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The effect of beetroot fiber on the physicochemical, microbial and sensory properties of mixed probiotic fruit juice based on pomegranate and strawberry juice

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ABSTRACT

This study aimed to investigate the effect of beetroot fiber on the physicochemical, microbial and sensory properties of a mixed probiotic juice based on pomegranate and strawberry juice. For this purpose, samples of 100% (Control sample) pomegranate juice, 100 %(Control sample) strawberry juice and 50:50 pomegranate: strawberry juice containing probiotic bacteria *Lactobacillus plantarum* (10^8 cfu/mL) and different levels of sugar beet powder (0, 0.5, 1 and 1.5%) were prepared. The results showed that the use of sugar beet puree had a significant effect on the parameters of the juice samples. A decrease in pH, an increase in acidity%, turbidity (NTU), Brix degree, viscosity (CP), total phenol content (ppm), and antioxidant activity (IC50 mg/mL) of different juice samples were observed upon addition of sugar beet puree and an improvement in the activity of probiotic bacteria up to about 2% increase in viability ($p<0.05$).A significant decrease in brightness index and also a significant increase in redness and yellowness indices were observed in Synbiotic juice samples ($p<0.05$). An increase in probiotic bacteria survival was observed depending on the percentage of sugar beet concentration as a prebiotic during the storage time of the samples. No significant effect of sugar beet puree on sensory characteristics (taste, aroma, color and overall acceptance) was also observed ($p>0.05$). The closest treatment to the control treatment is T2 treatment containing 100% pomegranate juice + 10^8 cfu/mL probiotic bacteria + 0.5% beet puree.

1- Introduction

Probiotics are generally defined as live microbial supplements that improve the microbial balance of the host intestine and improve the functioning of the gastrointestinal tract. Regular consumption of probiotic microorganisms has many health benefits, including increased lactose tolerance, antimicrobial properties, anticarcinogenic properties, as well as antimutagenic properties, and other beneficial effects. [1]. The consumption of mixed fruit juices, as well as fruit and vegetable juices, has great potential. These beverages contain significant amounts of vitamins, minerals, fiber, antioxidants, and bioactive compounds. Therefore, in addition to increasing the consumption of these nutrients by the population, fruit juices also meet the emerging demand for healthier and more natural products. From this perspective, some authors have investigated the use of probiotic fruit or vegetable juices as potential matrices for the development of a variety of functional foods [2].Beetroot is the most widely cultivated vegetable worldwide and is attractive for consumption due to its sweet taste, nutritional properties and technological applications of the betalain pigment. The typical edible part of beetroot is the tuberous root, which is consumed as a vegetable or processed to produce juice, powder, pickles and extracts. However, beetroot root products and their processing produce large amounts of waste in the form of stems and leaves, which are safe for human consumption and contain several nutrients and bioactive compounds [3]. The beneficial effects of beetroot on health are mostly related to its high content of soluble and insoluble fibers, pectins, betalains and phenolic compounds, especially phenolic acids and flavonoids, which have high antioxidant, anti-inflammatory and anticancer properties. Beetroot consumption is associated with positive effects on the digestive and cardiovascular systems and endurance exercise performance and is a source of high-value compounds for the food industry. Fruit juices are attractive to different people of different age groups and are consumed daily by a wide range of people due to their high content of vitamins and minerals, their health benefits, their non-allergenicity, and their low allergen content compared to other foods [3].Fruit juices contain a high amount of various sugars that can promote the growth of probiotic strains, including lactic acid bacteria and bifidobacteria [4]. According to the FAO definitions, probiotic bacteria are those microorganisms that are consumed live and, after consumption, settle in the intestine. These microorganisms have beneficial effects on the health of the consumer by improving the natural intestinal microflora. Among these microorganisms, we can mention Lactobacillus plantarum, which reduces cholesterol and blood fibrosis, reduces bloating and abdominal pain, reduces intestinal irritability, etc. Lactobacillus plantarum is a facultative heterofermentative bacterium that is also capable of fermenting the polysaccharide raffinose. It also has a high tolerance to low pH, so the viability and probiotic activity of this bacterium are higher than other Lactobacillus species, which is an important feature during the fermentation process [5,6,7]. Lactic acid bacteria, especially Lactobacilli and Bifidium bacteria, are normally part of the digestive system ecosystem [8]. Lactic acid bacteria are a heterogeneous group of Gram-positive, non-spore-forming, catalase-negative, and facultative anaerobes that have high potential in food production, especially fermented dairy products, from a biotechnological perspective [9]. Sugar beet fiber, as a fibrous product obtained from sugar production, is an important source of dietary fiber, with total digestible fiber of 75 to 80%, but so far this source has not been widely used in food production. Sugar beet is rich in soluble and insoluble dietary fiber [10]. Given the increasing interest of consumers in using foods containing prebiotic compounds as well as increasing public awareness of the health-promoting effects of probiotic microorganisms, the aim of this study was to investigate the effect of beetroot fiber on the physicochemical, microbial, and sensory properties of a probiotic mixed fruit juice based on pomegranate and strawberry juice.

2-Preparing red beet puree

Red beetroot was washed with clean water, then black spots were removed and cut into small cubes. 1 kg of red beetroot was mixed with 200 ml of water and boiled for 10 minutes. After cooling, it was mixed in an electric mixer. The resulting mixture was stored in plastic containers at a freezing temperature of -18°C until use [11].

2-1- Production of probiotic juice samples

Juice samples were prepared with different percentages (Sample 1: 100% pomegranate, Sample 2: 50% pomegranate-50% strawberry, Sample 3: 100% strawberry). Concentrations of 0, 0.5, 1 and 1.5% red beetroot puree were added to each sample. The juices were pasteurized at 65°C for 30 minutes [12]. Finally, a concentration of 108 cfu/ml of Lactobacillus plantarum was added to the juice. The samples were incubated at 37°C for 72 hours. Immediately after that, all treatments were stored at 4°C for fourteen days and subjected to physicochemical, sensory and microbial tests [13]. The treatments used in the study are given in Table 2-1.

Table 2-1- Treatments used in the research

Treatment code	Formulation
T1(Control)	100% pomegranate juice + 10^8 cfu/mL probiotic bacteria
T2	100% pomegranate juice + 10^8 cfu/mL probiotic bacteria + 0.5% beetroot puree
T3	100% pomegranate juice + 10^8 cfu/mL probiotic bacteria + 1% beetroot puree
T4	100% pomegranate juice + 10^8 cfu/mL probiotic bacteria + 1.5% beetroot puree
T5	50:50 percent pomegranate juice:strawberry + 10^8 cfu/mL probiotic bacteria
T6	Juice 50:50 percent pomegranate:strawberry juice + 10^8 cfu/mL probiotic bacteria + 0.5 percent sugar beet
T7	Juice 50:50 percent pomegranate:strawberry juice + 10^8 cfu/mL probiotic bacteria + 1 percent sugar beet
T8	50:50 percent pomegranate:strawberry juice + 10^8 cfu/mL probiotic bacteria + 1.5 percent sugar beet
T9	100% strawberry juice + 10^8 cfu/mL probiotic bacteria

T10	100% strawberry juice + 10^8 cfu/mL probiotic bacteria + 0.5% beetroot puree
T11	100% strawberry juice + 10^8 cfu/mL probiotic bacteria + 1% beetroot puree
T12	100% strawberry juice + 10^8 cfu/mL probiotic bacteria + 1.5% beetroot puree

2-2-Physicochemical experiments

2-2-1-Measurement of pH

The pH meter was calibrated with buffers 4 and 7. A sample was poured into the beaker and the pH meter electrode was placed inside it. After the number on the pH meter stabilized, the number was read and reported [14].

2-2-2-Measurement of acidity

In a 500 ml Erlenmeyer flask, 250 ml of distilled water was poured and placed on a gas flame and boiled. In the boiling state, 25 ml of the sample was slowly poured and after several boilings, it was allowed to cool. 1 g of phenolphthalein was poured and shaken. The sample was titrated with 0.1 normal sodium hydroxide until a stable pale pink color appeared [14].

$$\text{Acidity (percentage)} = \frac{0.007 \times V2}{V1} \times 100$$

Where:

V1: Sample volume in milliliters

V2: Volume of 0.1 normal sodium hydroxide used in milliliters

2-2-3- Brix measurement

First, the device was set to zero with distilled water. Then, a few drops of the test sample at a temperature of 20°C were placed on the prism of the refractometer (Brix 32-0 ATC optical refractometer, Iran) which was calibrated in terms of sucrose. After eliminating light scattering and creating two equal light and dark sections on the display screen, the concentration of water-soluble solids was read in terms of Brix at a temperature of 20°C. The result was expressed in grams or percent of the sample [14].

2-2-4-Turbidity measurement

10 ml of fruit juice was centrifuged at 4200 × g at 25 °C for 10 minutes. Then the supernatant was collected and measured using a spectrophotometer using distilled water as a blank at a wavelength of 660 nm. The turbidity of the samples was calculated from the following formula, where Abs represents the absorbance of the supernatant at 660 nm [15].

$$\text{Turbidity} = 100 - 100 \times 10 - \text{Abs}$$

2-2-5-Color Measurement

The color indices L* (transparency-opacity index), a* (redness-greenness index), and b* (yellow-blueness index) of the juice samples were determined using a Hunterlab HP colorimeter, made in China [16].

2-2-6-Viscosity measurement

The viscosity of the juice samples was measured by a Berkfield viscometer using spindle number S00 at a temperature of 20°C and a shear force of 3.4-85/s [17].

2-2-7-Amount of phenolic compounds

First, the standard solution of the juice samples (55 µL) was mixed with 100 µL of Folin-Ciocalteu reagent and mixed thoroughly. After 45 min, 200 µL of 1 M sodium carbonate solution was added to the mixture and then the resulting mixture was kept for 1 h before measuring the absorbance at 760 nm of light. Gallic acid standards (10 to

100 µg/mL) were prepared and used to create a standard curve [18].

2-2-8-Measurement of antioxidant activity

First, an amount of each sample (25 µL) was added to 250 µL of DPPH solution (0.025 mg/mL) and then kept in the dark for 20 minutes until the reaction was complete. Finally, the absorbance of the samples was read at a wavelength of 517 nm according to equation 1 [19].

Equation 1:

$$\%A = \frac{Ac - As}{Ac} \times 100$$

A :Percentage of DPPH free radical scavenging

A_c :Optical absorption of control sample

A_s :Optical absorption of the sample in nanometers

2-3- Microbial tests

2-3-1- Mold and yeast enumeration

1 ml of each sample was transferred to a sterile plate; then 12 to 15 ml of YGC medium was added to the plate. Then, they were placed on a flat, cool surface to solidify. The plates were incubated upside down at 25 ± 1°C for 5 days; after the incubation period, the colonies on the plate were grown and counted based on cfu/g [20].

2-3-2- Probiotic Bacteria Tests

2-3-2-1-Determination of the viability activity of the probiotic strain

To enumerate Lactobacillus plantarum bacteria, after preparing a dilution of the samples, they were cultured in MRS agar medium and incubated at 37°C for 48 hours and then counted. Microbial culture and examination of the viability of probiotic bacteria were performed by sampling the juice samples prepared in duplicate [21].

2-4- Sensory evaluation

This test was conducted using a five-point hedonic (scoring) method by sixteen (8 men - 8 women) semi-trained sensory evaluators. Each evaluator was given differently coded samples and the taste, odor, color, texture, and overall acceptability factors were evaluated for the samples [22].

2-5- Statistical analysis

The experiment was carried out in a factorial manner in a completely randomized design. Two-way analysis of variance was used to determine the significance of $p<0.05$ and the non-significance of the treatments. Comparison of means was performed with Duncan's test at a probability level of 5%.

3- Results and discussion

The results of the average pH of different probiotic juice samples are shown in Figure 3-1. According to the results, different treatments and storage time had a significant effect on the pH of different probiotic juice samples ($p<0.05$). According to the results, 100% strawberry and 100% pomegranate juices had the highest and lowest pH values, respectively ($p<0.05$). This significant decrease in pH was more evident with an increase in the percentage of puree from 0.5 to 1.5 percent ($p<0.05$). 100% strawberry and 100% pomegranate juices had the highest and lowest pH values (or the lowest and highest acidity). Given the acidic nature of the two juice samples (strawberry juice has a pH of 3.3 [11] and pomegranate juice has a pH of 3.7 [23]), these results were expected. In addition, the results showed that the addition of sugar beet puree significantly reduced the pH (or increased acidity) of all three juice samples (Figure 3-2). This is because the fiber in sugar beet is used by probiotic bacteria, through which organic acids are produced, and the accumulation of organic acids leads to a decrease in pH (or increased acidity) in the environment [24]. This significant decrease in pH was more evident with an increase in the percentage of puree from 0.5 to 1.5 percent. On the 30th day of storage, the highest pH was observed in samples T5, T6 and T7 (3.38, 3.40 and 3.41, respectively) and the lowest pH was observed in sample T4 (2.6 percent). Also, on the 30th day of storage, the lowest pH was observed Acidity was observed in sample T8 (0.95%). While samples T3 and T4 (2.11 and 2.13, respectively) showed the highest acidity. During storage time, probiotic bacteria have more opportunity to convert sugar into acid and sugar in the juice is converted into acid by lactic acid bacteria and as a result acidity increases and pH decreases and there is an inverse relationship between acidity and pH [24]. According to Iranian Standard No. 2616 (1402), the pH range of pomegranate juice is reported to be in the range of 2.6 to 3.7 and its acidity is in the range of 0.5 to 1.5. Therefore, basically all pomegranate juice samples had pH and acidity within the standard permissible range during 30 days [25]. Brimondi et al. (2018) produced probiotic strawberry juice with Lactobacillus casei and Lactobacillus plantarum and showed that during storage, pH and microbial population decreased and acidity increased [26].

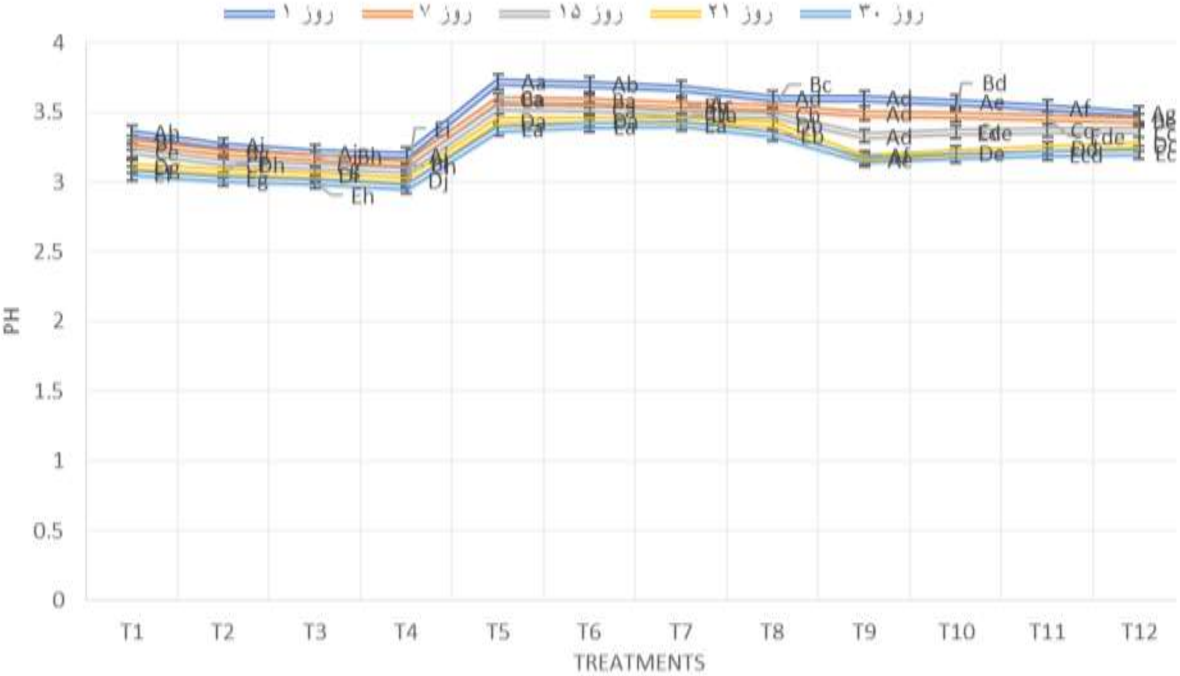

Figure 3-1- Results of the average pH of functional fruit juice samples during 30 days of storage
*T1 Control treatment: 100% pomegranate juice + 108 cfu/ml probiotic bacteria/ T2: 100% pomegranate juice + 108 cfu/ml probiotic bacteria + 0.5% beetroot puree/ T3: 100% pomegranate juice + 108 cfu/ml probiotic bacteria + 1% beetroot puree/ T4: 100% pomegranate juice + 108 cfu/ml probiotic bacteria + 1.5% beetroot puree/ T5: 50% pomegranate juice: 50% strawberry juice + 108 cfu/ml probiotic bacteria/ T6: 50% pomegranate juice: 50% strawberry juice + 0.5% beetroot puree/ T7: 50% pomegranate juice: 50% Strawberry + 108 cfu/ml probiotic bacteria + 1% beetroot puree/T8: 50% pomegranate juice: 50% strawberry + 108 cfu/ml probiotic bacteria + 1.5% beetroot puree/T9: 100% strawberry juice + 108 cfu/ml probiotic bacteria/T10: 100% pomegranate juice + 108 cfu/ml probiotic bacteria + 0.5% beetroot puree/T11: 100% pomegranate juice + 108 cfu/ml probiotic bacteria + 1% beetroot puree/T12: 100% pomegranate juice + 108 cfu/ml probiotic bacteria + 1.5% beetroot puree *Different lowercase letters indicate statistically significant differences between treatments (p<0.05) *Capital letters Different indicates a statistically significant difference between times (p<0.05).

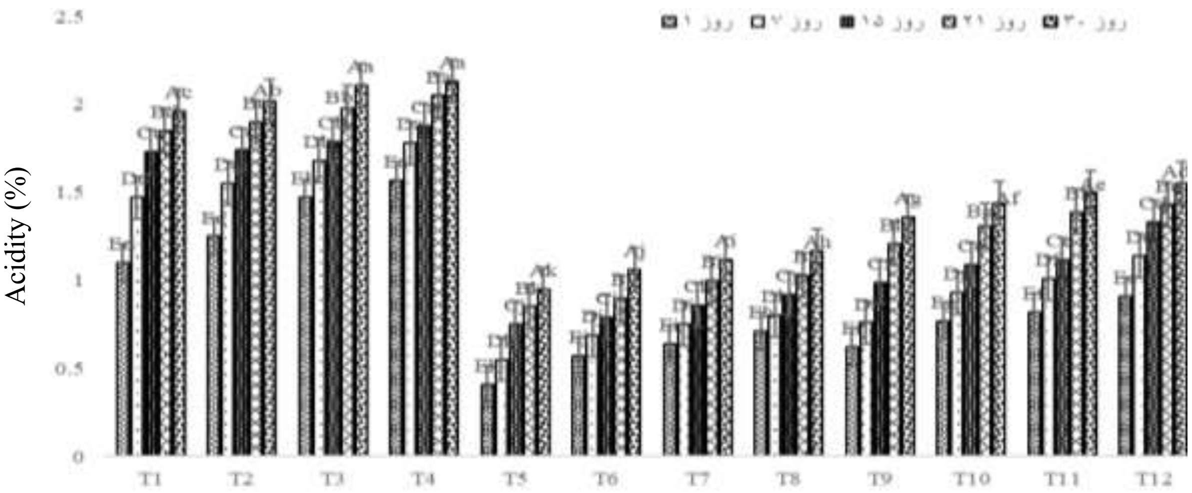

Figure 3-2 - Results of the average acidity of functional fruit juice samples during 30 days of storage

The results of the average Brix levels of different probiotic juice samples are shown in Figure 3-3. According to the results, different treatments and storage time had a significant effect on the Brix levels of different probiotic juice samples ($p<0.05$). According to the results, 100% pomegranate juices had the highest and 100% strawberry juices had the lowest Brix levels ($p<0.05$). In addition, the results showed that the addition of sugar beet puree significantly increased the Brix levels of the juice samples ($p<0.05$). However, increasing the percentage of puree from 0.5 to 1.5 percent had no significant effect on the Brix levels ($p>0.05$). In addition, a significant decrease in the Brix levels was observed during 30 days of storage in all groups studied ($p<0.05$).

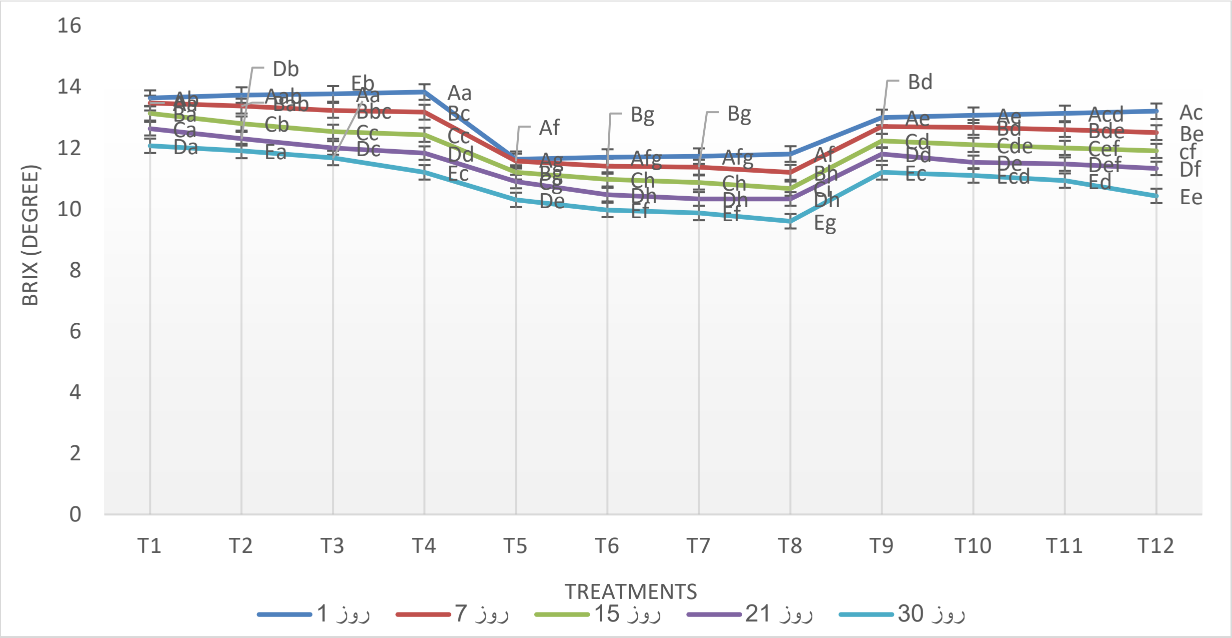

Figure 3-3- Results of average Brix of functional fruit juice samples during 30 days of storage

Samples T1 and T2 (12/07 and 11/90, respectively) showed the highest Brix because fibrous and polysaccharide compounds are consumed by probiotic bacteria over time. Babaei et al. (2016) investigated the production of vegetable mixtures including 85% tomato juice, 5% green bell pepper juice, 5% celery juice, and 5% coriander juice using probiotics Lactobacillus casei and Lactobacillus acidophilus. During fermentation and storage, with increasing bacterial density and storage time, the Brix of the probiotic drink decreased significantly[27].Different treatments and storage time had a significant effect on the turbidity of different probiotic juice samples ($p<0.05$). According to the results, 50:50 pomegranate and strawberry juices had the highest turbidity ($p<0.05$). This is due to the fiber and solids present in the fruit itself used in the preparation of the juice [11]. In addition, the results showed that the addition of sugar beet puree significantly increased the turbidity of the juice samples ($p<0.05$). This significant increase was more evident with an increase in the percentage of puree from 0.5 to 1.5 ($p<0.05$). In addition, a significant decrease in turbidity was observed during 30 days of storage in all groups studied ($p<0.05$) (Figure 4-3). In addition, the results showed that the addition of sugar beet puree significantly increased the turbidity of the juice samples. This significant increase was more evident with the increase in the percentage of puree from 0.5 to 1.5, which is due to the fiber contained in sugar beet. In addition, a significant increase in turbidity was observed during 30 days of storage in all groups studied, which researchers attribute to the activity of bacteria, fiber consumption, and as a result, the production of additional substances in the early stages by bacteria [28]. So that on the 30th day of storage, the lowest turbidity was observed in samples T3 and T4 (0.201 and 0.202 NTU, respectively). While sample T5 (0.434 NTU) showed the highest turbidity. In this regard, Pir Mohammadi et al. (2016) investigated the possibility of producing synbiotic apple-banana juice after 28 days of storage. The results showed that over time, due to bacterial activity, the transparency of the beverage decreased and its color intensity and turbidity increased. The reason for these changes was reported to be bacterial activity, fiber consumption, and as a result, the production of additional substances by the bacteria in the early stages [28].

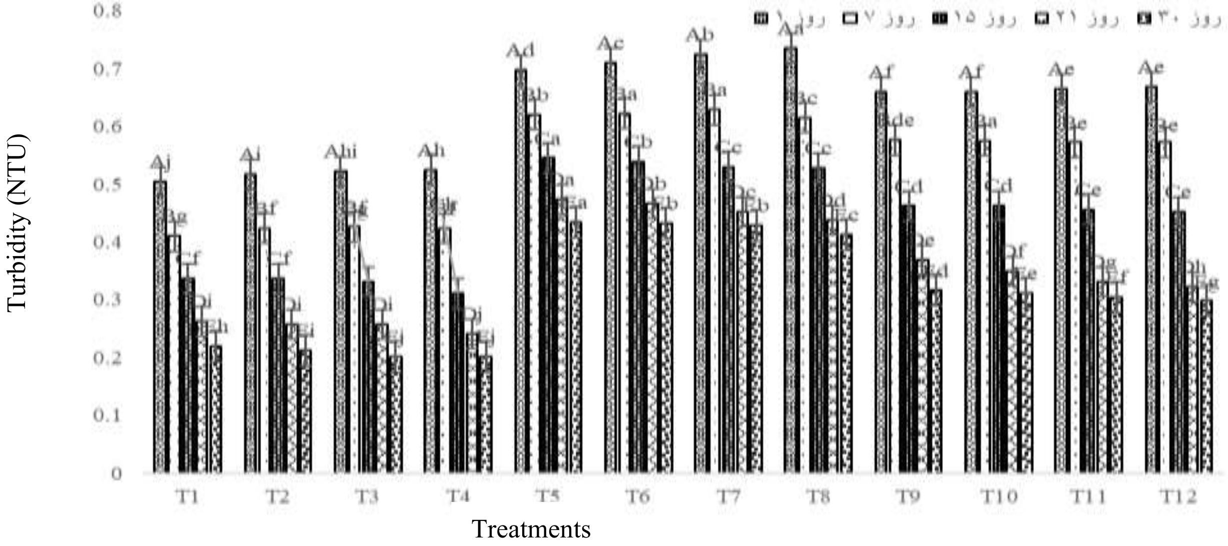

Figure 3-4- Turbidity of functional fruit juice samples during 30 days of storage

The lightness index of different probiotic juice samples is shown in Figure 3-5. According to the results, different treatments and storage time had a significant effect on the brightness index of different probiotic juice samples ($p<0.05$). According to the results, 100% pomegranate juices had the highest lightness index ($p<0.05$). The results also showed that adding sugar beet puree caused a significant decrease in the lightness index of the juice samples ($p<0.05$). This significant decrease was more evident with an increase in the percentage of puree from 0.5 to 1.5 ($p<0.05$). In addition, a significant decrease in the lightness index was observed during 30 days of storage in all groups studied ($p<0.05$). On the 30th day of storage, the lowest index was observed in samples T7 and T8 (50:50% pomegranate:strawberry juice, respectively, containing 1 and 1.5% sugar beet puree, respectively) ($p<0.05$). While sample T1 (100% pomegranate juice) showed the highest brightness index ($p<0.05$).

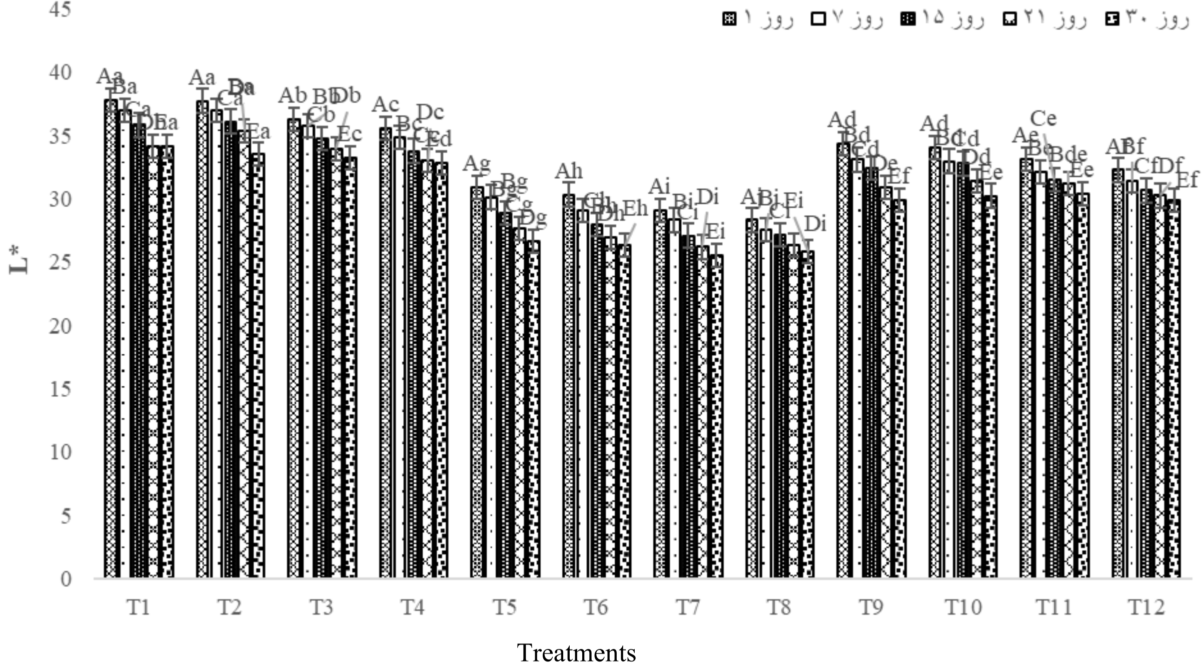

Figure 3-5- Lightness index (L^*) of functional fruit juice samples during 30 days of storage

The lightness (L*) varies between 0 and 100, and the larger the value, the brighter the sample. Carotenoids in fruit juice are in the trans form, which produces higher color intensity, and may become unstable in low acidic or high alkaline conditions, as well as during storage. Therefore, the reason for the changes in the aforementioned indicators could be the isomerization process (caused by temperature, light, and acid) or oxidation (caused by light, temperature, metals, and enzymes) of the carotenoid molecules in fruit juices, resulting in a change in the color of the sample. It is also possible that the activity of probiotic bacteria leads to the conversion of trans to cis isomers and causes changes [29]. Phenols are soluble in water due to the formation of hydrogen bonds, but most of their derivatives are poorly soluble or insoluble in water. Phenolic substances lose protons in the presence of water and are converted into other compounds, and the antioxidant properties will be affected by the compounds in the nutrient-containing solution. By combining different raw materials, the acidic properties of the compounds increase or decrease, and as a result, it affects the brightness and other color parameters [30].

50:50% strawberry: pomegranate juices had the highest redness index ($p<0.05$). The results also showed that adding sugar beet puree significantly increased the redness index of the juice samples ($p<0.05$) (Figure 3-6). This significant increase was more evident with increasing the percentage of sugar beet puree from 0.5 to 1.5 ($p<0.05$). In addition, a significant decrease in the redness index was observed during 30 days of storage in all groups studied ($p<0.05$). So that on the 30th day of storage, the highest and lowest redness index values were observed in samples T8 (50:50% strawberry: pomegranate juice containing 1.5% sugar beet puree) and T2 (100% pomegranate juice containing 0.5% sugar beet puree), respectively ($p<0.05$).

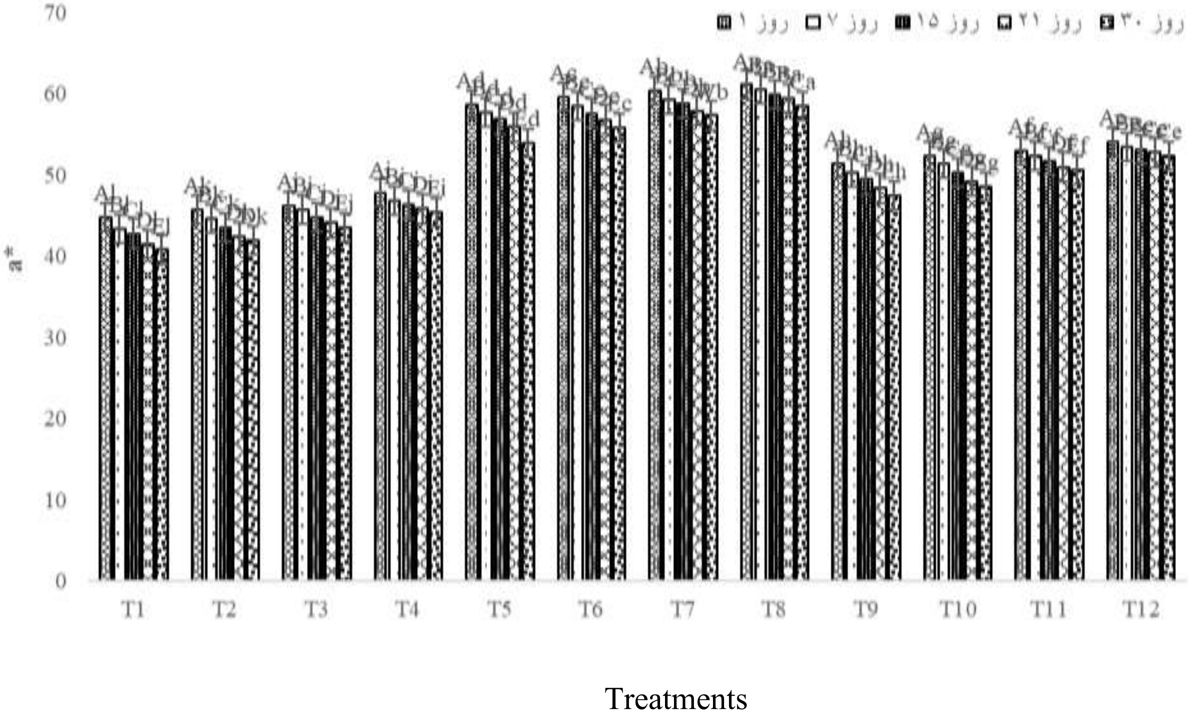

Figure 3-6- Redness index (a^*) of functional fruit juice samples during 30 days of storage

Red beetroot contains high amounts of betalains, a group of numerous water-soluble nitrogen-containing pigments derived from betalamic acid. Within the betalain group, there are two classes of compounds: the yellow-orange betaxanthins and the purple-red betacyanins. The main betacyanin pigment in red beetroot (Beta vulgaris rubra) is betanin, which is a betanidin-5-O-β-glucoside. Betanin is therefore the aglycone form of betanin. To date, a food color extracted from red beetroot (Beta vulgaris rubra), known as “beetroot red”, is available as E162 in the United States and Europe [31].Different treatments and storage time had a significant effect on the yellowness index of different probiotic juice samples ($p<0.05$). According to the results, 100% pomegranate juices had the highest yellowness index ($p<0.05$). The results also showed that adding sugar beet puree significantly increased the yellowness index of the juice samples ($p<0.05$). This significant increase was more evident with increasing the percentage of sugar beet puree from 0.5 to 1.5 ($p<0.05$) (Figure 3-7). In addition, a significant increase in the yellowness index was observed during 30 days of storage in all groups studied ($p<0.05$). So that on the 30th day of storage, the highest and lowest yellowness index values were observed in samples T3 and T4 (100% pomegranate juice containing 1 and 1.5% sugar beet puree, respectively) ($p<0.05$).

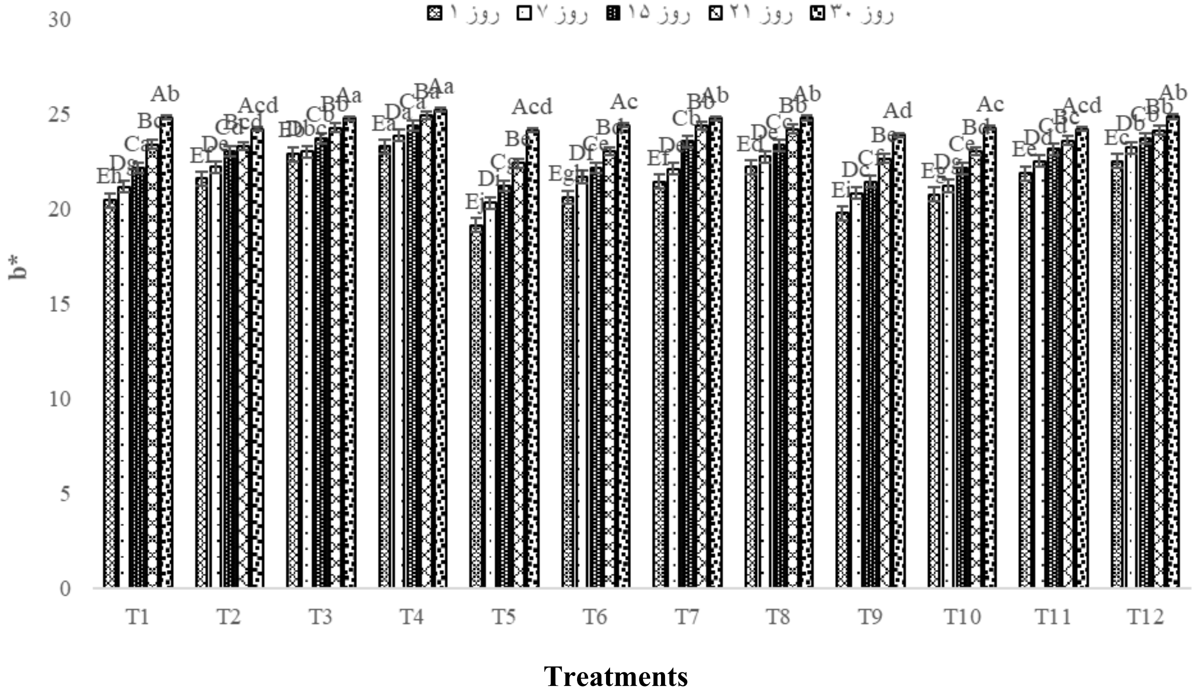

Figure 3-7- Yellowness index(b^*) of functional fruit juice samples during 30 days of storage

Adding inulin to the samples did not significantly change b*. The lowest value of a* was observed in the control treatment and the highest in the treatments containing 1.2% w/w sugar beet fiber. Pereira et al. (2011) examined a probiotic beverage fermented from apple juice using Lactobacillus casei bacteria during a storage period of 42 days at 4°C and showed that the color indices of brightness (L*), yellowness (b*) increased (due to the color of the carotenoid rejection present in the apple) and the redness index (a*) decreased.[32] Mokhtar et al. (2020) studied the effect of adding pomegranate peel extract and guava leaf extract at concentrations of 0, 0.1, 0.2 and 0.3% on the physicochemical, antioxidant, microbiological and sensory properties of pasteurized guava nectar during storage at room temperature (25 °C) and showed that adding pomegranate peel extract and guava leaf extract reduced the color (L*, a* and b*) [33]. Majzoubi et al. (2010) reported that it was probably due to the presence of fiber in the product that prevents the passage of light, which reduces the brightness of Berber bread containing sugar beet pulp [34]. Basiony et al. (2023) The addition of red beet puree with pomegranate and strawberry juice in different proportions, except for the color (increasing the red color), had little effect on the physical and chemical properties of yogurt, and the addition of fruit juice significantly reduced the brightness [11]. Khakbaz et al. (2017) showed that the interaction effect of two variables, cherry juice and red grape juice, on the color level of composite fruit juice samples was significant [35].Different treatments and storage time had a significant effect on the total phenol content of different probiotic juice samples ($p<0.05$). According to the results, 100% pomegranate juices had the highest total phenol content ($p<0.05$). The results also showed that adding sugar beet puree significantly increased the total phenol content of the juice samples ($p<0.05$). This significant increase was more evident with increasing the percentage of sugar beet puree from 0.5 to 1.5 ($p<0.05$). In addition, a significant decrease in total phenol content was observed during 30 days of storage in all groups studied ($p<0.05$) (Figure 3-8). So that on the 30th day of storage, the highest total phenol content was observed in sample T4 (100% pomegranate juice containing 1.5% sugar beet puree) ($p<0.05$). The lowest total phenol content was observed in T5 (50:50 pomegranate and strawberry juice) ($p<0.05$).

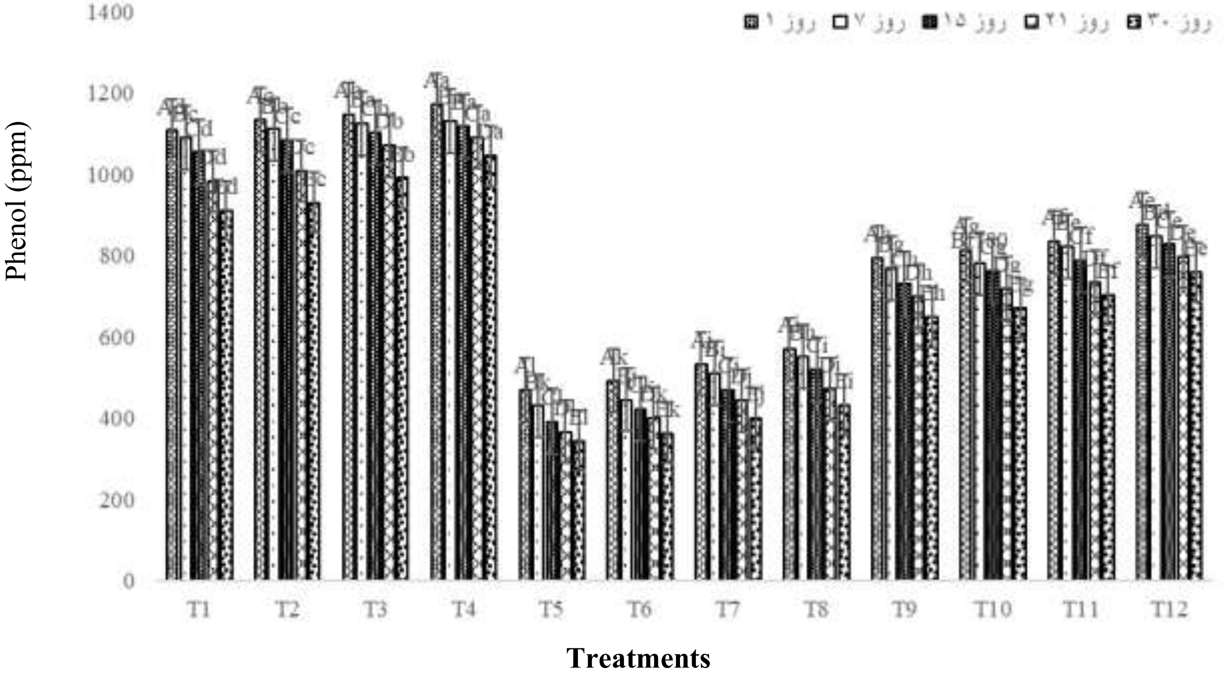

Figure 3-8- Phenol content of functional fruit juice samples during 30 days of storage

The primary flavonoids found in pomegranates, beets, and strawberries include flavonols, flavan-3-ols, flavones, flavanones, anthocyanins, anthocyanidins, proanthocyanidins, dihydroflavonols, and isoflavones. On the other hand, prominent nonflavonoids include simple phenols, hydrolyzable tannins, cinnamic acid, coumarins, xanthones, stilbenes, lignans, sesquioids, benzophenones, acetophenones, phenylacetic acid, and benzoic acid [36].

Pomegranate contains important bioactive compounds in many of its parts, including polyphenols, flavonoids, and anthocyanins, which have medicinal and functional properties, antioxidant properties, anticancer benefits, and antiatherogenic effects. Pomegranate juice is a nutritious beverage known for its sweet and sour taste, as it contains both glucose and phenolic compounds [23]. Strawberries are a common and important fruit in the Mediterranean diet due to their high content of essential nutrients and beneficial phytochemicals that appear to have relevant biological activities in human health. Among these phytochemicals, anthocyanins and ellagitannins are the main antioxidant compounds [11]. Beetroot is also a source of a variety of bioactive compounds (such as dietary fiber, pectic-oligosaccharides, betalains, and phenolics) with proven beneficial effects on human health. Beetroot extract and beetroot pectin and pectic-oligosaccharides have been shown to positively modulate the composition and activity of the intestinal microbiota through significant bifidogenic effects, in addition to stimulating the growth and metabolism of probiotics. Betalains and phenolics in beetroot appear to increase the production of metabolites (e.g. short-chain fatty acids) by gut microbiota and probiotics, which are associated with various beneficial effects on host health. The prominent content of betalains and phenolics with antioxidant, anti-inflammatory and anticarcinogenic properties has been linked to the positive effects of beetroot on gastrointestinal health [3].Habib et al. (2023) showed in a study that pomegranate juice concentrate is a rich source of polyphenols that exhibit significant antioxidant activity and potential health benefits for the prevention and treatment of diseases. In this study, the polyphenol profile of pomegranate juice concentrate was investigated for the first time and it was found that pomegranate juice concentrate can prevent oxidative damage to bovine serum albumin and deoxyribonucleic acid as well as acetylcholinesterase, α-amylase and tyrosinase activities. The primary polyphenols identified in pomegranate juice concentrate are 4-hydroxy-3-methoxybenzoate, epicatechin, catechin, rutin, ferulic acid, p-coumaric acid and cinnamic acid. As a result, pomegranate juice concentrate may be a useful ingredient in the formulation of functional foods and can be used in the food, nutritional, and pharmaceutical industries [37].Saleem et al. (2025) investigated the nutritional, antioxidant, physicochemical and sensory properties of pomegranate concentrate, beetroot concentrate, carrot concentrate and whey supplement drinks. The results showed that pomegranate concentrate showed the highest concentration of ash, sodium, potassium, calcium, magnesium, iron, zinc and ascorbic acid compared to beetroot concentrate and carrot concentrate. Also, the highest total phenolic content, total flavonoid content, 2, 2-diphenyl-1-picrylhydrazyl (DPPH) and iron reducing antioxidant power (FRAP) were recorded in pomegranate concentrate compared to beetroot concentrate and carrot concentrate, while the maximum beta-carotene and anthocyanin were observed in carrot concentrate and pomegranate concentrate[38]. Basiony et al. (2023) showed by adding red beet puree with pomegranate and strawberry juice in different proportions to yogurt that adding these juices significantly increased the total phenolic content of yogurt [11]. Different treatments and storage time had a significant effect on the antioxidant activity of different probiotic juice samples ($p<0.05$). According to the results, 100% pomegranate juices had the highest antioxidant activity ($p<0.05$). The results also showed that adding sugar beet puree significantly increased the antioxidant activity of the juice samples ($p<0.05$). This significant increase was more evident with increasing the percentage of sugar beet puree from 0.5 to 1.5 ($p<0.05$). In addition, a trend of decreasing antioxidant activity was observed during 30 days of storage in all groups studied ($p<0.05$)

(Figure 3-9). On day 30 of storage, the highest antioxidant activity was observed in sample T4 (100% pomegranate juice containing 1.5% sugar beet puree) (p<0.05). The lowest antioxidant activity was observed in T5 (50:50 pomegranate and strawberry juice) (p<0.05).

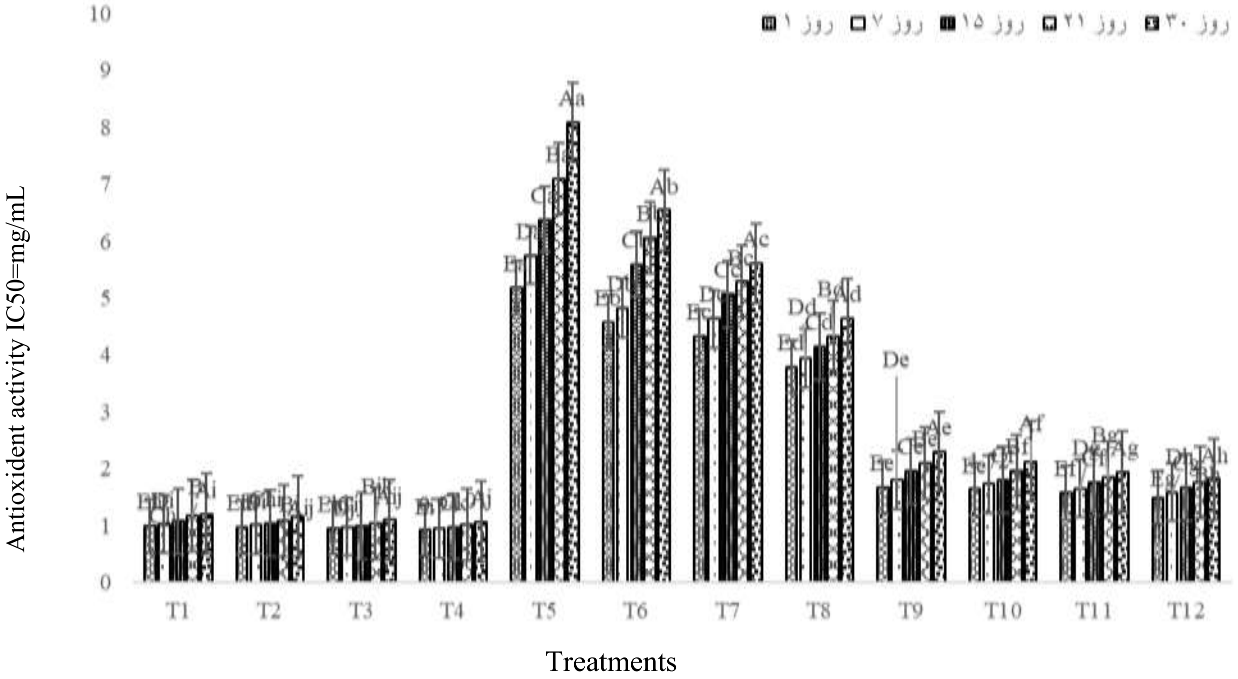

Figure 3-9 - Antioxidant activity of functional fruit juice samples during 30 days of storage

Pomegranate juice is an important source of phenolic compounds, of which anthocyanins are one of the most important, especially the 3-glucosides and 3,5-diglucosides of delphinidin, cyanidin and pelargonidin. These components, together with galangal tannins, ellagic acid derivatives and other hydrolyzable tannins, may contribute to the antioxidant activity of pomegranate juice [39]. Strawberries are also a common and important fruit in the Mediterranean diet due to their high content of essential nutrients and beneficial phytochemicals, which appear to have relevant biological activities in human health. Among these phytochemicals, anthocyanins and ellagitannins are the main antioxidant compounds [11]. In general, pomegranate (Punica granatum), carrot (Daucus carota) and beetroot (Beta vulgaris) are rich sources of antioxidant vitamins (A, C and E), carotenoids (including α-carotene, β-carotene, lutein, zeaxanthin, β-cryptoxanthin, and astaxanthin compounds). These polyphenolic compounds can be further classified into flavonoids and non-flavonoids. The primary flavonoids found in pomegranate, beetroot and carrot include flavonols, flavan-3-ols, flavones, flavanones, anthocyanins, anthocyanidins, proanthocyanidins, dihydroflavanols and isoflavones. On the other hand, prominent non-flavonoids include simple phenols, hydrolyzable tannins, cinnamic acid, coumarins, xanthones, acetylbenes, lignans, sesquioids, benzophenones, acetophenones, phenylacetic acid, and benzoic acid[36]. Mokhtar et al. (2020) studied the effect of adding pomegranate peel extract and guava leaf extract at concentrations of 0, 0.1, 0.2, and 0.3% on the physicochemical, antioxidant, microbiological, and sensory properties of pasteurized guava nectar during storage at room temperature (25°C) and showed that pomegranate peel extract and guava leaf extract showed high total phenolic content of 129.40 and 92.21 mg/g, respectively, and antioxidant activity of 91.15 and 87.34%, respectively[33]. Basiony et al. (2023) showed that adding sugar beet puree with pomegranate and strawberry juice to yogurt increased the antioxidant activity of this mixture [11]. Kaur et al. (2002) stated that the antioxidant activity of red beetroot in ethanolic extract was 73.3% and in aqueous extract was 55% [40].Different treatments and storage time had a significant effect on the mold and yeast counts of different probiotic juice samples ($p<0.05$). According to the results, mold and yeast growth was not observed in all treatments during 15 days and in T4 and T12 treatments (100% pomegranate juice and 100% strawberry juice, respectively) during 21 days ($p>0.05$). According to the results, the highest mold and yeast counts were observed in sample T5 (50:05 pomegranate and strawberry juice) on day 21 ($p<0.05$). In addition, the results showed that the addition of sugar beet extract reduced mold and yeast growth ($p<0.05$). This significant reduction was more evident with an increase in the percentage of sugar beet puree from 0.5 to 1.5 ($p<0.05$) (Figure 3-10). In addition, an increasing trend in mold and yeast counts was observed during 30 days of storage in all studied groups ($p<0.05$). So that on day 30 of storage, the highest mold and yeast counts were observed in sample T5 ($p<0.05$). The lowest total phenol content was observed in T5 (50:50 pomegranate and strawberry juice) ($p<0.05$).

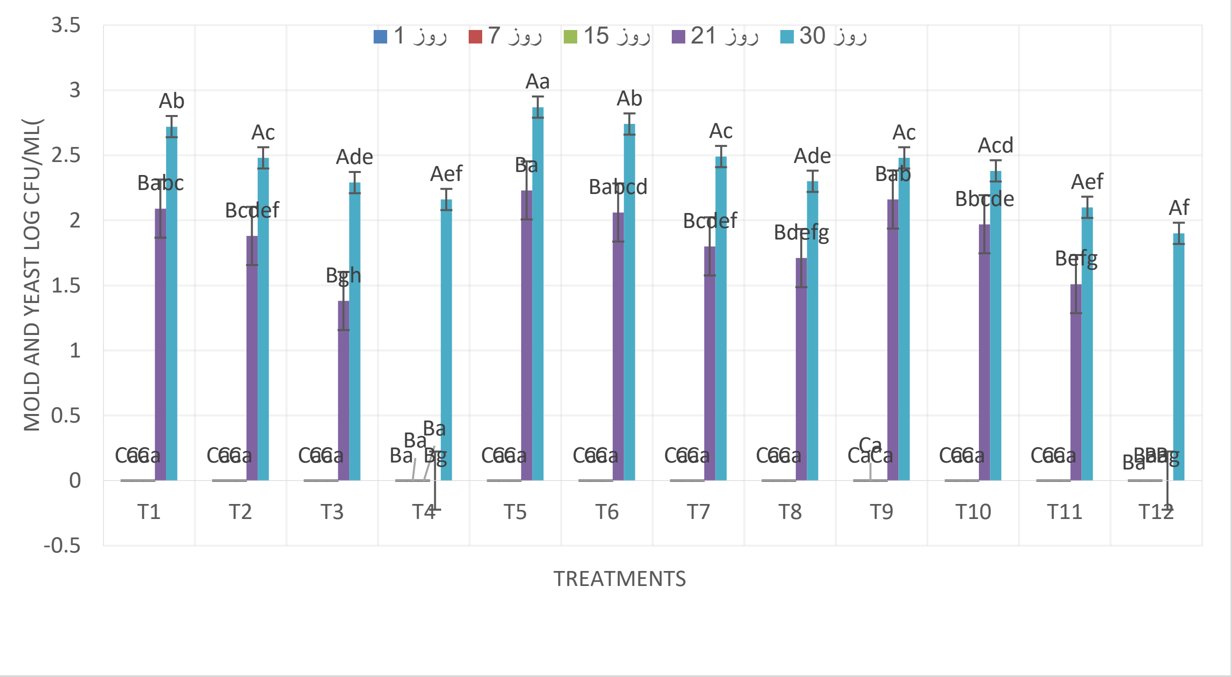

Figure 3-10 - Antibacterial activity (mold and yeast count) of functional fruit juice samples during 30 days of storage

Strawberries, pomegranates, and beets contain active phytochemicals that have therapeutic, antimicrobial, and antioxidant properties [11]. The addition of sugar beet extract reduced the growth of mold and yeast. Habib et al. (2023) showed that the primary polyphenols identified in pomegranate juice concentrate included 4-hydroxy-3-methoxybenzoate, epicatechin, catechin, rutin, ferulic acid, P-coumaric acid, and cinnamic acid, which, due to the presence of these bioactive compounds, pomegranate juice concentrate exhibits strong antibacterial effects against human pathogens such as Streptococcus mutans and Aeromonas hydrophila [37]. Mokhtar et al. (2020) investigated the effect of adding pomegranate peel extract and guava leaf extract at concentrations of 0, 0.1, 0.2, and 0.3% on the microbiological properties of pasteurized guava nectar during storage at room temperature (25°C) and showed that all nectar samples were microbiologically safe [33].Different treatments and storage time had a significant effect on the viability of probiotic bacteria in different probiotic juice samples ($p<0.05$). According to the results, 100% strawberry juices had the highest viability of probiotic bacteria ($p<0.05$). The results also showed that the addition of sugar beet puree significantly increased the viability of probiotic bacteria in juice samples ($p<0.05$). This significant increase was more evident with the increase in the percentage of sugar beet puree from 0.5 to 1.5 ($p<0.05$). In addition, a decreasing trend in the viability of probiotic bacteria was observed during 30 days of storage in all groups studied ($p<0.05$) (Figure 3-11). On day 30 of storage, the highest survival of probiotic bacteria was observed in sample T12 (100% strawberry juice containing 1.5% sugar beet puree) ($p<0.05$). The lowest survival of probiotic bacteria was observed in T5 (50:50 pomegranate and strawberry juice) ($p<0.05$).

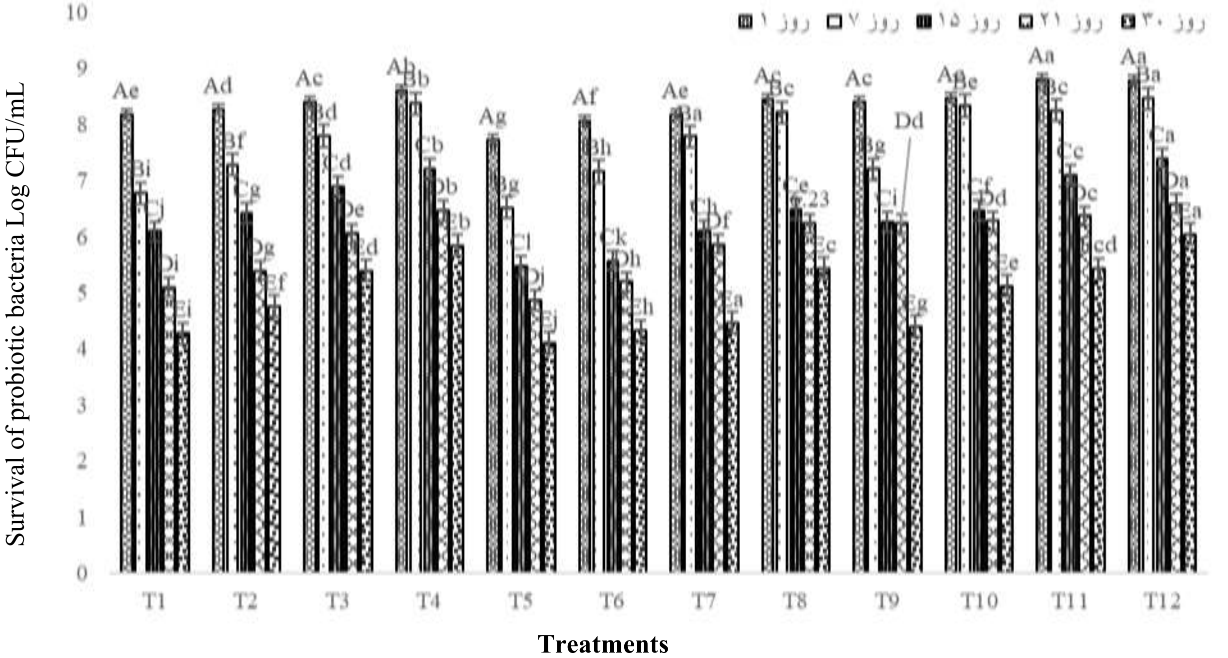

Figure 3-11- Survival of probiotic bacteria in functional fruit juice samples during 30 days of storage

Dietary fibers are prebiotic compounds that can increase the survival of probiotic microorganisms in food products during storage and have health effects on consumers [30]. Concentrated and processed fruit juice products can have very low levels of fiber, as a result of processing, the same amount of fiber is removed from the raw materials. Some dietary fibers can act as prebiotics and enhance and increase the survival of probiotics in foods. Fruit juice is an ideal medium and prebiotic for health-promoting functional ingredients due to its beneficial nutrients and an attractive flavor profile for all age groups [41]. Khezri et al. (2018) used fig juice as a base for inoculation of Lactobacillus delbruecki with inulin, and the results showed that fig juice is a suitable environment for the survival of Lactobacillus delbruecki[42]. Fruit fiber as a nutrient provides energy for bacteria and increases their growth and survival during storage [43]. Storage time had a significant effect on the sensory evaluation of the taste of different probiotic juice samples ($p<0.05$). While different treatments did not have a significant effect on the sensory evaluation of the taste of the samples, and a statistically significant difference was observed between the treatments within 30 days ($p>0.05$). However, a significant decrease in the sensory evaluation of the taste was observed in all the groups studied during 30 days of storage ($p<0.05$) Table 3-1.

Table 3-1- Results of the average sensory evaluation of the taste of different functional juice samples during 30 days of storage

Day Treatment	Day1	Day7	Day15	Day21	Day30
T1	4.00 ± 1.00^{Aabc}	2.66 ± 0.57^{Bbc}	2.00 ± 0.00^{Bc}	1.00 ± 0.00^{Cd}	1.00 ± 0.00^{Ca}
T2	4.33 ± 0.57^{Aabc}	3.33 ± 0.57^{ABabc}	2.33 ± 0.57^{BCbc}	1.33 ± 0.57^{Ccd}	1.33 ± 0.57^{Ca}
T3	3.33 ± 0.57^{Ad}	2.66 ± 0.57^{ABbc}	2.00 ± 0.00^{BCc}	1.33 ± 0.57^{Ccd}	1.33 ± 0.57^{Ca}
T4	3.33 ± 0.57^{Ad}	2.33 ± 0.57^{ABc}	2.33 ± 0.57^{ABbc}	2.66 ± 0.57^{ABab}	1.66 ± 0.57^{Ba}
T5	5.00 ± 0.00^{Aa}	4.00 ± 0.00^{Ba}	3.00 ± 0.00^{Cab}	2.00 ± 0.00^{CDbc}	1.00 ± 0.00^{Da}
T6	4.66 ± 0.57^{Aab}	3.66 ± 0.57^{Bab}	3.00 ± 0.00^{Bab}	2.00 ± 0.00^{Cbc}	1.33 ± 0.57^{Ca}
T7	4.33 ± 0.57^{Aabc}	3.33 ± 0.57^{ABabc}	2.66 ± 0.57^{BCbc}	2.33 ± 0.57^{BCab}	1.33 ± 0.57^{Ca}
T8	3.66 ± 1.15^{Acd}	3.33 ± 0.57^{ABabc}	3.00 ± 0.00^{ABab}	2.00 ± 0.00^{Bbc}	1.00 ± 0.00^{Ca}
T9	5.00 ± 0.00^{Aa}	3.66 ± 0.57^{Bab}	2.66 ± 0.57^{Cbc}	2.00 ± 0.00^{Dbc}	1.33 ± 0.57^{Ea}
T10	4.66 ± 0.57^{Aab}	3.66 ± 0.57^{Bab}	3.00 ± 0.00^{Cab}	2.00 ± 0.00^{Dbc}	1.33 ± 0.57^{Ea}
T11	4.66 ± 0.57^{Aab}	4.00 ± 0.00^{Aba}	3.00 ± 0.00^{Bab}	2.66 ± 0.57^{BCab}	1.66 ± 0.57^{Ca}
T12	4.00 ± 0.00^{Aabc}	3.33 ± 0.57^{Aabc}	3.66 ± 0.57^{Aba}	3.00 ± 0.00^{BCa}	2.00 ± 0.00^{Ca}

Storage time had a significant effect on the sensory evaluation of the odor of different probiotic juice samples ($p<0.05$). While different treatments did not have a significant effect on the sensory evaluation of the odor of the samples and no statistically significant difference was observed between the treatments within 30 days ($p>0.05$). However, a significant decrease in the sensory evaluation of the odor was observed in all the groups studied within 30 days of storage ($p<0.05$) (Table 3-2).

Table 3-2- Average results of sensory evaluation of odor of different functional juice samples during 30 days of storage

Day Treatment	Day1	Day7	Day15	Day21	Day30
T1	4.33 ± 0.57^{Aabc}	2.66 ± 0.57^{Bbc}	3.00 ± 0.00^{Cc}	1.33 ± 0.57^{Da}	1.00 ± 0.57^{Da}
T2	4.33 ± 0.57^{Aabc}	3.23 ± 0.57^{Aabc}	3.66 ± 0.57^{Bbc}	2.00 ± 0.00^{Ba}	1.33 ± 0.00^{Ca}
T3	3.66 ± 0.57^{Ad}	2.66 ± 0.57^{ABbc}	3.00 ± 0.00^{BCc}	1.66 ± 0.57^{Ca}	1.66 ± 0.57^{Ca}
T4	3.66 ± 0.57^{Ad}	2.33 ± 0.57^{Bc}	2.33 ± 0.57^{Bbc}	2.00 ± 0.00^{Ba}	1.66 ± 0.00^{Ba}
T5	5.00 ± 0.00^{Aa}	4.00 ± 0.00^{Ba}	3.66 ± 0.57^{Cab}	2.00 ± 0.00^{Da}	1.00 ± 0.00^{Da}
T6	4.66 ± 0.57^{Aab}	3.66 ± 0.57^{ABab}	3.66 ± 0.57^{BCab}	2.33 ± 0.57^{CDa}	1.66 ± 0.57^{Da}

T7	4.33 ± 0.57 ^{Aabc}	3.33 ± 0.57 ^{ABabc}	3.66 ± 0.57 ^{BCbc}	2.00 ± 0.57 ^{Ca}	1.33 ± 0.57 ^{Ca}
T8	4.00 ± 1.15 ^{Acd}	3.33 ± 0.57 ^{ABabc}	3.00 ± 0.00 ^{BCab}	2.00 ± 0.00 ^{Ca}	1.66 ± 0.57 ^{Da}
T9	5.00 ± 0.00 ^{Aa}	3.66 ± 0.57 ^{Bab}	2.66 ± 0.57 ^{BCbc}	± 0.57 ^{CDbc} 1.66	1.33 ± 0.57 ^{Ea}
T10	4.33 ± 0.57 ^{Aab}	3.66 ± 0.57 ^{Bab}	3.00 ± 0.57 ^{BCab}	2.33 ± 0.57 ^{CDbc}	1.66 ± 0.57 ^{Da}
T11	4.33 ± 0.57 ^{Aab}	4.00 ± 0.00 ^{Aba}	3.33 ± 0.57 ^{Bab}	2.66 ± 0.57 ^{Cab}	1.66 ± 0.57 ^{Ca}
T12	4.33 ± 0.57 ^{Aabc}	3.33 ± 0.57 ^{ABabc}	3.00 ± 0.00 ^{Abba}	2.00 ± 0.00 ^{BCa}	2.00 ± 0.00 ^{Ca}

Storage time had a significant effect on the sensory evaluation of color of different probiotic juice samples ($p<0.05$). While different treatments did not have a significant effect on the sensory evaluation of odor of the samples and no statistically significant difference was observed between treatments within 30 days ($p>0.05$). However, a significant decrease in sensory evaluation of color was observed in all groups studied within 30 days of storage ($p<0.05$) (Table 3-3).

Table 3-3- Results of the average sensory evaluation of the color of different functional juice samples during 30 days of storage

Day Treatment	Day1	Day7	Day15	Day21	Day30
T1	4.33 ± 0.57 ^{Aa}	3.33 ± 0.57 ^{Bbc}	2.33 ± 0.57 ^{Cc}	1.33 ± 0.57 ^{Dc}	1.00 ± 0.00 ^{Dd}
T2	4.33 ± 0.57 ^{Aa}	3.33 ± 0.57 ^{Bbc}	2.33 ± 0.57 ^{Cc}	1.33 ± 0.00 ^{Dc}	1.00 ± 0.00 ^{Dd}
T3	4.66 ± 0.57 ^{Aa}	3.66 ± 0.57 ^{Bbc}	2.66 ± 0.57 ^{Cbc}	2.00 ± 0.57 ^{Cc}	1.00 ± 0.00 ^{Dd}
T4	5.00 ± 0.00 ^{Aa}	4.00 ± 0.00 ^{Babc}	3.00 ± 0.00 ^{Cbc}	2.33 ± 0.57 ^{Dbc}	1.33 ± 0.57 ^{Ecd}
T5	4.00 ± 0.57 ^{Aa}	3.00 ± 0.00 ^{ABc}	2.33 ± 0.57 ^{BCc}	2.66± 0.57 ^{BCabc}	1.66 ± 0.57 ^{Cbcd}
T6	4.66 ± 0.57 ^{Aa}	3.66 ± 0.57 ^{ABbc}	3.33 ± 0.57 ^{Babc}	2.66± 0.57 ^{BCabc}	1.66 ± 0.57 ^{Cbcd}
T7	4.66 ± 0.57 ^{Aa}	3.66 ± 0.57 ^{ABbc}	2.66 ± 0.57 ^{ABbc}	2.66±0.57 ^{BCabc}	2.00 ± 0.57 ^{Cbc}
T8	5.00 ± 0.00 ^{Aa}	2.00 ± 0.00 ^{Dbc}	3.66 ± 0.57 ^{Cab}	4.00± 0.00 ^{Babc}	5.00 ± 0.00 ^{Aa}
T9	4.33 ± 0.57 ^{Aa}	1.33 ± 0.57 ^{Ccd}	2.66 ± 0.57 ^{ABc}	3.33± 0.57 ^{ABbc}	4.33 ± 0.57 ^{Aa}
T10	4.33 ± 0.57 ^{Aa}	1.33 ± 0.57 ^{Ccd}	2.66 ± 0.57 ^{Bbc}	3.33± 0.57 ^{ABbc}	4.33 ± 0.57 ^{Aa}
T11	4.66 ± 0.57 ^{Aa}	2.33 ± 0.57 ^{Bab}	3.66 ± 0.57 ^{Bab}	4.33± 0.00 ^{Bab}	4.66 ± 0.57 ^{Aa}
T12	5.00 ± 0.00 ^{Aa}	3.00 ± 0.00 ^{Da}	4.00 ± 0.00 ^{Bba}	5.00± 0.00 ^{Ba}	5.00 ± 0.00 ^{Aa}

Storage time had a significant effect on the sensory evaluation of overall acceptability of different probiotic juice samples ($p<0.05$). While different treatments did not have a significant effect on the sensory evaluation of overall acceptability of the samples and no statistically significant difference was observed between treatments within 30 days ($p>0.05$). However, a significant decrease in the sensory evaluation of overall acceptability was observed in all studied groups within 30 days of storage ($p<0.05$).

Table 4-17- Results of the average sensory evaluation of overall acceptance of different functional juice samples during 30 days of storage

Day Treatment	Day1	Day7	Day15	Day21	Day30

T1	4.33 ± 0.57^{Aab}	3.00 ± 0.00^{Bbc}	2.00 ± 0.00^{Cc}	1.00 ± 0.57^{Dd}	1.00 ± 0.00^{Db}
T2	4.33 ± 0.57^{Aab}	3.33 ± 0.57^{ABbc}	2.33 ± 0.57^{BCbc}	1.66 ± 0.00^{Ccd}	1.33 ± 0.00^{Cab}
T3	4.00 ± 0.00^{Ab}	3.00 ± 0.00^{Bbc}	2.33 ± 0.57^{Cbc}	1.66 ± 0.57^{Ccd}	1.66 ± 0.00^{Dab}
T4	4.00 ± 0.00^{Ab}	2.66 ± 0.57^{Bc}	2.33 ± 0.57^{Bbc}	2.66 ± 0.57^{Bab}	1.66 ± 0.57^{Bab}
T5	5.00 ± 0.00^{Aa}	3.33 ± 0.57^{Bbc}	2.33 ± 0.57^{Cbc}	2.33 ± 0.57^{CDbc}	1.33 ± 0.57^{Dab}
T6	4.66 ± 0.57^{Aab}	3.66 ± 0.57^{ABab}	3.00 ± 0.00^{BCabc}	2.33 ± 0.57^{CDbc}	1.66 ± 0.57^{Dab}
T7	4.66 ± 0.57^{Aab}	3.66 ± 0.57^{ABab}	3.00 ± 0.00^{Babc}	2.66 ± 0.57^{Bab}	1.66 ± 0.57^{Cab}
T8	4.00 ± 0.00^{Ab}	4.00 ±0.00^{ABabc}	3.66 ± 0.57^{BCa}	3.00 ± 0.00^{CDab}	2.00 ± 0.00^{Db}
T9	5.00 ± 0.00^{Aa}	3.66 ± 0.57^{Bab}	2.66 ± 0.57^{Cabc}	2.33 ± 0.57^{Cbc}	1.66 ± 0.57^{Dab}
T10	4.33 ± 0.57^{Aab}	3.66 ± 0.57^{ABab}	3.00 ± 0.00^{Cabc}	2.33 ± 0.57^{BCbc}	1.66 ± 0.57^{Cab}
T11	4.66 ± 0.57^{Aab}	4.00 ± 0.00^{ABab}	3.66 ± 0.57^{BCa}	3.33 ± 0.57^{Ca}	2.33 ± 0.57^{Da}
T12	5.00 ± 0.00^{Aa}	4.00 ± 0.00^{Aa}	3.33 ± 0.57^{Aab}	3.00 ± 0.00^{Bab}	2.33 ± 0.00^{Ca}

Different treatments did not have a significant effect on the sensory evaluation of probiotic juice samples. All juice samples had the highest acceptability and acceptance before the storage period, while a decrease in sensory evaluation was reported in all groups during 30 days of storage. Saleem et al. (2025) examined the sensory properties of pomegranate concentrate, beetroot concentrate, carrot concentrate and their complementary whey drinks and showed that the sensory evaluation results of pomegranate-whey concentrate were better for taste, color and overall acceptance and pomegranate concentrate is the best choice for adding value in ready-to-use functional drinks [38]. Mokhtar et al. (2020) investigated the effect of adding pomegranate peel extract and guava leaf extract at concentrations of 0, 0.1, 0.2 and 0.3% on the physicochemical, antioxidant, microbiological and sensory properties of pasteurized guava nectar during storage at room temperature (25 °C) and showed that adding pomegranate peel extract and guava leaf extract did not have a significant effect on all sensory characteristics. From the results obtained, it is concluded that the combination of guava nectar with pomegranate peel extract and guava leaf extract is effective in producing safe nectar with better nutritional and sensory qualities[33]. Majzoubi et al. (2010) reported that high concentration of sugar beet fiber in Berber bread has an adverse effect on the taste as well as the activity of starter yeast[34]. Due to the desirable nutritional properties and taste of red grape and cherry juices, and also to achieve an optimal formulation for the production of new juices enriched with dietary fiber inulin, Heshmati et al. (2017) used a study to investigate the combination of these two juices and inulin and showed that the new formulation had higher overall acceptability and acceptance and also increased the nutritional value of the resulting combined juice, which indicates that the desired goal of producing this combined juice has been achieved [35].

4- Conclusion

With the passage of time and the growth of the target bacteria in the 100% pomegranate juice, 50:50 pomegranate and strawberry and 100% strawberry drinks, the pH decreased significantly and the acidity increased, unlike the pH. The results also showed that the addition of beet puree caused a significant increase in the amount, independent of the concentration. However, a significant increase in the turbidity and Brix of the juices was observed depending on the concentration of sugar beet puree. Also, a significant decrease in the brightness index, a significant increase in the redness and yellowness index of the juice samples were reported with the addition of sugar beet. An increase in the phenol content and antioxidant activity of the juice samples was also observed during the addition of sugar beet puree. Inhibition of the growth of mold and yeast and an increase in the survival of probiotic bacteria during 21 days of storage were also observed in the samples containing sugar beet puree. No significant effect of adding sugar beet puree on sensory parameters (taste, odor, color, and overall acceptability) of juice samples was also observed. From the findings, it can be concluded that 100% pomegranate juice, 100% strawberry juice, and 50:50 pomegranate juice: strawberry juice containing sugar beet puree are suitable raw media for the growth of Lactobacillus plantarum bacteria.

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Author Contributions

All activities were carried out by the author.

Competing Interests

The author confirms that he / she has no financial conflicts of interest or competing interests in this study.

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مقاله علمی_پژوهشی

تاثیر فیبر چغندرقرمز (لبو) بر ویژگی‌های فیزیکوشیمیایی، میکروبی و حسی آب میوه مخلوط پروبیوتیک بر پایه آب انار، توت فرنگی

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چکیده

این مطالعه با هدف تاثیر فیبر چغندرقرمز بر ویژگی‌های فیزیکوشیمیایی، میکروبی و ماندگاری حسی آب میوه مخلوط پروبیوتیک بر پایه آب انار و توت فرنگی انجام شد. برای این منظور، نمونه‌های ۱۰۰ درصد آبمیوه انار(نمونه شاهد)، ۱۰۰ درصد آبمیوه توت فرنگی(نمونه شاهد) و ۵۰:۵۰ آبمیوه انار: توت فرنگی حاوی باکتری پروبیوتیک *لاکتوباسیلوس پلانتاروم* (cfu/mL $۱۰^{۸}$) و سطوح مختلف پودر چغندر قند (۰، ۰/۵، ۱ و ۱/۵ درصد) تهیه شد. خواص فیزیکوشیمیایی، شاخص رنگ، بقاء باکتری پروبیوتیک و حسی نمونه‌های آبمیوه طی ۳۰ روز ارزیابی شد. آنالیز آماری با استفاده از نرم‌افزار SPSS و آزمون چند دامنه‌ای دانکن انجام شد. نتایج نشان داد استفاده از پوره چغندر قند بر پارامترهای نمونه‌های آبمیوه تأثیر معناداری داشت. کاهش pH، افزایش اسیدیته٪، افزایش کدورت(NTU)، درجه بریکس، ویسکوزیته CP، محتوی فنل کل(ppm) و فعالیت آنتی‌اکسیدانی(IC50 mg/mL) نمونه‌های آبمیوه مختلف طی افزودن پوره چغندر قند و بهبود فعالیت باکتری‌های پروبیوتیک تا حدود ۲ درصد افزایش قابلیت زنده مانی مشاهده شد ($p<0.05$). کاهش معنادار شاخص روشنایی و همچنین افزایش معنادار شاخص‌های قرمزی و زردی در نمونه‌های آبمیوه پروبیوتیک مشاهده شد($p<0.05$). همچنین مهار رشد کپک و مخمر و افزایش بقاء باکتری پروبیوتیک در نمونه‌های آبمیوه پروبیوتیک مشاهده شد. افزایش بقاء باکتری پروبیوتیک وابسته به درصد غلظت چغندر قند به عنوان پری-بیوتیک طی زمان نگهداری نمونه‌ها مشاهده شد. عدم تأثیر معنادار پوره چغندر قند بر ویژگی‌های حسی (طعم، عطر، رنگ و پذیرش کلی) نیز گزارش شد($p>0.05$). نزدیک ترین تیمار به تیمار شاهد، تیمار T2 حاوی ۱۰۰ درصد آب انار، cfu/mL $۱۰^{۸}$ باکتری پروبیوتیک و ۰/۵ درصد پوره چغندر می باشد.