Journal of Food Science and Technology (Iran)

Homepage:www.fsct.modares.ir

Scientific Research

The effect of propolis extract on physicochemical, sensory and microbial characteristics of synbiotic yogurt inoculated with *Lactobacillus casei*

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ARTICLE INFO

Article History:
Received:2024/1/17
Accepted:2024/3/10

Keywords:

propolis,

yogurt,

synbiotic, prebiotic,

probiotic,

Lactobacillus casei

DOI: **10.22034/FSCT.21.152.77.**

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ABSTRACT

Dairy products such as yogurt are considered as one of the most popular foods in the world. Beside the probiotics, functional ingredients such as prebiotics are also used in various products. One of the functional ingredients is propolis which has antioxidant, anti-inflammatory, anti-fungal, anti-viral and anti-tumor properties, and in addition to this properties it can be a prebiotic which can have beneficial effects on the human digestive system. This study was conducted to investigate the effect of propolis extract on the physicochemical, sensory and microbial characteristics of synbiotic yogurt inoculated with *Lactobacillus casei*. This study was conducted in five treatments (control (A), 1% (B), 2% (C), 3% (D), 4% (E)) and three replications. Physical and chemical properties such as antioxidant activity and total polyphenol, acidity and pH, syneresis, texture (hardness, adhesiveness, springiness and chewiness), probiotics survival as well as sensory properties (taste, odor, texture, color and general acceptance) of yogurt samples in days 1, 7, 14 and 21 were measured. According to the results of the sensory evaluation team, the highest level of sensorial favorability was related to the control treatment. The lowest pH value in the control sample was 1% and showed a significant difference with the 2%, 3% and 4% treatments. The results of the survival of *L. casei* on different days showed that the effect of time and propolis percentage on the survival of probiotic was significant. The highest count of *L. casei* was observed in 4% treatment. It can be concluded that propolis can be used as a prebiotic in yogurt, which can improve the functional and textural properties of yogurt.

1-Introduction

Over the past few decades, with the increase in the level of awareness of the general public regarding the high consumption of fat and diseases such as vasoconstriction, cardiovascular diseases, high blood pressure, and cancer, the demand for the production of healthy food products such as low-fat dairy products and probiotics has increased. For this reason, nowadays, most consumers pay attention not only to the healthiness of food and its nutritional value, but also to its health benefits [1, 2]. Functional foods are the foods that contain one or more special compounds that have a practical effect on improving the health and well-being of the consumer. These useful components may be naturally increased in the food or may be intentionally added to it in the production process and cause health effects such as regulation of metabolic activities, physical fitness, improvement of the digestive system, heart and blood vessels and etc [1-3]. According to the reports presented, yogurt is one of the most popular dairy products and also one of the most accepted and widely consumed probiotic products in the world, which is widely consumed all over the world. Due to its high nutritional value and the presence of useful bacteria, it has received a lot of attention [4, 5]. According to the researchers' report, the most common means used to deliver live cells of *Lactobacillus acidophilus* and *Bifidobacterium bifidum* to humans is yogurt [6-8]. Today, yogurt production methods have changed due to advances in technologies, although there is not so much changes in lactic acid bacteria [9-11]. The yogurts produced in the industry are very diverse, including low-fat yogurts, probiotic yogurts, drinking yogurts, and frozen yogurts [9, 12, 13]. Probiotic products are one of the most common types of beneficial foods, and in recent years, increasing efforts have been made to use probiotic microorganisms in the production of various foods [14]. A new group of foods called synbiotics contain probiotics and prebiotics [15]. Probiotics are live microorganisms that settle in the intestine after consumption and have positive effects on human health [15]. Also, several investigations have proven the effective role of prebiotic compounds in the sensory characteristics of fermented milk products such as yogurt, and it has also been determined that prebiotic compounds improve the structure and texture of synbiotic yogurt [16]. One of the compounds that has not been investigated so far is propolis, which is one of the most useful bee products and is a colloidal and gummy substance in terms of its physical structure [7, 17, 18]. Also, propolis has antioxidant and antimicrobial properties and can be used instead of chemical preservatives [19, 20]. Most importantly, prebiotic oligosaccharides in honey increase the viability of probiotic bacteria. For this reason, honey components can be used as a food matrix for the formulation of synbiotics [21-23], because propolis can play a prebiotic role [24]. The chemical composition of propolis has a direct relationship with changes in weather conditions and environmental conditions. Propolis has a fat-like structure, hard and brittle, and becomes soft, flexible, gummy and very sticky when heated. It has an aromatic and pleasant smell and its color varies depending on the source and age of the resins (green, red, yellow and brown) [25]. Propolis is recognized as generally safe (GRAS), it is considered in the category of green products [26], and it is also a functional material [27]. Due to the prebiotic nature of propolis, simultaneous consumption of prebiotic and probiotic products has a synergistic effect and causes an increase in the population of beneficial bacteria and also a decrease in the population of harmful bacteria in the intestine [28]. According to the mentioned issues, it seems necessary to pay attention to the beneficial probiotic dairy products

due to their high beneficial properties and the importance of preserving probiotic bacteria in synbiotic products. The purpose of this research is to investigate the viability of probiotics in yogurt by using propolis and to evaluate the physical, microbial and sensory characteristics of the product.

2- Materials and Methods

2.1. Samples preparation

This study was conducted in the Faculty of Agricultural Sciences, Gilan University, Gilan province, and Pegah Guilan Pasteurized Milk Company, with five treatments and in triplicate for each treatment. The factors of interest were examined on days 1, 7, 14 and 21. Propolis was obtained from Ardebil city, (Aihal Bal sales center). Sterilized milk (1.5% fat) was obtained from Pegah dairy company. The microbial strains used included the combined culture of yogurt (YoFlex®-L904) containing *Lactobacillus delbrueckii* subsp. *bulgaricus* and *Streptococcus thermophilus* as well as the probiotic single strain culture of *Lactobacillus paracasei* (L. CASEI 431®) LC-01, in freeze-dried form and of DVS type were obtained from Christian Hansen (Chr. Hansen), Denmark.

Large pieces of propolis were divided into smaller pieces, and then the soaking method was used for extraction. The required amount of propolis was mixed with 100 ml of distilled water at a temperature of 65 °C, preserved for 2 hours and ocassionally shaken until the end of the period. After cooling, the extract was centrifuged for 55 minutes. Then it passed through a Whatman 42 filter (size 12.5 cm). Before extracting and after extracting, propolis was kept in the freezer until the time of testing. The extract was filtered and sterilized before adding to the sample [20]. To produce the samples, milk was heated to 40°C and then propolis was added with specific concentrations. This study consisted of five treatments (control without propolis (A), 1% propolis (B), 2% propolis (C), 3% propolis (D), 4% propolis (E)) and three replications for each treatment were performed. In order to better hydration of propolis, it was used before thermal processing of milk. Next, the milk was heated for 3 minutes at a temperature of 90 °C [29]. The amount of one-tenth (0.1) percent of the starter and probiotic strain in the amount of five-tenths (0.5) percent was equivalent to the initial inoculation of 10^7 CFU/g based on the specified instructions from the factory packaging and calculating the ratio of inoculation. The mentioned proportion of the propolis was added to milk (this mixing was done at 44-45 °C). Then, it was placed in an incubator with a temperature of 42 °C for 4.5 hours until the pH reached 4.6. Then, it was removed from the incubator and transferred to the cold room (4-5 °C).

2.2. Probiotic viability

The viability of probiotic bacteria in yogurt samples was assessed using MRS agar medium containing bile salts by pour plate method. To do so, appropriate dilutions of the sample were prepared in sterile physiological serum solution and the cultured plates were incubated at about 37°C. Colonies were counted after 72-h incubation using an anaerobic jar and their number was reported in log of colony-forming units per gram (log cfu/g) [30].

2.3. Physicochemical properties

pH and acidity

To measure the pH value, after preparing the sample in a bain-marie, the pH values of the control and propolis treatments were measured using a pH meter (National Standard No. 4404). The sample of each treatment was poured into the beaker separately with 3 repetitions and the electrode of the pH meter was completely

placed inside the sample after adjustment. After the pH meter was fixed, the pH value was determined [31]. The acidity of yogurt was measured using Iranian National standard No. 2852. To do this, the sample was titrated with n/9 normal sodium hydroxide in the presence of phenolphthalein reagent. Finally, the acidity was expressed in Dornic degrees [32].

2.4. Texture measurement

The texture was measured by Micro Texture measuring device (stable system, England), and the penetration force of the cylindrical probe was recorded up to a depth of 10 mm at a speed of 1 mm/s. The probe used had a diameter of 36 mm and a height of 3.5 mm, and the speed of the probe before and during the test was 1 mm/s and after the test was 10 mm/s [33]. The measured properties included hardness (the height of the main peak in the first curve in the forward stage in N), cohesiveness (the area under the second curve in the forward stage to the area under the first curve in the forward stage), springiness (the distance between the beginning of the second curve and the peak), the gumminess (the product of the hardness and cohesiveness values), the chewiness (the product of the springiness and gumminess values), adhesiveness (the area under the curve in the negative area) and adhesive force (the maximum force in negative area) [34].

2.5. Sensory evaluation

Sensory properties of the yogurt samples such as flavor (aroma and taste), appearance, mouthfeel, and total acceptance were evaluated using a 5-point hedonic test. Flavor, texture and color of yogurt samples were evaluated by 9 panelists on the specified days [34]. They were asked to consider color, aroma, flavor, hardness, apparent transparency and total acceptance and give scores on a five-point scale with descriptive terms included in a pre-designed table with a maximum of 5 points (1= unusable, 2= usable, 3= good, 4= very good, 5= excellent).

2.6. Statistical analysis

Data were analyzed using SPSS software. The normality of the data was checked using the Kolmogorov-Smirnov test and the homogeneity of the data was tested using the Levene's test. Then, the presence or absence of significant difference between the treatments was evaluated by the one-way ANOVA and Duncan multi-range test. The significance level was considered as $p<0.05$.

3-Results

3.1. Physicochemical properties

3.1.1. pH and acidity value

The effect of different percentages of propolis on the pH and acidity of the samples is shown in Table 1. As shown in the Table 1, the pH increased with increasing propolis percentage over time. The pH of the samples ranged from 4.22 to 4.53. The effect of time on all samples was significant ($p<0.05$). The lowest pH was observed for control sample, followed by sample B (1%) on day 21. The highest pH was found for samples D (3%) and E (4%) on the first day. The current results showed that generally sample D (3%) had the highest acidity.

Table 1- Results of measurement of pH and acidity of different synbiotic yogurt treatments inoculated with *L. casei*

Treatments	Day 1	Day 7	Day 14	Day 21
	pH			
A	4.5 ± 0.007^{c}	4.41 ± 0.005^{b}	4.33 ± 0.000^{e}	4.22 ± 0.011^{b}
B	4.51 ± 0.005^{bc}	4.41 ± 0.005^{c}	4.35 ± 0.005^{d}	4.23 ± 0.011^{b}
C	4.52 ± 0.005^{ab}	4.44 ± 0.001^{bc}	4.37 ± 0.000^{c}	4.25 ± 0.005^{a}

D	4.53 ± 0.001[a]	4.45 ± 0.015[b]	4.40 ± 0.001[a]	4.26 ± 0.011[a]
E	4.53 ± 0.005[a]	4.48 ± 0.005[a]	4.38 ± 0.005[b]	4.25 ± 0.011[a]
		Acidity		
A	53.75 ± 0.23[c]	77.86 ± 0.11[d]	81.20 ± 0.34[d]	82.60 ± 0.34[e]
B	76.06 ± 0.30[c]	78.06 ± 0.30[cd]	81.53 ± 0.23[d]	83.53 ± 0.46[d]
C	76.86 ± 0.50[b]	78.66 ± 0.23[bc]	82.13 ± 0.23[c]	84.46 ± 0.50[c]
D	78.60 ± 0.34[a]	79.20 ± 0.69[b]	83.93 ± 0.11[a]	86.86 ± 0.23[a]
E	79.29 ± 0.34[a]	80.53 ± 0.23[a]	83.46 ± 0.23[b]	85.66 ± 0.57[b]

Different letters in each column represent significant differences ($p<0.05$).

Treatments (percentage of propolis) are A: Control, B: 1%, C: 2%, D: 3% and E: 4%.

In the study Gunes-Bayir et al. (2022) on yogurt samples containing propolis and cinnamon, the samples containing the highest concentration of cinnamon (2.5%) and propolis (0.03%) had the lowest titratable acidity and the highest pH value. This trend could be seen with lower concentration of cinnamon [35]. The findings of the present study depended on increasing titratable acidity by propolis, which also led to a decrease in the pH value. Our results are in agreement with the results obtained by Korkmaz et al. (2021) who examined homemade yogurt containing propolis powder and extract and showed that the pH value of different yogurts decreased significantly from day 1 to day 7. The change in pH value was insignificant. The presence of propolis affected the absorption of water and the mobility of hydrogen ions and caused a decrease in pH and an increase in acidity. Santos et al. (2019) studied the quality parameters of probiotic yogurt containing Brazilian red propolis as a replacement for potassium sorbate in regular yogurt and suggested that the addition of red propolis at a concentration of 0.05% instead of potassium sorbate did not change the acidity of the yogurt. In Korkmaz et al., (2021) research, in a similar study examined homemade yogurt prepared with propolis extract, the acidity levels of different yogurts increased from day 1 to day 7 [36]. Also, our findings are consistent with the results obtained by Gheibi et al. (2021) who investigated the pH and acidity of milk samples containing aqueous propolis extract and found a decrease in pH and an increase in titratable acidity during storage at two temperatures compared to control, although the changes were insignificant [20]. In a recent study, the results showed that the pH level in all treatments decreased and acidity increased with increasing time. Esfandiari and Moslehishad (2019) stated that the cause of this phenomenon is mostly related to the production of lactic acid by lactic acid bacteria, which can produce four molecules of lactic acid from two molecules of lactose [37]. Also, the results of studies have shown that the process of decreasing pH and increasing acidity during storage is normal [37, 38]. The results related to pH values and acidity of yogurt showed that by adding propolis extract, pH values decreased and acidity values increased ($p<0.05$). It seems that the addition of propolis extract has increased the metabolic activity of bacteria in yogurt [37]. So that in the initial times of the incubation, with the increase of the substrate for the growth of microorganisms, the metabolic activities of the bacteria increase and cause a decrease in pH and an increase in acidity in treatments containing the extracts [38].

3.1.3. Examining the properties of aqueous extract of propolis

Table 2- Results of measurement of total polyphenols and DPPH of aqueous propolis extract

Parameters	Content	Unit
Total polyphenols	8.7	100 ml.mg
DPPH radical scavenging	38.62	100 ml.mg

The results of the examination of total polyphenols and DPPH compounds are presented in Table 2. In the current study, the total polyphenol and DPPH compounds of aqua propolis were evaluated. The results showed that the amounts of total polyphenols and DPPH were 8.7 and 38.62, respectively. The most important pharmacologically active components in propolis are flavones, flavonols, and flavanones, which are called flavonoids. As a result, propolis has various therapeutic properties and biological activities, including antimicrobial, antifungal, antiviral, wound healing, boosting the immune system, and stopping the growth of cancer cells [39]. Propolis is commercially used as a dietary and therapeutic supplement. Also, the antioxidant, antimicrobial and antifungal activities of propolis make it a good product to be used in food technology [40]. The total phenolic compounds is an important parameter for quantitative evaluation and measuring the biological capacity of the product [41]. Tosic et al. (2017) investigated total phenolic compounds of the ethanolic extract of propolis collected from different parts of Argentina, which was prepared by maceration method for one week and reported that its amount ranged from 41.8 to 33.32 w/w % [42]. Esfandiarifard (2021) studied the antioxidant activity of ethanolic, methanolic and aqueous extracts of propolis and stated that the highest antioxidant activity (80.62) was observed for the methanolic extract followed by the aqueous extract (48.41). The ethanolic extract had the lowest antioxidant activity. They also stated that propolis extract is a good barrier to the formation of free radicals and all reactive oxygen species and this is one of the reasons for the health benefits of propolis [19].

3.2. Evaluation of textural properties

3.2.1. Hardness, Adhesiveness, Springiness, Chewiness

The results of the investigation of the effect of aqueous propolis extract on the hardness adhesiveness, springiness and chewiness of synbiotic yogurt texture inoculated with *L. casei* are presented in Table 3. The highest hardness on days 1 and 7 was found for sample A, and on days 14 and 21 for sample B. Sample E (4%) had the lowest hardness. The highest adhesiveness on days 1, 7, 14 and 21 was found for sample B (1%). The lowest adhesiveness was observed for sample E (4%). The results of the present study showed that during the days of the experiment, the amount of adhesiveness in different treatments initially increased and then decreased. The highest springiness on days 1, 7, 14 and 21 was found for sample D (3%). Also, the lowest springiness on day 1 was found for sample B (1%), on day 7 for sample A, and on day 14 and 21 for sample E (4%) ($p<0.05$). The highest value of the chewiness parameter is related to sample A (0%) and the lowest chewiness is related to sample E (4%) ($p<0.05$). The results of this study show that during the test days, with the increase of storage days in different treatments, the amount of chewing (chewing ability) initially increased and then decreased ($p<0.05$). The results of this study showed that during the test period, with the increase in the storage period, the hardness and stickiness of the samples decreased in different treatments.

Table 3- Results of measurement of hardness, adhesiveness, springiness and chewiness of different synbiotic yogurt treatments inoculated with *L. casei*

Treatments	Day 1	Day 7	Day 14	Day 21
	Hardness			
A	19.99 ± 0.02^{a}	21.05 ± 0.02^{a}	21.02 ± 0.01^{c}	21.10 ± 0.15^{b}
B	19.73 ± 0.15^{b}	20.29 ± 0.02^{b}	22.61 ± 0.02^{a}	22.04 ± 0.02^{a}
C	18.38 ± 0.25^{c}	19.94 ± 0.01^{c}	21.15 ± 0.04^{b}	20.07 ± 0.09^{c}
D	16.98 ± 0.10^{d}	19.36 ± 0.04^{d}	20.55 ± 0.05^{d}	19.12 ± 0.55^{d}

E	16.10 ± 0.02^{e}	18.79 ± 0.15^{e}	19.89 ± 0.03^{e}	18.28 ± 0.03^{e}
		Adhesiveness		
A	2.13 ± 0.02^{d}	3.97 ± 0.03^{b}	4.11 ± 0.01^{b}	4. 01 ± 0.02^{b}
B	3.95 ± 0.03^{a}	4.79 ± 0.01^{a}	4.56 ± 0.03^{a}	4.50 ± 0.01^{a}
C	2.63 ± 0.02^{b}	3.69 ± 0.02^{d}	3.88 ± 0.02^{c}	3.83 ± 0.04^{c}
D	2.58 ± 0.03^{b}	3.49 ± 0.01^{d}	3.61 ± 0.05^{d}	3.04 ± 0.04^{d}
E	2.48 ± 0.02^{c}	2.20 ± 0.01^{e}	3.15 ± 0.04^{e}	2.02 ±0.05^{e}
		Springiness		
A	14.23 ± 0.02^{ab}	14.03 ± 0.02^{d}	14.12 ± 0.02^{a}	14.24 ± 0.01^{a}
B	14.20 ± 0.17^{b}	14.75 ± 0.01^{a}	13.79 ± 0.04^{c}	13.44 ± 0.03^{b}
C	14.42 ± 0.08^{a}	14.34 ± 0.01^{b}	13.96 ± 0.07^{b}	13.05 ± 0.02^{c}
D	14.36 ± 0.01^{ab}	14.30 ±0.02^{c}	14.35 ± 0.05^{d}	14.39 ± 0.04^{a}
E	14.24 ± 0.12^{ab}	14.27 ± 0.02^{c}	13.15 ± 0.05^{e}	12.99 ± 0.04^{c}
		Chewiness		
A	9.88 ± 0.02^{a}	10.39 ± 0.01^{c}	11.39 ± 0.03^{a}	11.38 ± 0.01^{a}
B	9.82 ± 0.03^{a}	11.50 ± 0.02^{b}	10.89 ± 0.04^{b}	10.74 ± 0.05^{b}
C	9.42 ± 0.37^{ab}	10.40 ± 0.01^{c}	10.46 ± 0.06^{c}	10.62 ± 0.03^{c}
D	9.01 ± 0.45^{b}	11.89 ± 0.01^{a}	9.79 ± 0.03^{d}	9.04 ± 0.04^{d}
E	8..03 ± 0.42^{c}	9.80 ± 0.05^{d}	9.30 ± 0.04^{e}	8.30 ± 0.02^{e}

Different letters in each column represent significant differences ($p<0.05$).
Treatments (percentage of propolis) are A: Control, B: 1%, C: 2%, D: 3% and E: 4%.

The feeling caused by touching foods is often considered as one of their important characteristics. The important properties include firmness, softness, juiciness, chewiness, fibrousness, grittiness, oiliness and tenderness.

A concept which has not been defined well is texture. Texture is related to adhesiveness, elasticity and other physical properties of food. Texture characteristics of food are divided into geometrical, mechanical (particle size, shape and position) and properties related to moisture and fat content. The primary indicators related to mechanical properties are hardness, cohesiveness, viscosity, elasticity and adhesiveness. Secondary indicators include tenderness, chewiness and gumminess. Different types of texture have been identified, which are graded based on compression and toughness. The hardness degree can be found by cutting and separating different parts of food without any deformation of each separated section. Standard measurement scales for hardness, tenderness, chewiness, adhesiveness and viscosity have been developed. These scales are also used in sensorial measurement of texture [43]. Hardness is defined as the force required to disrupt the yogurt texture and it is the most important factor for determination of yogurt firmness [44]. The hardness of the samples ranged from 16 to 23. It initially increased and then decreased, indicating the proper synergistic property of propolis [45]. Sandoval et al. (2004) stated that carbohydrate molecules are able to firmly bond with water molecules and trap them due to increasing water absorption power, thus increasing the viscosity of the aqueous phase, resulting in increasing of resistance to the applied force. Also, the results revealed that an increase in the rate of homogenization and fat increased the hardness of the samples [46]. Yogurt viscosity is an important characteristic that affects its quality. Stirred yogurt is a homogenous and viscous substance, and this viscosity can be affected by influencing factors such as incubation temperature, fat and casein content, heat treatment of milk, acidity of milk, type of starter and additives [38]. In relation to the adhesiveness of yogurt samples, it can be said that the adhesion force is the force necessary to overcome the surface attraction force between the particles, the more the structure of the yogurt is preserved from hardness, the adhesiveness will be greater, which is an accordance with the result of the hardness [47]. Propolis has high adhesive strength, creating a good adhesiveness when mixed with yogurt

because of its strong reaction with fats and proteins. In this study, adhesiveness at first increased and then decreased.

3.3. Syneresis or separation of serum measurement

The results of the investigation of the effect of aqueous propolis extract on the syneresis of synbiotic yogurt inoculated with *L. casei* are shown in Table 4. The results indicated that the effect of different percentages of propolis and also the day of storage on the yogurt syneresis was significant ($p<0.05$). The highest syneresis rate was found for sample A (0%) on days 1, 7, 14 and 21 ($p<0.05$). The lowest syneresis rate was found for sample E (4%) on days 1, 7, 14 and 21 ($p<0.05$).

Table 4- Results of measurement of syneresis of different synbiotic yogurt treatments inoculated with *L. casei*

Treatments	Day 1	Day 7	Day 14	Day 21
	Syneresis			
A	19.99 ± 0.11^{a}	21.55 ± 0.19^{a}	22.96 ± 0.06^{a}	24.03 ± 0.06^{a}
B	19.99 ± 0.11^{a}	21.22 ± 0.19^{b}	22.22 ± 0.38^{b}	23.44 ± 0.38^{b}
C	19.55 ± 0.38^{b}	20.22 ± 0.19^{c}	22.92 ± 0.06^{b}	22.59 ± 0.42^{c}
D	18.99 ± 0.11^{c}	19.25 ± 0.12^{d}	20.11 ± 0.19^{d}	20.92 ± 0.06^{e}
E	18.77 ± 0.19^{c}	19.22 ± 0.19^{d}	20.73 ± 0.12^{c}	21.62 ± 0.27^{d}

Different letters in each column represent significant differences ($p<0.05$).
Treatments (percentage of propolis) are A: Control, B: 1%, C: 2%, D: 3% and E: 4%.

Syneresis in yogurt is an undesirable property and, along with water holding capacity, is considered as one of the quality indicators of yogurt during storage. The results showed that until 14th day of the storage, the syneresis of the samples decreased significantly because of increased solid matter and water absorption and holding property. As the concentration of propolis increases, the syneresis rate significantly decreases due to the involvement of water molecules in the structure of the propolis and the increase in the viscosity of the product [48]. The findings of the present study are consistent with the results obtained by other researchers who used gum in the formulation of different dairy products such as yogurt, yogurt drink and whipped cream and reported that the addition of beewax led to a decrease in syneresis and its higher concentration caused a significant decrease in the serum separation [49-51]. Our results are in agreement with the results obtained by Korkmaz et al. (2021) who found a decrease in syneresis in homemade yogurt prepared with propolis extract during storag [36].

Temiz et al. (2014) stated that most hydrocolloids cause an increase in viscosity due to their water absorption properties [52]. Hydrocolloids have high water absorption properties and this water absorption is positively correlated with hydrocolloid concentration [53]. The results of the present study are consistent with the results of Won Young et al., (2020). These researchers stated that the addition of olive leaf extract to yogurt reduces the amount of syneresis and increases the viscosity of the yogurt. Also, the amount of syneresis increases and viscosity decreases by increasing the storage time [38]. Syneresis in yogurt is influenced by the physical conditions of yogurt during the storage period. In this regard, adding extract leads to an increase in dry matter and as a result, the texture becomes firmer and the syneresis decreases [54].

3.4. Sensory evaluation

3.4.1. Aroma, taste, color and texture

As shown in Table 5, the effect of treatment and time and the interactive effects of treatment and time on total acceptance of the yogurt samples were significant ($p<0.05$). According to Table 5, it was

observed that the panelists found significant differences in the aroma, taste, color and texture of the yogurt treatments among the control and propolis-containing yogurt treatments ($p<0.05$). Based on the results of the sensory evaluation, the level of aroma, taste, color and texture of the yogurt treatments were determined and the lowest level of the desirability of yogurt belonged to sample E (4%) ($p<0.05$). During the storage time, the sensory desirability of aroma, taste, color and texture of the yogurt treatments significantly decreased, and at the end of the 21st day of storage, the lowest desirability was observed compared to the first day of production ($p<0.05$). Also, according to the report of the evaluation team, the lowest amount of desirability of the texture of yogurt belonged to the control treatment ($p<0.05$). During the storage time, the sensory desirability of texture of yogurt treatments decreased significantly, and at the end of the 21st day of storage, the lowest amount of sensory desirability of texture and firmness was observed compared to the first day of production ($p<0.05$).

Table 5- Results of measurement of Aroma, Taste and Color of different synbiotic yogurt treatments inoculated *with L. casei*

Treatments	Day 1	Day 7	Day 14	Day 21
		Aroma		
A	4.55 ± 0.53^{a}	4.01 ± 0.77^{a}	3.33 ± 0.55^{a}	3.11 ± 0.33^{a}
B	4 ± 0.70^{ab}	3.66 ± 0.50^{ab}	3.01 ± 0.01^{ab}	2.77 ± 0.44^{ab}
C	4 ± 0.72^{ab}	3.66 ± 0.51^{ab}	3.04 ± 0.02^{ab}	2.55 ± 0.52^{ab}
D	4.22 ± 0.66^{ab}	3.44 ± 0.52^{ab}	2.66 ± 0.50^{b}	2.55 ± 0.52^{b}
E	3.77 ± 0.66^{b}	3.33 ± 0.50^{b}	2.55 ± 0.52^{c}	2.33 ± 0.50^{b}
		Taste		
A	4.44 ± 0.52^{a}	4 ± 0.71^{a}	3.33 ± 0.5^{a}	3.11 ± 0.3^{a}
B	4.22 ± 0.44^{ab}	3.44 ± 0.52^{b}	2.88 ± 0.33^{ab}	2.44 ± 0.5^{b}
C	4.11 ± 0.33^{ab}	3.33 ± 0.50^{b}	2.66 ± 0.5^{b}	2.22 ± 0.41^{b}
D	3.77 ± 0.44^{b}	3.33 ± 0.52^{b}	2.55 ± 0.52^{b}	2.22 ± 0.40^{b}
E	3.77 ± 0.44^{b}	3.33 ± 0.50^{b}	2.55 ± 0.52^{b}	2.22 ± 0.40^{b}
		Color		
A	4.66 ± 0.50^{a}	4.22 ± 0.66^{a}	$4 \pm .001^{a}$	3.77 ± 0.44^{a}
B	4.66 ± 0.50^{a}	4.11 ± 0.60^{a}	3.77 ± 0.44^{a}	3.66 ± 0.50^{a}
C	4.55 ± 0.52^{a}	4.11 ± 0.60^{a}	3.77 ± 0.44^{a}	3.33 ± 0.50^{a}
D	4.55 ± 0.52^{a}	4.11 ± 0.33^{a}	3.66 ± 0.70^{a}	3.33 ± 0.50^{a}
E	4.55 ± 0.52^{a}	$4 \pm .50^{a}$	3.66 ± 0.50^{a}	3.33 ± 0.50^{a}
		Texture		
A	4.22 ± 0.44^{a}	4 ± 0.001^{b}	3.77 ± 0.66^{b}	3 ± 0.50^{b}
B	4.22 ± 0.44^{a}	4 ± 0.000^{b}	4 ± 0.000^{ab}	3.11 ± 0.33^{ab}
C	4.33 ± 0.50^{a}	4.22 ± 0.44^{ab}	4.22 ± 0.44^{ab}	3.11 ± 0.60^{ab}
D	4.33 ± 0.50^{a}	4.22 ± 0.44^{ab}	4.22 ± 0.44^{ab}	3.55 ± 0.52^{a}
E	4.44 ± 0.52^{a}	4.33 ± 0.50^{a}	4.44 ± 0.52^{a}	3.55 ± 0.52^{a}

Different letters in each column represent significant differences ($p<0.05$).

Treatments (percentage of propolis) are A: Control, B: 1%, C: 2%, D: 3% and E: 4%.

3.4.5. Total acceptance

According to Figure 1, it was observed that the effect of treatment and time and the interactive effects of treatment and time on total acceptance of the yogurt treatments were significant ($p<0.05$). The panelists found no significant differences in the texture desirability of the yogurt containing propolis and control sample on days 1 and 7 ($p>0.05$). However, based on the results of sensory evaluation of evaluators in other treatments, the total acceptance of other treatments decreased significantly, and the least desirability was observed for sample E (4%) ($p<0.05$). During the storage, the total acceptance of the propoils-containing yogurt treatments decreased significantly, and at the end of day 21, the lowest total

acceptance was observed compared to the first day of production (p<0.05).

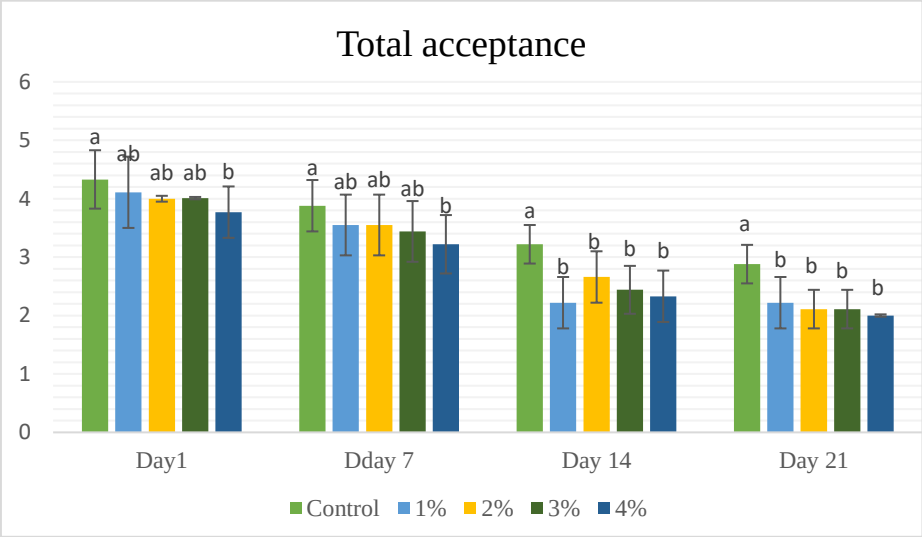

Fig 1 -Results of measurement of total acceptance of different synbiotic yogurt treatments inoculated with L. casei
Different letters in each column represent significant differences (p<0.05).

Treatments (percentage of propolis) are A: Control, B: 1%, C: 2%, D: 3% and E: 4%.

3.5. Viability of probiotics

The results of the viability of *L. casei* in different days with different concentrations of propolis are presented in Figure 2. Based on the results, the effect of time and propolis on the viability of probiotic bacteria was significant (p<0.05). The count of *L. casei* was higher in shorter times of storage, and it decreased as the time days increased. Also, by increasing the concentration of propolis, the survival of *L. casei* increased and treatment E (4%) showed the highest survival of *L. casei* after 21 days of investigation.

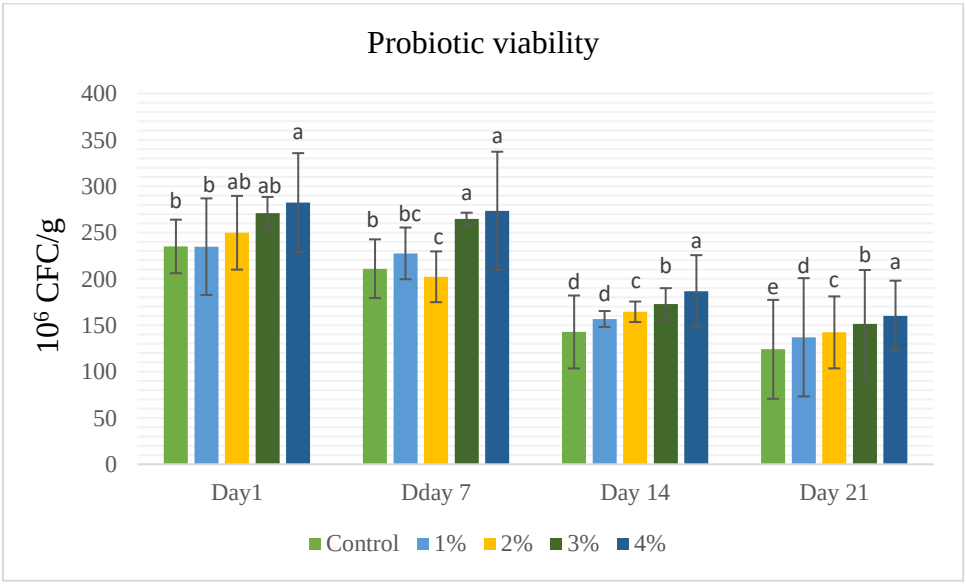

Fig 2- Results of probiotic *L. casei* viability
Different letters in each column represent significant differences (p<0.05).
Treatments (percentage of propolis) are A: Control, B: 1%, C: 2%, D: 3% and E: 4%.

One of the most important characteristics of probiotic microorganisms is their viability and survival in various products in order to be present in the product at the time of consumption. According to the report of most researchers, at least 10^6 CFU/g of product is necessary to exert the health effects of probiotics. The probiotic species, growth temperature, stimulators and inhibitors, pH value, incubation time, inoculation level, metabolite concentrations and nutrient availability are the most important factors affecting the probiotic viability and survival in various products [55, 56]. The results of this study showed that increasing storage time was conversely related to bacterial survival. In the other words, the survival of probiotics decreased over time due to the effect of produced acid on the bacteria over time, which decreases the bacterial resistance and causes their death [57]. Another reason could be high secretion of alkaline substances to adjust the environment, which eventually leads to an increase in internal pH, thereby causing cell death [58-60]. Also, the researchers stated that with increasing storage time at low temperatures and decreasing the pH in probiotic yogurts, the viability of probiotics decreases [61-65]. It has been reported that glycosides improve the growth of probiotic bacteria. Also, the increase in the viability could be attributed to the high polyphenol content of propolis, as a natural compound of plant extracts, which directly affects the count of probiotic bacteria [66-69]. Faraji et al. (2012) investigated the optimization of the low-fat probiotic yogurt production process using a composite design. To optimize the formulation of low-fat probiotic yogurt, the effect of different concentrations of inulin, chitosan and xanthan at three levels (1, 2 and 3%) on the viability of *L. acidophilus* during 15 days of storage was studied. The results revealed that higher concentration of inulin and chitosan increased the growth and survival of *L. acidophilus* [70]. Similarly, the results showed that higher concentrations of honey and propolis resulted in an increase in the count of probiotic bacteria which decreased over time. Our results are agreement with the results obtained by other researchers [35, 36, 71-74], in which they studied viability of probiotic bacteria in homemade yogurt containing propolis extract and observed the highest survival rate of *Lactobacillus* species within 7 days in samples containing propolis. Also, Prudêncio et al. (2014) in their survey, stated that the limitation of access to nutrients in the environment is one of the important factors in decreasing the count of probiotic bacteria [75]. Shahdadi et al. (2014) in their study reported that the population of probiotic bacteria decreases over time [76]. Faraji et al (2020) found that the count of *L. acidophilus* in all refrigerated samples decreased from day 1 to day 21. The most important factors affecting the reduction of the number of probiotic bacteria during refrigerated storage include the changes in acidity, the production of metabolites such as organic acids and hydrogen peroxide by traditional yogurt bacteria, as well as the limited access to nutrients in the environment. Given the fact that in all treatments, the count of probiotic per gram of the product (10^6 CFU/g) exceeded the minimum recommended number in a probiotic product, all the samples could be claimed to have the healthful properties of a probiotic product.

4- Conclusion

In this study, the effect of propolis extract on physicochemical, sensory and microbial characteristics of synbiotic yogurt inoculated with *L. casei* was evaluated. The results showed that the addition of propolis extract has a positive effect on the physical and chemical properties of the product. In the samples containing propolis extract, pH and syneresis were lower, and on the other hand, the acidity level and also the viability of probiotic were higher than the control treatment. Although according to the results of the sensory evaluation team, the highest

level of favorability was related to the control treatment, but due to the effects of propolis extract on textural (sensory) properties, as well as the viability of probiotic, it can be concluded that yogurt production with the addition of 4% propolis can be a functional food that consumer can benefit from its nutritional attributes.

5-Acknowledgments

This article is extracted from the master's thesis of the Department of Food Science and Technology of University of Guilan and the project of the Creativity and Prosperity Center with the number of 022409. Hereby, the authors of the article are grateful to Pegah Guilan Company for providing the relevant facilities.

6-References

[١] A. Sarwar *et al.*, "Effect of chilled storage on antioxidant capacities and volatile flavors of synbiotic yogurt made with probiotic yeast Saccharomyces boulardii CNCM I-745 in combination with inulin," *Journal of Fungi*, vol. 8, no. 7, p. 713, 2022.

[٢] H. Ö. Yilmaz, N. Y. Ayhan, and Ç. S. Meriç, "Buckwheat: A useful food and its effects on human health," *Current Nutrition & Food Science*, vol. 16, no. 1, pp. 29-34, 2020.

[٣] C. García-Viguera and R. Domínguez-Perles, "Enriched nutritional beverages, much more than an ingredient mix addition," in *II International Symposium on Beverage Crops 1274*, 2018, pp. 17-28 .

[٤] S. N. Meydani and W.-K. Ha, "Immunologic effects of yogurt," *The American journal of clinical nutrition*, vol. 71, no. 4, pp. 861-872, 200.٠

[٥] N. H. El-Abbadi, M. C. Dao, and S. N. Meydani, "Yogurt: role in healthy and active aging," *The American journal of clinical nutrition*, vol. 99, no. 5, pp. 1263S-1270S, 2014.

[٦] J. Ezendam and H. van Loveren, "Probiotics: immunomodulation and evaluation of safety and efficacy," *Nutrition Reviews*, vol. 64, no. 1, pp. 1-14, 2006.

[٧] H. Taheri, F. Tabandeh, H. Moravej, M. Zaghari, M. Shivazad, and P. Shariati, "Potential probiotic of Lactobacillus johnsonii LT171 for chicken nutrition," *African Journal of Biotechnology*, vol. 8, no. 21, 2009.

[٨] L. Yilmaz-Ersan and E. Topcuoglu, "Evaluation of instrumental and sensory measurements using multivariate analysis in probiotic yogurt enriched with almond milk," *Journal of food science and technology*, pp. 1-11 ,2022.

[٩] E. Baglio, *Chemistry and technology of yoghurt fermentation*. Springer, 2014.

[١٠] O. Boukria *et al.*, "Biochemical, physicochemical and sensory properties of yoghurts made from mixing milks of different mammalian species," *Foods*, vol. 9, no .11 ,p. 1722, 2020.

[١١] M. Rifky, K. Serkaev, and M. Samadiy, "Technology development to incorporate functional oil sources in yoghurt to improve functional properties," *Journal of Coastal Life Medicine*, vol. 11, pp. 928-938, 2023.

[١٢] I. Ahmad, M. Hao ,Y. Li, J. Zhang, Y. Ding, and F. Lyu, "Fortification of yogurt with bioactive functional foods and ingredients and associated challenges-A review," *Trends in food science & technology*, vol. 129, pp. 558-580, 2022.

[١٣] D. A. Savaiano and R. W. Hutkins , "Yogurt, cultured fermented milk, and health: A systematic review," *Nutrition reviews*, vol. 79, no. 5, pp. 599-614, 2021.

[١٤] M. Akın, M. Akın, and Z. Kırmacı, "Effects of inulin and sugar levels on the viability of yogurt and probiotic bacteria and the physical and sensory characteristics in probiotic ice-cream," *Food chemistry*, vol. 104, no. 1, pp. 93-99, 2007.

[١٥] I. Figueroa-Gonzalez, G. Rodriguez-Serrano, L. Gomez-Ruiz, M. Garcia-Garibay, and A. Cruz-Guerrero, "Prebiotic effect of commercial saccharides on probiotic bacteria isolated from commercial products," *Food Science and Technology*, vol. 39, pp. 747-753, 2019.

[١٦] B. Tungland and D. Meyer, "Nondigestible oligo-and polysaccharides (Dietary Fiber): their physiology and role in human health and food," *Comprehensive reviews in food science and food safety*, vol. 1, no. 3, pp. 90-109, 2002.

[١٧] A. K. Kuropatnicki, E. Szliszka, and W. Krol, "Historical aspects of propolis research in modern times," *Evidence-based*

complementary and alternative medicine, vol. 2013, 2013.

[١٨] M. Besharati and M. Eftekhari, "Propolis and the immune system," *Journal of Biosafety*, vol. 10, no. 2, pp. 131-146, 2017.

[١٩] M. Esfandiarifard, "Study on the antioxidant activity of propolis extract and its effect on the oxidation of sunflower oil," *Journal of food science and technology (Iran)*, vol. 17, no. 107, pp. 119-130, 2021.

[٢٠] N. Gheibi, J. Shahbazi, Z. Zarmohammadi, M. Alipoor Heydari, E. Kakaeie, and M. Sofiabadi, "Effect of oral administration of ethanolic extracts of propolis on passive avoidance learning and memory in adult male mice," *Journal of Ardabil University of Medical Sciences*, vol. 17, no. 1, pp. 104-112, 2017.

[٢١] A. Piccioni *et al.*, "How do diet patterns, single foods, prebiotics and probiotics impact gut microbiota?," *Microbiology Research*, vol. 14, no. 1, pp. 390-408, 2023.

[٢٢] S. Salar, S. Jafarian, and S. A. Mortazavi, "Physiochemical and sensory characteristics of synbiotic beverage yogurt developed from Buffalo´ s colostrum & milk," *Journal of food science and technology (Iran)*, vol. 18, no. 116, pp. 247-257, 2021.

[٢٣] H. Sales-Campos, S. C. Soares, and C. J. F. Oliveira, "An introduction of the role of probiotics in human infections and autoimmune diseases," *Critical reviews in microbiology* ,vol. 45, no. 4, pp. 413-432, 2019.

[٢٤] G. T. Macfarlane, H. Steed, and S. Macfarlane, "Bacterial metabolism and health-related effects of galacto-oligosaccharides and other prebiotics," *Journal of applied microbiology*, vol. 104, no. 2, pp. 305-344, 2008.

[٢٥] V. Bankova, M. Popova, and B. Trusheva, "Propolis volatile compounds: chemical diversity and biological activity: a review," *Chemistry Central Journal*, vol. 8, pp. 1-8, 2014.

[٢٦] K. Tzima, D. Makris, C. Nikiforidis, and I. Mourtzinos, "Potential use of rosemary, propolis and thyme as natural food preservatives," *J. Nutr. Health*, vol. 1, no. 6, 2015.

[٢٧] F. Galeotti, F. Maccari, A. Fachini, and N. Volpi, "Chemical composition and antioxidant activity of propolis prepared in different forms and in different solvents useful for finished products," *Foods*, vol. 7, no. 3, p. 41, 2018.

[٢٨] S. Patruica and I. Hutu, "Economic benefits of using prebiotic and probiotic products as supplements in stimulation feeds administered to bee colonies," *Turkish Journal of Veterinary & Animal Sciences*, vol. 37, no. 3, pp. 259-263, 2013.

[٢٩] H. Yadav, S. Jain, and P. R. Sinha, "Oral administration of dahi containing probiotic Lactobacillus acidophilus and Lactobacillus casei delayed the progression of streptozotocin-induced diabetes in rats," *Journal of Dairy Research*, vol. 75, no. 2, pp. 189-195, 2008.

[٣٠] W. Ebid and A. Mabrouk, "Physicochemical and microbiological properties of functional Labneh fortified with mandarin peel powder during refrigeration storage," *Int. J. Food Sci. Nutr*, vol. 7, pp. 46-53, 2022.

[٣١] M. Guldas and R. Irkin, "Utjecaj praška Spiruline platensis na mikrofloru jogurta i acidofilnog mlijeka," *Mljekarstvo: časopis za unaprjeđenje proizvodnje i prerade mlijeka*, vol. 60, no. 4, pp. 237-243 ,2010.

[٣٢] F. Fallahi and M. Madani, "Study of contamination of different dairy products distributed in Isfahan to saprophytic fungi," *Biological Journal of Microorganism*, vol. 3, no. 11, 2014.

[٣٣] H. Kesenkaş, "Effect of using different probiotic cultures on properties of Torba (strained) yoghurt," *Dairy/Mljekarstvo*, vol. 60, no. 1, 2010.

[٣٤] J. Cortes-Ruiz, R. Pacheco-Aguilar, G. Garciasanchez, and M. Lugo-Sanchez, "Functional characterization of a protein concentrate from bristly sardine made under acidic conditions," *Journal of Aquatic Food Product Technology*, vol. 10, no. 4, pp. 5-23, 2001.

[٣٥] A. Gunes-Bayir, M. G. Bilgin, D. Guclu, S. Pogda, and A. Dadak, "Preparation and evaluation of novel functional fermented dairy products containing propolis and cinnamon," *Journal of Food Science and Technology*, vol. 59, no. 6, pp. 2392-2401, 2022.

[٣٦] I. O. Korkmaz, C. Bilici, and S. Korkmaz, "Sensory, pH, synaeresis, water-holding capacity, and microbiological changes in homemade yogurt prepared with maca (Lepidium meyenii) powder and propolis extract," *International Journal of Gastronomy and Food Science*, vol. 23, p. 100291, 2021.

[۳۷] H. Esfandiari and M. Moslehishad, "Evaluation of physicochemical, sensory and rheological properties of stirred yogurt fortified with rice bran and lettuce extract during shelf-life," *Journal of food science and technology (Iran)*, vol. 16, no. 90, pp. 245-258, 2019.

[۳۸] W.-Y. Cho, D.-H. Kim, H.-J. Lee, S.-J. Yeon, and C.-H. Lee, "Quality characteristic and antioxidant activity of yogurt containing olive leaf hot water extract," *CyTA-Journal of Food*, vol. 18, no. 1, pp. 43-50, 2020.

[۳۹] G. M. Hanafi, S. Darvishi, N. Darvishi, M. Sayedin-Ardabili, and F. Mirahmadi, "Antibacterial effect of essential oil of mastic resin on Staphylococcus aureus, Escherichia coli and Clostridium sporogenes," *Scientific Journal of Kurdistan University of Medical Sciences*, vol. 17, no. 1, 2012.

[٤٠] M. I. González-Martín *et al.*, "Determination of the mineral composition and toxic element contents of propolis by near infrared spectroscopy," *Sensors*, vol. 15, no. 11, pp. 27854-27868, 2015.

[٤١] L. G. Dias, A. P. Pereira, and L. M. Estevinho, "Comparative study of different Portuguese samples of propolis: Pollinic, sensorial, physicochemical, microbiological characterization and antibacterial activity," *Food and Chemical Toxicology*, vol. 50, no. 12, pp. 4246-4253, 2012.

[٤٢] S. Tosic, G. Stojanovic, S. Mitic, A. Pavlovic, and S. Alagic, "Mineral composition of selected Serbian propolis samples ",*Journal of apicultural science*, vol. 61, no. 1, pp. 5-15, 2017.

[٤٣] H. R. Kargozari, H. Ghaemi, and M. A. Heravi, "Cohesive devices in argumentative, descriptive, and expository writing produced by Iranian EFL university students," *Modern Journal of Language Teaching Methods*, vol. 2, no. 3, pp. 25-47, 2012.

[٤٤] D. Mudgil, S. Barak, and B. Khatkar, "Texture profile analysis of yogurt as influenced by partially hydrolyzed guar gum and process variables," *Journal of food science and technology*, vol. 54 ,pp. 3810-3817, 2017.

[٤٥] M. Kashaninejad, M. Najaf Najafi, and A. Shateri, "Optimization of viscoelastic properties of low-fat stirred yogurt using mixture-process variable experiments," *Journal of Food and Bioprocess Engineering*, vol. 4, no. 2, pp. 160-167 , 2021.

[٤٦] O. Sandoval-Castilla, C. Lobato-Calleros, E. Aguirre-Mandujano, and E. Vernon-Carter, "Microstructure and texture of yogurt as influenced by fat replacers," *International dairy journal*, vol. 14, no. 2, pp. 151-159, 2004.

[٤٧] A. Motamedzadegan, S. A. Shahidi, and S. Ebdali, "Evaluation effects of gelatins types on functional properties of fat free set style yogurt," *Journal of food science and technology (Iran)*, vol. 12, no. 47, pp. 221-230, 2015.

[٤٨] N. Aziz, R. Pandey, I. Barman, and R . Prasad, "Leveraging the attributes of Mucor hiemalis-derived silver nanoparticles for a synergistic broad-spectrum antimicrobial platform," *Frontiers in microbiology*, vol. 7, p. 225890, 2016.

[٤٩] Z. Ghasempour, M. Alizadeh, and M. R. Bari, "Optimisation of probiotic yoghurt production containing Zedo gum," *International Journal of Dairy Technology*, vol. 65, no. 1, pp. 118-125, 2012.

[٥٠] F. Rezaee, T. Mohammadabadi, M. Chaji, and M. R. Mashayekhi, "Effects of phenolic components of Scrophularia striata Boiss powder on feed intake, digestibility, rumination and rumen protozoa population in Lori-Bakhtiari sheep," *Iranian Journal of Animal Science*, vol. 47, no. 1, pp. 155-164, 2016.

[٥١] N. Raoufi, R. Kadkhodaee, G. O. Phillips, Y. Fang, and M. N. Najafi , "Characterisation of whey protein isolate–gum tragacanth electrostatic interactions in aqueous solutions," *International Journal of Food Science & Technology*, vol. 51, no. 5, pp. 1220-1227, 2016.

[٥٢] H. Temiz, Z. Tarakçı, and A. Islam, "Effect of cherry laurel marmalade on physicochemical and sensorial characteristics of the stirred yogurt during storage time," *stress*, vol. 5, p. 7, 2014.

[٥٣] S. S. Tometri, M. Ahmady, P. Ariaii, and M. S. Soltani, "Extraction and encapsulation of Laurus nobilis leaf extract with nano-liposome and its effect on oxidative, microbial, bacterial and sensory properties of minced beef," *Journal of Food Measurement and Characterization*, vol. 14, pp. 3333-3344, 2020.

[٥٤] R. Coda, A. Lanera, A. Trani, M. Gobbetti, and R. Di Cagno, "Yogurt-like beverages made of a mixture of cereals, soy and grape must: Microbiology, texture, nutritional

and sensory properties," *International Journal of Food Microbiology,* vol. 155, no. 3, pp. 120-127, 2012.

[٥٥] M. Bermudez-Brito, J. Plaza-Díaz ,S. Muñoz-Quezada, C. Gómez-Llorente, and A. Gil, "Probiotic mechanisms of action," *Annals of Nutrition and Metabolism,* vol. 61, no. 2, pp. 160-174, 2012.

[٥٦] J. S. Bajaj *et al.,* "Probiotic yogurt for the treatment of minimal hepatic encephalopathy," *Official journal of the American College of Gastroenterology| ACG,* vol. 103, no. 7, pp. 1707-1715, 2008.

[٥٧] R. Mohammadi, S. Sohrabvandi, and A. Mohammad Mortazavian, "The starter culture characteristics of probiotic microorganisms in fermented milks," *Engineering in Life Sciences,* vol. 12, no. 4, pp. 399-409, 2012.

[٥٨] V. Jayamanne and M. Adams, "Determination of survival, identity and stress resistance of probiotic bifidobacteria in bio-yoghurts," *Letters in applied microbiology,* vol. 42, no. 3, pp. 189 ,١٩٤-.٢٠٠٦

[٥٩] L. Chen, Q. Gu, P. Li, S. Chen, and Y. Li, "Genomic analysis of Lactobacillus reuteri WHH 1689 reveals its probiotic properties and stress resistance," *Food Science & Nutrition,* vol. 7, no. 2, pp. 844-857, 2019.

[٦٠] Ç. Hökelekli, F. Ergin, and A. Kucukcetin, "Incorporation of Encapsulated Yoghurt Bacteria into Stirred Yoghurt to Improve their Survival in an In Vitro Digestive Conditions," *Food and Bioprocess Technology,* vol. 17, no. 3, pp. 747-766, 2024.

[٦١] F. Sarvari, A. M. Mortazavian, and M. Fazeli, "Biochemical characteristics and viability of probiotic and yogurt bacteria in yogurt during the fermentation and refrigerated storage," 2014.

[٦٢] E. Mani-López, E. Palou, and A. López-Malo, "Probiotic viability and storage stability of yogurts and fermented milks prepared with several mixtures of lactic acid bacteria," *Journal of Dairy Science,* vol. 97, no. 5, pp. 2578-2590, 2014.

[٦٣] A. B. Shori, G. S. Aljohani, A. J. Al-zahrani, O. S. Al-sulbi, and A. S. Baba, "Viability of probiotics and antioxidant activity of cashew milk-based yogurt fermented with selected strains of probiotic Lactobacillus spp," *Lwt,* vol. 153, p. 112482, 2022.

[٦٤] K. Naemeh, M. S. Ali, M. Elham, and A. Akram, "Production of the whey protein-based probiotic beverages incorporated with Bifidobacterium bifidum, Lactobacillus acidophilus, and peppermint essence nanoliposomes," *Journal of Food Measurement and Characterization,* vol. 17, no. 3, pp. 2708-2717, 2023.

[٦٥] N. M. Meybodi, A. M. Mortazavian, M. Arab, and A. Nematollahi, "Probiotic viability in yoghurt: A review of influential factors," *International Dairy Journal,* vol. 109, p. 104793, 2020.

[٦٦] N. F. Fazilah, A. B. Ariff, M. E. Khayat, L. Rios-Solis, and M. Halim, "Influence of probiotics, prebiotics, synbiotics and bioactive phytochemicals on the formulation of functional yogurt," *Journal of functional foods,* vol. 48, pp. 387-399, 2018.

[٦٧] Á. D. Camargo-Herrera, C. Bernal-Castro, C. Gutiérrez-Cortes, C. N. Castro, and C. Díaz-Moreno, "Bio-yogurt with the inclusion of phytochemicals from carrots (Daucus carota): a strategy in the design of functional dairy beverage with probiotics," *Journal of Food Science and Technology,* vol. 60, no. 9, pp. 2297-2308, 2023.

[٦٨] S. A. Ibrahim *et al.,* "A review and comparative perspective on health benefits of probiotic and fermented foods," *International Journal of Food Science & Technology,* vol. 58, no. 10, pp. 4948-4964, 2023.

[٦٩] Z. Abdi-Moghadam *et al.,* "Functional yogurt, enriched and probiotic: A focus on human health," *Clinical Nutrition ESPEN,* 2023.

[٧٠] N. Faraji, M. Alizadeh Khaled Abad, A. Khosrowshahi, and S. Faraji, "Optimization of Low Fat Probiotic Yogurt Production Using Combined Design," *Iranian Food Science and Technology Research Journal,* vol. 8, no. 2, 2012.

[٧١] F. Güney and Ö. Ertürk, "Determination of the effects of propolis ethanolic extract on some properties of fruit yoghurt during storage," *Mustafa Kemal Üniversitesi Tarım Bilimleri Dergisi,* vol. 25, no. 2, pp. 145-152, 2020.

[٧٢] R. H. Luchese, E. R. Prudêncio, and A. F. Guerra, "Honey as a functional food," *Honey analysis,* pp. 287-307, 2017.

[٧٣] A. Kennas, H. Amellal-Chibane, F. Kessal, and F. Halladj, "Effect of pomegranate peel and honey fortification on physicochemical, physical, microbiological and antioxidant properties of yoghurt powder," *Journal of the Saudi Society of Agricultural Sciences,* vol. 19, no. 1, pp. 99-108, 2020.

[٧٤] S. Sarkar and S. Chandra, "Honey as a functional additive in yoghurt–a review," *Nutrition & Food Science,* vol. 50, no. 1, pp. 168-178, 2019.

[٧٥] E. S. Prudêncio, C. M. Müller, C. B. Fritzen-Freire, R. D. C. Amboni, and J. C. C. Petrus, "Effect of whey nanofiltration process combined with diafiltration on the rheological and physicochemical properties of ricotta cheese," *Food Research International,* vol. 56, pp. 92-99, 2014.

[٧٦] F. Shahdadi, H. Mirzaie, M. Kashaninejad, M. Khomeiri, A. M. Ziaiifar, and A. Akbarian, "Survival of probiotics encapsulated in calcium alginate and resistant starch beads in drinking yoghurt produced with essential oils during storage and in simulated gastrointestinal juice conditions," 2014.

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مقاله علمی–پژوهشی

بررسی تاثیر عصاره بره موم بر ویژگی های فیزیکوشیمیایی، حسی و میکروبی ماست سین بیوتیک تلقیح شده با *لاکتوباسیلوس کازئی*

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اطلاعات مقاله

تاریخ های مقاله :

تاریخ دریافت: ۱۴۰۲/۱۰/۲۷

تاریخ پذیرش: ۱۴۰۲/۱۲/۲۰

کلمات کلیدی:

بره موم،

ماست،

سین بیوتیک،

پری بیوتیک،

پروبیوتیک، *لاکتوباسیلوس کازئی*

DOI:10.22034/FSCT.21.152.77.

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چکیده

فرآورده‌های لبنی پروبیوتیک همچون ماست یکی از مواد غذایی پرطرفدار در دنیا محسوب می‌شوند. همچنین ترکیبات فراسودمند از جمله پری بیوتیک‌ها در کنار پروبیوتیک‌ها در محصولات مختلف مورد استفاده قرار می‌گیرند. یکی از ترکیبات فراسودمند بره موم بوده که دارای خواص آنتی اکسیدانی، ضد التهابی، ضد قارچی، ضد ویروسی و ضد توموری بوده و علاوه بر این خواص، خود به عنوان یک پری بیوتیک مطرح می‌باشد. این مطالعه با هدف بررسی اثر عصاره بره موم بر ویژگی‌های فیزیکوشیمیایی، حسی و میکروبی ماست سین بیوتیک تلقیح شده با *لاکتوباسیلوس کازئی* انجام شد. این مطالعه در پنج تیمار (شاهد بدون بره موم (A)، ۱٪ بره موم (B)، ۲٪ بره موم (C)، ۳٪ بره موم (D)، ٤ ٪ بره موم (E)) و سه تکرار برای هر تیمار انجام شد. خواص فیزیکی و شیمیایی مانند فعالیت آنتی اکسیدانی و پلی فنول کل، اسیدیته و pH، آب اندازی، بافت (سختی، چسبندگی، فنری و قابلیت جویدن)، زنده مانی پروبیوتیک‌ها و همچنین خواص حسی (مزه، بو، بافت، رنگ و پذیرش کلی) نمونه‌های ماست در روزهای ۱، ۷، ١٤ و۲۱ اندازه گیری شدند. بالاترین میزان مطلوبیت حسی مربوط به تیمار شاهد بود. کمترین میزان pH در نمونه شاهد و ۱٪ بود و با تیمارهای ۲٪، ۳٪ و ٤٪ اختلاف معنادار نشان داد. نتایج زنده مانی *ل. کازئی* در روزهای مختلف نشان داد که اثر زمان و درصد بره موم بر بقای باکتری پروبیوتیک معنی دار بود. بیشترین تعداد *ل. کازئی* در تیمار ٤٪ مشاهده شد. به طور کلی می توان نتیجه گرفت که از بره موم به عنوان یک پری بیوتیک می توان در ماست استفاده نمود که می تواند در بهبود خواص عملکردی و بافتی ماست مفید و موثر باشد.