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Full Research Paper

Production of a probiotic camel milk enriched with pomegranate peel powder

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Abstract

In this study, the probiotic bacterium *Lactobacillus acidophilus* with different percentages of pomegranate peel powder (0, 0.5, 1, 1.5, and 2%) were used to produce a functional camel milk-based beverage. The physicochemical, antioxidant and sensory properties of the resulting drinks were evaluated. The results showed that enrichment of milk with pomegranate peel powder improved the survival of probiotic bacteria from 6.95 to 7.35 Log CFU/ml. Addition of pomegranate peel to beverages increased their antioxidant activity from 7 to 85.33, 9.13 to 93.66 and 0.126 to 0.435 as measured by DPPH free radical scavenging, $ABTS^{+}$ free radical scavenging and reduction potency tests, respectively. Rheological studies also showed that the addition of pomegranate peel powder to beverages increased their viscosity from 5.65 to 21.5 mPa. Adding pomegranate peel powder to beverages also changed the color factors (L*, a* and b*) so that increasing the level of pomegranate peel powder increased the red and yellow color in the samples. Also, the results of the sensory evaluation, including taste, appearance, smell and general acceptance indicated that the produced beverages were well-liked by consumers. However, the results of sensory evaluation showed that adding high percentages of pomegranate peel powder to beverages could reduce the sensory acceptance of the final product.

Keywords: Dairy Products, Functional Food, Lactobacillus, Milk, Prebiotics.

Introduction

Camel milk, which is consumed fresh or sour, plays an essential role in the nutrition of desert people. Camel milk is comparable to cow's milk in terms of functional, health and technological characteristics (Salami *et al.*, 2008; Moslehishad *et al.*, 2013). Many health benefits have been reported for camel's milk, such as anti-diabetic, cholesterol-lowering, antihypertensive, antioxidant, and anti-cancer effects. It has also been reported that the allergic effects of camel's milk are much less than those of cow's milk because camel's milk lacks beta-lactoglobulin, an allergenic protein (Shori *et al.*, 2012; Hajian *et al.*, 2020). Due to the importance and numerous benefits of camel milk, the production of functional products based on camel milk recently has received much attention (Solanki and Hati, 2018). Probiotics are living microorganisms that provide therapeutic effect in the digestive tract of living organisms, especially the large intestine. Their benefits include prevention of gastrointestinal disorders, increased immune system, anti-cancer properties, lowering blood cholesterol, improving joint diseases, production of a wide range of enzymes, antimicrobial effects and modification and improvement of lactose metabolism (Saljooghi *et al.*, 2017; El Hatami *et al.*, 2018).

Pomegranate is a fruit that is native to Iran and possesses numerous health properties (Moghadam *et al.*, 2020). This fruit is rich in bioactive compounds such as ELI tannins and anthocyanins. Due to its high nutritional value, pomegranate is considered as a nutraceutical, and today it has attracted much attention from researchers (Sorrenti *et al.*, 2019). Hence, various parts of pomegranate such as fruit juice and extract are widely used as health products (Dogahe *et al.*, 2015). One of the by-products of pomegranate processing is its skin, which is discarded without use or used as animal feed. Pomegranate peel is rich in antioxidant compounds and has antimicrobial properties. Pomegranate peel contains various phenolic

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compounds such as ellagic acid, lignins, catechins, epicatechins and tannins (Ali *et al.*, 2019; Moghadam *et al.*, 2020). Therefore, it has been reported that it can be used in the formulation of dairy products.

Currently, foods containing probiotics are recognized as one of the best functional food products, and their health benefits can even be doubled by enrichment with other compounds (Debon *et al.*, 2010). Many authors have studied different characteristics of probiotic cow's milk (El Hatmi *et al.*, 2018), camel milk (Saljooghi *et al.*, 2017; Mahmoudi, *et al*, 2019), bio-doogh (Ziaolhagh and Jalali, 2017), camel yogurt (Ladjevardi, *et al*., 2016), and yogurt (Ibrahim *et al.*, 2020).

In this study, we aimed to produce a probiotic drink from camel milk by using *Lactobacillus acidophilus*. We used pomegranate peel powder to add to its functional properties.

Materials and Methods

All experiments were performed in the fall and winter of 2019.Camel milk was collected from camel farms in Shahroud city (Taroud village), Iran. All milk samples were transported to the Food Laboratory of Shahroud, University of Medical Sciences at a temperature of 4°C during transport. Milk fat was separated by the method described by Salami et al. (2010) to prepare skimmed milk. First, milk was poured into 250 ml Falcons and then was centrifuged for 20 minutes at 6000 g. Subsequently, the lipid phase was separated from the milk as a supernatant. *L. acidophilus* was obtained as a dry powder from Christin Hansen, Denmark. Then a suitable amount of it was dissolved in 50 ml of sterilized skimmed milk (121°C for 15 minutes) and activated at 42°C for 15 minutes before use. Pomegranate peel powder was purchased from a local market, Shahroud, Iran. 2,2-diphenyl-1-picrylhydrazyl (DPPH) and 2, 2'-Azino-Bis-3-Ethylbenzothiazoline-6-Sulfonic Acid (ABTS) were purchased from Sigma-Aldrich USA. Other materials used in this study were purchased from Merck Germany or Sigma Aldrich, USA and all of them were analysis grade.

Production of beverage samples

Thirteen g of skim milk powder was dissolved in 100 g of distilled water (w/w) and different percentages of pomegranate peel powder (0, 0.5, 1 and 1.5 w / w) were added to it. The activated strain of *L. acidophilus* was then added to the samples in sufficient quantities to obtain an initial cfu/ml of 10^9. After inoculation, the samples were transferred to a hot water bath so that pH could be measured and recorded. All samples were fermented at 42°C until they reached a pH of 4.5, and then the samples were transferred to the refrigerator for three weeks to perform various experiments on them.

Determining the viability of probiotic bacteria

One ml of beverage samples was added to 9 ml of 0.1 ml sterile peptone water and diluted accordingly. The bacteria were cultured in MRS medium, the pH of which had previously been raised to 5.4 with acetic acid. It was then incubated at 37°C for 48 hours. After incubation, the bacteria were counted (Batista *et al.*, 2017).

Evaluation of antioxidant activity

In the present study, the antioxidant activity of the beverages was evaluated by three different methods, including DPPH free radical scavenging method, $ABTS^+$ free radical scavenging and reducing power during storage, which will be explained below.

Free radical scavenging of DPPH

The ability of the samples to inhibit DPPH free radicals was measured by the method described by Tapal and Tiku (2012) with some changes. For this purpose, first, an ethanolic solution of DPPH with a concentration of 0.1 mM was prepared. Then 200 µl of the sample or distilled water as the control sample was added to 2 ml of DPPH solution. After this step, the samples were kept in the dark place for 30 minutes and then centrifuged for 10 minutes at 8000 rpm. Finally, the absorbance of the

samples at 517 nm was determined using a spectrophotometer, and the percentage of free radical scavenging was calculated using the equation (1).

$$Inhibition\ percent = \frac{A_{conrol} - A_{sample}}{A_{control}} \quad (1)$$

Where $A_{control}$ is the absorption of the control sample and A_{sample} is the absorption of the sample.

$ABTS^+$ free radical scavenging

The ability of the samples to inhibit $ABTS^+$ free radicals was determined by mixing 7.4 mM $ABTS^+$ in phosphate buffer with 2.6 mM potassium persulfate. This solution was stored at room temperature for 18 hours before use. The solution was then diluted with distilled water to an absorbance of 0.7 at 734 nm. Then 200 microliters of beverage or distilled water (as control samples) were mixed with 2 ml of $ABTS^+$ solution and their adsorption was read at 734 nm. Finally, the percentage of free radical scavenging ABTS was determined using the following formula (Mohammadian *et al.*, 2020).

$$ABTS\ radical\ scavenging\ activity(\%) = \frac{A_{control} - A_{sample}}{A_{control}} \quad (2)$$

Where $A_{control}$ is the absorption of the control sample and A_{sample} is the absorption of the sample.

Reducing power

The reducing power of the samples was also used to evaluate the antioxidant activity of different samples (Tapal and Tiku, 2012). For this purpose, 0.1 ml of beverage samples were mixed with 2.5 ml of 0.2 M phosphate buffer at pH 6.6 and 2.5 ml of potassium ferric cyanide (0.1%) for 20 minutes and heated at 50°C. Then 2.5 ml of 10% trichloroacetic acid was added to the samples, and after mixing, they were centrifuged at 1500 g for 10 minutes. Then 2.5 ml of the supernatant was mixed with 2.5 ml of distilled water and 0.5 ml of $FeCl_3$ (0.1%), and after 10 minutes, their adsorption at 700 nm was read using a spectrophotometer. Higher absorption indicates higher antioxidant activity.

Viscosity

After 3 weeks of storage, the apparent viscosity of different beverage samples was determined using a rotary viscometer (Model LV-DV3T, Brookfield Engineering Inc., USA) equipped with a SC4-18 spindle at 25°C. For this purpose, 20 ml of each beverage sample was poured into the viscometer cup, and its viscosity was recorded.

Color indices

Colorimetryof beverage samples containing different percentages of pomegranate peel powder was performed using a Hunterlab device (Minolta colorimeter, CR-300, Japan). Components L* (brightness, 0-100), a* (green/red, from -60 to +60) and b* (blue/yellow, from -60 to +60) were recorded (Moghadam *et al.*, 2020).

Sensory evaluation

Sensory characteristics of beverage samples, including taste, odor, appearance and overall acceptance were measured based on a 5-point hedonic method. For this purpose, panelists consisting of 30 untrained people received samples randomly without knowing the type of sample. This test was performed by panelists based on 5-point hedonic test and its scoring was very bad= 1, bad= 2, average= 3, good= 4 and very good= 5 (Saljooghi *et al.*, 2017).

Statistical analysis

This research was carried out in a completely random design. Also, data analysis was performed by one-way analysis of variance (one-way ANOVA) and comparison of mean data with at least three replications by Duncan's multi-range method at 5% probability level using SPSS software version 19.

Results and Discussion

Survival of *l. Acidophilus*

Survival of *L. acidophilus* in a functional camel milk drink containing different concentrations of pomegranate peel powder is shown in Table 1. Significant changes in

bacterial viability were observed in each treatment during 21 days of storage so that the final bacterial population at the end of the storage period in all treatments was less than the first day. Therefore, the survival of *L. acidophilus* in fermented camel milk drink generally decreased during the storage period in all samples. Decreased biological activity of this probiotic bacterium during storage can be due to the low pH of fermented products, which is one of the most important factors in reducing the viability of probiotics. Another reason for the decrease in the viability of probiotic bacteria in fermented beverages can be due to the shock of environmental stress, after inoculation (Nagpal *et al.*, 2012).

The results of this study also showed that the reduction in bacterial viability in samples containing pomegranate peel powder was less than the control sample. In fact, at the end of the storage period, the survival of bacteria in the sample containing pomegranate peel powder was higher, and with increasing the percentage of pomegranate peel powder, more survival was observed. The number of probiotic bacteria in the samples containing pomegranate peel powder was in the standard range (minimum 10^7 cfu/ml). Therefore, it can be said that some compounds in pomegranate peel, such as phenolic compounds, led to increase the survival of probiotic bacteria. In line with the results of this study, other researchers have suggested that adding pomegranate peel extract to a fermented milk drink improves the survival of probiotic bacteria (Al-Hindi and Abd El Ghani, 2020). Other researchers have also suggested that probiotic bacteria, such as *L. acidophilus* can break down tannic acid in pomegranate peel and generate energy from it, which can improve their survival (Ibrahim and Awad, 2020).

Table 1. Comparison of viability (Log cfu/ml) of probiotics in different treatments during storage.

Pomegranate peel powder (%)	Time (day)			
	0	**7**	**14**	**21**
0	9.00 ± 0.00^{a}	8.15 ± 0.07^{b}	7.65 ± 0.00^{a}	6.95 ± 0.21^{a}
0.5	9.00 ± 0.00^{a}	8.20 ± 0.14^{b}	7.70 ± 0.07^{a}	7.00 ± 0.14^{a}
1	9.00 ± 0.00^{a}	8.30 ± 0.14^{ab}	7.75 ± 0.07^{a}	7.15 ± 0.21^{a}
1.5	9.00 ± 0.00^{a}	8.50 ± 0.00^{a}	7.80 ± 0.07^{a}	7.20 ± 0.14^{a}
2	9.00 ± 0.00^{a}	8.55 ± 0.07^{a}	7.95 ± 0.14^{a}	7.35 ± 0.21^{a}

Different superscript letters in each column indicate a statistically significant difference ($p < 0.05$).

Antioxidant properties of beverages

In the present study, three methods were used to evaluate the antioxidant activity of beverage samples during storage. These methods include the percentage of free radical scavenging DPPH, the percentage of free radical scavenging ABTS and also the reducing power test. In all three methods, a larger number indicates greater antioxidant activity. The results are shown in Tables 2, 3 and 4, respectively. As can be seen in these tables, with increasing the percentage of pomegranate peel in beverage formulations, their antioxidant activity has also increased significantly. In all three methods, the lowest antioxidant activity was related to the control sample without pomegranate peel, and the highest antioxidant activity was related to the sample containing 2% of pomegranate peel powder. This increase in antioxidant activity due to the increase in the percentage of pomegranate peel in the beverage formulation might be as a result of the presence of antioxidant compounds in pomegranate peel that have a high ability to inhibit free radicals. The most important of these antioxidants are phenolic compounds in pomegranate peel, the most important of which are catechins, punicalin, gallic acid and ellagic acid (Smaoui *et al.*, 2019). In line with the results of the present study, other researchers have shown that the addition of pomegranate peel powder to yoghurt has significantly inhibited free radicals of $ABTS^{+}$ and DPPH (Kennas *et al.*, 2020). The researchers also claimed that the increase in antioxidant activity due to the addition of pomegranate peel powder is due to the phenolic

contents. These compounds are natural antioxidants in pomegranate peel.

Table 2. The percentage of free radical scavenging DPPH during storage time in different samples.

Pomegranate peel powder (%)	Time (day)			
	0	7	14	21
0	5.20±0.26^{e}	5.33±0.46^{e}	6.26±0.20^{e}	7.00±0.30^{e}
0.5	57.16±0.76^{d}	62.00±2.00^{d}	64.66±1.52^{d}	69.66±1.52^{d}
1	61.16±1.25^{c}	66.33±1.30^{c}	73.16±1.04^{c}	73.66±1.54^{c}
1.5	65.66±2.08^{b}	70.83±1.04^{b}	75.83±1.04^{b}	78.93±0.90^{b}
2	74.83±1.60^{a}	79.16±1.04^{z}	83.50±1.32^{a}	85.33±2.51^{a}

Different superscript letters in each column indicate a statistically significant difference ($p < 0.05$).

Besides, the results showed that the antioxidant activity of beverage samples during storage was significantly increased, which could be due to the occurrence of fermentation by the existing probiotic bacteria. Fermentation has increased the antioxidant activity of the samples. Increased antioxidant activity due to fermentation can be due to the increase in free phenol content in the samples during the fermentation process as well as the enzymatic activity of bacteria in the beverage (Vuong *et al.*, 2006). In fact, during fermentation, phenolic amino acids and phenolic peptides appear to be formed from proteins in milk, which have good antioxidant activity. Previous studies have also shown that the presence of amino acids such as tyrosine (phenolic group), methionine, histidine (imidazole group), tryptophan (indole group), cysteine and proline in camel milk casein may be related to the antioxidant properties during fermentation (Korhonen and Pihlanto, 2006).

Table 3. Investigation of the percentage of $ABTS^{+}$ free radical scavenging during storage time in different samples.

Pomegranate peel powder (%)	Time (day)			
	0	7	14	21
0	6.60±0.55^{e}	7.13±0.32^{e}	8.03±0.15^{e}	9.13±0.32^{e}
0.5	66.00±1.00^{d}	68.66±1.52^{d}	71.33±1.52^{d}	73.66±1.42^{d}
1	71.33±1.52^{c}	75.00±1.00^{c}	78.00±2.00^{c}	82.16±1.25^{c}
1.5	76.16±1.60^{b}	79.16±0.76^{b}	83.66±1.53^{b}	88.33±1.04^{b}
2	85.00±2.00^{a}	89.66±1.50^{a}	91.33±1.56^{a}	93.66±1.52^{a}

Different superscript letters in each column indicate a statistically significant difference ($p < 0.05$).

Table 4. Reduction power (absorption at 700 nm) during storage time in different samples.

Pomegranate peel powder (%)	Time (day)			
	0	7	14	21
0	0.092±0.010^{d}	0.108±0.004^{e}	0.117±0.002^{e}	0.126±0.007^{e}
0.5	0.255±0.007^{c}	0.269±0.002^{d}	0.306±0.006^{d}	0.317±0.002^{d}
1	0.285±0.007^{b}	0.300±0.002^{c}	0.326±0.006^{c}	0.342±0.004^{c}
1.5	0.306±0.008^{b}	0.329±0.012^{b}	0.344±0.005^{b}	0.353±0.002^{b}
2	0.390±0.006^{a}	0.403±0.002^{a}	0.423±0.004^{a}	0.435±0.005^{a}

Different superscript letters in each column indicate a statistically significant difference ($p < 0.05$).

Color factors and viscosity

Color is one of the important characteristics of food products that affect their desirability. Therefore, in the present study, the color factors of beverages, including L*, a* and b* were evaluated, and the results are shown in Table 5. Therefore, in the present study, the color factors of beverages, including L*, a* and b* were evaluated. The results showed that with increasing the percentage of pomegranate peel

in beverages, the lightness or L * of the samples decreased, but the factors a* and b* increased. These results indicate that the increase in pomegranate peel in the drink has led to increase the turbidity, yellowness, and also redness in the samples. This increase in color can be due to the presence of some anthocyanin pigments in pomegranate peel. In line with these results, other researchers showed that increasing the amount of pomegranate peel powder in mung bean protein-based edible films decreased the transparency and also increased the redness and yellowness of the samples (Moghadam *et al*., 2020). In another study, researchers showed that enriching yogurt with pomegranate peel powder altered the color factors of the final product, and therefore pomegranate peel could also be used as a coloring agent in food formulations (Kennas *et al.*, 2020). Other researchers have suggested that enriching chicken broth with pomegranate peel powder reduced the brightness of the samples, which could be due to the dullness of the pomegranate peel (Shrama and Yadav, 2020).

Another important factor in food products is their rheological properties. Therefore, in the present study, the viscosity of beverage samples was examined in the presence of different percentages of pomegranate peel. The results showed that with increasing the amount of pomegranate peel in the formulation, the viscosity of the samples were also increased, which could be due to the presence of some hydrocolloids and polysaccharides, such as pectin in pomegranate peel, which has the property of increasing viscosity (Yang *et al*., 2018). The pectin in pomegranate peel can cause the accumulation of proteins in camel's milk, such as casein and whey proteins, through electrostatic bonding, which can increase the viscosity of the product (Al-Hindi and Abd El Ghani, 2020). In line with these results, the researchers showed that the addition of pomegranate peel powder to yogurt increased the viscosity.

Table 5. Color factors and viscosity of different samples after 3 weeks of storage.

Pomegranate peel powder (%)	L*	a*	b*	Viscosity (mPa)
0	36.57 ± 1.52^{a}	1.17 ± 0.03^{d}	3.48 ± 0.52^{c}	5.65 ± 0.21^{d}
0.5	35.21 ± 0.28^{ab}	1.77 ± 0.10^{d}	4.47 ± 0.41^{c}	7.85 ± 0.49^{d}
1	34.48 ± 0.54^{bc}	3.43 ± 0.16^{c}	5.24 ± 0.32^{c}	11.00 ± 1.41^{c}
1.5	33.70 ± 0.28^{bc}	6.77 ± 0.46^{b}	8.91 ± 1.01^{b}	16.45 ± 1.34^{b}
2	33.10 ± 0.42^{c}	9.00 ± 0.34^{a}	11.62 ± 0.79^{a}	21.50 ± 0.70^{a}

Different superscript letters in each column indicate a statistically significant difference ($p < 0.05$).

Sensory properties

One of the most important characteristics of food products is their sensory properties, which have a great impact on the consumer. Therefore, the sensory characteristics of the produced beverage, including taste, appearance, smell, and general acceptance were evaluated. As shown in Table 6, in all sensory properties, the highest score is related to the control sample without pomegranate peel and the sample with 0.5% of pomegranate peel powder. Therefore, these results showed that adding 0.5% of pomegranate peel powder to the drink did not have side effect on sensory properties. While with increasing the percentage of pomegranate peel powder in the formulation (one per cent and above), the sensory evaluation score decreased slightly. This indicates that the drink containing high percentages of pomegranate peel powder has not been very desirable to consumers. In line with the results of the present study, other researchers who enriched muffin cakes with pomegranate peel powder also stated that cakes containing pomegranate peel powder had lower sensory scores compared to the control sample (Topkaya and Isik, 2019). Another study showed that the enrichment of fermented dairy beverages with pomegranate peel extract and probiotic lactic acid bacteria did not make a significant difference in their sensory properties (Al-Hindi and Abd El Ghani, 2020). Therefore,

the results of the present study have shown that the by-products of the juice industry, such as pomegranate peel, which are considered as waste, can be effectively used to produce useful products.

Table 6. The score of sensory characteristics of different samples after 3 weeks of storage.

Pomegranate peel powder (%)	score			
	Taste	Appearance	Smell	Total acceptance
0	5.00±0.00^{a}	5.00±0.00^{a}	5.00±0.00^{a}	5.00±0.00^{a}
0.5	5.00±0.00^{a}	5.00±0.00^{a}	5.00±0.00^{a}	5.00±0.00^{a}
1	4.80±0.44^{ab}	5.00±0.00^{a}	4.60±0.54^{ab}	4.80±0.44^{a}
1.5	4.40±0.54^{bc}	4.60±0.54^{ab}	4.20±0.44^{b}	4.40±0.54^{ab}
2	4.00±0.00^{c}	4.20±0.44^{b}	3.60±0.54^{c}	4.00±0.70^{b}

Different superscript letters in each column indicate a statistically significant difference ($p < 0.05$).

Conclusion

In the present study, the probiotic bacterium *L. acidophilus*, along with different percentages of pomegranate peel powder as a substance rich in bioactive compounds were used to produce a beneficial health drink based on camel milk. The results showed that the use of pomegranate peel powder improved the survival of probiotics. The results also showed that the enrichment of the drink with different percentages of pomegranate peel powder caused a change in viscosity as well as the color factors of the final product. Fermentation, as well as the use of pomegranate peel powder, improved the antioxidant properties of the beverages produced. Pomegranate peel powder is also a rich combination of bioactive compounds with high antioxidant properties that can be used to improve the antioxidant properties of food products. Also, the results of the sensory evaluation showed that the produced drinks had good desirability in terms of aroma, taste, appearance, smell and general acceptance among consumers. In general, the results of the present study showed that camel milk could be a suitable environment for the growth of probiotics and by using a suitable percentage of pomegranate peel powder a beneficial camel milk drink with desirable biochemical properties along with an increase in antioxidant activity could be produced.

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References

Al-Hindi, R.R., and Abd El Ghani, S. 2020. Production of functional fermented milk beverages supplemented with pomegranate peel extract and probiotic lactic acid bacteria. *J. Food Qual.*, 2020: 4710273.

Ali, A., Chen, Y., Liu, H., Yu, L., Baloch, Z., Khalid, S. and Chen, L. 2019. Starch-based antimicrobial films functionalized by pomegranate peel. *Int. J. Biol. Macromol.*, 129: 1120-1126.

Batista, A.L.D., Silva, R., Cappato, L.P., Ferreira, M.V.S., Nascimento, K.O., Schmiele, M. and Pimentel, T.C. 2017. Developing a synbiotic fermented milk using probiotic bacteria and organic green banana flour. *J. Funct. Foods*, 38: 242-250.

Debon, J., Prudencio, E.S. and Petrus, J.C.C. (2010). Rheological and physico-chemical characterization of prebiotic microfiltered fermented milk. *J. Food Eng.*, 99(2): 128-135.

Dogahe, M.K., Towfighi, A., Khosravi-Darani, K., Dadgar, M., Mortazavian, A.M. and Ahmadi, N. 2013. Influence of pomegranate peel on viability of probiotic bacteria in pomegranate juice. *Iranian J. Nutri. Sci. & Food Technol.*, 7(5): 17-23.

El Hatmi, H., Jrad, Z., Oussaief, O., Nasri, W., Sbissi, I., Khorchani, T. and Canabady-Rochelle, L.L. 2018. Fermentation of dromedary camel (*Camelus dromedarius*) milk by *Enterococcus faecium*, *Streptococcus macedonicus* as a potential alternative of fermented cow milk. *LWT - Food Sci. and Tech.,* 90: 373-380.

Hajian, N., Salami, M., Mohammadian, M., Moghadam, M. and Emam-Djomeh, Z. 2020. Production of low-fat camel milk functional ice creams fortified with camel milk casein and its antioxidant hydrolysates. *Appl. Food Biotechnol.,* 7(2): 95-102.

Ibrahim, A., Awad, S. and El-Sayed, M. 2020. Impact of pomegranate peel as prebiotic in bio-yoghurt. *Br. Food J.,* 122(9): 2911-2926.

Kennas, A., Amellal-Chibane, H., Kessal, F. and Halladj, F. 2020. Effect of pomegranate peel and honey fortification on physicochemical, physical, microbiological and antioxidant properties of yoghurt powder. *J. Saudi Soc. Agric. Sci.,* 19(1): 99-108.

Korhonen, H. and Pihlanto, A. 2006. Bioactive peptides: production and functionality. *Int. Dairy J.,* 16(9): 945-960.

Ladjevardi, Z.S., Yarmand, M., Emam-Djomeh, Z., Niasari-Naslaji, A. 2016. Physicochemical properties and viability of probiotic bacteria of functional synbiotic camel yogurt affected by oat β-glucan during storage. *J. Agr. Sci. Tech.* 18(5):1233-1246.

Mahmoudi, M., Khomeiri, M., Saeidi, M., Kashaninejad, M., Davoodi, H. 2019. Study of Potential Probiotic Properties of Lactic Acid Bacteria Isolated from Raw and Traditional Fermented Camel Milk. *J. Agr. Sci. Tech.,* 21(5):1161-1172.

Moghadam, M., Salami, M., Mohammadian, M., Khodadadi, M. and Emam-Djomeh, Z. 2020. Development of antioxidant edible films based on mung bean protein enriched with pomegranate peel. *Food Hydrocolloids,* 104: 105735.

Mohammadian, M., Moghaddam, A.D., Sharifan, A., Dabaghi, P. and Hadi, S. 2020. Nanocomplexes of whey protein fibrillar aggregates and quercetin as novel multi-functional biopolymeric ingredients: interaction, chemical structure, and bio-functionality. *J. Iran. Chem. Soc.,* 17: 2481-2492.

Moslehishad, M., Mirdamadi, S., Ehsani, M.R., Ezzatpanah, H. and Moosavi-Movahedi, A.A. 2013. The proteolytic activity of selected lactic acid bacteria in fermenting cow's and camel's milk and the resultant sensory characteristics of the products. *Int. J. Dairy Technol.,* 66(2): 279-285.

Nagpal, R., Kumar, A., Kumar, M., Behare, P.V., Jain, S. and Yadav, H. 2012. Probiotics, their health benefits and applications for developing healthier foods: a review. *FEMS Microbiol. Lett.,* 334(1): 1-15.

Salami, M., Moosavi-Movahedi, A.A., Ehsani, M.R., Yousefi, R., Haertle, T., Chobert, J.M. and Pourtakdoost , S. 2010. Improvement of the antimicrobial and antioxidant activities of camel and bovine whey proteins by limited proteolysis. *J. Agric. Food Chem.,* 58(6): 3297-3302.

Salami, M., Yousefi, R., Ehsani, M.R., Dalgalarrondo, M., Chobert, J.M., Haertle, T. *et al*. 2008. Kinetic characterization of hydrolysis of camel and bovine milk proteins by pancreatic enzymes. *Int. Dairy J.,* 18(12): 1097-1102.

Saljooghi, S., Mansouri-Najand, L., Ebrahimnejad, H., Doostan, F. and Askari, N. 2017. Microbiological, biochemical and organoleptic properties of fermented-probiotic drink produced from camel milk. *Veterinary Research Forum,* 8(4): 313.

Sharma, P. and Yadav, S. 2020. Effect of Incorporation of Pomegranate Peel and Bagasse Powder and Their Extracts on Quality Characteristics of Chicken Meat Patties. *Food Sci. Animal Res.,* 40(3): 388.

Shori, A.B. 2012 Comparative study of chemical composition, isolation and identification of micro-flora in traditional fermented camel milk products: Gariss, Suusac, and Shubat. *J. Saudi Soc. Agric. Sci.,* 11(2): 79-88.

Smaoui, S., Hlima, H.B., Mtibaa, A.C., Fourati, M. *et al*. 2019. Pomegranate peel as phenolic compounds source: Advanced analytical strategies and practical use in meat products. *Meat Sci.*, 158: 107914.

Solanki, D. and Hati, S. 2018. Fermented camel milk: A Review on its bio-functional properties. *Emirates J. Food and Agric.*, 30(4): 268-274.

Sorrenti, V., Randazzo, C.L., Caggia, C., Ballistreri, G., Romeo, F.V., Fabroni, S. and Vanella, L. (2019). Beneficial effects of pomegranate peel extract and probiotics on pre-adipocyte differentiation. *Frontiers in Microbiology*, 10: 660.

Tapal, A., and Tiku, P. 2012. Complexation of curcumin with soy protein isolate and its implications on solubility and stability of curcumin. *Food Chem.*, 130(4): 960-965.

Topkaya, C. and Isik, F. 2019. Effects of pomegranate peel supplementation on chemical, physical, and nutritional properties of muffin cakes. *J. Food Process. Preserv.*, 43(6): 13868.

Vuong, T., Martin, L. and Matar, C. 2006. Antioxidant activity of fermented berry juices and their effects on nitric oxide and tumor necrosis factor-alpha production in macrophages 264.7 gamma no (–) cell line. *J. Food Biochem.*, 30(3): 249-268.

Yang, X., Nisar, T., Hou, Y., Gou, X., Sun, L. and Guo, Y. 2018. Pomegranate peel pectin can be used as an effective emulsifier. *Food Hydrocolloids*, 85: 30-38.

Ziaolhagh, S.H. and Jalali, H. 2017. Physicochemical properties and survivability of probiotics in bio-doogh containing wild thyme essence and xanthan gum. *Int. Food Res. J.*, 24(4): 1805-1810.

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تولید شیر شتر پروبیوتیک غنی‌سازی شده با پودر پوست انار

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چکیده

در این مطالعه، از باکتری پروبیوتیک *Lactobacillus acidophilus* با درصدهای مختلف پودر پوست انار (صفر، ۰/۵، ۱ ، ۱/۵ و ۲ درصد) برای تولید یک نوشیدنی فراسودمند مبتنی بر شیر شتر استفاده شد. خصوصیات فیزیکوشیمیایی، آنتی‌اکسیدانی و حسی نوشیدنی‌های حاصل ارزیابی شد. نتایج نشان داد که غنی‌سازی شیر با پودر پوست انار باعث بهبود بقای باکتری‌های پروبیوتیک از ۶/۹۵ به ۷/۳۵ Log CFU/ml می‌شود. با افزودن پوست انار به نوشیدنی‌ها، فعالیت آنتی‌اکسیدانی آن‌ها در روش مهار رادیکال‌های آزاد DPPH، مهار رادیکال‌های آزاد ABTS و قدرت احیاکنندگی، به‌ترتیب از ۷ به ۸۵/۳۳، ۹/۱۳ به ۹۳/۶۶ و ۰/۱۲۶ به ۰/۴۳۵ افزایش یافت. مطالعات رئولوژیکی نشان داد که افزودن پودر پوست انار به نوشیدنی‌ها باعث افزایش ویسکوزیته آن‌ها از ۵/۶۵ به ۲۱/۵ mPa می‌شود. افزودن پودر پوست انار همچنین باعث تغییر عوامل رنگ (L*، a* و b*) شد و افزایش پودر پوست انار رنگ قرمز و زرد در نمونه‌ها را افزایش داد. همچنین، نتایج ارزیابی حسی، از جمله طعم، ظاهر، بو و پذیرش کلی نشان داد که نوشیدنی‌های تولید شده مورد پسند مصرف‌کنندگان قرار گرفته‌اند. با این حال، نتایج ارزیابی حسی نشان داد که افزودن درصد بالای پودر پوست انار به نوشیدنی‌ها می‌تواند میزان پذیرش حسی محصول نهایی را کاهش دهد.

واژه‌های کلیدی: پروبیوتیک، پری‌بیوتیک، شیر، غذاهای فراسودمند، فراورده‌های لبنی، لاکتوباسیلوس

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