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The antimicrobial effects of probiotic and traditional yoghurts produced using commercial starter cultures on some foodborne pathogens

Bazı gıda kaynaklı patojenler üzerinde geleneksel yoğurt üretiminde kullanılan ticari starter kültürlerin ve probiyotiklerin antimikrobiyal etkisi

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ABSTRACT

Objective: Although many techniques have been developed for food preservation, foodborne diseases are still an important problem. The studies aimed at solving this problem have increased in recent years using lactic acid bacteria with antimicrobial activities in foods.

Materials and Methods: In this study, the antimicrobial effects of various lactic acid bacteria species, commercial yoghurt and probiotic yoghurt cultures and their supernatants on pathogen bacteria including *Salmonella typmimurium* NRLL E4463, *Listeria monocytogenes* Scott-A, *Escherichia coli* O157:H7, *Staphylococcus aureus* 6538P were examined by well diffusion and disc diffusion methods

Results: It was determined that there were no statistical differences between the well diffusion and disc diffusion methods in terms of antimicrobial effects. It was also found that all of the lactic acid bacteria in MRS broth had substantial antimicrobial activities against the pathogens in both diffusion methods; however the antimicrobial effects of the supernatants obtained from cultures developed in media prepared from 10% skim milk powder showed diversity in terms of antimicrobial activity.

Conclusion: These commercial cultures are thought to make a positive contribution with to help in the control of foodborne diseases.

Keywords: Antimicrobial activity, lactic acid bacteria, pathogens, probiotics, yoghurt

ÖZ

Amaç: Gıda muhafazası için birçok teknik geliştirilmiş olmasına rağmen, gıda kaynaklı hastalıklar hala önemli bir sorundur. Gıdalarda antimikrobiyal aktiviteye sahip laktik asit bakterilerinin kullanılmasıyla son yıllarda bu sorunu çözmeye yönelik çalışmalar artmıştır.

Materyal ve Yöntem: Bu çalışmada piyasadan temin edilen çeşitli laktik asit bakterileri, yoğurt bakterileri ve probiyotik yoğurt kültürlerinin *Escherichia coli* 0157:H7*, Listeria monocytogenes* Scott-A, *Salmonella typhimurium* NRLL E 4463 ve *Staphylococcus aureus* 6538P gibi patojen bakteriler üzerine antimikrobiyal etkileri hem kuyu difüzyon hem disk difüzyon yöntemi ile incelenmiştir.

Araştırma Bulguları: Antimikrobiyal etkiler açısından kuyu difüzyon ve disk difüzyon yöntemleri arasında istatistiksel olarak farklılık olmadığı belirlenmiştir. Her iki difüzyon yönteminde de MRS broth'taki laktik asit bakterilerinin tamamının patojenlere karşı önemli antimikrobiyal aktiviteye sahip olduğu, ancak% 10 yağsız süt tozundan hazırlanan ortamlarda geliştirilen kültürlerden elde edilen süpernatanların antimikrobiyal etkileri açısından çeşitlilik gösterdiği bulunmuştur.

Sonuç: Bu ticari kültürlerin, gıda kaynaklı hastalıkların kontrolüne yardımcı olmak için olumlu bir katkı sağladığı düşünülmektedir.

Anahtar sözcükler: Antimikrobiyal aktivite, laktik asit bakterisi, patojenler, probiyotik, yogurt

INTRODUCTION

Yoghurt, especially both set type yoghurt and stirred yoghurt, is an important dairy product with different textural properties, fat content and aroma ingredients and has been consumed since the earliest ages of humanity (Shah 2003; McKinley 2005; Pelaes Vital et al. 2015; Fazilah et al. 2018). Fermentation is a method that has been used for many years to extend the shelf-life of foods and provide a good structure and flavor in the final product. (Hashemi Gahruie et al. 2015). Yoghurt is produced using a conventional starter culture containing *Lactobacillus delbruckeii* subsp. *bulgaricus* and *Streptococcus thermophilus* (Tamime and Robinson 1985; Donkor et al. 2007). Some strains of *Bifidobacterium* and *Lactobacillus* genera are frequently used in bioyoghurt or probiotic yoghurt production as probiotic cultures. (Corbo et al. 2001; Graciela and Maria 2001; Baltova and Dimitrov 2014; Barat and Özcan, 2016). Bacteria used in probiotic yoghurts or fermented milk products must have beneficial health effects and contain a sufficient number of live cells in the products. (Fazilah et al. 2018). Probiotic bacteria found in food products include *L. acidophilus* NCFB 1748, NCFM, LA5, *Lactobacillıs rhamnosus* GG, *L. casei shirota*, *L. johnsonii* LA1 (Saarela et al. 2000).

Probiotic bacteria, colonizing steadily in the gastrointestinal tract, are resistant to acidic conditions of gastric fluids, bile acid, and salts. They also prevent the development of other bacteria in the intestinal tract by lactic acid production (Guarino et al. 2015; Dubreuil 2017; Prabhurajeshwar and Chandrakanth 2019). They prevent the proliferation of pathogenic microorganisms by reducing the intestinal pH, secreting bacteriocins or antimicrobial peptides, organic acids, diacetyl, acetoin, and hydrogen peroxide (Zhang et al. 2019). Probiotic microorganisms compete with pathogenic microorganisms for binding to the receptors. The same mechanism applies to nutrients found in the intestinal lumen (Coşkun 2006).

Enterotoxigenic *Escherichia coli* (ETEC) strains are the cause of gastrointestinal infections. These pathogens can cause diarrhea with exotoxins, which are produced in the small intestine by these bacteria (Dubreuil 2017). Various studies have reported that cultures containing probiotic species including *Lactobacillus, Bifidobacterium*, *Enterococcus, Pediococcus, Streptococcus,* and *Saccharomyces* have a positive effect when used in the treatment of diseases caused by enterotoxigenic *E. coli*, particularly in diarrhea (Macfarlane and Cummings 1999; Hajikhani et al. 2007; Dubreuil 2017). Numerous researchers have reported that, in various fermented milk inoculated with *Listeria monocytogenes* and *Salmonella typhimurium* and in some cheese types which contained Shiga-toxin-producing *E. coli,* the use of probiotic microorganisms and lactic acid bacteria inhibited the development of these pathogens (Callon et al. 2016; Haraguchi et al. 2019). For the control of antibiotic-resistant *S. typhimurium* in farm animals, as a result of administrating probiotics along with feed at 10^{10} cfu/animal/day, it was observed that IgM, IgA and IgG levels increased against *S. typhimurium* infection (Naqid et al. 2015). The studies have reported that commercial strains of *Lactobacillus acidophilus* and *Lactobacillus casei* exhibited antimicrobial activity against *S. aureu*s, inhibited the biofilm formation and lipase activity (Tripathi and Jha 2004; Sikorska and Smoragiewicz 2013). Edalati et al. (2019) investigated the antagonistic potential of lactic acid bacteria with probiotic potential isolated from camel's milk and reported that the isolated bacteria exhibited higher inhibitory activity against *S. aureus* subsp. *aureus* PTCC 1431 compared to that against *E. coli* ATCC 25922. It has been suggested that regular probiotic intake reduces colon tumors and prevents colon cancer. Although the anti-tumor effects have not yet been confirmed, some studies have suggested that such an effect can emerge in the case of retention, suppression and blocking of procarcinogens, enzyme activity, decrease in the intestinal flora with the decrease in pH and stimulation of the immune system by the increase in γ-interferon production (Fooks et al. 1999; Fonden et al. 2000; Rafter 2003).

The microorganism count usually measures potential efficacy of probiotics in one gram of food product. According to the regulations, probiotic products must contain a certain level of probiotic bacteria. The counts of *Bifidobacteria* and other probiotic microorganisms are recommended to be at least 10^6-10^7 cfu/g or cfu/ml in a 100 mL or 100 g fermented product. In order for probiotics to perform these functions, it is thought that live bacteria count should be at least 10^8 -10^9 in the small intestine. (Rybka and Kailasapathy 1995; Oliveira et al. 2009). Foodborne poisoning and intestinal pathogens causing diarrhea are an important health concern in some developed and developing countries. The resistance to drugs

used against these bacteria has led to new strategies such as the consumption of lactic acid bacteria and probiotics along with foods. In this study, the antimicrobial effect of yoghurts prepared with commercial probiotic yoghurt cultures and traditional yoghurt culture and the supernatants of these cultures on important foodborne pathogens *Escherichia coli* O157: H7, *S. typhimurium*, *S. aureus*, and *L. monocytogenes* were determined.

MATERIALS and METHODS

Commercial starter cultures and test strains

The traditional yoghurt culture Lyfast SBS 6.33/A (SBS) containing *Streptococcus thermophilus* and *Lactobacillus delbrueckii* subsp. *bulgaricus* was obtained from Mayasan Biotech.(Delvo® Fresh**)** in Turkey. The lyophilized starter cultures, *Lactobacillus acidophilus* 145 (Visbyvac-Serie 1000), Yoghurt V1 (Visbyvac-Serie 50) containing *Streptococcus thermophilus* and *Lactobacillus delbrückii* subsp*. bulgaricus* and Yoghurt 709 (Visbyvac-Serie 50) containing *Streptococcus thermophilus* and *Lactobacillus delbruckii* subsp*. bulgaricus* were provided from Wisby (Germany)/ Türker Co. The probiotic yoghurt starter culture DVS (50) ABT-3 (Nutrish) containing *Streptococcus thermophilus, Bifidobacteria* and *Lactobacillus acidophilus* 145 (ABT), was obtained as frozen pellets from Chr. Hansen's Laboratory, Inc. (Peyma). The BL culture containing *Bifidobacterium*, the LBA culture containing *Lactobacillus casei* subsp*. rhamnosus* and the BA culture containing *Bifidobacterium* and *Lactobacillus casei* subsp*. rhamnosus* were obtained from Ezal.

E. coli O157:H7, *L. monocytogenes* Scott A, *S. typhimurium* NRRL E 4463 and *S. aureus* 6538P were supplied from Ege University, Engineering Faculty, Food Engineering Department and were stored in Tryptone Soy Broth (TSB, Oxoid CM 129) at 4ºC. DeMan-Rogose Sharp Broth (MRS, Difco CM 359) was used to develop the lactic acid bacteria. While Tryptone Soy Broth (TSB, Oxoid CM 129) was used to develop the pathogenic cultures, Plate Count Agar (PCA, Oxoid CM 325) was used for the enumeration of the pathogenic cultures. For the enumeration of pathogens in the fermentation environment, Brillant Green Agar (BGA, Oxoid CM 263) was used for *S. typhimurium* NRRL E 4463 while Listeria Selective Agar (LS, Oxoid CM 856) was used for *L. monocytogenes*, Sorbitol Mac-Conkey Agar (SMC, Oxoid CM 813) was used for *E. coli* O157:H7 and Baird Parker Agar (BPA, Merck, 1.05406) which was added egg yolk tellurite was used for *S. aureus* 6538P.

Preparation of starter culture and pathogen strains

For the activation of the lyophilized cultures, skim milk was prepared from sterile skim milk powder with 10% dry matter. The–stock starter cultures were added according to the manufacturer's directives and were inoculated in this medium under aseptic conditions. *L. acidophilus* 145 was incubated at 37°C for 16 hours while *L. casei* subsp*. rhamnosus (*LBA*), Bifidobacterium* (BL*),* and the culture (BA), which contained both *L. casei* subsp*. rhamnosus* and *Bifidobacterium* were incubated at 37 °C for 24 hours. The other mixed cultures Yoghurt V1 and Yoghurt 709 cultures containing *S. thermophilus* and *L. bulgaricus* and ABT Nutrish probiotic yoghurt culture containing *S. thermophilus, Bifidobacteria* and *L. acidophilus* were incubated at 42°C for 4 hours. Subsequently, the activated *L. acidophilus* and *L. casei* subsp*. rhamnosus* and the mixed yoghurt cultures were inoculated in media prepared from 10% skim milk powder at 2%. In comparison *Bifidobacterium* was inoculated in the same media at 10% and again left to incubate at 42°C for 4 hours. To determine the antimicrobial activity, cultures were transferred to MRS broth medium and incubated at 37°C for 18-24 hours, and, thus, a fresh culture was obtained. Pathogen cultures were inoculated separately into 10 mL of TSB and incubated at 35ºC for 24 h. Cultures were transferred at least two times before use.

Antimicrobial activity

To determine the antimicrobial effects of lactic acid bacteria obtained from commercial sources on some foodborne pathogenic microorganisms, two different applications of agar diffusion methods, "well diffusion" and "disc diffusion" methods were adopted, and these two methods were compared. Lactic acid bacteria developed in media prepared from 10% skim milk powder, following their incubation periods, were centrifuged at 5000 rpm for 10 minutes, and the pH value of the supernatant

was set to 6.5 using 1 N NaOH to prevent a possible inhibitory effect other than those by bacteriocins, such as acidity. Then, the supernatant was sterilized by filtration through a membrane filter (Sartorius) with a pore diameter of 0.45 µm.

For the well diffusion method, using a sterile gel cutter, four wells with a diameter of 6 mm were aseptically spaced at equal intervals in the solidified medium. Approximately 100 µml lactic acid bacteria developed in sterile media prepared from 10% skim milk powder was inoculated into the first well while 50-100 µml lactic acid bacteria developed in MRS broth for 18-24 hours was inoculated in the second well and the supernatant which was tested for its bacteriocin content was inoculated in the third well. For the control, sterilized pure water was added to a well. Petri plates were incubated for 1 hour at room temperature to allow the fluids to be absorbed by the medium and then they were left to incubate at 37 °C for 24 hours. At the end of the incubation period, the petri plates were observed for the formation of inhibition zones (Harris et al*.* 1989; Gonzalez et al. 1993). In disc diffusion method, 6-mm-diameter discs were aseptically soaked with supernatant, cultures developed in media prepared from skim milk powder and MRS broth and evenly placed in Nutrient Agar (NA) media, which was previously inoculated with pathogenic bacteria. The petri plates were left to stand for one hour at room temperature and then left to incubate at 37°C for 24 hours. At the end of the incubation period, the petri plates were observed for inhibition zone formations (Özbaş and Aytaç 1996). All the analytical procedures were carried out with parallel petri plates with three repetitions.

Statistical Analyses

The Sign Test was adopted to compare the well diffusion and disc diffusion tests used to determine the antimicrobial activity (Ünver and Gamgam 1999).

RESULTS and DISCUSSIONS

The antimicrobial effects of monoculture and mixed cultures on *S. typhimurium* NRRL E 4463*, L. monocytogenes* Scott-A, *E. coli* O157:H7, and *S. aureus* 6538P are given in Table 1. As seen in Table 1, *L. acidophilus* 145 culture developed in MRS broth and media prepared from 10% skim milk powder, and its supernatant had inhibitory effects on *S. typhimurium* and *L. monocytogenes* Scott-A in both well diffusion and disc diffusion methods. *L. acidophilus* developed in MRS broth had an inhibitory effect on *E. coli* O157:H7, whereas *L. acidophilus* developed in media prepared from skim milk powder exhibited no zone formation and it was also seen that its supernatant. On the other hand, *L. acidophilus* developed in MRS broth and skim milk powder had an inhibitory effect on *S. aureus* by both methods whereas its supernatant had no effect. As a result of statistical analyses, it was found that there were no significant differences between well diffusion and disc diffusion methods. In the antimicrobial activities of lactic acid bacteria, decreasing pH due to lactic acid formation in the end product can be shown as the main reason (Axelsson 2004) while bacteriocins and organic substances produced by the lactic acid bacteria can also play an important role (Kankainen *et al.* 2009). Bacteriocins affect on Gram-positive pathogens, while organic acids have an effect on both Gram-positive and Gram-negative pathogens (Abee et al. 1995; Alakomi et al. 2000). *L. acidophilus* produces bacteriocins including laktocidin, acidolin, acidophilin, lactacin M, lactacin F and lactacin B. Among these bacteriocins, laktocidin has a wide range spectrum, effective on Gram-positive and Gram-negative bacteria, and shows a combined effect with organic acids and H_2O_2. It has been reported that *L. acidophilus* had an inhibitory effect on pathogens including *S. aureus*, the enteropathogenic *E. coli*, *S. typhimurium* and *C. perfringens* (Kılıç 2001). The inhibitory effects of *L. acidophilus* culture on *S. typhimurium* and *L. monocytogenes* were attributed to the bacteriocins that were thought to be produced by *L. acidophilus* and the organic acids formed in the environment. The fact that there was no supernatant activity against *E. coli* O157:H7 indicates that the bacteriocins that may form have no effect on this pathogen. Sadowska *et al.* (2010) have reported that *L. acidophilus* supernatants containing a bacteriocin-like substance produced had strong antimicrobial activity against *S. aureus*. Özbaş and Aytaç (1996), in line with the results obtained in the present study, have reported that *L. acidophilus* had an inhibitory effect on *L. monocytogenes* both in the product obtained as a result of the research and the supernatant in contrast, no inhibition zone was formed against *E. coli* O157:H7 in both cases. The obtained results were similar to those reported by Gonzales et al. (1993), Gupta et al. (1996), Chateau et al. (1993); Coconnier et al. (1997), and Camard et al. (1997).

Table 1. The antimicrobial effects of lactic acid bacteria on *S. typhimurium* NRRL E 4463*, L. monocytogenes* Scott-A*, E. coli* O157:H7 and *S. aureus* 6538P

Çizelge 1. *Laktik asit bakterilerinin S. typhimurium NRRL E 4463, L. monocytogenes Scott-A, E. coli O157:H7 ve S. aureus 6538P üzerine etkisi*

		S. typhimurium NRRL E4463			*L. monocytogenes* Scott-A			*E. coli O157:H7*			*S. aureus* 6538P		
		C	P	S	C	P	S	C	P	S	C	P	S
L. acidophilus 145	W	+	+	+	+	+	+	+	_	_	+	+	_
	D	+	+	+	+	+	+	+	_	_	+	+	_
Bifidobacterium(BL)	W	+	_	_	+	+	_	+	_	_	+	_	_
	D	+	_	_	+	+	_	+	_	_	+	_	_
L. casei subsp. *rhamnosus(LBA)*	W	+	_	_	+	_	_	+	_	_	+	_	_
	D	+	_	_	+	_	_	+	_	_	+	_	_
Bifidobacterium and *L.casei* subsp. *rhamnosus(BA)*	W	+	_	_	+	+	_	+	_	_	+	_	_
	D	+	_	_	+	+	_	+	_	_	_	_	_
ABT (L. *acidophilus, Bifidobacterium* and *S. thermophilus)*	W	+	+	+	+	+	+	+	+	_	+	+	_
	D	+	+	+	+	+	+	+	_	_	+	+	_
SBS *(L. bulgaricus* and *S. thermophilus)*	*W*	+	_	_	+	_	_	+	_	_	+	_	_
	D	+	_	_	+	_	_	+	_	_	+	_	_
Yoghurt V1 *(L. bulgaricus* and *S. thermophilus*	*W*	+	_	_	+	_	_	+	_	_	+	_	_
	D	+	_	_	+	_	_	+	_	_	+	_	_
Yoghurt 709 *(L. bulgaricus* and *S. thermophilus*	*W*	+	_	_	+	_	_	+	_	_	+	_	_
	D	+	_	_	+	_	_	+	_	_	+	_	_

C: Culture in MRS Broth W: well diffusion (+): zone formation observed P: Product (%10 skim milk)

D: disc diffusion (-): zone formation not observed S: Supernatant of culture

Bifidobacterium developed in MRS broth showed inhibitory effects on *S. typhimurium, E. coli* O157:H7 and *S. aureus* in both well diffusion and disc diffusion tests. However, the product developed in media prepared from skim milk powder and its supernatant showed no effect. Although the inhibitory effect was often less in milk compared with broth media (Daly et al. 1972), it was observed that *Bifidobacterium* species developed in both MRS broth and skim milk powder had an inhibitory effect on *L. monocytogenes* (Table 1.). However, the obtained supernatant did not form a zone, indicating that it did not show any inhibitory effect. Naidu et al. (1999) have reported that, although *Bifidobacterium* species did not produce H_2O_2 or bacteriocins, they produced acetic acid and lactic acid and associated the lack of inhibitory effects of supernatants with the lack of bacteriocin production. Fujiwara et al. (1997), similar to the present study, determined that *Bifidobacterium* species, especially *B.longum* had an inhibitory effect on the enterotoxigenic *E. coli*. Ibrahim and Bezkorovainy (1993) have reported that related with lactic acid and acetic acid production, *Bifidobacterium* species had an inhibitory effect on *E. coli*; in addition, *Bifidobacterium* species produced a lactic acid, which has a higher inhibitory effect compared to lactic acid, and the combined inhibitory effect of lactic acid and acetic acid was higher.

It was found that *L. casei* subsp. *rhamnosus* developed in MRS broth had inhibitory effects on *S. typhimurium, L. monocytogenes, E. coli* O157:H7, and *S. aureus* in both methods. In contrast, no inhibitory effect was observed for this bacterium when developed in media prepared from skim milk powder or for its supernatant. Özbaş and Aytaç (1996), in their study using the agar diffusion method, have reported that *L.casei* developed in MRS broth, its product obtained due to fermentation and its supernatant had antimicrobial effects on *L. monocytogenes.* However, they had no antimicrobial effects on *E. coli* O157:H7. Kamal *et al.* (2018) have reported that *L. rhamnosus* supernatants had strong antimicrobial activity against *E. coli* O157:H7, *S. aureus,* and *Yersinia enterocolitica* but not against *Salmonella enterica* serovar *Typhimurium*. On the other hand, Tejero-Sariñena et al. (2012) determined that *L. rhamnosus* supernatants showed an antimicrobial activity against enterotoxigenic and

enteropathogenic (ETEC and EPEC) *Escherichia coli* including *S. typhimurium*. It was determined that the mixed culture containing *Bifidobacterium* and *L. casei* subsp*. rhamnosus* had an inhibitory effect on *S. typhimurim*, *L. monocytogenes* and *E. coli* O157:H7 in both well diffusion and disc diffusion methods. The culture formed an inhibition zone against *S. aureus* in well diffusion method however; formed no inhibition zone in disc diffusion method. In addition, the product obtained using media prepared from skim milk powder had no inhibitory effects on *S. typhimurim, E. coli* O157:H7 and *S. aureus* in both well diffusion and disc diffusion methods however it was effective on *L. monocytogenes*. Also, the supernatants obtained from the product had no inhibitory effects on all of the pathogenic bacteria used in the study by either methods. *L. casei* subsp*. rhamnosus* showed antimicrobial activity against all pathogens when only developed in MRS Broth, whereas it showed antimicrobial activity against *L. monocytogenes* when used in combination with *Bifidobacterium* in media prepared using 10% milk powder. It was seen that *Bifidobacterium* had higher antimicrobial activity against *Listeria*.

The probiotic yoghurt culture ABT, which contained *L. acidophilus, Bifidobacterium* and *S. thermophilus* had inhibitory effects on *S. typhimurium* NRRL E 4463 and *L. monocytogenes* Scott-A in both MRS broth and skim milk powder media in both diffusion methods. In addition, the supernatant of this culture had an antimicrobial effect on *S. typhimurium* NRRL E 4463 and *L. monocytogenes* Scott-A in both diffusion methods. The probiotic yoghurt culture developed in MRS had an antimicrobial effect on *E. coli* O157: H7 and *S. aureus* 6538P by both methods. It was found that the product formed a zone on *E. coli* O157:H7 in well diffusion method, whereas no zone formation was observed in disc diffusion method. On the other hand, it was observed that the product had an inhibitory effect on *S. aureus* 6538P in both methods, whereas the supernatants did not affect on *E. coli* O157: H7 and *S. aureus* 6538P. Tejero-Sariñena et al. (2012) have reported that *L. acidophilus,* compared to those of other lactic acid bacteria, had a higher antimicrobial effect on *E. coli, S. aureus, S. typhimurium* and *C. difficile*. Among the *Bifidobacterium* species used in the study, *B.infantis* had the lowest antimicrobial activity whereas *B. longum, B. breve* and *B. bifidum* had high antimicrobial activities. The fact that ABT culture had a supernatant activity on *S. typhimurium* and *L. monocytogenes* indicated that this effect was associated with various antimicrobial substances rather than acidity. Indeed, *S. thermophilus, L. bulgaricus* and *L. acidophilus* have been reported to produce bulgarican and acidophilin that have inhibitory effects on other microorganisms (Özbaş and Aytaç, 1996). Bodnaruk *et al.(*1998) have reported that the yoghurt containing *S. thermophilus, L. bulgaricus,* and *L. acidophilus* delayed the development of *Y. enterocolitica* better compared to yoghurts containing the conventional yoghurt bacteria *S. thermophilus* and *L. bulgaricus*.

It was determined that the SBS culture containing the conventional yoghurt bacteria were effective on *S. typhimurium* NRRL E 4463*, L. monocytogenes, E. coli* O157:H7 and *S. aureus* 6538P in both diffusion methods only when developed in MRS broth. When the culture was developed in media prepared from 10% skim milk powder and a supernatant was obtained from the culture, it was found that the culture and the supernatant had no inhibitory effects. As is the case in the SBS culture, it was found that Yoghurt V1 culture had inhibitory effects on pathogenic bacteria when developed in MRS broth; however the culture and its supernatant had no inhibitory effects when developed in media prepared from skim milk powder. Also, Yoghurt 709 culture, as is the case in V1 and SBS cultures, exhibited inhibitory effects on all of the pathogens when developed in MRS broth however the culture and its supernatant had no inhibitory effects when developed in media prepared from skim milk powder. When traditional yoghurt cultures SBS, Yoghurt V1 and Yoghurt 709 containing the conventional yoghurt bacteria *L. bulgaricus* and *S. thermophilus* were developed solely in MRS broth medium, it was determined that the bacteria had inhibitory effects on *S. typhimurium, E. coli* O157: H7, *S. aureus* and *L. monocytogenes* in both diffusion methods. In parallel with the present study, Akpınar et al. (2011) found that *L. bulgaricus* isolated from homemade yoghurts showed high antimicrobial activity against *E. coli*, while *S. thermophilus* showed high antimicrobial activity against *Klebsiella pneumonia*. Varadaraj et al. (1993) used the well diffusion method to isolate *L. delbrueckii* subsp. *bulgaricus* from Dahi, a dairy product from India, and developed the bacteria in media prepared from 10% skim milk powder. The researchers have reported that *L. delbruecki* ssp. *bulgaricus* exhibited antimicrobial activity on *S. aureus* and *B. cereus;* however it had no antimicrobial effect on *E. coli*. In another study, Erdoğrul and Erbilir (2006) have reported that *L.*

delbruecki ssp. *bulgaricus* had higher antimicrobial activity against *E. coli*, *S. aureus* and *P. aeroginosa* than it had against *K. pneumonia* and *S. typhimurium*.

CONCLUSION

This study investigated the antimicrobial properties of commercial starter cultures used in fermented dairy products sold in the market. As a result, it was determined that all the cultures developed in MRS Broth (C) exhibited antimicrobial activity against the pathogenic bacteria used in the study. However, the antimicrobial activity of ABT commercial starter culture developed in media prepared from 10% milk powder (P) and their supernatant (S) was determined only against four pathogens. Furthermore, it was found that the cultures containing *Bifidobacterium* species had antimicrobial activity against *Listeria monocytogenes* both in MRS Broth and media prepared from 10% milk powder. This study revealed that the commercial starter cultures used in fermented dairy products sold in the market had antimicrobial effects on some foodborne pathogens, however these effects were related to the environment in which the lactic acid bacteria was developed. Growth medium can directly affect the components synthesized by the bacteria. It is believed that taking the antimicrobial activity as a criterion into consideration for the selection of starter cultures that will be used in the production of fermented dairy products will be affective in the inhibition of pathogenic bacteria contaminated due to various reasons including inadequate heat treatment and post-heat treatment contaminations from the production line or personnel.

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