Short communication: Survival of the characteristic microbiota in probiotic fermented camel, cow, goat, and sheep milks during refrigerated storage

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ABSTRACT

The objective of this study was to monitor the viability during storage of *Lactobacillus acidophilus* LA-5 (A), *Bifidobacterium animalis* ssp. *lactis* BB-12 (B), and *Streptococcus thermophilus* CHCC 742/2130 (T) in probiotic cultured dairy foods made from pasteurized camel, cow, goat, and sheep milks fermented by an ABT-type culture. The products manufactured were stored at 4°C for 42 d. Microbiological analyses were performed at weekly intervals. *Streptococcus thermophilus* CHCC 742/2130 was the most numerous culture component in all 4 products both at the beginning and at the end of storage. The viable counts of streptococci showed no significant decline in fermented camel milk throughout the entire storage period. The initial numbers of *Lb. acidophilus* LA-5 were over 2 orders of magnitude lower than those of *Strep. thermophilus* CHCC 742/2130. With the progress of time, a slow and constant decrease was observed in lactobacilli counts; however, the final viability percentages of this organism did not differ significantly in the probiotic fermented milks tested. The cultured dairy foods made from cow, sheep, and goat milks had comparable *B. animalis* ssp. *lactis* BB-12 counts on d 0, exceeding by approximately 0.5 log₁₀ cycle those in the camel milk-based product. No significant losses occurred in viability of bifidobacteria in fermented camel, cow, and sheep milks during 6 wk of refrigerated storage. In conclusion, all 4 varieties of milk proved to be suitable raw materials for the manufacture of ABT-type fermented dairy products that were microbiologically safe and beneficial for human consumption. It was suggested that milk from small ruminants be increasingly used to produce probiotic fermented dairy foods. The development of camel milk-based probiotic cultured milks appears to be even more promising because new markets could thus be conquered. It must be emphasized, however,

that further microbiological and sensory studies, technology development activities, and market research are needed before such food products can be successfully commercialized.

Key words: camel, fermented milk, *Bifidobacterium*, *Lactobacillus*

Short Communication

The regular consumption of lactic acid bacteria through fermented milks has long been associated with improved health and longevity (Metchnikoff, 1907). Over the last few decades, several strains of various *Bifidobacterium* and *Lactobacillus* spp. have received attention as probiotic organisms (Klein et al., 1998; Biavati et al., 2000; Zacarchenco and Massaguer-Roig, 2006). These bacteria are known to have health-promoting effects and, for this reason, they have been incorporated into a wide variety of dairy foods throughout the world (Alm, 1991; Ashraf and Shah, 2011; Karimi et al., 2012).

The numerous health benefits reported for lactobacilli and bifidobacteria include reduction in lactose intolerance in some individuals, treatment and prevention of diarrhea, alleviation of constipation, contribution to faster recolonization of the intestinal microbiota after administration of antibiotics, possible treatment of inflammatory bowel disease, reduction in serum cholesterol level, increased resistance to microbial infections, effect on immune function, and potential role in cancer prevention (Möller and de Vrese, 2004; Leahy et al., 2005; Zavisic et al., 2012). However, the therapeutic effects exerted by probiotic bacteria are dependent on the number of viable microbial cells reaching the human gut (Leahy et al., 2005; Ghoddusi and Hassan, 2011). Although no worldwide consensus exists as to the minimum concentration of bacteria that need to be consumed to produce a beneficial effect on human health (Farnworth, 2008), various authors argue that numbers of at least 10⁶ cfu/mL should be present at the time of consumption if a health claim is to be made (Sanders and Huis in't Veld, 1999; Shah, 2000; Kechagia et al., 2013).

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Unlike classic yogurt bacteria, probiotic organisms grow slowly in milk and, therefore, *Streptococcus thermophilus* and *Lactobacillus delbrueckii* ssp. *bulgaricus* are often added to cultured milks to speed up the fermentation process (Tharmaraj and Shah, 2003; Ashraf and Shah, 2011).

Although bovine milk production represents ca. 83% of the total world milk production, milking animals are not limited to cows in many parts of the world and, thus, buffalo (13% of world production), goat (2.2%), sheep (1.3%), and camel (0.3%) milks are also available in significant quantities (El-Salam, 2011; IDF, 2011). Every mammal species has a unique milk composition in terms of both major (proteins, fats, and lactose) and minor (e.g., vitamins, oligosaccharides, free amino acids, assimilable peptides, trace minerals, and so on) milk constituents (Hashim et al., 2009; Mayo et al., 2010; Fukuda, 2013), and this may influence the growth and survival rates of lactobacilli and bifidobacteria.

The objective of this research was to monitor the viability during refrigerated storage of *Lactobacillus acidophilus* LA-5 (**A**), *Bifidobacterium animalis* ssp. *lactis* BB-12 (**B**), and *Streptococcus thermophilus* CHCC 742/2130 (**T**) in probiotic cultured dairy foods made from different varieties of milk fermented by an ABT-type culture. To our knowledge, this is the first study evaluating the survival of probiotic lactobacilli and bifidobacteria in fermented camel milk.

Dromedary camel milk was received from Emirates Industry for Camel Milk and Products (Dubai, United Arab Emirates), cow milk was kindly supplied by Lajta Hanság Inc. (Mosonmagyaróvár, Hungary), goat milk was obtained from Tebike Inc. (Győr-Ménfőcsanak, Hungary), and sheep milk was provided by Pharma-Gene-Farm Inc. (Mosonmagyaróvár, Hungary). The chemical composition of raw materials is shown in Table 1. Raw milks were heated to 80°C and held for 10 min in a Pearl M water bath (Julabo Labortechnik GmbH, Seelbach, Germany).

The ABT-5 culture, which consisted of *Lb. acidophilus* LA-5, *B. animalis* ssp. *lactis* BB-12, and *Strep. thermophilus* CHCC 742/2130, was purchased from Chr.

Hansen (Hørsholm, Denmark) in freeze-dried direct vat set form. It was added to the heat-treated process milks cooled to 40°C at the rate of 0.2 U/L corresponding to 2.0% (vol/vol) conventional bulk starter.

Milks were fermented at 37°C until a pH value of 4.6 was reached. Thereafter, the fermented ABT milks were cooled to 15°C in ice water and were each separated into 21 fractions that were transferred in sterile tightly capped centrifuge tubes (50 mL; Greiner Bio One Hungary Inc., Mosonmagyaróvár, Hungary). After 24 h of cooling at 8°C (d 0), the samples were stored at refrigeration temperature (4°C). The entire experimental program was repeated twice.

Three tubes of all 4 products were taken at each sampling time (i.e., following 0, 7, 14, 21, 28, 35, and 42 d of storage). Samples were aseptically removed from centrifuge tubes and diluted by mixing 10 mL with 90 mL of 0.1% peptone water. Further dilutions were made as required. The pour-plate method was used to enumerate microorganisms.

M17 agar (Merck KGaA, Darmstadt, Germany) was used to enumerate *Strep. thermophilus* CHCC 742/2130. The pH of the medium was 6.8 ± 0.2 at 25°C. The inoculated plates were incubated at 45°C for 24 h under aerobic conditions. *Streptococcus thermophilus* CHCC 742/2130 formed lenticular colonies with a diameter of 1 to 2 mm. Colony-forming units, expressed as logarithm (base 10) per milliliter, were used to report survival of streptococci.

Lactobacillus acidophilus LA-5 was enumerated in de Man, Rogosa, and Sharpe (**MRS**)-clindamycin-ciprofloxacin agar (ISO-IDF, 2006). Commercial MRS agar (Merck KGaA) was rehydrated in distilled water according to the manufacturer's instructions. It was distributed in portions of 200 mL into bottles of 250 mL capacity and sterilized in a Varioklav 500E autoclave (H+P Labortechnik AG, Oberschleißheim, Germany) set at 121°C for 15 min. The final pH was 6.2 ± 0.2 at 25°C. Simultaneously, 2.0 mg of clindamycin hydrochloride (Sigma-Aldrich, St. Louis, MO) and 20.0 mg of ciprofloxacin hydrochloride (Sigma-Aldrich) were dissolved separately in two 10.0-mL aliquots of distilled water. Both solutions were then sterilized by filtering through a 0.22-μm membrane filter (Millipore Corp., Bedford, MA). Immediately before pouring, 0.1 mL of clindamycin stock solution and 1.0 mL of ciprofloxacin stock solution were added to 200 mL of MRS agar cooled to between 44 and 47°C. Thus, the complete MRS-clindamycin-ciprofloxacin agar had final clindamycin and ciprofloxacin concentrations of 0.1 and 10.0 mg/L, respectively. The plates were incubated at 37°C for 72 h. Anaerobic culture jars (2.5 L) were used to generate anaerobic conditions, atmospheric oxygen being absorbed by means of AnaeroGen AN 25 sachets

Table 1. Chemical composition (n = 2) of raw milks used for the manufacture of fermented dairy foods

Component (%, wt/wt)	Milk source			
	Camel	Cow	Goat	Sheep
Fat	2.31	3.71	3.29	5.95
Protein	2.85	3.25	2.95	5.42
Lactose	4.38	4.57	3.93	4.35
TS	10.30	12.21	10.98	16.88
SNF	8.17	8.56	7.74	10.88
Moisture	89.70	87.79	89.02	83.12

(Oxoid Ltd., Basingstoke, UK). The counts were expressed as logarithm (base 10) colony-forming units per milliliter. The lactobacilli identified on the basis of colonial type were confirmed by microscopic examination. *Lactobacillus acidophilus* LA-5 were gram-positive rods with rounded ends.

Transgalactosylated oligosaccharides-mupirocin lithium salt (**TOS-MUP**) agar (ISO-IDF, 2010) was used for enumeration of *B. animalis* ssp. *lactis* BB-12. The basic medium, TOS-propionate agar, was obtained from Merck KGaA. It contained (per liter) 10.0 g of peptone from casein, 1.0 g of yeast extract, 3.0 g of potassium dihydrogen phosphate, 4.8 g of dipotassium hydrogen phosphate, 3.0 g of ammonium sulfate, 0.2 g of magnesium sulfate heptahydrate, 0.5 g of L-cysteine monochloride, 15.0 g of sodium propionate, 10.0 g of galactooligosaccharide (TOS), and 15.0 g of agar. The ingredients were suspended in 950 mL of distilled water while being heated carefully with frequent agitation until completely dissolved. The basic medium was dispensed in 190-mL aliquots into 250-mL bottles and sterilized by autoclaving at 115°C for 15 min. The final pH was 6.3 ± 0.2 at 25°C. Simultaneously, 50 mg of lithium-mupirocin (MUP) selective supplement (Merck KGaA) was dissolved in 50 mL of distilled water, and the solution was sterilized by filtration through a membrane with pore diameter of 0.22 μm (Millipore Corp.). Immediately before pouring, at $48 \pm 1^\circ\text{C}$, 10 mL of MUP supplement solution was added to each 190 mL of TOS-propionate agar by using a syringe equipped with a sterile filter unit of 0.22- μm pore size (Millipore Corp.). The complete TOS-MUP agar thus had a final MUP concentration of 50 mg/L. The plates were incubated at 37°C for 72 h. Anaerobic conditions were generated using anaerobic culture jars (2.5 L) and AnaeroGen AN 25 sachets (Oxoid Ltd.). The counts were expressed as logarithm (base 10) colony-forming units per milliliter. The bifidobacteria colonies identified were irregularly shaped or lenticular, and were corroborated by observation under a microscope.

Yeasts and molds were enumerated in yeast extract glucose chloramphenicol (YGC) agar (Merck KGaA). The pH of the medium was 6.6 ± 0.1 at 25°C. The inoculated plates were incubated aerobically at 25°C for 5 d.

The most probable number (3-tube MPN) technique was used to enumerate coliforms and *Escherichia coli*. Brilliant Green Bile 2% broth (Oxoid Ltd.) supplemented with tryptophan and 4-methylumbelliferyl- β -D-glucuronide was distributed into test tubes fitted with Durham's tubes. The pH of the broth was 7.2 ± 0.1 at 25°C. The inoculated test tubes were incubated at 37°C for 24 to 48 h under aerobic conditions. In this test system, the presence of coliforms is indicated by

the formation of gas bubbles in the Durham's tubes. The coliform positive tubes are checked under UV light (366 nm). Kovács indole reagent (Merck KGaA) is then added to the tubes showing fluorescence under UV light, and the presence of *E. coli* is confirmed by the formation of a red ring after 1 to 2 min. Control cultures providing these observations were made, and the test samples were compared with the positive controls.

The pH value of samples was measured at room temperature with a Jenway 3510 pH meter and combined glass electrode (Keison Products, Chelmsford, UK) standardized with pH 4.00 and 7.00 standard buffer solutions (Merck KGaA).

The results were subjected to ANOVA using the general linear model procedure of STATISTICA data analysis software system (version 9.0; StatSoft Inc., Tulsa, OK), with time and product as fixed factors and repetition as covariate in the model. Significant differences among the logarithm (base 10) colony-forming units per milliliter or pH means were determined by using Duncan's multiple comparison test at $P < 0.05$ (StatSoft Inc.).

The data in Table 2 illustrate the changes in viable cell counts of *Strep. thermophilus* CHCC 742/2130 during storage at 4°C. This organism was the most numerous culture component in all 4 products both at the beginning and at the end of the 6-wk storage period. Food regulations in Hungary require fermented dairy foods to contain lactic acid bacteria of starter culture origin at concentrations of at least 10^7 cfu/g at the time of consumption (Codex Alimentarius Hungaricus Commission, 2004). The counts of streptococci alone largely exceeded this value throughout the entire storage period (Table 2). Our findings are in agreement with those of previous observers, that *Strep. thermophilus* generally survives well ($>10^8$ cfu/mL) in yogurt or similar fermented milks stored under refrigeration for 3 to 6 wk (Varga et al., 2002; Antunes et al., 2005; Kudelka, 2010). Surprisingly enough, the viable counts of *Strep. thermophilus* CHCC 742/2130 showed no decline ($P > 0.05$) in fermented camel milk over 6 wk of refrigerated storage. This did not apply to the other 3 products, however, wherein survival rates of streptococci differed ($P < 0.05$) depending on the raw material. The lowest streptococcal viability percentage of 13.2 was observed in fermented goat milk on d 42. At the same time, higher survival rates were measured for *Strep. thermophilus* both in fermented cow (55.0%) and sheep milks (30.2%), but these values also differed ($P < 0.05$) from each other.

As shown in Table 3, the initial viable counts of *Lb. acidophilus* LA-5 were over 2 $\log_{10}$ cycles lower than those of *Strep. thermophilus* CHCC 742/2130, and the 2 species (strains) also differed considerably in their

Table 2. Survival of *Streptococcus thermophilus* CHCC 742/2130 in fermented *acidophilus-bifidus-thermophilus* (ABT) milks during refrigerated storage at 4°C

Storage time (d)	ABT-type fermented dairy food source							
	Camel milk		Cow milk		Goat milk		Sheep milk	
	Log ₁₀ cfu/mL ¹	%	Log ₁₀ cfu/mL ¹	%	Log ₁₀ cfu/mL ¹	%	Log ₁₀ cfu/mL ¹	%
0	8.95 ± 0.13 ^{A,a}	100.0	8.68 ± 0.11 ^{A,b}	100.0	8.76 ± 0.14 ^{A,ab}	100.0	8.80 ± 0.22 ^{A,ab}	100.0
7	8.80 ± 0.03 ^{A,a}	70.8	8.70 ± 0.18 ^{AB,ab}	104.7	8.61 ± 0.06 ^{A,b}	70.8	8.74 ± 0.04 ^{A,a}	87.1
14	8.75 ± 0.32 ^{A,a}	63.1	8.68 ± 0.13 ^{A,a}	100.0	8.60 ± 0.31 ^{A,a}	69.2	8.75 ± 0.13 ^{A,a}	89.1
21	8.86 ± 0.09 ^{A,a}	81.3	8.50 ± 0.08 ^{AB,b}	66.1	8.66 ± 0.06 ^{A,b}	79.4	8.70 ± 0.25 ^{A,ab}	79.4
28	8.92 ± 0.11 ^{A,a}	93.3	8.52 ± 0.21 ^{AB,b}	69.2	8.63 ± 0.14 ^{A,b}	74.1	8.68 ± 0.24 ^{A,ab}	75.8
35	8.93 ± 0.21 ^{A,a}	95.5	8.50 ± 0.08 ^{AB,b}	66.1	8.10 ± 0.43 ^{AB,b}	21.9	8.58 ± 0.24 ^{AB,ab}	60.3
42	8.93 ± 0.16 ^{A,a}	95.5	8.42 ± 0.06 ^{B,b}	55.0	7.88 ± 0.21 ^{B,d}	13.2	8.28 ± 0.06 ^{B,c}	30.2

^{A,B}Means within a column with different uppercase superscripts differ ($P < 0.05$).

^{a-d}Means within a row with different lowercase superscripts differ ($P < 0.05$).

¹Values are means ± SD based on 6 observations (3 samples × 2 replicates).

survival rates. A slow and relatively constant decrease was observed in *Lb. acidophilus* LA-5 numbers and, as a result, viability percentages of this organism in the 4 products did not differ ($P > 0.05$) at the end of the 6-wk storage period. Approximately one-third to half of *Lb. acidophilus* LA-5 cells were capable of surviving refrigerated storage at 4°C. Camel, cow, goat, and sheep milks provided similar conditions for survival of the lactobacilli tested. As for the viability percentages of *Lb. acidophilus*, our results are different than those of Senaka Ranadheera et al. (2012), who reported a decline of almost 4 log₁₀ cycles in *Lb. acidophilus* LA-5 counts in a plain AB yogurt made from goat milk and stored at 4°C for 4 wk. In another trial by Nighswonger et al. (1996), *Lb. acidophilus* LA-5 also exhibited a loss ($P < 0.05$) in viability both in cultured buttermilk and in yogurt when stored for 28 d at 5 and 7°C, respectively.

Table 4 shows the survival rates of *B. animalis* ssp. *lactis* BB-12 in fermented ABT milks over a 6-wk storage period at 4°C. In most cases, the initial viable

numbers of *B. animalis* ssp. *lactis* BB-12 largely exceeded the minimum therapeutic threshold of 10⁶ cfu/mL (Sanders and Huis in't Veld, 1999; Shah, 2000; Kechagia et al., 2013). The cultured dairy foods made from cow, sheep, and goat milks had comparable ($P > 0.05$) bifidobacteria counts on d 0, exceeding those in the camel milk-based product by ca. 0.5 log₁₀ cycle ($P < 0.05$). No losses ($P > 0.05$) occurred in viability of *B. animalis* ssp. *lactis* BB-12 in fermented camel, cow, and sheep milks by the end of the 42-d-long storage period. In contrast, *B. animalis* ssp. *lactis* BB-12 counts decreased by almost 80% in cultured goat milk during 6 wk of refrigerated storage. As a result, the bifidobacteria counts in fermented camel and goat milks were not found to be different ($P > 0.05$) on d 42. Similarly, the final mean count of *B. animalis* ssp. *lactis* BB-12 in cultured cow milk (6.83 log₁₀ cfu/mL) did not differ ($P > 0.05$) from that in fermented sheep milk (6.80 log₁₀ cfu/mL); however, these values were higher ($P < 0.05$) than those measured in the other 2 products (Table 4). The most plausible explanation for these findings

Table 3. Survival of *Lactobacillus acidophilus* LA-5 in fermented *acidophilus-bifidus-thermophilus* (ABT) milks during refrigerated storage at 4°C

Storage time (d)	ABT-type fermented dairy food source							
	Camel milk		Cow milk		Goat milk		Sheep milk	
	Log ₁₀ cfu/mL ¹	%	Log ₁₀ cfu/mL ¹	%	Log ₁₀ cfu/mL ¹	%	Log ₁₀ cfu/mL ¹	%
0	6.71 ± 0.29 ^{AB,a}	100.0	6.48 ± 0.44 ^{A,a}	100.0	6.46 ± 0.15 ^{A,a}	100.0	6.83 ± 0.21 ^{A,a}	100.0
7	6.64 ± 0.16 ^{AB,a}	85.1	6.46 ± 0.03 ^{A,a}	95.5	6.44 ± 0.08 ^{A,a}	95.5	6.66 ± 0.19 ^{A,a}	67.6
14	6.59 ± 0.09 ^{A,a}	75.8	6.39 ± 0.04 ^{A,b}	81.3	6.44 ± 0.17 ^{A,ab}	95.5	6.77 ± 0.13 ^{A,a}	87.1
21	6.68 ± 0.07 ^{A,a}	93.3	6.35 ± 0.23 ^{A,ab}	74.1	6.37 ± 0.07 ^{A,b}	81.3	6.72 ± 0.10 ^{A,a}	77.6
28	6.46 ± 0.16 ^{AB,ab}	56.2	6.47 ± 0.18 ^{A,ab}	97.7	6.27 ± 0.08 ^{AB,b}	64.6	6.62 ± 0.09 ^{A,a}	61.7
35	6.35 ± 0.11 ^{B,a}	43.7	6.38 ± 0.15 ^{A,a}	79.4	6.01 ± 0.17 ^{B,b}	35.5	6.55 ± 0.13 ^{A,a}	52.5
42	6.36 ± 0.35 ^{AB,a}	44.7	6.09 ± 0.55 ^{A,a}	40.7	6.01 ± 0.16 ^{B,a}	35.5	6.53 ± 0.40 ^{A,a}	50.1

^{A,B}Means within a column with different uppercase superscripts differ ($P < 0.05$).

^{a,b}Means within a row with different lowercase superscripts differ ($P < 0.05$).

¹Values are means ± SD based on 6 observations (3 samples × 2 replicates).

Table 4. Survival of *Bifidobacterium animalis* ssp. *lactis* BB-12 in fermented *acidophilus-bifidus-thermophilus* (ABT) milks during refrigerated storage at 4°C

Storage time (d)	ABT-type fermented dairy food source							
	Camel milk		Cow milk		Goat milk		Sheep milk	
	Log ₁₀ cfu/mL ¹	%	Log ₁₀ cfu/mL ¹	%	Log ₁₀ cfu/mL ¹	%	Log ₁₀ cfu/mL ¹	%
0	6.39 ± 0.16 ^{A,b}	100.0	6.89 ± 0.04 ^{A,a}	100.0	7.00 ± 0.18 ^{A,a}	100.0	6.87 ± 0.17 ^{A,a}	100.0
7	6.35 ± 0.05 ^{A,b}	91.2	6.71 ± 0.43 ^{A,ab}	66.1	6.69 ± 0.09 ^{AB,a}	49.0	6.71 ± 0.25 ^{A,ab}	69.2
14	6.30 ± 0.04 ^{A,b}	81.3	6.78 ± 0.15 ^{A,a}	77.6	6.77 ± 0.32 ^{ABC,ab}	58.9	6.83 ± 0.05 ^{A,a}	91.2
21	6.27 ± 0.08 ^{A,b}	75.8	6.80 ± 0.09 ^{A,a}	81.3	6.62 ± 0.16 ^{ABC,a}	41.7	6.88 ± 0.13 ^{A,a}	102.3
28	6.37 ± 0.06 ^{A,b}	95.5	6.82 ± 0.19 ^{A,a}	85.1	6.59 ± 0.52 ^{ABC,ab}	38.9	6.86 ± 0.05 ^{A,a}	97.7
35	6.39 ± 0.25 ^{A,ab}	100.0	6.81 ± 0.10 ^{A,a}	83.2	6.49 ± 0.11 ^{BC,b}	30.9	6.83 ± 0.13 ^{A,ab}	91.2
42	6.24 ± 0.06 ^{A,b}	70.8	6.83 ± 0.08 ^{A,a}	87.1	6.33 ± 0.10 ^{C,b}	21.4	6.80 ± 0.16 ^{A,a}	85.1

^{A-C}Means within a column with different uppercase superscripts differ ($P < 0.05$).

^{a,b}Means within a row with different lowercase superscripts differ ($P < 0.05$).

¹Values are means ± SD based on 6 observations (3 samples × 2 replicates).

is that bovine and ovine milks provided bifidobacteria with higher levels of nutrients than did caprine and camel milks (Table 1), and this was very important because *Bifidobacterium* spp. are known to be fastidious microorganisms, demanding rich media for growth and survival (Scardovi, 1986). As far as the viability of bifidobacteria in fermented milks is concerned, the data found in the literature vary considerably, with counts ranging from <5 to >8 log₁₀ cfu/mL (Abu-Taraboush et al., 1998; Gueimonde et al., 2004; Senaka Ranadheera et al., 2012). It is worth mentioning, however, that the degree of loss in survival of bifidobacteria during 2 to 4 wk of storage is generally reported to be less than 1 log₁₀ cycle (Abu-Taraboush et al., 1998; Gueimonde et al., 2004; Senaka Ranadheera et al., 2012), which is in agreement with our results presented in Table 4.

No yeasts, molds, or coliform bacteria, including *E. coli*, were detected in any of the samples tested in this study, indicating that these preparations were microbiologically safe for human consumption. Postacidification occurred in our fermented ABT milks during 6 wk of refrigerated storage, and no marked difference was observed among the 4 products in this respect (data not shown). The results were consistent with those of Medina and Jordano (1995), who observed a pH decline of 0.3 to 0.4 units in ABT-type fermented dairy products during 36 d of storage at 7°C.

In conclusion, camel, cow, goat, and sheep milks proved to be suitable raw materials for the manufacture of ABT-type fermented dairy products potentially capable of producing a beneficial effect on human metabolism and health even after 6 wk of refrigerated storage. All the samples tested in this study were found to contain viable cells of probiotic *Lb. acidophilus* LA-5 and *B. animalis* ssp. *lactis* BB-12 at sufficiently high numbers (i.e., 10⁶ to 10⁷ cfu/mL). The cell counts of non-probiotic *Strep. thermophilus* CHCC 742/2130 also

exceeded, by 1 to 2 log₁₀ cycles, the minimum value required by the Codex Alimentarius Hungaricus. It is suggested that milk from small ruminants be increasingly used to produce probiotic fermented dairy foods. An even more promising idea is the development of camel milk-based probiotic cultured milks because new markets could thus be conquered. It must be emphasized, however, that further microbiological and sensory studies, technology development activities, and market research are needed before such food products can be successfully commercialized.

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