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Color, microbiological and sensory properties of low–fat probiotic yogurt supplemented with *Spirulina platensis* and *Ferulago angulata* hydroalcoholic extracts during cold storage

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Abstract*.* The aim of this study was to investigate the effects of *Ferulago angulata* and *Spirulina platensis* extract at 0.1 to 1% (v/v) on the color parameters, survivability of starter cultures and *Lactobacillus acidophilus* and sensory characteristics in low–fat yogurt during 1, 7, 14 and 21 d. The results showed that by increasing the extract concentration, average values of b* and light intensity (L*) was declined and control, showed the highest lightness during storage. Treatments containing *F. angulata* extract had a higher a* and b* values and color intensity (C*) in compartion with *S. platensis* extract. The mean values of total color difference (ΔE*) at the first week and last two weeks were higher in the treatments containing *S. platensis* and *F. angulata*, respectively. The mean *L. bulgaricus* count more than *St. thermophilus* and the mean count of starter cultures in the treatments containing *S. platensis* extract was significantly higher than *F. angulata* extract. However, the survivability of starter cultures and *L. acidophilus* at the end of the refrigerated storage was more than standardized number of bacteria (10^7–10^8cfu/ml) in yogurt. The color, flavor, consistency and overall acceptability scores of treatments containing *S. platensis* extract were significantly higher than the *F. angulata* extract. Therefore, these additives could be used successfully without having detrimental effects on bio–yogurt.

Keywords: *Ferulago angulata*, *Lactobacillus acidophilus,* probiotic, *Spirulina platensis,* yogurt.

Introduction

Probiotics, live microbial supplements, can provide health benefits on the host upon ingestion in a sufficient number [SHU *et al*., 2017].

Previous researches proved that probiotics contributed greatly to stronger immunity, lower cholesterol, blood pressure [AGHAJANI and POURAHMAD, 2012; AGHAJANI *et al*., 2012], improving lactose tolerance, preventing cancer, and *Helicobacter pylori* infection [SCHELL and BEERMANN, 2014].

The adequate survival of living probiotic should be maintained during shelf–life storage and internal gastro–intestinal tract to benefit human health [PRISCO and MAURIELLO, 2016].

Yogurt is the best well–known carrier of probiotic organisms transferring them to the consumers [AGHAJANI *et al*., 2014].

Interest for probiotics has arisen in recent years especially in relation to the addition of *Bifidobacterium, Lactobacillus acidophilus, Lactobacillus rhamnosus* and *Lactobacillus casei* to the fermented dairy products such as yogurt [FADAEI, 2013].

Extracts of many plants, herbs, seaweed and fruits rich in bioactive compounds are increasingly used as additive in yogurt for better nutritional and functional improvement.

For example, extracts have been used for preparation of yogurt by many researchers: crude extracts from artichoke [COSSU *et al*., 2009,], grape and grape callus extracts [CHOUCHOULI *et al*., 2013], tea infusions [NAJIGHEBAUER–LEJKO *et al*., 2011, SAMFIRA *et al*., 2015,], *Lycium barbarum* water extract [BABA *et al*., 2014], seaweed extracts [O'SULLIVAN *et al*., 2016], *Pleurotus ostreatus* aqueous extract [PELAES *et al*., 2015], black tea extracts [MUNIANDY *et al*., 2016], and mangos teen rind (*Garcinia mangostana* Lin.) extract [WIBAWANTI *et al*., 2018].

Herbal nutraceuticals are commonly used by people who seek alternative health care for prevention and treatment of disease. In the recent past, there has been rapid growth in demand for herbal medicines in food products like yogurt.

Ferulago angulata (Schlecht) Boiss. (Chevil or Chavir in Persian) is an important medicinal and aromatic plant [GHASEMI PIRBALOUTI, 2010].

Microalgae and cyanobacteria are a potential source of biomass for the production of various chemicals for the food, pharmaceutical, industrial and bio–energy sector [MARKOU *et al*., 2015].

Spirulina platensis (*S. platensis*), a cyanobacterium is multi–cellular and filamentous blue–green algae belong to the family of Oscillatoriaceae in the shape of a spiral coil, living both in the sea and freshwater [HWANG *et al*., 2011].

The objective of the current investigation was to study the effect of adding *S. platensis* and *F. angulata* extract to probiotic yogurt on the color parameters, microbiological and organoleptic attributes of functional yoghurt.

Material and methods

Low–fat milk (1 %), commercial starter YC–X11 containing *Streptococcus thermophilus* and *L. delbrueckii* subsp. *bulgaricus* and lyophilized cultures of *L. acidophilus* ATCC 4356 were obtained from Pegah, Co (Tehran, Iran), Chr. Hansen (Denmark) and Iranian Research Organization for Science and Technology of Tehran (Iran) respectively.

Powder of *S. platensis* and *F. angulata* aerial parts were purchased from Bonyan Danesh company (Gheshm, Iran) and local market (Kermanshah, Iran) respectively. The ethanol 99.7 % (v/v) and all other chemicals used were of analytical grade and were purchased from Merck (Germany).

Samples preparation. After confirming the *F. angulata* specified by the Herbarium group of the Research Institute of Forests and Rangelands of Iran (Alborz Province, Karaj), the *F. angulata* aerial parts were milled after the drying in shade, and transfer to the extraction section (Laboratory of Science and Technology Park of Tehran University, Karaj). Conditions for drying such as time and temperature was 24 h and 60 ºC respectively. The 40–mesh used, in other words, the particle size of grinded aerial parts (*F. angulata*) was 400 µm (0.4 mm).

Microwave–assisted extraction. In this method, laboratory microwave oven (power: 150 w., MicroSYNTH., Milestone company, Denmark) was used. 5 g samples *S. platensis* and *F. angulata* were mixed with different proportions of water/ethanol ratio (20:80). The resulting mixture was irradiated with microwave radiation (120 sec). To control the temperature, the time was applied alternately, so that, after each minute, the microwave radiation was sampled until the temperature reached less than 30°C in the refrigerator. For better microwave extraction, the sample was soaked in a solvent for 90 min without stirring. After the extraction, the flask was removed from the microwave oven, and the extract was filtered through Whatman No.1 filter paper, and the resultant solution was collected in a volumetric flask [PAN *et al*., 2000].

Preparation of L. acidophilus ATCC 4356. The lyophilized cultures were grown twice in tubes containing 10 ml of MRS broth (Quelab, Co., Canada) at 37 °C for 18 h. Then, bacterial suspension with 2 McFarland turbidity (6 $\times 10^8$ cfu.ml^{-1}) was prepared from the second culture [KRASAEKOOPT *et al*., 2004].

Preparation of yogurt. The yogurt samples were produced using skimmed milk in Pak Dairy Co. (Tehran, Iran). Firstly, the total solid content of the milk was adjusted to 11 %. Then, the milk was pasteurized at 95 °C for 5 min. After cooling down until 40 °C, DVS probiotic (*L. acidophilus*) was added to the milk. probiotic strain (10^8 cfu.g^{-1} of each strain) was inoculated simultaneously with the yogurt starter. *S. platensis* and *F. angulata* extract were added.

Control sample (without any extract) was also prepared. The prepared samples were poured into yogurt containers and incubated at 40 °C until reaching the pH value of 4.6. They were, subsequently, cooled down until 4 °C [SADEGHI *et al.*, 2017]. Eventually, the produced samples were stored at 4 °C for 21 days and were determined at 1, 7, 14 and 21 days.

Color measurements. The color of the yoghurt samples was measured instrumentally using a Hunter lab colorimeter (Hunter Lab, Color Flex, USA). The results were expressed in accordance with the CIELAB uniform color system in terms of L*, lightness (values increase from 0 to 100 %); a*, redness to greenness (positive to negative values, respectively); b*, yellowness to blueness (positive to negative values, respectively). The total color difference (ΔE*) and color intensity (chroma: C*) between the control and enriched samples were calculated by

$$\Delta E^* = [(\Delta L^*)^2 + (\Delta a^*)^2 + (\Delta b^*)^2]^{1/2}$$

and

$$C^* = [(a^*)^2 + (b^*)^2]^{0.5}$$

respectively. The measurements were done at 20±5 °C under constant light conditions and replicated 3 times, after storage for 1 day and 1, 2 and 3 weeks [KHOSRAVI DARANI *et al.*, 2017].

Enumeration of starter cultures and L. acidophilus. One g of each yogurt sample was diluted with 9 ml of 0.9 % sterile normal saline solution and was mixed uniformly with a vortex mixer.

Appropriate dilutions were made prior to pour–plating in duplicate onto selective media. *S. thermophilus* were enumerated on M17 agar (Merck, Darmstadt, Germany) after being incubated aerobically at 37 °C for 24 h.

L. delbrueckii subsp. *bulgaricus* was enumerated by culture on MRS agar (Merck, Darmstadt, Germany) adjusted to pH=5.2 and anaerobic incubation at 43 °C for 72 h [DAVE and SHAH, 1998]. Twenty–five grams of yogurt sample was mixed with 225 ml of 0.1 % sterile peptone water.

Tenfold serial dilutions were prepared by adding 1 ml of each dilution to 9 ml of sterile peptone water. Then, 0.1 ml of each dilution was inoculated in MRS–Bile agar (containing 0.15 % bile salt) during surface plating method, and after incubation at 37 °C for 72 h, number of colonies on selected plates were counted [KARIMI *et al.*, 2012].

Sensory assessment. The sensory panel was recruited from 15 potential panellists who were firstly subjected to a preliminary screening by a questionnaire, were then further screened for their ability to discriminate between basic tastes based on threshold testing as outlined by the Institute of Standards and Industrial Research of Iran (2007).

All participants were familiar with yogurt taste and had previous experience with sensory evaluation. A 5–point facial hedonic scale was used for sensory evaluation of yogurt. At first, each treatment was encoded randomly and evaluation procedure was performed.

Panellists were asked to evaluate the color, flavor, consistency and overal acceptability.

Approximately 20 g of yogurt were given to the participants in white plastic cups coded with three digits. Panellists used water to rinse their mouth before tasting different samples. Assessments were performed in individual booths and were recorded on a sensory evaluation sheet [MONTARROYOS *et al.*, 2017].

Statistical analysis

The statistical analysis was carried out using SPSS program (ver. 20) with multi–function utility. Experimental results were expressed as mean values± standard deviations.

The statistical evaluation of the results was performed using common statistical methods and the Microsoft Office Excel 2010 spreadsheet software.

Comparison of variance was carried out using one–way analysis of variance (ANOVA), followed up by the Duncan's Multiple Range test for the determination of statistically different groups. Differences were considered significant when $P<0.05$.

Results and discussion

Color changes ($L^*a^*b^*$, chroma and total color differences). Based on our results (Table 1 and 2), during storage, in all treatments, reduced the light intensity (L^*) by increasing the extracts level.

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Treatments containing *S. platensis* extract had a mean L* value higher than *F. angulata* extract.

Increased light intensity can be due to the presence of more casein micelles and increased light reflection.

It is also possible to change the arrangement of milk caseins with retentate, which can create a denser structure and more chain linkages by accumulation, and increase the L* value [ARYANA et al., 2007].

Table 1.

The L*a*b*changes of probiotic yogurt samples during cold storage

Treatments	L*			
	1st day	7th day	14th day	21st day
Control	95.17±0.89 ^{A,ab}	95.87±0.66 ^{A,a}	94.17±0.16 ^{B,a}	95.27±0.38 ^{A,a}
A	89.20±0.75 ^{B,c}	91.73±0.48 ^{A,b}	66.04±1.00 ^{D,e}	69.96±0.23 ^{C,f}
B	86.98±0.69 ^{B,d}	89.46±1.40 ^{A,c}	64.86±1.16 ^{D,ef}	72.97±0.03 ^{C,e}
C	85.01±1.40 ^{B,de}	90.22±0.06 ^{A,c}	63.85±0.51 ^{D,f}	72.86±0.57 ^{C,e}
D	84.50±0.22 ^{A,e}	84.50±0.27 ^{A,e}	63.93±0.74 ^{C,f}	69.44±0.38 ^{B,f}
E	79.59±0.71 ^{B,g}	84.99±0.11 ^{A,d}	60.14±0.03 ^{D,g}	63.54±0.36 ^{C,i}
F	76.12±0.44 ^{B,h}	79.34±0.99 ^{A,f}	60.56±0.53 ^{D,g}	65.90±0.60 ^{C,h}
G	74.16±0.27 ^{B,i}	75.18±0.06 ^{A,i}	51.59±0.29 ^{D,kl}	53.47±0.42 ^{C,n}
H	70.56±1.30 ^{B,jk}	78.22±0.09 ^{A,g}	52.06±0.96 ^{C,k}	52.26±0.28 ^{C,o}
I	70.89±1.65 ^{A,jk}	72.57±0.51 ^{A,j}	49.16±0.05 ^{C,m}	50.37±0.12 ^{B,p}
J	67.87±1.64 ^{B,k}	70.71±0.62 ^{A,k}	50.86±0.60 ^{C,l}	49.14±0.85 ^{D,q}
K	96.80±1.13 ^{A,a}	95.37±0.26 ^{B,a}	92.52±0.50 ^{D,b}	94.18±0.16 ^{C,b}
L	94.37±1.05 ^{AB,b}	95.12±0.73 ^{A,a}	93.71±0.45 ^{B,a}	93.82±0.12 ^{B,c}
M	84.64±0.73 ^{A,e}	78.20±0.09 ^{B,g}	75.07±0.99 ^{C,c}	76.09±0.18 ^{C,d}
N	81.92±1.54 ^{A,f}	76.13±0.12 ^{B,h}	75.20±0.36 ^{C,c}	75.73±0.27 ^{C,d}
O	81.31±1.13 ^{A,f}	68.36±0.46 ^{B,l}	67.85±0.57 ^{BC,d}	67.31±0.07 ^{C,g}
P	75.49±1.98 ^{A,hi}	68.11±1.06 ^{B,l}	58.44±0.49 ^{C,h}	67.35±0.29 ^{B,g}
Q	72.60±1.18 ^{A,j}	65.47±1.27 ^{B,m}	56.67±0.45 ^{D,i}	58.45±0.36 ^{C,k}
R	67.21±1.57 ^{A,k}	66.61±1.23 ^{A,m}	58.37±0.55 ^{C,h}	59.39±0.24 ^{B,j}
S	67.78±1.88 ^{A,k}	63.13±1.04 ^{B,n}	56.10±0.09 ^{D,i}	57.62±0.32 ^{C,l}
T	63.43±1.08 ^{A,l}	64.42±0.75 ^{A,mn}	54.14±0.12 ^{C,j}	55.59±0.52 ^{B,m}
a*				
Control	11.82±1.01 ^{A,a}	12.30±0.09 ^{A,b}	9.07±0.19 ^{B,d}	9.14±0.06 ^{B,c}
A	8.91±0.45 ^{A,bc}	7.94±0.03 ^{B,f}	7.57±0.41 ^{BC,f}	7.26±0.04 ^{C,g}
B	9.22±0.88 ^{A,bc}	7.88±0.03 ^{C,f}	8.41±0.27 ^{AB,e}	8.24±0.06 ^{B,e}
C	8.92±1.19 ^{A,bc}	7.52±0.47 ^{A,fg}	8/02±0.08 ^{A,f}	8.00±0.00 ^{A,f}
D	9.71±0.69 ^{A,b}	9.10±0.09 ^{A,e}	9.08±0.17 ^{AB,d}	8.85±0.13 ^{B,d}
E	9.21±1.19 ^{A,bc}	9.10±0.19 ^{A,e}	9.08±0.14 ^{A,d}	9.08±0.20 ^{A,c}
F	9.45±0.59 ^{A,b}	8.69±0.37 ^{B,e}	9.37±0.30 ^{A,d}	9.23±0.06 ^{A,c}
G	9.70±0.74 ^{B,b}	10.43±0.11 ^{B,d}	11.11±0.01 ^{A,c}	10.64±0.46 ^{B,b}
H	11.36±0.56 ^{B,a}	11.57±0.41 ^{B,c}	12.03±0.05 ^{A,b}	11.97±0.06 ^{AB,a}
I	9.80±0.57 ^{C,b}	12.60±0.52 ^{AB,ab}	12.99±0.19 ^{A,a}	12.31±0.40 ^{B,a}
J	8.40±1.08 ^{C,bc}	12.91±0.47 ^{A,a}	13.03±0.14 ^{A,a}	11.69±0.29 ^{B,a}
K	–9.85±1.51 ^{D,de}	7.30±0.26 ^{A,g}	–3.17±0.67 ^{C,i}	2.46±0.47 ^{B,i}
L	–8.22±1.79 ^{B,d}	7.14±0.06 ^{A,g}	7.06±0.05 ^{A,g}	7.04±0.06 ^{A,h}
M	–10.41±0.89 ^{C,de}	6.71±0.34 ^{B,g}	6.84±0.06 ^{B,h}	7.49±0.45 ^{A,g}
N	–8.23±1.96 ^{B,d}	–6.89±0.53 ^{B,h}	–7.45±0.34 ^{B,j}	–3.15±0.15 ^{A,j}
O	–7.98±1.42 ^{AB,d}	–7.57±0.52 ^{AB,h}	–8.27±0.38 ^{B,k}	–7.09±0.09 ^{A,l}
P	–13.78±2.89 ^{C,e}	–9.12±0.95 ^{B,i}	–10.10±0.09 ^{B,l}	–2.28±1.39 ^{A,j}
Q	–11.82±1.86 ^{C,e}	–9.03±0.04 ^{B,i}	–10.38±0.54 ^{C,l}	–6.43±0.67 ^{A,l}
R	7.59±0.86 ^{A,c}	–10.49±0.25 ^{C,j}	–11.09±0.09 ^{D,m}	–5.12±0.12 ^{B,k}
S	7.02±1.62 ^{A,c}	–12.92±0.66 ^{C,k}	–13.55±0.36 ^{C,n}	–9.33±1.19 ^{B,m}
T	12.88±1.56 ^{A,a}	–18.67±0.55 ^{C,l}	–20.09±0.09 ^{D,o}	–12.18±0.18 ^{B,n}

F. angulata extract (%)										*S. platensis* extract (%)									
T	S	R	Q	P	O	N	M	L	K	J	I	H	G	F	E	D	C	B	A
1	0.9	0.8	0.7	0.6	0.5	0.4	0.3	0.2	0.1	1	0.9	0.8	0.7	0.6	0.5	0.4	0.3	0.2	0.1

Control: without any extract

The yogurt proteolysis during storage by microbial protease or various additives can be effective factors on reducing the L* of yogurt. Reducing L* value may be due to anthocyanin accumulation [FAWOLE and OPARA, 2013].

The yogurt proteolysis during storage by microbial protease or various additives can be effective factors on reducing the L* of yogurt [KAYANUSH *et al*., 2006].

F. angulata–containing yogurts had a higher a* value in compartion with spirulina extract. By increasing the storage time, the variation of the a* value in the treatments containing *F. angulata* extracts was incremental and increased with a rise in extract level.

In other words, the green color intensity was reduced significantly and the red color was intensified. By increasing the level of spirulina extract, the average values of a* decreased and tend to negative (–a*). The lowest average of a* value, in other words, the strongest green color belonged to the treatment containing the highest level of spirulina extract (1 %).

Shokery and collab. reported that supplementation of probiotic yogurt by green tea leaves extract and *Moringa oleifera* leave extract reduced L* and increased b* values.

In the first two weeks, the mean values of a* decreased and in the final week, except for several treatments, increased. In other words, during this period, the greenness was declined [SHOKERY *et al*., 2017].

Results are in agreement with the findings of some studies. In the study by Rozan and collab., the mean values of a* decreased in yogurt enriched with carrot juice [ROZAN *et al*., 2017].

Table 2.

The L*a*b*changes of probiotic yogurt samples during cold storage

Treatments	L*			
	1st day	7th day	14th day	21st day
b*				
Control	28.61±0.52 ^{AB,a}	28.92±0.11 ^{A,a}	21.97±0.26 ^{B,c}	20.14±0.03 ^{C,d}
A	26.48±0.66 ^{A,b}	21.04±0.08 ^{B,i}	20.85±0.15 ^{B,d}	20.09±0.06 ^{C,d}
B	26.69±1.42 ^{A,b}	24.76±0.06 ^{B,d}	21.09±0.09 ^{C,d}	20.24±0.40 ^{D,d}
C	25.83±0.21 ^{A,b}	23.97±0.15 ^{B,e}	21.24±0.47 ^{C,cd}	21.04±0.04 ^{C,c}
D	26.44±1.06 ^{A,b}	24.60±0.56 ^{B,de}	21.02±0.04 ^{C,d}	21.00±0.00 ^{C,c}
E	26.00±1.52 ^{A,b}	23.15±0.15 ^{B,f}	22.02±0.13 ^{C,c}	20.95±0.25 ^{D,c}
F	27.71±1.07 ^{A,ab}	24.22±0.47 ^{B,de}	21.57±0.41 ^{B,cd}	20.78±0.19 ^{C,c}
G	26.28±1.14 ^{A,b}	24.83±0.15 ^{B,d}	23.02±0.20 ^{C,b}	21.23±0.40 ^{D,c}
H	27.60±1.44 ^{A,ab}	28.34±0.27 ^{A,b}	24.30±0.42 ^{B,a}	23.09±0.09 ^{C,a}
I	27.23±1.51 ^{A,ab}	22.32±0.11 ^{B,g}	22.02±0.04 ^{B,c}	22.01±0.16 ^{B,b}
J	23.01±1.65 ^{BC,c}	25.21±0.09 ^{A,c}	24.63±0.06 ^{B,a}	21.97±0.06 ^{C,b}
K	27.19±1.95 ^{A,ab}	22.14±0.04 ^{B,g}	20.14±0.04 ^{C,e}	18.17±0.06 ^{D,f}
L	26.56±1.82 ^{A,ab}	23.18±0.18 ^{B,f}	20.05±0.09 ^{C,e}	18.17±0.29 ^{D,f}
M	25.98±1.18 ^{A,b}	21.76±0.26 ^{B,h}	20.20±0.26 ^{C,e}	18.11±0.11 ^{D,f}
N	21.86±1.24 ^{A,c}	22.32±0.33 ^{A,g}	20.16±0.01 ^{B,e}	18.90±0.40 ^{C,e}
O	26.50±0.79 ^{A,b}	21.83±0.19 ^{B,gh}	20.15±0.04 ^{C,e}	19.27±0.31 ^{D,e}
P	26.43±1.21 ^{A,b}	22.00±0.12 ^{B,gh}	20.85±0.15 ^{C,d}	19.67±0.29 ^{D,d}
Q	26.26±0.34 ^{A,b}	23.06±0.10 ^{B,f}	20.84±0.16 ^{C,d}	19.00±0.27 ^{D,e}
R	25.56±0.44 ^{A,bc}	22.09±0.09 ^{B,gh}	21.10±0.09 ^{C,d}	19.53±0.26 ^{D,de}
S	25.86±1.19 ^{A,b}	22.43±0.65 ^{B,fg}	21.89±0.25 ^{B,c}	19.72±0.27 ^{C,d}
T	27.32±1.66 ^{A,a}	23.81±0.17 ^{B,e}	21.14±0.13 ^{C,d}	20.00±1.00 ^{C,d}

F. angulata extract (%)											*S. platensis* extract (%)								
T	S	R	Q	P	O	N	M	L	K	J	I	H	G	F	E	D	C	B	A
1	0.9	0.8	0.7	0.6	0.5	0.4	0.3	0.2	0.1	1	0.9	0.8	0.7	0.6	0.5	0.4	0.3	0.2	0.1

Control: without any extract

The results are expressed as mean ± standard deviation. The different small letters show the significant differences in each column ($p<0.05$). The different capital letters show the significant differences in each row ($p<0.05$).

In contrast Ozdemir and Devres reported a significant decline in the a* value by increasing the storage time.

During storage, the trend of a* changes in the treatments containing *F. angulata* extract was incremental and by increasing the extract concentration, the mean a* value increased.

In other words, the greenness was significantly reduced and increased redness [OZDEMIR and DEVRES, 2000].

In the present study, adding *S. platensis* extract has a significant effect on the greenness and decrease the a* value. The higher values of a* indicate the color tendency of the samples to redness

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and the reduction of greenness which due to presence of the dominant chlorophyll [NILSAH *et al*., 2004].

Varga and collab. stated that *S. platensis* extract reduces the a* value and creates a green color in yogurt [VARGA *et al*., 2002].

The results are expressed as mean ± standard deviation. The different small letters show the significant differences in each column (p<0.05).

The different capital letters show the significant differences in each row (p<0.05).

Table 3.

The changes of color intensity (C*) and total color difference (ΔE*) of probiotic yogurt samples during storage

Treatments	Color intensity (C*)			
	21st day	14th day	7th day	1st day
Control	28.64±0.22 A,e	28.80±0.18 A,b	21.84±0.25 B,gh	20.39±0.21 C,f
A	26.12±0.32 A,i	22.50±0.39 B,i	22.13±0.12 C,fg	21.78±0.75 C,cde
B	27.89±0.48 A,f	25.53±0.43 B,e	22.22±0.41 C,fg	21.62±0.54 C,de
C	27.30±0.06 A,g	25.19±0.23 B,ef	22.60±0.38 C,ef	22.30±0.26 C,cd
D	28.45±0.47 A,de	24.37±0.27 B,g	22.85±0.17 C,e	22.28±0.43 C,cde
E	27.49±0.43 A,fg	24.89±0.10 B,f	23.63±0.40 C,d	22.39±0.39 D,cd
F	29.28±0.06 A,c	24.45±0.40 B,fg	22.89±0.68 C,ef	22.59±0.39 C,c
G	27.82±0.33 A,f	26.79±0.31 B,d	25.48±0.33 C,c	23.39±0.37 D,b
H	29.95±0.29 A,ab	30.43±0.39 A,a	27.86±0.66 B,b	25.92±0.13 C,a
I	28.98±0.05 A,d	25.47±0.21 B,e	25.37±0.17 B,c	25.48±0.66 B,a
J	24.57±0.39 B,j	27.87±0.52 A,c	27.39±0.42 A,b	25.18±0.72 B,a
K	29.42±0.52 A,bcd	23.06±0.23 B,hi	20.09±0.38 C,j	18.82±0.43 D,g
L	27.75±0.28 A,f	24.30±0.33 B,g	20.61±0.58 C,ij	19.01±0.47 D,g
M	27.81±0.32 A,f	22.50±0.34 B,i	21.77±0.39 C,gh	20.12±0.49 D,f
N	24.64±0.11 A,j	23.38±0.26 B,h	21.61±0.68 C,gh	18.94±0.26 D,g
O	27.29±0.34 A,fg	23.14±0.08 B,h	21.35±0.37 C,hi	20.43±0.10 D,f
P	29.15±0.63 A,bcd	23.19±0.55 B,h	22.90±0.26 B,e	19.27±0.46 C,g
Q	28.30±0.43 A,e	24.44±0.33 B,g	23.13±0.14 C,de	20.67±0.29 D,f
R	26.59±0.06 A,h	24.35±0.26 B,g	23.65±0.47 B,d	20.41±0.24 C,f
S	26.52±0.24 A,hi	25.66±0.29 B,e	25.55±0.29 B,c	21.52±0.45 C,e
T	30.53±0.49 A,a	30.12±0.13 A,a	28.52±0.24 B,a	22.92±0.43 C,bc
Total Color Difference (ΔE*)				
A	4.59±0.05 B,f	3.42±0.22 C,e	5.64±0.11 A,g	5.45±0.15 A,de
B	3.13±0.12 B,h	3.47±0.27 B,e	5.38±0.50 A,g	5.34±0.18 A,e
C	4.30±0.20 C,g	3.25±0.25 D,e	6.16±0.17 A,f	5.29±0.14 B,e
D	4.67±0.06 C,f	4.36±0.17 D,e	6.18±0.13 A,f	5.65±0.06 B,d
E	5.13±0.02 B,d	4.33±0.13 C,e	6.34±0.12 A,ef	6.45±0.41 A,b
F	5.42±0.19 C,c	4.62±0.35 D,e	6.36±0.05 A,ef	5.85±0.08 B,c
G	5.42±0.37 B,cd	5.58±0.06 B,d	7.33±0.22 A,bc	7.30±0.28 A,a
H	6.18±0.07 B,ab	5.57±0.13 C,d	7.45±0.13 A,bc	7.62±0.29 A,a
I	6.07±0.06 B,b	6.30±0.41 B,abc	7.44±0.26 A,bc	7.47±0.17 A,a
J	5.49±0.36 C,cd	6.20±0.02 B,c	7.59±0.40 A,bc	7.59±0.35 A,a
K	4.83±0.23 A,ef	3.54±0.41 B,f	2.48±0.12 C,j	2.27±0.09 D,h
L	4.84±0.08 A,e	4.18±0.24 B,e	3.29±0.15 C,i	3.34±0.20 C,g
M	4.58±0.29 A,ef	4.51±0.22 A,e	4.39±0.32 A,h	4.44±0.18 A,f
N	4.42±0.05 A,g	4.60±0.51 A,e	4.58±0.24 A,h	4.35±0.29 A,f
O	4.66±0.21 A,ef	5.52±0.17 B,d	5.39±0.33 B,g	5.27±0.24 B,e
P	5.58±0.36 B,c	5.60±0.37 B,d	6.49±0.10 A,e	5.24±0.28 B,e
Q	6.20±0.23 B,ab	6.33±0.21 B,bc	6.75±0.13 A,d	6.30±0.15 B,b
R	6.09±0.08 B,ab	6.33±0.13 B,bc	8.49±0.40 A,a	6.30±0.41 B,b
S	5.53±0.42 C,c	6.44±0.05 B,b	7.18±0.14 A,c	6.34±0.19 B,b
T	51.6±015. B,a	6.88±0.17 B,a	7.63±0.08 A,b	6.63±0.22 B,b

See footnotes to Table 1; Tr = Treatment; CO = Control

Over time, the average values of b* were reduced except for a several treatments and the yellow intensity was reduced (Table 1 and 2).

One of the reasons to measure the b* parameter in *S. platensis* extract is due to the presence of a wide range of natural pigments such as chlorophyll, phycobiliprotein and biliprotein (e.g. c–phycocyanine and allophycocyanin) and in particular, carotenoid, phycoerythrin as red pigment and diatoxanthin [PINERO ESTRADA *et al,* 2001].

It seems that in the presence of high concentrations of *S. platensis* extract, the phycocyanine solubility reduced less and the b* value decreases [CAIR *et al*., 2000].

According to Table 3, by increasing storage time, the color intensity (C*) decreased, which was significantly higher in the 14th to 21st days.

On the 21st day, the highest C* value was related to the treatment containing 0.8 % *F. angulata* extract (H) which had not significant difference with treatments containing 0.9 (I) and 1 % (J) of this extract ($P>0.05$), but it's difference with other treatments and control was significant ($P<0.05$) (Table 3).

The mean values of C* in the treatments containing *F. angulata* extract were higher than spirulina extract, but the treatment containing the highest level of *S. platensis* extract (1 %) had the highest C* during the first three weeks, in comparison with treatments.

In the final week, the color intensity of treatments, especially *S. platensis* extract was reduced.

Therefore, along with the importance of the extract type used in the food formulation, storage time play an important role in color intensity.

In milk and dairy products such as yogurt, color intensity is associated with total solids (TS) and milk and yoghurt protein.

In this research, the values of $L^*=90$, $a^*=-2.20$ and $b^*=17$ were determined which the results of total color difference (ΔE^*) due to these three parameters are presented in Table 3.

The mean values of ΔE^* were higher in treatments containing spirulina extract on 14th and 21st day compared to the *F. angulata* extract.

On the 21st day, the highest ΔE^* was evaluated for the treatment containing 0.8 % *F. angulata* extract, which had not significant difference with 0.7, 0.9 and 1 % of the extracts.

In contrast, the lowest ΔE^* on the 21st day was related to the lowest level of *S. platentis* extract (0.1 %), which showed a significant difference with all treatments ($P<0.05$) (Table 3).

Barakat and collab. reported that there is a significant difference between the $L^*a^*b^*$ values and the color intensity in yogurts supplemented with pumpkin pulp [BARAKAT et al., 2017].

In the sensory evaluation of color, ΔE^* is a crucial parameter which $\Delta E^*=0$–0.5, $\Delta E^*=0.5$–1.5, $\Delta E^*=1.5$–3.0, $\Delta E^*=3.0$–6.0, $\Delta E^*=6.0$–12.0 and $\Delta E^*=>12.0$ indicates a little, small, notable, tangible, great and very clear difference respectively [LI, 1998].

The mean values of ΔE^* in the treatments containing spirulina extract were significantly higher than *F. angulata* and determined at the range of 6 to 12 in studied treatments. One of the reasons, is fat homogenization in the milk.

By decreasing the fat globule size, the light scattering increases, and leads to an increase the L^* and ΔE^* values [SORIA and VILLAMIEL, 2010].

The part of ΔE^* increase in treatments, can be due to co–pigmentation and preservation of extract pigments.

Also, decreasing redness and increasing yellowness and lightness, due to the pigment decomposition result in ΔE^* increase.

The results of present study are consistent with the findings of [GOUVEIA et al., 2007; 2008].

Culture and probiotic viability during storage. According to table 4, during the first week, the trend of variations in the viable counts of *L. bulgaricus* was significantly increased in extracts–containing yogurts, and increased 1 logarithmic cycle.

In the second week, there was a downward trend and continued until the 21st day.

At the end of the storage time, the minimum and maximum of *L. bulgaricus* count were observed in the treatment containing 0.5 % *F. angulata* extract and 1% *S. platensis* extract respectively.

In general, the *L. bulgaricus* count was significantly higher in treatments

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containing *S. platensis* extract than *F. angulata*, and there was a significant difference between this two groups of treatments (P<0.05).

Table 4.
Survival of starters bacteria and *L. acidophilus* (Logcfu.ml^{-1}) in probiotic yogurt samples during storage

Treatments	*L. bulgaricus* (Log cfu.ml^{-1})				*St. thermophiles* (Log cfu.ml^{-1})			
	1st day	7th day	14th day	21st day	1st day	7th day	14th day	21st day
Control	7.77±0.06 ^{B,abc}	8.66±0.17 ^{A,ab}	7.39±0.02 ^{C,e}	7.07±0.06 ^{D,de}	7.54±0.06 ^{A,bc}	7.34±0.02 ^{B,e}	7.33±0.11 ^{B,bcd}	7.12±0.02 ^{C,d}
A	7.19±0.02 ^{B,i}	7.83±0.03 ^{A,d}	7.11±0.10 ^{BC,gh}	7.07±0.06 ^{C,de}	7.10±0.03 ^{A,e}	7.15±0.03 ^{A,g}	7.13±0.03 ^{A,f}	7.11±0.03 ^{A,d}
B	7.18±0.03 ^{B,i}	7.65±0.05 ^{A,e}	7.03±0.06 ^{C,h}	7.07±0.05 ^{C,de}	7.12±0.02 ^{A,e}	7.13±0.02 ^{A,g}	7.07±0.06 ^{AB,f}	7.03±0.04 ^{B,e}
C	7.20±0.01 ^{B,i}	7.85±0.04 ^{A,d}	7.07±0.06 ^{C,h}	7.07±0.08 ^{C,de}	7.07±0.06 ^{A,e}	7.09±0.05 ^{A,g}	7.12±0.04 ^{A,f}	7.06±0.05 ^{A,de}
D	7.17±0.04 ^{B,i}	7.72±0.10 ^{A,de}	7.13±0.05 ^{B,gh}	7.07±0.06 ^{B,de}	7.09±0.08 ^{A,de}	7.07±0.09 ^{A,g}	7.07±0.05 ^{A,f}	7.07±0.06 ^{A,de}
E	7.20±0.02 ^{B,i}	8.09±0.08 ^{A,c}	7.18±0.03 ^{B,g}	7.00±0.01 ^{C,e}	7.14±0.04 ^{AB,de}	7.18±0.04 ^{A,f}	7.03±0.07 ^{B,f}	7.07±0.05 ^{B,de}
F	7.16±0.05 ^{B,i}	7.59±0.18 ^{A,e}	7.13±0.05 ^{B,gh}	7.11±0.03 ^{B,cd}	7.17±0.02 ^{B,d}	7.24±0.03 ^{A,f}	7.16±0.04 ^{B,ef}	7.12±0.03 ^{B,cd}
G	7.33±0.04 ^{B,gh}	8.58±0.08 ^{A,b}	7.19±0.10 ^{C,fg}	7.12±0.01 ^{C,cd}	7.18±0.03 ^{A,d}	7.19±0.03 ^{A,fg}	7.18±0.03 ^{A,ef}	7.12±0.02 ^{B,d}
H	7.38±0.03 ^{B,g}	8.58±0.06 ^{A,b}	7.30±0.05 ^{B,f}	7.12±0.02 ^{C,cd}	7.20±0.02 ^{A,d}	7.19±0.03 ^{A,fg}	7.18±0.03 ^{A,ef}	7.11±0.02 ^{B,d}
I	7/45±0.01 ^{B,f}	8.54±0.15 ^{A,ab}	7.20±0.09 ^{C,fg}	7.11±0.01 ^{C,d}	7.34±0.07 ^{A,c}	7.17±0.05 ^{BC,fg}	7.21±0.05 ^{B,e}	7.11±0.02 ^{C,d}
J	7.28±0.03 ^{B,h}	8.05±0.09 ^{A,c}	7.18±0.03 ^{C,g}	7.12±0.03 ^{C,cd}	7.14±0.04 ^{B,de}	7.13±0.04 ^{B,f}	7.22±0.03 ^{A,e}	7.11±0.02 ^{B,d}
K	7.23±0.02 ^{B,hi}	8.53±0.11 ^{A,ab}	7.15±0.06 ^{BC,gh}	7.11±0.02 ^{C,d}	7.39±0/03 ^{A,c}	7.44±0.06 ^{A,d}	7.31±0.01 ^{B,d}	7.12±0.02 ^{C,d}
L	7.62±0.01 ^{B,d}	8.65±0.10 ^{A,ab}	8.55±0.05 ^{A,c}	7.14±0.01 ^{C,cd}	7.45±0.05 ^{A,c}	7.45±0.06 ^{A,d}	7.30±0.02 ^{B,d}	7.14±0.01 ^{C,cd}
M	7.43±0.01 ^{B,f}	7.71±0.03 ^{A,e}	7.38±0.07 ^{B,ef}	7.15±0.01 ^{C,c}	7.70±0.05 ^{A,a}	7.35±0.05 ^{B,de}	7.26±0.04 ^{B,de}	7.14±0.02 ^{C,cd}
N	7.50±0.03 ^{B,e}	7.65±0.05 ^{A,e}	7.35±0.04 ^{C,ef}	7.17±0.02 ^{D,c}	7.65±0.05 ^{A,ab}	7.43±0.03 ^{B,d}	7.38±0.02 ^{B,c}	7.16±0.02 ^{C,c}
O	7.84±0.01 ^{C,a}	8.75±0.05 ^{A,a}	8.46±0.02 ^{B,d}	7.26±0.04 ^{D,b}	7.63±0.04 ^{A,ab}	7.45±0.06 ^{B,d}	7.49±0.02 ^{B,a}	7.23±0.02 ^{C,b}
P	7.81±0.04 ^{B,ab}	8.72±0.07 ^{A,a}	8.73±0.02 ^{A,b}	7.24±0.06 ^{C,bc}	7.59±0.06 ^{A,ab}	7.57±0.02 ^{A,c}	7.51±0.01 ^{B,a}	7.32±0.02 ^{C,a}
Q	7.71±0.01 ^{C,c}	8.82±0.03 ^{A,a}	8.69±0.06 ^{B,b}	7.30±0.05 ^{D,b}	7.68±0.04 ^{A,a}	7.72±0.03 ^{A,a}	7.44±0.01 ^{B,b}	7.20±0.02 ^{C,bc}
R	7.82±0.03 ^{B,ab}	8.78±0.10 ^{A,a}	8.80±0.05 ^{A,a}	7.31±0.07 ^{C,b}	7.55±0.05 ^{B,bc}	7.69±0.01 ^{A,a}	7.43±0.02 ^{C,b}	7.29±0.03 ^{D,ab}
S	7.69±0.04 ^{B,c}	8.71±0.14 ^{A,ab}	8.77±0.03 ^{A,ab}	7.47±0.07 ^{C,a}	7.45±0.05 ^{B,c}	7.64±0.03 ^{A,b}	7.40±0.03 ^{B,bc}	7.23±0.03 ^{C,b}
T	7.79±0.02 ^{B,b}	8.77±0.11 ^{A,ab}	8.82±0.03 ^{A,a}	7.55±0.05 ^{C,a}	7.47±0.03 ^{B,c}	7.65±0.05 ^{A,ab}	7.57±0.06 ^{A,a}	7.31±0.01 ^{C,a}

L. acidophilus (Log cfu.ml^{-1})				
Treatments	1st day	7th day	14th day	21st day
Control	7.49±0.01 ^{C,d}	8.23±0.04 ^{A,c}	8.11±0.01 ^{B,e}	7.00±0.00 ^{D,g}
A	7.41±0.02 ^{C,e}	8.21±0.02 ^{A,cd}	8.16±0.02 ^{B,d}	7.16±0.04 ^{D,f}
B	7.31±0.02 ^{B,fg}	8.14±0.01 ^{A,e}	8.16±0.02 ^{A,d}	7.16±0.04 ^{C,f}
C	7.34±0.01 ^{B,f}	8.22±0.07 ^{A,c}	8.12±0.03 ^{A,de}	7.14±0.04 ^{C,f}
D	7.28±0.02 ^{C,g}	8.20±0.02 ^{A,d}	8.14±0.01 ^{B,d}	7.13±0.04 ^{D,f}
E	7.22±0.02 ^{B,h}	8.10±0.00 ^{A,f}	8.10±0.01 ^{A,e}	7.07±0.06 ^{C,f}
F	7.21±0.02 ^{B,h}	8.12±0.02 ^{A,ef}	8.10±0.01 ^{A,e}	7.11±0.01 ^{C,f}
G	7.16±0.02 ^{B,i}	8.10±0.01 ^{A,f}	8.10±0.00 ^{A,e}	7.00±0.00 ^{C,g}
H	7.18±0.01 ^{B,hi}	8.02±0.03 ^{A,g}	8.00±0.00 ^{A,f}	7.10±0.02 ^{C,f}
I	7.11±0.01 ^{B,j}	8.07±0.06 ^{A,efg}	8.03±0.06 ^{A,ef}	7.11±0.01 ^{B,f}
J	7.12±0.02 ^{B,ij}	8.00±0.01 ^{A,g}	8.00±0.00 ^{A,f}	7.00±0.00 ^{C,g}
K	7.47±0.03 ^{B,d}	8.22±0.07 ^{A,c}	8.23±0.01 ^{A,c}	7.23±0.02 ^{C,e}
L	7.59±0.07 ^{B,cd}	8.29±0.02 ^{A,c}	8.28±0.03 ^{A,b}	7.25±0.06 ^{C,e}
M	7.54±0.06 ^{B,cd}	8.28±0.03 ^{A,c}	8.28±0.03 ^{A,b}	7.24±0.04 ^{C,e}
N	7.52±0.03 ^{B,d}	8.25±0.02 ^{A,c}	8.25±0.07 ^{A,bc}	7.33±0.01 ^{C,d}
O	7.65±0.05 ^{B,c}	8.24±0.06 ^{A,c}	8.26±0.05 ^{A,bc}	7.33±0.01 ^{C,d}
P	7.60±0.06 ^{B,cd}	8.29±0.04 ^{A,bc}	8.26±0.05 ^{A,bc}	7.37±0.03 ^{C,d}
Q	7.81±0.01 ^{C,a}	8.35±0.03 ^{A,b}	8.31±0.02 ^{A,b}	7.89±0.03 ^{B,a}
R	7.84±0.02 ^{B,a}	8.38±0.03 ^{A,ab}	8.35±0.04 ^{A,b}	7.45±0.03 ^{C,c}
S	7.77±0.01 ^{B,b}	8.34±0.03 ^{A,b}	8.31±0.03 ^{A,b}	7.65±0.05 ^{C,b}
T	7.84±0.03 ^{B,a}	8.44±0.03 ^{A,a}	8.42±0.02 ^{A,a}	7.51±0.04 ^{C,c}

See footnotes to Table 1.

There was a significant difference between control and treatments (P<0.05). More levels of two extracts, showed the highest number of bacteria on the final day. The number of *St. thermophilus* during the first week was significantly increased in most of the treatments. In the final week, the trend of bacteria changes in treatments and control were declined.

During storage, the viable counts of *St. thermophilus* in treatments containing microalgae extract was significantly higher than *F. angulata* extract (P<0.05) (Table 4). On the 21st day, the highest viable count belonged to the treatment containing 0.6 % *S. platensis* extract which had not significant difference in compare with treatment containing the highest level of this extract (1 %) (P>0.05). But it's difference with other treatments control was significant (P<0.05).

However, the survivability of starter cultures at the end of the refrigerated storage time was more than standardized number of bacteria. This result is consistent with report of Abu–Tarboush from 1996, but contradicts the results of study by Abdel Rahman and collab. [ABU–TARBOUSH, 1996, cited bv ABDEL RAHMAN et al., 2009].

The mean *L. bulgaricus* count more than *St. thermophilus* and the mean of starter cultures count in the treatments containing *S. platensis* extract was significantly higher than those containing *F. angulata* extract. *S. platensis* has been reported to significantly increase the viable cells of *Lactobacillus delbrueckii* subsp. *bulgaricus* and *St. thermophilus* in the yogurt [AKALIN et al., 2009].

In contrast, there are findings reported by researchers about reduction in *St. thermophilus* [VARGA *et al*., 2002] and *L. bulgaricus* [GUEIMONDE *et al*., 2004] in yoghurts enriched with *S. plantensis.*

According to Table 4, by increasing the storage time until the second week, the average viable count of L*. acidiphilus* showed a significant increase up to one logarithmic cycle. In contrast, in the third week, the viable count of *L. acidiphilus* decreased to one logarithmic cycle, but, the remaining numbers was higher than the standard viable count at the end of the storage period. Average number of *L. acidiphilus* during the storage time, was higher in treatment containing *S. platensis* extract than *F. angulata*, so, highest mean belonged to 0.7 % *S. platensis* extract at the end of storage period.

Higher concentrations of *S. platensis* extract and lower concentrations of *F. angulanta* extract, have a more stimulating effect on growth, activity and proliferation of *L. acidophilus* as a probiotic in yogurt. According to researches, phenolic compounds in the *F. angulanta* extract, by changing the microbial population, increase the beneficial bacteria such as bifidobacteria and lactobacillus [HAMMER *et al*., 1999].

Since probiotic viability is crucial to confer a health benefit (recommended daily dosage of 10^7–10^8 viable cells), efforts are being made to improve or sustain their viability during food processing and storage of food products until their consumption [DE PRISCO and MAURIELLO, 2016]. In the first two weeks, the average number of *L. acidophilus* had a significant increase, but after that, decreased. In general, by increasing the concentrations of *S. platensis* extract, *L. acidophilus* count increased.

Increasing the *S. platensis* concentration and reducing the acid production and higher pH can result in the high growth of *L. acidophilus* at higher concentrations of this microalgae.

In the present study, with respect to optimal survivability of *L. acidophilus* at the end of the refrigerated storage time and more than minimum number of standards, the product is considered to be functional food. The ability to use *L. acidophilus* from galactose and glucose from lactose hydrolysis could be another reason for increasing the probiotics count in the early weeks.

The fermentation progress by probiotics in yogurt, increases the resistance of these bacteria to the harsh conditions and viable bacteria count in the product during cold storage, which it's reason is increased adaptation of bacteria to environmental conditions. This aspect can also be reason for high viable cell of *L. acidophilus* in probiotic yogurt during storage period.

When cells are placed in a low pH environment, they need to consume high energy to maintain their intracellular pH, so, other main functions of the cell are affected by ATP deficiency stress and the cells cannot survive. Therefore, the use of extracts prevents the ATP deficiency in the cell and increase the probiotics growth [PONCELET *et al*., 2007].

Sensory assessment. The sensory evaluation of samples showed that the concentration of *S. platensis* and *F. angulata* extract had significant effects on the sensory characteristics. Based on Figure 1, the color scores of all treatments were reduced over storage time. During this period, the scores of treatments containing *S. platensis* extract were significantly higher than *F. angulata* extract ($P<0.05$). The control sample showed a higher color score than treatments during storage. Also, between all the treatments, the highest color score was related to treatment containing 0.4 % *S. platensis* extract. Similarly, Madukwe and collab. reported that the color of control sample had more score in comparsion with the yogurt enriched with *Moringa oleifera* [MADUKWE et al., 2013, BUTU, et al., 2014a, PETRACHE, et al., 2014].

In contrast, Ghiasi and collab. stated that yogurt samples containing different levels of strawberry extract had more color scores in comparsion with to control yoghurt [GHIASI et al., 2012]. Improving the color of yogurt fortified with herbal extracts is reported by Kim and collab. [KIM et al., 2009, BUTU, et al., 2014c, BUTNARIU, et al., 2016].

In contrast, in the study of Nguyen and Hwang, the color of the yogurt enriched with 3 % *Aronia melanocarpa* extract was not affected [NGUYEN and HWANG, 2016].

By increasing the storage time, the flavor scores of the treatments were declined, which was significantly higher during the 14th to the 21st days.

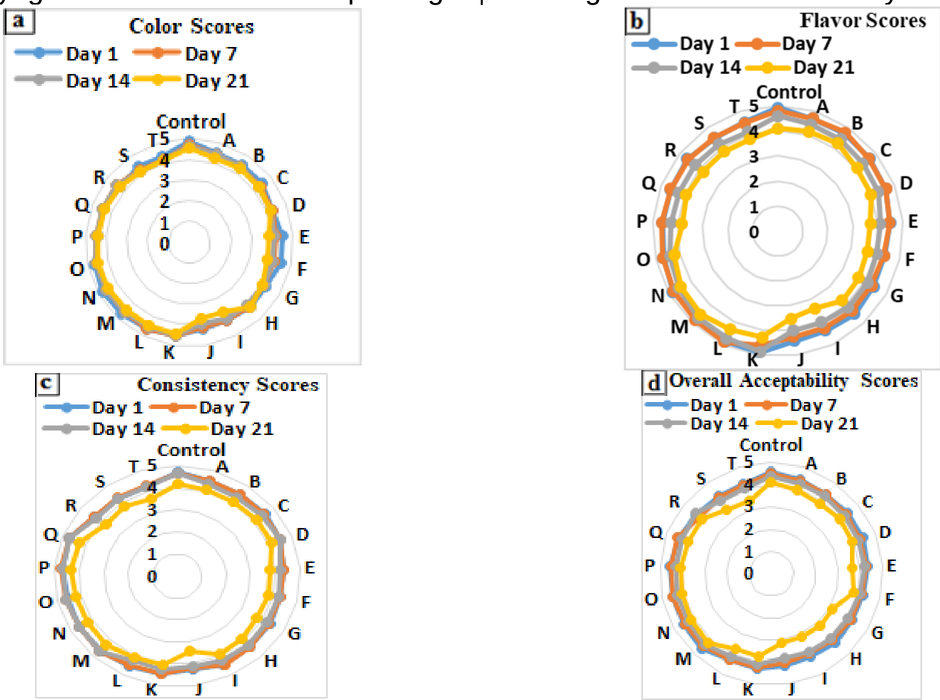

Figure 1. The changes of sensory attributes of probiotic yogurt samples during storage. Color (a); flavor (b); consistency (c); overall acceptability (d).

In general, the mean of flavor scores in treatments containing *S. platensis* extract was higher than *F. angulata*. During the last three weeks, the flavor scores of the treatments were significantly more than the control ($P<0.05$). Similarly, in a study by Mortazavian and collab., using two concentrations of 0.5 % and 1 % of *S . platensis* in yogurt, it was concluded that the sample containing 1% microalgae had an unpleasant flavor [MORTAZAVIAN et al., 2012].

The flavor of yogurt is different from other acidified milk products and includes the acetic acid and acetaldehyde [KOWALSKI et al., 2000]. The reduction of flavor scores is probably due to the accumulation of fermentative metabolites of probiotics such as acetic acid and hydrogen peroxide (H_2O_2) and increase the proteolysis during fermentation in treatments containing high levels of the extracts due to their stimulatory effects [BEHESHTIPOUR et al., 2013; DONKOR et al., 2007].

The greatest decrease was observed during the last week. Along with these results, Hashim reported that flavoring agents such as herbal extracts have a significant effect on final flavor of yogurt [HASHIM, 2001, BUTU, et al., 2014b, RODINO, et al., 2014, IVANOV, 2017, STOLERU et al., 2019].

By increasing the storage time, gradually, the consistency scores of treatments were also reduced. There was a significant difference between treatments and control during storage

(P<0.05). During the first two weeks, the mean scores of consistencies was increased and then, decreased.

Treatments containing 0.6% *S. platensis* extract showed the highest consistency score and its difference with the control and all treatments was significant (P<0.05).

In general, the highest consistency score was related to treatments containing 0.3 to 0.7 % *S. platensis* and the levels higher than 0.7 % of two extracts showed lower scores. In general, the scores of treatments containing *S. platensis* extract were significantly higher than of *F. angulata* extract. Treatments containing different levels of *S. platensis* extract had a higher mean consistency than *F. angulata* extract during storage.

These results are consistent with the Ayar and Gurlin and Gheisari and collab. in quality assessment of yogurt fortified with cherry, strawberry [AYAR and GURLIN, 2014, GHEISARI et al., 2016, BUTNARIU, 2014], *Cinnamomum verum* and *Mentha longifolia* extract and probiotic ice cream respectively.

In contrast, it contradicts the results of Kamruzzaman and collab. [KAMRUZZAMAN et al., 2002, IVANOV and JAVOROVA, 2017].

In the first two weeks, the control had the highest overall acceptability score, while treatment containing 0.3 % *S. platensis* extract had the highest score in the last two weeks. The lowest scores were related to treatments containing high levels of *F. angulata* extract (0.6–1 %), which was significantly different from other treatments and control (P<0.05) (Figure 1). Over time, the overall acceptability of samples was decreased.

These results are consistent with the Rozan and collab. studying the quality properties of yogurt enriched with *Daucus carota* and *Hibiscus sabdariffa* extract during cold storage [ROZAN et al., 2017].

There are reports of increasing the overall acceptability of yogurt samples containing herbal plant and fruits extracts by Ozturk and Akyuz or in 2002 Ayar [OZTURK and AKYUZ 1995, AYAR 2002, KURZBAUM, *et al.*, 2019, CARUSO *et al.*, 2019]. The scores of low levels of *S. platensis* extract were significantly higher than high levels of this extract and various levels of *F. angulata* extract (p<0.05). Amirdivani and Baba reported that there was a significant difference in overall acceptance between yogurts containing green tea with a control sample [AMIRDIVANI and BABA, 2013, BUTU, *et al.,* 2014b, IANCULOV, *et al.,* 2004]. It can be concluded that the treatments containing low levels of *S. platensis* extract in comparison with other treatments and the control obtained a higher score for overall acceptance.

Conclusions

The herbal extract and microalgae were shown to alter the quality of the yogurt when used at different levels.

This study demonstrated the effect of adding *Spirulina platensis* and *Ferulago angulata* extracts into a bio–yogurt.

Results showed that the use of *S. platensis* and *F. angulata* extracts improves color parameters, the viability of starter cultures and *L. acidophilus* as a probiotic and the sensory characteristics of bio– yogurt during cold storage.

Although, spirulina– containing yogurts had better results than *F.angulata* extract and control sample. Due to satisfaction of panelists and high survivability of *L. acidophilus* and yogurt starters, can be called yogurt samples as a functional food.

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