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THE EFFECT OF FRUITS TO THE CHARACTERISTICS OF FRUIT YOGURT

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This study investigated the effects of yoghurt on the chemical (titratable acidity and pH), microbiological (*L. delbrueckii subsp. bulgaricus, S. thermophilus*, mould and yeast counts) and sensory properties of yoghurt that was prepared with fruit (strawberry, apricot, banana, peach) (at a ratio of 20%) during the incubation (checked at 0, 90 and 210 minutes) and storage (checked at 1, 3 and 7 days) periods. When compared to plain yoghurt, the values of the traits analysed during this study were found to be significantly different about both the different fruits and the time intervals. The average acidity counts at the end of the storage period were found to be highest in strawberry yoghurt (0.665 LA), while apricot yoghurt was found to have the lowest pH rate (-0.390 pH). The average count of *L. delbrueckii subsp. bulgaricus* at the end of the storage period was found to be highest in strawberry yoghurt (2.983 $\log_{10}$ cfu/ml), while peach yoghurt was found to have the lowest rate of *L. delbrueckii subsp. bulgaricus* (1.568 $\log_{10}$ cfu/ml). The highest rate of *S. thermophilus* was found in peach yoghurt (2.648 $\log_{10}$ cfu/ml), while the lowest rate was in banana yoghurt (1.301 $\log_{10}$ cfu/ml). The highest yeast count was found in plain yoghurt (3.264 $\log_{10}$ cfu/ml) and the lowest mould count was in banana yoghurt (2.246 $\log_{10}$ cfu/ml). Sensory analysis of the fruit yoghurts revealed that, while the type of fruit had no statistically significant effect on the sensory characteristics, the most popular were banana and strawberry yoghurts. The results confirmed that the varieties of added fruit affected the pH and acidity rates of the yoghurt and influenced the development of microflora, so we concluded that these factors could consequently affect the product's shelf life.

Keywords: Fruit yoghurt, lactic acid bacteria, microflora, chemical, sensory analysis

INTRODUCTION

Yoghurt, which is usually made from cow milk, is formed by the coagulation of milk proteins by lactic acid that forms because of the growth of *Lactobacillus delbrueckii subsp. bulgaricus* and *Streptococcus thermophilus* (Tamine and Robinson, 2007). Since it contains a low rate of lactose, it can be easily digested, even by humans who have lactose intolerance. Yoghurt is a food that is rich in protein, unsaturated fatty acids, calcium, phosphorus, magnesium, zinc and Vitamin B (Gilliland, 1989; McKinley, 2005). Because of its probiotic characteristics (Lourens-Hattingh and Viljoen, 2001), yoghurt boosts the immune system and provides resistance to infections in addition to regulating intestinal flora (Hove *et al.*, 1999; Plessas *et al.*, 2012). About the rate of consumption, yoghurt ranks third among milk products, following cheese and butter. There is no statistical information about what percentage of total yoghurt consumption consists of fruit yoghurt. However, in recent years there has been more production of yoghurts containing various additives in order to increase consumption and to offer different alternatives. Many additives are added to yoghurt to improve its flavour, such as various fruits, some vegetables, coffee, oats, hazelnuts, almonds, and chocolate. Since fruit additives are more popular, the consumption of fruit yoghurts has increased in recent years (Bae *et al.*, 2000; Varga, 2006; Thomson *et al.*, 2007; Jaziri *et al.*, 2009; Mohamed *et al.*, 2015; Roy *et al.*, 2015). The sensory qualities of yoghurt can change due to the addition of fruit (Najgebauer-Lejko, 2014). In addition, pectin and sugar from the fruit mixes with the yoghurt, causing an increase in its consistency and viscosity, which improves the sensation in the mouth. Pectin is reversely absorbed by casein and increases steric repulsion, which reduces aggregation (Nongonierma *et al*., 2007).

Since ingredients added to yoghurt during production can affect the yoghurt microflora, they may also have a positive or negative effect on the quality of the yoghurt. There is very limited research about the technological, physicochemical, organoleptic, and microbiological properties of yoghurts that have had fruit added. The aim of this study was to investigate the effects that adding banana, apricot, peach, and strawberry has during incubation and storage, and to identify the changes in microbiological, chemical and sensory characteristics.

MATERIALS AND METHODS

The cow milk that was used to produce the fruit yoghurts in this study were procured from the Veterinary Faculty Farm at Kafkas University. Chemical analysis of the milk revealed that the dry matter rate was 12.4% and the milk fat was 3.4%. The milk was exposed to 5 minutes of pasteurization at 90°C.

Then 3% yoghurt starter culture yeast (Chr. Hansen's YC-180) was heated to 45°C and added. The inoculated milk was then divided into 5 groups to prepare banana, strawberry, apricot, peach, and plain yoghurt. The milk was poured into sterile 200 ml cups containing 20% pulp, and the preparations were left to incubate at 42°C until they reached pH 4.6 (approximately 3.5 hours). After incubation, the yoghurts were kept at 4°C while performing the analyses (Aksu and Nas, 1996).

The chemical analyses were performed at the start (0 minutes), middle (90 minutes) and end (210 minutes) of the incubation and at 1, 3 and 7 days of storage. Acidity (LA), titratable acidity and pH measurements were performed using a pH-meter (Hanna HI 8521) (Meyer *et al.*, 2007).

The microbiological analyses were performed at the start (0 min), middle (90 min) and end (210 min) of the incubation and at 1, 3 and 7 days of storage. The number of *L. delbrueckii subsp. bulgaricus* was determined using MRS agar (Oxoid CM 361) (IDF, 1983), while the number of *S. thermophilus* was determined using M17 agar (Oxoid CM785) (Elmer and James 2001, Dave and Shah 1996). In addition, the mould and yeast counts were determined using Potato Dextrose Agar (Oxoid CM 139) in accordance with the recommendations.

Sensory analyses were performed the day after the fruit yoghurts were produced. For the sensory analyses, the fruit yoghurts were evaluated by 28 panellists using a 5-point hedonic scale (1-worst, 5-very good) on the 2nd day after production in terms of appearance, smell, flavour, and consistency (Metin, 2006; Clark *et al.*, 2008).

All the data obtained from chemical, microbiological and sensory analyses were analysed using ANOVA procedures using SPSS (Statistical Software 10.0 for Windows, SPSS Inc., USA). Significant differences between the traits were determined by using the Tukey comparison test at $p<0.05$ (Pripp, 2012). All the analyses were repeated in duplicate.

RESULTS

The results of the chemical (acidity and pH) and microbiological (*L. delbrueckii subsp. bulgaricus*, *S. thermophilus* and mould and yeast) analyses of fruit yoghurts during the incubation and storage periods have been presented in Table 1. The results of the sensory analyses of the fruit yoghurts performed by the panellists have been presented in

Table 1. Mean values of chemical and microbiological traits measured during the incubation and storage periods (log_{10} cfu/ml ±Std error).

	Yoghurt type	0 min	90 min	210 min	A	1 day	3 days	7 days	B
Plain yoghurt	Acidity (LA)	0.706±0.04	0.756±0.03	0.812±0.03	0.106±0.03	0.807±0.03	1.039±0.04	0.929±0.07	0.117±0.05
	pH	4.532±0.01	4.372±0.01	4.182±0.10	-0.350±0.05	4.352±0.08	4.202±0.13	4.122±0.12	0.060±0.10
	*L.d.s.b**	4.569±0.21	5.877±0.16	7.037±0.33	3.392±0.23	7.241±0.15	7.443±0.03	7.201±0.10	2.215±0.11
	*S.t.***	4.305±0.26	5.799±0.25	5.899±1.47	3.202±0.81	5.691±1.45	5.379±0.16	5.783±0.44	2.064±0.64
	Mould	2.222±0.18	2.192±0.15	2.002±0.00	-2.342±0.09	2.002±0.00	2.002±0.00	2.002±0.00	0.000±0.00
	Yeast	4.306±0.29	4.909±0.04	6.112±0.22	3.257±0.24	5.286±0.25	7.534±0.07	7.947±0.16	3.264±0.16
Strawberry yoghurt	Acidity (LA)	0.593±0.00	0.669±0.01	0.805±0.03	0.212±0.01	0.944±0.03	1.187±0.13	1.470±0.23	0.665±0.13
	pH	4.530±0.02	4.390±0.01	4.026±0.02	-0.504±0.02	3.872±0.05	4.040±0.06	3.950±0.03	-0.076±0.04
	*L.d.s.b**	4.435±0.17	4.933±0.37	5.806±0.33	3.137±0.25	6.607±0.16	7.081±0.13	6.768±0.22	2.983±0.19
	*S.t.***	4.804±0.20	5.760±0.32	6.109±0.08	3.116±0.14	6.408±0.20	6.448±0.08	6.203±0.36	1.973±0.26
	Mould	2.058±0.04	1.998±0.00	1.998±0.00	-1.778±0.02	1.998±0.00	1.998±0.00	1.998±0.00	0.000±0.00
	Yeast	3.533±0.29	4.051±0.31	4.763±0.07	3.090±0.17	5.612±0.07	6.298±0.26	5.016±0.59	2.403±0.32
Peach yoghurt	Acidity (LA)	0.536±0.01	0.580±0.00	0.666±0.01	0.130±0.01	0.853±0.00	0.890±0.02	0.868±0.03	0.202±0.01
	pH	4.510±0.02	4.380±0.01	4.060±0.06	-0.450±0.04	4.380±0.07	3.920±0.04	4.010±0.05	-0.050±0.06
	*L.d.s.b**	4.196±0.06	5.502±0.43	7.208±0.12	3.479±0.10	7.482±0.09	7.308±0.11	7.245±0.06	1.568±0.07
	*S.t.***	5.204±0.14	5.445±0.08	5.876±0.13	2.827±0.13	6.213±0.21	6.496±0.14	6.321±0.15	2.648±0.18
	Mould	2.058±0.02	1.998±0.00	1.998±0.00	-1.778±0.01	1.998±0.00	1.998±0.00	1.998±0.00	0.000±0.00
	Yeast	3.597±0.06	4.326±0.15	5.263±0.21	3.222±0.14	6.298±0.24	7.385±0.25	7.726±0.13	3.391±0.17
Apricot yoghurt	Acidity (LA)	0.540±0.02	0.577±0.01	0.692±0.02	0.152±0.02	0.867±0.01	1.063±0.04	1.121±0.08	0.429±0.05
	pH	4.520±0.01	4.520±0.01	4.370±0.01	-0.150±0.01	4.400±0.00	3.800±0.00	3.980±0.01	-0.390±0.01
	*L.d.s.b**	4.530±0.18	6.280±0.12	7.124±0.20	3.414±0.19	7.768±0.19	7.455±0.08	7.809±0.21	2.836±0.20
	*S.t.***	5.048±0.21	6.678±0.09	7.384±0.21	3.368±0.21	7.204±0.32	7.064±0.16	7.492±0.35	2.033±0.34
	Mould	2.373±0.16	2.147±0.00	2.002±0.22	-2.569±0.22	3.330±0.56	2.002±0.00	2.002±0.00	0.000±0.00
	Yeast	3.330±0.13	3.199±0.36	4.284±0.53	2.980±0.53	5.512±0.46	6.551±0.46	6.425±0.47	3.331±0.47
Banana yoghurt	Acidity (LA)	0.582±0.00	0.611±0.01	0.686±0.01	0.104±0.01	0.829±0.01	1.000±0.02	1.169±0.02	0.483±0.02
	pH	4.516±0.00	4.406±0.00	4.356±0.00	-0.160±0.00	4.326±0.03	4.406±0.00	3.896±0.03	-0.460±0.03
	*L.d.s.b**	4.459±0.32	5.818±0.14	6.316±0.27	3.269±0.30	6.748±0.36	7.129±0.08	7.181±0.18	2.937±0.27
	*S.t.***	4.731±0.37	5.655±0.21	5.965±0.26	3.091±0.31	6.112±0.29	5.645±0.32	5.985±1.48	1.301±1.35
	Mould	2.229±0.05	2.208±0.15	2.178±0.03	-1.708±0.04	3.274±0.14	2.640±0.28	2.002±0.00	-2.246±0.07
	Yeast	2.913±0.15	4.351±0.15	4.818±0.47	3.28±0.30	4.608±0.41	7.091±0.32	5.775±0.44	2.981±0.42

A: Difference between the beginning and end of incubation, B: Difference between the beginning and end of storage
L.d.s.b: L. delbrueckii subsp. bulgaricus, S.t.**: S. thermophilus*

Table 2. Analysis of fruit yoghurts by panellists and total scores for characteristics.

Points	Strawberry yoghurt				Banana yoghurt				Peach yoghurt				Apricot yoghurt			
	App	Con	Sme	Flav	App	Con	Sme	Flav	App	Con	Sme	Flav	App	Con	Sme	Flav
5	%10.7 (3)	%10.7 (3)	%21.4 (6)	%17.8 (5)	%28.5 (8)	%25.0 (7)	%46.4 (13)	%46.4 (13)	%7.1 (2)	%7.1 (2)	%7.1 (2)	%10.7 (3)	%7.1 (2)	%17.8 (5)	%21.4 (6)	%10.7 (3)
4	%25.0 (7)	%28.5 (8)	%46.4 (13)	%60.7 (17)	%28.5 (8)	%46.4 (13)	%28.5 (8)	%25.0 (7)	%28.5 (8)	%32.1 (9)	%32.1 (9)	%50.0 (14)	%32.1 (9)	%21.4 (6)	%32.1 (9)	%46.4 (13)
3	%46.4 (13)	%53.5 (15)	%25.0 (7)	%7.1 (2)	%21.4 (6)	%17.8 (5)	%17.8 (5)	%21.4 (6)	%30.5 (10)	%28.5 (8)	%30.5 (10)	%21.4 (6)	%32.1 (9)	%30.5 (10)	%17.8 (5)	%30.5 (10)
2	%10.7 (3)	%3.5 (1)	%7.1 (2)	%10.7 (3)	%14.2 (4)	%7.1 (2)	%3.5 (1)	%3.5 (1)	%17.8 (5)	%17.8 (5)	%21.4 (6)	%3.5 (1)	%21.4 (6)	%7.1 (2)	%21.4 (6)	%3.5 (1)
1	%7.1 (2)	%3.5 (1)	%0.0 (0)	%3.5 (1)	%7.1 (2)	%3.5 (1)	%3.5 (1)	%3.5 (1)	%10.7 (3)	%14.2 (4)	%3.5 (1)	%14.2 (4)	%7.1 (2)	%17.8 (5)	%7.1 (2)	%3.5 (1)
Points	90	95	102	106	100	107	114	115	85	84	89	95	87	88	95	100

App: Appearance, Con: Consistence, Sme: Smell, Flav: Flavour

Table 3. Statistical differences between acidity, pH, *L. delbrueckii subsp. bulgaricus, S. thermophilus*, mould, and yeast rates of different types of yoghurt (p<0.05).

	0 min	90 min	210 min	1 day	3 days	7 days
Acidity	Ba Aa	Cab BCa Aa ABab	Cab AbCab Bcab Ab ABb	Bc ABab Ab Ac	Abc Bbc Ac ABc ABd	Aab Bc Ac ABc ABe
pH	Ab Ad	Aab Ad Ab Ac	ABab Abc Ab Cd BCd	Bab Aab Bb Bc	BCa ABc ABa Aa Ca	ABab Aa ABa Ab
*L.d.s.b.**	Aa Aa	ABb Aab Bb	Ac Bbc Bc ABb	ABc Acd Bc Bb	Ac Acd	ABc Acd Bc
*S.t.***	Aa Aa	ABab Bb Aab Aa	Ab Abc Bb Aa	Aab ABb ABc Bb ABa	Aab BCb Cc Cb ABa	Aab Ac Ab Aa
Mould	Aa Aab	Aa Aab	Aa Aab	Aa Ab Bb Bc	Aa Bb	Aa Aa
Yeast	Ba ABa Aa	Bab ABab Aa	Bc ABabc ABb Aab	ABbc Ab ABcd Bc	Ad Ac	Bd Abc Abcd ABc

: Plain yoghurt, : Strawberry yoghurt, : Peach Yoghurt, : Apricot yoghurt, : Banana yoghurt
ABCD: Differences between the types of fruit, abcde: Differences between time intervals.
L.d.s.b.: L. delbrueckii subsp. bulgaricus, S.t.** S. thermophilus*

Chemical analysis revealed that acidity (LA) values for the incubation start-end point and storage period were 0.70-0.81/0.929 for plain yoghurt, 0.59-0.80/1.47 for strawberry yoghurt, 0.53-0.66/0.86 for peach yoghurt, 0.54-0.69/1.12 for apricot yoghurt, and 0.58-0.68/1.16 for banana yoghurt. pH values were found 4.53-4.18/4.12 for plain yoghurt, 4.43-4.02/3.95 for strawberry yoghurt, 4.51-4.06/4.01 for peach yoghurt, 4.52-4.37/3.98 for apricot yoghurt, and 4.51-4.35/3.89 for banana yoghurt.

Microbiological analysis of the rate of microflora revealed that the rates of *L. delbrueckii subsp. bulgaricus* ($\log_{10}$ cfu/ml) at the incubation start-end point and storage period were 4.56-7.03/7.20 for plain yoghurt, 4.43-5.80/6.76 for strawberry yoghurt, 4.19-7.20/7.24 for peach yoghurt, 4.53-7.12/7.80 for apricot yoghurt, and 4.45-6.31/7.18 for banana yoghurt. *S. thermophilus* rates ($\log_{10}$ cfu/ml) were found to be 4.30-5.89/5.78 for plain yoghurt, 4.80-6.10/6.20 for strawberry yoghurt, 5.20-5.87/6.32 for peach yoghurt, 5.04-7.38/7.49 for apricot yoghurt, and 4.73-5.96/5.98 for banana yoghurt. The mould and yeast growth rates ($\log_{10}$ cfu/ml) were found to be 2.22-2.00/2.00 for plain yoghurt, 2.05-1.99/1.99 for strawberry yoghurt, 1.99-1.99/1.99 for peach yoghurt, 2.37-2.00/2.00 for apricot yoghurt, and 2.22-2.17/2.00 for banana yoghurt. The yeast rates ($\log_{10}$ cfu/ml) were found to be 4.30-6.11/7.94 for plain yoghurt, 3.53-4.76/6.29 for strawberry yoghurt, 3.59-5.26/7.72 for peach yoghurt, 3.33-4.28/6.42 for apricot yoghurt, and 2.91-4.81/7.09 for banana yoghurt.

In sensory analyses of the yoghurts (Table 2), the appearance, consistency, smell, and flavour scores of the samples were found to be 90/95/102/106 for strawberry yoghurt, 100/107/114/115 for banana yoghurt, 85/84/89/95 for peach yoghurt, and 87/88/95/100 for apricot yoghurt. In quality assessments, the strawberry, banana, peach and apricot yoghurts received 90/100/85/87 points for appearance, 95/107/84/88 points for consistency, 102/114/89/95 points for smell and 106/115/95/100 points for flavour, respectively. These values were found to be statistically significant (p<0.05). Differences were observed both between the types of fruit and between the time intervals (Table 3).

DISCUSSION

This study on the effects of different fruits during the incubation phase and storage period of yoghurt production revealed that the acidity, pH values and bacteria in the microflora (*L. delbrueckii subsp. bulgaricus*, *S. thermophilus*, mould, and yeast) progressed at very different rates (Fig. 1). The differences were found to be statistically significant ($p<0.05$). Differences were observed both between the types of fruit and between the time intervals (Table 3). In chemical analyses of the fruit yoghurts, the lowest rate of acidity at the beginning of incubation was observed in peach yoghurt at 0.536 LA, while the highest rate was observed in plain yoghurt at 0.706 LA ($p=0.00$). The highest rate of change throughout the incubation phase was observed in strawberry yoghurt at 35.8% (Table 4), while the lowest rate of change was observed in plain yoghurt at 15.0%. In other words, the initial acidity of the yoghurts during incubation was observed to be at lower rates in fruit yoghurts, and these lower rates continued throughout the incubation. The highest rate of change during the storage period was also observed in strawberry yoghurt (147.9%) ($p=0.00$), and the lowest rate of acidity was observed in plain yoghurt (0.929). In other words, the rate of acidity decrease in fruit yoghurts was at least 2-3 times higher than in plain yoghurt (31.6%, 61.9% and 147.9%). Since the acidity change is affected by the sugar contained in fruit, the rate of the effect of different types of fruit was also examined. This situation is thought to be caused by differences between the sugar rates of the types of fruit.

When Celik *et al.* (2006) prepared yoghurt with cornelian cherry and Bochyeva *et al.* (2011) prepared fruit yoghurt using blueberry and blackberry juices, they both found that there were statistically significant ($p<0.05$) differences between the acidity rates and that the initial acidity rates were

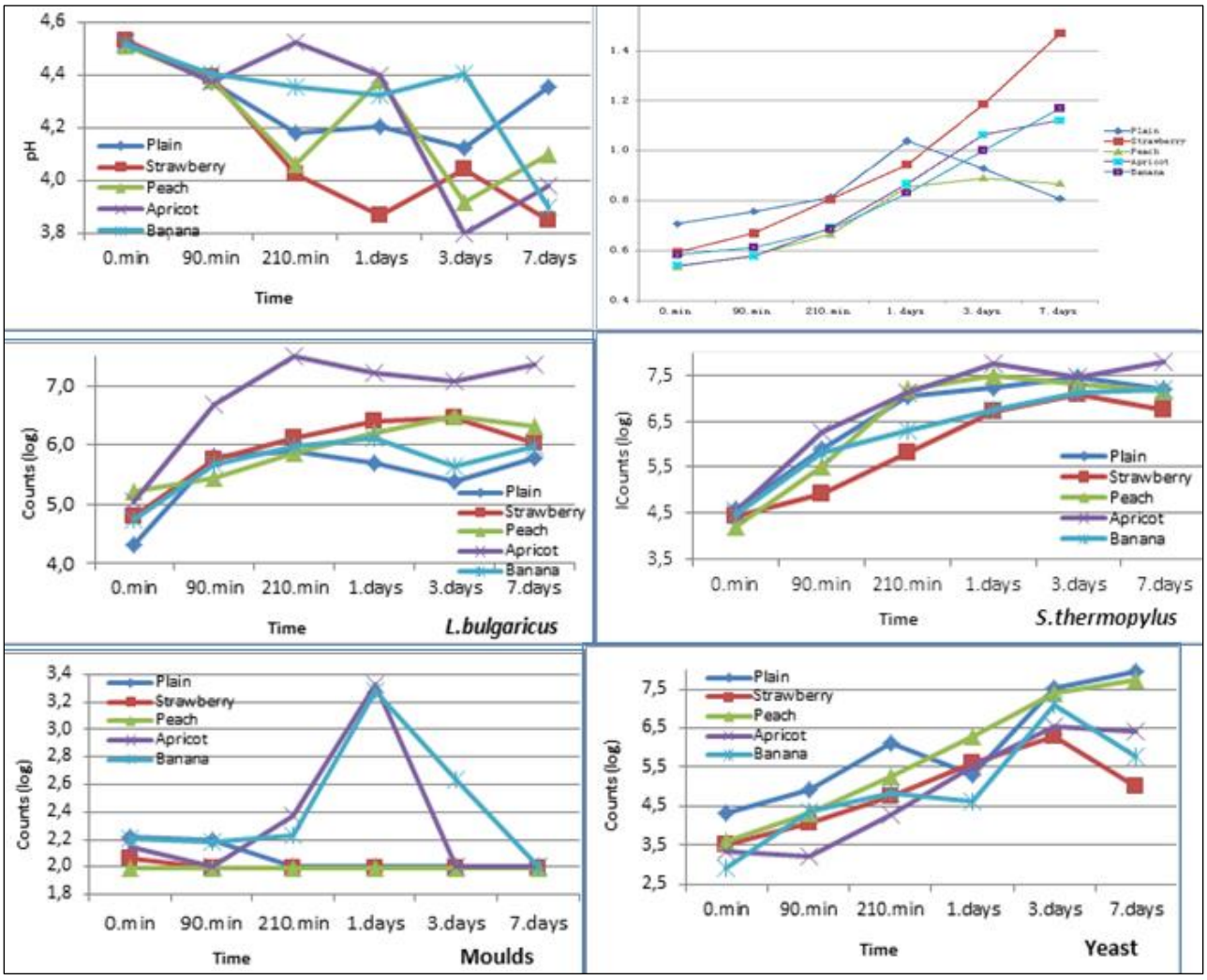

Figure 1. Rates of acidity, pH, *L. delbrueckii subsp. bulgaricus, S. thermophilus*, mould and yeasts in fruit yoghurts during incubation and storage.

also higher in fruit yoghurts than in plain yoghurts. They determined that the reason for these changes may be the use of fruit juice rather than the fruit itself. A study by Karagozlu, (1997) found the initial acidity rates of peach and strawberry yoghurts (0.59) to be close to our values. While the initial acidity rates of fruit yoghurts were found to vary between 0.53 and 0.59 in our study, the initial acidity rate of plain yoghurt was found to be lower. Contrary to our findings and the studies mentioned above, Yousef *et al.* (2013) found the initial acidity rate of yoghurt prepared with strawberry to be 1.27, which is close to the value we obtained on the 6th day.

About the changes in pH values, a comparison was made among the fruit yoghurts, which have very similar initial pH values during the incubation phase (4.51-4.53). Of these yoghurts, the highest rate of decrease was found in strawberry yoghurt with an 11.1% decrease down to 4.026, while the lowest rate of change was found in apricot yoghurt with a 3.3% decrease down to 4.370. The correlation between the decreases in pH rates and other traits of the yoghurts was observed only with *S. thermophilus*. During the storage period, the highest rate of pH decrease among the fruit yoghurts was observed in banana yoghurt with a 13.7% decrease down to pH 3.89, while the lowest rate of change was observed in plain yoghurt with a 9.1% decrease down to pH 4.12. At the end of storage period, the decrease in pH of all the fruit yoghurts was observed to be greater than it was in plain yoghurt. In a study done on yoghurt made with mulberry molasses, Celik and Bakırcı, (2003) reported that pH rates (4.01) were much higher than those of plain yoghurts, while Yousef *et al*. (2013), in complete contrast, reported that strawberry yoghurt had a lower pH value than plain yoghurt.

Microbiological analysis on the rate of increase in the count of *L. delbrueckii subsp. bulgaricus* during the incubation period indicated that the highest increase occurred in peach yoghurt at an increase of 71.8% (Table 4), while the lowest increase occurred in strawberry yoghurt at 30.9% (p=0.28). During the storage period, statistically significant differences were found for all the yoghurts in terms of the count of *L. delbrueckii subsp. bulgaricus* (p=0.00), but the highest rate of increase was found in apricot fruit with a 72.4% increase and the lowest rate of increase was obtained in strawberry yoghurt with a 52.6% increase.

About the rates of *S. thermophilus* during the incubation period, the highest rate of increase was observed in apricot yoghurt (46.3%) and the lowest rate of increase was observed in peach yoghurt (12.9%). During the storage period, the highest rate of increase was observed in apricot yoghurt (48.4%) and the lowest rate of increase was observed in peach yoghurt (21.5%), but the lowest value was found in plain yoghurt (5.783). Higher rates of acidity caused a higher count of *L. bulgaricus* and *S. thermophilus* in fruit yoghurts. In this regard, although the count of *S. thermophilus* was higher in proportion to plain yoghurt, all the fruit yoghurts except for banana yoghurt showed a lower rate of overall increase (21.5%, 48.4% and 52.6%).

Varga (2006) reported that the yoghurt he made by adding 5% honey did not exhibit significant changes in the development of lactic acid, pH or classic microorganisms. Similarly, Jaziri *et al.* (2008) reported no significant change in yoghurt they prepared by adding green and black tea, and Tarakci (2010) found similar results for yoghurt prepared with kiwi marmalade. Patrick and Shetty (2005) reported that phenolic antioxidants didn't affect the microflora in fermented milk products. To the contrary, in our study that was carried out with various types of fruit, the growth of *L. delbrueckii subsp. bulgaricus* and the formation of lactic acid in fruit yoghurts during the incubation process didn't remain low and even increased in peach and apricot yoghurts (71.8% and 57.3%), which exceeded the plain yoghurt (54.0%). The growth of *S. thermophilus* was observed to be higher in almost all the fruit yoghurts. When the yoghurt was stored at 4°C for 7 days, the effects of the types of fruit on the microflora were found to be as follows: the increase in the count of *L. delbrueckii subsp. bulgaricus* was higher in peach and apricot yoghurts (72.7% and 72.4%) than in plain yoghurts (34.3%), while the increase in the count of *S. thermophilus* was higher than plain yoghurt only for apricot yoghurt (48.4%). However, the numeric values were found to be higher than for plain yoghurt. During both periods, both *L. delbrueckii subsp. bulgaricus* and *S. thermophilus* were observed to develop more in apricot yoghurt than in plain yoghurt. During the storage period, except for the apricot yoghurt, it was observed that fruit did not have very positive effects on *S. thermophilus*.

In a study on plain, blueberry and blackberry yoghurt, Boycheva *et al.* (2011) reported the count of *L. delbrueckii subsp. bulgaricus* as 130.626 cfu/ml, 281.430 cfu/ml and 349.575 cfu/ml at the beginning, and 377.010 cfu/ml, 504.880 cfu/ml and 638.793 cfu/ml at 48 hours, and they also identified an approximately 50% increase. Similarly, Celik and Bakirci, (2003) reported that lactic acid bacteria values were higher than those in plain yoghurt. Akın and Konar, (2001) reported the count of lactic acid bacteria in strawberry and peach yoghurt (per ml) to be 330 and 513 million on the 1st day, and 738 and 390 million on the 10th day. In his study, Karagozlu, (1997) reported the count of *L. delbrueckii subsp. bulgaricus* in strawberry and peach yoghurts to be $19.5x10^7$ and $16.3x10^7$ on the 1st day of storage, and $23.8x10^7$ and $21.9x10^7$ on the 7th day of storage. In the same study, the count of *S. thermophilus* was found to be $27.0x10^7$ and $23.6x10^7$ on the 1st day of storage, and $23.6x10^7$ and $15.7x10^7$ on the 7th day of storage. Boycheva *et al.* (2011) found that the count of *S. thermophilus* was higher in fruit yoghurts when compared to plan yoghurt, and their evaluations were like ours. Contrary to these studies, Doroto *et al.* (2015) reported the counts of *S. thermophilus* during 28 days of storage to be $9.1x10^7$-$9.2x10^7$ in plain yoghurt, $9.0x10^7$-$9.3x10^7$ in carrot yoghurt, $9.4x10^7$-$9.5x10^7$ in pumpkin yoghurt, $9.4x10^7$-$1.0x10^8$ in broccoli

Table 4. Percentage of change in the chemical, microbiological traits of fruit yoghurts.

	Attributes	Incubation time			Storage time		
		0 min cfu/ml	90 min %[a]	210 min %[a]	1 day %[b/a]	3 days %[b/a]	7 days %[b/a]
Plain yoghurt	Acidity (LA)	0.706±0.04	7.1	15.0	-0.6/14.3	28.0/47.2	14.4/31.6
	pH	4.532±0.01	-3.5	-7.7	4.1/-4.0	0.5/-7.3	-1.4/-9.1
	*L.d.s.b**	4.569±0.21	28.6	54.0	2.9/58.5	5.8/62.9	2.3/57.6
	*S.t.***	4.305±0.26	34.7	37.0	-3.5/32.2	-8.8/25.0	-2/34.3
	Mould	2.222±0.18	-1.4	-9.9	0.0/-9.9	0.0/-9.9	0.0/-9.9
	Yeast	4.306±0.29	14.0	41.9	-13.5/22.8	23.3/75.0	30.0/84.6
Strawberry yoghurt	Acidity (LA)	0.593±0.00	12.8	35.8	17.3/59.2	47.5/100.2	82.6/147.9
	pH	4.530±0.02	-3.1	-11.1	-3.8/-14.5	0.4/-10.8	-1.9/-12.8
	*L.d.s.b**	4.435±0.17	11.2	30.9	13.8/49.0	22.0/59.7	16.6/52.6
	*S.t.***	4.804±0.20	19.9	27.2	4.9/33.4	5.6/34.2	1.5/29.1
	Mould	2.058±0.04	-2.9	-2.9	0.0/-2.9	0.0/-2.9	0.0/-2.9
	Yeast	3.533±0.29	14.7	34.8	17.8/58.9	32.2/78.3	5.3/42.0
Peach yoghurt	Acidity (LA)	0.536±0.01	8.2	24.3	28.1/59.1	33.6/66.0	30.3/61.9
	pH	4.510±0.02	-2.9	-10.0	7.9/-2.9	-3.5/-13.1	-1.2/-11.1
	*L.d.s.b**	4.196±0.06	31.1	71.8	3.8/78.3	1.4/74.2	0.5/72.7
	*S.t.***	5.204±0.14	4.6	12.9	5.7/19.4	10.6/24.8	7.6/21.5
	Mould	2.058±0.02	-2.9	-2.9	0.0/-2.9	0.0/-2.9	0.0/-2.9
	Yeast	3.597±0.06	20.3	46.3	19.7/75.1	40.3/105.3	46.8/114.8
Apricot yoghurt	Acidity (LA)	0.540±0.02	6.9	28.1	25.3/60.6	53.6/96.9	62/107.6
	pH	4.520±0.01	0.0	-3.3	0.7/-2.7	-13/-15.90	-8.9/-12.0
	*L.d.s.b**	4.530±0.18	38.6	57.3	9.0/71.5	4.7/64.6	9.6/72.4
	*S.t.***	5.048±0.21	32.3	46.3	-2.4/42.7	-4.3/39.9	1.5/48.4
	Mould	2.373±0.16	-9.5	-15.6	66.3/40.3	0.0/-15.6	0.0/-15.6
	Yeast	3.330±0.13	-3.9	28.6	28.7/65.5	52.9/96.7	50.0/92.9
Banana yoghurt	Acidity (LA)	0.582±0.00	5.0	17.9	20.9/42.4	45.8/71.8	70.4/100.9
	pH	4.516±0.00	-2.4	-3.5	-0.7/-4.2	1.2/-2.4	-10.6/-13.7
	*L.d.s.b**	4.459±0.32	30.5	41.6	6.8/51.3	12.9/59.9	13.7/61.1
	*S.t.***	4.731±0.37	19.5	26.1	2.5/29.2	-5.4/19.3	0.3/26.5
	Mould	2.229±0.05	-0.9	-2.3	50.3/46.9	21.2/18.4	-8.1/-10.2
	Yeast	2.913±0.15	49.4	65.4	-4.4/58.2	47.2/143.4	19.9/98.3

a: change in % from the beginning of incubation, b: change in % after the end of incubation; * *L. delbrueckii subsp. bulgaricus*, ** *S. thermophilus*

Table 5. Sensory characteristics (mean score ± standard deviation).

Yoghurt types	Appearance	Consistency	Smell	Flavour	Mean
Strawberry yoghurt	3.21±0.44	3.39±0.11	3.64±0.71	3.79±0.57	3.51±0.45
Banana yoghurt	3.57±0.34	3.82±0.26	4.07±0.48	4.11±0.42	3.89±0.37
Peach yoghurt	3.04±0.91	3.00±0.01	3.18±0.96	3.39±0.66	3.15±0.63
Apricot yoghurt	3.11±0.38	3.14±0.44	3.39±0.11	3.57±0.88	3.30±0.45
Mean	3.23±0.51	3.33±0.20	3.65±0.56	3.71±0.63	

yoghurt, and $9.1x10^7$-$9.2x10^7$ in yoghurt with red pepper, and they found that the count of *S. thermophilus* decreased in some of the yoghurts over time. Cakmakci *et al.* (2012) also reported decreases in the counts of *L. delbrueckii subsp. bulgaricus* and *Streptococcus salivarius* in probiotic yoghurt with banana during 14 days of storage, when compared to plain yoghurt. Salwa *et al.* (2004) found that there was no difference in the counts of *S. thermophilus* and *L. bulgaricus* in yoghurts prepared by adding carrot juice, when compared to plain yoghurt. In our study, the count of *S. thermophilus* was higher in fruit yoghurts than in plain yoghurt, which corroborates the findings of Boycheva *et al.* (2011) and Celik and Bakirci, (2003).

We observed that the rate of mould in fruit yoghurts was 1.99-2.37 $\log_{10}$ cfu/ml, and the rate of yeast was 2.91-7.72 $\log_{10}$ cfu/ml. About their growth, it was found that the mould rate decreased in yoghurts when compared to the beginning of the process. The highest rate of decrease occurred in apricot yoghurt with a 15.6% decrease in the incubation period, and the highest rate of decrease in the storage period was observed in banana yoghurt at 10.2%. Contrary to the moulds, the yeasts exhibited an increase in both the incubation and storage periods due to the sugar rate of the fruit. During the storage period, although the highest rates of increases were found in peach (114.8%) and banana (65.4%) yoghurt, the highest value throughout this period was observed in plain yoghurt

(7.947 $\log_{10}$ cfu/ml), and the difference between plain yoghurt and banana yoghurt was found to be statistically significant (p=0.00).

In a study on yoghurt prepared by adding 15% carrot juice, Salwa *et al.* (2004) reported that the counts of yeast and mould decreased. Akın and Konar, (2001) performed a study on fruit yoghurts made of cow and goat milk in which they reported that the development of yeast and mould was lower in peach yoghurt than in strawberry yoghurt, and that the counts of yeast and mould increased throughout the storage period in all the fruit yoghurts. Cakmakci *et al*. (2012) studied probiotic yoghurt with banana and reported increased counts of yeast and mould throughout the storage period. Tarakci and Kucukoner (2003) performed a study on fruit yoghurts they prepared by using different fruits, and found that the counts of yeast and mould were 2.2 $\log_{10}$ cfu/ml on the 1st day of storage and 2.64 $\log_{10}$ cfu/ml on the 6th day. The findings of these studies corroborate our results.

The sensory analyses were carried out only with fruit yoghurts, and the scores of the yoghurt characteristics have been presented in Table 5. The qualitative scores varied between 3.00 and 4.11 and, considering all the sensory characteristics (Table 5), the least popular one was peach yoghurt (3.15) and the most popular one was banana yoghurt (3.89). From the aspect of characteristics, it was determined that the highest score was given to the flavour of the yoghurt (3.71), while the lowest score was given to the appearance (3.23). The assessment of specific characteristics among the yoghurt types was as follows (Table 5). The least popular aspect was the consistency of peach yoghurt (3.00), and the most popular aspect was the flavour of banana yoghurt (4.11). Regarding studies that compare the sensory characteristics of fruit yoghurts, Karagozlu (1997) conducted a sensory analysis of yoghurts prepared with strawberry, peach and sour cherry, and reported that the most popular yoghurt in terms of appearance, structure, and consistency was the strawberry yoghurt, which was also the case in our study. Dorota *et al*. (2015) found that there was no sensory difference between plain yoghurt and vegetable yoghurts, and that the most popular one was yoghurt with sweet red pepper. Tarakci and Kucukoner (2003) reported that yoghurts prepared by adding sour cherries and grape molasses were preferred over those prepared with dates, rosehips or cranberries. Angelov *et al.* (2009) found that mulberry was preferred over molasses. Roy *et al.* (2015) reported that among fruit yoghurts prepared with watermelon, papaya and banana, yoghurt made with papaya was more popular.

***Conclusion*:** In conclusion, although the use of different fruits in fruit yoghurts led to changes in preferences in sensory characteristics, no statistically significant difference was found, but differences were observed in the growth of bacteria that constitutes the microflora (p<005). The effects of different types of fruit on the chemical traits such as acidity and pH were found to be statistically significant (p<005). The different results that were obtained in the microbiological analyses are thought to be possibly caused by the methods used, the types of fruit, storage durations and the starter culture used, while the differences in sensory analyses are thought to be possibly caused by the types of fruit used and local preferences for flavour. Growing of the microflora was affected by these ingredients, which were added into milk products to change the sensory characteristics and other features, they can have a positive or negative effect on the yoghurt's shelf life and sensory characteristics and, consequently, the quality of the product.

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