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The study of physicochemical, textural, and organoleptical properties of symbiotic apple jelly containing inulin based on carrageenan

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ABSTRACT

In this study, the production of synbiotic apple jelly containing inulin (0 to 3%) and Lactobacillus acidophilus bacteria (10^{11} cfu/ml) was studied. The amount of pH, brix, syneresis, turbidity, viability, textural characteristics and sensory evaluation tests were conducted. These evaluations were performed during the 30-day maintenance period. The results indicated that with the increase in the amount of inulin, pH, Brix and turbidity of the samples increased. The syneresis of apple jelly samples also decreased with the increase of inulin. Adding probiotic bacteria to apple jelly increased the syneresis of the samples. The results showed that with increasing time, the pH of apple jelly samples decreased from 4.07 to 3.98. The turbidity of the samples also increased significantly during the storage period. The most changes in the 30-day storage period were related to the syneresis tests, which increased the syneresis of the samples as the storage time increased. Synbiotic apple jelly samples had a softer texture than the control sample. The synbiotic apple jelly sample had better chewability than the control sample. *Lactobacillus acidophilus* had a higher viability in the sample containing inulin, which decreased with increasing time.

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1-Introduction

Consuming sweet products in different ways is one of the daily nutritional habits all over the world. The consumption of sweet products throughout the history of more than three thousand years has had an upward and diversified satiety, and it started with the consumption of all kinds of sweet fruits and plant secretions and honey, and has expanded to all kinds of synthetic sweeteners. The ready-made snack, which is one of the most attractive products for children due to its texture, taste, and desirable shape, often has low nutrients and colors of unnatural origin, which in the long run will lead to malnutrition and threaten the health of this growing population.] 1[. During recent years, many researchers have processed and produced food containing probiotic microorganisms. Meanwhile, jelly is one of the types of food that has many fans as a dessert, especially among children. Considering the popularity of this product, increasing its nutritional value can be important. There are different types of jelly, such as ready-to-eat jelly, dessert jelly, confectionery jelly, and beverage jelly. Ready-to-use jelly is a product that is prepared by mixing gelling materials such as carrageenan, gelatin, pectin, agar, etc., along with sugar or other sweeteners, permitted edible bulking agents, color, permitted edible essential oil or natural fruit extract powder, permitted edible acids, and other sub-dissolving materials (such as egg powder, cocoa powder, saffron, etc.) after processing.] 2[Fruit jelly is one of the types of desserts and suitable snacks that have been researched in different countries. In these products, compounds such as gelatin, modified starch, pectin, carrageenan, etc. are used to achieve the desired texture. These products are easy to eat, they have a long shelf life, they have a suitable and marketable appearance, they have a good mouth feel, and they are also useful in terms of health. According to the standard definition, jelly is a product that is prepared by mixing gelling materials such as gelatin, pectin, agar, starch, sugar, color, edible essences or natural extracts of fruits, edible acids and other by-components, after processing. Inulin is a non-digestible or slightly digestible sugar compound (oligosaccharide) found in more than 30,000 plant species. Chicory root is produced, processed and exported in Belgium, Holland and France] 3[. In addition, inulin is a compound with the ability to dissolve in water, which can dissolve up to 35% in water at a temperature of 90 degrees Celsius.] 4[. It is one of the best fat substitutes based on carbohydrates. Inulin is a water-soluble dietary fiber that contains a mixture of fructose oligomers and polymers with 1→2 β is formed. After reaching the intestinal environment as a source of carbon or energy, inulin selectively causes the growth or activity of probiotics (beneficial intestinal bacteria such as lactobacilli and bifidobacteria).] 5[. From the conducted research, we can refer to the production of probiotic jelly desserts containing Lactobacillus acidophilus and also the research conducted by Rajabpour et al.] 6 and 7 [Many studies have been conducted on the use of Lactobacillus acidophilus as a probiotic, but this microorganism has not been used in the presence of prebiotic inulin in jellies. Therefore, the purpose of this study is to produce synbiotic jelly containing inulin and Lactobacillus acidophilus and to investigate its physicochemical properties during the storage period.

2- Materials and methods

2-1- Production of jelly samples

In order to prepare jelly samples, sugar (16 to 18%), carrageenan (0.6 to 0.8%), sodium citrate (0.2%), citric acid (0.2%), essential oil and natural pigment were mixed together. The obtained mixture was heated at 80°C for 20 to 30 minutes. The final pH of the product was adjusted by citric acid in the range of 3-4. Finally, the samples were filled hot in sterilized containers and stored at 4°C.

Jelly samples were prepared in three groups:

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1- The sample without prebiotic substance and probiotic species (control sample).
2- Sample with probiotic species (with a concentration of 10 CFU/g[11]).
3- The synbiotic sample contained inulin and Bacillus acidophilus (1, 2 and 3% w/w).

2-2-Physico-chemical and microbial tests

2-2-1-pH measurement

The pH of the produced samples was measured using a pH meter (Metrohm 827 pH lab) during storage days.] 6[.

2-2-2- Measuring the amount of syneresis of jelly samples

To measure the amount of syneresis, the gel samples were cut into 30 x 80 mm dimensions and refrigerated at 7 °C in glass jars during the storage period. During this period, the water removed from the samples was removed by the absorbent tissue and the difference between the initial and final weight of the sample was reported as its syneresis using the following formula.] 8[.

$$Synersis\% = \frac{(In_0 - In_t)}{In_t} \times 100$$

where W0 is the initial weight and Wt is the final weight of the sample at the desired time.

3-2-2-Measuring the amount of turbidity of the samples

The turbidity of the jelly samples was measured by a turbidity meter (Aqua Lytic, Model: AL450T).] 6[.

4-2-2-Brix measurement

Brix of the samples was also measured by refractometer] 7[.

2-2-5- Determining the survival activity of probiotic species:

To count Lactobacillus acidophilus bacteria, after preparing the dilution from the samples, it was cultured in MRS agar culture medium and kept in a greenhouse at 37°C for 48 hours and then counted.] 9[.Microbial culture and checking the viability of probiotic bacteria, by taking samples of prepared jelly samples, were done weekly in two repetitions.

2-2-6-Evaluation of texture characteristics of gel samples

The texture of the gel samples was examined by a texture tester (Stable Micro system, Model: TA XT-Plus) and by the TPA test. In this test, the textural properties of the samples were measured, including hardness, stickiness, chewability and phenrite. For this purpose, a cylindrical probe with a diameter of 75 mm, a movement speed of 1 mm/s and a compression percentage of 70% was used.] 7[.

7-2-2- Sensory and organoleptic evaluation of samples

This test was performed by fifteen sensory evaluators using the five-point hedonic method. Each of the evaluators was given samples with a different code, and the factors of taste, smell, color, texture, and overall acceptance of the samples were examined.] 7[.

2-2-8-Statistical analysis

Data collected in a completely randomized design in 3 replications using the software SPSS were analyzed and the comparison of treatment means was done using Duncan's multiple range test at the probability level of 5% and the graphs were done using the software Excel was drawn

3-Results

1-3- Examining pH changes of gel samples

According to the analysis of variance conducted on the pH values of synbiotic apple jelly samples, it was found that the applied changes caused significant changes in the pH values of the samples.p<0.05). Thus, by changing the percentage of inulin, probiotic bacteria and the storage time of apple jelly, the pH value of the samples changed significantly.

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Table 3-1-Analysis Variance of pH values of Samples of synbiotic apple jelly

Dependent Variable:pH					
Source	Type III Sum of Squares	df	Mean Square	F	Say.
Corrected Model	.425[a]	23	.018	328.377	.000
Intercept	1168.620	1	1168.620	2.078E7	.000
Inulin	.316	3	.105	1.874E3	.000
Probiotic	.010	1	.010	174.222	.000
StorageTime	.094	2	.047	833.167	.000
Inulin * Probiotic	.003	3	.001	15.556	.000
Inulin * StorageTime	.001	6	.000	3.537	.006
Probiotic * StorageTime	.001	2	.000	5.056	.010
Inulin * Probiotic * StorageTime	.001	6	.000	1.944	.093
Error	.003	48	5.625E-5		
Total	1169.047	72			
Corrected Total	.428	71			

a. R Squared = .994 (Adjusted R Squared = .991)

The changes in the pH of synbiotic apple jelly samples against the changes in the percentage of inulin are shown in Figure 1-3. In this figure, it can be seen that with the increase in the percentage of inulin in the synbiotic jelly samples, the pH value of the samples also increased significantly (p<0.05).

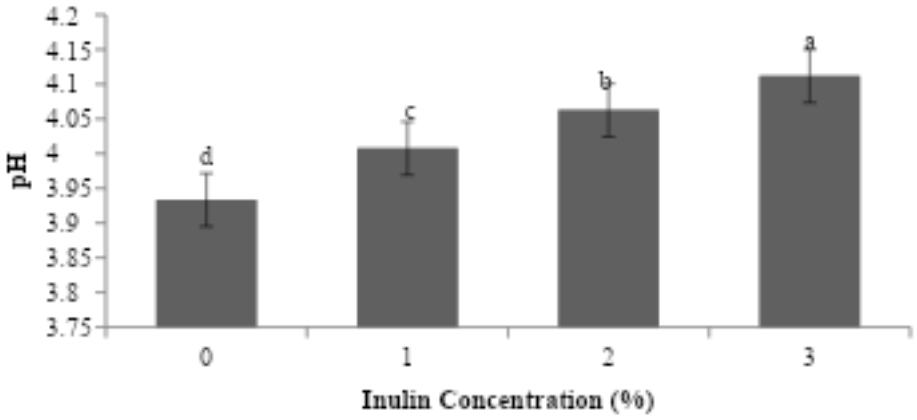

Fig. 3-1. Changes in the pH value of gel samples with changes in the percentage of inulin

The pH changes of synbiotic apple jelly samples against the amount of probiotic bacteria are shown in Figure 2-3. The results indicated that by adding 10 CFU/ml[8] Lactobacillus acidophilus bacteria to apple jelly samples, the pH of the samples did not change significantly (p>0.05). However, with the addition of probiotic bacteria to the jelly samples, the drop in pH value was 0.03 units.

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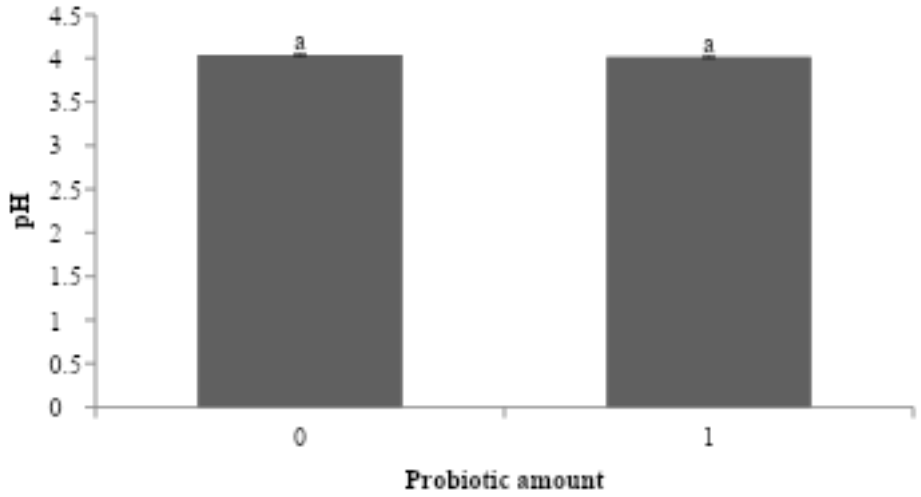

Fig.3-2. The viability of Lactobacillus acidophilus with pH changes

Samples of synbiotic apple jelly produced containing prebiotic inulin and probiotic Lactobacillus acidophilus were evaluated for pH during the 30-day storage period. According to Figure 3-3, it can be stated that with increasing storage time, the pH value of apple samples also decreased significantly (p<0.05).

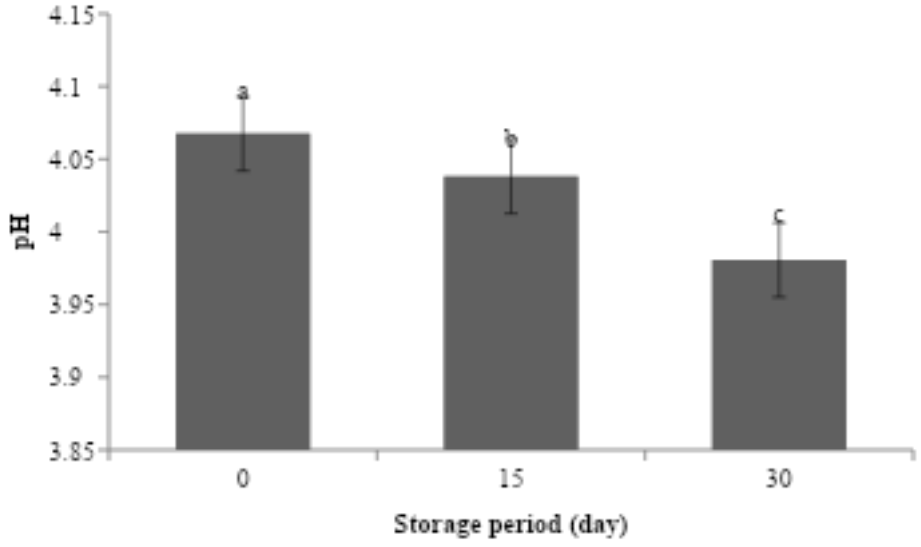

Fig. 3-3. Changes in the pH value of gel samples during the storage period

2-3- Examining Brix changes of gel samples

The statistical analysis conducted on the Brix data of a sample of synbiotic jelly indicated that the application of shelf life variables, changing the percentage of inulin and adding probiotic strain to apple jelly samples caused significant changes. p<0.05 in the Brix values of the samples, and these changes were examined at the 95% probability level (Table 2-3).

Table 3-2. Analysis Variance of Brix values of synbiotic apple jelly samples

Dependent Variable:Brix					
Source	**Type III Sum of Squares**	**df**	**Mean Square**	**F**	**Say.**
Corrected Model	493.991[a]	23	21.478	1.093E5	.000
Intercept	43000.054	1	43000.054	2.189E8	.000
Inulin	395.557	3	131.852	6.711E5	.000
Probiotic	33.397	1	33.397	1.700E5	.000

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StorageTime	32.344	2	16.172	8.231E4	.000
Inulin * Probiotic	.125	3	.042	211.936	.000
Inulin * StorageTime	.005	6	.001	4.110	.002
Probiotic * StorageTime	32.562	2	16.281	8.287E4	.000
Inulin * Probiotic * StorageTime	.002	6	.000	1.785	.122
Error	.009	48	.000		
Total	43494.055	72			
Corrected Total	494.001	71			

a. R Squared = 1.000 (Adjusted R Squared = 1.000)

Brix changes of a sample of synbiotic apple jelly against changes in inulin percentage are shown in Figure 4-3. As can be seen, with the increase in the amount of inulin, the Brix of the samples also increased, and this increase was significant at the 95% probability level (p<0.05) (Figure 4-3).

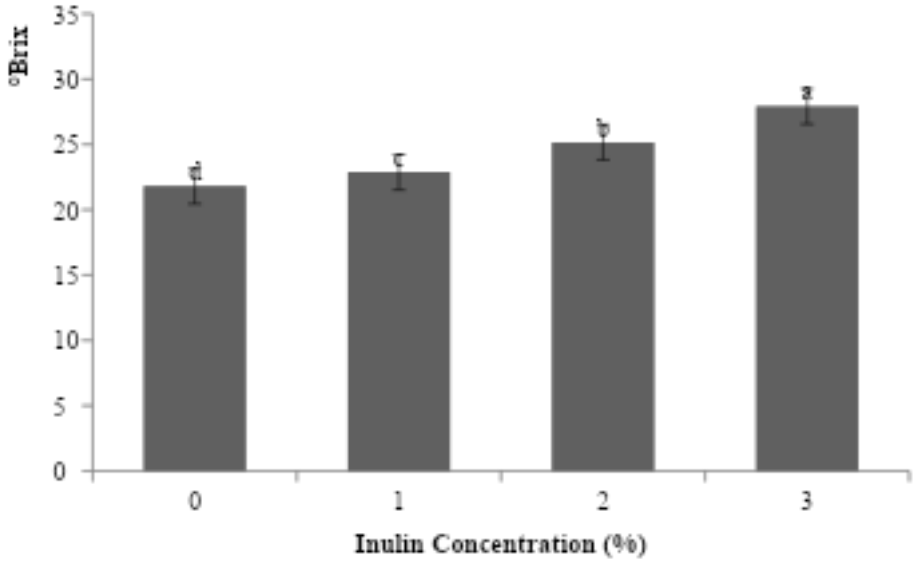

Fig.3-4. Changes in Brix value of gel samples with changes in inulin percentage

According to Figure 5-3 and the statistical analysis, it can be stated that the addition of Lactobacillus acidophilus probiotic strain to the amount of 10 cfu/ml[11] For example, apple jelly has reduced their Brix. Brix reduction of apple jelly samples with the addition of probiotic strain was significant at the 95% probability level (p<0.05) (Figure 5-3).

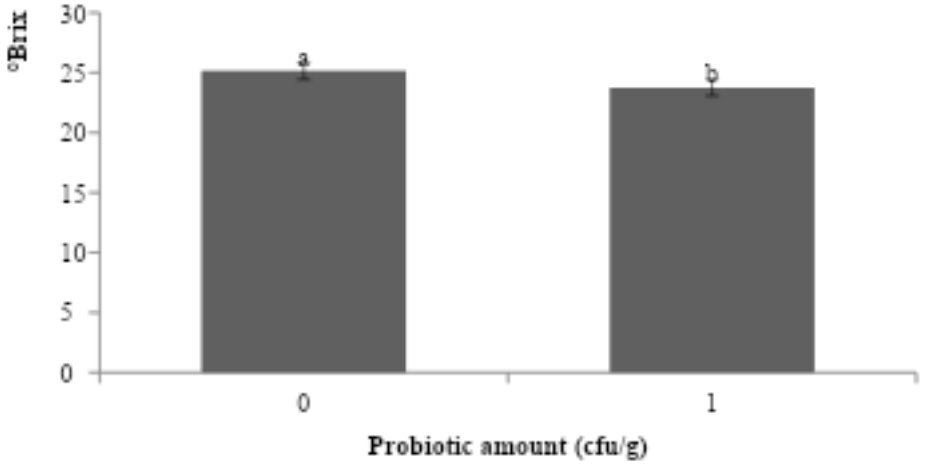

Fig. 3-5. Interaction between Brix value of gel samples and Lactobacillus acidophilus bacteria

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Brix changes of synbiotic apple jelly samples during 30 days storage period were investigated. As shown in Figure (3-6), Brix of apple jelly samples always decreased with increasing storage time from day 0 to day 15 and then from day 15 to day 30. This reduction occurred significantly and the lowest was observed on the 30th day of product production.p<0.05).

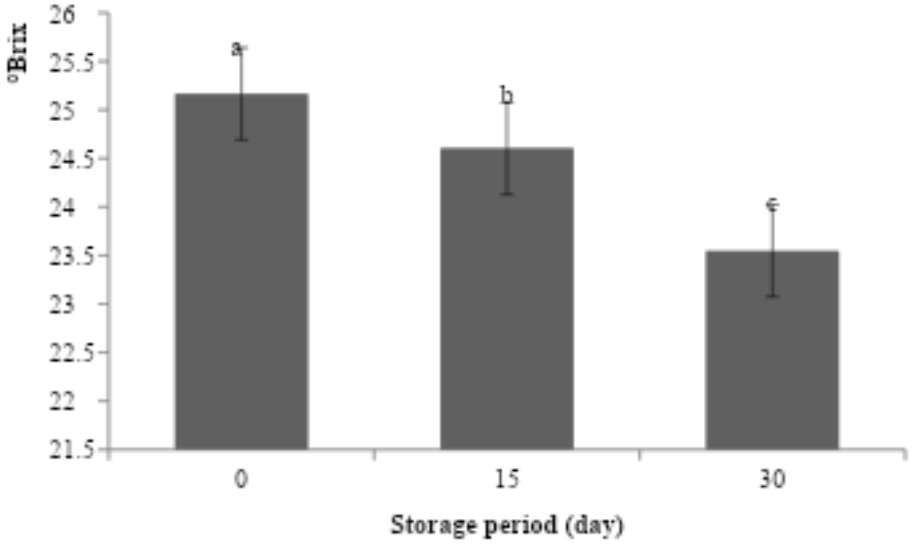

Fig.3-6. Changes in Brix value of gel samples during the storage period

3-3-Examining changes in turbidity of gel samples

The variance analysis table of the turbidity of synbiotic jelly samples containing inulin and Lactobacillus acidophilus bacteria is presented in Table 3-3. In Table 3-3, the effect of shelf life of jelly samples along with double and triple mutual effects of all studied parameters are presented. The results of analysis of variance indicate that the studied parameters have led to significant changes in the turbidity results of synbiotic jelly samples.p<0.05).

Table 3-3. Analysis Variance of Turbidity values of synbiotic apple jelly samples

Dependent Variable:Turbidity					
Source	**Type III Sum of Squares**	**df**	**Mean Square**	**F**	**Say.**
Corrected Model	4001.704[a]	23	173.987	1.711E5	.000
Intercept	13162.531	1	13162.531	1.295E7	.000
Inulin	3863.079	3	1287.693	1.267E6	.000
Probiotic	.146	1	.146	143.410	.000
StorageTime	138.384	2	69.192	6.806E4	.000
Inulin * Probiotic	.084	3	.028	27.451	.000
Inulin * StorageTime	.002	6	.000	.276	.946
Probiotic * StorageTime	.003	2	.001	1.392	.258
Inulin * Probiotic * StorageTime	.007	6	.001	1.192	.327
Error	.049	48	.001		
Total	17164.284	72			
Corrected Total	4001.753	71			

a. R Squared = 1.000 (Adjusted R Squared = 1.000)

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In Figure 7-3, the changes in the amount of turbidity against the changes in the percentage of inulin are shown. The turbidity values changed from the minimum NTU 54.5, which was related to the control sample, to the maximum NTU 25.14, which was related to the sample containing 3% inulin. According to Figure 9, with the increase in the amount of inulin, the turbidity of the samples also increased significantly (p<0.05).

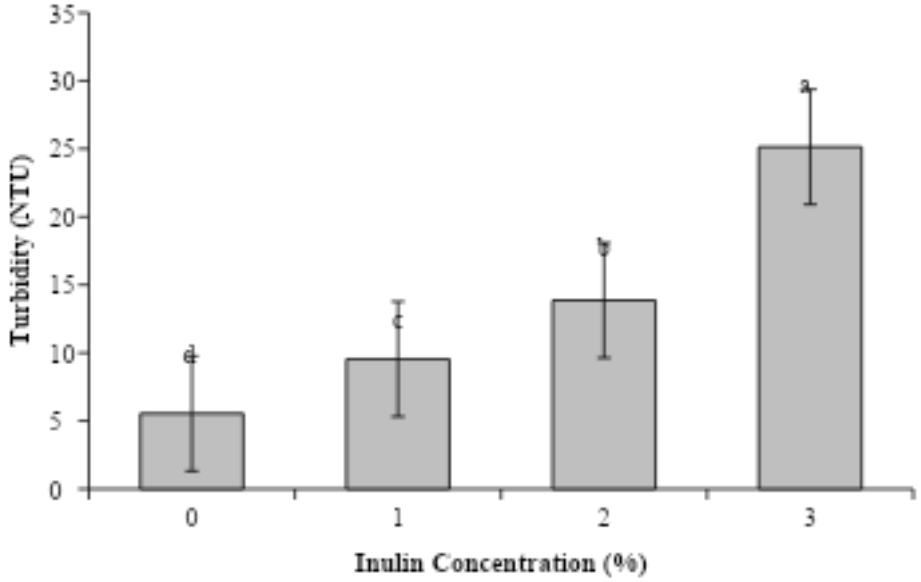

Fig.3-7. Changes in Turbidity value of gel samples with different percentage of Inulin

According to Figure 8-3, the addition of Lactobacillus acidophilus bacteria did not have significant changes in the amount of turbidity of synbiotic apple jelly samples.p>0.05). However, with the addition of probiotic bacteria, the turbidity of the jelly samples increased slightly.

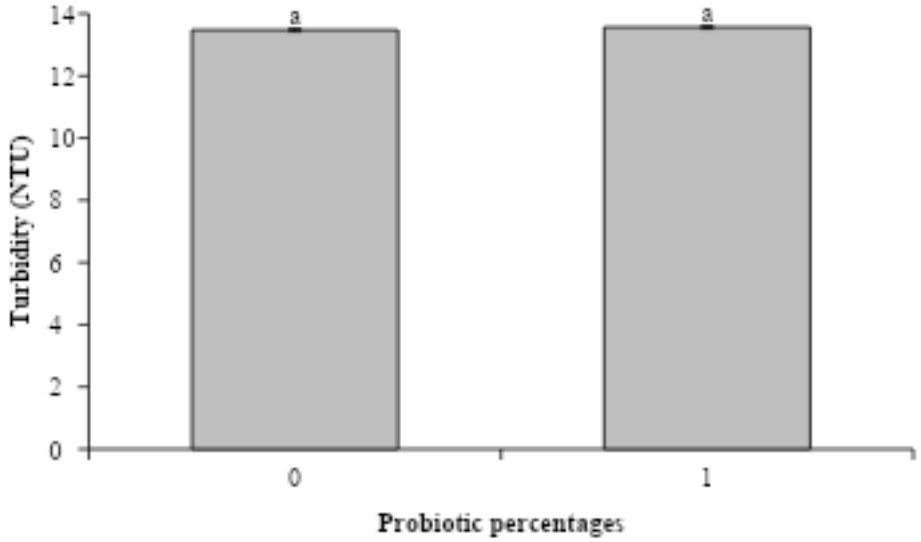

Fig.3-8. Changes in Turbidity value of gel samples with different percentage of probiotic

During the 30-day storage period and at 15-day intervals, the turbidity of synbiotic apple jelly samples was investigated. The results indicated that the turbidity of the jelly samples always increased with the increase

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of the shelf life of the jelly from zero to the 30th day. with the explanation that the increase in turbidity during the first fifteen days was not significant (p>0.05) but with the passage of time up to thirty days, we saw a significant increase in turbidity values (p<0.05) (Figure 9-3).

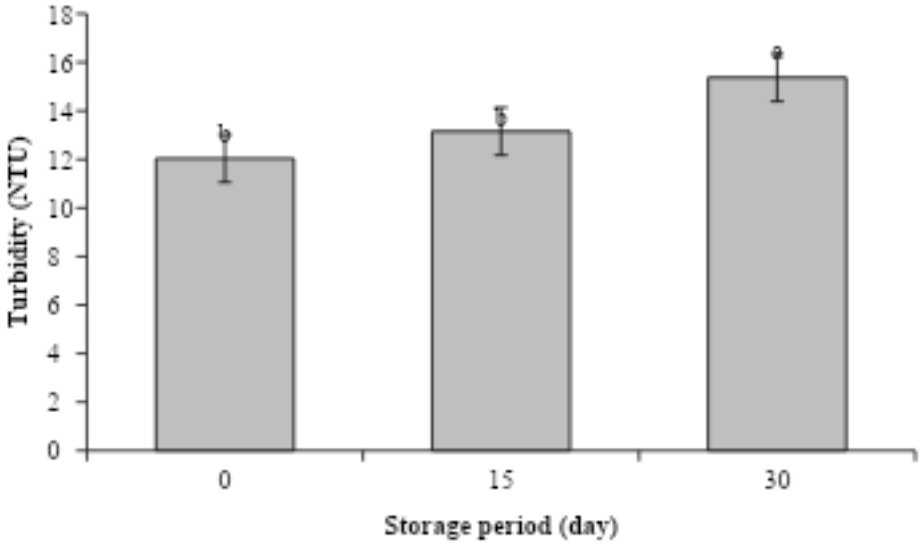

Fig. 3-9. Changes in turbidity value of gel samples during the storage period

4-3- Investigating changes in syneresis of gel samples

In Table 4-3, the analysis of variance of syneresis values of synbiotic apple jelly samples containing inulin and Lactobacillus acidophilus bacteria is presented. The results indicate that the addition of inulin and probiotic bacteria to the apple jelly samples caused significant changes in the amount of syneresis of the jelly samples.p<0.05) (Table 3-4).

Table 3-4. Variance analysis table of syneresis values of synbiotic apple jelly samples

Source	Type III Sum of Squares	df	Mean Square	F	Say.
Corrected Model	1016.454[a]	23	44.194	3.924E3	.000
Intercept	1785.315	1	1785.315	1.585E5	.000
Inulin	24.418	3	8.139	722.757	.000
Probiotic	.050	1	.050	4.399	.041
StorageTime	980.178	2	490.089	4.352E4	.000
Inulin * Probiotic	.003	3	.001	.090	.965
Inulin * StorageTime	11.696	6	1.949	173.104	.000
Probiotic * StorageTime	.076	2	.038	3.368	.043
Inulin * Probiotic * StorageTime	.033	6	.005	.488	.814
Error	.541	48	.011		
Total	2802.309	72			
Corrected Total	1016.994	71			

a. R Squared = .999 (Adjusted R Squared = .999)

The syneresis of synbiotic apple jelly samples with the addition of inulin from zero to 3% was investigated. According to Figure 10-3, it can be stated that with the increase in the percentage of inulin, the syneresis of the jelly samples decreased significantly (p<0.05). The highest amount of syneresis was related to the control sample that did not contain inulin, and the lowest amount of syneresis was observed in the sample containing 3% of inulin (Figure 10-3).

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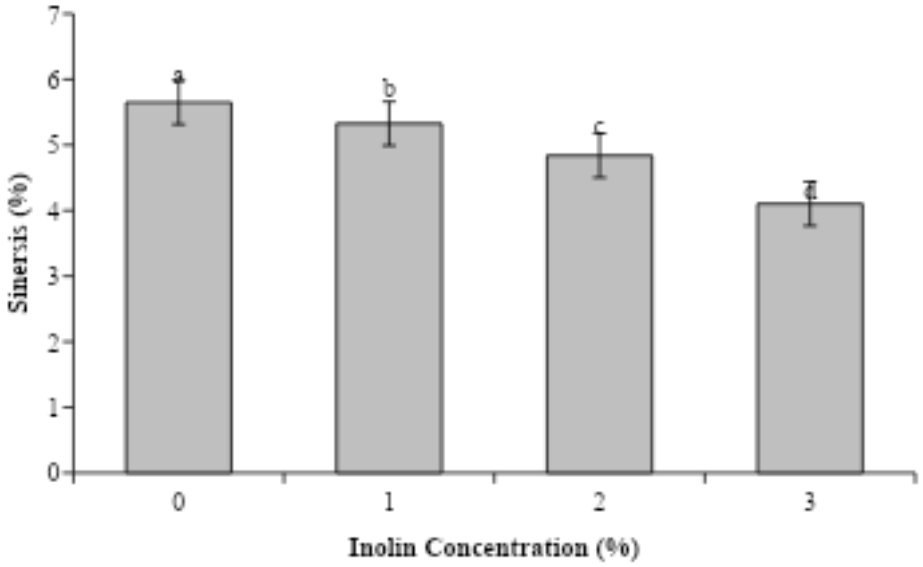

Fig. 3-10. Changes in the amount of syneresis of gel samples against changes in the percentage of inulin

Figure 11-3 shows how the syneresis of synbiotic apple jelly samples has changed in the presence and absence of Lactobacillus acidophilus bacteria. According to the results, the addition of probiotic bacteria led to a significant increase in the syneresis of the samples (p<0.05).

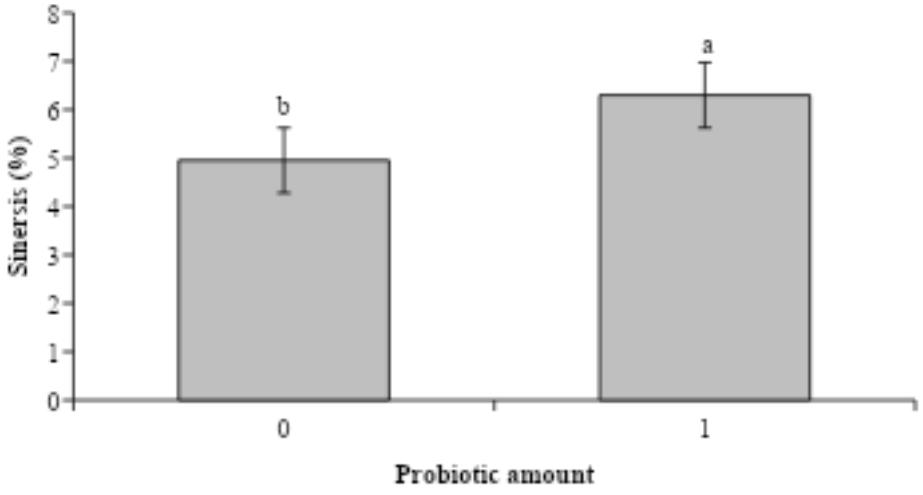

Fig. 3-11. Changes in syneresis value of gel samples against Lactobacillus acidophilus bacteria

The syneresis of synbiotic apple jelly samples was measured and analyzed at the moment of production, 15 days later and 30 days after production. The lowest amount of syneresis was observed on day zero and a few hours after the production and molding of the samples. With the increase of storage time, syneresis increased so that the highest amount of syneresis was related to the sample stored after thirty days (Figure 12-3).

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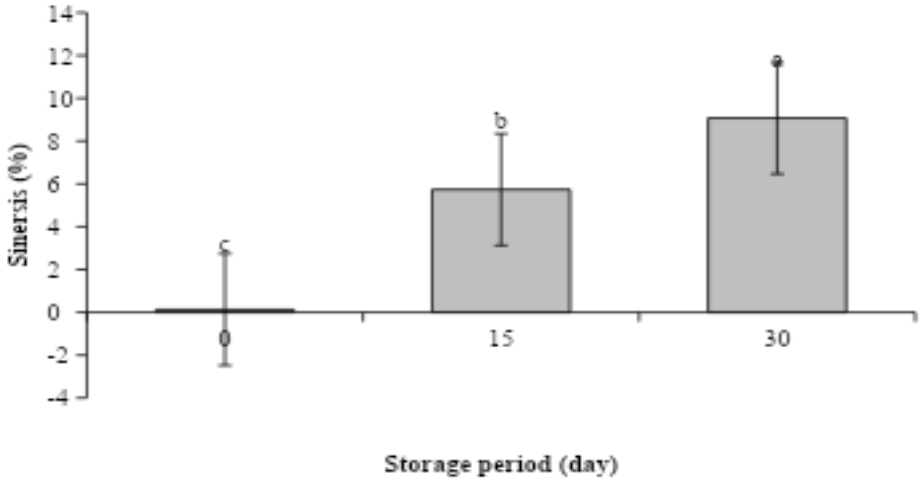

Fig.3-12. Changes in syneresis value of gel samples during the storage period

3-5-Determining the optimal conditions for the production of synbiotic apple jelly

The results of the physicochemical tests performed on synbiotic apple jelly were analyzed in order to determine the best treatment with minimum pH, maximum brix, minimum turbidity and maximum syneresis, and finally the treatment containing 3% inulin containing 10 cfu/ml^8 Lactobacillus acidophilus bacteria was selected as the optimal sample, and together with the control sample, which lacked inulin and probiotic bacteria, they were examined to perform additional tests including histometry, survival characteristics, and organoleptic properties.

6-3- Investigating the viability of probiotic bacteria

According to Figure 13-3, it can be stated that the population of Lactobacillus acidophilus bacteria decreased with the increase in shelf life of synbiotic apple jelly samples. It can also be stated that the sample of synbiotic apple jelly containing inulin oligosaccharide had a higher population than the control sample at both time zero and day 30.

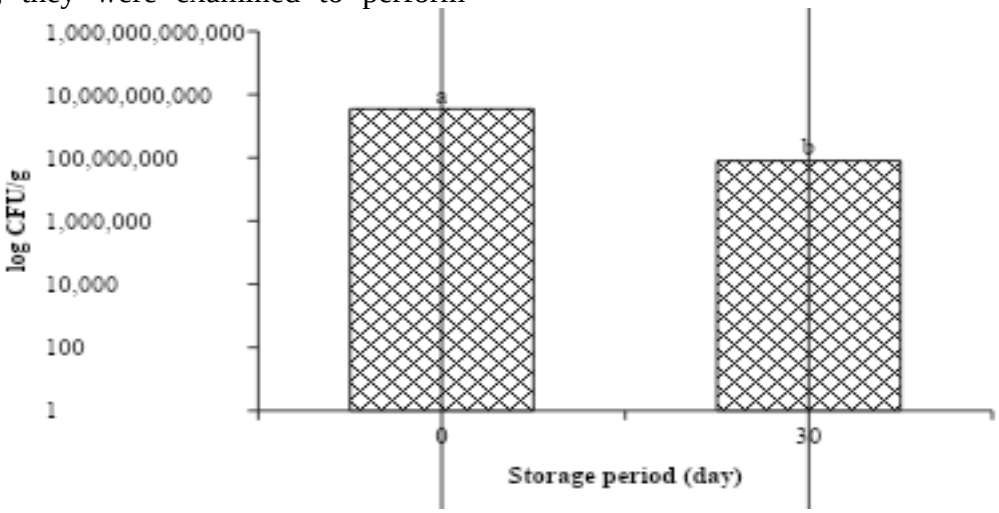

Fig.3-13. Changes in the population of Lactobacillus acidophilus bacteria in two periods of 0 and 30 days after inoculation in apple jelly samples

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3-7- Examining the textural characteristics of synbiotic apple jelly samples

The examination of tissue profile characteristics[1] (TPA) of apple jelly samples was done using histometer. Its results are presented in Table 5-3. These results include hardness, adhesiveness, cohesiveness, springiness, and chewiness, which were measured for the synbiotic jelly sample and the control jelly sample. The results showed that the control sample had higher hardness and adhesion than the synbiotic sample. But the synbiotic sample had more chewability than the control sample (Table 8).

Table 3-5. Texture characteristics of synbiotic and control apple jelly samples

Treatments	Texture characteristics				
	Hardness	Adhesivness	Cohesivness	Springines	Chewiness
Control	3783.7	-105.103	0.855	140	4530.94
Synbiotic	2200	-73.5	0.851	96.67	1810.81

3-8- Examining the organoleptic properties of synbiotic apple jelly samples

Table 1 shows the analysis of variance results of sensory evaluation of apple jelly samples. According to it, it can be stated that the samples of synbiotic apple jelly that contained Lactobacillus acidophilus bacteria and inulin were significantly different from each other in terms of the sensory properties that were investigated in this study.p<0.05) (Table 6-3). In other words, by adding the combination of prebiotics and probiotic bacteria, the organoleptic properties of the jelly samples, including aroma, color, taste, mouthfeel and overall desirability of the samples, underwent significant changes.

Table 3-6- Variance analysis table of sensory evaluation results of biotic apple jelly samples

Source	Dependent Variable	Type III Sum of Squares	df	Mean Square	F	Say.
Corrected Model	**Flavor**	1.500[a]	1	1.500	4.500	.101
	Color	2.667[b]	1	2.667	8.000	.047
	Taste	2.667[c]	1	2.667	8.000	.047
	MouthFeeling	.167[d]	1	.167	.500	.519
	Desirability	2.667[c]	1	2.667	8.000	.047
Intercept	**Flavor**	104.167	1	104.167	312.500	.000
	Color	96.000	1	96.000	288.000	.000
	Taste	96.000	1	96.000	288.000	.000
	MouthFeeling	73.500	1	73.500	220.500	.000
	Desirability	96.000	1	96.000	288.000	.000
Treatment	**Flavor**	1.500	1	1.500	4.500	.101
	Color	2.667	1	2.667	8.000	.047
	Taste	2.667	1	2.667	8.000	.047
	MouthFeeling	.167	1	.167	.500	.519
	Desirability	2.667	1	2.667	8.000	.047
Error	**Flavor**	1.333	4	.333		
	Color	1.333	4	.333		
	Taste	1.333	4	.333		
	MouthFeeling	1.333	4	.333		
	Desirability	1.333	4	.333		
Total	**Flavor**	107.000	6			

-Texture Profile Analysis[1]

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	Color	100.000	6
	Taste	100.000	6
	MouthFeeling	75.000	6
	Desirability	100.000	6
Corrected Total	**Flavor**	2.833	5
	Color	4.000	5
	Taste	4.000	5
	MouthFeel	1.500	5
	Desirability	4.000	5

a. R Squared = .529 (Adjusted R Squared = .412)
b. R Squared = .667 (Adjusted R Squared = .583)
c. R Squared = .667 (Adjusted R Squared = .583)
d. R Squared = .111 (Adjusted R Squared = -.111)

Figure 17-3 shows changes and differences in sensory parameters of apple jelly samples in two synbiotic and control samples. The addition of inulin and probiotic bacteria significantly increased the taste score of the synbiotic sample compared to the control sample (p<0.05) (Figure 3-17).

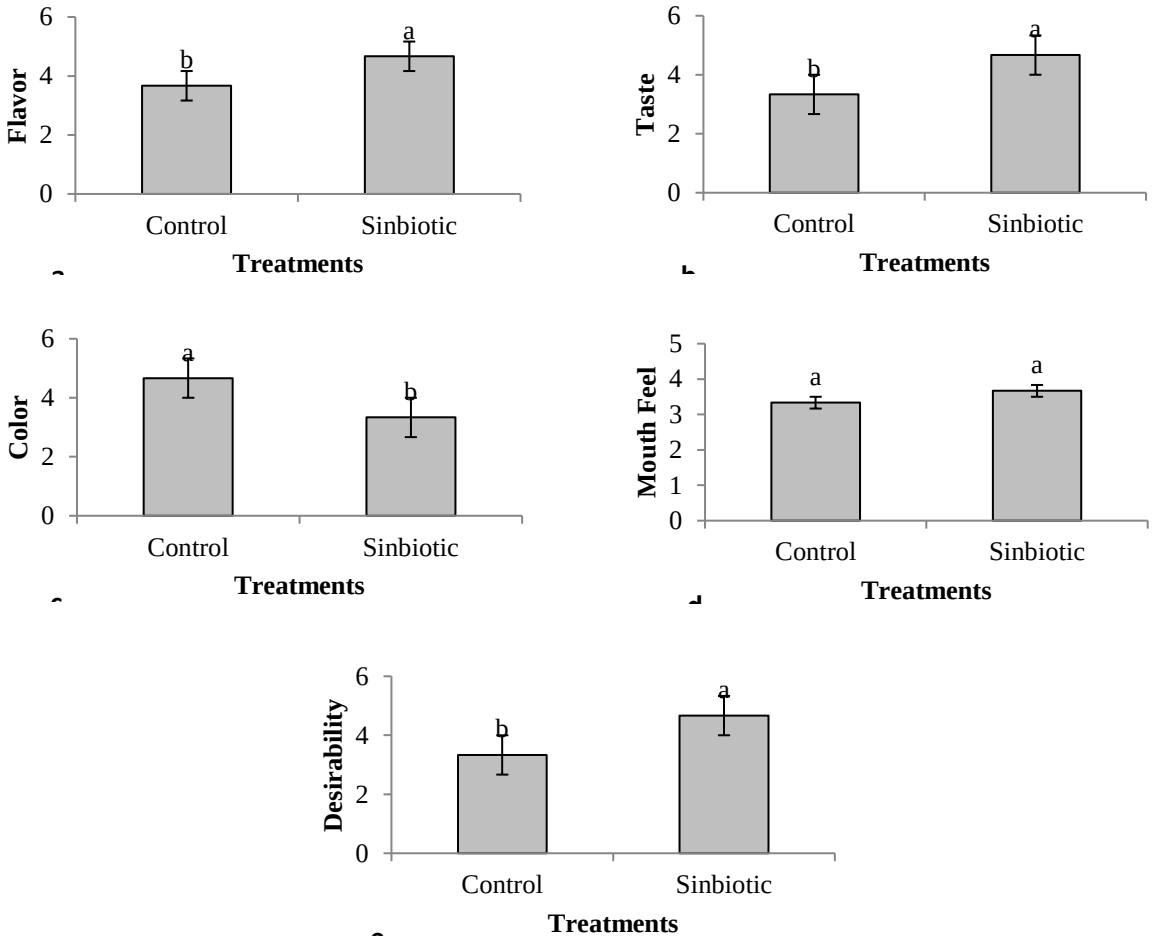

Fig. 3-17. Changes in organoleptic parameters including aroma (a), taste (b), color (c), mouthfeel (d) and overall acceptance (e)

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Also, the synbiotic sample received higher scores in the parameters of taste (Figure 17-3b), mouthfeel (Figure 3-17d) and overall desirability (Figure 17-3e) compared to the control sample. This difference is significant in terms of overall taste and desirability.$p<0.05$) and was insignificant for oral sensation ($p>0.05$). The color of the control sample received a higher score than the synbiotic sample, which had a significant difference with each other at the 95% probability level ($p<0.05$) (Figure 16-c).

4- General discussion and conclusion

1-4- Check the value changes pH Samples of synbiotic apple jelly

The results indicated that with the increase in the amount of inulin, the pH of the apple jelly samples increased significantly ($p<0.05$) (Figure 3). It seems that the effect of amphoteric factors on the hydrocarbon chain of inulin was the reason for increasing the pH value of the samples. Hosseini et al. (2016) stated the pH of apple jelly samples to be about 3.7 and cherry jelly to be 2.3.] 10[Adding Lactobacillus acidophilus bacteria to the gel samples, although it decreased the pH value of the samples, but this decrease was not significant at the 95% probability level. It seems that at the beginning and after the addition of probiotic bacteria, there was no significant effect on the pH value of the samples, but the effect of adding probiotic bacteria over time and during the storage period of the prepared apple jelly was revealed. According to Figure 5, as the storage time of the synbiotic gel samples increased, the pH of the samples decreased significantly. It can be stated that with the addition of inulin, the metabolic and biological activity of the bacterial cell has increased and as a result of its cellular production, the pH has decreased.] 11[. Karajian et al. (1400) stated that by increasing the percentage of inulin as a fat substitute, the pH of synbiotic samples decreased.] 12[.

2-4- Examining the changes in Brix value of synbiotic apple jelly samples

Brix of apple jelly samples containing inulin and Lactobacillus acidophilus bacteria was investigated during the thirty-day storage period and with the effect of these two variables. The results showed that with the addition of inulin, the Brix of the samples increased significantly, so that the Brix values changed from at least 21.80%, which was related to the control sample, to 27.91%, which was related to the sample containing 3% inulin. In other words, with the increase in the amount of inulin, the Brix of the samples also increased constantly. The reason for this is related to the effect of adding inulin. On the other hand, by adding Lactobacillus acidophilus probiotic strain to the gel samples, Brix of these samples decreased. The reduction of Brix is related to the addition of probiotic bacteria due to the consumption of this carbohydrate substance and as a result the reduction of Brix. Also, with the increase of shelf life of the product, Brix decreased from 25.16% to 23.55%. This is due to the consumption of sugar and inulin contained in the apple jelly formulation, which led to a decrease in the Brix value of the samples. Hosseini et al.] 10[Rajabpour Niko et al. (2019) reported that by increasing the shelf life of synbiotic jelly samples for six weeks, the Brix of these samples decreased from 27% to 20.75%, and the results of this study are consistent with the results of the current research.] 7[.

3-4- Examining changes in turbidity of synbiotic apple jelly samples

The turbidity of the synbiotic apple jelly samples produced was investigated using a turbidity meter. The results indicated that with the increase in the percentage of inulin from zero to 3%, the turbidity also increased significantly. Inulin is a white powder which, by adding it to the jelly formulation, has increased the turbidity of the samples. After adding Lactobacillus acidophilus bacteria to the apple jelly samples, the turbidity

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increased slightly and slightly, which was not significant.p>0.05). Addition of probiotic bacteria in the studied concentration did not significantly change the amount of turbidity. As the shelf life of synbiotic apple jelly samples passed from 0 to 30 days, the turbidity of the samples increased. This increase can be due to the decrease in moisture content and the production of secondary compounds due to the activity of microorganisms. In the visual examination of synbiotic jelly samples, with the passage of time, small bubbles were observed inside the jelly tissue, which seems to be caused by the activity of Lactobacillus acidophilus bacteria. In 2016, Talebzedeh et al., who studied the production of probiotic jelly using Lactobacillus acidophilus bacteria, stated that the addition of this bacterium in both encapsulated and free form led to an increase in the turbidity of jelly samples. The addition of encapsulated alginate also led to an increase in the turbidity of the jelly samples, which was consistent with the results of this study.] 6[. The measurement of turbidity is important in this aspect, which is directly related to the appearance and visual effect of the product] 13[.

4-4- Investigating changes in syneresis value of synbiotic apple jelly samples

Syneresis of synbiotic jelly samples containing inulin and Lactobacillus acidophilus bacteria was investigated by gravimetric method. Therefore, the higher the syneresis is, the greater the difference between the initial weight and the final weight, and the lower the syneresis, the smaller the weight difference. Therefore, it can be said that the samples with less syneresis have a higher quality. Adding inulin to apple jelly samples caused this oligosaccharide compound to absorb the water in the jelly tissue and prevent the samples from becoming watery. Therefore, with the increase in the amount of inulin, syneresis decreased. On the other hand, the addition of Lactobacillus acidophilus bacteria increased the syneresis of the samples. The reason for this can be attributed to the use of sugar and inulin in the jelly formulation, because these compounds are preservatives and absorbers of moisture and free water in the tissue of the jelly, and with the removal or consumption of these compounds by microorganisms, the water-holding capacity of the jelly decreases. With the passage of storage time of the produced jellies, their syneresis increased. This change can be attributed to the activity of the probiotic species, the production of acid by it and the disruption of the electrolyte balance and finally the reduction of water retention capacity by the uniform texture of the primary jelly.

5-4-onDetermination of survival characteristics of synbiotic apple jelly samples

To accurately count living microorganisms in different samples, the general consensus among researchers is to grow a bacterial species and create a colony. This issue goes back to the time of Koch, a famous scientist in the 19th century. According to this convention, a viable cell is usually considered to have the ability to multiply and create a colony] 14[.The results of this research indicated that by adding inulin to the formulation of apple jelly samples, the viability of Lactobacillus acidophilus bacteria has increased. On the other hand, with the passing of the shelf life of apple jelly samples, the viability of probiotic bacteria has decreased in the sample. This can be attributed to the reduction of nutrients in the sample during the storage period. On the other hand, with the consumption of nutrients, secondary metabolites are produced by the microorganism, which, along with the reduction of nutrients, leads to the reduction of the bacterial population. Depending on the environmental conditions and stress factors, microbes exist in different growth stages and different metabolic states. [15 and 16]. Various acidic compounds such as acetic acid and citric acid are produced as a result of the growth and proliferation of

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lactic acid bacteria, as a result of which the pH of the environment decreases and over time the conditions for cell growth and survival are destroyed. Therefore, with the passage of time, we saw a decrease in the bacterial population in the apple jelly samples. These results are also consistent with the results of the study by Sharifi Soltani et al. (2015) who studied the production of probiotic yogurt containing cocoa powder.] 9[.

6-4- Examining the textural characteristics of synbiotic apple jelly samples

The texture of synbiotic and control apple jelly samples was evaluated by TPA test using a 75 mm probe. This test, which simulates a situation similar to chewing food in the mouth, is performed on the sample in two round-trip cycles and provides different results such as hardness, adhesiveness, cohesiveness, springiness, and chewiness. According to the obtained results, it can be stated that the addition of inulin and probiotic strain has created a softer texture and less adhesion in synbiotic jelly samples. This can be attributed to the positive effect of inulin in increasing the growth of Lactobacillus acidophilus bacteria. Because as a result of the growth of this bacterium, more metabolic compounds, including acetic acid and citric acid, are produced, and as a result, the texture of the sample becomes softer and its hardness decreases. Mirzaee et al. (2021) stated that the addition of thyme essential oil and pomegranate seed oil to candy reduced the hardness and stickiness of the samples, which was consistent with the results of this research.] 17[. Miranda et al. (2020), who studied the production of synbiotic jelly containing forest fruits and Lactobacillus coagulans bacteria, stated that the texture cohesion and stiffness of the samples did not change significantly with each other.] 18[.

7-4- check the characteristics Organoleptic Samples of synbiotic apple jelly

The organoleptic properties of control and synbiotic apple jelly samples were evaluated by a fifteen-member team of trained evaluators. For this perspective, the evaluators completed their comments on sensory parameters including aroma, color, taste, mouthfeel and general desirability in questionnaires designed for this purpose. The results showed that the synbiotic apple jelly samples received a higher aroma score, mouthfeel, taste and overall desirability than the control sample. The addition of inulin and the preparation of conditions for the growth and proliferation of Lactobacillus acidophilus caused the production of flavor-producing substances in synbiotic jelly samples. Therefore, these samples received a higher flavor score than the control sample. Also, the synbiotic jelly sample scored more in the mouthfeel parameter than the control sample. The reason for this can be attributed to the acidification and reduction of sample pH and the production of secondary metabolites due to the growth of Lactobacillus acidophilus. Because, on the one hand, these compounds cause a better taste, and on the other hand, according to histological results, these samples were softer than the control sample. The control sample received more points than the synbiotic sample only in the color parameter, which can be attributed to the creation of a white halo due to the addition of inulin to the synbiotic sample.

5-Resources

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مقاله علمی_پژوهشی

بررسی خواص فیزیکوشیمیایی، بافتی و ارگانولپتیکی ژله سیب سین‌بیوتیکحاوی اینولین بر پایه کاراگینان

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چکیده

در این مطالعه تولید ژله سیب سین بیوتیک حاوی اینولین (۰ تا ۳ درصد) و باکتری لاکتوباسیلوس اسیدوفیلوس (10^{11} cfu/ml) مورد مطالعه قرار گرفت و آزمون‌های pH، بریکس، سینرسیس، کدورت، زنده مانی، خصوصیات بافتی و ارزیابی حسی بر روی نمونه‌ها صورت پذیرفت. این ارزیابی‌ها در دوره نگهداری ۳۰ روزه انجام شد. نتایج نشان داد، با افزایش مقدار اینولین، مقادیر pH، بریکس و کدورت نمونه‌ها افزایش یافت. سینرسیس نمونه‌های ژله سیب نیز با افزایش مقدار اینولین کاهش یافت. افزودن باکتری پروبیوتیک به ژله سیب باعث افزایش آب اندازی نمونه‌ها گردید. با افزایش زمان pH نمونه‌های ژله سیب از ۴/۰۷ تا ۳/۹۸ کاهش یافت. کدورت نمونه‌ها نیز در طی دوره نگهداری به صورت معنی داری افزایش یافت. بیشترین تغییرات در دوره نگهداری ۳۰ روزه به آزمایشات سینرسیس مربوط بود که با افزایش زمان نگهداری، سینرسیس نمونه‌ها افزایش یافت. نمونه‌های ژله سیب سین بیوتیک از بافت نرم‌تری نسبت به نمونه شاهد برخوردار بودند. نمونه ژله سیب سین بیوتیک قابلیت جویدن بهتری نسبت به نمونه شاهد داشت. *لاکتوباسیلوس اسیدوفیلوس* قابلیت زنده مانی بالاتری در نمونه حاوی اینولین دارا بود که با افزایش زمان قابلیت زنده مانی آن کاهش یافت.

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