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Effect of Pectin Hydrocolloid on Quality Characteristics and Shelf-life of Industrial Liquid Kashk during Refrigeration Storage

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ABSTRACT

Kashk is a well-known acid-fermented dairy product with high nutritional value widely consumed in Iran. The main problem with liquid Kashk is phase separation, potentially affecting its rheological textural and microbial quality during storage. In the present study, pectin hydrocolloid was used as a stabilizer in liquid Kashk formulation, and their effects on the physicochemical (pH, acidity, water holding capacity, syneresis, color), textural (hardness), and sensory attributes of the product were investigated during 60 days storage at 4 ˚C. Four batches of liquid Kashk were prepared using the following formulations: Control (without stabilizer), and P-0.1, P-0.2, and P-0.3 were incorporated with 0.1, 0.2, and 0.3 % (w/w) pectin, respectively. During storage, pectin addition resulted in higher acidity and lower pH of the Kashk, compared to Control. P-0.2 and P-0.3 samples exhibited the highest water-holding capacity and the lowest syneresis compared to the control and P-0.1 samples throughout the storage period. The addition of pectin positively affected the hardness of the samples. With an increase in pectin concentration, the hardness of the samples increased, and from day 30 of storage onwards, the hardness of the P-0.2 and P-0.3 formulations was significantly higher than that of P-0.1 and the Control ($P < 0.05$). Color attributes, including lightness, yellowness, and whiteness index of samples, were influenced considerably by fortification with pectin. Mold and yeast count, as well as the coliform count of samples, were negative during storage. In sensory evaluation, visual syneresis, texture and consistency, color and appearance, and overall acceptability scores were influenced by the concentration of the stabilizer. The highest overall acceptance scores during sensory evaluation belonged to the P-0.3. The results indicate that adding pectin can positively impact the quality characteristics of Kashk.

1. Introduction

Curd is one of the known fermented dairy products that contains a high amount of quality protein (55-70 percent), calcium and phosphorus, which can be used as an extremely beneficial food for most age groups, especially children and pregnant and lactating women. be considered [1]. In Iran, curd is one of the most popular dairy products and is actually considered an inseparable part of many traditional dishes. Curd in Iran is available in two forms, liquid and dry, and in the second case, generally, it should be soaked and softened before being consumed [2]. Liquid curd and industrial liquid curd are the most common types of curd produced in Iran. According to the national standard of Iran No. 2452 [3], liquid curd is prepared after soaking the traditional dry curd for a sufficient period of time and then adding specific amounts of water and salt if needed, and then the curd is ground by industrial machines and before packaging. It is subjected to thermal processes [4]. According to Iranian National Standard No. 6127 [5], industrial liquid curd, which is a by-product of dairy factories, after fermentation and concentration of milk or its fermented by-products (whole milk, low-fat milk, fat-free milk, skimmed milk, buttermilk, buttermilk, whey or a mixture of them) is produced by industrial methods and then by adding whey powder and salt, the thermal process and packaging are completed [2,4].

One of the challenges in the production and storage of pasteurized liquid curds is phase separation[1] and water launch[2] It occurs gradually in the product. This separation not only negatively affects the taste and sensory characteristics of the product, but also increases the possibility of the growth of microorganisms. Therefore, the production of liquid curd with the desired consistency and stability is one of the challenges of the dairy industry [6]. In addition, phase separation is easily and qualitatively detectable by visual observation and thus can affect customer satisfaction [7]. Therefore, the dairy industry has always been looking for an effective solution to reduce the possibility of phase separation and water formation and to improve the rheological characteristics of the product. Polysaccharide gums as stabilizers[3] They are usually added to dairy products and other foods containing milk proteins, with the aim of improving viscosity and changing textural characteristics. The effect of these hydrocolloids in increasing water holding capacity and texture stability has been proven in acidic dairy products such as yogurt, buttermilk, kefir and dried yogurt [8-12]. Modifying the formulation of fermented dairy products with polysaccharides with thickening and gelling capabilities not only improves their physicochemical characteristics and storage stability, but also preserves their organoleptic characteristics for a longer period of time [6].

Despite the fact that liquid curd is one of the most widely consumed dairy products in Iran, but limited research has been done in the field of improving the physicochemical characteristics and shelf life of this product by using food stabilizers. Among the researches carried out in this field is the use of psyllium hydrocolloid gel[4] to the extent of 0.1-0.75 percent [6], modified starches at three levels of 0.5, 1 and 1.5 percent [4] and Katira gum at the level of 0.1-0.3 percent] [2] pointed out that in all the mentioned studies, the positive effect of hydrocolloids on textural characteristics and the reduction of phase separation and dewatering and the appropriate concentrations of each of them to create desirable characteristics have been mentioned.

Hydrocolloids such as pectin have many uses in the dairy industry. Pectin is also considered a heteropolysaccharide that is mainly found in plant cell walls and does not have a single structure. Pectin is composed of subunits such as homogalacturonan, rhamnogalacturonan I, rhamnogalacturonan II and xylogalacturonan and is used as a gelling agent, thickener, stabilizer and emulsifier in the food industry [13]. A report on the use of pectin gum in curd was not found in scientific sources. Considering the acceptable effect of this stabilizer in improving the textural and qualitative characteristics of other dairy products and foodstuffs, in this study the effect of different concentrations of pectin gum on the physicochemical, microbiological and sensory characteristics of liquid curd during a 60-day storage period in the refrigerator was investigated. took

2- Materials and methods

1-2- Materials

1 - Phase separation
2 - Syneresis
3 - Stabilizer
4 - *Plantago ovata*research

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Culture mediums required to perform microbial tests including YGC culture medium[5] (Ibresco, Karaj, Iran) and Violet Red Bile Agar[6] (VRBA) were obtained from Ibresco Company (Karaj, Iran) and Merck Company (Merck, Darmstadt, Germany), respectively. Brand name pectinVidopectin FA 2750 from UNIPECTIN brand (Switzerland) was purchased According to the manufacturer's information, the origin of this pectin is citrus peel and it is of the amidated type with low methoxyl degree and high reactivity with calcium.[7] is. The recommended class of the manufacturer of this product is suitable for use in dairy products such as yogurt. Other chemicals used including sodium hydroxide, phenolphthalein were also purchased from Merck (Darmstadt, Germany) and sodium chloride from Dr. Majalli Chemical Industries Complex (Tehran, Iran).

2-2- Curd preparation

Liquid curd was prepared at Ramek Dairy Factory (Shiraz, Iran). The curd prepared for the present research was industrial liquid curd, which according to the national standard of Iran No. 6127 [5], the possibility of using traditional dry curd up to 5 percent is allowed. Traditional dry curd was purchased and made in the factory using the Artisan 5000 mill (Sina Tehiz, Tehran, Iran).) It turned into powder. Yogurt is already made using X16 yogurt starterwas prepared Powdered curd (2 percent of the total formula) was added to yogurt (91.5 percent of the total formula). Then the resulting mixed protein was adjusted to 8 percent by adding milk protein concentrate containing 70 percent protein (6.5 percent of the total formula). Pectin with concentrations of 0.1, 0.2 and 0.3 percent w/w was added in powder form and little by little. A formulation without pectin was also produced as a control sample. Next, the temperature of the resulting mixture was raised to 60 degrees Celsius and it was homogenized using a two-stage homogenizer system at a pressure of 150 bar. The pasteurization process was done intermittently at 85°C for 30 minutes. The prepared curds were sealed in 100g polyethylene containers by hot filling method and then kept in refrigerator temperature for 60 days. The chemical composition of curd on the day of production, including percent protein, dry matter and salt, was determined by relevant methods [5 and 14]. Therefore, a total of 4 batches of 3 kg of curd were prepared as control (without thickener), P-0.1(contains 0.1 percent pectin), P-0.2(contains 0.2 percent pectin) and P-0.3(containing 0.3 percent pectin) were named. Table 1 shows different types of curd formulations and their components. During the storage time, various qualitative tests were performed on the samples at 15-day intervals

2-3- Curd quality tests

2-3-1- Curd chemical tests

The overall chemical composition of the produced curd was determined based on the national standard of Iran [15]. percent salt, protein and dry matter respectively 0.32± 1.45 percent, 0.60 percent± It was 7.53 percent and 20.41 percent. Other chemical tests of curd were performed during the storage period, which are mentioned below.

1-1-3-2- pH measurement

According to the instructions of the national standard of Iran (No. 2852, 1385), in order to measure the pH, the electrode of the PM12E pH meter device (Fan Azma Gostar, Karaj, Iran) was placed directly in the sample container. The pH of the samples was determined using a pre-calibrated pH meter at ambient temperature. For each reading, the electrode was in contact with the sample for about 1 minute until stabilization [15]. Measurements were made on three different dishes of each treatment.

2-1-3-2- titratable acidity measurement[8] (FACING)

Curd TA was measured by the titration method with sodium. 10 grams of the curd sample was weighed in an Erlenmeyer flask and 10 ml of water was added to it and the sample was stirred well. Then 5 drops of phenolphthalein reagent (1% solution in ethanol) were added and the titration continued with 1 normal solution until the appearance of a stable pink color (5 seconds). The amount of TA in grams of lactic acid in 100 grams of curd sample was calculated with the following equation:

$$TA = \frac{N \times 0.009 \times 100}{M} \quad (1)$$ equation

In the above relationship, N is the amount of milliliters of consumed profit and M is the initial weight of the sample. Also, 0.009 grams of lactic acid is equivalent to one milliliter of 0.1 normal soda consumed according to the formula.

5 - Yeast Extract Glucose Chloramphenicol Agar
6 - Violet Red Bile Agar
7 - LM amidated pectin, citrus, high calcium reactive
8 - Titratable acidity

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TA is the amount of acidity in terms of percentage of lactic acid [16].

2-3-2- Physical tests

1-2-3-2- water storage capacity[9] (WHC) and launching

The WHC of curd samples was measured using a centrifuge. In each measurement, 5 grams of the sample was weighed inside the falcon and the weight of the empty falcon, the sample and the total weight of the sample and the falcon were recorded. The samples were centrifuged at 10°C with 4500 rpm for 30 minutes.Model TL 320 (Selecta lab, Barcelona, Spain) became. Finally, the upper phase was carefully emptied and the total weight of the falcon and sediment was recorded. WHC was calculated with equation 2:

$$WHC\ (hundred\ doors) = [1 - (Mp / Mi)] \times 100$$ Equation (2)

where inM_i AndMp respectively, the initial weight of the sample and the Romand weight were separated [17, 18].

To measure the water content of the curd samples, the same procedure was used to measure the WHC. with the difference that the act of centrifugation by the model device MIKRO 22 R (Hettich Zentrifugen, Germany) at 4°C and equivalent RCFg 222 was done for 10 minutes. After that, the supernatant was discarded and the precipitate was weighed. Equation 3 was used to measure watering:

%water launch=
$$[W_i - W_p]/W_i \times 100$$

where inIN_i AndIN_p respectively, the initial weight of the sample and the weight of the remaining pellet [19].

2-2-3-2- size paint

The color measurement was done immediately after opening the packages. Curd samples were poured into a completely clean glass plate of the machine and the color of the samples was measured with a colorimeterNO Colorflex (Hunter Associates Laboratory, Inc, Virginia, United States) By reading invoices$L*$ (light),$a*$ (red) and$b*$ (yellow) after calibrating the device with a white plate (1.43=$b*$، 96/0- $a*$= and 06/91=$L*$) was determined. The reported values are the average of 3 measurements for each group per day. whiteness index[10] It was determined by equation 4:

$$WI = L^* - 3b^*$$ Equation (4)

In this regard$L*$ And$b*$ respectively, the values related to brightness and yellowness of each treatment are measured at each time [20].

3-2-3-2- Determining texture characteristics

Measuring the hardness of curd samples usingCT3 4500 tissue measuring device (Brookfield, Middleboro, MA, USA) And it took place in Shahrekord branch of Islamic Azad University. The histometer was equipped with a TA25/1000 probe with a cell load of 4.5 kg. Samples by back extrusion method[11] and were analyzed with a speed of 0.5 mm/s during two compression-decompression cycles. Stiffness was calculated using the device software and from the TPA curve. Texture tests were performed in 3 separate replications for each curd formulation on days 1, 15, 30, 45, and 60 of storage.

2-3-3- Microbial tests

In this research, the microbial tests performed on the curd samples included the total count of mold, mold, and yeast, which were performed on the 1st, 15th, 30th, 45th, and 60th days of storage. On the days of the experiment, 3 samples of each treatment were weighed under open sterile conditions and 10 grams of curd samples were weighed with a spoon sterilized with 70 percent alcohol. 90 ml of sterile physiological serum was added to the sample and by shaker device مدلZX3 (VELP Scientifica, Italy) They were homogenized for 5 minutes at room temperature. On the test days, the appropriate dilutions ($^{1-}$10 to^{3-}10) It was prepared from a homogenized sample using sterile physiological serum and used to count microorganisms. VRBA culture medium and pour plate method were used to count the total form. The plates were incubated at 30°C for 24 hours and then dark red colonies (with an approximate diameter greater than 0.5 mm) were counted. Results in CFU Log per gram of sample reported [21]. To count mold and yeast, surface

9 -Water-holding capacity
10 - Whiteness index
11 - Back extrusion

culture method and YGC agar culture medium were used. After culturing the appropriate dilutions, the plates were incubated at 25°C for 3 days. Results in terms of CFU/g Log in gram sample reported [22].

2-3-4- Sensory tests

Sensory evaluation of curd samples was done on days 1, 30 and 60 of the storage period. This test was carried out by 18 sensory evaluators, including students, employees of Shahid Chamran University of Ahvaz, as well as employees of Ramek Company (7 men and 11 women with an average age of 37). In order to perform the sensory evaluation, curd samples with random numbers were given to each of the evaluators and they were asked to evaluate the samples in terms of color and appearance, smell, taste, texture and consistency, apparent wateriness and overall acceptance. The samples were evaluated by each evaluator after opening the package. In the intervals between the samples, the evaluators were asked to rinse their mouth with water. The mentioned qualitative traits were evaluated with the 5-point hedonic method. The scoring method was as follows: 5 points: very good, 4 points: good, 3 points: acceptable, 2 points: bad, 1 points: very bad. The average score of 3 was considered as the acceptance or rejection threshold of the sample in terms of sensory evaluators**.**

4-2- Statistical analysis

The effect of different concentrations of pectin (0.1, 0.2 and 0.3 percent), storage time and their mutual effects on the quality characteristics of curd using ANOVA analysis of variance (complete designrandom) with the generalized linear model procedure[12] (GLM) itemwere investigated. Comparison of averages with Tukey's method[13] at a confidence level of 95 percent using Minitab software[14] version 16 (*Minitab Inc.; State College, PA, deer*) Done. All physicochemical and microbial tests were performed in three replicates (on three separate packages). Results based on average± Standard deviation was reported. Graphs were drawn with Excel software. In the sensory evaluation section, considering that the responses were of rank type, from the non-parametric Kruskal-Wallis test[15] was used and comparing the means with Mann-Whitney special test[16] occurred.

3. Results and Discussion

1-3- titratable pH and acidity changes

In the samples containing pectin on day 1, a significant difference was observed with the control sample in terms of pH values, and in general, with the increase in pectin content, the pH of the samples decreased more than the control sample (Figure 1). After 15 days of storage, the pH of pectin-containing samples decreased (0.05).*P* <) and this reduction continued until the last day of storage. In samples containing pectin, a significant difference was observed between the pH of different days of storage of P-0.1 and P-0.2 samples, and the pH of each of these samples decreased significantly. However, until the 45th day of storage, no significant difference was observed between P-0.1 and P-0.2 in terms of pH values (0.05*P* >). The pH of P-0.3 sample on days 1, 15 and 60 of storage was significantly lower than the other two samples containing pectin (Figure 1). On the 60th day of storage, the pH of control samples, P-0.1, P-0.2, and P-0.3, respectively, decreased by 0.55, 0.54, 0.56, and 0.60 compared to day 1.

In samples containing pectin, on the 1st day of storage, a significant difference was observed between the control sample and P-0.1 with P-0.2 and P-0.3 (0.05*P* <) (Figure 2). From the 30th day of storage onwards, the highest level of acidity was observed in P-0.3 sample and no significant difference was observed between P-0.1 and P-0.2 (0.05*P* >). On the last day of storage, the acidity values of the samples containing 0.3 and 0.2 percent pectin were significantly higher than the control sample. On the 60th day of keeping the acidity values of P-0.1 samples، P-0.2and P-0.3It increased by 56.06, 66.93 and 72.14 percent, respectively, compared to day 1, while in the control sample, the increase in acidity was 52.08 percent. No significant difference was observed between the acidity values of each sample containing pectin on the 15th and 30th days of storage (0.05*P* >).

According to Iranian National Standard No. 2852 [15], pH and acidity are among the important qualitative parameters of curd, whose changes should be investigated during the curd storage period. In this study, pH and acidity had an inverse relationship with each other. The

- General linear model[12]
- Tukey's test[13]
- Minitab[14]
- Kruskal Wallis test[15]
- Mann-Whitney[16]

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addition of pectin gum was associated with a slight decrease in pH compared to the control sample on the first day of storage, and part of this difference can be attributed to the characteristics and nature of the pectin powder used. Pectin has somewhat acidic properties due to the presence of galacturonic acid units, and the pH of this powder is 1.4-6.4 according to the analysis sheet provided by the manufacturer. In general, the acidity of the pH and the high acidity of the curd samples is due to the fact that most of the formulation of these curds is yogurt (91.5 percent) and a small amount of it is dry curd powder (2 percent), which naturally has pH is acidic. According to the national standard of Iran No. 6127 [5], the maximum pH and minimum acidity (in terms of lactic acid percentage) in industrial liquid curds should be 4.2 and 1.3 percent, respectively. According to figures 1 and 2, the pH and acidity of all the curd samples are in accordance with the mentioned standard characteristics. The high acidity of the curd samples is related to the continued fermentation of the remaining lactose. These results show that despite the pasteurization of fermented products, some heat-resistant lactic strains survive and cause an increase in acidity and a decrease in pH with their activity during the storage period [23].

In adding modified tapioca starchContains cross-linked phosphorylated tapioca starch[17] (CLTS), tapioca starch with octenylsuxenyl substituted groups[18] (OSTS) and tapioca starch with hydroxypropyl groups[19] (HPTSپ (In the curd formulation, on the first day of storage, the addition of starch at different levels (0.5, 1 and 1.5 percent) significantly increased the acidity values. pH and acidity of samples containing HPTS did not show much changes. The range of changes in the pH of the samples on the first day was 3.78-3.87, which reached 3.58-3.70 on the 60th day of storage, and the acidity range was 1.72-1.80 on the 1st day, which reached 88. 1-80/1 percent arrived at the end of maintenance. The acidity of all samples increased significantly from day 1 to day 60, which was associated with a decrease in pH in the samples. The increase in acidity in the presence of polysaccharide compounds was attributed to the increase in the viability of lactic acid bacteria and the conversion of lactose into lactic acid [4]. Curd samples containing hydrocolloid gel obtained from psyllium (*Plantago ovata* Forsk) (PHG) in concentrations of 0.75– 0.1 percent and different ratios of dry curd powder (DKP) (15-25 percent) were investigated in terms of pH changes. The results showed that both factors had a significant effect on pH values, and the highest pH values were observed in samples containing 15 percent of dry curd and 0.75 percent of PHG. Changes in pH were attributed to fermentation by lactic acid bacteria and these changes were less in samples containing lower amounts of DKP due to lower lactose content. The increase in the amount of PHG was associated with the increase in the pH values of the samples, which was attributed to the increase in the viscosity of the environment, the lack of oxygen, and the decrease in the transfer rate of substrates such as lactose to bacteria, and as a result, the lactic fermentation process slowed down [6].

2-3- Water storage capacityand water launch

Phase separation is the spontaneous release of water from the body of products such as yogurt or curd, which is caused by the weak gel network of the product. WHC is actually the tendency of products to retain water or its resistance to water phase separation. Changes in these two characteristics should be monitored during storage [24]. The results of the analysis of variance showed that the type of treatment, storage time and their mutual effects had a significant effect on water softening and WHC of curd samples (0.05*P* <). A control sample showed the highest amount of watering on different days of the experiment, so that the amount of watering on the 1st day of the experiment was 1.02± It was 20.80% and after 60 days of storage, it increased significantly and reached 1.06.± It reached 39.36 percent (Figure 3). Samples containing pectin were able to delay the process of watering compared to the control sample. On the 1st day of the experiment, the amount of water in the samples containing pectin varied between 77.77-15.38 percent. On the 15th day of maintenance, the watering rate in the P-0.1 sample was not significantly different from the control sample (0.05*P* >) and in an interval of 30 to 60 days, no significant changes were observed in terms of the amount of watering in this sample (0.05*P* >). In P-0.2 and P-0.3 samples, despite the significant decrease in watering compared to the control sample, the percentage of watering did

- phosphorylated cross-linked tapioca starch[17]
- Octenyl succinic anhydride substituted tapioca starch[18]
- Hydroxypropylated tapioca starch[19]

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not have a constant trend during the test days and increased until the 30th day of storage and then decreased. On the last day of storage, the amount of watering in P-0.1, P-0.2, and P-0.3 samples decreased by 41.41, 52.83, and 75.59 percent, respectively, compared to the control sample (Figure 3).

The samples containing pectin also had high WHC, so that on the 1st day of storage, the WHC values varied between 19.95-91.36 percent, which was significantly higher than the control sample (0.72).± 88.04 percent) (0.05*P* <). Samples containing pectin had higher WHC values than the control sample on all test days (0.05*P* <) and the WHC values of samples P-0.1, P-0.2 and P-0.3 were variable between 90.02-92.81 percent, 93.30-94.76 percent and 95.96-19.47 percent, respectively. was (Figure 4). There was no significant difference between the WHC values of each P-0.3 and P-0.2 samples between different days of the experiment (0.05*P* >) and indeed their WHC did not show significant changes over time. Watering of curd samples, especially the control sample, gradually increased during its storage time. One of the main reasons for liquefaction in products such as curd as a concentrated yogurt containing high percentages of salt is the rearrangement of the casein network of yogurt in the formulation due to strong protein-protein interactions, which causes a decrease in the WHC of proteins and as a result, an increase in liquefaction during It takes time [2, 25].

The higher amount of water in samples containing pectin in the first days of storage can be attributed to the formation of fewer hydrogen bonds between pectin and water. During the storage period and especially from the 30th day of storage onwards, these bonds increased and the amount of watering decreased compared to the 15th and 30th days of storage, and pectin showed a better performance in controlling the watering process. In polysaccharides such as pectin, which are anionic in nature, the stabilization mechanism of dairy products is different. Pectin is one of the hydrocolloids that can stabilize dairy products by forming a gel. Gel formation is the random connection of polymer components dispersed in a dispersion in such a way that it forms a three-dimensional network that accommodates water in its spaces. The condition for the formation of this gel network is the presence of connection points between two polymer strands. The mechanism of gel formation by pectin, which is an anionic polysaccharide, is ionic gelation in which hydrocolloid chains establish cross-links with cations. Pectin can form thermally reversible gels at acidic pH [26]. Also, due to the presence of charge in their structure, such anionic hydrocolloids can react with positively charged particles such as the charges in casein micelles and help strengthen the casein network through polysaccharide-protein interactions [4]. This study is of the type with low methoxyl degree. In LM pectins, about 20-40% of carboxyl acid groups are methylated and therefore have a large number of free acid groups to bind to divalent ions. This group is able to form a gel in a wide range of pH (2-6) both in the presence and without the presence of sugar, but the necessary condition for the formation of a gel by this group is the presence of calcium ions (Ca^{+2}) is. If enough transverse connections are made between acidic groups and divalent ions, a three-dimensional network is obtained that can trap water and form a gel [27]. In a study by Shiroodi et al. [2], the effect of different percentages of katira gum (0.1-0.5 percent) on the occurrence of water in low-fat curd was evaluated, and the results showed that with the increase in the concentration of katira, its effect on the prevention of water increased and the highest amount was observed in curd containing 0.1 percent of katira. The performance of Katira was attributed to the increase in the viscosity of the continuous phase and the trapping of the accumulated casein particles. In another study, the effect of adding citrus fiber rich in pectin at two levels of 0.1 and 1 percent in the form of soft powder and coarse particles was evaluated on the liquefaction of molded yogurt. The results showed that in all the fibers in both forms were able to strongly inhibit saturation and especially in yogurt containing fibers with coarse particles, no saturation was detected and the highest amount of saturation was observed in the control sample. The ability of these fibers to inhibit waterlogging was attributed to the stabilization of water by the insoluble components of the fiber network and the gel formation of pectin components in the fiber [28].

3-3- Color parameters

Color is one of the most important factors in the marketability of dairy products. Enrichment of dairy products should be associated with minimal changes in appearance characteristics during processing and storage [29, 30]. Table 2. Measured values for factorsL^*، b^* and whiteness index (*WI*) shows different formulations of liquid curd during 60 days of storage. It should be noted the changesa^* It was

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not significant during the storage time in any of the treatments (0.05*P* >). The results of analysis of variance showed that the type of formulation, storage time and their mutual effects had a significant effect on all three color factors of curd samples (0.05*P* <). In samples containing 0.2 and 0.3 percent pectin on day 1 and 15, the factor values*L** It decreased significantly compared to the control sample (0.05*P* <). On the 30th day of storage, there was a significant difference between the control samples and all samples containing pectin powder (0.05*P* <) but the difference between the values*L** P-0.2 and P-0.3 samples were not observed (Table 2). in 45 days of maintenance*L** The control sample was significantly lower than the samples containing pectin (0.05*P* <) but no significant difference was observed between the control sample and P-0.2 on the 60th day of storage (0.05*P* >). Also, the results indicate that there is a significant difference between the values*L** On different days of the test, each of the samples contained pectin. The highest amount in control samples*L** It was related to the 30th day of storage and then decreased, while in the samples containing pectin, this amount was observed on the 45th day of storage and then gradually decreased (Table 2).

Adding pectin to curd formulation with a significant reduction of factor*b** It was compared to a control sample. Part of the observed color change and increase*b** can be attributed to the white color of the pectin powder used, which is stated as Cream to white in the analysis sheet provided by the manufacturer. On day 1, curds containing pectin powder have amounts*b** were lower than the control sample, but no significant difference was observed between the effect of different levels of pectin powder on this factor (0.05*P* >). On other test days, a significant difference was observed between the samples containing different levels of pectin (0.05).*P* <) so that the P-0.3 sample has the highest amount and the P-0.1 sample has the lowest amount*b** appropriated Except for P-0.1 sample, in other two samples containing pectin, with increasing storage time*b** increased significantly (0.05*P* <). Changes *b** In the control sample and P-0.3, it did not show a clear trend, in the P-0.1 sample, despite a slight decrease*b** Between days 1 and 15, a significant increase in these values was observed on other test days (0.05*P* <). In P-0.2 samples, there is a significant increase*b** We were during the maintenance period

WI is one of the important color characteristics in white food products, and since liquid curd with white color is known to be creamy, therefore, this index has values in hand.*L** And*b** Was calculated. On all days of the experiment, the P-0.1 treatment had the highest WI values. Also, with an increase in pectin percentage, the WI index decreased on all test days, due to the increase*b** and reducing values*L** Is. Except for the 30th day of storage, the control sample showed the lowest WI values and had a significant difference with the samples containing pectin. The WI changes of sample P-0.1 did not have a regular trend over time, but the highest amount was observed on day 15, which was not significantly different from day 45 (0.05*P* <). On day 30, P-0.1 and P-0.2 had the highest WI values, but no significant difference was observed between the control sample and P-0.2 (0.05*P* >). In P-0.2 and P-0.3 samples, a gradual increase in WI was observed until the 45th day of storage, after which it decreased significantly (0.05*P* <) (Table 2). In general, although the color characteristics of curd samples showed significant changes with the addition of pectin, these changes could not be detected by eye. Therefore, the acceptability of the product is not affected, which is evident in the sensory evaluation results.

In a study of adding psyllium hydrocolloid gel (PHG) and dry curd powder on the factor*L** Liquid curd samples were examined during storage. The results showed that at a constant level of dry curd, the amount of PHG increased with a significant decrease*L** was with us. The researchers acknowledged that the size of the particles in a colloidal system strongly affects the ability to scatter light. As a result of electrostatic interactions between PHG and casein micelles, at the level of 0.5% PHG, a large number of small particles were formed, which are able to scatter more light. However, at higher concentrations of hydrocolloid, due to the increase in the amount of anionic polysaccharides not absorbed on the casein micelles, the repulsion rate increased and the particle size increased, and as a result, the amount*L** decreased [6]. In a study by Ng et al. [31], the effect of pectin, inulin, beta-glucan and galactoligosaccharide on the color factors of non-fat stirred yogurt was investigated. The results showed that the addition of these compounds had an effect on the values*a** And*b** Didn't have but invoice*L** was affected by the addition of these compounds. Samples containing inulin, galactoligosaccharide and beta-glucan and control*L** were more than pectin.

4-3- Stiffness[20]

Food texture is all the rheological and structural (geometric and surface) aspects of the product that can be understood by mechanical, tactile and sometimes visual and auditory methods [32]. Curd texture is one of the determining quality parameters. Usually, evaluation of the texture of food occurs visually at the time of consumption or in the mouth and during chewing, although some aspects of the appearance of the product will also be effective in this evaluation [23]. In the texture profile of food samples, stiffness is the amount of force required in the first deformation [33]. Among the characteristics determined in the tissue profile by the histometer, changes in stiffness were investigated. The results related to the analysis of curd samples during 60 days of storage in the refrigerator are shown in Table 3. The results of analysis of variance indicated that the effect of treatment, storage time and their mutual effects on the changes in hardness of the samples were significant (0.05).*P* <). Adding pectin to the curd formulation resulted in significant changes in the hardness of the samples compared to the control group. 1 day after production, the hardness of P-0.1 and P-0.2 samples was significantly lower than the control sample (0.05*P* <). After that and during the storage period, the hardness of all samples increased, but this increase was not significant for all samples from the 30th day of storage onwards (0.05).*P* >). In all measurement days except the 30th day, the highest hardness belonged to the P-0.3 sample (127-66-190 g). The hardness of P-0.2 sample on day 30 was higher than P-0.3 and on day 15 there was no significant difference with it (0.05*P* >). The stiffness of the P-0.1 sample from the 15th day of storage was higher than the control sample, but no statistically significant difference was observed between them (0.05*P* >). The mechanism of effect of pectin on the textural characteristics of curd is closely related to the improvement of their WHC, which was examined in section 2-3. Limited studies have been conducted in the field of examining the textural properties of curd after adding hydrocolloids, and their effect on the textural properties is different according to the type of hydrocolloid, the characteristics and formulation of curd, as well as the production process of curd. The addition of modified starches was associated with a significant increase in hardness from 448.3 g in a control sample to 695.9993-9993 g in samples containing different types of modified tapioca starch. The increase in hardness of the samples was primarily related to the increase in dry matter after adding starch. In addition, the active groups of amylose/amylopectin in the starch chains and the absorption of more water and the increase in the viscosity of the continuous phase caused an increase in the hardness of the samples [4]. The addition of hawthorn pectin and commercial pectin to the stirred yogurt formulation at different levels (0.025-0.2 percent) was associated with significant changes in textural characteristics compared to the control sample. The results showed that at the level of 0.2% pectin, the degree of stiffness increased by 51.09% compared to the control sample, and this pectin was able to strengthen the internal network structure of the yogurt, followed by an increase in stability and a decrease in water retention. There was a positive correlation between the concentration of hawthorn pectin and the degree of texture stiffness, but in the case of commercial apple pectin, the stiffness increased (up to a concentration of 0.1 percent) and then decreased [34].

5-3- Microbiological characteristics

During the storage time, no growth of mold, mold and yeast was observed in the samples, which is probably due to the pasteurization of the curd samples. According to the national standard of Iran No. 2406 [35], the microbial limits in the count of total form, Escherichia coli, coagulase-positive staphylococci, mold and yeast, and sulfite-reducing clostridium are respectively 10 CFU/g, negative, negative and CFU/ g is 10. All the curd formulations examined until the end of the microbial period had the permissible limits of Iran's standard in terms of the growth of spoilage microorganisms. ,

6-3- sensory characteristics

Sensory evaluation makes it possible to perform a complete analysis of the different characteristics of food that are perceived by the five human senses [36]. As can be seen in Table 4, there was no significant difference between the acceptability of the smell of the pectin-containing samples and the control sample in any of the sensory evaluation days, and this score showed a significant decrease for all samples until the end of the storage period (0.05).*P* <). In terms of taste, the treatments containing pectin had a lower taste

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score than the control, and most of the evaluators perceived a more acidic taste in the samples containing pectin. This more acidic taste can be related to higher acidity and lower pH of samples containing pectin. However, no significant difference was observed between the scores of the pectin-containing samples and the control sample on the 1st and 60th days of sensory evaluation (0.05*P* >) but on day 30, the taste score of the control sample was significantly higher than other formulations (0.05*P* <). Although along with the results of decreasing pH and increasing acidity during the storage of the samples, the sensory score of the taste and smell of the samples also decreased gradually, nevertheless, these scores remained acceptable for all the samples until the last day of storage (score higher than 3) (Table 4). The lack of significant changes in the smell and taste score of the samples showed that although the acidity of the samples increased during the storage time, which indicates the continuation of lactic fermentation in the product, but this fermentation produces compounds that cause changes in taste and smell. The product or creating an unpleasant smell has not been accompanied.

Also, the apparent water in the control and P-0.1 samples was consistent with the results of the tests to determine the water with the lower scores given to this feature. On days 1 and 30, samples P-0.2 and P-0.3 received more points in terms of this property in terms of sensory evaluators. On the last day of storage, P-0.1 received the lowest score in the sense that it had a significant difference with other formulations containing pectin. Apparent watering score for all samples decreased during storage time. In all evaluation days, the highest color and appearance scores were related to the P-0.3 and P-0.2 treatments, respectively, and the lowest ones belonged to the Control and P-0.1 treatments, respectively. One of the reasons for this high score was the uniform appearance of the sample in these two treatments, which is usually the first basis for judging the quality of the product, and in curds containing high concentrations of pectin, these curds received a higher score due to the lack of water and uniform appearance. The color and appearance scores of the control samples, P-0.2 and P-0.3 did not show any significant difference during storage time (0.05*P* >) but this score for a P-0.1 sample on the 30th and 60th days of storage had a significant difference with day 1 (0.05*P* <) (Table 4). The consistency of curd is one of the most important features that consumers evaluate at the time of consumption and it is closely related to the amount of curd thickening. Also, the evaluation of the consistency and texture of the samples by the evaluators was consistent with the results obtained in the stiffness analysis of the samples. The evaluators were able to evaluate this feature of curd well and distinguish the samples from each other. The results of analysis of variance indicated that the effect of treatment and storage time on the score of texture and consistency of different curd treatments was significant (0.05*P* <) but their mutual effects of this sensory feature were not significant (0.05*P* >). Control samples and P-0.1They had the lowest tissue score and there was a significant difference with the sample P-0.3 on all the test daysthey showed The score of texture and consistency of the control and P-0.1 samples did not remain acceptable on the 60th and 30th days of storage, respectively (score less than 3). Also, the changes of this score were not significant for all samples (P>0.05) (Table 4). Analysis of variance showed that the main effects of treatment and storage time on the overall acceptance score of curd samples were significant (0.05*P* <). In all sensory evaluation days, the highest sensory evaluation score was related to P-0.3, P-0.2, P-0.1 and control treatments, respectively, and a significant difference between P-0.3 and the control sample was observed on the 1st and 60th days of storage. The reduction of overall acceptance score during storage time was not significant for any of the samples. On the last day of the test, the overall acceptance score of all samples was higher than the acceptance limit (Table 3).

The effect of three modified tapioca starches on sensory properties was evaluated. The results showed that there was no significant difference between the smell of all types of curd during the storage period, which is in line with the results of this research. The color score of different samples did not show significant changes during the storage time. The scores related to the evaluation of stickiness, mouthfeel, taste and overall acceptability decreased significantly during the storage period. The results also indicated that the increase in the concentration of each type of starch caused an increase in the score of texture, stickiness, mouthfeel, taste and overall acceptance [4].

4- General conclusion

The results of this research showed that pectin is a known, permitted and safe hydrocolloid in food products that can be used in

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the formulations of fermented milk products, including curd, and can modify their functional and even technological characteristics. The results of this research showed that the occurrence of water in industrial liquid curd containing pectin is far lower than the control sample of this product, which can be explained by the increase in WHC of these curds compared to the control group. The results also showed that another beneficial effect of adding pectin to curd is the remarkable performance of this gum in the final texture and firmness of the product, which also affects the sensory characteristics and acceptability of the consumer. Although the addition of pectin causes significant changes in the color factors included*L** *b** and WI, but these changes in the sensory test did not significantly affect the opinion of the evaluators. Adding pectin to curd at the level of 0.1 percent had unacceptable effects on sensory characteristics such as texture, consistency, and apparent wateriness, and the scores of these characteristics were significantly lower than other formulations containing pectin. Since it is recommended that the production of dairy products containing hydrocolloids should be accompanied by minimal changes in the sensory and technological characteristics of the product, it is recommended to use pectin hydrocolloid at the level of 0.2-0.3 percent in the formulation of industrial liquid curd.

5- Appreciation and thanks

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6- Resources

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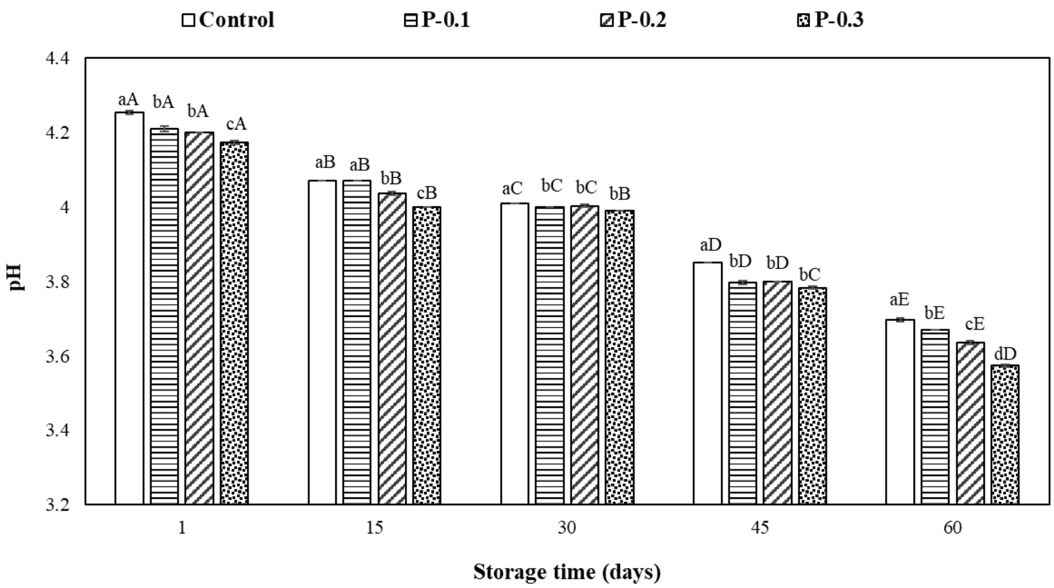

Fig 1 Effect of pectin concentration on pH values of Kashk samples during cold storage (4 ± 1 °C) for 60 days

On each day, values with the different lowercase letters on the bars are significantly different (P < 0.05). For each formulation, values with the different uppercase letters on the bars are significantly different (P < 0.05).

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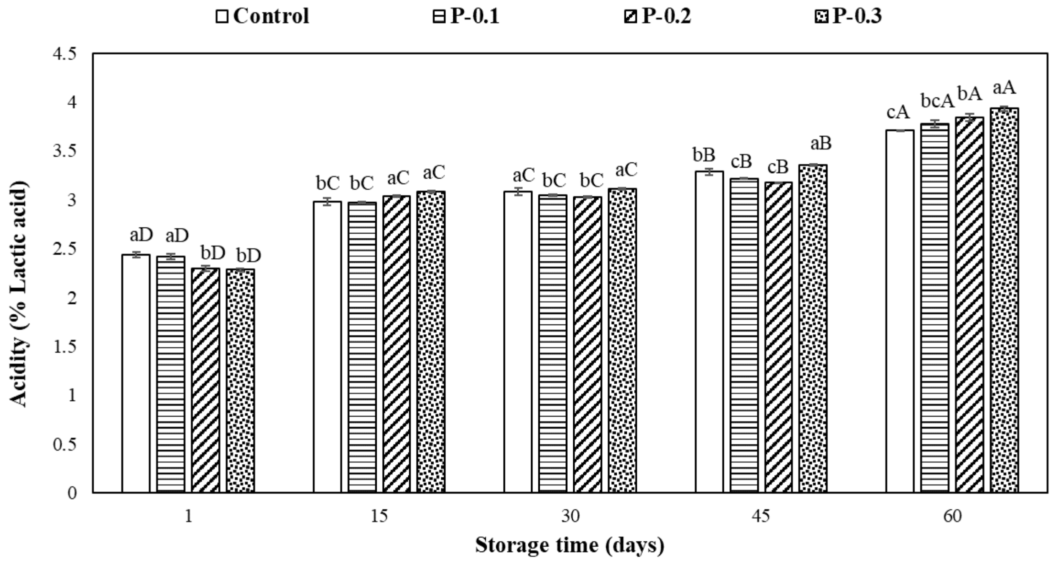

Fig 2 Effect of pectin concentration on titrable acidity values of Kashk samples during cold storage (4 ± 1 °C) for 60 days

On each day, values with the different lowercase letters on the bars are significantly different ($P < 0.05$). For each formulation, values with the different uppercase letters on the bars are significantly different ($P < 0.05$).

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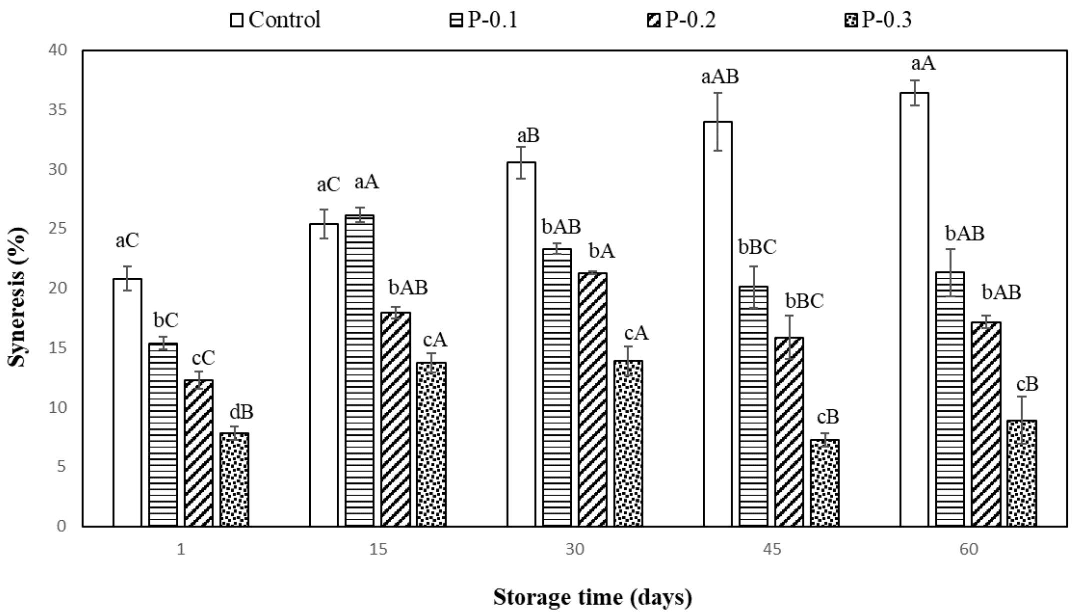

Fig 3 Effect of pectin concentration on syneresis values of Kashk samples during cold storage (4 ± 1 °C) for 60 days
On each day, values with the different lowercase letters on the bars are significantly different ($P < 0.05$). For each formulation, values with the different uppercase letters on the bars are significantly different ($P < 0.05$).

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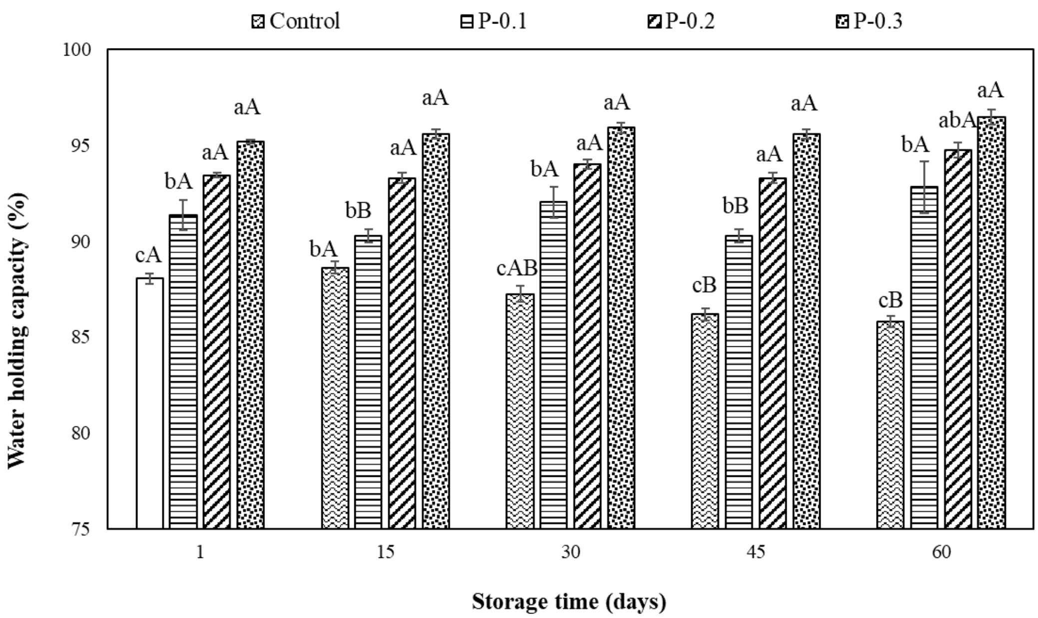

Fig 4 Effect of pectin concentration on water holding capacity of Kashk samples during cold storage (4 ± 1 °C) for 60 days.
On each day, values with the different lowercase letters on the bars are significantly different ($P < 0.05$). For each formulation, values with the different uppercase letters on the bars are significantly different ($P < 0.05$).

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Table 1 Ingredients of different formulations of industrial liquid Kashk

Formulation	Ingredients			
	Dried Kashk (%)	Yogurt (%)	Milk protein concentrate (%)	Pectin
Control	2	91.5	6.5	0
P-0.1	2	91.5	6.5	0.1
P-0.2	2	91.5	6.5	0.2
P-0.3	2	91.5	6.5	0.3

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Table 2 Effect of pectin concentration on color attributes of Kashk samples during cold storage (4 ± 1 °C) for 60 days

Color parameter	Formulation	Storage time (days)									
		1		15		30		45		60	
Lightness (*L**)	Control	86.10 ± 0.00	aC	86.56 ± 0.01	aB	86.97 ± 0.04	aA	85.26 ± 0.00	cD	86.03 ± 0.00	cC
	P-0.1	86.06 ± 0.00	aC	86.86 ± 0.00	aA	86.38 ± 0.00	bB	86.86 ± 0.00	aA	86.48 ± 0.00	aB
	P-0.2	85.52 ± 0.38	bD	85.33 ± 0.01	bE	85.82 ± 0.00	cC	86.20 ± 0.00	bA	86.04 ±0.01	cB
	P-0.3	84.99 ± 0.01	cE	85.42 ± 0.00	bD	85.82 ± 0.00	cC	86.49 ± 0.00	bA	86.16 ± 0.00	bB
Yellowness (*b**)	Control	11.34 ± 0.00	aC	11.22 ± 0.00	aE	11.32 ± 0.00	aD	11.37 ± 0.00	aB	11.45 ± 0.02	aA
	P-0.1	10.85 ± 0.00	bC	10.80 ± 0.01	cE	10.82 ± 0.00	dD	10.92 ± 0.01	dB	11.12 ± 0.00	dA
	P-0.2	10.85 ± 0.01	bE	10.88 ± 0.01	bD	10.91 ± 0.01	cC	10.99 ± 0.00	cB	11.17 ± 0.03	cA
	P-0.3	10.88 ± 0.02	bC	11.22 ± 0.00	aA	11.22 ± 0.00	bA	11.14 ± 0.02	bB	11.23 ± 0.01	bA
Whiteness index (WI)	Control	52.06 ± 0.05	cB	52.90 ± 0.04	bA	52.99 ± 0.03	bA	51.15 ± 0.02	cC	51.70 ± 0.13	cB
	P-0.1	53.60 ± 0.02	aCD	54.45 ± 0.04	aA	53.90 ± 0.00	aBC	54.09 ± 0.04	aAB	53.10 ± 0.09	aD
	P-0.2	52.96 ± 0.42	bAB	52.68 ± 0.02	bBC	53.08 ± 0.05	bA	53.22 ± 0.03	bA	52.78 ± 0.08	bC
	P-0.3	52.33 ± 0.07	cB	51.76 ± 0.02	cC	52.16 ± 0.02	cBC	53.06 ± 0.06	bA	52.42 ± 0.05	bB

Values are mean±standard deviation (n =3). For each color attribute on each day, values in the same column with the different lowercase letters are significantly different ($P < 0.05$). For each formulation, values in the same row with the different uppercase letters are significantly different ($P < 0.05$).

Table 3 Effect of pectin concentration on texture attribute (hardness) of Kashk samples during cold storage (4 ± 1 °C) for 60 days

Texture property	Formulation	Storage time (days)									
		1		15		30		45		60	
Hardness (g)	Control	113.33 ± 5.63	bB	114.00 ± 0.81	cB	122.33 ±4.64	cAB	134.33 ±0.94	cAB	147.00 ± 4.26	cA
	P-0.1	97.66 ± 1.54	cB	129.16 ± 7.57	bA	132.66 ± 7.03	cA	140.83 ± 5.66	cA	153.00 ± 9.62	cA
	P-0.2	101.83 ± 0.94	cC	138.66 ± 7.30	aB	168.50 ± 4.70	aA	170.83 ± 8.42	bA	170.66 ± 8.58	bA
	P-0.3	127.66 ± 0.94	aB	141.66 ± 5.24	aB	148.66 ± 11.72	bAB	186.00 ± 7.78	aA	190.00 ± 12.72	aA

Values are mean±standard deviation (*n* =3). Values in the same column with the different lowercase letters are significantly different on each day ($P < 0.05$)., Values in the same row with the different uppercase letters for each formulation are significantly different ($P < 0.05$).

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Table 4 Effect of pectin concentration on sensory attributes of Kashk samples during cold storage (4 ± 1 °C) for 60 days

Sensory attributes	Formulation	Storage time (days)					
		1		30		60	
Odor	Control	4.61 ± 0.48	aA	4.05 ± 1.02	aAB	3.77 ± 0.85	aB
	P-0.1	4.55 ± 0.49	aA	3.88 ± 1.04	aAB	3.77 ± 0.85	aB
	P-0.2	4.72 ± 0.44	aA	3.88 ± 0.80	aAB	3.66 ± 0.88	aB
	P-0.3	4.66 ± 0.66	aA	4.11 ± 0.87	aAB	3.61 ± 0.89	aB
Color and appearance	Control	4.00 ± 0.66	aA	3.52 ± 0.76	bA	3.61 ± 0.89	abA
	P-0.1	4.66 ± 0.47	aA	3.50 ± 0.89	bB	3.50 ± 0.89	bB
	P-0.2	4.62 ± 0.47	aA	4.05 ± 0.70	aA	4.00 ± 0.66	aA
	P-0.3	4.66 ± 0.47	aA	4.00 ± 0.81	aA	3.83 ± 0.89	abA
Texture and consistency	Control	3.16 ± 0.89	bA	3.11 ± 1.14	bA	2.83 ± 0.83	cA
	P-0.1	3.58 ± 0.75	bA	2.77 ± 0.85	bA	3.00 ± 0.88	cA
	P-0.2	3.77 ± 0.62	abA	3.94 ± 0.62	aA	3.58 ± 0.91	bA
	P-0.3	4.38 ± 0.75	aA	4.38 ± 0.59	aA	4.05 ± 0.77	aA
Visual syneresis	Control	3.88 ± 0.93	bA	3.44 ± 0.95	bAB	3.33 ± 0.66	abB
	P-0.1	3.83 ± 0.68	bA	3.22 ± 1.13	bB	3.05 ± 0.70	bB
	P-0.2	4.44 ± 0.68	aA	4.11 ± 0.73	aAB	3.66 ± 0.88	aB
	P-0.3	4.61 ± 0.48	aA	4.22 ± 0.78	aA	3.72 ± 0.86	aB
Taste	Control	4.33 ± 0.66	aA	4.22 ± 0.85	aA	3.50 ± 0.95	aB
	P-0.1	4.11 ± 0.73	aA	3.55 ± 1.06	bB	3.41 ± 1.00	aB
	P-0.2	4.27 ± 0.80	aA	3.55 ± 0.89	bB	3.33 ± 0.81	aB
	P-0.3	4.38 ± 0.59	aA	3.50 ± 0.89	bB	3.33 ± 0.81	aB
Overall acceptability	Control	3.72 ± 0.65	aA	3.33 ± 0.66	aA	3.33 ± 0.66	aA
	P-0.1	3.77 ± 0.71	aA	3.38 ± 0.75	aA	3.40 ± 0.66	aA
	P-0.2	4.16 ± 0.60	aA	3.50 ± 0.61	aA	3.51 ± 0.59	aA
	P-0.3	4.22 ± 0.62	aA	3.61 ± 0.75	aA	3.83 ± 0.68	aA

For each sensory attribute on each day, values in the same column with the different lowercase letters are significantly different ($P < 0.05$). For each formulation, values in the same row with the different uppercase letters are significantly different ($P < 0.05$).

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تأثیر هیدروکلوئید پکتین بر ویژگی‌های کیفی و ماندگاری کشک مایع صنعتی طی نگهداری در یخچال

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چکیده

کشک یک محصول لبنی اسیدی با ارزش غذایی بالا است که در ایران به طور گسترده مصرف می‌شود. مشکل اصلی کشک مایع جداسازی فازی است که به طور قابل ملاحظه‌ای ویژگی‌های رئولوژیکی، بافتی و کیفیت میکروبی آن را در طی ذخیره سازی تحت تاثیر قرار می‌دهد. در مطالعه‌ی حاضر، هیدروکلوئید پکتین به عنوان پایدار کننده در فرمولاسیون کشک مایع مورد استفاده قرار گرفت. اثرات آن‌ها بر ویژگی‌های فیزیکوشیمیایی (pH، اسیدیته، ظرفیت نگهداری آب، سینرزیس، رنگ)، بافتی (سفتی) و حسی محصول در طی ٦۰ روز نگهداری در دمای ٤ درجه سانتی‌گراد بررسی شد. چهار گروه کشک مایع شامل کنترل (بدون پایدار کننده) و P-0.1 و P-0.2 و P-0.3 به ترتیب حاوی ۰/۱، ۰/۲ و ۰/۳ در صد (وزنی/وزنی) پکتین آماده‌سازی شدند. در طی نگهداری، افزودن پکتین باعث افزایش اسیدیته و کاهش بیشتر pH کشک نسبت به گروه کنترل شد. نمونه‌های P-0.2 و P-0.3 بیشترین ظرفیت نگهداری آب و کمترین سطح آب اندازی را نسبت به نمونه‌ی کنترل و P-0.1 در طول نگهداری نشان دادند. افزودن پکتین تاثیر مثبتی بر سفتی نمونه‌ها داشت. با افزایش سطح پکتین میزان سفتی نمونه‌ها افزایش یافت و از روز ۳۰ نگهداری به بعد سفتی فرمولاسیون‌های P-0.2 و P-0.3 به طور معنی‌داری بالاتر از P-0.1 و کنترل بود ($P < ۰/۰۵$). ویژگی‌های رنگی نمونه‌ها شامل روشنائی، زردی و اندیس سفیدی نمونه‌ها به طور معنی‌داری تحت تاثیر افزودن پکتین قرار گرفت ($P < ۰/۰۵$). شمارش کلی فرم و کپک و مخمر در تمامی تیمارها در طول زمان نگهداری منفی بود. در ارزیابی حسی، امتیازات آب اندازی ظاهری، بافت و قوام، رنگ و ظاهر و پذیرش کلی با غلظت پکتین تحت تاثیر قرار گرفت. بیشترین امتیاز پذیرش کلی در روزهای ارزیابی حسی متعلق به P-0.3 بود. نتایج نشان داد، افزودن پکتین می‌تواند ویژگی‌های کیفی کشک را به طور مطلوبی تحت تاثیر قرار دهد.