Angiotensin converting enzyme-inhibitory activity and antimicrobial effect of fermented camel milk (*Camelus dromedarius*)

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This study aimed to determine the angiotensin converting enzyme-inhibitory activity and antimicrobial effect of fermented camel milk. Samples were prepared either using *Lactobacillus acidophilus* and *Streptococcus thermophilus* or *Lactobacillus helveticus* and *Str. thermophilus* and labelled as S1 and S2, respectively. The IC_{50} values of S1 and S2 samples ranged between 113–200 and 70–133 μg/mL, respectively. The antimicrobial effects of S1 and S2 samples against *Bacillus cereus*, *Salmonella Typhimurium* and *Staphylococcus aureus* were apparent after 12 h of incubation and continued until 15 days of storage, whereas unfermented camel milk exhibited no antimicrobial effects against any of the tested pathogens.

Keywords Camel milk, Angiotensin converting enzyme, Antimicrobial effect, Bioactive peptides, *Lactobacillus*.

INTRODUCTION

Food is no longer considered by health professionals and consumers to provide basic nutrition needs but also expected to provide disease-preventive attributes. Thus various dairy products have been introduced to the market to protect consumers from certain nutrition-related diseases. Fitzgerald and Murray (2006) reported that certain health benefits associated with fermented dairy products were due to the release of bioactive peptides during the fermentation process. Angiotensin converting enzyme-inhibitory (ACE-I) peptide is one of the most studied bioactive peptides (Meisel and Bockelmann 1999) and known as a major regulator of blood pressure. Daily ingestion of fermented bovine sour milk containing a starter culture of *Lactobacillus helveticus* and *Saccharomyces cerevisiae* was found to reduce risk of hypertension and contribute towards the maintenance of health (Yamamoto et al. 1999). Likewise, long-term feeding of milk fermented with *L. helveticus* containing Val-Pro-Pro and Ile-Pro-Pro peptides has also been found to lower blood pressure in rats and human subjects (Sipola et al. 2002). In addition, McCann et al. (2006) isolated two antimicrobial peptides from bovine αS1 and αS2 casein; these peptides showed antimicrobial activity against Gram-positive bacteria. Moreover, lactobacilli strains have been reported to produce antimicrobial substances such as lactic acid, diacetyl and bacteriocins that are considered to be inhibitory to pathogens and other bacteria (Curry and Crow 2011).

Most research in the literature has focused on the functional properties of bovine milk, while camel milk has not been given enough attention. Furthermore, information on camel milk health benefits in the literature is limited. Recent studies have shown that camel milk protein is an important nutritional and functional source (Alhaj and Al Kanhal 2010). Few differences were found between ACE-I peptide of camel milk proteins and other ruminants (Alhaj and Al Kanhal 2010; Alhaj and Kanekanian 2014). Camel milk was found to exhibit antimicrobial effect against...
Gram-positive and Gram-negative bacteria (Benkerroum et al. 2004). This might be due to the presence of natural antimicrobial substances in camel milk, including lysozyme, lactoferrin, lactoperoxidase and immunoglobulins (El-Agamy et al. 1992). Other components corresponding to αS2-casein from ovine milk hydrolysate were also reported to have antibacterial activity against several Gram-positive and Gram-negative micro-organisms (López-Expósito et al. 2006). Camel milk, on the other hand, provides particular health benefits, depending on the amino acid sequence of the bioactive peptide. These bioactive peptides could be generated or indirectly enriched by adding starter or nonstarter cultures. The addition of Lactobacillus rhamnosus to camel milk was recently studied, which was shown to exhibit ACE-I activity (Moslehishad et al. 2013). Furthermore, the addition of L. helveticus 130B4 to Mongolian camel milk resulted in the production, isolation and identification of ACE-I peptides, including the nonapeptide Ala-Ile-Pro-Pro-Lys-Lys-Asn-Gln-Asp (Quan et al. 2008).

Many ACE-I peptides identified in the literature were produced from bovine milk proteins using only L. helveticus strains (Yamamoto et al. 1999; Sipola et al. 2002) or in combination with Streptococcus thermophilus (Donkor et al. 2007). The addition of a Str. thermophilus strain to milk was reported to result in production of peptides active against pathogens during milk fermentation (Campagna et al. 2004). The combination of two or more different types of strains was found to exhibit a wider variety of functional components than milk cultured with a single strain (Kuwabara et al. 1995). Therefore, either L. helveticus or Lactobacillus acidophilus was incorporated with Str. thermophilus in this study, to enhance the potential functional properties of camel milk, including antimicrobial effects and ACE-I activity. This study aimed to determine the ACE-I activity and antimicrobial effects of dromedary fermented camel milk.

MATERIALS AND METHODS

Material and cultures

Angiotensin converting enzyme from rabbit lung (ACE), hippuryl-His-Leu, ethyl acetate, cadmium chloride, lactic acid and Leu-Gly were purchased from Sigma-Aldrich (Saint Louis, Missouri), USA. De Man, Rogosa and Sharpe (MRS) agar, MRS broth, peptone water and MRS broth at 40 °C were purchased from Sigma-Aldrich (Saint Louis, Missouri), USA. De Man, Rogosa and Sharpe (MRS) broth at 40 °C for up to 24 h (repeated three times). Then an aliquot of 1 mL of active overnight culture was inoculated in 100 mL of sterilised skimmed milk at 40 °C for 48 h of multiple transfers to obtain approximately 10^8 colony-forming units (CFU)/mL as a preculture.

Preparation of water soluble extracts (WSE) and water soluble permeate (WSP) from fermented camel milk

Whole camel milk from different breeds (Majahiem, Hamra and Wadhah) of Camelus dromedaries (one humped) was collected from a private farm located in the central region of Saudi Arabia. Milk was mixed equally at the same volume, and then fat was separated using Laboratory Supply Company (Labsco) separator (Friedberg, Germany). Skimmed milk was sterilised using Arnold method at 85 °C for 30 min (exposing milk to steam in an open valve autoclave apparatus for three successive days) as described by Alhaj et al. (2011) and then inoculated with pre-culture of a total of 3% of either L. acidophilus (1.5%) and Str. thermophilus (1.5%) or L. helveticus (1.5%), and Str. thermophilus (1.5%), labelled as S1 and S2, respectively. Samples were then incubated at 40 °C for up to 10 h until the culture medium reached pH 4.4. The fermented samples were then stored at 4 °C for 14 days to determine ACE-I activity and antimicrobial activity during incubation and storage. The WSE from S1 and S2 samples was prepared by centrifugation at 12 000 g for 10 min at 4 °C using an Hermle centrifuge (HERMLE Labortechnik GmbH, Z36HK, Wehingen, Germany). The collected supernatant was then filtered through a Millipore syringe filter (45 μm) according to the method described by Quiros et al. (2005) with some modifications (filter type). The WSE of unfermented camel milk was prepared by adding 7% lactic acid to milk to reach pH 4.4 followed by filtration using a 45-μm syringe filter. Of the WSE samples, some (taken at 6 h, 12 h, 3 d, 9 d and 15 d) were selected for further fractionation with Amicon filters (3 kD) because they were giving high ACE-I activity and antimicrobial effects. These were then compared with unfermented camel milk (0 h). The WSP of all the samples (fermented and unfermented) was prepared according to the product instruction by ultrafiltration of WSE samples (10 mL) through Millipore Amicon filter of 3 kD at 5000 g for 30 min using Hermle centrifuge (Z36HK). The resultant WSE and WSP of all samples were collected in 1.5-mL Eppendorf tubes and stored at ~20 °C until use.

Total bacterial counts of fermented camel milk

Total bacterial counts of S1 sample containing L. acidophilus and Str. thermophilus or S2 sample containing (ATCC 25923) were from American Type Culture Collection (ATCC Saint Cloud, Minnesota, USA) in freeze-dried form.

Growth condition of strains

The freeze-dried L. acidophilus, Str. thermophilus and L. helveticus were activated individually in sterile 10 mL MRS broth at 40 °C for up to 24 h (repeated three times). Then an aliquot of 1 mL of active overnight culture was inoculated in 100 mL of sterilised skimmed milk at 40 °C for 48 h of multiple transfers to obtain approximately 10^8 colony-forming units (CFU)/mL as a preculture.

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Total bacterial counts of fermented camel milk

Total bacterial counts of S1 sample containing L. acidophilus and Str. thermophilus or S2 sample containing
**L. helveticus** and **Str. thermophilus** were undertaken using the pour plate method (Donkor et al. 2006). Serial dilutions of S1 and S2 samples were carried out in sterile 0.15% (w/v) peptone water. Triplicate samples of 1 mL aliquots from the serial dilutions were used for enumeration on MRS agar medium and incubated at 40 °C for 72 h under anaerobic conditions. Colony-forming units/mL of each sample were counted. The average of total bacterial counts of both samples (S1 and S2) were determined at different time intervals of 3-, 6-, 9- and 12-h incubation and after 1-, 3-, 6-, 9-, 12- and 15-days’ storage and represented as log CFU/mL.

### Determination of degree of hydrolysis and free amino acid

The Ortho-Phthalaldehyde method was used to determine the degree of hydrolysis of WSE from fermented and unfermented camel milk at an absorbance of 340 nm using a UV–Vis spectrophotometer, and expressed as free amino group (FAG) concentration (mM) of Leu-Gly as described by Church et al. (1983). The free amino acid content of WSE from fermented and unfermented camel milk was determined and expressed as absorbance at 507 nm on a UV–Vis spectrophotometer using Cd-ninhydrin method, as described by Yu et al. (2012).

### Determination of ACE-I activity and IC50 of fermented camel milk

The angiotensin converting enzyme-inhibitory activity of WSE and WSP from unfermented and fermented camel milk samples (S1 and S2) was determined using the method described by Benkerroum et al. (2000). The pH of WSE and WSP samples was neutralised with 1 mol/L NaOH to eliminate the effects of organic acid and hydrogen peroxide. Müller Hinton Agar medium was prepared, sterilised and poured into Petri dishes at volume of 20 mL. After solidification, the MH-agar plates were used for disc diffusion susceptibility test as follows: MH-agar plates were seeded with 0.1 mL of an overnight pathogenic culture *(B. cereus, E. coli, S. Typhimurium and Staph. aureus)*. Discs were placed on the surface of inoculated MH-agar, and 50 μL of WSE and WSP from unfermented and fermented camel milk (S1 and S2) at 0 h, 12 h, 3 d, 9 d and 15 d was loaded on the discs. All plates were incubated at 37 °C for 24 h, and then the inhibition zones diameters were measured.

### Statistical analysis

Experiments were run in triplicates and analysed for ±standard deviation (SD) using SAS statistical software (SAS Institute, Cary, NC, USA). Two sample differences were determined using two sample *t*-test. Multiple differences were determined using *ANOVA* with Duncan analysis. All data were assumed to be normally distributed, and results were deemed significant when *P* < 0.05 throughout.

### RESULTS AND DISCUSSION

#### Total count and survival

The results in Figure 1 show that mixed starters including *L. acidophilus* and *Str. thermophilus* in S1 sample and *L. helveticus* and *Str. thermophilus* in S2 sample were able to grow and survive in camel milk during the incubation time (24 h) and cold storage (up to 14 day). The average of total bacterial counts of S1 and S2 samples after 3-h incubation was 3 x 10^6 CFU/mL (6.48 log) and
2.2 × 10^7 CFU/mL (7.34 log), respectively, and the difference was not significant. These results are in agreement with those reported in bovine acidophilus milk (Gomes et al. 1998). However, significant P < 0.05 differences in total count were noticed between S1 and S2 samples at 12 h of incubation time. These results could be attributed to the high free amino acids (FAAs) in the raw camel milk, which was higher than that reported by Abu-Taraboush et al. (1998) for bovine milk. The higher the amino acid content, the better the bacterial growth and metabolism throughout the fermentation process (Mehaia and Al-Kanhal 1992). Total counts increased slowly to a maximum of 9 × 10^8 CFU/mL (8.95 log) and 3 × 10^8 CFU/mL (8.47 log) for S1 and S2 samples, respectively, after 3-day storage at 4 °C (Figure 1). These numbers are above the minimum level (10^7 CFU/mL) of live probiotic cells required to support health claims during the product’s shelf life (EU 2003). In addition, the results showed significant P < 0.05 increase in total counts between 3 and 15 d for both samples (S1 and S2). However, between the end (15 days) and 6th day of storage, the total counts of S1 and S2 samples were slightly increased or remained stable at 10^8 CFU/mL due to acid development (pH 4.17). Gopal (2011) reported that survival of L. acidophilus was higher at refrigerated temperature (5–9 °C) compared to a room temperature of 25 °C.

**Degree of hydrolysis (proteolytic activity)**

The fermented camel milk samples, S1 and S2, exhibited different proteolytic activity trends when Ortho-phthalaldialdehyde and Cd-ninhydrin methods were used (Figure 2a,b). The results showed that the FAAs of S1 and S2 samples were higher than that noticed in unfermented sample i.e. (naturally occurring). However, the liberation of most peptides of varying sizes and FAAs occurred during the first 12 h of fermentation with both samples (S1 and S2), as shown in Figure 2 (b). This may be due to the high FAAs content of camel milk (Abu-Taraboush et al. 1998) and the suitable of pH and temperature that enhanced the proteolytic activity of the strains during the first 12 h of incubation. The increase in absorbance values in relation to FAAs between 0 h (unfermented) and after 12 h incubation for both samples (S1 and S2) was significant at P < 0.05. The FAAs concentration increased gradually until it reached a maximum at 15 day of cold storage. This increase was associated with better survival and viability in S1 and S2 in fermented camel milk samples (Figure 1). These results are in agreement with that reported by Donkor et al. (2006) on bovine milk, where an increase in proteolytic activity
resulted in better survival of certain probiotic strains, including *L. acidophilus* and *Str. thermophilus*, in yoghurt during storage. The FAAs in S1 and S2 samples showed an increasing trend; this increase was significant *P* < 0.05 between 12 h and 15 day in S1 sample and among 12 h, 6 day and 15 day in S2 sample (Figure 2b).

The concentration of FAG in WSE in unfermented camel milk was 0.045 mM (Leu-Gly). The addition of starter cultures increased FAG concentration in both camel milk samples, S1 and S2, as shown in Figure 2 (a). The concentration of FAG significantly (*P* < 0.05) increased after 3 h of incubation to 2.27 and 3.35 mM (Leu-Gly) in S1 and S2 samples, respectively. Afterwards, different trends were noticed between S1 and S2 samples, where the FAG concentration was slightly higher after 15 day of storage in S1 sample, while sample S2 showed a significant (*P* < 0.05) increase in FAG concentration during 12-h, 3-d and 15-d storage. Moreover, the maximum FAG concentration of 6.33 mM in S2 sample was noticed after 15 d storage as shown in Figure 2 (a). This trend was also reported by Abu-Taraboush *et al.* (1998) when different bifidobacteria strains were added to camel milk.

**Angiotensin converting enzyme-inhibitory activity and IC$_{50}$ of fermented camel milk**

The IC$_{50}$, which represents the concentration of ACE inhibitor (fermented camel milk) needed to inhibit 50% of ACE activity, was determined. The results (in Table 1) showed an unexpected IC$_{50}$ value of 144 µg/mL for WSP from unfermented camel milk. This inhibitory effect was also reported in unfermented bovine milk proteins by Mullally *et al.* (1997) and Donkor *et al.* (2007). This was attributed to the presence of some bioactive peptides that were produced by the enzymatic activities of the contaminating bacteria in the raw milk (Otte *et al.* 2007) or by the endogenous enzymes of the milk itself (Gobbetti *et al.* 2004). Moreover, the concentration of FAG in unfermented camel milk was low 0.045 mM and the IC$_{50}$ value was 144 µg/mL. This activity could be due to the ACE-inhibitory peptides rather than their overall concentration, that is a high concentration of inactive ACE-inhibitory peptides is less effective and provides lower ACE-inhibitory activity than potent ACE-inhibitory peptide. Hydrolysis is therefore necessary to release ACE-Inhibitory peptides from the sequence of camel milk caseins.

The IC$_{50}$ values of WSP from S1 and S2 samples ranged between 113–200 and 70–133 µg/mL, respectively, as shown in Table 1. This trend of increase and decrease in IC$_{50}$ value of S1 and S2 samples was also reported by Donkor *et al.* (2007) and Moslehishad *et al.* (2013) and attributed to the balance between the formation of ACE-I peptides and further breakdown into inactive peptides and amino acids. Results showed that the higher ACE-I activity (%) of fermented camel milk was in general giving lower IC$_{50}$ as shown in Table 1. However, the highest IC$_{50}$ value of 200 µg/mL was noticed in WSP from S1 sample after 12-h incubation; this was higher than the IC$_{50}$ values of unfermented camel milk samples (144 µg/mL). This increase in IC$_{50}$ value (from 144 to 200 µg/mL) was significant (*P* < 0.05) and may be due to further hydrolysis of active ACE-I peptides in the S1 sample. Moreover, this was associated with the release of most of the ACE-I peptides and the highest FAG concentration in S1 sample, as shown in Figure 3. Fuglsang *et al.* (2003) reported that some lactic acid bacteria, including lactococci and lactobacilli (26 strains), were shown to have a proportional relationship between ACE-I activity and peptides release. The IC$_{50}$ value of WSP from S1 samples exhibited a downward trend after initially increasing during the 12-h incubation. The IC$_{50}$ values decreased significantly (*P* < 0.05) (ACE-I activity increased) to 174, 113 and 121 µg/mL during cold storage of 3, 9 and 15 d, respectively. This may be due to the production of potent ACE-I peptides or further degradation of inactive ACE-I peptides.

On the other hand, the IC$_{50}$ value of WSP from S2 sample significantly (*P* < 0.05) decreased from 144 µg/mL (0 h) to 80 µg/mL during the first 12 h of incubation time due to formation of ACE-I peptides. This was followed by

<table>
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<th>Table 1</th>
<th>ACE-I activity and IC$_{50}$ of water soluble permeate (WSP) from fermented camel milk during incubation and cold storage time. Standard deviations are given in brackets.</th>
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IC$_{50}$: Concentration of an ACE-inhibitor (fermented and un-fermented camel milk) needed to inhibit 50% of ACE activity; S1: WSP of camel milk fermented with *Streptococcus thermophilus* and *Lactobacillus acidophilus*. S2: WSP of camel milk fermented with *S. thermophilus* and *L. helveticus*. 0 h: WSP from unfermented camel milk.
an increasing trend during cold storage at 4 °C (3–9 day). These results showed significant ($P < 0.05$) differences in IC$_{50}$ value in WSP from S2 samples among 12-h, 3-day and 9-day time. Moreover, the results of S2 sample (Table 1) showed a sharp decrease in IC$_{50}$ value of 70 µg/mL at the end of storage (15 day) due to the formation of potent ACE-I peptides. This was associated with the release of the most potent ACE-I peptides and the highest FAG concentration, as shown in Figure 3. The correlation between the release of peptides and ACE-I activity was reported by Papadimitriou et al. (2007) and Otte et al. (2007). The variation noticed in IC$_{50}$ values between the S1 and S2 samples was significant at $P < 0.05$ for all incubation and storage times. These variations were also reported by other researchers investigating fermented camel milk (Moslehishad et al. 2013) and fermented bovine milk (Donkor et al. 2007).

The ACE-I activity in the current study was strain dependent, in agreement with Donkor et al. (2005), whereas S1 samples containing L. acidophilus and Str. thermophilus exhibited lower ACE-I activity compared to S2 samples which contained L. helveticus and Str. thermophilus. Furthermore, significant ($P < 0.05$) differences in ACE-I activity were noticed between the S1 and S2 samples at 12-h, 3-d and 15-d. Lactobacillus helveticus has stronger proteolytic activity as it requires most amino acids to fulfil its exceptional need for amino acids (Morishita et al. 1981). This could theoretically explain the superiority of the S2 samples with regard to ACE-I activity compared to S1 samples. Nonetheless, the low ACE-I activity may indicate that fermented milk does not possess the same range of hypotensive potentials as known classical inhibitors (Donkor et al. 2005). The selected proteolytic digestion strain plays the main role in the formation of ACE-I peptides in hydrolysed milk.

**Antimicrobial effect of fermented camel milk**

The WSE from unfermented camel milk samples (0 h) in the current study exhibited no antimicrobial effect (inhibition zone) against all the tested pathogens, as shown in Table 2. In contrast, WSE from S1 and S2 samples showed varying degrees of inhibition against B. cereus, S. Typhimurium and Staph. aureus after 12-h incubation and continued until 15 d storage. This may be due to the production of antimicrobial peptides in the S1 and S2 samples by the added culture. The inhibition zone diameters of WSE from S1 samples against B. cereus, S. Typhimurium and Staph. aureus all measured 12 mm after 12-h incubation. The inhibition zone between 3- and 15-d storage either remained unchanged or increased to 14 mm in the case of B. cereus after 15-d storage (Table 2). A larger inhibition zone against B. cereus, S. Typhimurium, E. coli and

<table>
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<th>Pathogens</th>
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<th>Escherichia coli</th>
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S1: WSE from camel milk fermented with *Lactobacillus acidophilus* and *Streptococcus thermophilus*; S2: WSE from camel milk fermented with *L. helveticus* and *S. thermophilus*; 0 h: WSE from unfermented camel milk. ++, very large inhibition zone (ca 14–16 mm); +, large inhibition zone (ca 11–13 mm); ±, medium inhibition zone (ca 8–10 mm); –, no inhibition zone.
Staph. aureus was reported in another study (cheese produced from bovine milk) with two strains of L. acidophilus (Tharmaraj and Shah 2009). Nonetheless, no effect was observed for all the S1 samples against E. coli. In comparison, WSE from S2 samples showed antimicrobial effect against all tested pathogens, whereas the inhibition zone diameter of WSE from S2 samples against B. cereus, E. coli, S. Typhimurium and Staph. aureus after 12-h incubation was 11, 13, 14 and 14 mm, respectively. The inhibition zone between 3 and 15 d was stable against S. Typhimurium Staph. aureus and E. coli, but decreased against B. cereus after 15-d storage. The inhibition zone of S2 samples (9 and 15 day) against B. cereus decreased due to further degradation of antimicrobial peptides, which producing smaller inactive antimicrobial peptides. However, the inhibition zone diameters of B. cereus, E. coli, S. Typhimurium and Staph. aureus were 13, 13, 14 and 16 mm, respectively, after 15 d storage (Table 2).

The WSE from S1 and S2 samples (0 h, 12 h, 3 day, 9 day, 15 day) were further filtered through an Amicon filter of less than ≤3 kD to determine the antimicrobial effect of the resultant WSP. The WSP of all unfermented camel milk samples exhibited no antimicrobial effects against all the tested pathogens. Similarly, WSP from S1 samples showed no inhibitory effect against B. cereus, E. coli and S. Typhimurium (Table 3). Nonetheless, WSP from S1 samples showed inhibitory effect against Staph. aureus after 12-h incubation and continued up to 15-d storage. Their inhibition zone diameters ranged between 8 and 13 mm. On the other hand, WSP from S2 samples exhibited inhibitory effect against B. cereus, E. coli, S. Typhimurium and Staph. aureus after 12 h incubation. Their inhibition zone diameters were 9, 8, 8 and 10 mm, respectively (Table 3). This inhibitory effect was stable and continued up to 15 d for all S2 samples (Table 3). McCann et al. (2006) isolated and identified a positively charged peptide (f99–109) from bovine αs1-casein using pepsin hydrolysis. This peptide has shown antimicrobial activity against S. Typhimurium, E. coli, Salmonella Enteritidis and Citrobacter freundii and Gram-positive bacteria Bacillus subtilis and Listeria innocua. The antimicrobial effect of WSP for both samples (S1 and S2) was lower than that of WSE samples. This is most likely because some of the antimicrobial peptides (lager than 3 kD) were retained in the Amicon filter. In general, the antimicrobial effects of S2 samples containing L. helveticus and Str. thermophilus were higher than that noticed in S1 samples containing L. acidophilus and Str. thermophilus. This might be due to the extent of proteolytic activity of L. helveticus, which resulted in more antimicrobial peptide formation in S2 samples.

CONCLUSION

Fermented camel milk has shown potential health benefits, including ACE-I activity and antimicrobial effects. Nonetheless, it was evident that WSP from unfermented camel milk have ACE-I activity (IC₅₀) of 144 μg/mL but show no antimicrobial effects against all the tested pathogens. These health benefits were found to be time and strain dependent, whereas significant (P < 0.05) differences in IC₅₀ values were noticed between S1 and S2 samples at all incubation and storage times. The inhibition effect of WSE from fermented camel milk samples (S1 and S2) against B. cereus, S. Typhimurium and Staph. aureus was apparent after 12 h of incubation and continued until 15 d storage. The results show that S2 samples containing L. helveticus and Str. thermophilus were superior to S1 samples containing L. acidophilus and Str. thermophilus with regard to ACE-I activity and antimicrobial effect. Potential health benefits need to be confirmed in vivo. This would promote the

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<td>±</td>
<td>–</td>
<td>±</td>
</tr>
<tr>
<td>3 d</td>
<td>–</td>
<td>±</td>
<td>–</td>
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</tr>
<tr>
<td>9 d</td>
<td>–</td>
<td>±</td>
<td>–</td>
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</tr>
<tr>
<td>15 d</td>
<td>–</td>
<td>±</td>
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</tr>
</tbody>
</table>

S1: WSP from camel milk fermented with Lactobacillus acidophilus and Streptococcus thermophilus. S2: WSP from camel milk fermented with L. helveticus and S. thermophilus. 0 h: WSP from unfermented camel milk. ++, very large inhibition zone (ca 14-16 mm); +, large inhibition zone (ca 11-13 mm); ±, medium inhibition zone (ca 8-10 mm); –, no inhibition zone.
introduction of a commercial product with potential health benefits, but fermentation conditions have to be optimised as well as sensory evaluation.

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