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REGULAR ARTICLE

Effects of exopolysaccharide-producing starter cultures on physicochemical, rheological and sensory properties of fermented camel's milk

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Abstract

The aim of this study was to examine the influence of using exopolysaccharide (EPS) producing starter cultures on physicochemical, rheological and sensory properties of fermented camel milk. Four starter cultures of the strains of non-EPS and EPS-producing were combined and distribution in four treatments portions to made yoghurt from camel's milk. Results showed that the maximum acetaldehyde and diacetyl contents were found in control treatment during 7 days storage period. The EPS concentration was detected between 41.3 to 269.3 mg/kg in the yoghurt made with non-EPS and EPS-producing starter cultures. The highest EPS concentration was observed in treatment C (1.5% EPS-producing *Streptococcus thermophilus* plus 1.5% non EPS-producing Lb. delbrueckii ssp. bulgaricus) during 14 days storage period, then reduced at the end of the storage period. Yoghurt made with any EPS-producing strains had significantly ($P<0.05$) lower firmness, syneresis and higher viscosity values than control yoghurt. Overall acceptability scores of the sensory evaluation revealed that the yoghurt made with EPS-producing starter cultures in treatment C was the most accepted, while the control treatment was the least. According to the results, exopolysaccharide enhance viscosity, texture and mouthfeel and to avoid syneresis in yoghurt. The results of this study suggest that the use of EPS-producing cultures could provide better textures for camel milk yoghurt than those imparted by additives.

Key words: Exopolysaccharide, Fermented camel milk

Introduction

The dromedary (*Camelus dromedarius*) is known for its ability to survive drought periods and camel milk has been called the white gold of the desert (Wernery, 2006). Milk is considered a secondary product and milk yield of the Egyptian camels is 4.5 L/d on average (Ibrahim, 2009). However, under more favorable climatic conditions, as in the north of the country or under the intensive oasis production system, milk yield usually ranges between 6 and 12 L/d (Hammadi et al., 2006).

Camel's milk is more technically difficult to process than milk from other domestic animals. Recently, little work dealt with manufacturing of camel milk products, such as cheese (Mehaia, 1994; Ibrahim, 2009; Konuspayeva et al., 2014), butter (Fatah et al., 1989; Berhe et al., 2013), ice cream (Abu-Lehia, 1989) and fermented camel milk (Farah et al., 1990; Konuspayeva and Faye, 2011; Ibrahim, 2013) has been reported.

The appearance, mouthfeel and acceptability are quality parameters of yoghurt texture. Many additives are proposed to increase firmness and avoid syneresis: stabilizers, hydrocolloids (Keogh and O'Kennedy, 1998), gelatin, whey protein or calcium (Ares et al., 2007; Supavititpatana et al., 2008).

The starters including *S. thermophilus* and Lb. delbrueckii ssp. bulgaricus are able to produce exopolysaccharide (EPS) in relatively small quantity, 40 to 400 mg/L (De Vuyst et al., 2003). EPS is a molecule having water binding ability and consequently an effect on the texture of yoghurt (Broadbent et al., 2003), especially on firmness and level of syneresis (Hassan et al., 1996), mouth thickness, shininess, clean cut, viscosity and creaminess (Folkenberg et al., 2005).

No work has been carried out to study the influence of EPS-producing starter cultures on physiochemical properties of fermented camel milk. So, the objectives of the present study are a trial to improve the physicochemical, rheological

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and sensory properties of fermented camel milk by using EPS-producing starter cultures.

Materials and Methods

Culture and Growth Conditions

Strains of EPS-producing *Lb. delbrueckii ssp. bulgaricus* CHCC 3984 (LbEPS) and *Streptococcus thermophilus* CHCC 3534 (StrEPS) and non-capsule forming *Lb. delbrueckii ssp. bulgaricus* CHCC 769 (LbNEPS) and *Streptococcus thermophilus* CHCC 5842 (StrNEPS) used in this study were obtained from Chr. Hansen (Hørsholm Bøge Allé 10-12, DK-2970, Denmark). The strains were grown in skim milk (10 g/100 ml) into sterile and stored at 4°C.

Production of camel's milk Yoghurt

Fresh camel's milk was obtained from Sidi-Barani areas Matrouh Governorate, North West Coast, Egypt. The gross composition of raw milk was: Total solids 12.13±0.11%; Fat 3.35±0.04%; Total protein 3.29±0.05%; lactose 4.67±0.09%; Titratable Acidity 0.17±0.01% and pH 6.65±0.03.

The method of yoghurts manufacture used was proposed by Tamime and Robinson (1985). The raw milk was heated up to 40°C and skim milk powder was added (skim milk powder used had 34% protein, 52% lactose ,1% fat, 6.8% ash and 5.2% moisture obtained from (Valio Co. Helsinki, Finland), so that the total solids content was increased to 15%. Milk was heat treated at 90°C for 30 min and cooled to 42°C, and then divided in four equal portions where,

1) Treatment (A): camel milk inoculated with 1.5% (v/v) non EPS-producing Lb. delbrueckii ssp. bulgaricus CHCC 769 plus 1.5% (v/v) non EPS-producing *Streptococcus thermophilus* CHCC 5842 as (control).

2) Treatment (B): camel milk inoculated with 1.5% (v/v) non EPS-producing *Streptococcus thermophilus* CHCC 5842 plus 1.5% (v/v) EPS-producing *Lb. delbrueckii ssp.* Bulgaricus CHCC 3984.

3) Treatment (C): camel milk inoculated with1.5% (v/v) EPS-producing *Streptococcus thermophilus* CHCC 3534 plus 1.5% (v/v) non EPS-producing Lb. delbrueckii ssp. bulgaricus CHCC 769.

4) Treatment (D): camel milk inoculated with 1.5% (v/v) EPS-producing *Streptococcus thermophilus* CHCC 3534 plus 1.5% (v/v) EPS-producing Lb. delbrueckii ssp. Bulgaricus CHCC 3984.

Each portion was inoculated with 3% (v/v) starter cultures, then transferred to 200 g polystyrene plastic cups and incubated at 42°C for 8-10 h until coagulation, then cooled and stored at 4°C for 21 days. Analyses were performed in the experimental yoghurt after 1, 7, 14 and 21 days of storage. The experiment was repeated three times in duplicate.

Microbiological Analysis

Fermented milk samples were subjected to microbiological analysis at days1, 7, 14 and 21. All microorganisms that were put into yoghurt were enumerated by using different media and methods mentioned below. One gram of yoghurt was accurately weighted and transferred quantitatively to sterile conical flask 100 ml with deionized water containing 0.9% NaCl and 0.1% peptone and mixed with a stomacher. Subsequent dilutions were made in peptone water and the volume was made up to the mark to get the final 1/100 dilution and used in making further dilution.

Total aerobic mesophilic bacterial count

Total aerobic mesophilic bacterial counts were determined by using tryptone glucose extract agar (T.G.E.A) (Oxoid Ltd., Basingstoke, UK) as described by American Public Health Association (APHA, 1992). The plates were incubated at 37° C for 2-3 days.

Streptococcus thermophilus

M17 agar containing 5g/L lactose (Oxoid Ltd., Basingstoke, UK) was used to enumerate *S. thermophilus* (Torriani et al., 1996). The pH of the medium was 6.9 ± 0.1. The inoculated plates were incubated aerobically at 37°C for 48 h.

Lb. delbrueckii subsp. bulgaricus

Acidified (pH 5.2) MRS (deMan, Rogasa, Sharpe) agar (Difco Laboratories) supplemented with 0.5 g/L cysteine was used for enumeration of *Lb. delbrueckii subsp. bulgaricus* according to Dave and Shah (1996). Plates were incubated under anaerobic conditions using AnaeroGen in plastic anaerobic jars (Oxoid) at 37°C for 72 h.

Enterobacterial group counts

Enterobacterial group count was estimated by plating suitable dilution on violet red bile agar medium (V.R.B.A) (Oxoid Ltd., Basingstoke, UK) as described by American Public Health Association (APHA, 1992). The plates were incubated for 24 h at 35±1°C.

Yeast and Moulds count (Y&M)

Oxytetracycline-glucose-yeast extract agar (OGYE agar) (Oxoid Ltd., Basingstoke, UK) medium was used in counting Yeast and Moulds as described by American Public Health Association (APHA, 1992). Plates were incubated at 25±1°C for 4-5 days.

Chemical analysis

Yoghurt samples were analyzed for total solids, fat, total protein, ash content % and titratable acidity % as described by Ling (1963). Lactose content % was determined by the phenol-sulfuric spectrophotometeric method as reported by Barnett and Abd-El-Tawab (1957). The pH value of samples was measured at room temperature with an HI 8521 pH-Meter and combined glass electrode (Hanna Instruments Deutschland GmbH, Karlsruhe, Germany). The total volatile fatty acids (TVFA, as ml N/10 NaOH/10 g) were determined by the distillation method described by Kosikowski (1982). Diacetyl (spectrophotometric method) according to Lees and Jago (1970), and Acetaldehyde (spectrophotometric method) by using method of Lees and Jago (1969). All the analyses were performed in triplicate.

The EPS content was determined as follows: 1 volume of fermented milk was mixed with 1 volume of 20% (wt/vol) trichloroacetic acid (TCA), heated at 100°C for 5 min, and centrifuged at 3500×g for 10 min at 20°C. The supernatant was removed, and the pellet was suspended in 0.5 volumes of 10% (wt/vol) TCA and centrifuged again. Aqueous phases were pooled and dialyzed at 4°C against deionized water for 4 d. The EPS concentration in the suspension after dialysis was quantified using the phenol-sulphuric method of Dubois et al. (1956) and was expressed as glucose equivalent with glucose as the standard.

Rheological measurements

Apparent viscosity

Apparent viscosities of yoghurts were measured on cup at 20°C with a Brookfield viscometer (model DV II+ Pro Brookfield Engineering Laboratories, Inc., Middleboro, MA) after 1, 7, 14 and 21 d of storage. The spindle used (LV-SC4-34 spindle at 4 rpm) in 150 g of yoghurt. The spindle was allowed to rotate in the sample for 1 min at 20°C (Shihata and Shah, 2002).

Gel firmness

The gel firmness was measured by a texture analyzer (model TAXT2, Stable Microsystems, Surrey, UK) with a P20 probe (diameter 20 mm) and 25 kg load cell. Firmness was measured as the force (g) required breaking the gel when the probe traveled a distance of 2 cm into the yoghurt sample at a speed of 0.2 mm/s (Sandoval-Castilla et al., 2004).

Syneresis

The syneresis of yoghurts was measured according to Tamime et al. (1996) with a minor modification. The method was based on spontaneous movement of whey out of the gel under the force of gravity. One hundred grams of yoghurt samples were inverted on a fine mesh screen placed on top of a funnel. After 2 h of drainage at 5±1°C, the quantity of whey expelled from a 100 g yoghurt sample was expressed as milliliters of drained whey.

Sensory evaluation

Panel of seven judges were chosen from the staff of the Desert Research Center (DRC) to conduct the sensory evaluation of the yoghurt. Panel members evaluated all yoghurt for appearance, texture and flavor (odor and taste) .The attributes of flavor and texture were given priority over appearance, as advised by Tamime and Robinson (1985). The samples were scored on their organoleptic properties using score card for flavor (10points), body and texture (5 points) and appearance and color (5 points).

Statistical analysis

Statistical analysis for experimental data was analyzed as completely randomized design. The obtained data were carried out according to the SPSS package (SPSS v.18, Chicago, II 60611, USA, 2012). Differences were considered significant at ($P<0.05$).

Results and Discussion

The data presented in Table 1 showed the changes in chemical composition of fermented camel's milk made with non EPS and EPS-producing starter cultures during storage period at 4±1°C for 21 days. It was clear that the titratable acidity (TA) % and TVFA in all treatments gradually increased ($P<0.05$) with increasing storage period.

The highest values of titratable acidity % found in control treatment during 21 days storage period. These results were in agreement with that obtained by Abbas and Osman (1998) Salama (2002) and Badran et al. (2004) who reported that the TA increased gradually during storage period. The majority of EPS-producing microorganisms utilize carbohydrates as their energy source as well as their carbon source for EPS formation, but the non-EPS-producing starter cultures utilize carbohydrates as their energy source as well as their carbon source for lactic acids and volatile production formation (Lo et al., 2007).

During storage, TVFA gradually increased ($P<0.05$) in all treatments until the end of storage period. The highest values of TVFA found in treatment B during 21 days storage period. The increase in TVFA may be due to several lipases and

esterases (Gupta and Prasad, 1989; Benech et al., 2003).

Results showed that the maximum acetaldehyde and diacetyl content were found in treatment A during 7 days storage period then decreased in the end of storage period. These results are in agreement with that finding of Tamime and Robinson (1999). Salama (2002) and Badran et al. (2004) found that acetaldehyde and diacetyl contents gradually increased during 3 days of storage period and then decreased in the end of storage period.

However, during storage period, the amount of acetaldehyde decreased because of the reduction by microbial enzymes in order to form other substances such as ethanol (Güler-Akın, 2005). Bonczar and Regula (2003) reported a continuous increase in acetaldehyde content of the yoghurt through 14 days of storage period. Bonczar et al. (2003) determined that the acetaldehyde contents of yoghurts stored for 14 days increased up to day 7 followed by a decrease.

In general, Ott et al. (2000) and Bongers et al. (2004) reported that non EPS-producing strains of yogurt bacteria produced high levels of acetaldehyde. In contrast, ropy or viscous strains produce low levels of acetaldehyde.

The EPS concentration was detected around between 41.3 to 269.3 mg/L in the yoghurts made with non EPS and EPS-producing starter cultures. The highest EPS concentration was observed in treatment C during 14 days storage period and then reduced ($P<0.05$) at the end of the storage period.

Fatouma et al. (1997) and Grobben et al. (1995) reported that the quantities of EPS and the viscosity of milk cont aining different species of lactic acid bacteria in pure strain cultures vary considerably. The amounts of EPS range from 50 to 350 mg/L for *Streptococcus thermophilus* and from 60 to 150 mg/L for *Lactobacillus delbrueckii ssp. bulgaricus*.

These results are in agreement with that finding of Frengova et al. (2000). They reported that the polymer forming of *thermophilic streptococci* was higher than that of the lactobacilli and the quantities of EPS produced by different strains varied considerably. The reason for this difference could be due to the varying EPS producing abilities of these cultures.

There are several possible reasons for the difference between studies, including the use of different strains and the level of inoculation of starter cultures, the differences in fermenting conditions and methods of isolation, purification and quantification of EPS.

The changes in EPS content during storage were explored by different authors (Amatayakul et al., 2006; Doleyres et al., 2005) with different conclusions, probably linked to the different method used.

Elsewhere, the presence of lactose could modify the results. Indeed, the pheno-sulfuric method used for quantifyng EPS is not specific. In consequence, low concentrations of EPS (41.3 mg/L) was found in non-EPS yoghurt because of their lactose residue.

Table 1. Changes in chemical properties of camel's milk yoghurt made with non EPS (control) and EPS-producing cultures during storage period at 4±1 °C for 21 days.

Treatments	Storage (Days)	Titratable acidity %	EPS mg/kg	TVFA (ml N/10 NaOH/10 g)	Diacetyl mg/kg	Acetaldehyde mg/kg
Lb^{NEPS}+ Str^{NEPS} (A)	1	0.76^{j}±0.01	45.3^{n}±0.58	4.71^{gh}±0.01	0.73^{de}±0.06	29.20^{b}±1.06
	7	0.80^{hij}±0.01	53.7^{m}±2.31	5.72^{de}±0.19	1.17^{a}±0.06	33.07^{a}±1.01
	14	0.92^{cd}±0.07	61.3^{l}±1.15	6.19^{bc}±0.56	0.80^{d}±0.10	26.27^{e}±0.64
	21	1.03^{a}±0.06	41.3^{o}±0.58	6.25^{abc}±0.13	0.47^{hi}±0.06	19.20^{i}±1.06
Lb^{EPS} + Str^{NEPS} (B)	1	0.78^{ij}±0.02	161.0^{k}±1.00	4.87^{ge}±0.06	0.90^{c}±0.01	26.80^{de}±0.35
	7	0.83^{ghi}±0.01	185.7^{g}±0.58	5.35^{gh}±0.65	1.10^{ab}±0.04	28.07^{bcd}±0.12
	14	0.87^{efg}±0.02	198.0^{e}±1.73	6.38^{abc}±0.20	0.63^{g}±0.06	20.80^{h}±0.35
	21	0.94^{bc}±0.05	167.0^{j}±0.01	6.72^{a}±0.19	0.50^{h}±0.01	13.73^{j}±0.83
Lb^{NEPS} + Str^{EPS} (C)	1	0.78^{ij}±0.02	214.0^{c}±4.00	4.50^{h}±0.01	0.67^{ef}±0.06	22.33^{g}±0.12
	7	0.84^{efgh}±0.02	253.3^{b}±2.89	5.07^{fg}±0.38	0.80^{d}±0.01	27.67^{cd}±1.94
	14	0.89^{de}±0.03	269.3^{a}±1.15	6.00^{cd}±0.10	0.53^{h}±0.06	19.33^{i}±0.46
	21	0.97^{b}±0.02	192.7^{f}±2.52	6.64^{ab}±0.12	0.40^{i}±0.01	10.80^{k}±0.35
Lb^{EPS} + Str^{EPS} (D)	1	0.78^{ij}±0.02	180.3^{h}±1.53	4.60^{gh}±0.10	0.73d^{e}±0.06	24.13^{f}±0.90
	7	0.84^{fgh}±0.01	208.3^{d}±2.89	4.79^{gh}±0.18	1.07^{b}±0.06	28.80^{bc}±0.35
	14	0.88^{def}±0.03	190.3^{f}±0.58	5.47^{ef}±0.15	0.73^{de}±0.06	22.67^{g}±0.31
	21	0.98^{b}±0.05	175.3^{i}±1.53	6.52^{ab}±0.16	0.53^{h}±0.06	12.93^{j}±0.12

^{abcde}Means followed by different letter in the same column are significantly different ($P<0.05$).

Regarding the changes in viscosity, firmness and syneresis of camel's milk yoghurt made with non EPS (control) and EPS-producing cultures during storage period at 4±1°C for 21 days (Table 2), firmness and syneresis gradually decreased ($P< 0.05$) in all treatments until the end of storage period. The highest values of syneresis and firmness ($P< 0.05$) was found in fresh control treatment, while the highest values of viscosity ($P< 0.05$) was found in treatment D during 21 days storage period.

The differences in viscosities among fermented milks made with EPS-producing strains can be attributed to differences in the amount and molecular characteristics of EPS and their ability to interact with proteins (Dupont et al., 2000).

The firmness (g) of yoghurts made using ropy EPS-producing starter cultures was generally lower than that in control yoghurt made with non EPS-producing starter cultures. Similar results were reported by other researchers (Marshall and Rawson, 1999; Hassan et al., 1996) who observed that yoghurt made using EPS-producing starter had lower firmness compared to the control sample.

The exopolysaccharide (EPS) content in yoghurt affects the yoghurt texture. In general, they reduce firmness of yoghurt (Folkenberg et al., 2006). Furthermore, combinations of the two types of EPS-producing cultures improved not only the total EPS production but also yoghurt texture (Marshall and Rawson, 1999).

On the other hand, yoghurt made with non EPS-producing cultures (control) showed higher ($P < 0.05$) syneresis than yoghurt made with EPS-producing cultures. This result is in agreement with studies conducted by Folkenberg et al., (2005 and 2006) who reported that yogurts made with non EPS-producing cultures showed higher syneresis than did these made with non EPS-producing cultures. The difference in syneresis in milk fermented with these EPS-producing cultures should be attributed only to differences in EPS and their interaction with the protein network.

However, EPS have the ability to bind water (De Vuyst and Degeest, 1999) which counteracts the negative effect of the open structure. Therefore, syneresis of milk fermented with EPS-producing cultures depends on the ability of EPS to bind water, which is affected by their type and amount and by their distribution and interactions with the protein network.

Furthermore, a longer fermentation time in camel milk allows more structural rearrangements, which leads to formation of weak structure with increased spontaneous syneresis, This result is in agreement with reported by Lee and Lucey, (2004) who reported that rearrangements of casein particles in the gel network and the rate of solubilization of colloidal calcium particles are the driving forces for spontaneous syneresis.

Table 2. Changes in rheological parameters of camel's milk yoghurt made with non EPS (control) and EPS-producing cultures during storage period at 4ºC for 21 days.

Treatments	Storage (Days)	Viscosity (cp)	Firmness (g)	Syneresis (ml/100 g)
Lb^{NEPS}+ Str^{NEPS} (A)	1	565^{l}±5.00	68.0^{a}±0.1	42.3^{a}±0.58
	7	587^{k}±5.77	67.7^{a}±0.6	39.0^{b}±0.40
	14	643^{j}±28.87	62.3^{de}±0.6	38.3^{b}±0.58
	21	633^{j}±5.77	58.3^{f}±0.6	37.0^{c}±1.00
Lb^{EPS} + Str^{NEPS} (B)	1	840^{j}±4.00	66.7^{b}±0.6	32.3^{e}±0.58
	7	883^{i}±5.77	65.7^{c}±0.6	30.3^{f}±0.58
	14	937^{g}±7.64	63.0^{d}±0.1	27.3^{h}±0.58
	21	915^{h}±5.00	62.0^{e}±0.1	29.3^{ef}±0.58
Lb^{NEPS} + Str^{EPS} (C)	1	1260^{e}±4.00	50.3^{h}±0.6	24.3^{j}±0.58
	7	1317^{d}±5.77	51.3^{g}±0.6	21.7^{k}±0.58
	14	1367^{b}±5.77	48.3^{i}±0.6	20.3^{l}±0.58
	21	1363^{b}±5.77	43.7^{j}±0.6	26.0^{i}±1.00
Lb^{EPS} + Str^{EPS} (D)	1	1152^{f}±2.89	39.3^{l}±0.3	28.0^{gh}±1.00
	7	1270^{e}±10.00	41.2^{k}±0.3	27.7^{gh}±0.58
	14	1333^{c}±5.77	35.7^{lm}±0.6	25.3^{ij}±0.58
	21	1390^{a}±4.00	36.3^{m}±0.6	28.7^{fg}±0.58

^{abcde}Means followed by different letter in the same column are significantly different ($P < 0.05$).

Many changes were observed in survival of Total aerobic bacteria, *S. thermophiles and Lb. delbrueckii ssp. bulgaricus*, Enterobacterial groups and yeasts and moulds of camel's milk yoghurt made with non EPS (control) and EPS-producing cultures during storage period at 4±1°C for 21 days (Table 3).

The viable counts of total aerobic count in yoghurt increased with increasing storage periods and then remained nearly decreased until the end of storage period with significant differences ($P<0.05$) between all treatments. This trend was similar in yoghurt produced using non EPS or EPS-producing starter cultures. Furthermore, during the storage period, the viable counts of *S. thermophilus* and of *Lb. delbrueckii* ssp. bulgaricus in the yoghurt made with non EPS or EPS-producing starter cultures gradually decreased after 14 days with significant differences ($p<0.05$) between all treatments. The viable counts of *S. thermophilus* were higher in almost all fresh samples then *Lb. delbrueckii ssp.* bulgaricus predominance during the end of storage period. This may be explained by the differences in the fermentation time in camel milk that affects the population of this bacterium. Similar results were reported by Abu-Tarboush (1996) found that the streptococci were always more numerous than the lactobacilli during fermentation of camel milk at 42ºC for 4 h.

On the other hand, Abdel Moneim et al., (2006) showed the predominance of lactic acid bacteria in garris product (Sudanese traditional fermented camel milk) and the major genus was Lactobacillus (74%). Also Lore et al. (2005) investigated suusac (Kenyan traditional fermented camel milk) and found the total lactic acid bacteria counts were 6.8 log cfu/ml and the main genus was *Lactobacillus* spp.

The viable count of lactic bacteria was higher in yoghurt produced with Lb. delbrueckii ssp. bulgaricus because its proptectice effect, non-observed with *S. thermophilus* even after cold storage (Amatayakul et al., 2006; Salvator and Fiszman (2004). As long as these products were refrigerated, the viable cell counts of lactic acid bacteria gradually decreased till the end of storage period. This phenomenon could be attributed to the fact that the population of viable yoghurt bacteria increased to attain the highest count just after manufacture of yoghurt, and then decreased during refrigerated strong of the product (Hamann and Marth, 1984).

Table 3. The Changes of viable bacteria and Yeast & Moulds counts of camel's milk yoghurt made with non EPS and EPS-producing cultures during storage period at 4°C for 21 days (log cfu/ml).

Treatments	Storage (Days)	Total aerobic count (log cfu/ml)	*S. thermophilus* (log cfu/ml)	*Lb. delbrueckii subsp. bulgaricus* (log cfu/ml)	*Enterobacterial* groups (log cfu/ml)	Yeast & Moulds (log cfu/ml)
Lb^{NEPS}+ Str^{NEPS} (A)	1	7.69^{bcde}±0.04	7.30^{c}±0.63	6.54^{e}±0.44	ND	ND
	7	7.90^{abcd}±0.04	7.44^{abc}±0.60	7.01^{cde}±0.28	ND	ND
	14	8.12^{ab}±0.16	7.90^{a}±0.08	7.17^{bcd}±0.10	ND	ND
	21	7.48^{cde}±0.01	7.11^{abc} ±0.67	7.10^{cde}±0.15	ND	ND
Lb^{EPS} + Str^{NEPS} (B)	1	7.40^{de}±0.08	7.27^{abc} ±0.61	6.93^{de}±0.08	ND	ND
	7	7.55^{cde}±0.04	7.35^{abc} ±0.56	7.11^{cde}±0.60	ND	ND
	14	7.93^{abc}±0.02	7.43^{abc} ±0.09	7.61^{abcd}±0.50	ND	ND
	21	7.29^{e}±0.01	7.00^{bc}±0.01	6.95^{de}±0.50	ND	ND
Lb^{NEPS} + Str^{EPS} (C)	1	7.54^{cde}±0.10	7.44^{abc}±0.40	7.32^{abcd}±0.12	ND	ND
	7	8.32^{a}±0.58	7.77^{ab}±0.05	7.92^{a}±0.08	ND	ND
	14	8.16^{ab}±0.08	7.74^{ab}±0.12	7.85^{ab}±0.12	ND	ND
	21	7.37^{e}±0.05	6.78^{abc}±0.11	7.07^{cde}±0.70	ND	ND
Lb^{EPS} + Str^{EPS} (D)	1	7.46^{cde}±0.02	7.27^{abc}±0.61	7.19^{bcd}±0.13	ND	ND
	7	8.19^{ab}±0.57	7.67^{ab}±0.54	7.72^{abc}±0.33	ND	ND
	14	8.30^{a}±0.69	7.76^{ab}±0.63	7.54^{abcd}±0.05	ND	ND
	21	7.25^{e}±0.03	7.00^{bc}±0.01	7.07^{cde}±0.70	ND	ND

^{abcde} Means followed by different letter in the same column are significantly different .($P<0.05$).
ND = not detected.

Results showed that the coliform bacteria and yeasts & moulds were not detected in all yoghurt treatments either fresh or stored which are due to the good hygienic conditions during the preparation and storage of yoghurt. Also, it may be due to the role of lactic acid bacteria in preservation of the product which associated with their ability to produce some antimicrobial compounds (El- Nagar and Shenana, 1998; Ibrahim et al., 2004).

Regarding the sensory quality acceptance of yoghurt, the visual appearances made with EPS-producing strains were the same than for with non EPS-producing: the gels were smooth and without syneresis.

However, the yoghurt made with non EPS-producing (control) had significantly ($P<0.05$) lower ratings for body and texture, appearance and color, flavor and overall acceptance score due to wheying-off on the fermented milk surface (Table 4). Moreover, treatments B, C and D flavor was acceptable till 14 days of storage period with rich mouth feel and good acid taste. After 16 days, the acceptable decreased with an appearance due to wheying-off on the fermented milk surface.

The overall acceptability scores of the sensory evaluation revealed that the fermented camel milk by EPS-producing starter cultures in treatment C was the most accepted, while the control treatment was the least.

The flavor of non-EPS yoghurts was prefered by the panel of consumers as the scores were higher ($P<0.05$). This difference could be attributed to the acetaldehyde content.

The development of acidity during storage contributed also to the decrease of flavour score. Similar results have been reported for various fermented milk products such as yoghurt, dahi, and cultured buttermilk (Doleyres et al., 2005; Behare et al., 2009).

Conclusion

The use of EPS-producing starter cultures reduced the level of syneresis and increased the viscosity of camel milk yoghurt. On the other hand, the use of non EPS- producing starter culture gave a better flavor based on acetaldehyde content in the yoghurt samples. However, the presence of EPS compensates increasing texture and mouthfeel of camel milk yoghurt. According to the results, EPS enhance viscosity, texture and mouthfeel and to avoid syneresis in camel milk yoghurt. The results of this study suggest that the use of EPS-producing starter cultures could provide better textures for camel's milk yoghurt than those imparted by additives.

Table 4. Sensory evaluation of camel's milk yoghurt made with non- EPS (control) and EPS-producing cultures during storage at 4±1°C for 21 days.

Treatments	Storage (Days)	Flavour (Max 10 Points)	Body and Texture (Max 5 Points)	Appearance and Colour (Max 5 Points)	Overall Acceptability Score (20)
Lb^{NEPS}+ Str^{NEPS} (A)	1	7.7^{b}±0.76	3.1^{e}±0.90	3.4^{b}±0.53	14.3^{c}±1.25
	7	7.6^{b}±0.53	3.1^{e}±0.69	3.7^{b}±0.49	14.4^{c}±0.53
	14	8.1^{ab}±0.38	3.4^{de}±0.53	3.4^{b}±0.53	15.0^{c}±0.82
	21	7.7^{b}±0.76	3.3^{de}±0.49	3.6^{b}±0.53	14.6^{c}±1.51
Lb^{EPS} + Str^{NEPS} (B)	1	7.9^{b}±0.69	4.3^{abc}±0.49	4.4^{a}±0.53	16.6^{b}±1.27
	7	8.3^{ab}±0.76	4.4^{ab}±0.53	4.6^{a}±0.53	17.3^{ab}±1.11
	14	8.4^{ab}±0.79	3.9^{bcd}±0.69	4.4^{a}±0.53	16.7^{b}±1.11
	21	8.3^{ab}±0.95	3.7^{cde}±0.49	4.4^{a}±0.53	16.4^{b}±1.51
Lb^{NEPS} + Str^{EPS} (C)	1	8.1^{ab}±0.90	4.7^{a}±0.49	4.6^{a}±0.53	17.4^{ab}±1.13
	7	8.9^{a}±0.38	4.6^{a}±0.53	4.9^{a}±0.38	18.3^{a}±0.95
	14	8.3^{ab}±0.76	4.6^{a}±0.53	4.6^{a}±0.53	17.4^{ab}±0.98
	21	8.1^{ab}±0.69	4.9^{a}±0.38	4.6^{a}±0.53	17.6^{ab}±0.53
Lb^{EPS} + Str^{EPS} (D)	1	8.0^{ab}±0.58	4.3^{abc}±0.49	4.6^{a}±0.53	16.9^{b}±0.69
	7	8.1^{ab}±0.90	4.7^{a}±0.49	4.9^{a}±0.38	17.7_{ab}±1.60
	14	8.4^{ab}±0.53	4.6^{a}±0.53	4.6^{a}±0.53	17.6^{ab}±0.79
	21	8.0^{ab}±0.82	4.7^{a}±0.49	4.6^{a}±0.53	17.3^{ab}±1.11

^{abcde}Means followed by different letter in the same column are significantly different ($P < 0.05$).

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