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Fig juice Fortified with Inulin and Lactobacillus Delbrueckii: A Promising Functional Food

Sima Khezri[1], Razzagh Mahmoudi[2], Parvin Dehghan[3*]

1- Department of Food Science and Technology, Faculty of Nutrition and Food Sciences, Student Research Committee, Tabriz University of Medical Sciences, Tabriz, Iran.

2- Medical Microbiology Research Center, Qazvin University of Medical Sciences, Qazvin, Iran.

3- Department of Food Science and Technology, Assistance Professor of Nutrition, Faculty of Nutrition and Food Sciences, Nutrition Research Center, Tabriz University of Medical Sciences, Tabriz, Iran.

Abstract

Background and Objective: Nowadays, consumption of functional foods is favored because of their health promoting characteristics. Also there is an increasing demand for nondairy products because of lactose intolerance in dairies. Fig juice as a source of dietary fiber and other nutrients would be a functional food. Adding probiotics and prebiotics makes it more functional for daily use. No study has yet been done on synbiotic fig juice. Accordingly, the aim of this study was to characterize synbiotic fig juice prepared by *Lactobacillus delbrueckii* and inulin.

Material and Methods: Samples consisted of control fig juice; fig juice fermented by *Lactobacillus delbrueckii* (probiotic) and fig juice containing inulin fermented by *Lactobacillus delbrueckii* (synbiotic) were produced. Physico-chemical parameters, total phenolic content, antioxidant capacity and microbial survival aspects were analyzed during the fermentation period. Aforementioned parameters were also evaluated in 4 weeks with one week time intervals. Sensory characteristics of fig juices were assessed in the second week of storage.

Results and Conclusion: The results showed significant differences among treatments ($p \leq 0.05$) in physico-chemical indices during incubation and storage time. Total phenolic content and antioxidant capacity of fermented fig juices were significantly increased in comparison to the control samples ($p \leq 0.05$). Viability of *Lactobacillus delbrueckii* was increased in both probiotic and synbiotic treatments during incubation; but a significant reduction was observed during storage time. Sensory analysis revealed that there were significant differences in terms of odor, taste and overall acceptance between the fermented fig juices and control ($p \leq 0.05$) and the highest scores were obtained for control. Considering viable counts of *Lactobacillus delbrueckii* depicted that fermented fig juice could be a suitable medium for survival and proliferation of *Lactobacillus delbrueckii* in adequate amount for health promotion. So this research showed that fig juice can be a potential product for manufacture of a new functional food.

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***Corresponding author:**

Parvin Dehghan,

Department of Food Science and Technology, Assistance Professor of Nutrition, Faculty of Nutrition and Food Sciences, Nutrition Research Center, Tabriz University of Medical Sciences, Tabriz, Iran.

Tel: +98-41-13376229
Fax: +98-41-13376229
E-mail: dehghanp@tbzmed.ir.ac

1. Introduction

Nowadays the global market for functional food products have experienced rapid growth. In the recent years, there has been an increasing interest in consumption of fruit juices in order to provide a healthy diet, supplemented with minerals, vitamins, antioxidants, which is also contributes to their unique taste. In this sense, technologists have been focused on the manufacture of new products enriched with bioactive compounds with acceptable sensory characteristics [1,2].

Due to several medicinal properties, fig juice is introduced as a healthy drink. Fig *(Ficus carica)* is used therapeutically as food supplements, because it improves body immunity and other health attributes. A clinical study showed that fig fruit supplementation improved symptoms in patients suffering from functional constipation. Supplementation with fig fruit increased the number of bowel movements, reduced defecation time, and improved the abdominal pain [3]. Fig juice is known as an excellent source of vitamin C, which is helpful in boosting the immune system. Also natural polyphenols such as flavonoids, proanthocyanidin are found in fig juice that helps balance blood pressure [4]. It is worthy to mention that along history, the dried fig is widely used in traditional medicine through its diverse beneficial effects such as antipyretic, purgative, aphrodisiac, diuretic, astringent and carminative properties. Several investigations showed their antitumor activity against certain types of cancer such as stomach, colon, and liver. Notwithstanding the potential of figs as functional food, figs also possess other nutritional properties, phytochemicals, antioxidant and antibacterial compounds [5-7].

One way to meet the demand for healthier food is by enriching food products; probiotication, which is accomplished by direct incorporation of prebiotics and probiotics [8]. Probiotics are live microorganisms that when supplied in adequate amounts, are able to colonize in the gastrointestinal tract tingubontric tohealth benefits in the host [9]. Beverages can be an appropriate delivery system for probiotics. Several health benefits attributed to the probiotics are antimicrobial, antimutagenic, anticarcinogenic, antidiarrheal and antihypertensive properties, improving lactose digestion, lowering cholesterol and reducing mineral malabsorption (10). According to a previous study based on survivability of three species of lactic acid bacteria *(Lactobacillus (L.) casei*, *L. plantarum* and *L. delbrueckii)* in fig juice, results showed that, *L. delbrueckii* could survive and grow well in high acidity and low pH in fermented fig juice in comparison to other species. It was concluded that *L. delbrueckii* which had the highest viability would be used as suitable cultures for production of probiotic fig juice [5]. It can be characterized as a probiotic species because it is believed to exert health promoting effects on the host by modulating the intestinal microflora and provide suitable survival and stability in lower pH mediums like in fruit juices [11].

Prebiotics are selectively fermentable ingredients that allow specific changes, both in the composition and activity of the gastrointestinal microbiota that confers benefits upon the well-being of the host and improves metabolic parameters in chronic diseases such as type 2 diabetes [12]. Inulin has widely been reported as a prebiotic that has shown to manipulate the composition of the colonic microflora. The short-chain fraction, oligofructose, is much more soluble and sweeter than native and long-chain inulin, can also improve the mouth feel, because its properties are closely related to those of other sugars. Long-chain inulin is less soluble and more viscous than the native product and can act as texture modifier [13,14].

The incorporation of probiotic organisms into products such as beverages provides a potential to improve consumers health attributes. However, a major problem with application of probiotic in fruit juices is their viability in acidic medium, which could be solved by proliferation promoting compounds such as inulin, which is projected in the context of synbiotic products [15].

To the best of our knowledge, no other work has been carried out to develop a synbiotic fig juice. Therefore, the objective of this study was to evaluate the effect of the concomitant addition of *L. delbrueckii* as a probiotic culture and inulin as a prebiotic ingredient on the microbial survivability, physico-chemical parameters, total phenolic content, antioxidant capacity and sensory profile of fig juices; in order to prepare a healthy synbiotic drink.

2. Materials and Methods

2.1. Strains and cultures

L. delbrueckii DSMZ 15996 was supplied by the Deutsche Sammlung von Microorganismen und Zellkulturen (GmbH, Germany). Bacterial cultures were stored frozen at -20°C in MRS medium (Merck, Germany) containing 20% glycerol. The cultures were grown at 37°C for 24 h in MRS broth and were used as an inoculum. All other chemical were of analytical grade.

2.2. Preparation of fig juice

Commercial concentrated fig with approximate 68-72 Brix, was supplied from Tin Tin Co. (Shiraz, Iran) and kept at 4°C prior to use. Firstly, the fig juice concentrate was diluted to 20° Brix by deionized water and then pasteurized at 80°C for 5 minutes. Samples were prepared in special test tubes (25 × 200 mm), each containing 40 ml of fig juice with or without 20 g l^{-1} oligofructose-enriched inulin (Frutafit IQ, Sensus, Borchwef 3, 4704 RG Roosendaal, Netherlands) as the prebiotic component. So the test tubes containing the control fig juice, fig juice with *L. delbruckii* (probiotic) and fig juice with *L. delbruckii* and inulin enriched with oligofructose (synbiotic) were prepared and produced. Probiotic and synbiotic samples were inoculated with the 24 h cultivated cultures (final count >10^6 CFU g^{-1}) and incubated at 37°C for 72 h. Finally, samples were taken at 24 h intervals and experiments were done at 0 (initial condition), 24, 48, and 72 h.

2.3. Microbiological analysis

After 72 h of fermentation, the fermented samples were stored at 4°C for 28 days. In order to count probiotics, samples were taken at weekly intervals, then the viability of *L. delbrueckii* in fig juice was determined and the results were expressed as log of colony forming units (log CFU ml^{-1}). Viable cell counts were reported by the standard plate method with Lactobacilli MRS-Agar medium after 48 h of incubation at 37°C [16].

2.4. Chemical analysis

The pH value of prepared probiotic juices was measured by a digital pH meter (Metrohm 744, Netherland). Approximately 10 g of fig juice with the same volume of distilled water was diluted before titration. The titratable acidity was determined by titrating with 0.02 N NaOH using a pH meter to an end point of pH 8.3 ± 0.01. Acidity was measured based on lactic acid and data was expressed as percentage of lactic acid [17]. The level of total soluble solids (TSS), as Brix, was assessed using a digital refractometer (ATAGO, Japan). Reducing sugar content was measured as glucose equivalents by the DNS method using a UV-visible spectrophotometer [18].

2.5. Total polyphenol assay

The total polyphenol contents of fig juices were determined by using Fulin-Ciocalteu method with some modifications. Briefly, 1 ml of standard solution of Gallic acid (20, 40, 60, 80 and 100 mg l^{-1}) was decanted in 25 ml volumetric flask containing 9 ml of distilled deionized water [19]. Then 1 ml of Fulin-Ciocalteu reagent was added to the mixture and shaken. After 5 min, 10 ml of 7% Na_2CO_3 solution was added and the solution was diluted to the volume with distilled deionized H_2O and mixed. After incubation for 90 min at room temperature, the absorbance against prepared reagent blank (distilled deionized H_2O) was measured at wavelength of 750 nm using UV-visible spectrophotometer (Pharmacia Biotech, England). Total polyphenol content of fig juices were reported as mg Gallic acid Equivalent (GAE) per 100 ml.

2.6. Antioxidant activity

The free radical scavenging capacity was determined using the stable 2,2-diphenyl-1-picrylhydrazyl radical (DPPH) as described by Brand-Williams (20). Briefly, 50 µlof each sample were added into 950 µL of 153 mmol l^{-1} DPPH methanolic solution. Then solutions were kept in dark for 30 min at ambient temperatures. The reduction in absorbance was recorded at 517 nm until a constant reading was obtained. The absorbance reading for the sample extracts and controls (consisting of 50 µl of water in place of fig juice) was used for the calculation of the inhibition percentage of DPPH oxidation as follows:

Eq. 1

$$\text{DPPH scavenging activity} = \frac{[A^{control}{}_{517} - A^{extract}{}_{517}]}{A^{control}{}_{517}} \times 100$$

2.7. Sensory evaluation

The sensory assessment of fig juices was conducted on day 14 of storage time. Sensorial attributes of fermented fig juices were characterized according to their taste, odor, color and overall acceptance. Ten expert panelists were chosen to run the 9 point hedonic test [21]. Water was used for mouth rinsing during sensory test.

2.8. Statistical analysis

All data were analyzed through one-way ANOVA by Minitab 15 and significant effects ($p \leq 0.05$) of variables were measured by Sidak's multiple range test. Each treatment was in triplicate and also the whole experiments and treatments were analyzed in three repetitions. Sensory characteristics were analyzed using a Kruskal-Wallis analysis of variance.

3. Results and Discussion

3.1. Kinetics of the *L. delbrueckii* proliferation in fig juice

The results showed a slight reduction in the population of *L. delbrueckii* during 24 h incubation in fermented fig juices (Figure 1), which is in agreement with Yanez et al. who indicated that low pH levels could lead to a decrease in the maximum growth rate and an extended length of the lag phase. After 48 h of fermentation, cell numbers of lactic acid bacteria increased significantly ($p \leq 0.05$) in both probiotic (8.41 log CFU ml^{-1}) and synbiotic (8.83 log CFU ml^{-1}) juices [22]. Extended fermentation time over 48 h did not lead to any significant increments in the proliferation of lactic acid bacteria which are in agreement with those obtained by Yoon et al. [23]. This phenomenon could be related to an increase in the acidity of the juice.

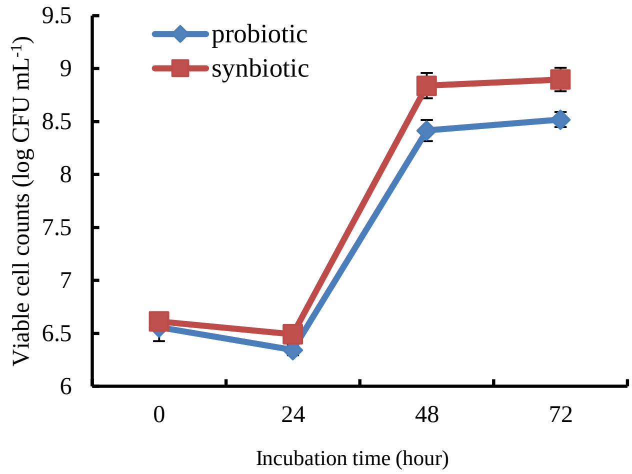

Figure 1. Growth kinetic of *L. delbrueckii* during fermentation of fig juices.
Error bars represent the standard deviation.

3.2. Physicochemical parameters

Changes of physicochemical characteristics like pH, titratable acidity, brix and reducing sugars of fig juice during fermentation and refrigerated storage are shown in Table 1. The pH decreased slowly for the first 24 h of fermentation, and then dropped more quickly until 4.21 and 4.11 for probiotic and synbiotic treatments respectively after the 48 h fermentation. Also, the results showed that lactobacilli remained viable even during refrigerated storage, and the pH decreased slightly as the storage time was extended. Orange juice supplemented with *L. paracasei* and oligofructose was previously studied by Costa et al. [24]. According to the authors, pH of prebiotic, probiotic and synbiotic treatments had no significant difference compared to control treatments during 28 days of storage. The results of that study are not consistent with the results of the current study. The difference in results is possibly due to the high buffering capacity of these products, different organic acid profile and even different total soluble content which could modulate the pH. Also, some of the strains, including *L. casei* are able to metabolize citric acid during the process [25].

The acidity of all fermented fig juices increased significantly ($p\leq0.05$) after the 72 h fermentation. The synbiotic juices produced a higher amount of lactic acid compared to that of the probiotic juices. The results of decreased pH and increased acidity showed a similar trend. Yeo et al. also observed that addition of inulin to soymilk significantly increased the acid production of probiotics in comparison with the control sample [26]. The authors attributed this to inulin stimulating the metabolic activities of the starter bacteria, resulting in improved development of acidity. The high acidity of probiotic products can be protective against the development of food spoilage microorganisms and prolong their shelf life [27].

As it was shown, soluble solids in synbiotic fig juice (21.6±0.05 ºB) were significantly ($p\leq0.05$) higher than that of probiotic and control juices (20 ºB) on the first day. Keenan et al. reported that total soluble solids were significantly higher in apple purees containing prebiotic additions (inulin and FOS) compared to controls. That was expected as soluble sugars which were increased in purees enriched with prebiotics as they contain additional glucose, fructose and sucrose (inulin 10% and FOS 14%) [28]. The brix of the fermented fig juices decreased significantly throughout the fermentation and storage periods ($p\leq0.05$). Considering that brix contains water-soluble solids and sugars contained in juice are part of the brix, fermentation and the conversion of sugars into organic acids (lactic acid), leads to a decrease in sugar content and finally decrease in brix.

Probiotic and synbiotic juices significantly ($p\leq0.05$) decreased sugar levels from an initial value of 13.33 and 14 g per 100g to 9.25 and 9.81 g per 100g respectively after the 28 days of storage. In synbiotic juice, sugar was consumed at a much faster rate than that of the probiotic juice. Juices supplemented with prebiotic, reduced sugar more significantly ($p\leq0.05$) than the pure and probiotic juices. Results indicated that as the storage time increased, the sugar content of samples stored at 4°C decreased gradually. These results are in agreement with those obtained by Mousavi et al. [29] which also showed the same trend in sugar content of fermented pomegranate juice. The sugar results were again supported by a decrease in pH and increase in juice acidity. The effect of prebiotic was probably due to the enhanced α-galactosidase activity of probiotics, which leads to the hydrolysis of oligosaccharides, such as inulin, and also increases the consumption of simple sugars, including glucose and fructose [26]. The physicochemical characteristics (pH, titratable acidity, brix and reducing sugars) of control fig juice remained almost constant during the fermentation and storage time.

Table 1. Physicochemical parameters (pH, Titratable acidity, brix and sugar) of fig juices.

Parameters	Treatments	Fermentation time (hour)				Storage time (days)			
		0	24	48	72	7	14	21	28
pH	control	4.52±0.1 a	4.52±0.01 a	4.51±0.01 a	4.5±0.01 a	4.47±0.01 a	4.46±0.02 a	4.45±0.02 a	4.44±0.01 a
	probiotic	4.52±0.1 a	4.42±0.01 b	4.21±0.03 b	4.18±0.02 b	4.02±0.03 b	3.9±0.03 b	3.82±0.02 b	3.76±0.03 b
	synbiotic	4.52±0.1 a	4.38±0.02 c	4.11±0.02 c	4.08±0.02 c	3.93±0.02 c	3.8±0.03 c	3.72±0.04 c	3.66±0.03 c
Titratable acidity (%)	control	0.25±0.1 a	0.25±0.01 c	0.26±0.01 c	0.26±0.01 c	0.27±0.01 c	0.28±0.02 c	0.29±0.02 c	0.3±0.02 c
	probiotic	0.25±0.1 a	0.34±0.01 b	0.59±0.02 b	0.61±0.02 b	0.72±0.03 b	0.82±0.03 b	0. 9±0.03 b	0.94±0.04 b
	synbiotic	0.25±0.01 a	0.39±0.02 a	0.71±0.02 a	0.73±0.02 a	0.84±0.02 a	0.94±0.03 a	1.01±0.02 a	1.05±0.03 a
Brix (g/100g)	control	20 b	20±0.05 b	20±0. 1 a	20±0.05 a	19.9 a	19.8±0.05 a	19.8±0.1 a	19.7±0.05 a
	probiotic	20 b	19.7±0.1 c	18.1±0.1 c	17.7±0.1 c	17.4±0.05 c	17.2±0.05 c	17±0.15 c	16.9±0.1 c
	synbiotic	21.6±0.5 a	21.4±0.05 a	19.6±0.05 b	19±0.1 b	18.5 b	18.1±0.1 b	17.9±0.1 b	17.8±0.1 b
Sugar (g/100g)	control	13.33 b	13.33±0.5 a	13.3±0.1 a	13.29±0.8 a	13.27±0.1a	13.26±0.5 a	13.25±0.03 a	13.24±0.04 a
	probiotic	13.33 b	12.75±0.12b	11.25±0.3 c	10.75±0.5 c	10.15±0.2c	9.78±0.13 c	9.43±0.1 c	9.25±0.08 c
	synbiotic	14±0.05 a	13.31±0.4 a	11.64±0.1 b	11.06±0.1 b	10.6±0.11b	10.37±0.1 b	9.97±0.07 b	9.81±0.12 b

Means ± standard deviation in the same column followed by different lowercase letters indicate statistically significant differences at $p\leq0.05$ between the treatments of fig juice.

3.3. Total Polyphenolic Compounds and Antioxidant Activity of fig Juice

Initially, the TPC of fig juice samples was 54.6 g GAE ml^{-1}. Synbiotic juice had higher TPC (71.73 mg GAE per 100 ml) in comparison with probiotic juice (60 mg GAE per 100 ml) after 72 h of fermentation. Fermentation seemed to have a positive effect on the polyphenolic content and it increased progressively with an increase in fermentation time as shown in Figure 2. A similar pattern was observed for the antioxidant activity. DPPH radical scavenging activities of unfermented fig juice after the 72 h fermentation was 73.87% and those of the fermented fig juices were 89 and 95.44% for probiotic and synbiotic treatments, respectively.

As shown in Figure. 3, the concentration of total polyphenolic compounds markedly decreased during storage time. The maximum rate of reduction was evident in control sample (44%) and in the case of probiotic and synbiotic, there was approx 30% and 25% reduction in TPC respectively. After 28 days of storage, the DPPH scavenging capacity significantly ($p \leq 0.05$) decreased for all treatments. The highest decrease was found for unfermented samples (38.11%) and for probiotic and synbiotic samples the value was 17 and 16 % respectively.

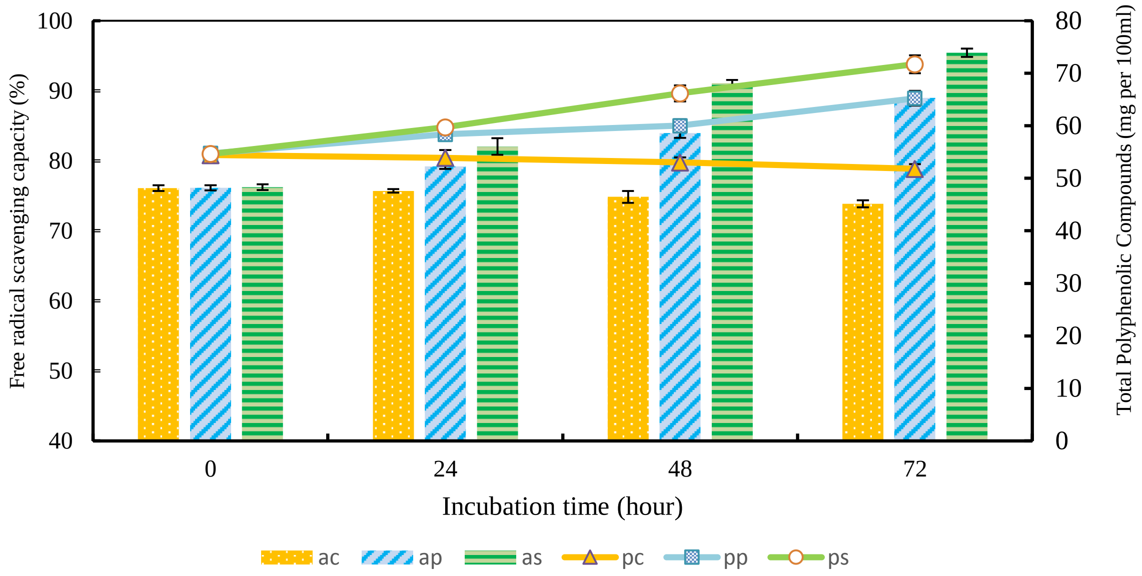

Figure 2. Total polyphenolic compounds (mg GAE per 100 ml) and free radical scavenging capacity (%) of fig juices fermented at 37°C for 72 h.
ac= antioxidant-control; ap= antioxidant-probiotic; as= antioxidant-synbiotic; pc= polyphenolic-control; pp= polyphenolic-probiotic; ps= polyphenolic-synbiotic.
Error bars represent the standard deviation.

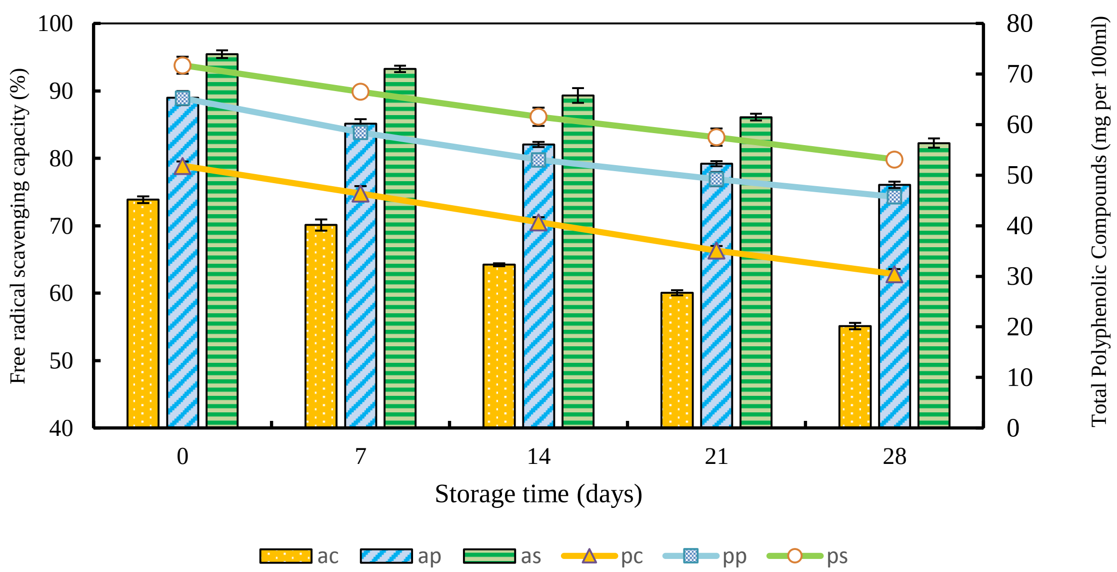

Figure 3. Total polyphenolic compounds (mg GAE per 100 ml) and free radical scavenging capacity (%) of fig juices during storage for 28 days.
ac= antioxidant-control; ap= antioxidant-probiotic; as= antioxidant-synbiotic; pc= polyphenolic-control; pp= polyphenolic-probiotic; ps= polyphenolic-synbiotic.
Error bars represent the standard deviation.

The enhancement of antioxidant activity by fermentation is mostly due to an increase in phenolic compounds via microbial hydrolysis. Phenolic glycosides are hydrolyzed by microbial enzymes such as b-glucosidase and the aglycone content increases, which can act as an antioxidant [30]. Glycosylated polyphenols shows less bioavailability and absorption rates in the small intestine due to their higher molecular weight and hydrophilic characteristic than their aglycones [31]. Another possible explanation is antioxidant activity of lactic acid bacteria. Many lactic acid bacteria themselves have enzymatic and non-enzymatic antioxidant mechanisms that reduce the generation of reactive oxygen species to levels that are not harmful to cells [32]. Our results are also in agreement with those presented by Pereira et al. [33] who evaluated the effect of lactic acid fermentation on antioxidant activity and total polyphenolic compounds content of cashew apple juice. These authors reported that juice fermentation with *L. casei* increased and preserved the antioxidant properties of cashew apple juice (antioxidant activity of fermented juices were higher than the non-fermented juice during the storage). The same behavior was observed for total polyphenolic compounds content. According to the research conducted on pomegranate juice by Mousavi et al. lactic acid fermentation significantly increased juice antioxidant activity. DPPH-scavenging effect of the pomegranate juices reached 72% and 89% by *L. plantarum* and *L. acidophilus*, respectively from the initial amount of 57% [34].

This outcome is contrary to that of Jaiswal et al. who found that fermentation had a negative effect on the polyphenols content of cabbage juice [35]. In the case of *L. plantarum* and *L. brevis*, after 24 h of fermentation, there was approx 15% reduction in TPC, while in the case of *L. rhamnosus* the loss was more prominent (24%) and similar set of results were observed for antioxidant capacity. Kim et al. [17] showed reductions in the antioxidant properties in fermented potato juice with LAB, which was not consistent with our results. These authors claimed that lactic acid bacteria have a range of enzymes such as β-glucosidase, p-coumaric acid decarboxylase and decarboxylase which may help in degrading certain phenolic compounds.

3.4. Viability of probiotic bacteria during cold storage

The survival of *L. delbrueckii* during cold storage of fermented fig juice is shown in Figure 4. Viability of probiotics was decreased significantly (p≤0.05) during storage time; however, the rate of decline was lower in the synbiotic treatment in comparison with the probiotic. Their viable cell counts reached 6.59 log CFU ml^{-1} in probiotic juice and 7.49 log CFU ml^{-1} in synbiotic juice after 4 weeks of cold storage.

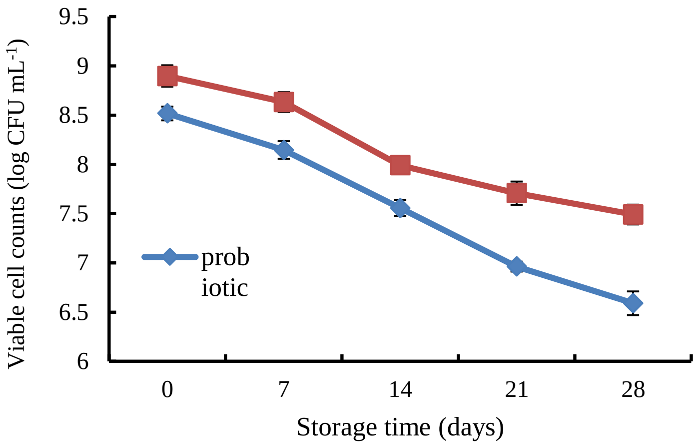

Figure 4. Viability of *L. delbrueckii* (log cfu ml^{-1}) in the fermented fig juices during storage for 28 days.
Error bars represent the standard deviation.

Pimentel et al. assessed the viability of *L. paracasei* in the clarified apple juice and reported that the number of probiotic bacteria in apple juice and apple juice supplemented with oligofructose decreased from an initial amount of 8.20 log CFU ml^{-1} to 5.6 and 6.7 log CFU ml^{-1} after 28 days of storage at 4°C [36],. According to these results, reduction in probiotic viability could be due to acidity, the presence of oxygen in the media or the low level of nitrogenous compounds. The ability of microorganisms to grow and survive greatly depends on its adaptability to the environment [37]. Past studies have shown the positive effects of fructans on the survivability of probiotics [38,39]. Fructans, play an important role in the cellular metabolism. Inulin demonstrated a protective effect on cell survival. It also protects cells against acidity and adverse environmental conditions [40]. The underlying mechanism of protection of probiotics by inulin during cold storage is most likely related to the fact that inulin serves as the carbon source available for cell maintenance, thus preventing cell injuries caused by acidity. Semjonovs et al. also indicated that fructans increased *Bifidobacterium lactis* viability in fermented cabbage juice during storage at 4°C for 2 weeks [41]. Nikmaram et al. investigated *L. casei* growth in the presence of inulin (0, 0.5, 1, and 2%) and reported that yogurt drink samples supplemented with pomegranate juice with 2 and 0% inulin showed significantly highest and lowest (p≤0.05) viable bacterial counts respectively [42]. The results of this research support the idea that inulin has an enhancing effect on probiotic viability which are consistent with the findings of the current study.

Nazzaro et al. represented that the presence of inulin and fructooligosaccharides did not alter the number of *L. rhamnosus* and *L. Bulgaricus* in synbiotic carrot juice. This outcome differs from the findings presented here. Difference in results can be due to several factors such as strain, pH, growth promoters and inhibitors, presence of hydrogen peroxide and oxygen, concentration of metabolites, buffering capacity of the media and availability of nutrients [43].

Takagi et al. evaluated the growth of *L. delbrueckii*, *L. paracasei* and *L. plantarum* on fructose or inulin in co-culture systems. The results showed that *L. delbrueckii*, in contrast to the other two strains, grew faster in the inulin enriched mediums than on fructose. It was also shown that *L. delbrueckii* initially imports inulin into its cells and then consumes it intracellularly [44].

3.5. Sensory evaluation

Organoleptic properties are considered as one of the important characteristics of probiotic products and the first condition for consumer acceptance [1]. As seen in Table 2 there were significant differences in terms of odor, taste and overall acceptance between the fermented fig juices and control ($p \leq 0.05$), but no significant difference was observed in the color of samples. The highest score for overall acceptability was 7.8 for control juice followed by 6.1 for synbiotic juice and 5.7 for probiotic juice. According to the panelists, no significant difference between the sensory scores of probiotic and synbiotic juices was noticed ($p>0.05$).

Table 2. Sensory properties of fig juice samples

Attributes	Treatments		
	Control	Probiotic	Synbiotic
Color	6.9±0.73 a	6.8±0.63 a	6±0.81a
Odor	7.5±0.7 a	6.4±0.69 b	6±0.66 b
Taste	7.9±0.73 a	5.5±0.84 b	5.8±0.78 b
Overall acceptance	7.8±0.63 a	5.7±0.94 b	6.1±0.73 b

Means ± standard deviation within a row with different lowercase letters indicate ($p \leq 0.05$) differences between treatments of fig juices for the same sensory attribute.
Hedonic Values (color, odor, taste and overall acceptance): 1- disliked extremely; 9- liked extremely.

Daneshi (45) analysed sensory properties of milk/carrot juice mix drink inoculated with *L. acidophilus*, *L. plantarum*, *L. rhamnosus* and *B. lactis.* They observed that, the color, flavor, taste and consistency of the samples decreased as the storage time increased, and after 20 days storage reached the lowest score. The results of this study are in accordance with the present study.

Ellendersen et al. reported good sensory acceptance for apple juice probioticated with *L. casei*. However, the fermented apple beverage stored for 28 days showed a more noticeable acidic flavor [27].

In the study of Pereira et al. the lightness of probiotic apple juice decreased and turbidity increased during refrigerated storage periods. These results were because of the biomass rise of the *L. casei* [46],. In present study, due to the fact that fig juices were inherently turbid, no significant differences were seen among control, probiotic and synbiotic treatments in term of color.

The metabolism of probiotics leads to the production of compounds that have a negative effect on the aroma and taste of the products [47]. Therefore, reducing the overall acceptance of treatments in this study is probably due to the production of metabolites, including lactic acid by *L. delbrueckii.* The probable reason for any significant difference between synbiotic and probiotic treatments, despite the high acidity in the synbiotic one, could be related to a decrease in acidity perception with the increasing sugar content [33].

It has been reported that frequent consumption, informing consumers about the health effects of functional juices and improving their taste by adding tropical fruit juices such as mango and pineapple in order to mask the medicinal taste of probiotic strains, are likely to have a positive effect on the acceptability of functional juices [48].

4. Conclusion

The results of the present study demonstrated that the addition of probiotic strains and prebiotic source to the fig juice had drastic functional properties. In this fruit juice, the nutritional properties of the figs as well as the health properties of probiotic and prebiotic bacteria were combined. Synbiotic juice incorporated with *L. delbrueckii* was found to be better in terms of probiotic property and antioxidants. At the end of storage period, the viable count of the synbiotic juices remained about 1 log cycles higher than probiotic juices and maintained above the minimum requirement (6 log CFU ml^{-1}) for probiotic products. Although sensory scores were lower in treatments compared to control, but masking medicinal flavor and organoleptic attributes by other components such as tropical fruits would be an alternative approach. Therefore, fig juice could serve as a suitable carrier for probiotic and prebiotic supplementation. Overall, fermentation could improve the bioavailability of polyphenols and also fermented fig juices rich in antioxidants can be a good bio-processing technique used to develop novel functional foods.

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6. Conflict of Interest

The authors claim that there is no conflict of interest.

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آب انجیر غنی شده با اینولین و *لاکتوباسیلوس دلبروکی*: یک غذای فراسودمند نوید بخش

سیما خضری[۱]، رزاق محمودی[۲]، پروین دهقان[۳]*

۱- گروه علوم و صنایع غذایی، دانشکده تغذیه و علوم غذایی، کمیته تحقیقات دانشجویی، دانشگاه علوم پزشکی تبریز، تبریز، ایران.

۲- مرکز تحقیقات میکروبشناسی پزشکی، دانشگاه علوم پزشکی قزوین، قزوین، ایران.

۳- گروه علوم و صنایع غذایی، دانشکده تغذیه و علوم غذایی، مرکز تحقیقات تغذیه، دانشگاه علوم پزشکی تبریز، تبریز، ایران.

چکیده

سابقه و هدف: امروزه، مصرف غذاهای فراسودمند به‌لحاظ داشتن خواص سلامتی‌بخش، مورد توجه قرار گرفته‌است. همچنین تقاضا برای فراورده های غیرلبنی به دلایلی مثل عدم تحمل لاکتوز در فراورده‌های لبنی افزایش یافته است. آب انجیر به‌عنوان منبع فیبر رژیمی و سایر مواد مغذی می تواند غذایی فراسودمند باشد. افزودن زیست‌یار (Probiotic) و کمک زیست‌یار (Prebiotic) فراسودمندی آن را برای مصرف روزانه افزایش می‌دهد. مطالعه‌ای تاکنون بر روی آب انجیر سین‌بیوتیک[۱] انجام نشده است. بنابراین، هدف این مطالعه تعیین ویژگی‌های آب انجیر سین‌بیوتیک تهیه‌شده با *لاکتوباسیلوس دلبروکی* و اینولین بود.

مواد و روش‌ها: نمونه‌هایی شامل آب انجیر شاهد؛ آب انجیر تخمیر شده با *لاکتوباسیلوس دلبروکی* (تیمار زیست‌یار) و آب انجیر حاوی اینولین تخمیر شده با *لاکتوباسیلوس دلبروکی* (تیمار سین بیوتیک) تولید گردیدند. ویژگی‌های فیزیکوشیمیایی، محتوای کل پلی‌فنل، ظرفیت آنتی اکسیدانی و وضعیت زنده‌مانی میکروبی در طول دوره تخمیر بررسی شد. همچنین به‌مدت چهار هفته، با فاصله زمانی یک هفته، ویژگی‌های مورداشاره ارزیابی شدند. ویژگی‌های حسی آب انجیرها در هفته دوم نگهداری بررسی شد.

یافته‌ها و نتیجه‌گیری: نتایج نشان داد تفاوت معنی‌داری از لحاظ شاخص‌های فیزیکوشیمیایی در مدت گرمخانه‌گذاری و نگهداری بین تیمارها وجود دارد($p\leq۰/۰۵$). محتوای کل پلی‌فنل و ظرفیت آنتی‌اکسیدانی در آب انجیرهای تخمیرشده در مقایسه با نمونه‌های شاهد به‌طور معنی‌داری افزایش یافت ($p\leq۰/۰۵$). زنده‌مانی *لاکتوباسیلوس دلبروکی* در تیمارهای زیست‌یار و سین‌بیوتیک در مدت گرمخانه‌گذاری افزایش یافت؛ اما زنده‌مانی باکتری‌های پروبیوتیک کاهش معنی‌داری داشت. ارزیابی حسی نشان داد که بین تیمارهای زیست‌یار و سین‌بیوتیک با تیمار شاهد از لحاظ بو، طعم و پذیرش کلی تفاوت‌های معنی‌داری وجود دارد ($p\leq۰/۰۵$) و نمونه شاهد بالاترین امتیاز را به‌دست‌آورد. با توجه به تعداد *لاکتوباسیلوس دلبروکی* زنده، نشان داده شد که آب انجیر تخمیر شده می‌تواند محیط مناسبی برای بقا و تکثیر *لاکتوباسیلوس دلبروکی* در حد مورد نیاز برای تأمین سلامتی باشد. بنابراین، این مطالعه نشان داد که آب انجیر می تواند فراورده‌ای بالقوه برای تولید غذایی فراسودمند جدید باشد.

تعارض منافع: نویسندگان اعلام می‌کنندکه هیچ تعارض منافعی وجود ندارد.

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- فعالیت آنتی‌اکسیدانی
- آب انجیر
- اینولین
- *لاکتوباسیلوس*
- زیست‌یار

***نویسنده مسئول**

پروین دهقان، گروه علوم و صنایع غذایی، دانشکده تغذیه و علوم غذایی، مرکز تحقیقات تغذیه، دانشگاه علوم پزشکی تبریز، تبریز، ایران

تلفن: ۹۸۴۱۱۳۳۷۶۲۲۹+
دورنگار: ۹۸۴۱۱۳۳۴۰۶۳۴+
پست الکترونیک:
dehghanp@tbzmed.ir.ac

[۱] فرزیست‌یار(symbiotic)، مکمل غذایی حاوی مواد زیست‌یار و کمک‌زیست‌یار