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Effect of Using Cactus Pear Pulp on The Properties of Goats' Milk Bio- Yoghurt Drinks

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GOATS' MILK bio-yoghurt drinks were made using different levels (5, 10 and 15 %w/w) of cactus pear fruits' (*Opuntia dillenii*) pulp (CPFP) and fermented with Yo-Fast1 (containing of *Lactobacillus delbrueckii* ssp. *bulgaricus* & *Streptococcus thermophilus*) as commercial yoghurt starter and ABT-5 (containing of *Lactobacillus acidophilus*, *Streptococcus thermophilus* & bifidobacteria) starter culture with potential probiotic properties. All treatments differed significantly ($p \leq 0.05$) in their properties; depending on the percent of CPFP added, starter culture used and storage period (9 days at 60.5°±C). Fresh yoghurt drinks made with CPFP displayed ($p \leq 0.05$) higher rheological parameters than that of the control except flow behaviour index values. The viscosity of all yoghurt drinks increased while, the whey separation decreased with the increase of added CPFP till the end of storage period. Furthermore, with increasing the percentage of CPFP used, there were slight and gradual decreases ($p \leq 0.05$) in the pH values of all treatments as compared with control. Also, the colour parameters for all yoghurt drinks changed slightly during storage and the rate of pigments degradation depending on the percentage of CPFP used. Results exhibited new bio- yoghurt drinks rich in the total phenolic compounds and high in antioxidant activity, which are increased significantly ($p \leq 0.05$) with rising CPFP levels added. Also, the counts of viable cells in all treatments were maintained at an acceptable level (>10^6cfu/ml) to be considered as functional foods until the end of storage period. Sensory evaluation showed that all CPFP yoghurt drinks treatments were more accepted by the panellists, rated above average, particularly when fermented with probiotic starter culture. The addition of CPFP significantly improved the quality attributes of goats' milk yoghurt drinks and could be considered as new goats' milk products with probiotic properties and health benefits.

Keywords: Bio-goats' milk yoghurt drinks, Cactus pear fruit pulp, Physicochemical properties, Rheological properties, Antioxidant activity, Sensory properties.

Introduction

The importance of goats as providers of essential food around the world increased significantly, which is reflected in the largest animal number increase during the last 20 years (FAO, 2014). Milk production of goats is likely to be much greater than in official statistics, because of the large amounts of unreported home consumption, especially in developing countries (Park & Haenlein, 2006 and Eissa et al., 2010). Goats' milk is preferred to cows' or buffaloes' milk in many parts of the world (Albenzio & Santillo, 2011). Goats' milk has been described as having higher digestibility, lower allergenic properties especially in non-sensitized children, higher buffering capacity and distinct alkalinity than cows' milk (Senaka Ranadheera et al., 2012). Besides, certain therapeutic properties, several biological functions have been reported (Slačanac et al., 2010). Thus, the use of milk with particular nutritional properties as goats' milk alone or in combination with bacterial strains having probiotic properties represents one of the technology options for manufacturing new dairy healthy products (Saad et al., 2013).

The use of different fruits (Peaches, cherries, apricots, and blueberries, ….etc) and additives are frequently used in yoghurt production since time ago to improve its nutritional and sensory properties as well as its consumption (Arslan & Ozel, 2012). Cactus pear fruit (*Opuntia*. *Ficus indica*; *Opuntia*

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spp., Cactaceae) is fleshy bush tree, widely distributed and grows in arid and semi arid regions; native to the desert zones of north-western Mexico and the south-western United States. The Mediterranean basin (Italy, Spain, Egypt and Morocco) is important production region also. In Egypt, the cultivated area reached more than 3000 Fadden (cultivated in newly reclaimed areas, arid and semi arid zone) with an annual production of 29442 tons prickly pear fruits. The production is mainly located in four governorates (Kalubia, Giza and Al-Nubaria city-Beheira, Alexandria) which represent 92.76% of the total production. Opuntia dillenii is one of cactus pear species newly cultivated in Egypt since 2012 (El-Samahy et al., 2014). There are green, red, yellow and purple cactus pear (Opuntia spp) fruits due to the presence of various pigments such as betalains and carotenes (El-Samahy et al., 2006). Cactus pear fruits are characterized by diverse functional components such as: pigments, carotenoids, phenolic compounds including f1avonoids, betalains and ascorbic acid, mucilage, fiber, and other constituents. Furthermore, it had higher vitamin C content than apple, pear, grape and banana, rich in potassium, calcium and phosphorous and low in sodium. The antioxidant activity of cactus pear was found to be 2-fold higher compared with pear, apple, tomato and grape but similar to that of red grape raisin, orange and grapefruit (Yahia & Mondragon, 2011). It has also antinflammatory, anticancer effect and analgesic properties. Also, cactus fruit are reducing blood lipid and total cholesterol, low-density lipids and triglycerides. So, the consumption of cactus pear fruits is recommended for their beneficial and therapeutic properties (Siriwrdhana et al., 2006). The pulp of Cactus pear fruit could be processed in different products (jams, marmalades, syrups, puree, juice, dehydrated sheets and concentrated juice). Also, there is an increasing interest for large scale processing of cactus pear fruit for the production of colouring foodstuffs, functional dairy products and beverage. The high content of soluble solids also makes the cactus pears' pulp suitable for the growth of micro-organisms, considered to be as a prebiotics for the production of functional dairy products (MoBhammer et al., 2006 and Yahia, 2011). A number of authors have studied cactus pear fruit chemical composition and nutritional value (Yahia & Mondragon, 2011) but, until now much less work has been done on the development of fermented product with cactus pear fruit (El-Samahy et al., 2014).

Consequently, this work was undertaken to study the possibility of preparation probiotic goats› milk yoghurt drink using different concentrations of cactus pear fruit (*Opuntia dillenii*) pulp with the emphasize on the physicochemical, rehological properties, antioxidant activity and sensory quality attributes as surviving microorganisms during storage period in attempts to achieve a goats' milk yoghurt drinks as potentially functional dairy products.

Materials and Methods

Materials

1-Goats' milk used in this study were collected randomly from Shami goats animals with small holder herds grazed in Ras Sudr area, South Sinai Governorate, Desert Research Center. Milk was immediately maintained and stored under refrigerated conditions until used. Bulk goats' milk samples contained 13.02 ±0.45 % total solids, 3.99±0.28 % fat, 3.65±0.27% total protein, 4.63±0.34 % lactose (by the difference) , 0.75±0.01 % ash and pH of 6.64±0.65.

2- Mature local cactus pear fruits (*Opuntia dillenii spp*.) were obtained from a farm belongs to Ras Sudr research station (season 2015), South Sinai Governorate, Desert Research Center. Carboxy methyl cellulose (CMC) was obtained from Danisco Ingredients (Copenhagen, Denmark). Also, sugar (sucrose) was purchased from a local market.

3-Two commercial freeze-dried DVS mixed bacterial starters namely: Yo-Fast1 (containing of *Lactobacillus (Lb.) delbrueckii* ssp. *bulgaricus & Streptococcus (Str.) thermophilus)* as yoghurt starter and ABT-5 (containing of *Lb. acidophilus, Str. thermophilus* & bifidobacteria) with potential probiotic properties (from Chr. Hansen Laboratory Copenhagen, Denmark). Starter culture was prepared separately. Fresh buffaloes' skim milk (0.1% fat and 9.5% SNF) was autoclaved (121ºC / 10 min) , then inoculated by DVS Freeze-dried starters at 0.02 % (w/v). The cultured were incubated at 42˚C for Yo-Fast1 starter and 39˚C for ABT-5 starter, until curdling of milk. Cultures were prepared 24 hr before use. Stock cultures and working cultures were prepared as described by Lee and Lucey (2004).

Preparation of cactus pear pulp

Fresh ripened cactus pear with peel were washed (under tap water) thoroughly to remove the thorns, cut to remove seeds, un-coloured top and bottom sides, then sucrose (2%) was added to the obtained pulp and mixed (using Braun Power Max MX 3000 Blender, Germany), filtered through a matrix of stainless steel without addition of any water, then homogenized at 55-60˚C for 2 min using high speed mixer (30000 rpm/min^{-1}) (X 520, UAC 30-R, Chicago

II 6064). The prepared fruit puree homogenates were filled into jars and pasteurized 72°C for 15 sec and cooled immediately. Characteristics of the resultant cactus pear fruits' pulp used in the manufacturing of functional goats' milk fruits yoghurt drinks are presented in Table 1.

Preparation of goats' milk yoghurt drinks

Preliminary experiments were conducted to optimize the level of sucrose and CMC in the manufacture of goats' milk yoghurt drink. It was found by sensory acceptability test that, addition of 2 % sucrose was perceived as most appropriate sweetness. Also, adding 0.2% CMC gave the desired body and texture to goats' milk yoghurt drink. Goats' milk was homogenized at 55-60°C for 2 min using high speed mixer (30000 rpm/min^{-1}) (X 520, UAC 30-R, Chicago II 6064). CMC was added to goats' milk at the ratio of 0.2 % (w/v), heated in a water bath at 85°C for 30 min. Goats' milk was divided into 2 equal portions.

The first was cooled to 42°C and the second to 39°C for inoculation with 3 % (v/v) (10^8 - 10^9 cfu/ml) of Yo-Fast1 and ABT-5 mother cultures, respectively. The different treatments were dispensed into one L plastic cups, incubated to ~ 3 h for Yo-Fast1 culture and ~ 4 h for ABT-5 culture, then immediately cooled at 6±0.5°C for 4 h. After that, Cactus pear pulp was added to the goats' yoghurt at the ratios of (control),5,10 and 15%. All formulations (packed into 200 ml sterilized bottles) cooled and storage at 6±0.5°C for 9 days. The final goats' milk fruit yoghurt drink treatments were subjected to physicochemical properties analysis during storage when fresh and after 3, 6 and 9 days at 6±0.5°C.

Analysis of cactus pear fruits' pulp

Total soluble solids (TSS), as Brix, was measured using a refractometer (Abbe Hergestellt in der DDR, Germany) at 20°C. Total solids, moisture, fat, total nitrogen (using micro-Kjeldahel method) , ascorbic acid, ash, vitamin C, total acidity (as citric acid), pH, pectin, crude fiber and dietary fiber according to AOAC (2012).

The total phenolic compounds, betalains, antioxidant activity were determined according to the methods described by Jaramillo- Flores et al. (2003) , Stintzing et al. (2003) and Lee et al. (2003), respectively.

Chemical and physicochemical determinations of goats' milk and cactus pear yoghurt drinks

The total solids, fat (using Gerber method), total nitrogen (using micro-Kjeldahel method) and ash (using Thermolyne,type 1500 Muffle Furnace) contents; as well as pH values determined by using digital pH meter (Inolad model 720, Germany) in fresh goats' milk and yoghurt samples were measured according to AOAC (2012). Total carbohydrates were calculated by the difference for all samples analysed. Also, the pH values of goats' milk yoghurt drink treatments were measured when fresh (samples

TABLE 1. Composition and physico-chemical characteristics of cactus pear pulp.

Physico-chemical characteristics		Content
Total solids (%)		12.97±0.36
Moisture (%)		87.03±0.92
Total soluble solids (TSS) (%)		9.48±0.27
Fat (%)		0.88±0.02
Total protein (%) [1]		0.29±0.01
Ash (%)		1.72±0.09
Total carbohydrates (%)[2]		9.24±0.25
Total Pectin (%) for dry weight		2.31±0.17
Dietary fiber (%) for dry weight		3.91±0.18
Crude fiber (%) for dry weight		0.84±0.02
Acidity (%) as citric acid		0.18±0.01
Vitamin C (mg. 100g $^{-1}$)		33.05±0.60
Betacyanin (mg.100g $^{-1}$)		24.57±0.41
Betaxanthin (mg.100g $^{-1}$)		25.77±0.54
Total betalains (mg.100g $^{-1}$)		50.34±0.72
Total phenolic compounds (mg GAE. 100g $^{-1}$)		92.05±0.97
Antioxidant activity (%)		38.28±0.63
pH		4.58±0.24
Colour readings	*L*	40.12±0.69
	a	13.52±0.40
	b	2.15±0.11

[1]: Total protein =TN × 6.25; [2]: Calculated by the difference

after 24hr of refrigerated storage) and during storage period (6±0.5°C for 8 days). Synersis was measured as mentioned by Farouq & Haque (1992) as the amount of spontaneous whey (ml /100g) drained off after 2 hr at 7°C when fresh and during storage in all treatments. Acetaldehyde and diacetyl (µmol/ml) contents were determined according to Lees and Jago (1969) and (1970), respectively. The antioxidant activity and total phenolic compounds of yoghurt drink were extracted and determined as described by Li et al. (2009)

Measurements of viscosity were done using Brookfield DV-E Viscometer (Brookfield Engineering Laboratory Inc., Stoughton, MA) with a helipath stand mounted with a spindle No.SC4-21 that rotated at different rpm ranged from (20-200) at shear rates ranging from 3.13 to 31.3 s^{-1} Data were collected Using Wingather soft ware (Brookfield Engineering Laboratory Inc., Stoughton, MA). Viscosity was monitored at 7°C as formerly described by Djurdjevic′ et al. (2001). Dynamic viscosity (poise) (p) was calculated at a constant shear rate of 15.65 s^{-1}. The rehological properties were fitted to Herschel - Bulkley (generalized power law equation). It is main benefit is it's applicable to great number of non - Newtonian fluids over a wide range of shear rates (Steffe, 1996). The equation of this model is: $\sigma = \sigma_{\circ} + K.(\gamma)^{n}$ where σ is the shear stress (mPa), $\sigma_{\circ}$ is the yield stress(mPa), γ is the shear rate (s^{-1}), K

Bacteriological analyses of goats' milk yoghurt drinks

All goats' milk yoghurt drink was prepared for bacteriological analysis according to the method described in the Standard Methods for the Examination of Dairy Products (Wehr & Frank, 2004). Viable cells counts of Lb. delbrueckii ssp. bulgaricus on MRS agar (pH 5.2) (Anaerobic incubation at 45 ºC for 72 hr), Lb. acidophilus on MRS-sorbitol agar (Anaerobic incubation at 37°C for 72 hr), Str. thermophilus on ST agar (Aerobic incubation at 37°C for 24 hr) and bifidobacteria on MRS agar (Oxoid) supplemented with L-cystein and lithium chloride (Sigma Chemical CO.,USA) (Anaerobic incubation at 37°C for 72 hr) were enumerated as described by Dave & Shah (1996). The plates were incubated in an anaerobic environment (BBL Gas Pak, Becton Dickinson Microbiology Systems). The results expressed as $\log_{10}$ colony forming unit (cfu)/ml of sample. The results expressed as $\log_{10}$ colony forming unit (cfu)/ml of sample and the survival % at the end of refrigeration storage period was also calculated according to Nebesny et al., (2007).

Sensory evaluation of goats' milk yoghurt drinks

Sensory evaluation was carried out according to the score sheet described by Clark et al. (2009). Goats' milk yoghurt drink samples were subjected to sensory assessment by 15 staff members of the Animal Production Division, Desert Research Center, Cairo, Egypt. All samples were evaluated when fresh (one day) and throughout storage for 8 days at 6±0.5°C. Acceptability of the different goats' milk yoghurt drink samples were evaluated as follows: flavour (1-10 points), body and texture (1-5 points) and appearance and colour (1-5points), also the panellists were asked to list any defects.

Statistical analyses

All experiments and analysis were done in triplicate. Statistical analyses were carried out using the General Liner Models procedure of the SPSS® 16.0 Syntax Reference Guide (SPSS®, 2007) The results were expressed as least squares means with standard errors of the mean. Statistically different groups were determined by the LSD (least significant difference) test ($p \leq 0.05$).

Results and Discussion

Physico-chemical properties of fresh cactus pear goats' milk yoghurt drinks

Table 2 shows that the cactus pear (CP) pulp concentrations used in the manufacture of goats' milk yoghurt drinks (GMYDs) had significant and more pronounced effect ($p \leq 0.05$) on the chemical composition than the type of starter culture used ($p \geq 0.05$) as evident from the increase in the total solids , ash , total carbohydrate and crude fiber contents. Also, it could be observed from the data that, GMYDs treatments with probiotic starter culture showed slight decreased in total protein content than that made by use yoghurt starter culture; this may be due to the limited proteolysis of milk protein by lactic acid bacteria, same findings reported by Salama (2002). On the other side, all GMYDs made with yoghurt (Yo-Fast1) starter culture showed an increase in total solids, total protein and ash contents, but a decrease in total carbohydrate content than those fermented with probiotic (ABT-5) starter culture (Table 2). Salama &Hassan (1994) recorded minor differences in the lactose content of fresh fermented milk products but variably decreased in all products during the storage. Further more, increasing the concentration of the cactus pear puree decreased ($p \leq 0.05$) protein and fat content being the highest and lowest values in control and T3(15% cactus pear fruits' pulp), respectively. This result was agreement with the finding observed by (Tarakci and Kucukoner, 2003). Meanwhile, increasing the concentration of cactus pear (CP) fruits' puree increase and decrease the content of ash, total carbohydrate in T3 and control in the same order, either fermented with yoghurt or probiotic starter cultures. A similar observation was also reported by Hossain et al., (2012) and Farahat and El-Batawy (2013). The presented data reveled that, the acetaldehyde and diacetyl contents in all yoghurt drinks were significantly influenced ($p \leq 0.05$) by both the concentrations cactus pear and the starter culture used. The highest amounts of acetaldehyde and diacetyl were observed with treatments containing of 15% cactus pear fruit pulp. On the other side, treatments fermented with Yo-Fast1 starter culture was characterized with the lower amounts of acetaldehyde and diacetyl than that with ABT-5 starter culture. Also, Ostlie et al. (2003) reported that, Lb. acidophilus is of special interest for its stability to produce both acetaldehyde and diacetyl.

Changes in pH values of goats' milk yoghurt drinks during storage

As evident from data presented in Table 3 , with increasing the concentration of cactus pear fruit puree used, there were slight and gradual decreases ($p \leq 0.05$) in the pH values of all yoghurt drinks as compared with the control. It could be due to the high amounts of crud fiber in cactus pear fruit pulp which affect the growth factors availability used by starter culture. A similar observation was reported by Debashis Kumar et al. (2015). Also, differences in carbohydrate content between treatments may be responsible for the coagulum formation and the reduction in pH as a result of the production of organic acids (*e.g.* lactic acid) (Hashim et al., 2009). The presence of Furthermore, yoghurt drinks made with Yo-Fast1 starter was characterized with lower pH values as compared with that fermented by probiotic starter. It could be attributed to the high activity of yoghurt starter to ferment lactose (Tamime and Robinson, 2007).

TABLE 2. Physicochemical properties of fresh cactus pear goats' milk yoghurt drinks

Physicochemical properties	Type of starter	Treatments			
		Control	T1	T2	T3
Total solids	Yo-Fast 1	$13.65^{Dd}\pm0.41$	$14.25^{CDcd}\pm0.40$	$14.94^{BCbc}\pm0.46$	$15.65^{Aa}\pm0.53$
	ABT-5	$13.63^{Dd}\pm0.47$	$14.23^{CDcd}\pm0.38$	$14.92^{BCbc}\pm0.48$	$15.63^{Aa}\pm0.49$
Fat	Yo-Fast 1	$4.24^{Aa}\pm0.13$	$4.18^{ABab}\pm0.18$	$4.15^{Bb}\pm0.16$	$4.13^{Bb}\pm0.17$
	ABT-5	$4.24^{Aa}\pm0.14$	$4.18^{ABab}\pm0.15$	$4.15^{Bb}\pm0.13$	$4.13^{Bb}\pm0.19$
Total protein (N×6.38)	Yo-Fast 1	$3.85^{Aa}\pm0.12$	$3.83^{Aa}\pm0.16$	$3.81^{ABab}\pm0.10$	$3.78^{Bb}\pm0.11$
	ABT-5	$3.83^{Aa}\pm0.18$	$3.80^{Aa}\pm0.10$	$3.78^{ABab}\pm0.12$	$3.76^{Bb}\pm0.14$
Total carbohydrate[1]	Yo-Fast 1	$4.73^{Cc}\pm0.16$	$5.04^{Cc}\pm0.11$	$5.70^{Bb}\pm0.22$	$6.39^{Aa}\pm0.27$
	ABT-5	$4.75^{Cc}\pm0.19$	$5.07^{Cc}\pm0.10$	$5.73^{Bb}\pm0.23$	$6.41^{Aa}\pm0.29$
Ash	Yo-Fast 1	$0.83^{Cc}\pm0.03$	$0.88^{Bb}\pm0.03$	$0.92^{ABab}\pm0.04$	$0.95^{Aa}\pm0.06$
	ABT-5	$0.81^{Cc}\pm0.01$	$0.86^{Bb}\pm0.02$	$0.90^{ABab}\pm0.03$	$0.93^{Aa}\pm0.04$
Crude fiber	Yo-Fast 1	-	$0.32^{Bb}\pm0.01$	$0.36^{ABab}\pm0.02$	$0.40^{Aa}\pm0.03$
	ABT-5	-	$0.32^{Bb}\pm0.01$	$0.36^{ABab}\pm0.01$	$0.40^{Aa}\pm0.02$
Diacetyle (µmol/ml)	Yo-Fast 1	$0.75^{Cc}\pm0.01$	$0.92^{Bb}\pm0.06$	$0.98^{Aa}\pm0.09$	$1.11^{Aa}\pm0.08$
	ABT-5	$0.88^{Cc}\pm0.03$	$0.96^{Bb}\pm0.05$	$1.02^{Aa}\pm0.07$	$1.14^{Aa}\pm0.09$
Acetaldehyde (µmol/ml)	Yo-Fast 1	$24.93^{Dd}\pm0.67$	$27.44^{Cc}\pm0.63$	$31.11^{Bb}\pm0.65$	$34.25^{Aa}\pm0.69$
	ABT-5	$26.11^{Dd}\pm0.62$	$29.84^{Cc}\pm0.60$	$33.51^{Bb}\pm0.72$	$36.45^{Aa}\pm0.73$
pH	Yo-Fast 1	$5.22^{Ab}\pm0.19$	$5.17^{Ab}\pm0.18$	$5.11^{Bc}\pm0.14$	$4.92^{Bc}\pm0.19$
	ABT-5	$5.41^{Aa}\pm018$	$5.36^{Ba}\pm0.11$	$5.30^{Bb}\pm0.15$	$5.12^{Bc}\pm0.17$

Control: goats' milk yoghurt drinks made without cactus pear fruit pulp ; T1: contains 5 % cactus pear pulp ; T2: contains 10 % cactus pear pulp; T3: contains 15 % cactus pear pulp ; 1 Calculated by the difference.
A, B,C,…: Significant $P \leq 0.05$ between cactus pear pulp concentrations.
a,b,c,… : Significant $P \leq 0.05$ between bacterial starter culture strains and cactus pear pulp concentrations.

Furthermore, a gradual variably (p≤0.05) decrease in pH values could be observed in all treatments till the 9^{th} day of cold storage duration, which could be attributed to a limited growth of different bacterial starter cultures and the slow fermentation of lactose residual, which agree with that by Farnsworth *et al*., (2006).

Wheying-off of goats' milk yoghurt drinks

From Table 4, it can be observed that, the wheying-off (ml/100g) of yoghurt drinks was significantly decreased (P<0.05) with the addition of fruit pulp and remarkably with the addition of 15% fruit pulp (T3)

It could be due to the high total solid, pectin and fiber contents in the cactus pear pulp added led to absorb of unbound water and decrease the syneresis (Ismail et al., 2016). Contrary, the control yoghurt drinks treatments presented a higher index of syneresis as compared to other treatments either fermented with yoghurt or probiotic starter cultures. This might be related to the degree of water retention by the protein matrix (Djurdjevic et al., 2001). Furthermore, all yoghurt drinks treatments fermented with Yo-Fast1 starter culture significantly ($p \leq 0.05$) had higher amounts of whey separation than those fermented with ABT-5 culture, being the lowest values with T3 (15 % cactus pear puree) treatments till the end of storage. Hassan (2008) and Purohit et al. (2009) stated that, some strains of lactic acid bacteria used in the manufacture fermented milk products produced exopolysaccharides, which affect syneresis of fermented products. Also, exopolysaccharides have the ability to bind water and reduce whey syneresis (De Vuyst & Degeest, 1999). The whey separation in all yoghurt drinks treatments and the control decreased ($p \leq 0.05$) as storage time progressed till the 9^{th} day and this is compatible with the results of Al-Kadamany et al., (2003) who attributed that, the whey separation in acid milk gels has been linked to rearrangements of particles making up the casein gel network.

TABLE 3. Changes in pH values of goats' milk cactus pear stirred yoghurt during storage at (6±0.5°C for 9 days).

Storage period (days)	Type of starter	Treatments			
		Control	T1	T2	T3
Fresh	Yo-Fast 1	5.22^{Ade}±0.18	5.17^{ABef}±0.16	5.12^{BCfg}±0.16	5.08^{Cg}±0.14
	ABT-5	5.43^{Aa}±0.21	5.38^{ABab}±0.19	5.33^{BCbc}±0.19	5.27^{Ccd}±0.18
3	Yo-Fast 1	5.13^{Ac}±0.15	5.07^{ABcd}±0.14	5.01^{BCde}±0.13	4.96^{Ce}±0.13
	ABT-2	5.36^{Aa}±0.21	5.32^{Aa}±0.20	5.21^{Bb}±0.18	5.15^{Bbc}±0.15
6	Yo-Fast 1	4.98^{Aef}±0.15	4.93^{ABfg}±0.13	4.89^{BCg}±0.13	4.85^{Cg}±0.12
	ABT-2	5.25^{Aa}±0.17	5.17^{BCbc}±0.16	$5.10C^{Dcd}$±0.15	5.06^{Dde}±0.13
9	Yo-Fast 1	4.90^{Ade}±0.10	4.84^{ABef}±0.11	4.80^{BCfg}±0.10	4.74^{Cg}±0.09
	ABT-2	5.13^{Aa}±0.20	5.03^{Bb}±0.14	4.98^{BCbcd}±0.13	4.95^{Ccd}±0.12

Control: goats' milk yoghurt drinks made without cactus pear fruit pulp ; T1: contains 5 % cactus pear pulp ; T2: contains 10 % cactus pear pulp; T3: contains 15 % cactus pear pulp ; 1 Calculated by the difference.

A, B,C,…: Significant $P \leq 0.05$ between cactus pear pulp concentrations.

a,b,c,… : Significant $P \leq 0.05$ between Storage period / bacterial starter culture strains and cactus pear pulp concentrations.

TABLE 4. Whey separation (ml/100g) of goats' milk cactus pear yoghurt drinks during cold storage period.

Storage period (days)	Type of starter	Treatments			
		Control	T1	T2	T3
Fresh	Yo-Fast 1	8.45^{Aa} ±0.29	7.62^{Bb} ±0.50	6.81^{Cc} ±0.43	5.85^{Dd} ±0.19
	ABT-5	7.53^{Ab} ±0.48	6.46^{Bc} ±0.36	5.66^{BCde} ±0.22	5.20^{Ce} ±0.18
3	Yo-Fast 1	7.28^{Aa} ±0.39	6.52^{Bb}±0.38	5.78^{Cc}±0.26	5.04^{Dd}±0.29
	ABT-5	6.16^{Ab}±0.35	5.47^{Bc}±0.23	4.74^{Cd}±0.22	4.51^{Cd}±0.21
6	Yo-Fast 1	5.94^{Aa}±0.28	5.55^{Aab}±0.21	4.76^{Bc}±0.19	4.38^{Bd}±0.18
	ABT-2	5.26^{Abc}±0.24	4.83^{ABc}±0.20	4.41^{Bd}±0.18	4.11^{Cd}±0.17
9	Yo-Fast 1	5.74^{Aa}±0.26	4.87^{Bbc}±0.22	4.43^{Bcd}±0.19	3.89^{Cde}±0.15
	ABT-2	4.80^{Abc}±0.15	4.44^{Ac}±0.14	3.98^{BCd}±0.10	3.45^{Ce}±0.10

*See foot note Table 3

Phenolic compounds (mg /100 g) and total antioxidants activity (DPPH %) of goats' milk yoghurt drinks

The phenolic compounds and total antioxidants activity contents in yoghurt drinks were significantly influenced ($p \le 0.05$) by the cactus pear pulp concentration, the starter culture used and storage period as shown in Table 5. The antioxidant and phenolic compounds contents increased ($p \le 0.05$) with rising cactus pear pulp levels added; due to the high levels of phenolic compounds and antioxidant activity of the cactus pear pulp (Table 1). The highest amounts of phenolic compounds and DPPH contents were observed in yoghurt drinks containing of 15% cactus pear pulp (T3) followed by that containing 10% (T2) either fermented with Yo-Fast 1 or ABT-5 and the same trend was found throughout the storage period. The total phenolic compounds contents of fresh yoghurt drinks increased with the increase of the added cactus pear puree being was 7.76, 11.61 and 15.42 mg/100g for yoghurt drinks containing 5, 10 and 15 %, of cactus pear puree respectively. Same trend observed through storage (Table 5). Matter et al., (2016) stated that, peel and pulp of cactus pear fruit presented high levels of dietary fiber, indigestible fraction, and phenolic compounds.

Also, the total phenolic compounds and antioxidant activity decreased ($p \le 0.05$) in all treatments during the storage period being the highest values in probiotic cactus pear puree yoghurt drinks. Same trend have been reported by (Khalil, 2013). Meanwhile, the control yoghurt drinks were characterized with lowest values of phenolic compounds and total DPPH % as compared with that containing of cactus pear puree being the lowest values with yoghurt starter cultures; either when fresh or during the cold storage period. It could be due to the metabolic end products of LAB might be contributing to the higher antioxidant potential in comparison with that of control sample (Madhu et al., 2012). Also, significant correlation was observed between the total phenolics and the antioxidant (Table 5). The results are in agreement with earlier findings by Kullisaar et al., (2003). Moreover, since these fruits show the highest antioxidant content in the peel, they seem to be particularly suitable for unpeeled whole fresh fruit consumption and thus promote health related benefits.

Rheological behavior of fresh goats' milk yoghurt drinks

Table 6 shows the rehological parameters of the tested cactus pear yoghurt drinks samples. The obtained consistency coefficient (K-values) indicate that, the K-values of yoghurt drinks treatments were increased ($p \le 0.05$) with increasing the cactus pear puree used and this increase was more pronounced with the probiotic yoghurt treatment compared

TABLE 5. Changes in phenolic compounds (mg gallic acid equivalents (GAE) /100 g sample) and total antioxidant activity (%) of goats' milk yoghurt drinks during storage at (6±0.5°C for 9 days).

Storage period (days)	Type of starter	Treatments			
		Control	T1	T2	T3
Phenolic compounds (mg/100g)					
Fresh	Yo-Fast 1	$1.76^{Dd}\pm0.03$	$7.76^{Cc}\pm0.27$	$11.61^{Bb}\pm0.41$	$15.42^{Aa}\pm0.48$
	ABT-5	$1.79^{Dd}\pm0.05$	$7.97^{Cc}\pm0.29$	$11.65^{Bb}\pm0.38$	$15.46^{Aa}\pm0.51$
3	Yo-Fast 1	$1.72^{Dd}\pm0.04$	$6.62^{Cc}\pm0.21$	$10.66^{Bb}\pm0.32$	$14.25^{Aa}\pm0.44$
	ABT-2	$1.75^{Dd}\pm0.04$	$6.66^{Cc}\pm0.22$	$10.71^{Bb}\pm0.33$	$14.31^{Aa}\pm0.42$
6	Yo-Fast 1	$1.66^{Dd}\pm0.03$	$5.24^{Cc}\pm0.18$	$9.03^{Bb}\pm0.25$	$12.93^{Aa}\pm0.36$
	ABT-2	$1.69^{Dd}\pm0.02$	$5.29^{Cc}\pm0.20$	$9.14^{Bb}\pm0.29$	$13.06^{Aa}\pm0.39$
9	Yo-Fast 1	$1.64^{Dd}\pm0.03$	$4.41^{Cc}\pm0.18$	$8.28^{Bb}\pm0.26$	$12.11^{Aa}\pm0.34$
	ABT-2	$1.67^{Dd}\pm0.03$	$4.44^{Cc}\pm0.19$	$8.33^{Bb}\pm0.25$	$12.36^{Aa}\pm0.37$
Total antioxidant activity (%)					
Fresh	Yo-Fast 1	$4.24^{Dd}\pm020$	$39.41^{Cc}\pm0.70$	$40.23^{Bb}\pm0.79$	$42.51^{Aa}\pm0.84$
	ABT-5	$4.27^{Dd}\pm0.21$	$39.50^{Cc}\pm0.72$	$40.29^{Bb}\pm0.81$	$42.83^{Aa}\pm0.82$
3	Yo-Fast 1	$4.19^{Dd}\pm0.20$	$35.44^{Cc}\pm0.61$	$36.46^{Bb}\pm0.65$	$37.53^{Aa}\pm0.67$
	ABT-2	$4.22^{Dd}\pm0.19$	$35.49^{Cc}\pm0.64$	$36.54^{Bb}\pm0.67$	$37.62^{Aa}\pm0.69$
6	Yo-Fast 1	$4.13^{Cc}\pm0.16$	$30.34^{Bb}\pm0.58$	$32.11^{Aa}\pm0.61$	$32.45^{Aa}\pm0.64$
	ABT-2	$4.16^{Cc}\pm0.17$	$30.40^{Bb}\pm0.60$	$32.18^{Aa}\pm0.62$	$32.53^{Aa}\pm0.66$
9	Yo-Fast 1	$4.11^{Dd}\pm0.15$	$27.22^{Cc}\pm0.54$	$28.53^{Bb}\pm0.58$	$29.84^{Aa}\pm0.61$
	ABT-2	$4.14^{Dd}\pm0.13$	$27.29^{Cc}\pm0.55$	$28.61^{Bb}\pm0.60$	$29.93^{Aa}\pm0.63$

*See foot note Table 3

with the control. The stirred process has increased the k-values and decreased the flow behaviour index (n-values) indicating that, cactus pear pulp strengthens the structure and consistency coefficient of yoghurt drinks samples. The trend of the obtained results agrees with those reported by El-samahy et al., (2014). The decrease in Flow behaviour index (n-values) is an indicator for the increasing pseudo plasticity of yoghurt drinks.

Furthermore, n-values for the T3 treatments were significantly ($p \leq 0.05$) lower than those of other treatments and the control which indicate that the former was more viscous than the latter yoghurt drinks. The apparent viscosities of cactus pear yoghurt drinks treatment was significantly ($p \leq 0.05$) higher than the control. It could be due to that, the viscosity of yoghurt is commonly attributed primarily to hydrocolloids, its protein and fat content, heat treatment, combination of the lactic acid bacteria used, acidification rate and storage time which modify the texture of food products (Sodini et al., 2004). Thus the variation in consistency coefficient was primarily due to the quantity of the inclusion of cactus pear fiber pulp and it's containing of pectin and soluble fiber. The present data suggested that incorporation of cactus pear pulp increased markedly the viscosity of yoghurt drinks. Also, yoghurt drinks made with cactus pear fruit pulp tended exhibited ($p \leq 0.05$) higher rehological parameters than that of the control except flow behaviour index values (Table 6). This may be due to the thickening effect of pectin and soluble fiber in *Opuntia spp*. and the presence of mucilages (complex polymeric substances of carbohydrate nature with a highly branched structure) which is proposed as two distinctive water soluble fractions; one is pectin with gelling properties with Ca^{+2}, and the other is mucilage without gelling properties (Goycoolea and Cardenas, 2004). Furthermore, the TS of the yoghurt used in the mix increased significantly the rehological characteristics of the resultant yoghurt drinks. It can easily note that, there is a substantial impact of the supplementation with cactus pear pulp on dietary fiber and total solids contents of yoghurt drink (Table 2). Because of using goat's milk only in its preparing (control) was free from dietary fiber which is could be influenced the rehological parameters (Buriti et al., 2014 and Ismail et al., 2016).

Flow behaviour of goats' milk yoghurt drinks

The flow behaviour of different goats' milk yoghurt drinks as affected by the added percent of cactus pear fruit pulp and starter cultures used during cold storage are illustrated in Fig 1 - 4 when fresh, 3, 6 and 9 days, respectively. During the investigated time of shearing, the dynamic viscosity values ($p \leq 0.05$) decreased as the shear rate increased in all treatments till the end of storage period. The fall in viscosity with shear rate might be due to the destruction of the interactions within the yoghurt network structure. Our results agree with Lazaridou and Biliaderis (2007). Furthermore, all treatments exhibited a pseudoplastic shear thinning, non-Newtonian fluid behaviour (Jumah et al., 2001). This shear thinning behavior is due to the progressive breakdown of aggregates formed between milk caseins by the action of the decrease in pH (Fguiri et al., 2012). As it can be seen, all cactus pear yoghurt drinks treatments were characterized with higher dynamic viscosity values during the investigated time of shearing and showed higher upward shifting of the flow curve, as compared with the control either when fresh (Fig. 1) or at the end of storage period (Fig. 4) being the highest values with the highly treated cactus pear treatments (T3). Concerning the type of starter used, yoghurt starter (Yo-Fast1) was resulted in the downward shifting of the flow curve as compared with that made by probiotic starter (ABT-5) cultures. In addition, this decrease in flow curve indicated that there was decrease in the viscosity of yoghurt samples prepared with the Yo-Fast1 than that made with probiotic starter culture. In addition, the increase in the viscosity values of fermented milk products with probiotic starter cultures could be due to the produce of exopolysaccharides that increased the viscosity (Purohit et al., 2009).

Furthermore, during the investigated time of shearing, the change in the viscosity was linear with the increase in the concentration of cactus pear fruit pulp; T3 yoghurt drinks was characterized with the highest dynamic viscosity values and showed higher upward shifting of the flow curve especially when fermented by probiotic starter; as compared with other treatments and the control either when fresh or till the 9th day of storage period (Fig.4). It could be due to its firmness, and lowest whey separation (Table 5) which is affected the increase in viscosity (De Lorenzi et al., 1995). Meanwhile, the control characterized with the lowest viscosity values throughout the storage period (downward shifting of the viscosity). A possible explanation could be due to the formation of a weak gel (weak curd formed lower curd firmness) that weakened with the ongoing decrease in pH, same observations reported by Mizuno and Lucey (2007). Also, as the storage period advanced the viscosity in all yoghurt drinks increased gradually with a slow rate being the highest values with T3 treatments either fermented with yogurt or probiotic starter as shown in Fig. 4, it could be related to the highest total solid contents and lowest whey separation (Table 2 and 5, respectively). The same trend was founded in the stirred yoghurt by Beal et al. (1999) and Abu-Jdayil et al. (2000).

Colour properties of goats' milk yoghurt drinks during storage period

The colour values of fresh and stored yoghurt drinks treatments with different concentration of cactus pear fruit pulp are shown in Fig. 5. All colour parameters of fresh yoghurt drinks were affected ($p \leq 0.05$) by the percentages of cactus pear fruit pulp added, type of starter used as well as extending the storage period for 9 days at 6±0.5°C (Fig. 5 A,B). Colour is an important aspect because its changes could affect the final quality of the product (Stintzing et al., 2003). It is clear that, the colour parameters for all yoghurt drinks changed slightly during storage, due to the oxidation of phytochemical compounds in cactus pear fruit. Also, the rate of pigments degradation depended on its concentration (Stintzing et al., 2005). The white colour was reduced for all yoghurt drinks treatments during the storage period (results are not shown) while the green and yellow colour for all yoghurt drinks treatments increased at the end of the storage period. Furthermore, the whitness (L value) was decreased while, "a" and" b" values increased ($p \leq 0.05$) with the increased of cactus pear fruit pulp used till the 9th day of storage. It could be explained on the basis of yellow-orange colour of the fruit used.

TABLE 6. Rheological parameters of fresh goats' milk yoghurt drinks

Treatments	Type of starter	Rheological Parameter				
		Apparent Viscosity (mPas)	Plastic Viscosity (mPas)	Consistency coefficient ($mPas^n$)	Flow behaviour index	Yield stress (N/m^2)
Control	Yo-Fast 1	28.75^{Gb}±0.43	20.57^{Gb}±0.35	22.78^{Fb}±0.37	0.51^{Aa}±0.61	0.77^{Fb}±0.83
	ABT-5	31.95^{Fa}±0.47	26.95^{Fa}±0.39	28.32^{Ea}±0.39	0.48^{BCb}±0.50	0.80^{Ea}±0.86
T1	Yo-Fast 1	36.42^{Eb}±0.49	27.09^{Eb}±0.40	29.19^{Eb}±0.44	0.49^{Ba}±0.52	0.82^{Db}±0.89
	ABT-5	43.45^{Da}±0.46	33.28^{Da}±0.51	35.38^{Da}±0.45	0.46^{DEb}±0.48	0.86^{Ca}±0.91
T2	Yo-Fast 1	44.09^{Db}±0.50	33.42^{Db}±0.46	35.72^{Db}±0.41	0.47^{CDa}±0.52	0.85^{Cb}±0.90
	ABT-5	55.59^{Ba}±0.64	43.43^{Ba}±0.53	45.73^{Ba}±0.47	0.44^{Fb}±0.47	0.89^{Ba}±0.85
T3	Yo-Fast 1	51.12^{Cb}±0.54	39.64^{Cb}±0.50	41.84^{Cb}±0.46	0.45^{EFa}±0.51	0.90^{Bb}±0.94
	ABT-5	65.81^{Aa}±0.67	52.37^{Aa}±0.54	54.67^{Aa}±0.53	0.42^{Gb}±0.41	0.95^{Aa}±0.93

*See foot note Table 2

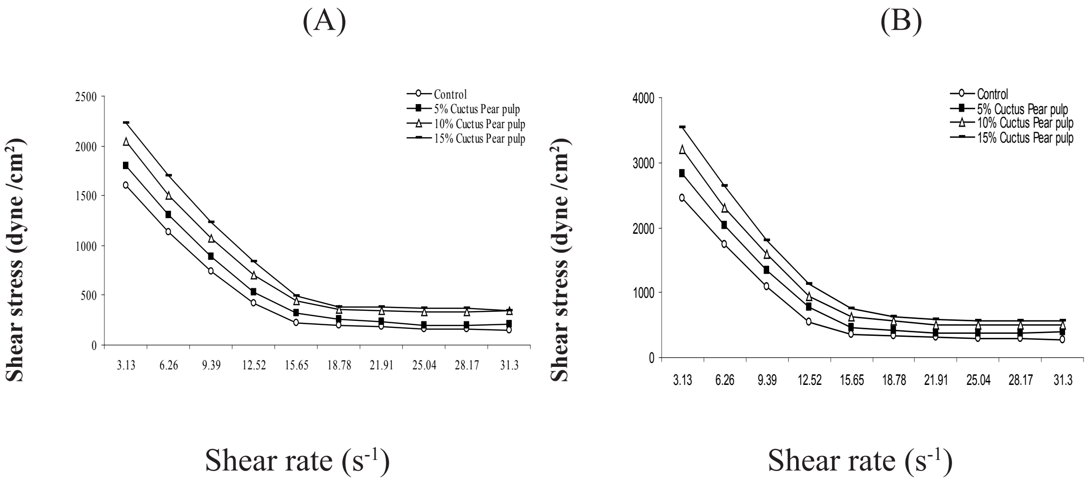


Fig.1. Flow behaviour of fresh goats' milk yoghurt drinks made with and without different concentrations of cactus pear fruit pulp and fermented with yoghurt (A) and probiotic starter (B) cultures, respectively.

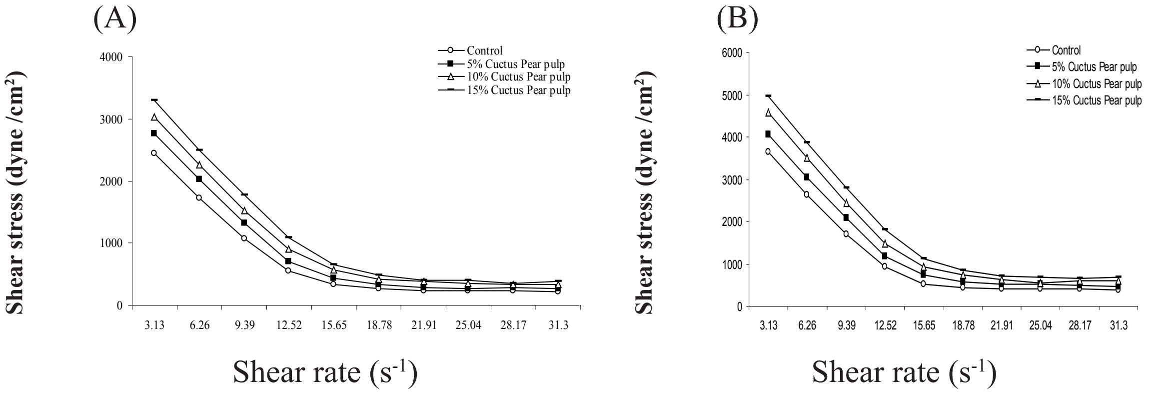


Fig. 2. Flow behaviour of goats' milk yoghurt drinks made with and without different concentrations of cactus pear fruit pulp and fermented with yoghurt (A) and probiotic starter (B) cultures, respectively during the storage period at 6±0.5°C/3 days.

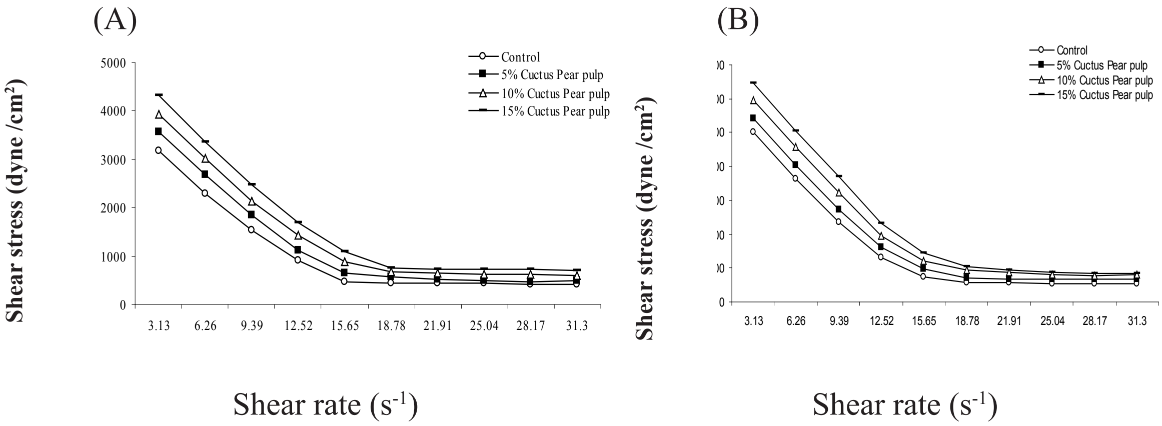


Fig. 3. Flow behaviour of goats' milk yoghurt drinks made with and without different concentrations of cactus pear fruit pulp and fermented with yoghurt (A) and probiotic starter (B) cultures, respectively during the storage period at 6±0.5°C/6 days.

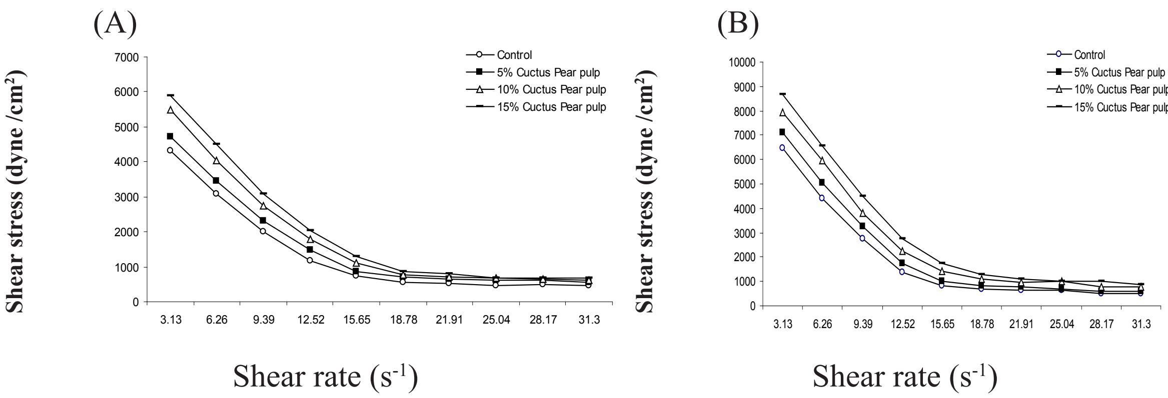
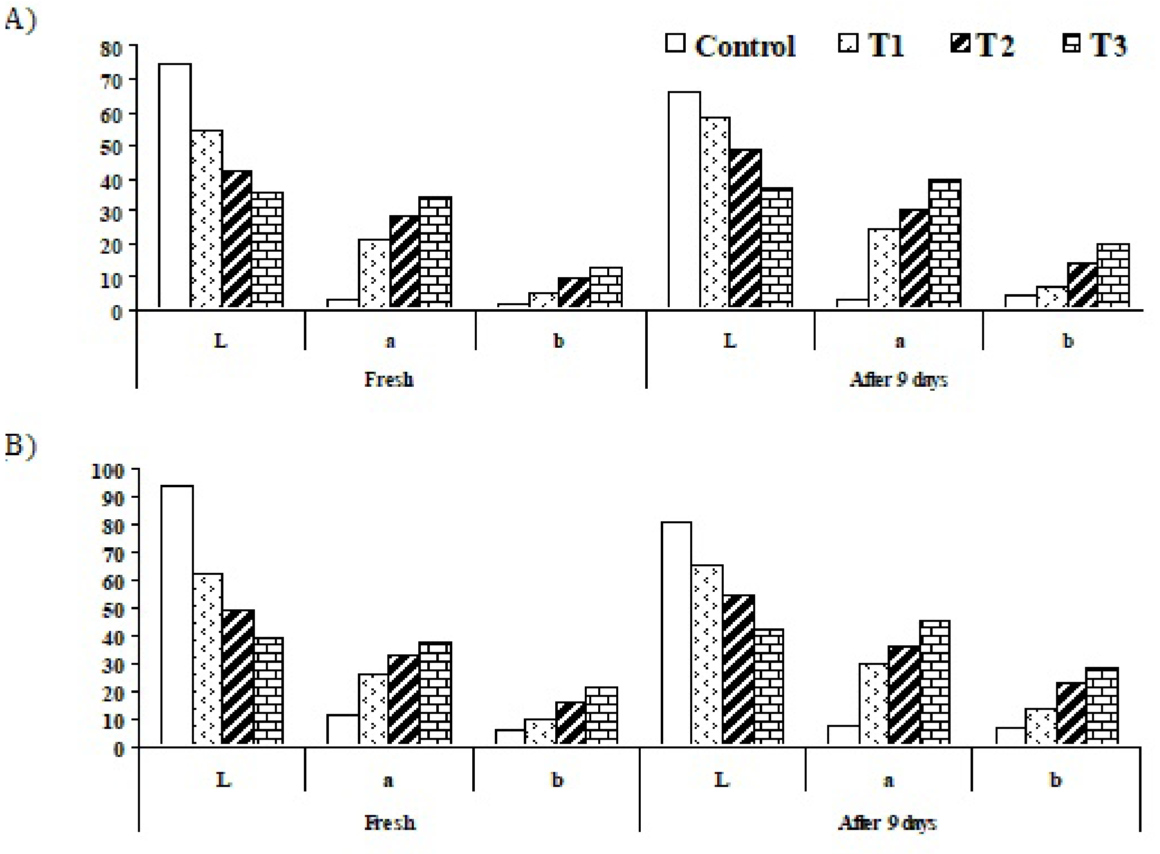


Fig.4. Flow behaviour of goats' milk yoghurt drinks made with and without different concentrations of cactus pear fruit pulp and fermented with yoghurt (A) and probiotic starter (B) cultures, respectively during the storage period at 6±0.5°C/9 days.

Also, increasing the concentration of yoghurt in the formulation tended to have whiter colour (higher L values) being the highest values for the control followed by T1 either in fresh or at the end of storage. MoBhammer et al. (2006) found that, the degradation rate of the colour pigments of cactus pear fruit (*Opuntia* spp) decreased with the higher concentration of pigments. So, cactus pear fruit could be considered as suitable colouring foodstuff for low acid products such as yoghurt. Also, probiotic yoghurt drinks tended to receive higher over all colour acceptability reading than that made with yoghurt starter culture. Additionally, the colour quality evaluated negatively changed throughout the storage period in all yoghurt drinks treatments. Overall, all yoghurt drinks kept the same trend of the colour reading during storage (results are not shown). The highest green and yellow colour values existed in T3 and T2 samples when matched with the control at the end of the storage period. The treatment with 15% cactus pear fruit pulp was considered as the best treatment over other treatments.

Bacteriological properties of goats' milk yoghurt drinks during storage

Significant differences ($p \leq 0.05$) were found in log bacterial cell counts between different yoghurt drinks treatments as affected by the concentration of cactus pear pulp, starter culture used and storage period (6±0.5°C for 9 days) (Table 7).



Control: goats' milk yoghurt drinks made without cactus pear fruit pulp ; T1: goats' milk yoghurt drinks with 5 % cactus pear fruit pulp ; T2: goats' milk yoghurt drinks with 10 % cactus pear fruit pulp; T3: goats' milk yoghurt drinks with 15 % cactus pear fruit pulp

Fig. 5. Colour properties of goats' milk yoghurt drinks made with and without different concentrations of cactus pear fruit pulp and fermented with yoghurt (A) and probiotic starter (B) cultures, respectively when fresh and at the end of storage period

Generally, the total viable bacterial cells count in all yoghurt drinks samples decreased ($p \leq 0.05$) to minimum counts ($\log_{10}$ CFU / ml) at the end of storage period. It could be due to the accumulation of acids or reduction of availability of nutrient required for the growth (Kabeir et al., 2015). Among treatments, T3 (15% cactus pear pulp) and the control had the highest and lowest percentage survival counts after 9 days of storage, respectively. Generally, *Str. thermophilus* ($\log_{10}$ CFU / ml) was the most prevalent in all treatments either when fresh or during storage period, followed by *Lb. delbruecki ssp. bulgaricus* cells ($p \leq 0.05$). Whereas, the survival rate of *Lb. acidophilus* was higher than that of bifidobacteria in probiotic yoghurt drinks treatments. Also, Bifidobacteria exhibited the lowest levels of viable cells in all yoghurt drinks throughout the storage period. The variances in Bifidobacterium survival were interpreted by its metabolic activity in different fermented products, which might be affected by the composition and availability of nitrogen and carbon sources in growth media (Buriti et al., 2014). Furthermore, there was a gradual decrease in bifidobacteria counts during cold storage, while *Lb. delbrueckii* ssp. *bulgaricus*, *Str. thermophilus* and *Lb. acidophilus* were gradually increased until 3rd day of storage, and then decreased. Contrary, losses of viability levels of *Str. thermophillus* and *L.*

TABLE 7. Viable cell counts ($\log_{10}$ CFU / ml) of bacterial starter strains of goats' milk cactus pear stirred yoghurt during storage (6±0.5°C for 9 days).

Treatments^{Z}/ bacterial starter strains	Storage period (days)	Viable counts ($\log_{10}$ CFU/ ml)			
		Control	T1	T2	T3
Yo-Fast1*					
Lb. delbruecki ssp. *Bulgaricus*	0	$7.33^{Bc}\pm0.24$	$7.40^{Bbc}\pm0.25$	$7.60^{Bb}\pm0.29$	$7.81^{Bab}\pm0.31$
	3	$7.64^{Aa}\pm0.22$	$7.83^{Aa}\pm0.26$	$8.00^{Aa}\pm0.28$	$8.20^{Aa}\pm0.30$
	6	$7.23^{Cc}\pm0.23$	$7.42^{Bbc}\pm0.25$	$7.63^{Bb}\pm0.26$	$7.84^{Ba}\pm0.24$
	9	$6.91^{Dd}\pm0.20$	$7.00^{Cd}\pm0.21$	$7.24^{Cc}\pm0.25$	$7.45^{Cbc}\pm0.29$
Survival (%)		$94.27^{B}\pm0.95$	$94.59^{B}\pm0.96$	$95.29^{AB}\pm0.92$	$95.39^{A}\pm0.94$
Str. Thermophilus	0	$7.63^{Bc}\pm0.21$	$7.89^{Cbc}\pm0.23$	$8.00^{Bbc}\pm0.27$	$8.40^{Ba}\pm0.29$
	3	$8.00^{Abc}\pm0.25$	$8.33^{Aab}\pm0.26$	$8.55^{Aa}\pm0.24$	$8.70^{Aa}\pm0.28$
	6	$7.72^{Bc}\pm0.23$	$8.04^{Bbc}\pm0.24$	$8.26^{Ab}\pm0.26$	$8.44^{Ba}\pm0.27$
	9	$7.31^{Cd}\pm0.20$	$7.59^{Dcd}\pm0.21$	$7.72^{Cc}\pm0.23$	$8.14^{Cbc}\pm0.31$
Survival (%)		$95.81^{B}\pm0.93$	$96.19^{AB}\pm0.95$	$96.50^{A}\pm0.91$	$96.90^{A}\pm0.94$
ABT-5**					
Lb. acidophilus	0	$7.09^{Bbc}\pm0.21$	$7.29^{Bb}\pm0.23$	$7.47^{Bab}\pm0.26$	$7.67^{Ba}\pm0.27$
	3	$7.35^{Ab}\pm0.24$	$7.54^{Aab}\pm0.26$	$7.73^{Aa}\pm0.27$	$7.92^{Aa}\pm0.29$
	6	$6.94^{Cbc}\pm0.20$	$7.10^{Cb}\pm0.22$	$7.31^{Bb}\pm0.23$	$7.54^{Bab}\pm0.25$
	9	$6.61^{Dc}\pm0.18$	$6.81^{Dc}\pm0.19$	$7.00^{Cbc}\pm0.20$	$7.22^{Cb}\pm0.21$
Survival (%)		$93.23^{B}\pm0.94$	$93.42^{B}\pm0.96$	$93.71^{AB}\pm0.94$	$94.13^{A}\pm0.97$
Str. Thermophilus	0	$7.63^{Bbc}\pm0.26$	$7.92^{Bb}\pm0.29$	$8.15^{Bab}\pm0.30$	$8.33^{Ba}\pm0.31$
	3	$7.94^{Abc}\pm0.29$	$8.24^{Aa}\pm0.30$	$8.42^{Aa}\pm0.31$	$8.63^{Aa}\pm0.34$
	6	$7.61^{Bbc}\pm0.25$	$7.91^{Bbc}\pm0.29$	$8.12^{Bab}\pm0.30$	$8.32^{Ba}\pm0.31$
	9	$7.23^{Cd}\pm0.22$	$7.55^{Ccd}\pm0.24$	$7.81^{Cbc}\pm0.27$	$8.00^{Cbc}\pm0.29$
Survival (%)		$94.76^{B}\pm0.92$	$95.33^{AB}\pm0.91$	$95.83^{A}\pm0.94$	$96.04^{A}\pm0.93$
Bifidobacteria	0	$7.00^{Ab}\pm0.18$	$7.23A^{ab}\pm0.19$	$7.41^{Aa}\pm0.23$	$7.60^{Aa}\pm0.25$
	3	$6.81^{Ac}\pm0.17$	$7.05^{Bbc}\pm0.18$	$7.23^{Aab}\pm0.21$	$7.44^{Aa}\pm0.23$
	6	$6.52^{Bcd}\pm0.15$	$6.73^{Cc}\pm0.17$	$6.94^{Bbc}\pm018$	$7.13^{Bab}\pm0.19$
	9	$6.22^{Cd}\pm0.14$	$6.44^{Dcd}\pm0.15$	$6.62^{Ccd}\pm0.18$	$6.82^{Cc}\pm0.20$
Survival (%)		$88.86^{B}\pm0.90$	$89.07^{AB}\pm0.92$	$89.34^{A}\pm0.88$	$89.74^{A}\pm0.91$

*See foot note Table 3

* ** Z

acidophilus during storage were lower in cactus pear yoghurt drinks than that of control (Table 7), makes it suitable as a probiotic fruit beverage (Yoon et al., 2005 and Ismail et al., 2016). The present results indicated that, the counts of viable cells in all yoghurt drinks treatments maintained acceptable levels (>10^6 CFU / ml) to be considered as functional foods until the end of the cold storage (Akın et al., 2007). For practical application, a pH value of the final product must be maintained above 4.6 to reduce the decline of bifidobacteria population (Vinderola et al., 2000).

Changes in sensory evaluation of goats' milk yoghurt drinks during storage

All goats' milk yoghurt drinks were acceptable with significant differences (p≤0.05) among each other, where the concentration of cactus pear pulp , starter culture used , as well as time of the storage were the principle factors (p≤0.05) influencing on the organoleptic properties scores (Table 8). It is clear that, no marked change occurred in colour and appearance either in fresh or in stored treatments. Moreover, all cactus pear treated treatments characterized by specific taste which is due to the concentration of fruit pulp used. The resultant products had a good general appearance, body and texture (soft, smooth and lubricity texture) and pleasant creamy flavour. Among treatments, T3 (containing of 15% cactus pear pulp) rated the highest preference in the organoleptic properties either when fresh or during storage and were characterized with perfect flavour, body and texture.

Nonetheless, it gained the lowest scores in appearance and color; especially when fermented with yoghurt starter culture followed by their containing of 5 % cactus pear pulp (T1). It could be due to the darkness colour noticed when increasing the cactus pear pulp. While, T2 (10 % cactus pear pulp) tended to receive the highest appearance & colour (Table 8). On the other side, the control treatments ranked the lowest organoleptic scores with small amount of free

TABLE 8. Sensory evaluation of goats' milk yoghurt drinks during storage (6±0.5°C for 9 days).

Organoleptic properties	Storage period (days)	Treatments z			
		Control	T1	T2	T3
		Yo-Fast 1*			
Flavour (1-20 points)	0	17.5^{Cc}±0.31	18.0^{Bb}±0.33	18.5^{Aa}±0.34	18.8^{Aa}±0.36
	3	17.5^{Cc}±0.30	18.0^{Bb}±0.31	18.5^{Aa}±0.32	18.8^{Aa}±0.34
	6	17.0^{Dd}±0.28	17.5^{Cc}±0.29	18.0^{Bb}±0.30	18.5^{Aa}±0.35
	9	16.5^{De}±0.22	17.5^{Cc}±0.28	18.0^{Bb}±0.27	18.5^{Aa}±0.33
Body & Texture (1-10 points)	0	7.5^{Dd}±0.10	8.5^{Cb}±0.11	9.0^{Ba}±0.15	9.8^{Aa}±0.16
	3	7.5^{Dd}±0.09	8.0^{Cc}±0.10	8.5^{Bb}±0.12	9.5^{Aa}±0.14
	6	7.0^{Dd}±0.08	7.5^{Cd}±0.09	8.0^{Bc}±0.11	9.0^{Aa}±0.13
	9	6.5^{De}±0.07	7.5^{Cd}±0.10	8.0^{Cc}±0.11	8.5^{Ab}±0.12
Appearance & colour (1-10 points)	0	8.0^{Cc}±0.10	8.5^{Bb}±0.13	9.5^{Aa}±0.15	9.0^{Aa}±0.14
	3	8.0^{Cc}±0.08	8.5^{Bb}±0.10	9.5^{Aa}±0.17	9.0^{Aa}±0.12
	6	7.5^{Dd}±0.07	8.0^{Cc}±0.09	9.0^{Aa}±0.14	8.5^{Bb}±0.10
	9	7.0^{Ee}±0.06	7.5^{Dd}±0.08	8.5^{Bb}±0.11	8.0^{Cc}±0.09
		ABT-5 **			
Flavour (1-20 points)	0	18.5^{Cc}±0.33	18.5^{Cc}±0.31	19.0^{Bb}±0.34	19.8^{Aa}±0.37
	3	18.5^{Cc}±0.27	18.5^{Cc}±0.32	19.0^{Bb}±0.33	19.5^{Aa}±0.35
	6	18.0^{Dd}±0.31	18.0^{Dd}±0.28	19.0^{Bb}±0.35	19.5^{Aa}±0.38
	9	17.5^{De}±0.29	18.0^{Cd}±0.30	18.5^{Bc}±0.32	19.0^{Ab}±0.34
Body & Texture (1-10 points)	0	8.5^{Cd}±0.12	9.0^{Bc}±0.14	9.5^{Aab}±0.15	9.8^{Aa}±0.18
	3	8.5^{Cd}±0.11	9.0^{Bc}±0.15	9.5^{Aab}±0.16	9.8^{Aa}±0.19
	6	8.0^{De}±0.08	8.5^{Cd}±0.11	9.0^{Bc}±0.14	9.6^{Aa}±0.17
	9	7.5^{Df}±0.06	8.0^{Ce}±0.07	8.5^{Bd}±0.10	9.2^{Ab}±0.13
Appearance & colour (1-10 points)	0	8.5^{Cc}±0.10	9.0^{Bb}±0.12	9.7^{Aa}±0.16	9.5^{Aa}±0.15
	3	8.5^{Cc}±0.09	9.0^{Bb}±0.13	9.7^{Aa}±0.17	9.5^{Aa}±0.16
	6	8.0^{Dd}±0.07	8.5^{Cc}±0.10	9.5^{Aa}±0.15	9.0^{Bb}±0.12
	9	7.5^{De}±0.06	8.0^{Cd}±0.08	9.0^{A}b±0.12	8.5^{Bb}±0.11

*See foot note Table 2

whey throughout the storage period especially when Yo-Fast1 starter culture used in the fermentation process. Also, the plain (control) treatments gained the lowest flavour scores with goaty taste flavour, which is non preferable for the most of Egyptians consumer. Meanwhile, the addition of fruits and fiber ingredients appears as alternative to improve the sensory acceptability of goats' milk beverages ,besides contributing with nutrients which are not contained in milk, particularly dietary fiber (Ismail et al., 2016).

Concerning the type of starter used, yoghurt drinks made with Yo-Fast 1 starter culture ranked lower flavour scores than that fermented with probiotic starter culture; it could be due to the light acidic flavour and gel-like body and texture than that with probiotic culture (light sweetie flavour and ropy body and texture). Additionally, the total quality evaluated (colour, appearance, body, texture and flavour) negatively changed throughout the storage period in all yoghurt drinks treatments. The total quality scores of the final yoghurt drinks were significantly decreased ($p \leq 0.05$) with extending the storage period (Walkunde et al., 2008). The decrease in quality started to be seen after the 6th day of storage and all treatments scored the lowest at the 9th day of storage period. This may be contributed to the high content of several volatile compounds during the fermentation of pulp serve as a precursor of certain flavour compounds, which contribute to a complex blend of flavours in the product. Same findings recorded by El-Samahy et al. (2014).

Conclusion

Cactus pear pulp could be successfully used at the ratio of 5, 10 and 15 %w/w for production of a new type of goats' milk yoghurt drinks which improved the flavour and nutritional value. The pulp-enriched samples were characterized by the highest contents of antioxidant activity, total phenol compounds. The sensory scores of the bio- yoghurt drinks were high indicating acceptance. The total number of viable cells in probiotic treatments was maintained at the functional level (>10^6 CFU / ml) up to 9 days of storage. Addition of both probiotic bacterial strains and cactus pear pulp improved the textural, whey separation and viscosity properties of the treated treatments. Generally, chemical, rheological, microbiological, organoleptic, antioxidant activity and phenolic compounds indicated that the use of cactus pear pulp in the manufacture of goats' milk yoghurt drinks significantly ($p \leq 0.05$) improved several important characteristics especially when fermented with probiotic starter cultures and is highly recommended to get valuable bio- goats' milk products.

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تاثير استخدام لب فاكهه التين الشوكي علي جوده وخواص مشروب الزبادي الحيوي من لبن الماعز

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تم دراسة تأثير إضافة ثلاثه تركيزات مختلفة (5، 10، 15 % w/w) من لب فاكهه التين الشوكي علي خصائص مشروب اليوجهورت الحيوي المصنع من لبن الماعز بإستخدام بادئات تجارية وهى: Yo-Fast1 (يحتوى على *Lactobacillus delbrueckii ssp. bulgaricus* & *Streptococcus thermophilus*) كبادىء يوجهورت و ABT-5 (يحتوى على *Lactobacillus acidophilus, Streptococcus thermophilus* & *bifidobacteria*) كبادىء له خواص حيوية وأظهرت النتائج ما يلي:

وجود فروق معنويه ($P \leq 0.05$) فى الخواص بين المعاملات المختلفه لمشروب الزبادي باختلاف كل من التركيز المستخدم من لب فاكهه التين الشوكي و نوع البادىء المستخدم في عمليه التخمر ، و فترة التخزين) 9 أيام / 6±0.5°متميزت مشروبات الزبادي الطازج المصنوعة من لب فاكهه التين الشوكي بارتفاع معنوي ($p \leq 0.05$) و تحسن في قيم الخواص الريولوجيه مقارنه بالكنترول باستثناء قيم مؤشر سلوك التدفق flow behaviour index values.

- اظهرت النتائج ايضا زياده معنويه ($p \leq 0.05$) في قيم اللزوجه و انخفاض فصل الشرش في جميع المعاملات وكذلك الكنترول مع زياده تركيز لب الفاكهه المضاف حتي اليوم التاسع من التخزين. كما ادت زياده تركيز لب الفاكهه المضاف الي انخفاض معنوي ($p \leq 0.05$) في قيم رقم الاس الهيدروجيني مقارنه بالكنترول.

- اظهرت النتائج ايضا تغير في صفات اللون لمشروب الزبادي المصنع باستخدام تركيزات مختلفه من لب التين الشوكي خلال فتره التخزين واختلف معدل تدهور الصفات اللونيه باختلاف التركيز المستخدم من لب الفاكهه.

- وأظهرت النتائج ان مشروب الزبادي الحيوي الناتج مرتفع المحتوي من المركبات الفينولية الكلية و مضادات الأكسدة، حيث ازدادت قيمهم معنويا ($p \leq 0.05$) مع ارتفاع مستويات لب الفاكهه المضافة.
- هذا وحافظت المعاملات المختلفه من مشروب اليوجهرت على عدد من الخلايا الحية عند المستوى المقبول كأغذية وظيفية (10^6cfu/ml<) حتى نهايه فترة التخزين المبرد، كما أظهرت نتائج التقييم الحسي أن جميع المعاملات مقبولة مع وجود فروق معنويه ($P \leq 0.05$) بين بعضها البعض.

- اظهرت النتائج الدراسة الحالية أن إضافة لب فاكهه التين الشوكي ادي الي تحسين كبير في الخواص الغذائيه والفوائد الصحية لمشروب اليوجهرت الحيوي المصنع من لبن الماعز.