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# Evaluation of the textural characteristics of synbiotic ultrafiltrated cheese containing demenirelized UF-whey and lactulose powders

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## ABSTRACT

Nowadays, Functional food products as healthy diets have been considered extensively among consumers. Moreover, the use of particular microorganisms, for instance probiotic bacteria, offers probabilities to progress novel foods with appropriate shelf life. In the current research, in order to produce a functional ultrafiltrated (UF)-cheese, demineralized UF-whey powder (DUWP) at the levels of 0, 1 and 2%, and lactulose powder at the levels of 0 and 1% were used. Furthermore, *bifidobacterium bifidum* was used as probiotic bacteria. The textural characteristics in terms of hardness, cohesiveness, adhesiveness, springiness, gumminess and chewiness and sensorial propertis of the symbiotic cheese samples including odor, color, texture and taste were evaluated during 60 days of storage period at 4 ˚C. Results showed that addition of DUWP and lactulose powders except for adhesiveness and springiness caused significant decrease in all textural parameters ($P<0.001$). Besides, except for adhesiveness and cohesiveness, the mean values of textural parameters usually enhanced up to middle of the storage time and thereafter decreased up to end of storage period ($p<0.05$). Sensory results revealed that although addition of both DUWP and lactulose powders resulted in lower sensory scores, no significant differences were found between control (without DUWP and lactulose) and sample containing 1% of each both mentioned powders ($P>0.05$). Therefore, based on the obtained results, sample having 1% of DUWP and 1% of lactulose determined as the best symbiotic UF-cheese sample. Since the potential contribution of this product in community health promotion and reduction of diseases risk, the production and consumption of this functional cheese is proposed.

## ARTICLE INFO

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## 1- Introduction

Today, various fermented dairy products are produced all over the world, which can be classified into different categories. The most important of these products are yogurt, buttermilk, sour cream, koumiss, kefir and cheese. Cheese is the most popular fermented milk product that is widely produced and consumed.[۱]. Mainly, fermented milk products from milk, due to their coherent structure and the presence of suitable compounds such as protein (amphoteric role) and fat content (coating role), protect probiotics during the passage through the digestive tract.[۲]. Cheese matrix is created from free casein micelles in milk. Temperature and acidity are the most important factors in the development of cheese matrix. Initiating bacteria convert lactose into lactic acid and as a result pH They reduce milk. At the same time, according to the temperature ۳۲-۳۶ degrees Celsius and the effect of rennet containing the enzyme chymosin causes the milk solids (mainly casein) to stick together and form a complex protein matrix. This matrix begins to enlarge and the connections between it increase, so that finally a dense matrix containing minerals attached to casein along with fat globules is created.[۳].

Ultra-refining is a membrane separation process that selectively separates proteins and fats and thickens the milk. In the ultra-refining process, the milk is divided into two separate parts: non-perishable and afterwater. Nausea or retinitis[1] which is also referred to as condensed milk or permanent phase, contains casein compounds, whey proteins, fat and colloidal salts. Permeability or permeability[2] which is also called transitory and residual phase, it contains compounds of water, lactose, soluble solutes, non-protein nitrogen and water-soluble vitamins].[٤]. Ultra-refining is a suitable alternative process for the production of dairy products, the use of which increases performance and nutritional properties. The advantage of ultra-refining compared to other processes is that it saves energy, reduces the volume of milk during transportation, and develops new products with distinctive features, especially during cheese production. The cheese resulting from such a process has a soft and rubable texture, and the removal of water before the cheese-making process reduces the amount of syneresis or watered-down, and the whey proteins are trapped inside the curd during cheese production. Unlike traditional white cheese, Farapaloudeh white cheese enters the consumption cycle after a short ripening period (24 to 48 hours from the time of production).[۵].

Diet plays an important role in human health. Today, many studies show that diet can cause or prevent diseases. In recent years, special attention has been paid to the production of practical foods. The main goal of "functional foods" is to introduce beneficial microorganisms or compounds through daily dietary intake. Probiotic is a live microbial food supplement that beneficially affects health by improving the intestinal microbial balance of the host.[٦]. Probiotics are live microorganisms that are beneficial to the host when consumed in appropriate amounts.[۷]. Among its benefits, we can mention the inhibition of bacterial pathogens, reduction of serum cholesterol levels, reduction of constipation, diarrhea and intestinal cancer, improvement of lactose tolerance, absorption of calcium and

[1]- retention

[2]- permeate

vitamin synthesis, and stimulation of the immune system.^[. Research has also shown that by using probiotic bacteria, it is possible to effectively remove mycotoxins from food.9[.

Prebiotic compounds were initially defined as non-digestible food substances. These compounds have a beneficial effect on the health of the host by selectively stimulating the growth or activity of one or a limited number of bacteria in the large intestine, thereby improving the health of the host.10[. In addition, prebiotics can prevent the proliferation of pathogens and provide additional benefits to ensure the health of the host. The effect of these compounds is mainly more evident in the large intestine, but they can also affect the microbial flora of the small intestine. In particular, almost all dietary oligosaccharides and polysaccharides (including dietary fiber) have prebiotic activity, but not all dietary carbohydrates are prebiotic.10[. Therefore, in order to place a substance as a prebiotic compound, there is a need for a specific demarcation and classification.

If there are probiotic bacteria and prebiotic compounds in a food product, it is called a synbiotic product, and such a product can have the beneficial effects of both substances.11[. As mentioned, prebiotic compounds are one of the most important practical and effective compounds on the functioning of the digestive system, because they have a great effect on the beneficial bacteria in the intestine. Currently, a wide range of prebiotics with different origins and suitable chemical bonds are used, among which inulin, fructo-oligosaccharides, galacto-oligosaccharides and lactulose can be mentioned.12[. Lactulose is a prebiotic substance and a synthetic disaccharide consisting of one molecule of fructose and one molecule of galactose. Lactulose is the result of lactose isomerization. Lactose is present in a relatively large amount in milk and cottage cheese, which can be used to develop the flavor of food products]13[. Isomerization of lactulose is done by chemical and enzymatic methods, which chemical isomerization has a higher performance than enzymatic method. Since lactulose is not absorbed in the small intestine, it has the potential to act as a prebiotic. In addition, lactulose is a functional nutrient that can be widely used in food products and pharmaceutical products due to its valuable medicinal properties.14[.

Blue cheese is a byproduct of cheese production. Cottage cheese contains a large amount of water and more than half of the main solids in milk, including protein, lactose, minerals, and water-soluble vitamins. In the past few years, the dairy industry has increasingly turned to the treatment of cheese and recovery of the main components, including protein, lactose and minerals, using different techniques and technologies. The processing of blue cheese leads to the production of valuable products and the reduction of environmental pollution. However, every year, significant amounts of cheese are produced all over the world, and despite the high nutritional value, only half of it is used and the rest is thrown away.15[.

Due to the high biological value of serum proteins and their role in reducing triglycerides and blood pressure, the use of these proteins in the diet has been considered. Blue cheese protein concentrate[3] (WPC), whey protein isolate[4] (WPI)Hydrolyzed whey protein[5] (WPH), the

[3]- Whey Protein Concentrate

[4]- Whey Protein Isolate

[5]- Whey Protein Hydrolysate

protein components of blue cheese, components rich in alpha-lactalbumin and beta-lactoglobulin, casein glycomacropeptide, lactoferrin and lactoperoxidase are among the products of blue cheese. powderWPC And WPIIn recent years, it has been used in many food formulations. In probiotic fermentation products, these compounds are used as growth stimulants and increase the lifespan of probiotics.16 and 17[. In addition to having nutritional properties, whey proteins are widely used in food production due to their suitable functional properties such as high solubility, water absorption, gelatinization and emulsification capacities.]15 ،18-19[. Blue cheese protein contains 20 amino acids and 9 essential amino acids and is a rich and balanced source of sulfur and amino acids that play an important role as antioxidants and precursors of the intracellular antioxidant glutathione [20]. In addition to the presence of compounds with antimicrobial properties in whey (lactoferrin, lactoperoxidase, glycomacropeptide and sphingolipids), peptides with antimicrobial properties are produced during the passage of whey proteins in the digestive system and as a result of their proteolysis [20].

Currently, when preparing cheese by ultra-refining method, a significant volume of after-water or ultra-refined rennet is created, the composition of which is different from the rennet resulting from the usual cheese-making process. The powder prepared from ultra-refined cheese contains high salts, which limits its use in the food industry. Therefore, with the reduction of solvents, a higher quality powder called ultra-refined water cheese powder with reduced solvents ([6]DUWP) It is produced, which increases the possibility of using it in the formulation of food products.This research aims to investigate the effect of adding lactulose powders andDUWP Synbiotic ultra-refining was performed on textural and sensory characteristics of cheese samples.

## 2- Materials and methods

### 2-1- Materials used

Fresh whole cow's milk was used to produce ultra-refined cheese samples. Lactulose used in this research was purchased and used from Sigma (USA). Permit powder or milk ultra-refining wastewater with reduced solutes (DUWP) used in this research was purchased from Baltic Food Industry Company (Russia). Powder ingredientsDUWP It included 3.3% moisture, 3.8% protein, 88.5% lactose, 3.5% ash, and 0.9% fat. Mesophilic starter powdersCHOOZIT 230 (Contains a mixture of bacteria*Lactococcus lactis subspecies Cremoris*And*Lactococcus lactis subspecies lactis*) and thermophilic starterThey-Mix 532 (contains*Streptococcus thermophilus* And*Lactobacillus delbruecki subspecies bulgaricus*) from Germany's Danesco company and probiotic starter powder containing bacteria*Bifidobacterium Bifidium subsp*From Christian Hansen Company[7] Denmark was purchased. The mentioned powders are of the typeYOU and was kept at -18 degrees Celsius until use. Brand name rentChey-Max It was purchased from Christian Hansen, Denmark. Other chemicals

[6]- Demineralized whey powder

[7]- Chr. Hansen

The use in this research was of high quality and mostly purchased and used from Merck, Germany.

**2-2- Cheese production method**

Farapaloude cheese in Pegah milk factory in Shush Khuzestan according to the method]21[ And]22[ Produced from fresh whole milk. After two stages of bactofugation, the received raw milk was pasteurized and ultra-refined. After passing through the ultra-refining membrane, the milk was divided into two parts: permeate (over-refined cheese juice) and retentate or natraveh with 31% solid matter. Then powderDUWP (zero levels,۱ And۲ Percent,W/V) and lactulose (zero levels and۱ Percent,W/V) was additionally added, the operation of homogenization under pressure۷۰ Load by model homogenizerJHG-Q60-P60 (Ronghe machinery, China)and then pasteurization by plate pasteurizer at temperature۷۵ degrees Celsius for۱۵ Second done. It should be noted that the levels of powdersDUWP and lactulose in this research was determined after preliminary tests. Next, Natravah went to a plate pasteurizer and was pasteurized up to 78 degrees Celsius for 16 seconds. Then, mesophilic and thermophilic starter powder each in the amount۰۲۵/۰ percentage and probiotic starter powder to the extent۰۵/۰ percentage along with the amount of rent۰۳/۰ The percentage was increased. After placing Narava in 400g cheese containers, the packages entered the coagulation tunnel at a temperature of 31-30 degrees Celsius, and after exiting the tunnel and coagulation of the cheese, parchment paper was placed on the surface of the cheese. At the end, 2% of salt (weight/weight) was added to the containers containing cheese and then the packages were sealed with aluminum foil. Finally, the cheese packages were kept in a greenhouse at a temperature of 25-27 degrees Celsius and after 18-24 hours and ripeningpH Examples to۸/٤The samples were transferred to a cold room with a temperature of 5 degrees Celsius. in this research,Samples of extra-purified Iranian white cheese with probiotics (without lactulose powder andDUWP) as a control sample with synbiotic cheese samples (containing different amountspowderLactulose andDUWP) were evaluated on days 1, 30 and 60 in terms of physicochemical characteristics.

**2-3- Texture test**

tissue profile test (TPA) is the most dominant imitation test used to check the texture of food, especially cheese. The mechanism of action is that the samples are compressed twice during the act of chewing, similar to human actions. Texture test by texture measuring device (Stable Micro System ModelTA.XT.PLUS Made in England) and using probe noP/5S It was done according to the searcher's method in 2009. The speed of the probe was set to 1 mm/s and the probe penetrated into the sample up to 50% of the initial height of the cheese samples (10 mm depth). The speed of the probe before and after the test was set to 2 and 1 mm/s, respectively. In this test, features such as stiffness[8], adhesion[9]Continuity[10] ,

[8] - Hardness

[9] - Adhesiveness

[10] -Cohesiveness

reactionary[11]gummy[12] and chewing[13] Checked out. Before testing, the cheese samples were taken out of the refrigerator and kept at room temperature for 30 minutes to reach a constant temperature. The texture test was performed in all cheese samples in three repetitions and the average results were recorded [23].

### 4-2- Sensory evaluation

The most important organoleptic characteristics including color and appearance, taste and aroma, consistency and texture of Iranian white cheese samples refined by۱۰ One of the food industry students of Khuzestan University of Agriculture and Natural Resources was evaluated. Sensory evaluation based on a preference test, 9 points were compared with each other. Before evaluation, the samples were taken out of the refrigerator for 30 minutes and at ambient temperature (℃ ۲±22) were kept so that the temperature of all the samples during the evaluation is the same and does not affect the sensory results. Cheese samples after ripening (24 hours after production) in the first, 30 and۶۰ After processing, they were subjected to sensory evaluation]22[.

### ۲-۵- Statistical Analysis

In this research, according to two variables lactulose (at two levels) and powderDUWP (at 3 levels), 6 cheese treatments were produced and the cheese samples were compared with each other in terms of textural characteristics during two months of storage (at intervals of 1, 30 and 60 days after production). According to the production of cheese samples in 3 repetitions, a total of 54 samples were produced. Results by completely random design in factorial format with the help of statistical programSPSS (SPSS Inc., Chicago, ed۲۰) analysis and average results were compared with the help of Duncan's test at the 5% level.

## 3- Results and discussion

### ۳-۱- Evaluation of cheese hardness

Results of the effect of adding powderDUWP, lactulose powder on the firmness characteristics of different samples of ultra-refined synbiotic cheese during 60 days of storage at 4 degrees Celsius are presented in Tables 1 and 2 and Figure 1. The results show the significant effect of all three variables of cheese powder with reduced solutes (DUWP), lactulose powder and the duration of storage were on the hardness of the samples (۰۰۱/۰>*P*). In the meantimeSignificant interaction between variables in terms of Tissue stiffness was not observed (<0.05). *P*). As in the table۲ And Figure 1 can be seen, with increasing amounts of powdersDUWP and lactulose, quant The texture stiffness of the samples increased. AverageThe degree of stiffness in the containing samples۰۰ ۱ And۲ Powder percentageDUWP Respectively3/61, 3/48 and 3/38 and in Samples containing۰ And۱ The percentage of lactulose powder respectively۵۵ /۳ And۴۳/۳ Was determined. In addition, the quantity Texture stiffness of the samplesto the middle of the storage timeincreased, while after that and until the

[11] -speringiness

[12] -Gumminess

[13] -chewability

end of the storage time, its amount decreased.

According to the results obtained in this research, Barbosa et al. [24] stated that during storage in the refrigerator, the acidity of cheese curds increased and these changes in acidity cause an increase in synergism and, as a result, an increase in the texture of the samples. Ghaemi et al. [25] in a research Similarly, they reported that the hardness index of cheese samples increased at the beginning of the storage period and decreased at the end. They reduce the cause of increased stiffness at the beginning of the treatment periodpH And they related the reduction of stiffness to the increase of proteolysis reactions. Sarwar et al. [26] also found an increase in the stiffness of yogurt samples due to an increase in the fermentation activity of probiotics and a decrease in the amountpH In the produced samples compared to a control sample. On the other hand, Jovandeh [23] stated in a research that the addition of fermented whey protein concentrate to the milk used in cheese making interferes with the casein network and as a result significantly reduces the firmness of Iranian white cheese. The reduction of product stiffness as a result of the addition of whey proteins in other dairy products such as ice cream [27] and yogurt [28] has also been reported.

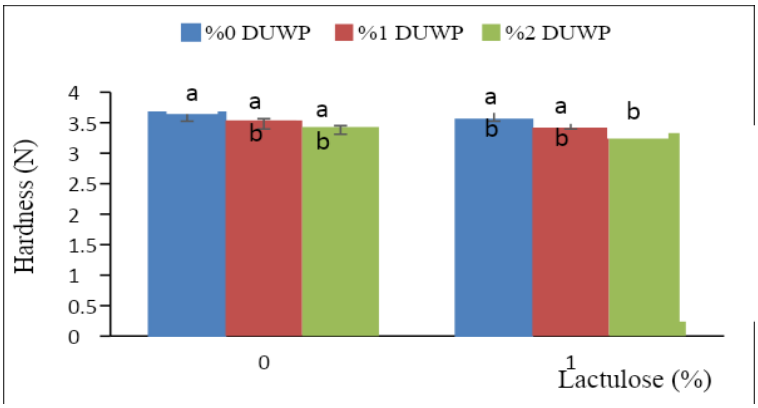


**FIG 1.** Effect of addition of demineralized ultrafiltrated whey powder (DUWP) and lactulose powder on hardness of synbiotic ultrafiltrated cheeses

### ۳-۲- Evaluation of cheese stickiness

Adhesion is the tendency of materials to stick to other surfaces. Results of the effect of adding powderDUWP and lactulose powder on the adhesive properties of different samples of ultra-purified synbiotic cheese during 60 days of storage at 4 degrees Celsius are shown in Tables 1 and 2.

The results show the non-significant effect of powder variablesDUWP, lactulose powder and storage time were on the stickiness of cheese samples (٠5/٠<*P*). The amount of stickiness of cheese samples due to the addition of powderDUWP and lactulose powder decreased to a small extent, which these changes lacked statistical significance. Also, the mutual effect of the variables on the amount of tissue adhesion was

insignificant (٠5/٠<*P*). The amount of adhesion in samples containing٠٠ ١ And٢ Powder percentageDUWP Respectively0.22, 0.21 and 0.19 were determined.The amount of adhesion of the samples due to addition٠ And١ The percentage of lactulose powder is also respectively٢١ /٠ And٢٠/٠ Was determined. Sarwar et al.]٢6[They attributed the decrease in adhesion to the increase in proteolysis. Based on the results of Nosrati et al]29[Add each of the powdersDUWP And lactulose increases the ratio of water-soluble nitrogen to total protein (as an indicator of proteolysis). Rashidi]30[Also, the increase in the amount of protein and the decrease in the amount of fat were considered to be the reason for the increase in the amount of stickiness of the cheese samples due to the increase in the internal strength of the rind particles. In another research, the researcher]23[reported that by increasing the amount of fermented cheese concentrate added to the milk used in cheese making, the stickiness of Iranian white cheese samples increased. The results showed that the storage time had no significant effect on the stickiness of the cheese samples. On the other hand, Abd-Rabo et al.31 [They stated that increasing the duration of storage had an effect on the decreasing process of adhesion.

**Table 1.** The results of analysis of variance (ANOVA) of the effect of demineralized ultrafiltrated whey powder (DUWP) and lactulose powder on texture characteristics of probiotic ultrafiltrated cheeses during 60 days storage at 4 °C

| Treatments | df | Mean Square | | | | | |
|---|---|---|---|---|---|---|---|
| | | Hardness | Adhesiveness | Cohesiveness | Springiness | Gumminess | Chewability |
| DUWP | 2 | $0.242^{***}$ | $0.003^{NS}$ | $0.019^{***}$ | $4.256^{NS}$ | $0.418^{***}$ | $125.128^{***}$ |
| Lactulose | 1 | $0.183^{***}$ | $0.003^{NS}$ | $0.009^{***}$ | $6.608^{NS}$ | $0.219^{***}$ | $84.480^{***}$ |
| Storage Time | 2 | $0.229^{***}$ | $0.005^{NS}$ | $0.002^{***}$ | $2.157^{NS}$ | $0.108^{***}$ | $37.996^{***}$ |
| DUWP× Lactulose | 2 | $0.000^{NS}$ | $0.000^{NS}$ | $0.000^{*}$ | $0.133^{NS}$ | $0.003^{NS}$ | $0.690^{NS}$ |
| DUWP×Storage Time | 4 | $0.019^{NS}$ | $0.000^{NS}$ | $0.000^{NS}$ | $0.055^{NS}$ | $0.008^{*}$ | $1.547^{NS}$ |
| Lactulose ×Storage Time | 2 | $0.003^{NS}$ | $0.000^{NS}$ | $0.000^{NS}$ | $0.059^{NS}$ | $0.002^{NS}$ | $0.256^{NS}$ |
| DUWP× *Lactulose* × *Storage Time* | 4 | $0.003^{NS}$ | $0.000^{NS}$ | $0.000^{NS}$ | $0.031^{NS}$ | $0.001^{NS}$ | $0.350^{NS}$ |
| error | 36 | 0.009 | 0.004 | 0.000 | 1.807 | 0.003 | 3.434 |

NS, *, ** and *** respectively indicate: non-significance, and significance at p<0.05 and p<0.01, p<0.001 levels.

**Table 2.** Texture characteristics of synbiotic ultrafiltrated cheeses containing demineralized ultrafiltrated whey powder (DUWP) and lactulose during 60 days storage at 4 °C

| Characteristics | Storage Time | *$P_0L_0$ (Control) | $P_1L_0$ | $P_2L_0$ | $P_0L_1$ | $P_1L_1$ | $P_2L_1$ |
|---|---|---|---|---|---|---|---|

| | (Day) | | | | | | |
|---|---|---|---|---|---|---|---|
| **Hardness (N)** | 1 | 3.59±0.17$^{Not}$ | 3.45±0.11$^{Babc}$ | 3.41±0.06$^{Abc}$ | 3.49±0.06$^{ABa}$ b | 3.39±0.05$^{ABbc}$ | 3.30±0.03$^{Bc}$ |
| | 30 | 3.89±0.08$^{Aa}$ | 3.67±0.07$^{Aabc}$ | 3.48±0.03$^{Acd}$ | | 3.55±0.17$^{Abcd}$ | 3.41±0.03$^{Ad}$ |
| | 60 | 3.54±0.15$^{Not}$ | 3.51±0.09$^{ABab}$ | 3.4±0.03$^{Acd}$ | 3.72±0.22$^{Oops}$ | 3.32±0.06$^{Bde}$ | 3.26±0.04$^{Be}$ |
| | | | | | 3.43±0.01$^{Bbc}$ | | |
| **Adhesiveness (N.mm)** | 1 | 0.25±0.05$^{Aa}$ | 0.23±0.05$^{Aa}$ | 0.22±0.05$^{Aa}$ | 0.23±0.06$^{Aa}$ | 0.22±0.05$^{Aa}$ | 0.20±0.05$^{Aa}$ |
| | 30 | 0.22±0.07$^{Aa}$ | 0.21±0.07$^{Aa}$ | 0.20±0.08$^{Aa}$ | 0.21±0.07$^{Aa}$ | 0.20±0.06$^{Aa}$ | 0.18±0.05$^{Aa}$ |
| | 60 | 0.21±0.07$^{Aa}$ | 0.20±0.08$^{Aa}$ | 0.19±0.08$^{Aa}$ | 0.20±0.07$^{Aa}$ | 0.19±0.07$^{Aa}$ | 0.16±0.06$^{Aa}$ |
| **Cohesiveness** | 1 | 0.36±0.02$^{ABa}$ | 0.34±0.005$^{AB}$ b | 0.30±0.01$^{And}$ | 0.35±0.01$^{ABa}$ b | 0.31±0.00$^{Bc}$ | 0.26±0.01$^{Ad}$ |
| | 30 | 0.38±0.01$^{Aa}$ | | 0.32±0.02$^{Ad}$ | | 0.33±0.01$^{Acd}$ | 0.28±0.02$^{But}$ |
| | 60 | 0.35±0.01$^{Not}$ | 0.35±0.003$^{Abc}$ | 0.31±0.01$^{And}$ | 0.36±0.01$^{Oops}$ | 0.30±0.01$^{Cc}$ | 0.27±0.00$^{Ad}$ |
| | | | 0.33±0.013$^{Bb}$ | | 0.33±0.01$^{Bb}$ | | |
| **Speringiness (mm)** | 1 | 14.34±1.00$^{Aa}$ | 14.00±1.07$^{Aa}$ | 13.62±1.25$^{Aa}$ | 13.81±0.92$^{Aa}$ | 13.32±1.02$^{Aa}$ | 12.59±1.26$^{Aa}$ |
| | 30 | 14.71±1.37$^{Aa}$ | 14.30±1.26$^{Aa}$ | 13.96±1.00$^{Aa}$ | 14.11±1.29$^{Aa}$ | 13.88±1.26$^{Aa}$ | 13.27±1.04$^{Aa}$ |
| | 60 | 14.21±1.26$^{Aa}$ | 13.77±1.90$^{Aa}$ | 13.26±1.62$^{Aa}$ | 13.66±1.35$^{Aa}$ | 12.91±1.76$^{Aa}$ | 12.30±1.94$^{Aa}$ |
| **Gumminess (N)** | 1 | 1.30±0.13$^{Not}$ | 1.16±0.04$^{Bbc}$ | 1.03±0.06$^{Ad}$ | 1.22±0.06$^{ABa}$ b | 1.07±0.01$^{Bcd}$ | 0.87±0.01$^{But}$ |
| | 30 | 1.48±0.00$^{Aa}$ | 1.28±0.01$^{Abc}$ | 1.11±0.05$^{Ad}$ | | 1.17±0.02$^{Acd}$ | 0.95±0.07$^{But}$ |
| | 60 | 1.24±0.04$^{Not}$ | 1.15±0.02$^{Bb}$ | 1.04±0.02$^{And}$ | 1.34±0.12$^{Ab}$ | 0.99±0.05$^{Cc}$ | 0.88±0.03$^{Ad}$ |
| | | | | | 1.14±0.04$^{Bb}$ | | |
| **Chewability (N.mm)** | 1 | 18.68±2.68$^{Aa}$ | 16.22±1.52$^{Oo}$ ps | 14.01±1.94$^{Ab}$ c | 16.94±1.87$^{Oo}$ ps | 14.23±1.27$^{AB}$ bc | 11.01±1.16$^{An}$ d |
| | 30 | 21.71±2.03$^{Aa}$ | | | | | |
| | 60 | 17.69±1.98$^{Aa}$ | 18.24±1.46$^{Ab}$ | 15.52±0.87$^{Ab}$ c | 18.94±3.05$^{Oo}$ ps | 16.29±1.65$^{Ab}$ | 12.61±0.97$^{An}$ d |
| | | | 15.79±1.98$^{Oo}$ ps | | | 12.76±2.00$^{Bb}$ c | |
| | | | | 13.81±1.93$^{Ab}$ c | 15.51±1.42$^{Oo}$ ps | | 10.87±1.89$^{An}$ d |

* P0, P1 and P2 are 0, 1 and 2% of whey permeate and L0 and L1 are 0 and 1% lactulose, respectively. Different small and capital letters indicate significant differences ($p<0.05$) in each row (treatments) and column (days) for each cheese characteristics, respectively.

### ۳-۳- Evaluation of cheese consistency

Coherence depends on the strength of internal bonds of the product, which is also expressed in cheese as the strength of internal bonds of casein micelles.Results of the effect of adding powderDUWP and lactulose powder on the consistency characteristics of different samples of ultra-purified synbiotic cheese during 60 days of storage at 4 degrees Celsius are shown in Tables 1 and 2 and Figure 2. The results indicate a significant effect of three powder variablesDUWP, lactulose powder and the duration of storage were on the consistency of the samples. Also nothingNo significant interaction was observed in terms of continuity between the tested variables(٠5/٠<*P*). Like the hardness of cheese, the consistency of the samples withIncreasing the amount of powderDUWP and lactulose decreased(٠٠١/٠>*P*). Average continuity in samples containing٠٠ ١ And٢ Powder percentageDUWP Respectively0.35, 0.32 and 0.29 and in samples containing ٠ And١ The percentage of lactulose powder respectively٣٤ /٠ And٣١/٠ Was determined.

Blue cheese powder increases the strength of internal bonds in the synbiotic cheese sample by establishing disulfide bonds with casein and increases its

cohesion. In accordance with the findings of this research, researchers such as Sarwar et al. [26] and El and Aza [32] investigated the effect of adding prebiotics on the cohesion of synbiotic samples. told. On the other hand, Jovandeh [23] reported in a research that the addition of blue cheese protein powder to production samples, by increasing proteolysis, causes a decrease in the consistency of the samples.

The results also showed that the consistency of the samples decreased significantly with the passage of storage time (0.001).>*P*). Contrary to the results of this research,Mahdavipour et al. [33] reported the trend of increased cohesion during the storage period in probiotic cheeses containing Bifidobacterium lactis strain and attributed it to the decrease in syneresis of the samples. The cause of this problem can be the weakening of the internal bonds in the structure of cheeses with high moisture and soft texture, which causes the irreversible change of the shape of the cheese against the pressure applied by the texture measuring device.

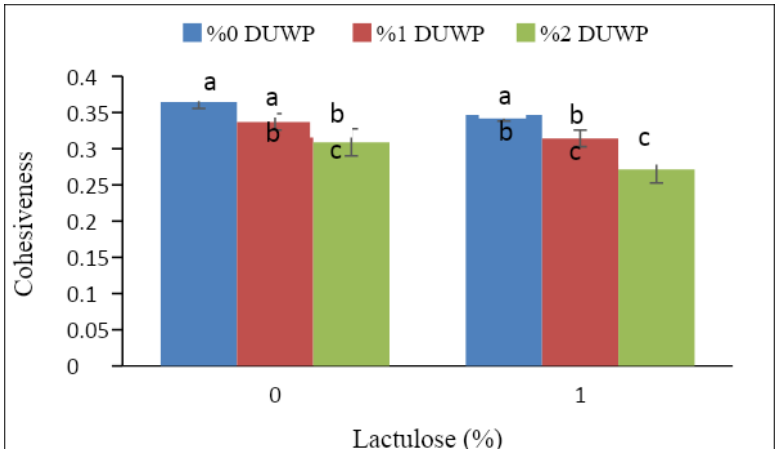


**FIG2.** Effect of addition of demineralized ultrafiltrated whey powder (DUWP) and lactulose powder on cohesiveness of synbiotic ultrafiltrated cheeses

### ۳-٤- Evaluation of cheese elasticity

Resilience or elasticity is the degree or intensity of returning to the original state after applying a small pressure in the mouth. Mechanically, resilience is the amount of deformation that the sample returns to its original state after applying pressure.۳4[. In the present study, the results of adding powderDUWP, lactulose and the duration of storage were checked on the elasticity and the results are in the tables۱ And۲ Is visible. As in the table۱ It can be seen, the effect of three powder variablesDUWP, lactulose powder and storage time were not significant on the elasticity. Also, the mutual effect of these variables on the elasticity was insignificant and lacked statistical significance. The amount of elasticity of the samples due to the addition of powderDUWP and lactulose powder in۳۰ On the first day, there was a slight increase in each sample and then a slight decrease until the end of the storage time (۰5/۰<*P*). The amount of elasticity in samples containing۰۰ ۱ And۲ Powder percentageDUWP Respectively14/14, 13/70 and 13/17 were determined.The degree of elasticity of the samples due to addition۰ And۱ The percentage of lactulose powder is also

respectively۰۱ /۱٤ And۳۲/۱۳ Was determined. In accordance with the findings of this research, Rashidi]30[ He stated that the addition of milk protein increases elasticity, but this increase was not statistically significant. seeker]۲3[In another research on the effect of adding water cheese fermentation concentrate on the textural characteristics of ultra-refined cheese, it was shown that increasing the amount of adding water cheese fermentation concentrate causes a decrease in the elasticity of Iranian white cheese samples. Adding whey proteins increases water absorption and loosens the cheese tissue and reduces the reversibility to the initial state after applying pressure. Azamboja et al.]۳5 [Also attributed the changes in the amount of elasticity during storage to the effects of proteolytic degradation of the protein matrix.

**۳-۵- Evaluation of the gum state of cheese**

Viscosity is the amount of energy required to break down a semi-solid food until it is ready for swallowing. Viscosity is the product of stiffness in continuity. Results of the effect of adding powderDUWP, lactulose powder and duration of storage on the gum characteristics of different samples of ultra-purified synbiotic cheese during 60 days of storage at 4 degrees Celsius are presented in Tables 1 and 2 and Figure 3. According to the results of the statistical analysis, the effect of these three variables on the viscosity of the produced cheese samples was significant. As in the table۱ It is visible the interaction of the powderDUWP And the duration of storage was significant on the amount of viscosity. The amount of viscosity duringThere was a significant increase in the first 30 days of storage and then a significant decrease until the end of 60 days of storage.

The amount of viscosity in samples containing۰۰ ۱ And۲ Powder percentageDUWP Respectively1.34, 1.14 and 0.98 were determined.The amount of viscosity of the samples due to addition۰ And۱ The percentage of lactulose powder is also respectively۲۰ /۱ And۰۷/۱ Was determined.Kinnik et al [36] investigated the effect of adding prebiotics and probiotics on the textural and aromatic characteristics of cheese produced from goat milk. They stated that although the viscosity of all samples changed indistinctly during storage, at the end of the period, a decreasing trend was observed in the viscosity of the samples. There is a direct relationship between the gum state of the samples and the hardness of the cheese; Therefore, according to the process of decreasing the hardness of the cheese samples at the end of the storage period, it is obvious that the reduction of the gum state at the end of the storage period is obvious. Also Goma [37] in the study of cheese texture changesUF During the storage period, he attributed the increase of textural indicators such as firmness and gum state during the initial period of cheese storage to the decrease in the moisture content of the samples and the decrease of these characteristics at the end of the storage period to the high proteolytic activity.

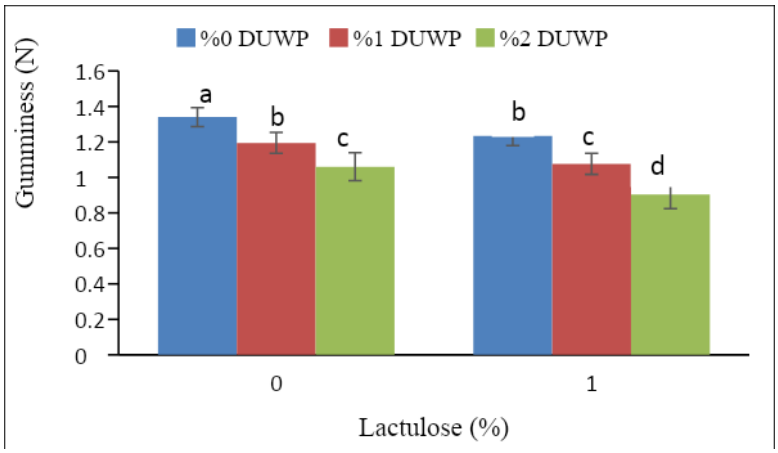


**FIG 3.** Effect of addition of demineralized ultrafiltrated whey powder (DUWP) and lactulose powder on gumminess of synbiotic ultrafiltrated cheeses.

### ۳-٦- Evaluation of cheese chewability

Chewability is the work required to chew and knead the samples during swallowing, which is obtained from the product of elasticity in the amount of gum. Chewability results during٦٠ Day of maintenance in the tables١ And٢ And also figure 4 is provided. The results are in the table١ It indicates that the effect of adding powderDUWP, lactulose powder and storage time are significant on chewability, while the mutual effect of these parameters was insignificant. Chewability as well as characteristics such as gum and firmness increased in the first 30 days of storage and then decreased until the end of 60 days of storage.

The amount of chewability in the containing samples٠٠ ١ And٢ Powder percentageDUWP Respectively18/24, 15/59 and 12/97 were determined.The amount of chewability of the samples due to addition٠ And١ The percentage of lactulose powder is also respectively٨٥ /١٦ And٣٥/١٤ Was determined.Increasing hardness values affects the process of chewing ability and causes an increase in chewing ability. The factors that affect the hardness of cheeses also affect the amount of chewability. The chewability of cheeses has a direct relationship with firmness and gumminess. In their studies, Fox et al [1] stated that at the end of the ripening period, the viscosity of the samples decreases, which is due to the hydrolysis of cheese compounds, especially the breakdown of proteins. Proteolysis leads to breaking and hydrolysis of insoluble para-casein molecules, and in turn, the compression of para-casein networks decreases and their solubility increases. Kinnik et al [36] in their studies considered the increase in the hardness of cheese samples as the reason for increasing the chewability and various factors such as the production method, milk composition, cheese moisture,pH, salt content, amount of lipolysis and proteolysis during ripening, culture type, probiotic bacteria and prebiotic strain used were found to be effective in this field.

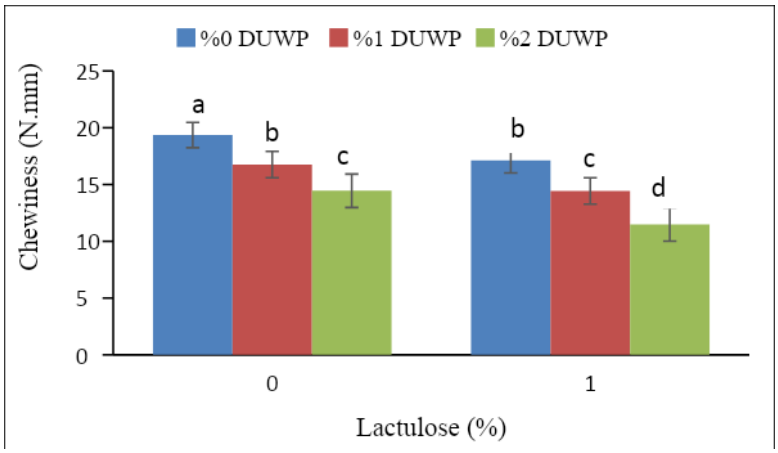


**FIG 4.** Effect of addition of demineralized ultrafiltrated whey powder (DUWP) and lactulose powder on Chewability content of synbiotic ultrafiltrated cheeses

### ۳-۷- Sensory evaluation

Sensory characteristics of the samples play a significant role in the acceptability of cheese by consumers. The two processes of lipolysis and proteolysis play an essential role in the sensory properties of cheese. It should be noted that the secondary changes that occur simultaneously with these processes are responsible for partial and general changes in the sensory characteristics of cheese. The main substrate of this process are caseins, lipids and soluble compounds in milk. With the passage of storage time, with the change of the microbial flora, the characteristics of the clot also change due to biochemical reactions, and because of this, new characteristics are created in the aroma, taste and texture of the samples.19[.

The results of statistical analysis of the effect of three powder variablesDUWP, lactulose powder and storage time on the sensory characteristics of cheese samples are shown in Tables 3 and 4.As in the table3 Visible, addDUWP and storage time cause significant changes (۰.۰۱/۰>*P*) in all sensory characteristics of cheese. Although the addition of lactulose powder did not have a significant effect on the texture of the cheese, it caused significant differences in other sensory characteristics of the cheese. In general, with increasing amounts of powdersDUWP and lactulose, the score of cheese sensory characteristics decreased. However, there is often a significant difference between the control sample andA sample of cheese containing 1% powderDUWP and one percent of lactulose It was not observed in different periods of maintenance.In addition, the results showed that there was no significant interaction between the tested variables.

**Table 3.** The results of analysis of variance (ANOVA) of the effect of demineralized ultrafiltrated whey powder (DUWP) and lactulose powder on sensory characteristics of low-fat ultrafiltrated synbiotic cheeses during 60 days storage at 4 ˚C.

| Treatments | df | Mean Square | | | |
|---|---|---|---|---|---|
| | | Odor | Taste | Color | Texture |
| **DUWP** | 2 | $0.731^{**}$ | $0.913^{**}$ | $0.764^{**}$ | $0.450^{**}$ |
| **Lactulose** | 1 | $0.342^{**}$ | $0.327^{**}$ | $0.150^{*}$ | $0.135^{NS}$ |
| **Storage Time (Day)** | 2 | $5.444^{**}$ | $5.283^{**}$ | $2.426^{**}$ | $8.813^{**}$ |
| **DUWP× Lactulose** | 2 | $0.019^{NS}$ | $0.051^{NS}$ | $0.001^{NS}$ | $0.003^{NS}$ |
| **DUWP×Storage Time** | 4 | $0.002^{NS}$ | $0.005^{NS}$ | $0.008^{NS}$ | $0.001^{NS}$ |
| **Lactulose ×Storage Time** | 2 | $0.006^{NS}$ | $0.002^{NS}$ | $0.033^{NS}$ | $0.004^{NS}$ |
| **DUWP×** *Lactulose × Storage Time* | 4 | $0.001^{NS}$ | $0.006^{NS}$ | $0.000^{NS}$ | $0.015^{NS}$ |
| **error** | 36 | 0.009 | 0.018 | 0.023 | 0.044 |

NS, * and ** respectively indicate: non-significance, and significance at $p<0.05$ and $p<0.01$ levels.

**Table 4.** Sensory characteristics of synbiotic ultrafiltrated cheeses containing demineralized ultrafiltrated whey powder (DUWP) and lactulose during 60 days storage at 4 ˚C.

| Characteristics (Score) | Storage Time (Day) | *$P_0L_0$ (Control) | $P_1L_0$ | $P_2L_0$ | $P_0L_1$ | $P_1L_1$ | $P_2L_1$ |
|---|---|---|---|---|---|---|---|
| **Odor** | 1 | $8.70\pm0.10^{Aa}$ | $8.62\pm0.10^{Aa}$ | $8.42\pm0.10^{A}$ b | $8.65\pm0.13^{A}$ a | $8.52\pm0.10^{O}$ ops | $8.22\pm0.08^{A}$ nd |
| | 30 | $8.00\pm0.13$ Not | $7.93\pm0.15^{Ch}$ apter | $7.67\pm0.06^{Bc}$ | $7.88\pm0.10^{C}$ hapter | $7.75\pm0.09^{Bb}$ c | $7.45\pm0.05^{Bd}$ |
| | 60 | $7.7\pm0.05^{Th}$ at | $7.58\pm0.10^{Ca}$ b | $7.33\pm0.06^{Cc}$ | $7.57\pm0.08^{C}$ b | $7.42\pm0.03^{Cc}$ | $7.07\pm0.08^{Cd}$ |
| **Color** | 1 | $8.58\pm0.13^{Aa}$ | $8.50\pm0.10^{Aa}$ | $8.17\pm0.15^{A}$ b | $8.55\pm0.13^{A}$ a | $8.50\pm0.20^{Aa}$ | $8.17\pm0.12^{A}$ b |
| | 30 | $8.27\pm0.16$ Not | $8.15\pm0.18^{No}$ t | $7.82\pm0.16^{B}$ bc | $8.13\pm0.13^{C}$ hapter | $8.03\pm0.06^{Ch}$ apter | $7.68\pm0.28^{Bc}$ |
| | 60 | $7.92\pm0.16$ That | $7.8\pm0.10^{Cab}$ | $7.58\pm0.14^{B}$ bc | $7.73\pm0.15^{Ca}$ b | $7.63\pm0.16^{Cb}$ c | $7.40\pm0.09^{Bc}$ |
| **Taste** | 1 | $8.92\pm0.08^{Aa}$ | $8.87\pm0.06^{Aa}$ | $8.57\pm0.16^{A}$ bc | $8.83\pm0.15^{O}$ ops | $8.77\pm0.13^{O}$ ops | $8.33\pm0.25^{A}$ nd |
| | 30 | $8.85\pm0.05^{Aa}$ | $8.78\pm0.03^{Oo}$ ps | $8.63\pm0.12^{A}$ nd | $8.78\pm0.03^{O}$ ops | $8.70\pm0.00^{A}$ bc | $8.25\pm0.09^{A}$ d |
| | 60 | $8.00\pm0.10^{Not}$ | $7.9\pm0.10^{Not}$ | $8.58\pm0.20^{B}$ bc | $7.90\pm0.17^{N}$ ot | $7.77\pm0.12^{Ch}$ apter | $7.36\pm0.24^{Bc}$ |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Texture** | 1 | 8.77±0.15 Aa | 8.72±0.24 Aa | 8.55±0.23 ops | 8.72±0.10 a | 8.65±0.15 ops | 8.32±0.21 b |
| | 30 | | 8.55±0.09 Aa | | | | |
| | 60 | 8.66±0.09 Aa | 7.422±0.24 Not | 8.27±0.13 b | 8.50±0.18 ops | 8.48±0.10 ops | 8.30±0.09 b |
| | | 7.53±0.25 Not | | 7.23±0.11 ot | 7.4±0.36 Not | 7.33±0.39 ot | 7.10±0.28 ot |

$P_0$, $P_1$ and $P_2$ are the levels of 0, 1 and 2% DUWP and $L_0$ and $L_1$ are the levels of 0 and 1% lactulose, respectively. Different small and capital letters indicate significant differences ($p<0.05$) in each row (treatments) and column (days) for each cheese characteristics, respectively.

On average, the color acceptability of the containing samples٠٠ ١ And٢ Powder percentageDUWP Respectively٢٠/٠٨ ١٠/٨ And٠٣/٨ was determinedAcceptability of the color of the samples due to addition٠ And١ The percentage of lactulose powder is also respectively٠٩ / ٨And٩٨/٧ was determined On average, the acceptability of the aroma of the samples containing٠٠ ١ And٢ Powder percentageDUWP Respectively٠٨/٠٨ 7/96 and 7/69 were determined.The amount of the aroma score of the samples due to addition٠ And١ The percentage of lactulose powder is also respectively٩٩ / ٧And٨٣/٧ was determined The acceptability of the taste of the containing samples٠٠ ١ And٢ Powder percentageDUWP Respectively٥٤/٠٨ ٤٦/٨ And١٢/8 was determined. Taste acceptability Examples due to addition٠ And١ The percentage of lactulose powder is also respectively٤٥/ ٨And٣٠/٨ was determined On average, the tissue acceptability of samples containing٠٠ ١ And٢ Powder percentageDUWP Respectively٢٦/٠٨ 8/19 And٩٦/7 was determined.The texture score of the samples due to addition٠ And١ The percentage of lactulose powder respectively 8/19 and 8/08 It was determined. Also, the acceptability of sensory characteristics decreased significantly with the passage of storage time.

Danesh et al.]38[ In the study of the effect of the use of whey protein concentrate on the sensory characteristics of ultra-refined cheese, they showed that the increase of whey protein concentrate up to٨% caused a significant increase in the sensory scores of the cheese samples, while increasing the concentration of the said concentrate had no special effect in this regard. Momenzadeh and colleagues]39 [Also, in confirmation of the results of this research, they reported a decrease in the sensory properties of synbiotic yogurt as a result of adding lactulose powder. In contrast, Golub et al.٤0 [They reported that the addition of prebiotics such as lactulose, inulin or a mixture of these two compounds, especially in dairy products, can increase the consistency and acceptability and can improve the mouthfeel.

## 4- Conclusion

The results of this research showed that the addition of powdersDUWP And lactulose caused a significant decrease in hardness, consistency, gummy state and chewability of synbiotic cheese samples, and as a result, the texture of the cheese became softer. Adding powdersDUWP and lactulose, although it caused a decrease in the score of the sensory characteristics of ultra-refined cheese samples, but often there was a significant difference between the control sample and the ultra-refined cheese sample.Synbiotic containing 1%powderDUWP and 1% lactulose powder did not see The texture characteristics and sensory properties of the cheese samples also changed significantly with the passage of storage time, and in general, the sensory scores and values of the

textural characteristics of the samples decreased with the passage of storage time.Considering the medicinal and health-giving properties of lactulose and the nutritional value of the powderDUWP،As well as the prebiotic properties of the two mentioned substances, the best sample should be selected in such a way that it does not have a significant difference in terms of the examined characteristics (tissue hardness and sensory properties) with the control sample; At the same time, it contains the most amount of powdersDUWP and lactulose. Therefore, a sample of ultra-processed synbiotic cheese contains ۱ Powder percentage DUWP And 1% lactulose powder was identified as an optimal sample.

## ۵- Appreciation

This research was done with the financial support of Khuzestan University of Agriculture and Natural Resources, and for this purpose, the authors express their gratitude. Also, the respected officials of Pegah Khuzestan factory and the research and development unit of the factory are appreciated for the production of cheese samples.

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**مقاله علمی_پژوهشی**

# ارزیابی ویژگی‌های بافتی پنیر فراپالوده‌ی سین‌بیوتیک حاوی پودر آب‌پنیر فراپالایش املاح‌گیری شده و لاکتولوز

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**چکیده**

امروزه، فرآورده‌های غذایی عملگرا به عنوان رژیم غذایی سلامت‌بخش به‌شکلی گسترده‌ای مورد توجه مصرف-کنندگان قرار گرفته است. همچنین، استفاده از میکروارگانیسم‌های خاص مانند باکتری‌های پروبیوتیک، امکان توسعه غذاهای نوین با قابلیت نگهداری مناسب را فراهم نموده است. در این پژوهش، به منظور تولید پنیر فراپالوده فراسودمند از پودر آب‌پنیر فراپالوده با املاح کاهش یافته (DUWP) در سطوح ۰، ۱ و ۲ درصد و پودر لاکتولوز در سطوح ۰ و ۱ درصد به عنوان ترکیبات پری‌بیوتیک استفاده گردید. به‌علاوه، از باکتری‌ها *بیفیدوباکتریوم بیفیدیوم* به‌عنوان باکتری پروبیوتیک استفاده شد. ویژگی‌های بافتی شامل سفتی، پیوستگی، چسبندگی، ارتجاع‌پذیری، حالت صمغی و قابلیت جویدن و خواص حسی شامل رنگ، رایحه، بافت و طعم نمونه‌های پنیر سین‌بیوتیک در طی ۶۰ روز نگهداری (۱، ۳۰ و ۶۰ روز) در دمای ۴ درجه‌ی سانتی‌گراد مورد ارزیابی قرار گرفت. نتایج نشان داد که افزودن پودر DUWP و پودر لاکتولوز به‌غیر از چسبندگی و حالت ارتجاعی سبب کاهش قابل توجه مقادیر ویژگی‌های بافتی شد ($P<۰/۰۰۱$). همچنین به‌طورکلی، به‌غیر از ویژگی چسبندگی و پیوستگی، سایر مقادیر پارامترهای بافت تا اواسط دوره نگهداری افزایش و پس از آن کاهش یافت. نتایج حسی نیز نشان داد که هرچند افزودن پودرهای DUWP و لاکتولوز سبب کاهش ویژگی-های حسی گردید، اما اختلاف معنی‌داری در اکثر موارد میان نمونه شاهد (فاقد پودرهای DUWP و لاکتولوز) و نمونه حاوی ۱٪ از هر یک از پودرهای مذکور مشاهده نگردید ($P>۰/۰۵$). بنابراین، براساس نتایج به دست آمده، نمونه سین‌بیوتیک حاوی ۱٪ پودر DUWP و ۱٪ پودر لاکتولوز به عنوان بهترین نمونه پنیر سین‌بیوتیک فراپالوده مشخص گردید. با توجه به پتانسیل این محصول در ارتقای سلامت جامعه و کاهش ابتلا به بیماری، تولید و مصرف این پنیر عملگرا پیشنهاد می‌گردد.