Journal of Food Science and Technology (Iran)

Homepage:www.fsct.modares.ir

Scientific Research

Effects of tea matcha on the viability of Lactobacillus plantarum and bifidobacterium bifidum in free form and capsules in the formulation of cake muffin

Hosna Ezzati [1], Mohammad Hossein Azizi [2]*, Seyed Ebrahim Hosseini[3]

1-MSc Student in Food Science and Technology, Islamic Azad University, Science and Research Branch, Tehran, Iran

2- Professor Department of Food Science and Technology, College of Agriculture, Tarbiat Modares University, Tehran, Iran

3- Associate professor of Food Science and Technology, Islamic Azad University, Science and Research Branch, Tehran, Iran

ARTICLE INFO

Article History:

Received: 2024/12/16

Review: 2025/12/11

Accepted: 2026/01/26

Keywords:

Lactobacillus plantarum,

Bifidobacterium bifidum,

microcapsules,

probiotics,

matcha tea,

muffin cake

DOI: **10.48311/fsct.2026.83940.0**

*Corresponding Author E-

azizit_m@modares.ac.ir

ABSTRACT

Probiotics are living microorganisms whose consumption of adequate amounts causes beneficial effects on host health. In this study, the antioxidant properties of matcha tea in the presence of probiotic bacteria were investigated. For this purpose, probiotic microcapsules were prepared using alginate and corn starch, and after studying morphological characteristics, polydispersity index, zeta potential, trapping, release in gastric and intestinal conditions, matcha tea at two levels of 1% and 3%, and Lactobacillus Plantarum and *Bifidobacterium bifidium* microcapsules were used in formulations of muffin cake treatments at levels of 0.1, 0.3 and 0.5% weight/weight. The morphological results of nanoparticles confirmed the formation of spherical biopolymer nanoparticles with relatively uniform sizes. The muffin cake evaluation results showed that matcha tea up to 3% percentage, increased moisture, pH, and free radical inhibition percentage significantly ($p\leq0.05$). Also, with increase in the percentage of matcha tea, tissue hardness decreased significantly ($p\leq0.05$). All sensory characteristics had significant reduced with 3% matcha tea and 0.5% of probiotic microcapsules, and the maximum survival of probiotic bacteria was observed at a 0.3% w/w level. Finally, the treatment of muffin cake with 1% matcha tea and 0.3% probiotic microcapsules was introduced as the optimal treatment.

1-Introduction

Probiotics are microorganisms that, if they reach the intestine in sufficient numbers and live, have health-promoting effects on the host. The health-promoting effects of probiotics include maintaining the natural intestinal microflora, strengthening the immune system, reducing blood cholesterol levels, and their anti-mutagenic and anti-cancer properties. According to standards, for probiotics to exhibit their health-promoting properties, they must be present in sufficient numbers.^{6}10 to^{7} 10 ^{1}cfu of these bacteria per gram of probiotic product. Prebiotics are also non-digestible compounds with low digestibility that enhance the growth or activity of probiotics, such as resistant corn starch, fructooligosaccharides, and galactooligosaccharides [1]. The trend toward probiotic foods derived from dairy products[2]In many parts of the world, probiotics have been used in foods such as breakfast cereals, baby food, and chocolates. Cereal products such as bread, cakes, and other flour and confectionery products are a rich and excellent source of proteins, vitamins, and minerals, and a wide range of people, including children, are the main consumers of these products. Therefore, converting these products into functional foods[3]It can play an important role in improving the health of the community. The functions of these bacteria include antimicrobial activity, improving metabolism, reducing serum cholesterol, stimulating the immune system, antimutagenic properties, anticancer properties, antidiarrheal properties, improving inflammatory bowel diseases, and suppressing Helicobacter pylori [2&3]. Bifidobacteria are bacteriaGram positiveand the manufacturerLactic acidare a large part ofMicroflora Intestinehumans and other animals. These bacteria play a very important and effective role in limiting the formation of exogenous and pathogenic colonies. Also, the presence of these bacteria in the intestine causes beneficial effects on human health, including nutritional effects such as the production of some vitamins needed by the body and increasing the digestibility of proteins, medicinal effects such as preventing intestinal infection, preventing or reducing diarrhea and strengthening the immune system [4]. These bacteria appear in the feces a few days after birth and then their number increases. Bifidobacteria are non-motile, non-spore-forming,Gram positive, are in various forms and anaerobic. One of the best known and most common species of Bifidobacteria,*Bifidobacterium longum*It is found in both infant and adult feces. (This species is very similar to*Bifidobacterium infantis*Therefore, errors often occur in their identification. One of the methods for increasing Bifidobacterium cells in the intestine is the oral consumption of these bacteria along with foods called probiotic products [5]. Lactobacilli are gram-positive, catalase and oxidase negative bacteria. The presence of these microorganisms in the microbial flora of a large number of fermented vegetable, dairy and meat products has been shown. The presence of this bacterium as a probiotic bacterium in the digestive tract has also been stated. Lactobacillus plantarum is one of the most widespread and important species of the lactic acid bacteria range, which is due to its high ability to adapt and adapt to different niches. Among the proven health effects of consuming food products containing*Lactobacillus plantarum,*It can help reduce infection of the system. Digestion and risk Intestinal inflammation and immune system stimulation effects Pointed out. Studies have shown that bacteria*Lactobacillus plantarum*As a natural inhibitor in bioprocessed foods, it prevents the growth of pathogenic bacteria and spoilage microorganisms during storage and increases the shelf life of the product[6]. Since probiotics do not grow and multiply appreciably in cereal and confectionery products due to the lack of nutritional base environment of these products, as well as the absence of fermentation process and low water activity of these products, various microencapsulation techniques have been used to increase the viability of probiotics in these products[7]. Microencapsulation[4]One of the most innovative methods is to coat micro-living cells with a layer of hydrocolloids on a microscopic scale to enclose and isolate them from the environment, which increases the viability of probiotics in different environmental conditions. Probiotics have been inoculated in microencapsulated and free forms in various products such as yogurt, frozen desserts, milk, frozen milk, chocolate, ice cream, mayonnaise, sausages, fruit and vegetable juices, cereal-based

-Colony forming unit[1]

-nondairy products[2]

-Functional Foods[3]

-Microcasulation[4]

products, baby food, bread, fish, desserts, cheese, and also inoculated under simulated gastrointestinal conditions [8]. Calcium alginate has been widely used in the microencapsulation of lactic acid bacteria and probiotics. Alginate is a linear and heterogeneous polysaccharide extracted from various algae. D-Mannuronic acid and L-glucuronic acid are its constituent units linked by glycosidic bonds. The advantages of microencapsulation with alginate include its easy technology and ease of use, non-toxicity, low cost, and the fact that it is recognized as a permitted food additive. Alginate capsules can be prepared by emulsion and extrusion methods. Mixing calcium alginate with resistant corn starch on the one hand creates a coherent and uniform structure, and on the other hand increases cell survival due to its prebiotic properties. In similar studies, probiotics have been inoculated in free and non-microencapsulated form in chocolate mousse and cereal-based product textures, and in microencapsulated form in dark and milk chocolate, bread textures, and baby food. However, no report has been published so far on the inoculation of probiotics in cake cream [9]. Matcha tea[5]A type of green tea powder that is very colorful and fragrant and has a subtle and hidden sweet taste. Its color is emerald green. In Japan, this tea is ground with special granite mills so that the chlorophyll inside it does not burn, so to speak. The Japanese also use a wooden mortar to grind it by hand. An important point that is rarely mentioned is that the word "Macha" refers to the powdered form of the Tencha tea plant.[6]It is said that the reason why matcha powder is unique is its special cultivation method. Matcha green tea bushes hibernate during the winter and, by storing minerals in themselves, when spring arrives and they wake up from hibernation, they produce the best spring matcha tea through photosynthesis [10]. Around mid-May, Japanese farmers create wooden canopies with aluminum frames over matcha bushes to reduce the amount of sunlight reaching the matcha bushes to about 60 to 75 percent. This practice increases the sweet taste and quality properties of matcha tea by increasing its amino acids. The harvesting of matcha tea in Japan is accompanied by a special ceremony. Although matcha green tea is also introduced as a Japanese tea, its original origin is China. In the 12th century, a monk belonging to the Zen school named Isasi[7]During his trip to China, he brought back to Japan various types of tea seeds, including matcha tea. Of course, at that time, matcha tea was not used in powder form in Japan at first, and this was an invention of the Chinese [11]. The most important properties of matcha tea are: boosting metabolism, preventing aging, burning excess fat, increasing the body's ability to burn fat, providing energy, detoxifying the liver, reducing stress, boosting good bacteria in the intestines, anti-inflammatory, keeping blood sugar and adrenaline low, and being anti-cancer. The ingredients of matcha tea include; amino acids, a carbon chain or ring. Amino acids play an effective role in boosting the body's metabolism. Catechin[8]; This substance is one of the most famous food antioxidants from a nutritional point of view. These antioxidants are present in more matcha green tea than in black tea. The presence of antioxidants is related to the presence of large amounts of catechin in matcha green tea[12]. Cake is one of the important and widely consumed cereal products and a product of wheat flour. Cake, which is considered a confectionery product, has different types and different calories, and the high calories in these types of products are usually attributed to the oil, eggs and sugar in their formulation[13]. MuffinsEnglishMuffin, or a type of Yazdi cakeBreadSemi-sweet orCakeIt is basically prepared for one person. Muffins are divided into two types: English muffins and American muffins. In the American muffin type, the dough is usuallyKorea، SugarandBaking powderIt is added and baked in thick paper cups. That is why the American type of muffin is calledCup cakeAlso called a cupcake. A cupcake is actually a type ofSponge cakeOrKorean cakewhich is baked in cup-shaped molds [14]. In this study, probiotic cake was developed by examining the effects of matcha as a prebiotic on the survival of*Lactobacillus Plantarum*and*Bifidobacterium bifidium*Produced and evaluated.

2- Research method

1-2-Preparation of probiotic bacteria

Lactobacillus plantarum1058 ATCCand Bifidobacterium bifidium29521 ATCC Purchased in pure and lyophilized form from the collection of the Scientific and Industrial Research Organization of Iran and added to 20 ml of culture

5-Matcha

6-Tencha

7-Eisai

8-Catechin

medium.MRSThe liquid was activated at 27°C for 24 hours. The resulting sample was then placed in 95 ml of culture medium.MRSThe liquid was inoculated and propagated under the above conditions. The resulting biomass was separated by centrifugation at 1500 g for 15 minutes at 25°C and washed in two steps with a sterile solution of 0.1% peptone water.[8].

2-2-MicroencapsulationProbiotics I see

Microencapsulation of probiotics was performed using the ionic gelation method under sterile conditions. First, 3 grams of sodium alginate and 2 grams of resistant corn starch were slowly added to 100 ml of distilled water and, after dissolution, sterilized in an autoclave.. After the solution was equilibrated with the environment, the alginate solution was mixed with the microbial suspension (0.1%) for 5 minutes to homogenize. To form an emulsion, the resulting mixture was poured into 500 ml of corn oil containing 0.2% calcium chloride salt (Merck, Germany). A uniform emulsion was formed using a magnetic stirrer (speed 500 rpm) for 30 minutes. In order to form capsules, 0.1 M calcium chloride was added to the desired solution and after 30 minutes when the capsules settled, a 350 g centrifuge was used to separate the capsules for 10 minutes. The separated capsules were washed with 0.1% peptone water solution and stored at 4 °C [12].

3.2-Probiotic microcapsule tests

1-3-2-Counting the number of bacteria trapped in microcapsules (microencapsulation efficiency)

One gram of microcapsule sample Prepared in 99 ml of 1% w/v sterile sodium citrate solution inpHAbout 6 were dispersed and stirred for 10 minutes at room temperature until the microcapsules completely dissolve and the bacteria are released, then using solid mediumMRS[9]Incubation was carried out under aerobic conditions at 37 degrees for 24 hours and the number of bacteria was counted in triplicate. [14].

2-3-2- Morphological examinationMicrocapsule I see

To examine the morphology of particles and observe their appearance using electron microscopy and the techniqueAS[10]For this reason, the microcapsules were attached to the cautery using double-sided adhesive.(SC 7620 England(fixed and coated with gold and palladium for 2 minutes. Observation of microcapsules by electron microscope (modelLEO 1450 VP Germany) with electron beamkv10 were accepted [16].

3-3-2-Investigating the viability of Lactobacillus plantarum and Bifidobacterium bifidium bacteria under simulated conditions

This observation is based on the descriptive method by (Rao *et al.*.,1989One gram of microcapsules containing bacteria were completely dissolved in 10 ml of simulated gastric juice (HCL M0.08 and 0.2 percentNaClandpH(about 1.5) without the presence of pepsin and incubated for 0, 30, 60, 90 and 120 minutes at 37 °C. After the required time, the microcapsules were separated and washed with 0.1% peptone solution and the number of bacteria was counted in triplicate [10]. Simulated intestinal conditions were performed according to the method of Charteris et al. (1998). Thus, pancreatin (Sigma Aldrich P1500) with 0.5% sodium chloride was mixed with 4.5% bile salt solution (Oxoid, Basingstoke U/K) to reach a final concentration of 1 g/liter. Then its pH was adjusted to about 7.4 with sterile 0.1 M sodium hydroxide solution, and the resulting solution was sterilized using a 0.45 microfilter (Millipore).

2_4_1 Preparing and baking muffin dough

The raw materials included wheat flour for preparation and production of dough and cake: 73% extraction wheat flour, sugar, liquid oil, eggs, powdered milk, water and baking powder were obtained from food stores. First, sugar and eggs were mixed in a mixer at high speed for 5 minutes. Then water and oil were added to it and the mixing process was continued at high speed for another 3 minutes. In the next step, all powdered ingredients and matcha tea were added with percentages according to the coding table of the research treatments (Table 1) after sieving twice and mixed completely at low speed for 1 minute until a smooth and uniform dough was obtained. It was added to the dough and mixed at very low speed for one minute until the dough became uniform. The prepared dough was poured into a 30-gram muffin tin with a diameter of 3.5 cm and a height of 2.5 cm and baked in an oven

9-DE MAN, ROGOSA and SHARPE

10-Scan electron microscope

at 170°C for 18 minutes. The prepared muffins were then removed from the oven and cooled at room temperature for 30 minutes. After the production stages were completed, the muffins were packed in polyethylene bags with a suitable lid, which were labeled with the date of manufacture and other specifications related to the desired treatment, and were stored at room temperature (25°C) for one month (shelf life) [16].

Table 1. Coding of research treatments

Percentage of probiotic microcapsules	Matcha percentage	Code of research treatments
1/0	1	**T1**
3/0	1	**T2**
5/0	1	**T3**
1/0	3	**T4**
3/0	3	**T5**
5/0	3	**T6**

Fig 1. Preparation steps of matcha muffin cake

5.2-Physicochemical and sensory tests of muffins

1-5-2-Evaluation of the degree of free radical inhibition

One method of measuring antioxidant activity is by evaluating the degree of DPPH free radical scavenging. In this step, 4 ml of 0.1 mM DPPH was mixed with 0.2 ml of the sample and the absorbance of the DPPH solution was determined at 517 nm and the antioxidant activity was obtained in terms of percentage of DPPH scavenging through the following equation [19].

Relationship 1 100× control absorbance/sample absorbance–Control absorption = percentage of antioxidant activity

2-5-2-Determination of pH

The pH of the muffin samples was determined using a Metrohm model 52-AACC02 electric pH meter. 10 g of the sample was thoroughly mixed with 100 ml of distilled water at room temperature

using a glass rod and allowed to settle. Then, without filtering, the pH of the supernatant solution was determined using an electric pH meter previously adjusted with buffer solution [20].

3-5-2-Muffin cake moisture

To perform this test, AACC 2000 standard, No. 16-44, was used. For this purpose, the treatments were placed in an oven (Jeto Tech brand, model OF-O2G, made in South Korea) at a temperature of 100-105 degrees Celsius for 2 hours after baking [1].

4-5-2- Muffin Cake Colorimetry

Examining the color of the crust and core of muffin samples by determining three indicatorsL^*، a^* ، b^*

The images were scanned one day after baking using a digital scanner with a resolution of 900 dpi. Each piece of the crust and core of the muffin samples was scanned separately. To measure these indicators, cross-sections of the muffin crust were first prepared and photographed. Then, the images were made available to Image J software. By converting the RGB color space toL^* ،a^*andb^*The following indicators were calculated [2].

5-5-2-Evaluation of probiotic survival in muffin cake

ForCountingThe microbial composition of probiotic bacteria was determined using the serial dilution method. ThusthatFrom a milligram of muffin cake sample, to dilutioncfu/gr $^{8}10$ were prepared. From each of these dilutions on plates and using culture mediumMRSAerobic agar cultivation was performed. The number of colonies obtained was counted after 72 hours of incubation at 37°C. The survival of probiotic bacteria was evaluated on the days of production, 15, 30 and 45 days of storage.[15].

6-5-2-Muffin cake texture test

DirectionEvaluationTexture properties were measured using the Texture Profile Analysis (TPA) shear test. During the evaluation, a Brookfield CTS (Brookfield CTS) made in the United States was used at a speed of 0.5 mm/s and a sensitivity of 6.8 g. First, cake samples measuring 30 × 36 × 36 mm were placed on the specified part of the device. In this test, a compression force of 40% was applied to the cake pieces during two reciprocating cycles, and then the corresponding graph was drawn and the texture information was stored. In the shear test, a shear force of 40% was applied to the cake pieces during two reciprocating cycles, and then the corresponding graph was drawn and the texture information was stored [21].

7-5-2-Evaluation of sensory characteristics

A 5-point hedonic method was used to evaluate sensory attributes. Sensory tests included appearance color, appearance, texture, taste, and overall acceptability. In this sensory evaluation, number 1 represents the lowest score and number 5 represents the highest score for the attribute being evaluated [22].

3-Results and Discussion

1-3-Results of microcapsule tests

1-1-3-Results of counting the number of bacteria trapped in microcapsules (microencapsulation efficiency)

The entrapment and release characteristics of the microcapsules are listed in Table 2.

Table 2. Entrapment and release characteristics of microcapsules

Release percentage	Population of trapped bacteria
01/0 ± 65	107 × 7 colony on gram

The data are the mean ± standard deviation of three replicates.

In general, the release of microcapsules at different stages has different profiles, but each of the three initial parts, which is the initial release stage,[11]1, Fixed release stage[12]and the degradation stage[13]or destruction. Also, many factors affect the rate of release of nanoparticles.Most biodegradable polymers used in microemulsion systems are degraded by hydrolysis. Hydrolysis is a reaction between water molecules and bonds in the main polymer chain. Typically, ester bonds are an example of such bonds, which, when broken sequentially, break the polymer chain into its monomers. As water molecules break chemical bonds along the molecular chain, the physical integrity of the polymer is broken, allowing the trapped compound to be released.TechniqueThe release of probiotic bacteria from microcapsules is described as a two-phase process; the initial stage involves the initial bursting[14]which causes

11- Burst release

12-Steady state

13-Degradation

14-Burst Release

slow release in microcapsules [24]. It takes about an hour for this initial release to occur and in lower percentage accumulations and the presence of probiotic bacteria in the process medium, it is a single-stage process.By increasing the amount of trappingProbiotic bacteria,The capture rate and ultimately the release rate increase. One of the factors affecting the release rate isMicrocapsulesThe size of the microcapsules is that by increasing the size of the microcapsules, the contact surface of the microemulsion is effectively reduced, which can reduce the release rate of the compounds trapped inside the microcapsules. Therefore, according to the results, the entrapment index is effectively affected by the size [27].
Prathyusha Rao et al. (2014) also found similar results regarding the relationship between nanoparticle size and release and entrapment in solid lipid nanoparticles. They found that increasing the size of nanoparticles significantly reduced the release percentage, which was consistent with the results of the present study.

The results of the microorganism count study inside the microcapsules indicate that 80% of the probiotic microorganisms were entrapped at the concentration used in the formulation. As the results show, the treatments containing alginate/resistant corn starch had an 80% entrapment or accumulation capability. One of the reasons for this situation can be attributed to the ability of alginate to create an egg-like network and trap the compounds in its structure [21].

2-1-3-Determining the size of microcapsules and their dispersion.

The size of the microcapsules and their dispersion are shown in Table 3.

Table 3. Size of microcapsules and polydispersity index

Zeta potential index (millivolt)	poly index dispersity	Microcapsule size (micrometer)
37+	2/0	210

3-1-3 - Morphology of microcapsules

According to Figure 1, it was observed that the microcapsules were spherical and homogeneous in appearance with sizes between 100 and 300 µm. There was no agglomeration between the particles and they were uniform. The morphology results of the nanoparticles also confirmed the formation of spherical biopolymer nanoparticles with relatively uniform sizes. The nanoparticles were separate from each other, spherical and uniform, and the amount of probiotic cells used did not affect the appearance and morphological characteristics of the microcapsules. The results of the study were consistent with the morphological characteristics of the beads prepared byNualkaekul *et al.,*2012also showed compliance. Calcium alginate capsules have a smooth and uniform surface and the presence of whey isolate layers can also be seen in the figure. Khosravi Zanjani et al. (2012) also showed that by encapsulating*Bifidobacterium bifidium*Similar microscopic images were also obtained using chitosan and calcium alginate capsules.

.

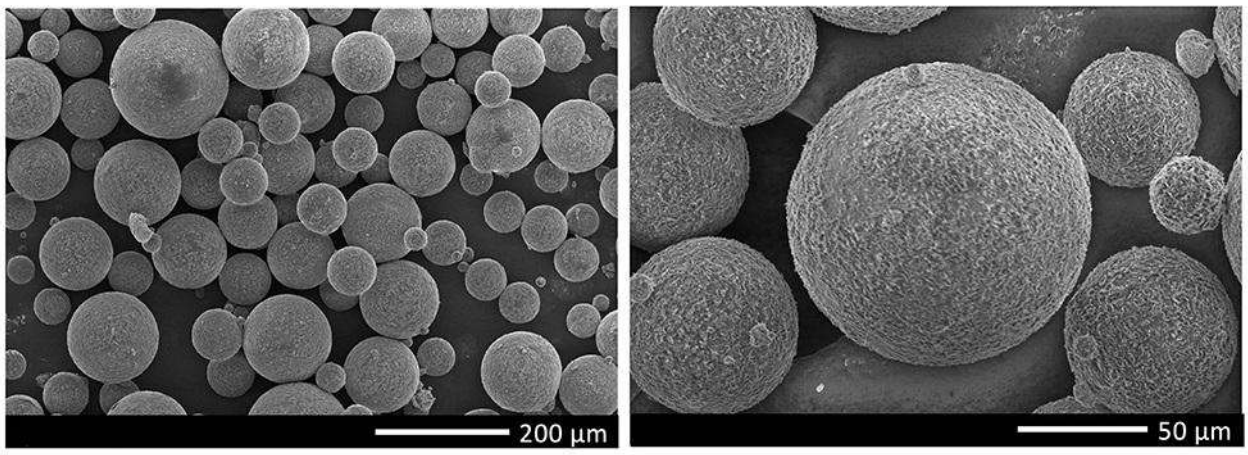

Fig2. Electron microscope images related to probiotic microcapsules

4-1-3-Investigating the viability of bacteria*Lactobacillus plantarum*and*Bifidobacterium bifidium*In simulated conditions

According to Figure 1, it was observed that there were significant differences between survival rates.Lactobacillus plantarum and Bifidobacterium bifidiumIt existed in different circumstances.(05/0≥p). Highest survival rateLactobacillus plantarum and Bifidobacterium bifidiumIt was in buffered environmental conditions and the lowest survival rateLactobacillus plantarum and Bifidobacterium bifidiumIt was observed in free form conditions (0.05).≥pBacterial survival rateLactobacillus plantarum and Bifidobacterium bifidiumIn the stomach and intestine conditions, it was lower than in the buffer condition and higher than in the free condition (0.05).≥pAlso, the survival rate in intestinal conditions was lower than in gastric conditions (0.05).≥p).

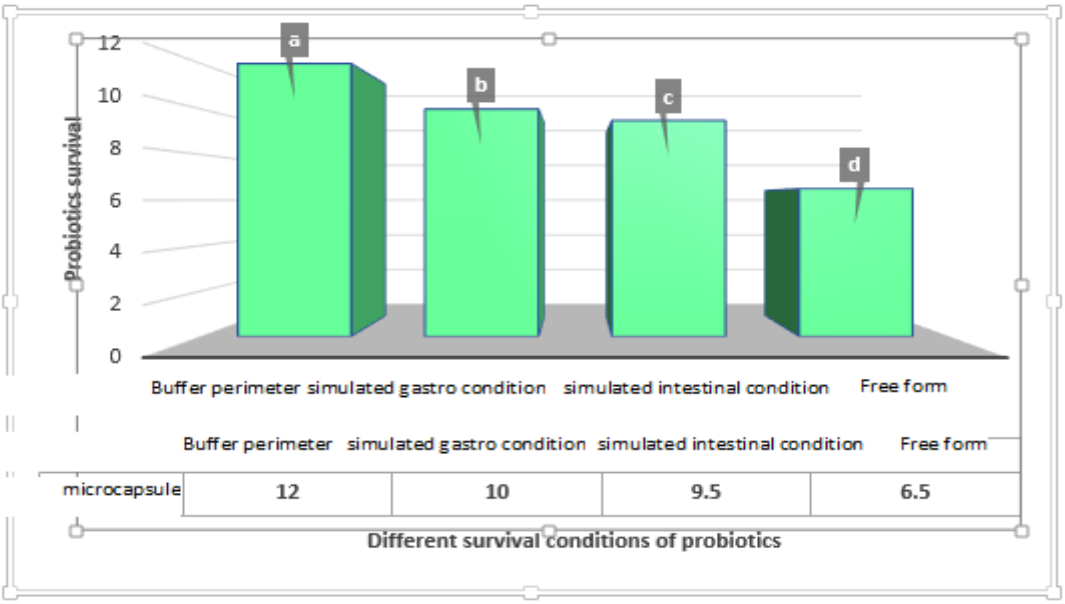

Chart 1. The survival of probiotics in the conditions of the environment with fersaline phosphate, conditions of the stomach, intestines and in free form

5-1-3-Results of evaluation of the percentage of free radical inhibition

The graph comparing the average percentage of free radical inhibition (Figure 1) shows that there were significant differences between treatments with different levels of matcha tea in terms of the amount of free radical inhibition (P<0.05).≥*p*). In general, with increasing the percentage of matcha tea levels used, the percentage of free radical inhibition in muffin cake treatments showed a significant increase, with the highest percentage of inhibition observed at three percent matcha tea levels in all treatments (P < 0.05).≥*p*). DPPH It is a free radical that changes color in the presence of substances with antioxidant properties and by gaining electrons. Its color change from purple to yellow is the basis for examining antioxidant properties. One of the important reasons for this is related to the inhibitory power. In general, phenols and polyphenols are widely found in many foods of plant origin and can have very high antioxidant effects. The mechanism of action of flavonoids for the manifestation of the antioxidant effect is the collection of free radicals such as superoxide, anions, lipid peroxide radicals and hydroxyl radicals. In addition, they have the ability to trap singlet oxygen and chelate metals. Stable radical trapping modelDPPHIt is used to evaluate the ability of different samples to trap free radicals. RadicalDPPHIt is a stable free radical with a central nitrogen atom that undergoes reduction to produce a stable molecule.H-DPPHIt changes color from purple to yellow. RadicalDPPHIt has absorption at 115 nm, but upon reduction by an antioxidant, the absorption decreases. The antioxidant activity of the samples is expressed as the disappearance of the purple color. According to the reduction percentage, the studied algae has good antioxidant properties and can be a good alternative to synthetic antioxidants. MethodDPPHIt is a simple, quick, and inexpensive method for measuring the antioxidant capacity of foods.DPPHIt is a stable radical and an inactive hydrogen acceptor and is widely used to study the antioxidant properties of bioactive compounds isolated from plant extracts. Reducing power indicates the electron-donating ability of the antioxidant. If a compound has this property, it can reduce the amount of oxidized intermediates formed during lipid peroxidation. In this way, it breaks the reaction chain and can act as a primary and secondary antioxidant.[17].

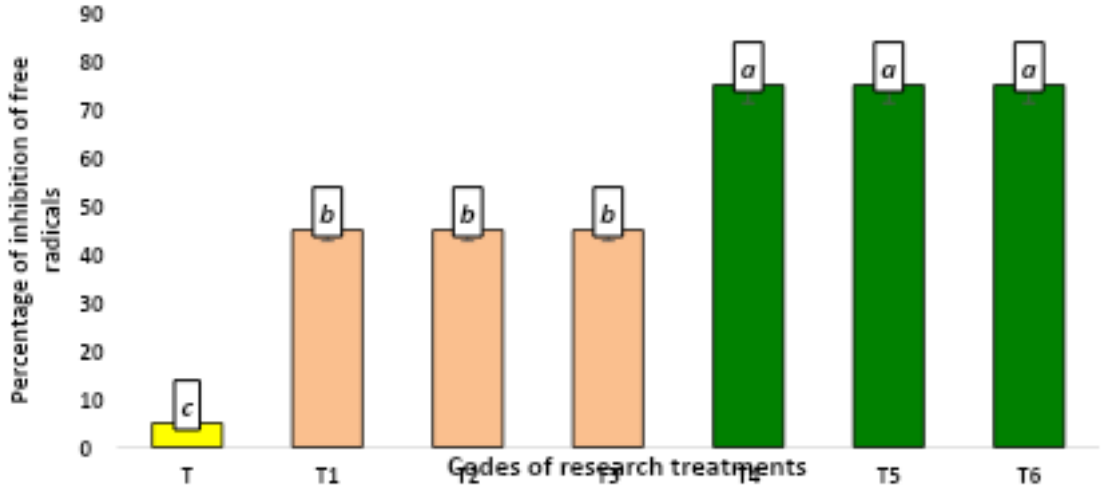

Chart 2. Comparison of the average percentage of inhibition of free radicals of muffin cake treatments

T Control muffin cake (without matcha tea and probiotic microcapsules), T1 Muffin cake with 1% matcha tea and 0.1% probiotic microcapsules, T2 Muffin cake treatment with 1% matcha tea and 0.3% probiotic microcapsules, T3 Muffin cake treatment with 1% matcha tea and 0.5% probiotic microcapsules, T4 Muffin cake treatment with 3% matcha tea and 0.1% probiotic microcapsules, T5 Muffin cake treatment with 3% matcha tea and 0.3% probiotic microcapsules, T6 Muffin cake treatment with 3% matcha tea and 0.5% probiotic microcapsules

There are various studies to investigate the antioxidant effects of matcha tea. It is obvious that in this study, the amount of bioactive compounds and antioxidants in it increases significantly with increasing the percentage of matcha tea used. However, since the phenolic content determines

the percentage of free radical inhibition, the percentage of free radical inhibition increases significantly with increasing the percentage of matcha tea used. According to this mechanism, antioxidants prevent the spread of subsequent chain reactions by donating a hydrogen atom to the free radical formed at the beginning of the oxidation process. From this perspective, the efficiency and extent of an antioxidant's effect depend on the ease with which this hydrogen atom can be separated from it. Of course, the free radical produced by the antioxidant after donating hydrogen should, if possible, not cause the formation of a fatty acid free radical and initiate its oxidation, and should also not be rapidly oxidized by oxygen. In general, in the phenomenon of potentiation or the emergence of an antagonistic state in the presence of a mixture of two antioxidants, these three characteristics should be affected in a positive or negative way. There were similar studies in this regard. Bahramian et al. (2019) investigated the effect of green tea extract on the physicochemical and sensory properties of Yazdi cake in a study and found that the use of green tea extract in the cake formulation increases the percentage of free radical inhibition, which was in agreement with the findings of the present study.[3].Tajik et al. (2016) investigated the effect of green tea and lemon essential oils on the physicochemical, microbial and sensory properties of oilcake. They found that the use of green tea essential oil significantly increased the percentage of free radical scavenging, which was in agreement with the findings of the present study.[4]..

6-1-3-Indicator evaluationpH Muffin Cake

In general, by increasing the levels of matcha tea used in the formulation of muffin cake treatments, the index valuepHshowed a significant increase ($0.05 \geq p$). The lowest index valuepHIt was observed at the level of zero percent matcha tea and the highest at the level of three percent matcha tea ($0.05 \geq p$). Average index comparison chartpH(Figure 4-5) shows that there were significant differences between treatments with different levels of matcha tea in terms of the indexpHThere was ($0.05 \geq p$). In general, as the percentage of matcha tea used increases, the indexpHIn the muffin cake treatments, it showed a significant increase, with the highest indexpHAt levels of three percent matcha tea, it was observed in all treatments ($0.05 \geq p$). One of the reasons for the changes in the indexpHIt is related to the presence of alkaloid compounds in matcha tea. Matcha tea is composed of caffeine, tannins, theophylline, theobromine, catechins, epicatechin gallate, fluoride, and vitamins.pHIt is related to matcha tea in the range of 9, which is a characteristic ofpHalso has a significant effect. In general, by increasing the percentage of matcha tea used in the muffin cake formulation, the amount ofpHThe final muffin cake also showed a significant increase, and there was also similar research in this regard.Mikołajczak & Sobiechowska(2019) In a study using matcha tea powder, they found that using different amounts of matcha tea powder on corn puffs yielded similar results. They found that the amount of the index pH Corn puff treatments significantly increased with increasing amount of matcha tea powder, which was in agreement with the findings of the present study. In another study, Hosseini et al. (2019) investigated the effect of aloe vera gel coating containing green tea extract and salicylic acid on the shelf life of Mazafati dates during storage and found that the use of green tea extract, which increased the amount of the indexpH Mazafati date treatments significantly increased with increasing amounts of green tea powder, which was in agreement with the findings of the present study.[12].Also, probiotic microcapsules with the percentage size used at any of the three levels had no significant effects on the rate ofpHMuffin cake treatments did not show that in this regard, the results of the present study can be compared with the study of Mohammadi et al. (2012) in examining the preparation of ultra-special mayonnaise with probiotic bacteria and found that the use of microcapsules had significant effects on the index.pHMuffin cake treatments did not show any agreement with the findings of the present study.[20].

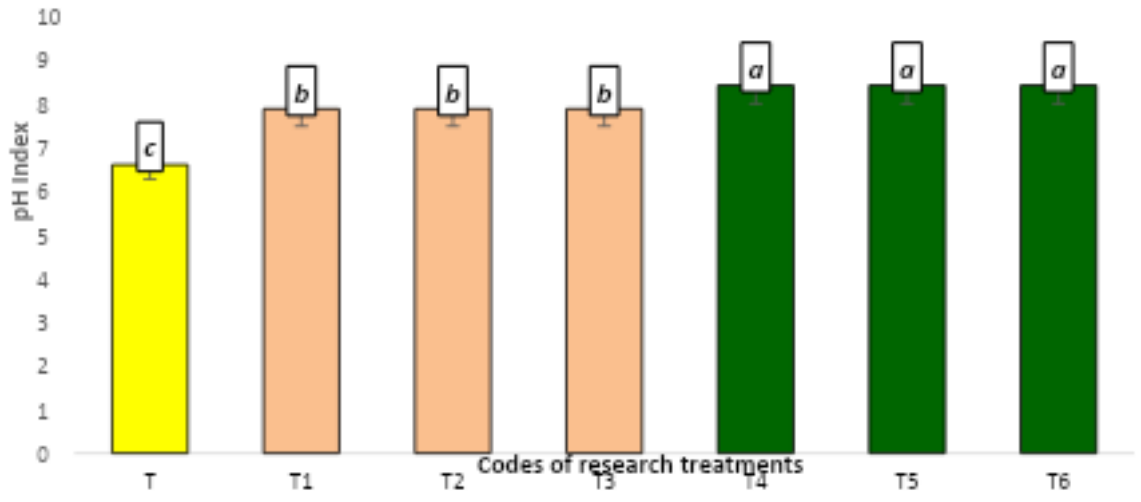

Chart 3. Comparison of the average pH index of muffin cake

T Control muffin cake (without matcha tea and probiotic microcapsules), T1 Muffin cake with 1% matcha tea and 0.1% probiotic microcapsules, T2 Muffin cake treatment with 1% matcha tea and 0.3% probiotic microcapsules, T3 Muffin cake treatment with 1% matcha tea and 0.5% probiotic microcapsules, T4 Muffin cake treatment with 3% matcha tea and 0.1% probiotic microcapsules, T5 Muffin cake treatment with 3% matcha tea and 0.3% probiotic microcapsules, T6 Muffin cake treatment with 3% matcha tea and 0.5% probiotic microcapsules

7-1-3-Results of moisture percentage evaluation

According to Figure 3, it was observed that there were significant differences between the percentage of moisture There was a significant difference at the one percent and three percent levels (0.05).≥*p*In general, by increasing the amount of matcha tea used in the formulation of muffin cake treatments, the moisture percentage showed a significant increase (0.05)≥*p*). Lowest moisture percentage It was observed at the level of zero percent matcha tea and the highest at the level of three percent matcha tea (0.05).≥*p*The comparison chart of the average moisture percentage index (Figure 3) shows that there were significant differences between treatments with different levels of matcha tea in terms of moisture percentage index (p<0.05).≥*p*). In general, with increasing the percentage of matcha tea levels used, the moisture index in muffin cake treatments showed a significant increase, with the highest moisture index being observed at three percent matcha tea levels in all treatments (P < 0.05).≥*p*). The moisture content of cake treatments increases significantly with the increase in the amount of matcha tea powder used, which is due to the water retention capacity of matcha tea fiber powder, and this can help maintain the moisture content of muffin cakes during storage and reduce the rate of their staleness to some extent. There were also similar articles in this regard. In a study by Khormaeipour et al. (2018), in investigating the enrichment of sponge cake with lemon peel powder and the use of stevia as a sugar substitute, they found that the use of lemon peel powder helps maintain the moisture content of cake treatments due to its fiber content, which was in agreement with the findings of the present study.[14]. The moisture content of cake treatments increases significantly with the increase in the amount of matcha tea powder used, which is due to the water retention capacity of matcha tea fiber powder, and this can help maintain the moisture of muffin cakes during storage and reduce the rate of their staleness to some extent. There were also similar articles in this regard. In a study by Khormaeipour et al. (2018), in investigating the enrichment of sponge cake with lemon peel powder and the use of stevia as a sugar substitute, they found that the use of lemon peel powder helps maintain the moisture content of cake treatments due to its fiber content, which was in agreement with the findings of the present study.[14].

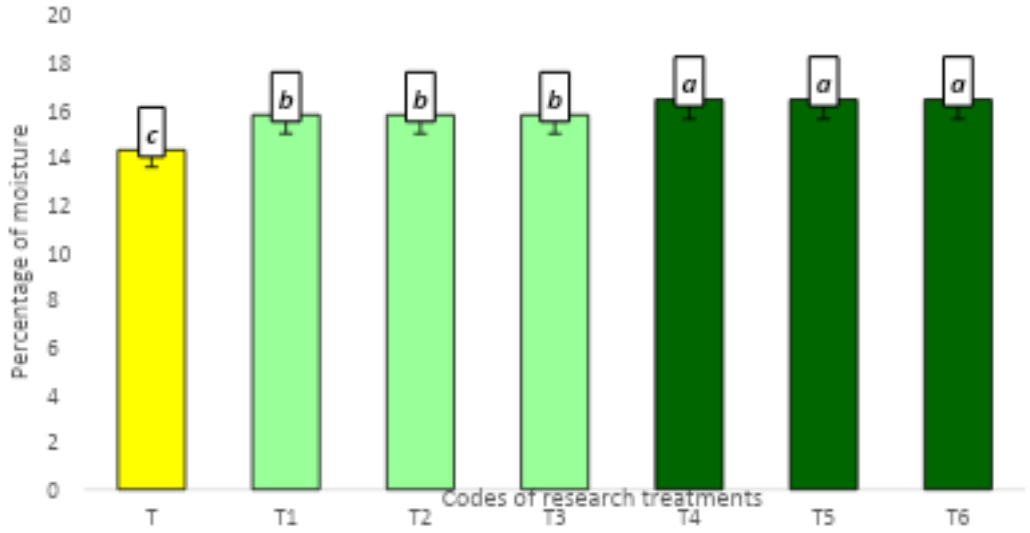

Chart 4. Comparison of the average moisture index of muffin cake

T Control muffin cake (without matcha tea and probiotic microcapsules), T1 Muffin cake with 1% matcha tea and 0.1% probiotic microcapsules, T2 Muffin cake treatment with 1% matcha tea and 0.3% probiotic microcapsules, T3 Muffin cake treatment with 1% matcha tea and 0.5% probiotic microcapsules, T4 Muffin cake treatment with 3% matcha tea and 0.1% probiotic microcapsules, T5 Muffin cake treatment with 3% matcha tea and 0.3% probiotic microcapsules, T6 Muffin cake treatment with 3% matcha tea and 0.5% probiotic microcapsules

8-1-3-Colorimetry of muffin cake treatments

In general, by increasing the levels of matcha tea used in the formulation of muffin cake treatments, the brightness index ($^*L$) showed a significant decrease (0.05)≥*p*The highest brightness index ($^*L$) It was observed at the zero percent level of matcha tea and the lowest at the three percent level of matcha tea (0.05).≥*p*Average brightness index comparison chart ($^*L$) (Figure 4) shows that there were significant differences between treatments with different levels of matcha tea in terms of brightness index ($^*L$) There was (0.05)≥*p*). In general, as the percentage of matcha tea surfaces used increases, the brightness index ($^*L$) In the muffin cake treatments, a significant decrease was shown, with the lowest brightness index ($^*L$) At levels of three percent matcha tea, it was observed in all treatments (0.05).≥*p*). Considering the color of the matcha tea treatments, it can be analyzed that with increasing the amount of matcha tea used, the brightness index ($^*L$(showed a significant decrease, which was not unexpected, and naturally the brightness index ($^*L$) at the 0.5% level was lower than the 0.3% level. There were similar studies in this regard. Tajik et al. (2016) also reached similar results in investigating the effect of green tea and lime essential oils on the physicochemical, microbial and sensory properties of oil cake. They found that the use of green tea essential oil significantly affects the amount of phenolic compounds in oil cake, which was also in agreement with the findings of the present study. In general, with increasing the levels of matcha tea used in the formulation of muffin cake treatments, the yellowness index (*b**(showed a significant decrease (0.05)≥*p*The highest jaundice index (*b**(It was observed at the level of zero percent matcha tea and the lowest at the level of three percent matcha tea) (0.05)≥*p*Comparison chart of average jaundice index (*b**(Figure 5) shows that there were significant differences between treatments with different levels of matcha tea in terms of yellowness index (*b**(There was) 0.05≥*p*). In general, with increasing percentage levels of matcha tea used, the yellowness index (*b**(in muffin cake treatments showed a significant decrease, with the lowest yellowness index (*b**(At levels of three percent matcha tea, it was observed in all treatments) (0.05)≥*p*). In general, as the percentage of matcha tea used increases, the redness index (*a**(In muffin cake treatments, it showed a significant increase, with the highest index being observed at three percent matcha tea

levels in all treatments (0.05).≥p). Redness to Greenness Index (a*(It is clear that with increasing the amount of matcha tea used, the color of the muffin cake treatments turned green, and this is consistent with the increase in the redness index to green.)a*(and this index is yellow to blue)b*) decreases. These two have opposite effects and increase the red-to-green index (a*), resulting in a yellowness index of blue (b*), which is in agreement with the findings of the present study. In a study, Khormali et al. (2020) investigated the effect of pumpkin and spinach powder on the physical, chemical and sensory quality of enriched sponge cake and found that the use of spinach powder significantly increased the redness-to-greenness index (a*), which was also in agreement with the findings of the present study. Ramet al. (2019) in a study examined the properties of cakes prepared with spinach powder and found significant changes in its colorimetric index in the form of a decrease in the brightness index (L*), jaundice (b*(and increase in redness index)a*) stated that the research findings were in agreement.

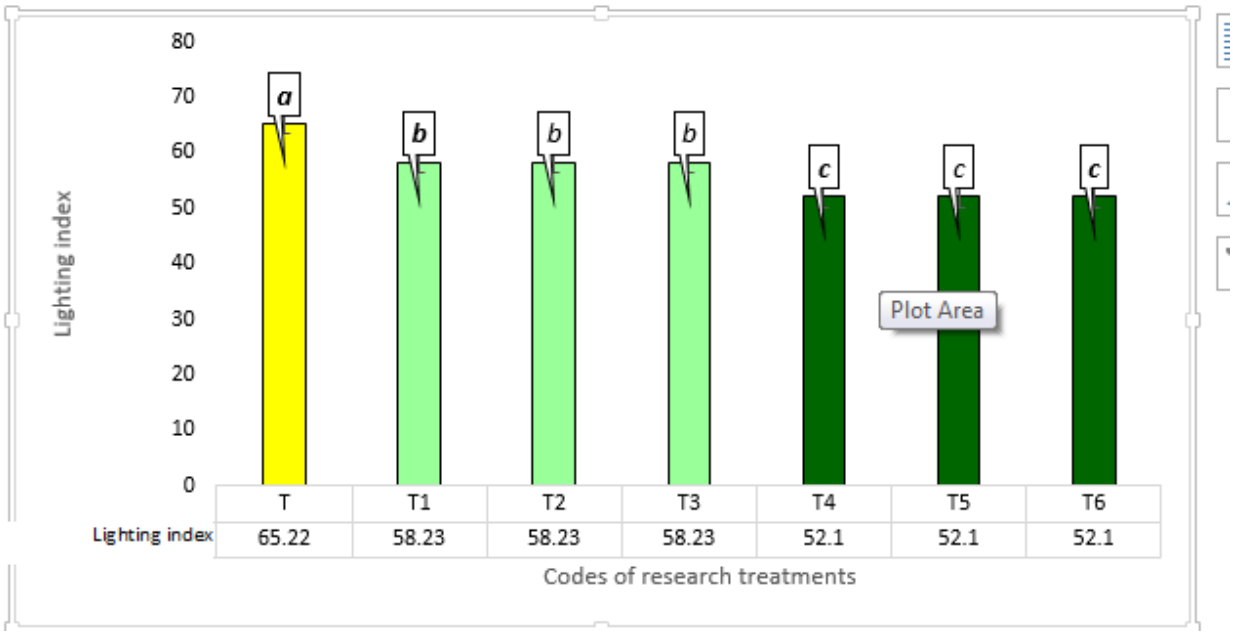

Chart 5. Comparison of the average brightness index (*L) of muffin cake

T Control muffin cake (without matcha tea and probiotic microcapsules), T1 Muffin cake with 1% matcha tea and 0.1% probiotic microcapsules, T2 Muffin cake treatment with 1% matcha tea and 0.3% probiotic microcapsules, T3 Muffin cake treatment with 1% matcha tea and 0.5% probiotic microcapsules, T4 Muffin cake treatment with 3% matcha tea and 0.1% probiotic microcapsules, T5 Muffin cake treatment with 3% matcha tea and 0.3% probiotic microcapsules, T6 Muffin cake treatment with 3% matcha tea and 0.5% probiotic microcapsules

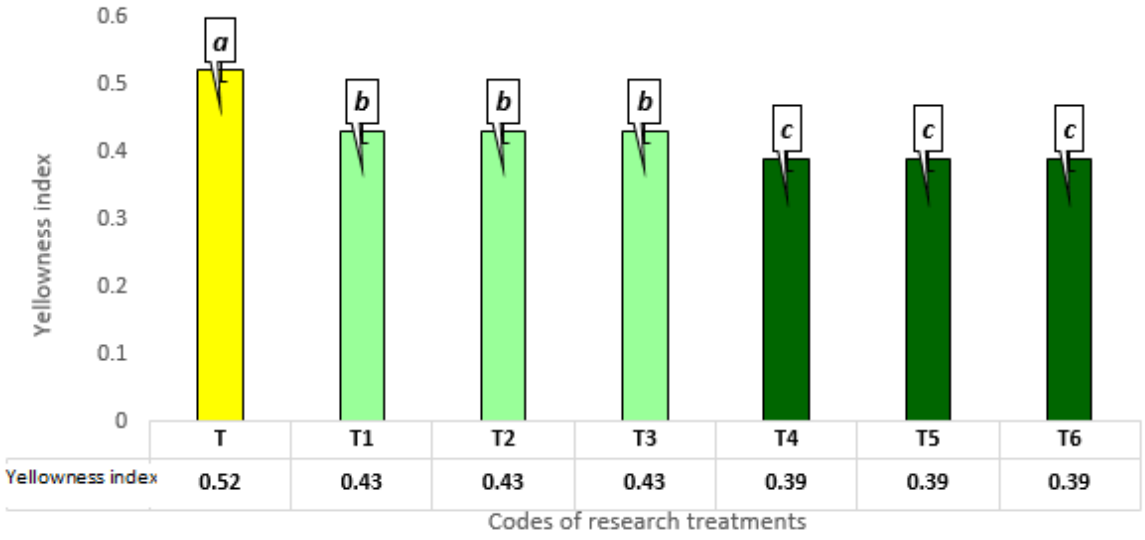

Chart 6. Comparison of the mean index of yellowness index (b*) of muffin cake

T Control muffin cake (without matcha tea and probiotic microcapsules), T1 Muffin cake with 1% matcha tea and 0.1% probiotic microcapsules, T2 Muffin cake treatment with 1% matcha tea and 0.3% probiotic microcapsules, T3 Muffin cake treatment with 1% matcha tea and 0.5% probiotic microcapsules, T4 Muffin cake treatment with 3% matcha tea and 0.1% probiotic microcapsules, T5 Muffin cake treatment with 3% matcha tea and 0.3% probiotic microcapsules, T6 Muffin cake treatment with 3% matcha tea and 0.5% probiotic microcapsules

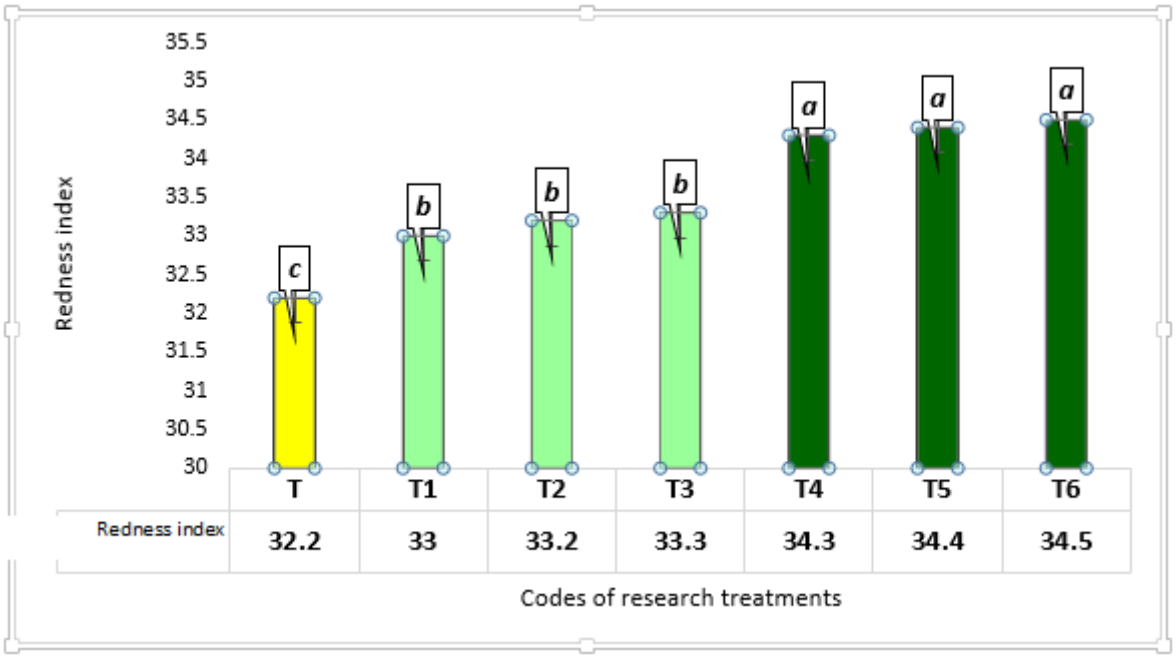

Chart 7. Comparison of average redness index (a*) of muffin cake

T Control muffin cake (without matcha tea and probiotic microcapsules), T1 Muffin cake with 1% matcha tea and 0.1% probiotic microcapsules, T2 Muffin cake treatment with 1% matcha tea and 0.3% probiotic microcapsules, T3 Muffin cake treatment with 1% matcha tea and 0.5% probiotic microcapsules, T4 Muffin cake treatment with 3% matcha tea and 0.1% probiotic microcapsules, T5 Muffin cake treatment with 3% matcha tea and 0.3% probiotic microcapsules, T6 Muffin cake treatment with 3% matcha tea and 0.5% probiotic microcapsules

9-1-3-Results of the hardness index evaluation

The comparison graph of mean tissue stiffness (Figure 7) shows that there were significant differences between tissue stiffness scores in treatments with different levels of matcha tea and probiotic microcapsules (P<0.05).≥*p*). In general, with increasing the percentage of matcha tea levels used and the use of probiotic microcapsules, the texture hardness index in muffin cake treatments showed a significant decrease, with the lowest texture hardness observed at levels of 3% matcha tea and 0.5% use of probiotic microcapsules in all treatments (P<0.05).≥*p*). It seems that the reduction in the strength of the gluten network in the muffin cake treatments by increasing the amount of matcha tea used significantly reduced the hardness index of the muffin cake treatments, which was also mentioned in the previous sections. On the other hand, with the increase in the amount of water activity and the creation of gelation caused by alginate and corn starch, as well as the presence of tannin compounds in the muffin cake treatments at the rate of 0.5% use, the hardness index of the muffin cake treatments showed a significant decrease. The extent of these changes was not noticeable and significant in 1% matcha and 0.1% probiotic microcapsules, and there were similar studies in this regard. Rahimi Nejad and Azizi Nejad (2016) studied the effect of inulin and green tea powder in pasta formulations and showed that increasing the amount of green tea powder above two percent reduced the firmness of the pasta treatments, which was in agreement with the findings of the present study.[10].

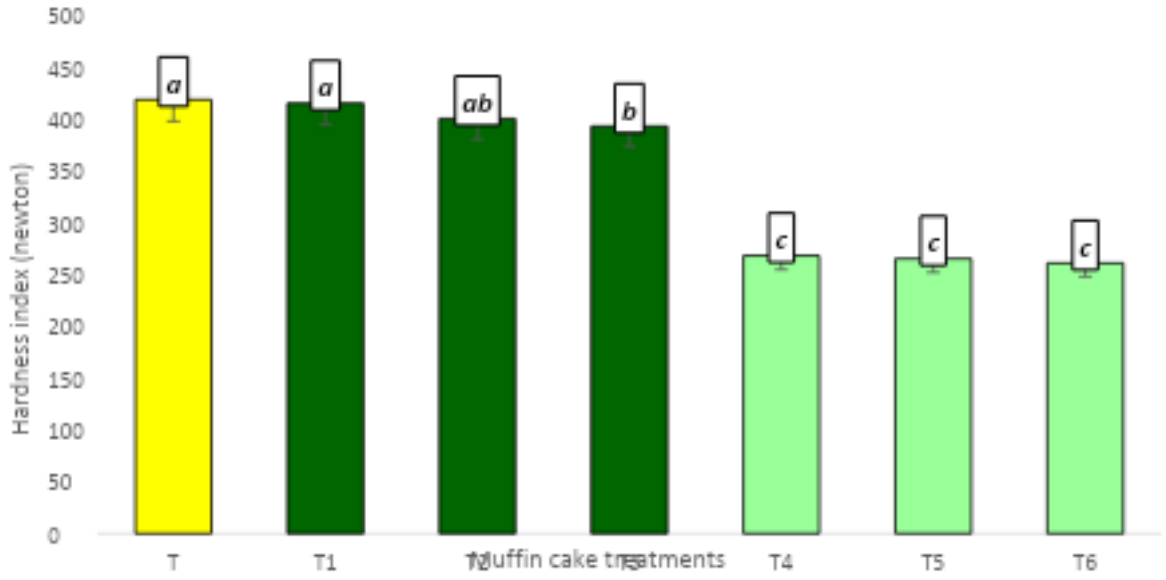

Chart 8. Comparison of the average hardness index of muffin cake texture

T Control muffin cake (without matcha tea and probiotic microcapsules), T1 Muffin cake with 1% matcha tea and 0.1% probiotic microcapsules, T2 Muffin cake treatment with 1% matcha tea and 0.3% probiotic microcapsules, T3 Muffin cake treatment with 1% matcha tea and 0.5% probiotic microcapsules, T4 Muffin cake treatment with 3% matcha tea and 0.1% probiotic microcapsules, T5 Muffin cake treatment with 3% matcha tea and 0.3% probiotic microcapsules, T6 Muffin cake treatment with 3% matcha tea and 0.5% probiotic microcapsules

10-1-3-Evaluation of the survival of probiotic bacteria in muffin cake treatments

According to Figure 8, it was observed that the effect of different levels of matcha tea and probiotic microcapsules, as well as the interaction effects of different levels of matcha tea × probiotic population levels, on the amount of texture hardness in cake treatments was significant (0.05).≥*p*). Matcha tea, due to its antioxidant compounds, can increase the survival of probiotic bacteria such as*Lactobacillus plantarum*and*Bifidobacterium bifidium* However, at high percentages of matcha tea, due to the bitterness of tannin and glycosidic compounds, the activity of probiotic bacteria decreases. On the other hand, by reducing the acidity level in the muffin cake formulation at a rate of three percent using matcha tea,*To*Reason Sensitivity Above Probiotic bacteria in alkaline conditions can reduce the survival of these compounds. At the end of the 45-day storage period at 4 ° C, there

was about a 1-1.5 logarithmic cycle decrease in the number of probiotic cells, under conditions and factors unfavorable for their growth that were present in the product or during the process and production of the product. The results also showed that the sample treated with 0.3% probiotic bacteria had a higher number of probiotic cells than the sample treated with 0.1% probiotic bacteria, which showed a direct relationship with the number of initial cells used in encapsulation and also the number of cells trapped inside the capsules. Also, in the 0.5% probiotic bacteria treatment, because the percentage of probiotic bacteria entrapment was lower than in the muffin cake treatment with the 0.3% probiotic bacteria, which has been reported in the previous sections, therefore, given the lower percentage of primary cells trapped from the beginning in the formulation at the end of day 45 of storage, it was also expected that the probiotic survival rate at the end of day 45 of storage would also be lower. In general, the highest probiotic survival at the end of day 45 of storage belonged to the muffin cake treatment with 1% matcha tea and 0.3% probiotic bacteria. Encapsulated cells require more time to undergo a logarithmic cycle (cycle) in the number of viable cells. Encapsulation, due to protection from acidic conditions and environmental stresses, also has an effect on the survival rate of probiotic bacteria, which is also confirmed in Figure 7. The survival of the probiotic bacteria mixture in this study under gastric and intestinal conditions is lower than under buffered conditions. The results of the research of Naeimi et al. (2012) were also consistent with the findings of the study, they found that encapsulation of probiotics increased their resistance to damage caused by freezing in a -18 freezer and increased the survival time of probiotic bacteria encapsulated in alginate.[13]Between treatmentsA,B,C and controlsA,B,CThere was also a significant difference. The control sampleCAlso with a droppHOrange juice on the twenty-fifth and twenty-fifth days Environmental conditions for activity*Bifidobacterium longum*becomes unfavorable and competitive, and a significant decrease in the probiotic population is observed (0.05).>*P*)According to research thatPicot &Lacroix(2003)They did,*Bifidobacterium bruchid*and*Bifidobacterium longum*Freeze-dried or fresh cultures in water-insoluble microcapsules prepared by emulsion or spray-drying. Using milk fat or denatured whey proteins as immobilizing agents, dispersing fresh cells in heat-denatured milk serum protein followed by spray-drying is a minimally destructive method. Survival*Bifidobacterium longum*During fermentation and storage of yogurt, encapsulation increased with a limited decrease in viability to 2.5 log cycles compared to 1.5 log cycles for free cells after four weeks at 4°C. In a study conducted byGoodbye*et al.*.,2009On microencapsulation*Lactobacillus plantarum*In the case of alginate coated with whey proteins, cells prepared by freeze-drying were inoculated into a 2% sodium alginate solution. This suspension was dripped into 100 ml of 0.1 M calcium chloride through a sterile syringe, which caused the drops to harden into spherical shapes. Then, the prepared microcapsules were separated and added to a 2% whey protein solution through a syringe (extrusion method was used for encapsulation and coating). The results showed that there was a significant difference ($p<0.05$) between the two methods.>*P*) between cell survival in coated and uncoated microcapsules was observed for all strains and also showed that coating with whey significantly increased bacterial survival in the microcapsules.[15]improved alginate. In the study*et al.*.,2000 WhichThe survival of bifidobacterium trapped in poly-L-lysine under acidic conditions and intestinal fluid was impressive.Picot *et al.*., 2004Microencapsulation of Bifidobacterium in whey protein-based microcapsules and its viability in yogurt were investigated. In this study, the bacteria*B.breve*R070and*B.Longum* R023They were encapsulated by emulsion and spray drying in denatured whey protein as an immobilizing agent. The survival rate*B.breve R070*The microencapsulated cells were 2.7 logarithmic cycles compared to free cells during 28 days of storage under gastrointestinal conditions, which was very high and significant. Research results*et al.*.,2012 Nualkaekul In the study of chitosan-coated alginate beads for viability*Lactobacillus plantarum*In pomegranate juice, it also showed that the cell concentration in pomegranate juice after six weeks of storage was higher thanCFU/ml It was 5.5 logarithmic cycles for single and coated bees while for free and uncoated cells it was 4 weeks after storage, which was also consistent with the results of our study.

-Beads[15]

Increased protection by chitosan coating with increasingpHJuice and in the case of coated willows aspHThe single and coated alginate beads showed an increase from 2.3 to 3.6 and 3.4, respectively, indicating an increase.pHThis is mainly because chitosan is soluble in various organic acids such as citric, malic, and succinic acids, all of which are found in orange juice [25]. Increase resistance In the case of single and double coated beads, the comparison with uncoated beads is justified in order to increase the ability of the polyelectrolyte matrix to buffer acidic compounds to the beads and also to increase the ability to form polysaccharide gels. The use of alginate and whey isolate in the formulation of capsules also increased cell protection in this study, which is generally due to the increase in the buffering capacity of the polymers and the reduction of acid activity [27]. Various factors affect the growth of Bifidobacterium longum. Studies have shown that the growth and proliferation*Bifidobacterium longum*Compared to*Lactobacillus acidophilus*and other lactic acid bacteria. This could be a result of sensitivity to oxygen, storage temperature, high acidity,pHLow and need growth supplements. High acidity andpHThe low levels of probiotic products are the most important factors in reducing the viability of probiotics in such products. Thus, in skim milk, cheese and yogurt, the viability of probiotics is ten times higher than in fermented products [26]. The results of Khosravi Zanjani et al. (2012) also showed that a storage temperature of 4°C had a significant effect on increasing the survival of the tested bifidobacteria ($p<0.05$).*P*). The stability study at 4°C to investigate the storage temperature variable and evaluate the effect of temperature on the viability of probiotics carried out by them showed that microencapsulated probiotics require a longer time to decrease to a logarithmic cycle at a storage temperature of 4°C. Growth factors are compounds that are directly nourished by bacteria and are energy sources as well as compounds that stimulate the growth of living microorganisms. For example, if a compound has better growth by changing the environmental conditions, it can be considered as a growth promoter rather than a growth factor [28].

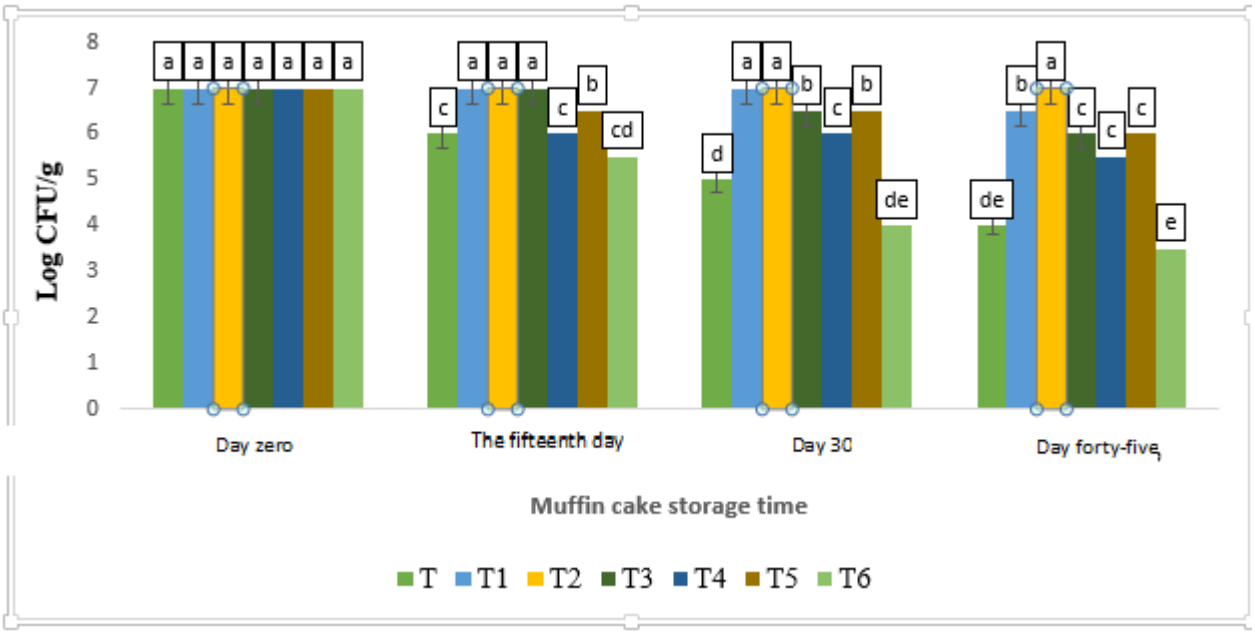

Chart 9. Comparison of the average survival index of probiotic bacteria of Muffin cake

T Control muffin cake (without matcha tea and probiotic microcapsules), T1 Muffin cake with 1% matcha tea and 0.1% probiotic microcapsules, T2 Muffin cake treatment with 1% matcha tea and 0.3% probiotic microcapsules, T3 Muffin cake treatment with 1% matcha tea and 0.5% probiotic microcapsules, T4 Muffin cake treatment with 3% matcha tea and 0.1% probiotic microcapsules, T5 Muffin cake treatment with 3% matcha tea and 0.3% probiotic microcapsules, T6 Muffin cake treatment with 3% matcha tea and 0.5% probiotic microcapsules

Studies have shown that adding antioxidant compounds such as gallates to probiotic fermented food products enhances the growth of some bacteria.Rahaei et al. (2019) investigated the effect of asparagus extract and green tea extract on the survival of probiotic bacteria,

antioxidant activity, and sensory properties of kefir. They found that green tea extract significantly reduced the survival rate of probiotic bacteria in kefir treatments, which was in agreement with the findings of the present study.

3-1-11- Evaluation of sensory characteristics

According to Figure 8, it was observed that there were significant differences between the sensory desirability of the apparent color at levels of 1% and 3% of matcha tea and levels of 0.1, 0.3, and 0.5% of probiotic bacteria ($p<0.05$).≥*p*In general, with increasing levels of matcha tea and probiotic microcapsules used in the formulation of muffin cake treatments, the sensory desirability of the apparent color showed a significant decrease (0.05).≥*p*The highest level of sensory desirability of the apparent color was observed at the level of 0% matcha tea and the lowest at the level of 3% matcha tea (0.05).≥*p*According to Figure 8, there were significant differences between the sensory desirability of appearance at levels of 1% and 3% of matcha tea and levels of 0.1, 0.3 and 0.5% of probiotic bacteria ($p<0.05$).≥*p*In general, with increasing levels of matcha tea and probiotic microcapsules used in the formulation of muffin cake treatments, the sensory desirability of appearance showed a significant decrease (0.05).≥*p*The highest level of sensory desirability of appearance was observed at the level of 0% matcha tea and the lowest at the level of 3% matcha tea (0.05).≥*p*Due to changes in the gluten network in high amounts of probiotic microcapsules and matcha tea, its weakening, as well as a decrease in the percentage of specific volume, the desirability of the appearance can also be affected, which is also confirmed in the results of the sensory desirability of the texture.Mikołajczakand(2019) investigated the effect of green matcha powder at different levels on the quality of corn puffs. In this study, corn puffs were produced with 0, 1, 2, and 5% matcha powder obtained by extrusion under laboratory conditions. They also acknowledged in their sensory evaluation that the appearance of puffs treated with high levels of matcha was affected and their desirability was reduced, which was consistent with the findings of the present study.In general, with increasing levels of matcha tea and probiotic microcapsules used in the formulation of muffin cake treatments, the sensory texture desirability showed a significant decrease (0.05).≥*p*The highest level of sensory texture desirability was observed at the level of 0% matcha tea and the lowest at the level of 3% matcha tea (0.05).≥*p*According to Figure 8, there were significant differences between the sensory taste preference at levels of 1% and 3% of matcha tea and levels of 0.1, 0.3 and 0.5% of probiotic bacteria ($P<0.05$).≥*p*In general, with increasing levels of matcha tea and probiotic microcapsules used in the formulation of muffin cake treatments, the sensory taste desirability showed a significant decrease (0.05).≥*p*The highest level of sensory taste desirability was observed at the level of 0% matcha tea and the lowest at the level of 3% matcha tea (0.05).≥*p*). Considering the presence of tannin compounds in the matcha tea formulation, it seems that increasing the percentage of matcha tea use by 3% significantly reduces the taste desirability of muffin cake treatments and induces a somewhat bitter taste to muffin cake treatments, which results in a significant reduction in the taste desirability of muffin cake treatments, which was also the subject of similar research in this regard. Rahaei et al. (2019) investigated the effect of asparagus extract and green tea extract on the survival of probiotic bacteria, antioxidant activity, and sensory characteristics of kefir. They found that green tea extract used in high amounts significantly reduced the taste desirability of kefir treatments, which was in agreement with the findings of the present study.[9]Ghanbari et al. (2020) studied the effect of green tea hydroalcoholic extract on the rheological properties of dough and staleness of barbari bread. They found that the use of green tea extract in high amounts can reduce the sensory desirability of the taste of bread treatments, which was in agreement with the findings of the present study. The use of probiotic microcapsules in amounts of 0.1 and 0.3 did not have adverse effects on the desirability of the taste of muffin cake treatments, but in amounts of 0.5 it can create a somewhat bitter aftertaste. On the other hand, due to the increase in alginate gelation with increasing its concentration and also corn starch, the degree of desirability of the taste is also somewhat affected. However, in amounts of 0.1 and 0.3%, the presence of alginate microcapsules prevented the undesirable taste of bacteria in muffin cake, but in an amount of 0.5%, the degree of desirability of the taste was affected due to the increase in the percentage of release and trapping of probiotic bacteria. There was also similar research in this regard. Khairkhahan et al. (2016) investigated the feasibility of producing probiotic

chocolate containing bacteria.*Bifidobacterium bruchid*Microencapsulated with calcium alginate and resistant corn starch by emulsion method achieved similar results, which were in agreement with the findings of the present study.[16].It was observed that there were significant differences between the sensory desirability of overall acceptance at levels of 1% and 3% matcha tea and levels of 0.1, 0.3 and 0.5% probiotic bacteria (P < 0.05).≥*p*In general, with increasing levels of matcha tea and probiotic microcapsules used in the formulation of muffin cake treatments, the overall sensory acceptability showed a significant decrease (0.05).≥*p*The highest level of overall sensory acceptability was observed at the level of 0% matcha tea and the lowest at the level of 3% matcha tea (0.05).≥*p*).

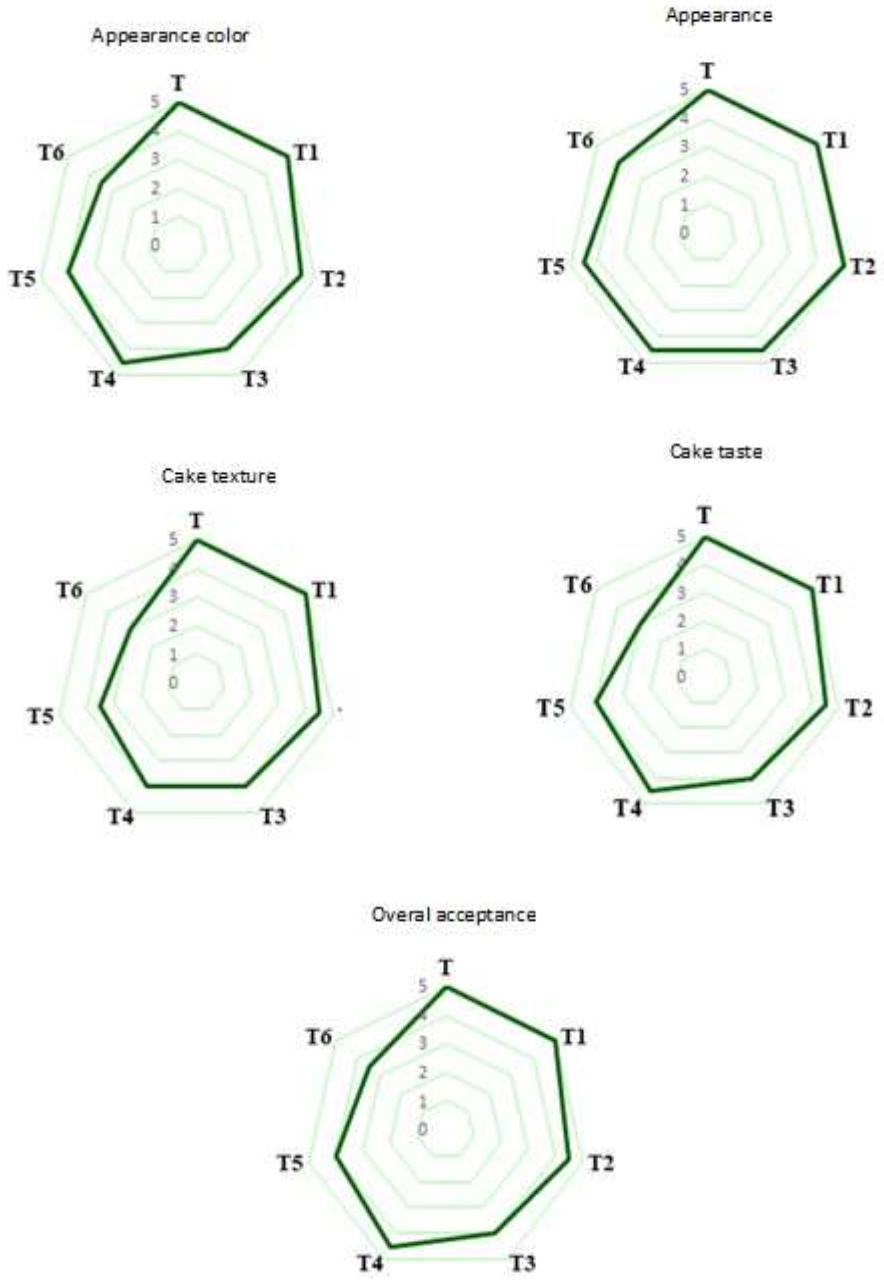

Chart 10. Comparison of the average sensory index of muffin cake treatments

T Control muffin cake (without matcha tea and probiotic microcapsules), T1 Muffin cake with 1% matcha tea and 0.1% probiotic microcapsules, T2 Muffin cake treatment with 1% matcha tea and 0.3% probiotic microcapsules, T3 Muffin cake treatment with 1% matcha tea and 0.5% probiotic microcapsules, T4 Muffin cake treatment with 3% matcha tea and 0.1% probiotic microcapsules, T5 Muffin cake treatment with 3% matcha tea and 0.3% probiotic microcapsules, T6 Muffin cake treatment with 3% matcha tea and 0.5% probiotic microcapsules

4- conclusion

The present study was designed considering the known effects of functional and antioxidant compounds on the survival rate of probiotic bacteria. The results of the study showed in summary that the use of matcha tea in amounts of 1% along with probiotic microcapsules in the amount of 0.3% can, while utilizing the valuable properties of matcha tea in the production of functional and antioxidant products, contribute to the survival of probiotic bacteria.*Lactobacillus plantarum*and*Bifidobacterium bifidium*Microencapsulation helps to increase their preservation and shelf life compared to the free form.

Financing
The author declares that he received no funding.

Authors' Contributions
All activities were carried out by the author.

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

5- Resources

[1] Akbari S., Suleimanianzad S., Sheikh Zainuddin M. 2013. Investigating the effect of microcoating on the survival of Lactobacillus casei ATCC39392 bacteria under osmotic pressure caused by sugar in simulated conditions in probiotic dairy desserts, the first national conference on snacks, Mashhad.

[2] Akbar Beglu Z, Prophet Doost S.H., Nikjo R. 2014. A review on microencapsulation of bioactive compounds and its methods, 23rd National Congress of Food Science and Industry of Iran, Islamic Azad University, Qochan Branch

[3] Bahramian A, Latifi Z, Ebadi M, Ghafouri Z, Mehrnoshad Ebrahimi Voldani Z. 2019. Investigating the effect of green tea extract on the physicochemical and sensory properties of Yazdi cake, Food Sciences and Industries, 104, 17. 27-39.

[4] Tajik Z, Natghi L, Baranji S. 2016. Investigating the effect of green tea and lemon essential oil on the physicochemical, microbial and sensory characteristics of oil cake, Journal of Food Industry Research, Volume 72, 3, 663-675.

[5] Iran Standard and Industrial Research Institute. 2015. Cake features and test methods. National Cake Standard No. 2553, 2.

[6] Sohrab Vandi S, Malganji S, Ivani MJ, Khosravi Darani K. 2013. Investigating the viability of Lactobacillus acidophilus and Bifidobacterium lactis during refrigerated storage in beer, 7, 5, 87-95.

[7] Soltani Lak A.A. and Marhamatizadeh M.H. 2020. Lactobacillus reuteri probiotic bacteria coating using soy protein isolate, whey and inulin and its survival during the storage period and simulated conditions of the digestive system, Iranian Journal of Food Science and Technology, 110, V 18, 77 -69.

[8] Rezaei Makram R., Mortazavi S.A., Habibi Najafi M.B., Shahidi F., Khemiri M. 2017. The effect of calcium alginate microencapsulation on the viability of Lactobacillus acidophilus PTCC 1643 in simulated conditions of human stomach and intestine, Quarterly Journal of Food Science and Industry, 7 2, 51-60.

[8] Rahai, M., Pourahmad, R., and Khurshidpour, B. 23019. The effect of asparagus extract and green tea extract on the survival of probiotic bacteria, antioxidant activity and sensory characteristics of kefir. Iran Food Sciences and Industries, 17(109), 43-54.

[9] Rahiminejad F and Azizi M.H. Investigating the effect of replacing inulin and green tea powder on the physicochemical, textural and sensory factors of pasta, Food Sciences and Industries, 68, 14, 155-147.

[10] Hissari, J., Moradi M., Fathi Achacheloi B. 2014. Evaluation of the possibility of producing probiotic red grape juice using Lactobacillus casei 431 and Lactobacillus acidophilus La-5, Journal of Food Industry Research, 25, 4, 666-655.

[11] Hosseini F.S., Akhwan H.R., Belwardi M., Bagheri P., Pakzad Moghadam M. 2018. The effect of aloe vera gel coating containing green tea extract and salicylic acid on shelf life of Mozafati dates during the storage period, Food Sciences and Industries, 88, 16, 47-60.

[12] Khosravi Zanjani AM, Ghiashi Tarzi B, Sharifan A, Bakhoda H, Mohammadi N. 2012. The effect of microcoating with calcium alginate and resistant corn starch on the survival of Lactobacillus casei and sensory characteristics in cake brain cream. Journal of Nutrition Sciences and Food Industry, 8th year, 1st issue, 48-39.

[13] Khormaipour M., Vazirizadeh L. and Mohebi G.H. 2018. Enrichment of sponge cake with lemon peel powder and the use of stevia as a substitute for sugar, Science and Food Industries88, 16, 135-145.

[14] Kharmali F, Hosseini Qaboos S.H, Fadavi A.2021. Investigating the effect of pumpkin and spinach powder on the physical, chemical and sensory quality of enriched sponge cake, food industry researches (agricultural knowledge), 3, 31, 133-150.

[15] Khairkhahan, N., and Ahri, H., and Asadi, G. (2016). Feasibility of producing probiotic chocolate containing Bifidobacterium berry microcoated with calcium alginate and resistant corn starch by emulsion method and checking its viability. Veterinary Microbiology (Garmsar Veterinary Research Journal), 13(2 (series 35)), 57-73.

[16] Feridouni H, Hossein Mardi F, Mahdikhani SH. 2016. The effect of adding green tea and stevia extract to Kombuja drink on its physicochemical and antioxidant properties, Journal of Food Science and Technology, 4, 18. 333-347.

[17] Toloui H., Aref Hosseini S.R., Hashemi Tolon S.H., Sadat Ejtehed H. 2013. The effect of probiotic bacteria Lactobacillus acidophilus and Bifidobacterium lactis on the levels of vitamin B2 and B3 in yogurt by high-performance liquid chromatography during the refrigeration period, Food Science and Nutrition, 11, 1, 15-20 .

[18] Milani, A., Naimi, H., and Mortazavi, S., and Kochaki, A. 2011. The effect of simulated conditions of the stomach and intestines on the survival of microencapsulated probiotic bacteria Lactobacillus casei in Masti Synbiotic ice cream. Iran Food Science and Industry Research, 8(2), 190-199.

[19] Mohammadi, N., Fahim Danesh, M., and Ahri, H., and Khosravi Zanjani, M. 2013. Production of ultra-special mayonnaise from the inoculation of probiotic bacteria coated with alginate and resistant corn starch. Food Science and Nutrition, 11(2 (series 42)), 73-80.

[20] Najafi Z, Mohed S, Ahmadi Chenarban H. 2018. The effect of replacing orange fiber with oil and egg on the physico-chemical and organoleptic properties of muffins. Journal of Iranian Food Science and Industry Research, 13, 4, 458-468.

[21] Nouri, N., Nohaddoost, B., Gandami Nasrabadi, H., and Akhundzadeh Basti, A. 2016. Studying the effect of nanoencapsulation of green tea extract on the survival of Lactobacillus casei and Bifidobacterium lactis in symbiotic ice cream. Veterinary Research Journal (Tehran University), 72(2), 195-205.

[22] Khosravi Zanjani MA, Ghiashi Tarzi B, Sharifan A, Bakhoda H, Mohammadi N. 2012. The effect of microcoating with calcium alginate and resistant corn starch on the survival of Lactobacillus casei and its sensory characteristics in cake brain worm, Iranian Journal of Nutrition and Food Industry, 8,1, 48-39.

[24] Roshni S. and Naqipour S. 2017. Investigating textural, visual and sensory characteristics of cupcakes containing flour
Chestnut and sodium stearoyl-2-lactylate, Food Science and Industry, number seventy-nine, fifteenth period, 111-120.

[25] Ghasemi S. and Mahdian A. 2017. Evaluation of prebiotic effects of fibers obtained from pineapple, pomegranate and wheat wastes in synbiotic yogurt containing probiotic Lactobacillus acidophilus La-5, Iranian Journal of Nutritional Sciences and Food Industries, 13th year, 4, 89-96.

[26] Abqari A., Sheikh Zainul Abidin M., Sulaimanianzad S., Dokhani S. 2017. Evaluation of the survival of Lactobacillus acidophilus in a non-fermented ice cream. 18th Congress of Food Science and Industry, Holy Mashhad.

[27] Khan Begi Dogahe M, Tawfiqi A, Khosravi Darani K, Dadgarm, Mortazavian SA. M., Ahmadi N. 2013. The effect of pomegranate peel extract on the survival of probiotic bacteria in pomegranate juice. Scientific-research quarterly of nutrition science and food industry 7, 5. 17-24.

[28] Khakpour A.R., Khandan Mustaf A.R., Khosh-Sekhre M.R., Khoshnavis A.R. 2014. The use of probiotics and prebiotics in the food industry to increase the health of the body, the 23rd National Congress of Food Sciences and Industries of Iran.

[29] Mortazavian, A. M. and Sohrab Vandi, S. 2016, a review of probiotics and probiotic food products, Eta Publications, Tehran.

[30] Mazaheri Tehrani M, Yaganehzad S, Reofi N. 2018. Investigating the effect of different ratios of whole soybean flour as fat substitutes and grinding time on textural, rheological and sensory characteristics of milk chocolate. Iran Food Science and Industry Research, 7(4): 262-255.

[31] Mahdian A., Karajian R. Investigating the effect of the microcoating process in calcium alginate bed and adding fiber from sugar beet pulp on the viability of Lactobacillus casei LC-01 and the quality characteristics of probiotic yogurt, 7, 3,25, 57-67.

[32] Moghadas Kia A, Darshti A, Qasimpour Z, Ehsani A. 2017. The effects of adding sodium caseinate and the microencapsulation process of Lactobacillus acidophilus strain and investigating the quality characteristics of probiotic yogurt during storage, Food Sciences and Industries78, 15, 55-69.

[33]. Yousefi L. 2013. Probiotics in food industry, Mehral Nabi Publications, 90.

مجله علوم و صنایع غذایی ایران

سایت مجله: www.fsct.modares.ir

مقاله علمی_پژوهشی

بررسی اثرات پری بیوتیکی چای ماچا بر زنده مانی باکتری های *لاکتوباسیلوس پلانتاروم* و *بیفیدوباکتریوم بیفیدیوم* به فرم آزاد و کپسوله در فرمولاسیون کیک مافین

حسنا عزتی [۱]، محمد حسین عزیزی [۲*]، سید ابراهیم حسینی [۳]

۱- دانشجوی کارشناسی ارشد علوم و صنایع غذایی، دانشگاه آزاد اسلامی واحد علوم و تحقیقات؛ تهران، ایران

۲-*استاد گروه علوم و صنایع غذایی، دانشگاه تربیت مدرس؛ تهران، ایران

۳- عضو هیئت علمی گروه علوم و صنایع غذایی؛ دانشگاه آزاد اسلامی واحد علوم و تحقیقات؛ تهران، ایران

اطلاعات مقاله

تاریخ های مقاله :

تاریخ دریافت: ۱۴۰۳/۰۹/۲۵

تاریخ داوری: ۱۴۰۴/۰۹/۲۰

تاریخ پذیرش: ۱۴۰۴/۱۱/۰۶

کلمات کلیدی:

لاکتوباسیلوس پلانتاروم و *بیفیدوباکتریوم بیفیدیوم*،
میکروکپسول،
پروبیوتیک،
چای ماچا،
کیک مافین

DOI: 10.48311/fsct.2026.83940.0

* مسئول مکاتبات:

azizit_m@modares.ac.ir

چکیده

پروبیوتیک‌ها میکروارگانیسم‌های زنده‌ای هستند که مصرف مقادیر کافی آنها موجب بروز اثرات مفید بر سلامت میزبان می شود. در این تحقیق از چای ماچا در حضور باکتری های پروبیوتیک استفاده شد. برای این منظور میکروکپسول های باکتری های پروبیوتیک با استفاده از آلژینات و نشاسته ذرت تهیه شد و پس از بررسی خصوصیات مورفولوژیکی، شاخص پلی دیسپرسیتی، پتانسیل زتا، به دام اندازی، رهایش در شرایط معده و روده، چای ماچا در دو سطح یک درصد و سه درصد و باکتری های *لاکتوباسیلوس پلانتاروم* و *بیفیدوباکتریوم بیفیدیوم* در سطوح ۰/۱، ۰/۳ و ۰/۵ درصد وزنی/وزنی در فرمولاسیون تیمارهای کیک مافین مورد استفاده قرارگرفتند. نتایج آزمون رنگ سنجی نشان داد که با افزایش میزان درصد استفاده از چای ماچا در کیک مافین شاخص روشنایی و زردی کاهش و شاخص قرمزی افزایش پیدا کرد و سطوح مختلف باکتری های پروبیوتیک اثرات معنی داری در شاخص های مذکور نداشت. نتایج ارزیابی کیک مافین نشان داد که با استفاده از چای ماچا تا ۳ درصد میزان شاخص درصد رطوبت، pH، درصد مهارکنندگی رادیکال های آزاد به طور معنی داری افزایش یافت ($p\leq$۰/۰۵) که حضور میکروکپسول های پروبیوتیک در مورد این شاخص‌ها اثرات معنی داری نداشت ($p>$۰/۰۵). همچنین با افزایش میزان درصد استفاده از چای ماچا شاخص‌های سختی بافت به طور معنی داری کاهش یافت ($p\leq$۰/۰۵). کلیه شاخص های حسی در سطوح ۳ درصد چای ماچا و ۰/۵ درصد میکروکپسول های پروبیوتیک با کاهش معنی داری مواجه شدند و بقای باکتری های پروبیوتیک نیز در سطح ۰/۳ درصد وزنی/وزنی به میزان حداکثر مشاهده شد. نهایتا تیمار کیک مافین دارای ۱٪ چای ماچا و ۰/۳٪ میکروکپسول‌های پروبیوتیک به عنوان تیمار بهینه معرفی گردید.