by examining the effect of edible coating containing cinnamon essential oil on some characteristics of tomatoes during storage, stated that with the passage of time, the amount of Brix increases, and this increase occurs with less intensity in the coated samples. 36 [.

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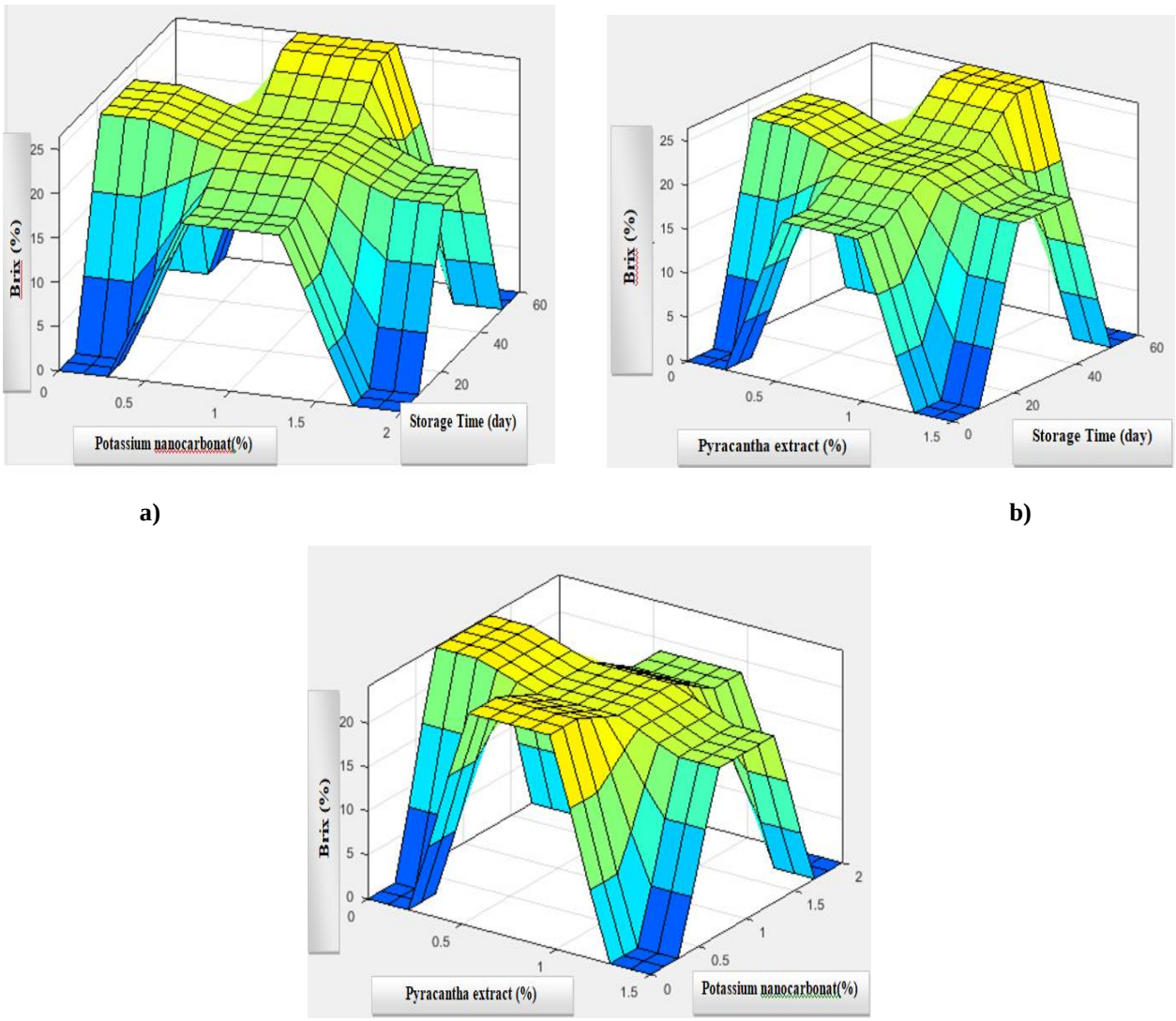

a) **b)**

c)

Figure 3- Effect of storage time and concentration of potassium nanocarbonate (a), storage time and concentration of Pyracantha extract (b) and concentration of nanocarbonate and Pyracantha extract (c) on Brix

Table 3- The comparison of hidden layers and the number of neurons in each hidden layer on the accuracy of output variables prediction.

		The type and membership functions of input variables					
		Triangular	Trapezoidal	Gaussian	Triangular	Trapezoidal	Gaussian
Desirable output	evaluation criteria	**2 2**	**2 2**	**2 2**	**3 3**	**3 3**	**3 3**
Brix	R^2	0.971	0.936	0.978	0.956	**0.995**	0.985
	MSE	0.0251	0.0025	0.0369	0.0258	**0.0265**	0.0589

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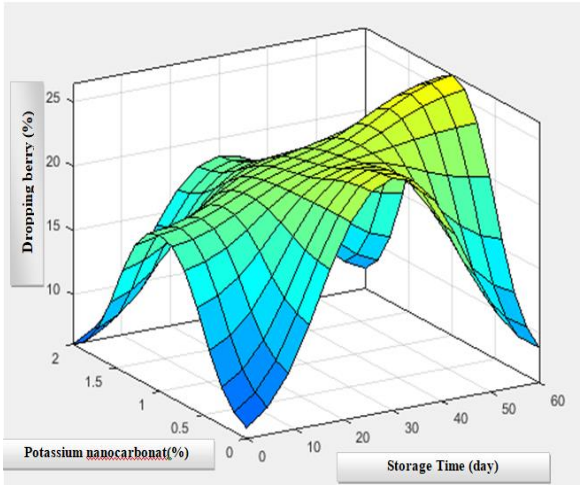
Dropping berry	R^2	0.908	0.865	0.968	0.927	0.928	**0.998**
	MSE	0.0651	0.0235	0.0358	0.0338	0.0275	**0.0189**
Malondialdehyde	R^2	0.929	0.927	0.917	**0.999**	0.944	0.948
	MSE	0.0651	0.0235	0.0158	**0.0108**	0.1325	0.1058
Cluster browning	R^2	0.819	0.913	0.937	**0.998**	0.924	0.978
	MSE	0.0651	0.0235	0.0158	**0.0118**	0.1295	0.1009
Aroma and taste	R^2	0.914	0.922	0.948	**0.998**	0.978	0.918
	MSE	0.0651	0.0235	0.0378	**0.0158**	0.1275	0.1199

2-3- Percentage of pill drop

Table 3 showed that for the featureGaussian function bubble collapse with 3-3 membership function was selected as the best model. On the other hand, the results showed that the percentage of pod drop increased with increasing storage time, but decreased with increasing concentration of potassium nanocarbonate and pyracantha extract (Figure 4). The reason for the falling of the pods with the passage of storage time can be attributed to the fungal contamination and the decrease in humidity in the clusters. Dehestani Ardakani and Mostofi (2019) stated that the use of plant essential oil and coating, due to the reduction of antifungal activity, reduces the drop of pods and the problem of cluster browning. They pointed out that chitosan can form a physical barrier against infection and prevent the germination and growth of moldy mycelium on the fruit, as a result softening, drop of the pod and browning of the cluster will be delayed [37]. Also, with the increase in the storage time, the increase in the intensity of respiration along with the production of ethylene causes a decrease in the oxygen levels, which stimulates the fruit drop [38]. Chen et al. (2019) also showed, in line with the findings of this section, that increasing the storage time leads to an increase in grape seed loss, but covering leads to a decrease in this parameter [39].



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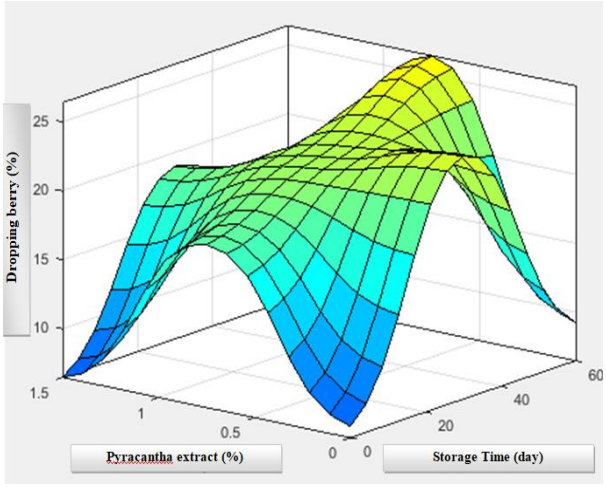

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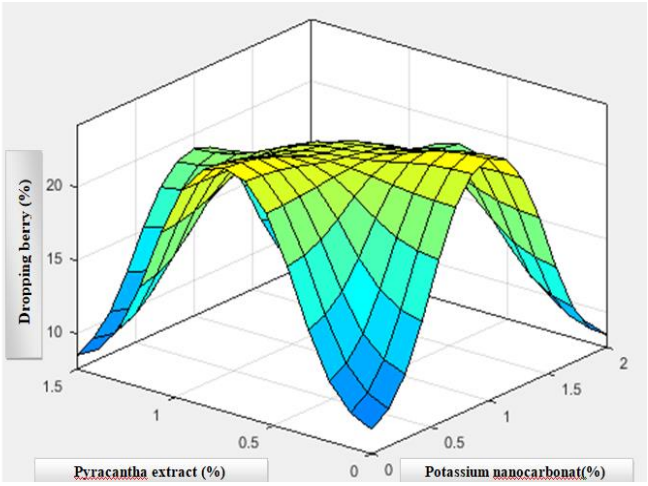

c)

Figure 4- Effect of storage time and concentration of potassium nanocarbonate (a), storage time and concentration of Pyracantha extract (b) and concentration of nanocarbonate and Pyracantha extract (c) on dropping berry

3-3- Malondialdehyde changes

According to the results given in Table 3 and the values of the correlation coefficient and the mean squared error presented, the triangular function with 3-3 membership function was selected as the optimal model for the output variable of malondialdehyde changes. The results showed that the amount of malondialdehyde increased with the increase in storage time, but decreased with the increase in the concentration of pyracantha extract and potassium nanocarbonate (Figure 5). The most important part of the damages caused by storing grapes in the warehouse is the production of free radicals related to the peroxidation of membrane lipids, which causes the production of malondialdehyde. This reaction becomes faster in fruit storage conditions and in the presence of active oxygen. Peroxidation of membrane lipids can lead to cell membrane rupture in plants. Malondialdehyde, which is a product of the breakdown of unsaturated fatty acids and lipid peroxidation, is used as a suitable biomarker for lipid oxidation, and due to its negative effect on health, the need to evaluate it in horticultural and food products is felt [40]. In this study, the amount of malondialdehyde increased during the storage of grapes in the warehouse, and this increase was noticeable in the control sample compared to the coated sample. These results show that the coating of grape fruit was a barrier against the oxidation of lipids and as a result the destruction of the cell membrane. Yuvi and Yanzhi (2013) investigated the effect of edible coating containing chitosan and beta-cyclodextrin on some qualitative properties of grapes and stated that with increasing storage, the amount of malondialdehyde increased, but the use of coating led to its decrease, which was in line with the results of this section [31]. . On the other hand, the results of this study are similar to the results of other researchers [41 and 42].

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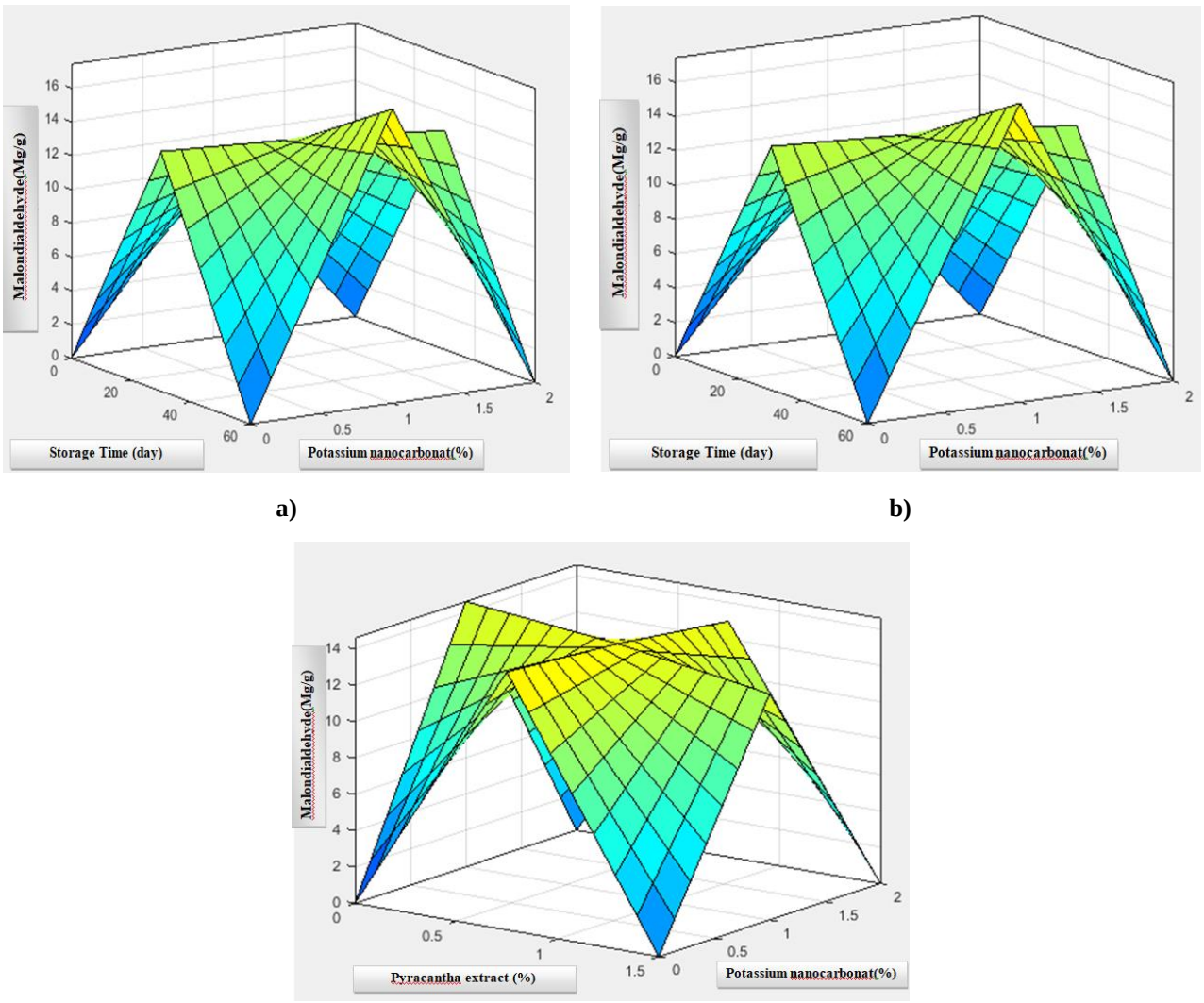

Figure 5- Effect of storage time and concentration of potassium nanocarbonate (a), storage time and concentration of Pyracantha extract (b) and concentration of nanocarbonate and Pyracantha extract (c) on Malondialdehyde

3-4- Grape cluster browning index

Table 3 indicated that for the featureBrowning index of bunch of grapes triangular function with 3-3 membership function was selected as the best model. According to the evaluators, the color of the bunch of grapes changed from green to dark brown in the first days of storage. Potassium nanocarbonate and pyracantha extract decreased the rate of cluster color change during storage in cold storage, and the evaluators assigned a higher score to the samples coated with both compounds (Figure 6). As the storage time increases, the amount of browning increases due to the loss of kernel water and the fact that cluster wood is the most sensitive to browning. In fact, the browning of stems is related to water loss and chlorophyll decomposition [43]. Feng et al. (2018) also reduced the browning index of apple slices during storage by using an edible coating containing whey protein isolate [44].

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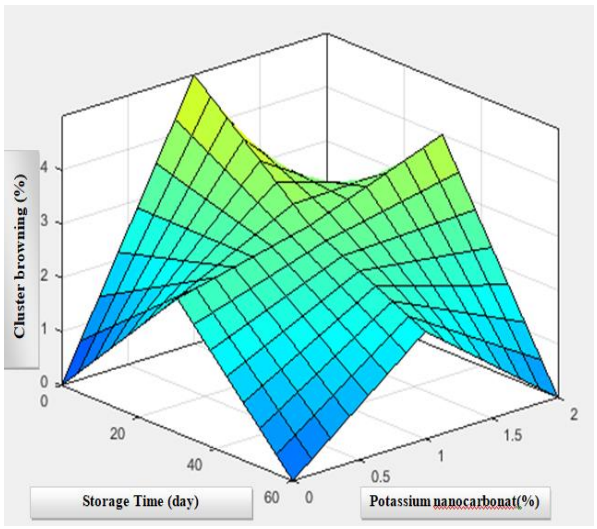
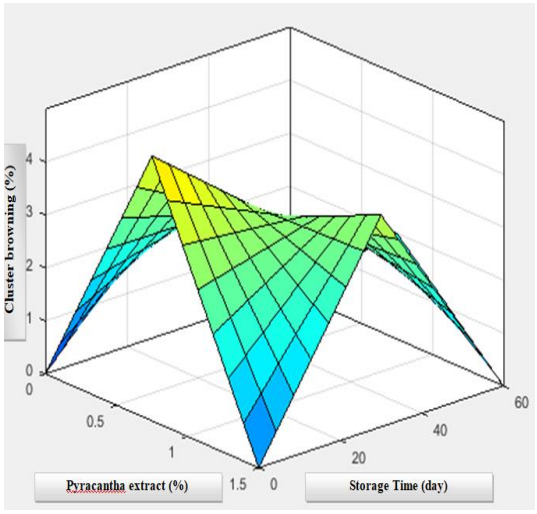


a)



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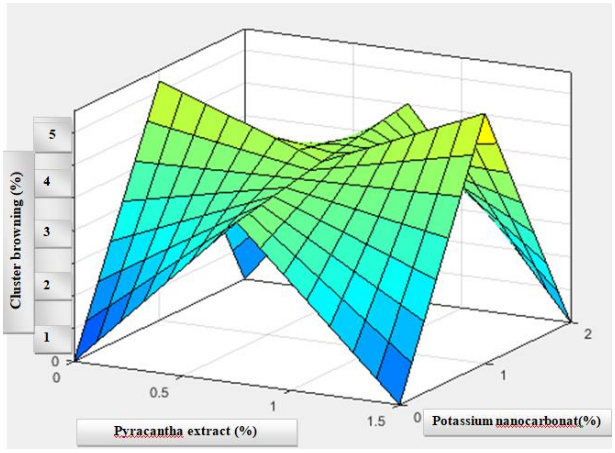

c)

Figure 6- Effect of storage time and concentration of potassium nanocarbonate (a), storage time and concentration of Pyracantha extract (b) and concentration of nanocarbonate and Pyracantha extract (c) on cluster browning

5-3- Flavor of the samples

According to the results given in Table 3 and the values of correlation coefficient and mean squared error presented, the triangular function with 3-3 membership function was selected as the optimal model for the output variable of flavor changes of the samples. In the investigation of the characteristics of flavor and taste in sensory evaluation with increasing shelf life, the scores obtained for the flavor and taste of the samples decreased, and the use of edible coating preserved the natural flavor and taste of grapes during the cold storage period, and with the increase in the percentage of potassium nanocarbonate and pyracantha extract, this effect increased. It was found (Figure 7) and these two compounds did not cause any additional and undesirable flavor in grapes. During storage of fruit in storage, its appearance and edible quality (aroma and taste) are significantly reduced due to increased respiration and enzymatic activities of the fruit [45]. In the coated samples, due to the lower intensity of respiration, the preservation of the components responsible for the aroma and flavor of the fruit is more. Because it is

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possible that by reducing the respiration of the fruit, bitter substances and compounds are produced and have a negative effect on the acceptance of the fruit. By obtaining these results, the better quality of coated fruits was also confirmed in terms of sensory characteristics [46].In the studyVargas et al. (2006) reported a decrease in the flavor and taste of samples coated with chitosan and oleic acid compared to the control sample.[47]. In general, the results of the present study and other studies showed that edible coatings reduce the negative effect caused by quality reduction during the storage period and can maintain the sensory characteristics of the coated fruits at an optimal level.

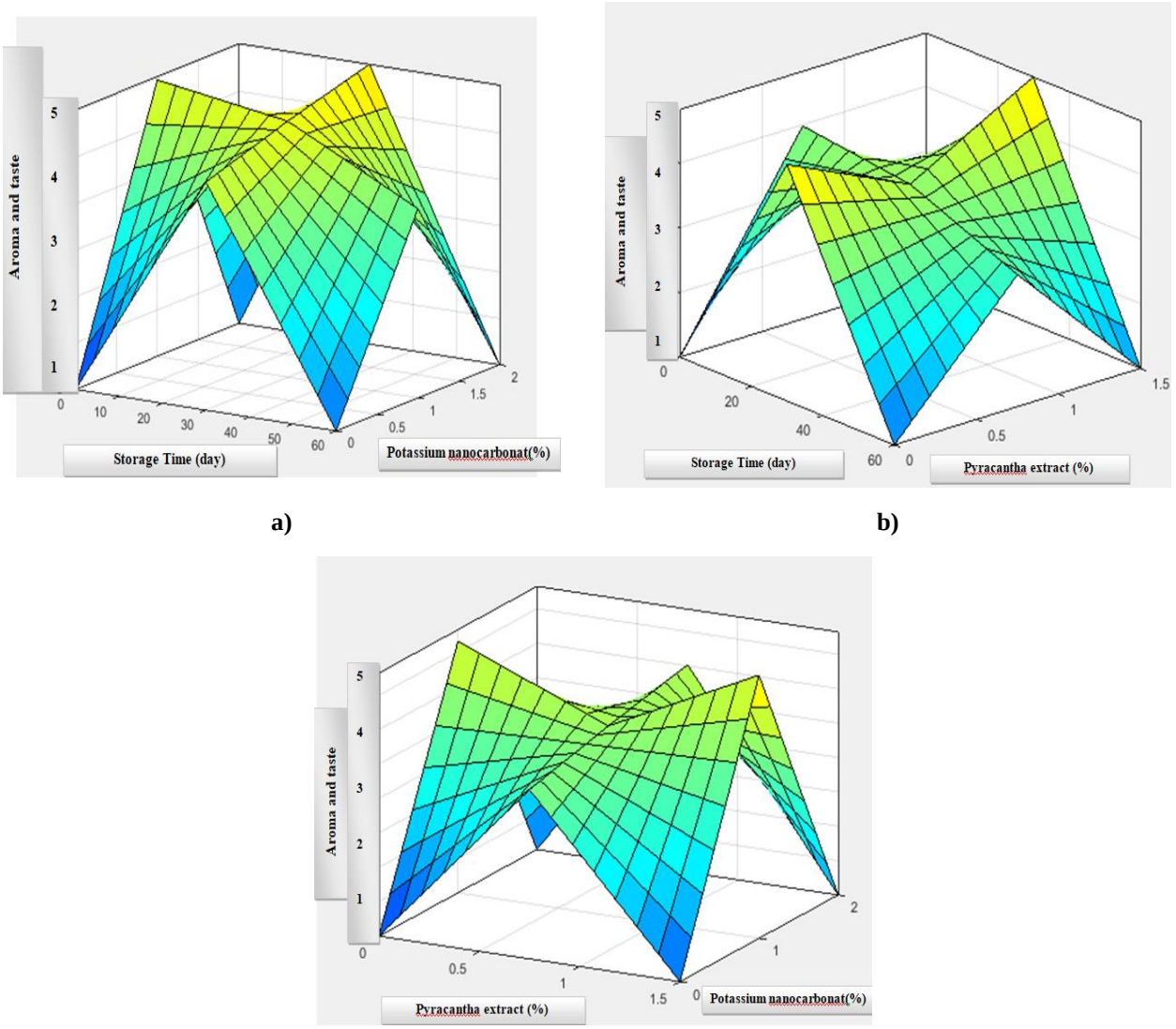

Figure 7- Effect of storage time and concentration of potassium nanocarbonate (a), storage time and concentration of Pyracantha extract (b) and concentration of nanocarbonate and Pyracantha extract (c) on aroma and taste

6-3- checking the accuracy of predicting model outputs

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Based on the obtained results, most of the models had a suitable estimation accuracy to predict the desired outputs. The final structure of adaptive neural fuzzy inference models includes the number of membership functions for each input, the number of rules,The number of training courses and the type of input and output membership functionsIt is shown in Table 4. The regression coefficient of the desired output values calculated in the laboratory and the values predicted by the model in this study is given in Figure 8. R coefficient values^2 Above 0.99 in this form, it shows the efficiency and accuracy of the presented models for predicting the desired parameters. Zandi et al. (2021) showed that the neural-fuzzy inference system has an acceptable performance in the qualitative classification and prediction of the physicochemical properties of limo, and due to the use of features extracted from images, it can be used as a non-destructive method in cold stores. In this study, the accuracy of the classification algorithm for Gaussian, triangular, and trapezoidal membership functions was 0.975, 0.931, and 0.960, respectively [48]. The use of fuzzy adaptive neural inference system and multiple linear regression to estimate the taste of oranges was investigated by Makram et al. The amount of vitamin C has red and blue colors [49]. The effects of harvesting and storage time on the storage quality of Corella aromatic pears were studied based on the Anfis system by New et al. (2020) and it was found that the Anfis system can predict some quality characteristics of pears with an accuracy of 0.98 [50].

Table 4-ANFIS optimized models parameters chosen for intended outputs.

Intended parameter	**Brix**	**Dropping berry**	**Malondialdehyde**	**Cluster browning**	**Aroma and taste**
Number of membership functions for Storage time	3	3	3	3	**3**
Number of membership function for potassium nano carbonate concentration	3	3	3	3	**3**
Number of membership functions for Pyracantha extract concentration	3	3	3	3	**3**
Type of inputs membership function	Trapezoidal	Gaussian	Triangular	Triangular	**Triangular**
Number of laws	27	27	27	27	**27**
Type of outputs membership functions	Constant	Constant	Constant	Constant	**Constant**

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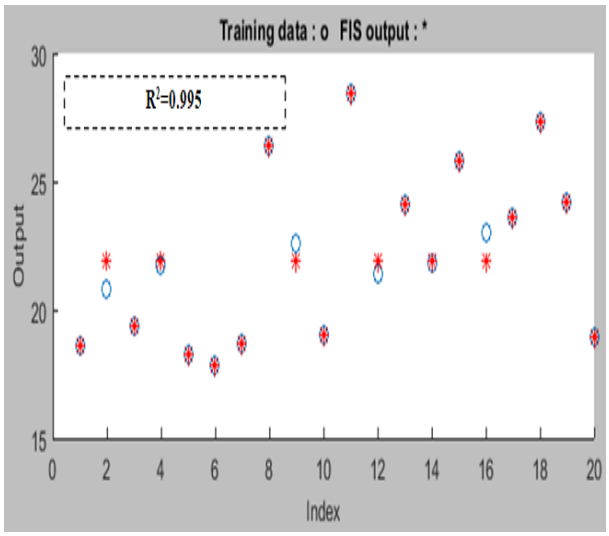

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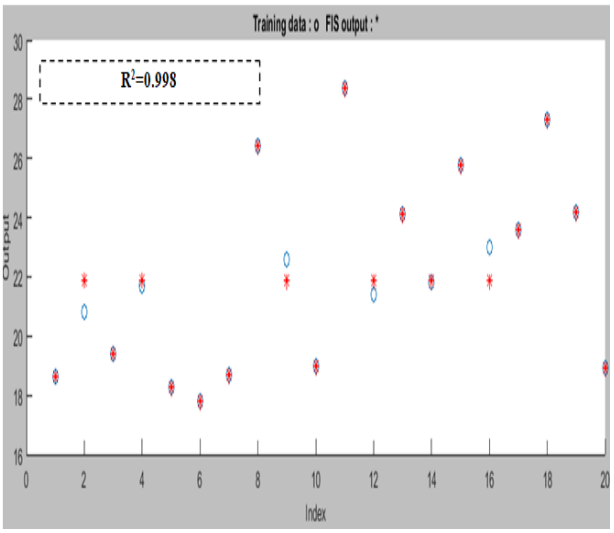

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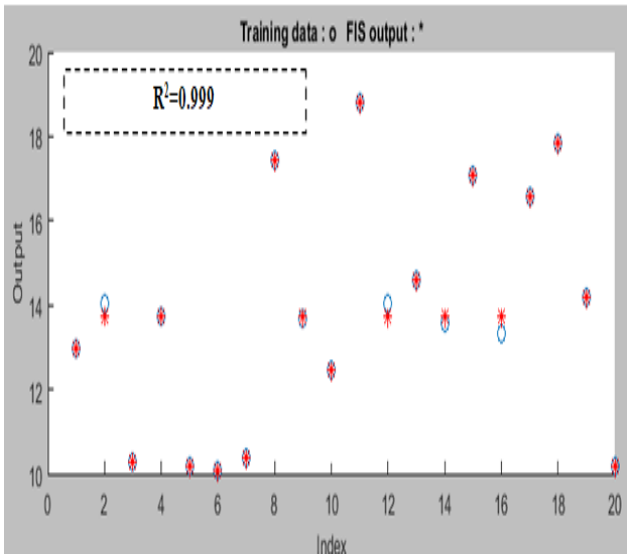

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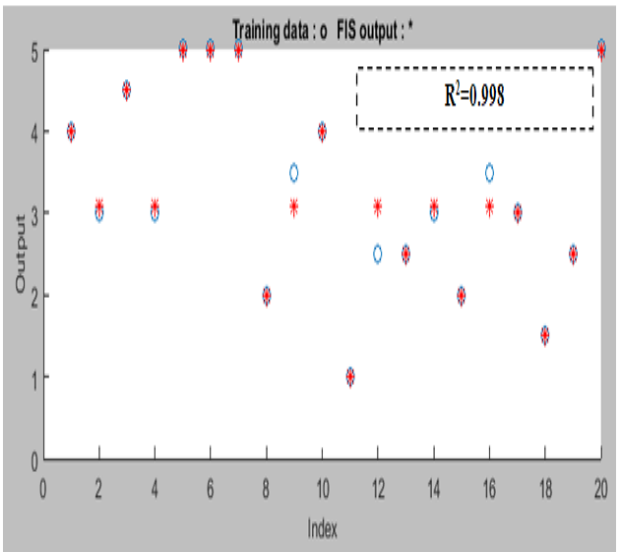

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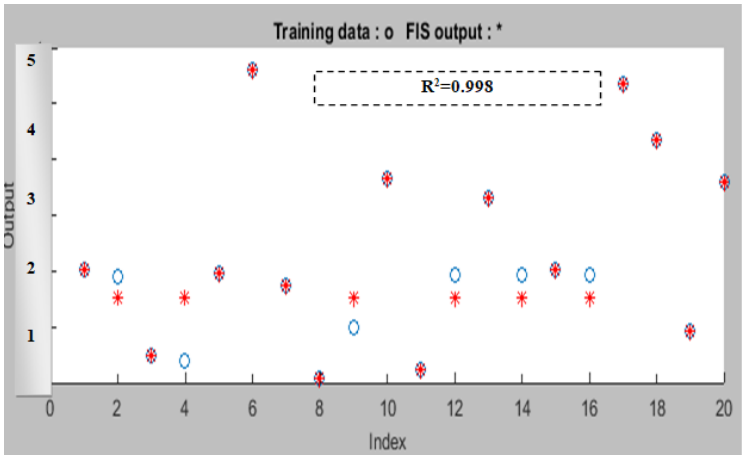

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Figure 8- The comparison of laboratory data and amounts predicted by ANFIS model for brix (a), Dropping berry (b), malondialdehyde (c), cluster browning (d) and aroma and taste (e)

4 - Conclusion

In this research, the possibility of predicting different outputs of storage conditions of grape bunches coated with maltodextrin containing potassium nanocarbonate and pyracantha extract has been investigated using the adaptive neural fuzzy inference system. The obtained results showed that Enfis system is a useful tool for predicting and finding non-linear mapping between desired parameters. All models perform well with R values^2 had more than 0.995 and had a favorable mean squared error. Considering the possibility of using these models in the design of on-line controls, it is possible to usethose recommended for better control of industrial processes and reducing costs, time and on the other hand improving the final product. On the other hand, the results showed that with increasing storage time, the amountBrix, kernel drop percentage, malondialdehyde and cluster browningIn all the samples, it increased, but the amount of aroma and flavor of the samples decreased, but the use of coating containing potassium nanocarbonate and pyracantha extract decreased the speed of these changes.

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* مسئول مکاتبات:

چکیده

در این پژوهش با توجه به عدم انجام مطالعه‌ای در مورد مدل‌سازی شرایط نگهداری میوه‌های انگور پوشش داده شده با مالتودکسترین حاوی نانوکربنات پتاسیم و عصاره پیراکانتا با استفاده از سامانه استنتاج فازی-عصبی تطبیقی (انفیس)، زمان‌های مختلف نگهداری (صفر تا ۶۰ روز)، غلظت نانوکربنات پتاسیم (صفر تا ۲ درصد) و غلظت عصاره پیراکانتا (صفر تا ۱/۵ درصد) مورد استفاده در پوشش خوراکی به‌عنوان ورودی و میزان بریکس، درصد ریزش حبه، میزان مالون‌دی آلدهید، قهوه‌ای شدن خوشه انگورها و **عطر و طعم نمونه‌ها** به‌عنوان خروجی در نظر گرفته شدند. سه تابع عضویت گوسی، مثلثی و ذوزنقه‌ای با ۲-۲-۲ و ۳-۳-۳ تابع عضویت مورد بررسی قرار گرفت. نتایج نشان داد که تابع ذوزنقه‌ای با ۳ - ۳ تابع عضویت و تابع گوسی با ۳- ۳ تابع عضویت به‌ترتیب برای متغیر خروجی بریکس و درصد ریزش حبه به‌عنوان بهترین مدل انتخاب شدند. در نهایت برای متغیرهای قهوه‌ای شدن خوشه، میزان مالون‌دی‌آلدهید و عطر و طعم نمونه‌ها مدل مثلثی با ۳-۳ تابع عضویت انتخاب گردیدند. از طرفی نتایج حاکی از آن بود که با افزایش زمان انبارداری، میزان بریکس، درصد ریزش حبه، مالون‌دی آلدهید و قهوه‌ای شدن خوشه در تمامی نمونه‌ها افزایش ولی میزان عطر و طعم نمونه‌ها کاهش پیدا کرد و استفاده از پوشش حاوی نانو کربنات پتاسیم و عصاره پیراکانتا سبب کاهش سرعت این تغییرات گردید. در پایان می‌توان بیان داشت که میزان ضرایب همبستگی بالا بین نتایج آزمایشگاهی و خروجی‌های مدل بیانگر دقت قابل قبول و قابلیت استفاده از این مدل‌ها در کنترل شرایط نگهداری میوه‌های انگور پوشش‌داده شده با مالتودکسترین حاوی نانوکربنات پتاسیم و عصاره پیراکانتا است.