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Research Article
Physicochemical Characteristics of Functional Goats' Milk Yogurt as Affected by some Milk Heat Treatments

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Abstract

Background: 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 functional products. **Objective:** This study aimed to study the possibility of preparation and properties of functional goats' milk yogurt using commercial yogurt and probiotic starter cultures for enhancing nutritional and functional values of these products with the emphasize on the effect of different heat treatment of the milk use in the manufacture on the physicochemical properties and sensory quality attributes during storage, in attempts to achieve a goats' milk yogurt that was typical of yogurt product as potentially functional dairy foods. **Materials and Methods:** Functional Goats' Milk Yogurt (FGMY) were made from goats' milk thermally treated at 63, 85 and 95°C for 30 min, whereas the control was pasteurized on 72°C for 15 sec, using Yo-Fast 1 (*Lactobacillus delbrueckii* ssp., *bulgaricus* and *Streptococcus thermophilus*) and ABT-2 (*Lactobacillus acidophilus*, *Streptococcus thermophilus* and bifidobacteria) as yoghurt and probiotic starters, respectively used for the fermentation process. The physicochemical, sensory properties as surviving starter microorganisms were followed in yogurt during storage period (9 days at 6±0.5°C). **Results:** Goats' milk yogurt treatments differed ($p \leq 0.05$) in their properties; depending on heat treatments, type of starter used and storage period. Results showed that, the effect of goats' milk heat treatment on the chemical composition of the resultant products was more pronounced than the type of starter culture. Meanwhile, the control sample was characterized by the highest index of syneresis and this index was decreased while, firmness of curd and dynamic viscosity increased in all treatments till the end of storage period. Also, the treatments made with Yo-Fast 1 showed higher total solids, protein and ash contents but lower carbohydrate content, pH and dynamic viscosity values than those made with probiotic starter. Also, *S. thermophilus* were the most prevalent viable microorganisms in all treatments while bifidobacteria cells showed the lowest counts. The counts of viable cells in all FGMY were maintained at an acceptable level to be considered as functional foods until the end of storage period. In terms of yogurt preference, sensory evaluation showed that all yogurt treatments were accepted by the panelists. **Conclusion:** In conclusion, the highest thermally treated goats' milk used in the manufacture yogurt treatments had good significant impact on the physiochemical properties, with higher dynamic viscosity values, lowest whey separation and strong curd compared with other treatments as well as the control throughout storage period especially when fermented with probiotic starter and could be considered as product with functional properties and health benefits.

Key words: Goats' milk yogurt, milk heat treatments, probiotic starters, physicochemical properties, bacteriological properties, sensory properties

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Competing Interest: The authors have declared that no competing interest exists.

Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

The importance of goats as providers of essential food around the world increased significantly, which reflected the largest number increase of goats during the last 20 years as well as, the largest increase in goats' milk production tonnage compared to other farm animals[1]. World production of goats' milk is in a steady increase from 14.38-18.42 MT, depending on the statistics of Food and Agriculture Organization (FAO) in Egypt the output reached[2] about 21.000 t. Milk production of goats is likely to be greater than reported in official statistics, because of the large amounts of unreported home consumption, especially in developing countries[3].

In recent years, the growing consumption of dairy products from goats' milk has required more knowledge about goats' milk properties. Also, in many parts of the world goats' milk is preferred to cows' or buffaloes' milk. Goats' milk has been described as having higher digestibility, due to reduced dimensions of casein micelles and fat globules as well as higher proportion of short to medium chain fatty acids, lower allergenic properties, higher buffering capacity as compared with cows' milk[4,5]. Furthermore, goats' milk contains also free taurine, one of the final metabolic products of sulphur-containing amino acids, which may have several biological functions[6]. Additionally, a certain therapeutic value in human nutrition has been attributed to goats' milk[4].

Fermented products constitute an important part of the human diet because fermentation is one of the cheapest ways of preserving the food, improving its nutritional value and enhancing its sensory properties[7]. Recently, the supplementation of fermented milk products with probiotic bacteria has been exponentially increasing[8], which is led to an increase in consumers' interest in functional foods[9]. 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 functional products[10].

In addition, goats' milk yogurt considered as an excellent carrier for probiotic cultures (Yo-Fast 10) and their survivals remained above 10^6 CFU g^{-1} during storage period[11]. A mixed starter comprising *Lactobacillus acidophilus*, *Bifidobacterium lactis* and *Streptococcus thermophilus* has been successfully used for fermentation of goats' milk[5,12,13]. In order to produce therapeutic benefits, a suggested range for the minimum level for probiotic bacteria in probiotic milk[14] is from 10^6-10^7 CFU mL^{-1}.

Yogurt is an important functional dairy product whose technological characteristics have been subject of numerous investigations. Consequently, consumption of products such as functional yogurt containing viable probiotic starter adds benefit to human health[15]. Although yogurt made from cows' milk is widely consumed in the world. Yogurt products have been prepared with varying success from ovine and caprine milk[16]. Relatively little has been published regarding processing goat milk as a functional yogurt[9].

The texture of yogurt is an important consumer attribute influencing its acceptability. The most important textural characteristics of yogurt are firmness and the ability to retain water[17]. Manufactures often modify yogurt texture by altering process conditions such as heat treatment and evaporation of the milk[18] or by increasing the total solids content of the milk to reduce wheying-off either by addition of milk solids or water-binding stabilizers or thickening agents[19-21].

Consequently, this study aimed to study the possibility of preparation and properties of functional goats' milk yogurt collected from Rural Bedouins at Ras Sudr area, South Sinai Governorate, Egypt by using commercial yogurt and probiotic starter cultures for enhancing nutritional and functional values of these products with the emphasize on the effect of different heat treatment of the milk use in the manufacture on the physicochemical properties and sensory quality attributes during storage, in attempts to achieve a goats' milk yogurt that was typical of yogurt product as potentially functional dairy foods.

MATERIALS AND METHODS

Materials: Goats' milk samples were collected randomly from Shami goat herd animals with small holder herds grazed in Ras Sudr area, South Sinai governorate. Animals were fed on natural vegetation for about 8 h day^{-1} and supplementary feeding in the farm of concentrate feed mixture to cover maintains energy requirements after return from the pasture at the night. Water was offered twice daily in early morning and late afternoon. The milk samples were immediately maintained and stored under refrigerated conditions until the transfer of the laboratory for analyses within 24 h. The chemical composition (Mean $\pm$ Standard Deviation) of raw goats' milk used in the manufacture of goats' milk yogurt treatments is shown in Table 1.

Bacterial strains: Two commercial freeze-dried DVS mixed bacterial starters of Yo-Fast 1 (containing of *Lactobacillus delbrueckii* ssp., *bulgaricus* and *Streptococcus thermophilus* as yogurt starter and ABT-2 (containing of *L. acidophilus*, *S. thermophilus* and bifidobacteria) with potential probiotic properties (from Chr. Hansen Laboratory

Table 1: Chemical composition (Mean±Standard Deviation) of fresh goats' milk used in yogurt manufacture

Sample	Milk constituents					
Goats' milk*	pH	Fat (%)	Protein (%)	Ash (%)	Total carbohydrates (%)	Total solids (%)
	6.65±0.03	3.95±0.06	3.65±0.07	0.73±0.02	4.62±0.09	12.95±0.08

*Bulk goats' milk sample, Protein (%): N×6.38, Total carbohydrates: Calculated by the difference

Copenhagen, Denmark) were used in the fermentation process. Freeze-dried bacterial starters were prepared separately as mother cultures in autoclaved (121°C/10 min) fresh buffaloes' skim milk (0.1% fat and 9.5% SNF) using a 0.02% (w/v) inoculums. The cultures were incubated at 42°C for Yo-Fast 1 starter and 37°C for ABT-2 starter, until curdling of milk. Cultures were prepared 24 h before use. Stock cultures and working cultures were prepared as described by Lee and Lucey[22].

Methods

Manufacture of goats' milk yogurt: Yogurt was made from goats' milk by the traditional method as described by Tamime and Robinson[23]. Four pilot-scale batches of yogurt were made (each of 6 kg milk). Goats' milk samples were divided into 4 equal portions. One of them was thermally treated at 72°C/15 sec and served as a control, while 3 other parts were thermally treated at 63°C (T1), 85°C (T2) and 95°C (T3) for 30 min in thermostatically-controlled water bath and were gently stirred during heating, each of milk was divided into 2 equal portions. The first was cooled to 42°C and the second to 37°C for inoculation with 3% (v/v) (10^8-10^9 CFU mL^{-1}) of Yo-Fast 1 and ABT-2 mother cultures, respectively. The different treatments were dispensed into 150 cc plastic cups, incubated to ~3 h for Yo-Fast 1 culture and ~4 h for ABT-2 culture, then immediately covered, cooled and stored at 6±1°C for 24 h. Different yogurt treatments monitored to different analysis during storage at 6±1°C for 9 days. All goats' milk yogurt treatments were subjected to physicochemical, rheological, bacteriological and sensory analyzes at zero day and after 3, 6 and 9 days of storage.

Chemical and physicochemical analysis: 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 different yogurt treatments according to the method of AOAC[24]. Total carbohydrates were calculated by the difference for all samples analysed. Also, the pH values of goats' milk yogurt treatments were measured when fresh (yogurt samples after 24 h of refrigerated storage) and during storage period at 5°C for 9 days. Synersis was measured as mentioned by Farooq and Haque[25] as the amount of spontaneous whey (mL/100 g) drained off after 2 h at 7°C when fresh and during storage in all yogurt treatments. Firmness was measured in fresh and stored yogurt as described by Amatayakul *et al.*[26]. using a penetrometer (Kochler Co., Inc., USA). The speed of penetration was set at 1 mm sec^{-1} and the depth of penetration was set at 10 mm. Viscosity was measured using a Brookfield DV-E viscometer (Brookfield Engineering Laboratory Inc., Stoughton, MA) with a helipath stand mounted with a T-C spindle size 0.15 cm that rotated at different rpm ranged from 20-200 at shear rates ranging from 4.2-42.1 sec^{-1}. Data were collected using Wingather software (Brookfield Engineering Laboratory Inc., Stoughton, MA). Viscosity was monitored at 6±0.5°C during storage period (zero time and after 3, 6 and 9 days) for all yogurt samples as formerly described by Durdevic-Denin *et al.*[27].

Bacteriological analysis: Samples of all goats' milk yogurt treatments were prepared for bacteriological analysis according to the method described in the Standard Methods for the Examination of Dairy Products[28]. Viable cells counts of *L. delbrueckii* ssp., *bulgaricus* on MRS agar (pH 5.2) (Anaerobic incubation at 37°C for 5 days), *L. acidophilus* on MRS-sorbitol agar (Anaerobic incubation at 37°C for 72 h), *S. thermophilus* on ST agar (Aerobic incubation at 42°C for 24 h) and bifidobacteria on MRS agar (Oxoid) supplemented with L-cystein and lithium chloride (Sigma Chemical Co., USA) (Anaerobic incubation at 37°C for 72 h) were enumerated as described by Dave and Shah[29]. 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^{-1}) of sample and the survival percentage at the end of refrigeration storage period was also calculated according to Nebesny *et al.*[30].

Sensory evaluation: The organoleptic evaluation for the functional goats' milk yogurt samples were subjected by 25 panelists of the staff member of Animal Production Division, Desert Research Center, Cairo, Egypt according to the scheme described by Clark *et al.*[31]. All yogurt treatments were evaluated when fresh (1 day) and throughout storage for

9 days at 6±0.5°C. The sensory attributes evaluated were as follows: Flavour (1-10 points), body and texture (1-5 points) and appearance and colour (1-5 points).

Statistical analysis: All experiments and analysis were done in triplicate. Statistical analysis were carried out using the general liner models procedure of the SPSS 16.0 syntax reference guide[32]. The results were expressed as least squares means with standard errors of the mean. Statistically different groups were determined by the Least Significant Difference (LSD) test ($p\leq 0.05$).

RESULTS AND DISCUSSION

Chemical composition of fresh goats' milk yogurt: The chemical composition of fresh (after 24 h of refrigerated storage at 6±0.5°C) yogurt samples manufactured from goats' milk subjected to different thermal treatments and fermented with yogurt (Yo-Fast 1) or probiotic (ABT-2) starter cultures are shown in Table 2. The results revealed that, the effect of goats' milk heat treatment used in the manufacture of yogurt on the chemical composition of the resultant products was more pronounced ($p\leq 0.05$) than that of type of starter culture used ($p\geq 0.05$).

No significant differences ($p\geq 0.05$) were found in the Total Solid (TS), Fat (F), Protein (P), Ash (A) and Carbohydrate (C) contents, between yogurt samples, depending on the type of starter culture. These results were in agreement with those obtained by Akalin[33] who stated that, the type culture used in the fermentation didn't affect on the TS, P, F and lactose ratios of yogurt, bioghurt, bifighurt and biogarde. The yogurt treatments made with Yo-Fast 1 starter were showed an increase in TS, P and A contents but a decrease in C content than those fermented with probiotic (ABT-2) starter. Moreover, Fatma[34] noticed that the stirred fermented milk made by ABT-4 culture showed slight decrease in TP than made by used YO-Flex yogurt culture, this may be due to the limited proteolysis of milk protein by lactic acid bacteria.

In addition, the thermal treatment of goats' milk for 85 or 95°C for 30 min before the manufacture yogurt led to products with significant ($p\geq 0.05$) different chemical composition, in terms of the content of TS, P and A. This confirms that heat-treatments affected the chemical composition of the milk[35]. On the other hand, the thermal treatment at 63°C for 30 min of goats' milk did not differ significantly in gross composition of yogurt than control one (72°C for 15 sec). This means that the normal pasteurization method do not affect the chemical composition of goats' milk yogurt and these results are in agreement with that result given by Raynal-Ljutovac *et al.*[16]. Moreover, all yogurt composition was in agreement with those obtained by Uysal *et al.*[36].

Among treatments, goats' milk yogurt made with milk previously heated to 95°C for 30 min (T3) were characterized by high contents of TS, F, P and A but low content of C; as compared with all other treatments (Table 2). The significantly ($p\leq 0.05$) highest values of TS were found in yogurt samples manufactured from goats' milk treated to 95 or 85°C for 30 min compared with control (manufactured from pasteurized milk at 72°C for 15 sec).

The protein content was only significantly ($p\leq 0.05$) affected by the applied treatment at 95°C for 30 min, while it was not significantly between the control and other treatments. The fat content was not affected by the applied thermal treatments of goats' milk with the exception in yogurt

Table 2: Chemical composition of goats' milk yogurt as affected by milk heat treatments and yogurt starter cultures

		Treatments			
Chemical composition (%)	Type of starter/bacterial strains	Control	T1	T2	T3
Total solids	Yo-Fast 1*	13.01 ± 0.14^{De}	13.07 ± 0.09	13.13 ± 0.09^{Bbc}	13.20 ± 0.11^{Aa}
	ABT-2**	12.97 ± 0.22^{De}	13.05 ± 0.14^{Cde}	13.11 ± 0.08^{Bdc}	13.18 ± 0.17^{Aab}
Fat	Yo-Fast 1*	3.95 ± 0.09^{Cc}	3.98 ± 0.16^{Cc}	4.02 ± 0.16^{Bb}	4.05 ± 0.23^{Aa}
	ABT-2**	3.95 ± 0.15^{Cc}	3.98 ± 0.15^{Cc}	4.02 ± 0.07^{Bb}	4.05 ± 0.15^{Aa}
Total protein (N×6.38)	Yo-Fast 1*	3.65 ± 0.11^{Cc}	3.67 ± 0.20^{BCbc}	3.69 ± 0.10^{ABab}	3.71 ± 0.19^{Aa}
	ABT-2*	3.61 ± 0.20^{Cd}	3.65 ± 0.13^{Bc}	3.67 ± 0.13^{ABab}	3.69 ± 0.21^{Aab}
Total carbohydrate#	Yo-Fast 1*	4.66 ± 023^{Aab}	4.65 ± 0.17^{Ab}	4.63 ± 0.19^{ABab}	4.62 ± 0.14^{Bc}
	ABT-2*	4.68 ± 0.14^{Aa}	4.67 ± 0.20^{Aa}	4.65 ± 0.08^{ABab}	4.64 ± 0.17^{Bbc}
Ash	Yo-Fast 1*	0.75 ± 0.18^{Cbc}	0.77 ± 0.22^{BCab}	0.79 ± 0.15^{ABab}	0.82 ± 0.13^{Aa}
	ABT-2 **	0.73 ± 0.16^{Cc}	0.75 ± 0.14^{BCbc}	0.77 ± 0.17^{ABab}	0.80 ± 0.20^{Aa}

Data represented average of 3 separate trials, Control: Yogurt made from heated milk at 72°C/15 sec, T1: Yogurt made from heated milk at 63°C/30 min, T2: Yogurt made from heated milk at 85°C/30 min, T3: Yogurt made from heated milk at 95°C/30 min, #Calculated by the difference, *Bacterial starter culture containing of *Lactobacillus delbrueckii* spp., *bulgaricus* and *Streptococcus thermophilus* (as commercial yogurt starter), **Bacterial starter culture containing of *Lactobacillus acidophilus*, *Streptococcus thermophilus* and bifidobacteria (with potential probiotic properties), A-C Means with the different capital superscript letters within the same raw indicate significant ($p\leq 0.05$) differences between bacterial strains Yo-Fast 1/bacterial strains ABT-2 and milk heat treatments, a-c Means with the different small superscript letters within the same column and property are significantly ($p\leq 0.05$) different between type of starter and milk heat treatments samples from thermally treated goats' milk≥85°C for 30 min (Table 2), the differences in this respect (95°C for 30 min) were significant.

The highest ash content was significantly ($p\leq0.05$) achieved in the yogurt from thermally treated milk at 95°C for 30 min, followed by the T2 yogurt treatments. Table 2 also presented that, among all treatments the control samples characterized by the lowest average value for ash content. The hydrolysis of lactose was significantly ($p\leq0.05$) highest in the goats' milk thermally treated for ≥85°C for 30 min than all other treatments. It could be due to that during heat treatment of milk, pH decreased, while titratable acidity increased and lactose content decreases during heat treatment. Same observations reported by Durdevic-Denin *et al.*[27] and Hussain *et al.*[37].

Moreover, a gradual decrease in the carbohydrate values could be observed in all yogurt treatments with increasing the heat treatments used before manufacture all yogurt treatments. Also, no significant differences ($p\leq0.05$) were found in fat and total carbohydrate but significant in ash and total solids contents between samples, depending on the previous milk heat treatment used. These differences in the chemical composition of yogurt treatments could be due to that, the effect of heat treatment used[20].

Changes in pH values of goats' milk yogurt during storage: The effect of the different thermal treatments of goats' milk prior to the manufacture as well as starter culture used on the changes in pH values of yogurt treatments during storage period (6±1°C for 9 days) are depicted in Fig. 1. It can be observed that the pH values varied between different goats' milk yogurt treatments according to the type of milk thermal treatments and starter cultures used as well as time of the storage ($p\leq0.05$). The yogurt treatments made with yogurt starter (Yo-Fast 1) was characterized by lower pH values during the cold storage period as compared with those made by probiotic starter (ABT-2) culture. The higher acidity of yogurt treatments made with Yo-Fast 1 starter could be attributed to the high activity of lactose in yogurt starter splitting lactose into glucose and galactose as the first step of fermentation[18]. These obtained results are in agreement with those of Oliveira *et al.*[38] and Lucas *et al.*[39] who reported that *L. bulgaricus* produces lactic acid during refrigerated storage, known as post acidification. It could be noticed from the presented data that, the yogurt treatments made from milk thermally treated before manufacture yogurt at 95°C for 30 min were characterized with lower pH values as compared with the control treatment either when fresh or during storage period (Fig. 1). The differences in acidity in response to the applied thermal treatments could be due to the phase change of calcium phosphate from the soluble phase to the colloidal one. The phase change is thought to result from the liberation of hydrogen ion[40]. In addition, with extending the storage days there were gradual decreases in the pH values reaching minimum values at the end of storage period due to the slow metabolic activity of the starter cultures[41]. Moreover, this decrease could be attributed to a limited growth of different bacterial starter cultures and the slow fermentation of lactose residual. Same findings reported by Barrantes *et al.*[42]. Hashim *et al.*[43] reported that lactose content was responsible for the coagulum formation and the reduction in pH as a result of the production of organic acids (e.g., lactic acid). A lower pH values in goats' milk yogurt has been also reported by Bozanic *et al.*[44] when compared to probiotic-fermented milk products, this could be attributed to the presence *L. delbrueckii* ssp., *bulgaricus* in the yogurt starter culture but absent in the ABT culture that was used[41,11].

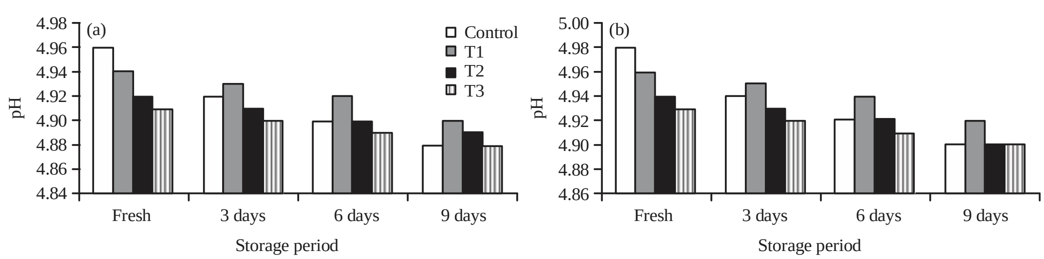

Fig. 1(a-b): Changes in pH values of goats' milk yogurt as affected by some milk heat treatments and fermented with (a) Yogurt and (b) Probiotic starter cultures during storage period (6±1°C for 9 days), Control: Yogurt made from heated milk at 72°C/15 sec, T1: Yogurt made from heated milk at 63°C/30 min, T2: Yogurt made from heated milk at 85°C/30 min, T3: Yogurt made from heated milk at 95°C/30 min, (a) Bacterial starter culture containing of *Lactobacillus delbrueckii* ssp., *bulgaricus* and *Streptococcus thermophilus* (as commercial yogurt starter) and (b) Bacterial starter culture containing of *Lactobacillus acidophilus*, *Streptococcus thermophilus* and bifidobacteria (with potential probiotic properties)

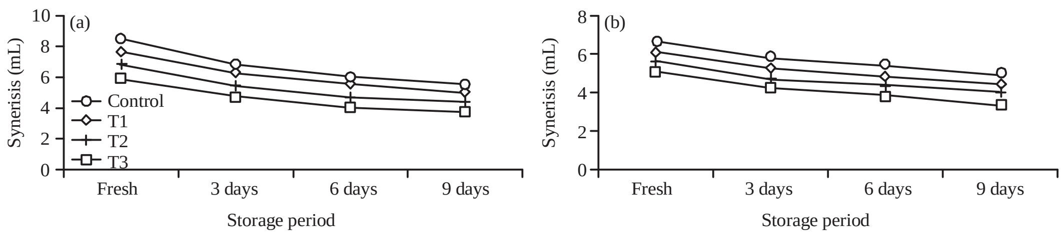

Fig. 2(a-b): Spontaneous whey separation (mL/100 g) of goats' milk yogurt samples as affected by some milk heat treatments and fermented with (a) Yogurt and (b) Probiotic starter cultures during storage period (6±1°C for 9 days), Control: Yogurt made from heated milk at 72°C/15 sec, T1: Yogurt made from heated milk at 63°C/30 min, T2: Yogurt made from heated milk at 85°C/30 min, T3: Yogurt made from heated milk at 95°C/30 min, (a) Bacterial starter culture containing of *Lactobacillus delbrueckii* ssp., *bulgaricus* and *Streptococcus thermophilus* (as commercial yogurt starter) and (b) Bacterial starter culture containing *of Lactobacillus acidophilus*, *Streptococcus thermophilus* and bifidobacteria (with potential probiotic properties)

Spontaneous whey separation (mL/100 g) of goats' milk yogurt: Spontaneous whey separation (mL/100 g) of goats' milk yogurt samples as affected by both of the subjected thermal treatments of milk, type of starter culture used in the manufacture of yogurt treatments when fresh and during storage at 6±0.5°C for 9 days are shown in Fig. 2.

Significant differences ($p \leq 0.05$) in syneresis rate were found between all yogurt treatments, where the type of starter, different milk heat treatments as well as time of the storage were the principle factors influencing the amounts of wheying-off. It can be seen that the control yogurt treatments has presented a higher index of syneresis as compared to other treatments. However, significant ($p \leq 0.05$) rate was only recorded in the highest thermally treated yogurt samples (T2 and T3). This might be related to the degree of water retention by the protein matrix. These results in agreement with those obtained by Durdevic-Denin *et al.*[27] who reported that heat treatment plays very important role in yogurt manufacture and quality. Also, it could be observed from Fig. 2, that the whey separation in all yogurt treatments as well as the control decreased ($p \leq 0.05$) as storage time progressed till the 9th day, possible explanation could be due to that, the whey separation in acid milk gels has been linked to rearrangements of particles making up the casein gel network, during heat treatments, complex between casein and whey protein is formed, which directly influences hydration of casein micelles. This is compatible with Al-Kadamany *et al.*[45]. Additionally, Somer and Kilic[46] reported that heat treatment promotes protein denaturation, which increases water binding and viscosity. Furthermore, goats' milk yogurt fermented with Yo-Fast 1 culture had higher amounts of whey separation than that fermented with ABT-2 culture being the lowest values with T3 treatments till the 9th day of storage (Fig. 2). Same finding reported by Hassan[47] and Purohit *et al.*[48] who 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[49].

The lowest whey separation level (better water holding capacity) was observed in yogurt made with milk treated to 95°C/30 min, it could be due to that, low levels of solubilization of Colloidal Calcium Phosphate (CCP) reduced whey separation and enhanced number of casein interactions. The rate of solubilization of CCP was considered as an important factor on whey separation and weak gel formation[22]. Heat treatment promotes protein denaturation, which increases water binding and viscosity[46].

On the other side, among all treatments the control yogurt samples were characterized with the highest whey separation levels (lower water holding) either when fresh or during storage. Also, higher whey synersis in the control treatments resulted in lower curd tension as indicated to a poor structure and weak curd. Greater solubilization of CCP from casein particles after gelation has been related to increased whey separation, also resulted a weak yogurt curd structure. Same observations also reported by Somer and Kilic[46], Mizuno and Lucey[50] and Ozcan-Yilsay *et al.*[51].

Firmness of goats' milk yogurt: The firmness (Penetrometer values) of goats' milk yogurt samples as affected by both of the subjected thermal treatments of milk, type of starter culture used in the manufacture of yogurt treatments when fresh and during storage at 6±0.5°C for 9 days are illustrated in Fig. 3. Higher penetrometer values indicated higher firmness. In terms, there were significant differences ($p \leq 0.05$)

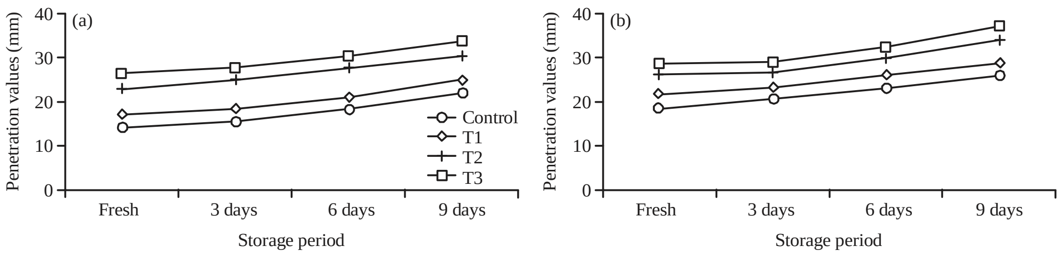

Fig. 3(a-b): Firmness (Penetrometer values/mm) of goats' milk yogurt samples as affected by some milk heat treatments and fermented with (a) Yogurt and (b) Probiotic starter cultures during storage period (6±1°C for 9 days), Control: Yogurt made from heated milk at 72°C/15 sec, T1: Yogurt made from heated milk at 63°C/30 min, T2: Yogurt made from heated milk at 85°C/30 min, T3: Yogurt made from heated milk at 95°C/30min, (a) Bacterial starter culture containing of *Lactobacillus delbrueckii* ssp., *bulgaricus* and *Streptococcus thermophilus* (as commercial yogurt starter) and (b) Bacterial starter culture containing of *Lactobacillus acidophilus*, *Streptococcus thermophilus* and bifidobacteria (with potential probiotic properties)

in the firmness between different yogurt treatments, where the type of starter, different milk heat treatments as well as time of the storage were the principle factors influencing yogurt firmness. Among treatments, the highest thermally treated yogurt samples (T3) characterized with the highest firmness values throughout the storage period Fig. 3. The obtained results in accordance with that of Somer and Kilic[46] who reported that heat treatment promotes protein denaturation, which increases water binding and viscosity.

Also, it could be due to that, low levels of CCP removal facilitated greater rearrangement and molecular mobility of the micelle structure, which may have helped to increase the formation of cross-links between strands in yogurt gel, resulted in firm curd. These results were in agreement with those obtained by Ozcan-Yilsay *et al.*[51]. Among treatments the control yogurt was characterized with the lowest firmness gel when fresh and during cold storage period. The obtained results are in accordance with Lee and Lucey[52] who reported that native whey proteins from unheated milk are inert fillers in yogurt. When milk is heated at >70°C, the major whey proteins, such as, β-lactoglobulin are denatured. During denaturation β-lactoglobulin interacts with the κ-casein on the casein micelle surface (and any soluble κ-casein molecules, i.e., κ-casein that dissociates from the micelle at high temperatures) by disulfide bridging, which results in increased gel firmness and viscosity of yogurt. Lucey *et al.*[53] mentioned that denatured whey proteins that have become attached to the surface of casein micelles are a critical factor involved in the increased stiffness of yogurt gels made from heated milk. Soluble complexes of denatured whey proteins with κ-casein also associate with the micelles during the acidification process.

Heat treatment of milk for 15 min at ≥80°C results in significantly increased denaturation of β-lactoglobulin compared with milk heated at 75°C for a similar time. The extent of denaturation of whey proteins during the heat treatment of milk affects the firmness and viscosity of acid milk gels[54]. Additionally, there was negative correlation between the changes in firmness and synersis in yogurt, same observation reported by Folkenberg *et al.*[55]. High levels of solubilization of CCP increased whey separation due to reduced number of casein interactions, whey separation is related to an unstable gel netstudy as well as weak yogurt structure or by other word lower curd tension[51]. Same observation reported by Lee and Lucey[22] and Lucey[56].

Throughout the storage at 6±0.5°C for 9 days, significant differences ($p \le 0.05$) were observed in firmness which is increased in all treatments including the control. This increased in the penetration values are in agreement with Farooq and Haque[25] and Barrantes *et al.*[57]. Also, goats' milk yogurt treatments fermented with Yo-Fast 1 culture had lower curd tension values compared with those fermented with ABT-2 culture either when fresh or during storage (6±0.5°C/9 days). It could be due to that, some strains of lactic acid bacteria used in the manufacture fermented milk products produced exopolysaccharides, which affect syneresis of fermented products Same observation reported by Lee and Lucey[22], Hassan[47], Purohit *et al.*[48] and Lucey[56]. Also, exopolysaccharides have the ability to bind water and reduce whey syneresis and as a result increase curd tension[49].

In general, lower curd tension and higher whey syneresis may be due to the decrease of total solids which exhibit weak body, poor texture and whey separation. With increasing the previous milk heat treatment due to greater total solids which is a reasons for increasing the curd tension and lower syneresis of this treatment. The curd tension progressively increased and whey syneresis decreased in all treatments with advanced storage being the lowest values in the control treatments either when fermented with yogurt or probiotic starter (Fig. 3), which may be attributed to the acidity development as well as the complete setting of curd during storage[58-60].

Microbiological properties of goats' milk yogurt: Data presented in Table 3 indicated that, significant differences ($p\leq 0.05$) were found in log bacterial cell counts between different goats' milk yogurt treatments as affected by the type of culture or milk heat treatment used in the manufacture and storage period (6±1°C for 9 days). Also, cells of *S. thermophilus* were prevalent in goats' milk yogurt treatments made with different starters either when fresh or during storage period being the highest mean in T3 treatments. On the other hand, the survival rate of *L. acidophilus* was higher than that of bifidobacteria in probiotic goats' milk yogurt treatments. Also, bifidobacteria was exhibited the lowest levels of viable cells in all functional fermented goats' milk yogurt throughout the storage period.

There was a gradual decrease in the viable cells counts detected of bifidobacteria counts during cold storage, while Survival of *L. delbrueckii* ssp., *bulgaricus*, *S. thermophilus* and *L. acidophilus* were gradually increased until the 3rd day of storage and then decreased in all yogurt treatments (Table 3). Survival of *L. acidophilus*, bifidobacteria, *L. delbrueckii* ssp., *bulgaricus* and *S. thermophilus* cells during the storage for 9 days at 6±1°C of all goats' milk yogurt treatments could be considered satisfactory. Slacanac *et al.*[12] and Ranadheera *et al.*[5] reported that, a mixed starter comprising *Lactobacillus acidophilus*, *Bifidobacterium lactis* and *Streptococcus thermophilus* has been successfully used for fermentation of goats' milk and a high viability of probiotic strains in a fermented goats' milk stored at 4°C for 10 days has been reported[13].

Additionally, the counts of viable cells in all goats' milk yogurt treatments were maintained at an acceptable level to

Table 3: Viable cell counts ($\log_{10}$ CFU$^{\#}$ mL^{-1}) of bacterial starter strains in goats' milk yogurt during storage at 6±0.5°C /9 days

Type of starter/bacterial strains	Storage period (days)	Treatments: Control	T1	T2	T3
Yo-Fast 1*					
Lactobacillus bulgaricus	0	7.72 ± 0.11^{EFGc}	7.76 ± 0.12^{DEbc}	7.80 ± 0.20^{BCab}	7.83 ± 0.15^{ABCa}
	3	7.74 ± 0.10^{DEFb}	7.78 ± 0.14^{CDb}	7.83 ± 0.11^{ABCa}	7.86 ± 0.16^{Aa}
	6	7.70 ± 014^{FGc}	7.75 ± 0.13^{DEbc}	7.79 ± 0.08^{CDb}	7.84 ± 0.17^{ABa}
	9	7.68 ± 0.11^{Gc}	7.72 ± 0.14^{EFGbc}	7.76 ± 0.21^{DEb}	7.81 ± 0.11^{BCa}
	Mean	7.71 ± 0.09^{d}	7.75 ± 0.19^{c}	7.80 ± 0.16^{b}	7.84 ± 0.23^{a}
Streptococcus thermophilus	0	8.66 ± 0.06^{EFd}	8.76 ± 0.16^{Dc}	8.84 ± 0.10^{BCb}	8.90 ± 0.18^{ABa}
	3	8.68 ± 0.11^{Ed}	8.79 ± 0.10^{Cc}	8.88 ± 0.14^{Bb}	8.93 ± 0.09^{Aa}
	6	8.65 ± 0.18^{EFd}	8.77 ± 0.14^{CDc}	8.85 ± 0.13^{BCb}	8.91 ± 0.15^{Aa}
	9	8.62 ± 0.20^{Fd}	8.74 ± 0.18^{DEc}	8.82 ± 0.17^{Cb}	$8.89A\pm0.14^{Ba}$
	Mean	8.65 ± 0.19^{d}	8.77 ± 0.15^{c}	8.85 ± 0.16^{b}	8.91 ± 0.11^{a}
ABT-2**					
Lactobacillus acidophilus	0	7.60 ± 0.08^{EFc}	7.65 ± 0.09^{CDb}	7.67 ± 0.14^{BCb}	7.72 ± 0.08^{Aa}
	3	7.62 ± 0.016^{DEFc}	7.68 ± 0.20^{BCb}	7.69 ± 0.18^{ABb}	7.74 ± 0.17^{Aa}
	6	7.59 ± 0.012^{EFc}	7.64 ± 0.15^{CDEb}	7.66 ± 0.07^{CDb}	$7.71A\pm0.14^{Ba}$
	9	7.56 ± 0.17^{Fc}	7.62 ± 0.18^{DEFb}	$7.64C\pm0.19^{DEb}$	$7.69A\pm0.17^{Ba}$
	Mean	7.59 ± 0.14^{d}	7.65 ± 0.20^{c}	7.67 ± 0.22^{b}	7.72 ± 0.09^{a}
Streptococcus thermophilus	0	8.63 ± 0.11^{GHd}	8.75 ± 0.16^{EFc}	8.83 ± 0.16^{DEb}	8.89 ± 0.11^{ABa}
	3	8.67 ± 0.15^{Gd}	8.79 ± 0.18^{DEc}	8.87 ± 0.11^{BCb}	8.92 ± 0.14^{Aa}
	6	8.64 ± 0.17^{GHd}	8.76 ± 0.11^{EFc}	8.84 ± 0.08^{CDb}	8.90 ± 0.15^{ABa}
	9	8.61 ± 0.06^{Hd}	8.73 ± 0.17^{Fc}	8.81 ± 0.23^{DEb}	8.88 ± 0.21^{ABa}
	Mean	8.64 ± 0.07^{d}	8.76 ± 0.21^{c}	8.84 ± 0.17^{b}	8.90 ± 0.09^{a}
Bifidobacteria	0	7.18 ± 0.08^{DEFc}	7.24 ± 0.15^{ABb}	7.27 ± 0.15^{Aab}	7.29 ± 0.12^{Aa}
	3	7.16 ± 0.19^{EFGc}	7.22 ± 0.13^{BCDc}	7.25 ± 0.12^{ABab}	7.27 ± 0.18^{Ac}
	6	7.14 ± 0.21^{FGb}	7.21 ± 0.14^{CDa}	7.23 ± 0.18^{BCa}	7.25 ± 0.16^{ABa}
	9	7.12 ± 0.11^{Gc}	7.19 ± 0.19^{DEb}	7.21 ± 0.14^{BCDab}	7.23 ± 0.08^{Ba}
	Mean	7.15 ± 0.16^{c}	7.22 ± 0.20^{b}	7.24 ± 0.19^{ab}	7.26 ± 0.17^{a}

Data represented average of 3 separate trials, Control: Yogurt made from heated milk at 72°C/15 sec, T1: Yogurt made from heated milk at 63°C/30 min, T2: Yogurt made from heated milk at 85°C/30 min, T3: Yogurt made from heated milk at 95°C/30 min, #Colony forming unit, *Bacterial starter culture containing of *Lactobacillus delbrueckii* spp., *bulgaricus* and *Streptococcus thermophilus* (as commercial yogurt starter), **Bacterial starter culture containing of *Lactobacillus acidophilus*, *Streptococcus thermophilus* and bifidobacteria (with potential probiotic properties), A,B,C....Means with the different capital superscript letters within the same raw indicate significant ($p\leq 0.05$) differences between storage period and milk heat treatments, a,b,c....Means with the different small superscript letters within the same column and property are significantly ($p\leq 0.05$) different between bacterial strains/storage period and milk heat treatments be considered as functional foods until the end of the cold storage. This indicated that, the total numbers of bacterial starter strains in all goats' milk yogurt treatments were high enough to provide functional properties (10^6 CFU mL^{-1}), which is the recommended minimum daily intake as mentioned by Akin *et al.*[61]. In order to produce therapeutic benefits, a suggested range for the minimum level for probiotic bacteria in probiotic[14] milk is from 10^6-10^7 CFU mL^{-1}.

Also, the presented date (Table 3) revealed that, that the probiotic cultures were relatively stable in the goats' milk yogurt treatments and their populations remained above10^6 CFU g^{-1} during storage period, improving that goats' milk yogurt could be an excellent carrier for the probiotic cultures. These data agree with Farnsworth *et al.*[11]. The *S. thermophilus* cells remained viable at count of 8.61 log CFU g^{-1} in fermented goats' milk[10].

Moreover, Guler-Akin and Akin[62] reported that the viable bacterial counts in yogurt and bio-yogurts made from goat milk using a yogurt and probiotic starter culture were above 10^7 CFU g^{-1} at the end of storage. Overall, streptococci seemed to have higher survival than lactobacilli during prolonged refrigerated conditions[63]. For practical application; a pH value of the final product must be maintained above 4.6 to prevent the decline of bifidobacteria populations[64].

Flow behaviour of goats' milk yogurt: The flow behaviour (shear stress/shear rate curves) of goats' milk yogurt as affected by the thermal treatments of milk used in yogurt manufacture and yogurt (Yo-Fast 1) or probiotic (ABT-2) starter cultures used in the fermentation process during storage at 6±0.5°C for 9 days are illustrated in Fig. 4-7.

There were significant differences ($p \leq 0.05$) between shear stress values of yogurt samples, depending on milk heat treatment, type of starters used in the manufacturing in one side and storage time on the other side. Also, the viscosity values of all samples studied significantly increased ($p \leq 0.05$) during storage and the yogurt from different treatments.

The yogurt behaved as a shear thinning non-Newtonian fluid and exhibited pseudoplastic behaviours[65]. This shear thinning behavior is due to the progressive breakdown of aggregates formed between milk caseins by the action of the decrease in pH (Fig. 1).

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, exhibited a pseudoplastic shear thinning behaviour. Same finding reported by Fguiri *et al.*[66]. Concerning the type of starter used in the manufacture, using of yogurt starter (Yo-Fast 1) in the fermentation process was resulted in the downward shifting

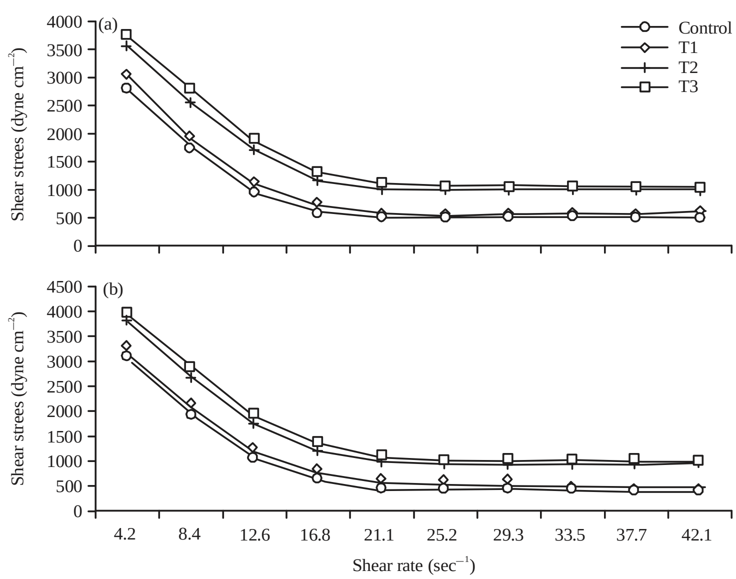

Fig. 4(a-b): Flow behaviour of fresh goats' milk yogurt as affected by some heat treatments and fermented by (a) Yogurt and (b) Probiotic starter cultures, respectively during the storage period at 6±0.5°C, Control: Yogurt made from heated milk at 72°C/15 sec, T1: Yogurt made from heated milk at 63°C/30 min, T2: Yogurt made from heated milk at 85°C/30 min, T3: Yogurt made from heated milk at 95°C/30 min, (a) Bacterial starter culture containing of *Lactobacillus delbrueckii* ssp., *bulgaricus* and *Streptococcus thermophilus* (as commercial yogurt starter) and (b) Bacterial starter culture containing of *Lactobacillus acidophilus*, *Streptococcus thermophilus* and bifidobacteria (with potential probiotic properties)

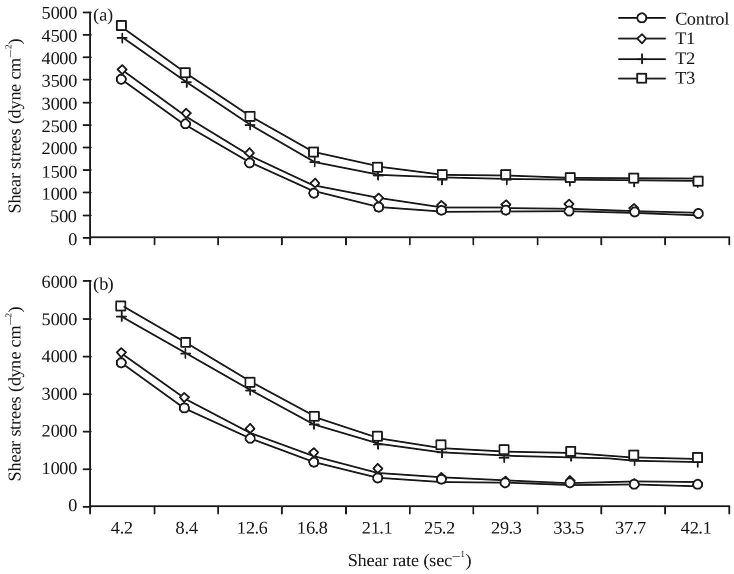

Fig. 5(a-b): Flow behaviour goats' milk yogurt as affected by some heat treatments and fermented by (a) Yogurt and (b) Probiotic starter cultures, respectively during the storage period at 6±0.5°C/3 days, Control: Yogurt made from heated milk at 72°C/15 sec, T1: Yogurt made from heated milk at 63°C/30 min, T2: Yogurt made from heated milk at 85°C/30 min, T3: Yogurt made from heated milk at 95°C/30 min, (a) Bacterial starter culture containing of *Lactobacillus delbrueckii* ssp., *bulgaricus* and *Streptococcus thermophilus* (as commercial yogurt starter) and (b) Bacterial starter culture containing of *Lactobacillus acidophilus*, *Streptococcus thermophilus* and bifidobacteria (with potential probiotic properties)

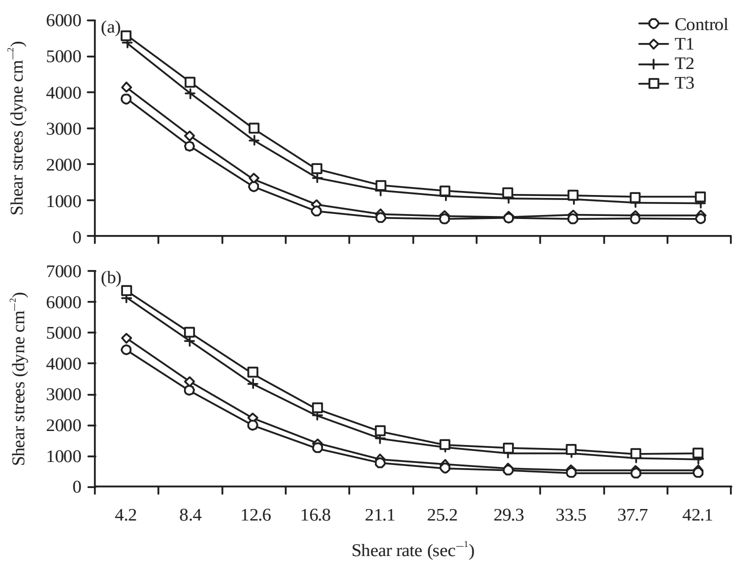

Fig. 6(a-b): Flow behaviour of goats' milk yogurt as affected by some heat treatments and fermented by (a) Yogurt and (b) Probiotic starter cultures, respectively during the storage period at 6±0.5°C/6 days, Control: Yogurt made from heated milk at 72°C/15 sec, T1: Yogurt made from heated milk at 63°C/30 min, T2: Yogurt made from heated milk at 85°C/30 min, T3: Yogurt made from heated milk at 95°C/30 min, (a) Bacterial starter culture containing of *Lactobacillus delbrueckii* ssp., *bulgaricus* and *Streptococcus thermophilus* (as commercial yogurt starter) and (b) Bacterial starter culture containing of *Lactobacillus acidophilus*, *Streptococcus thermophilus* and bifidobacteria (with potential probiotic properties)

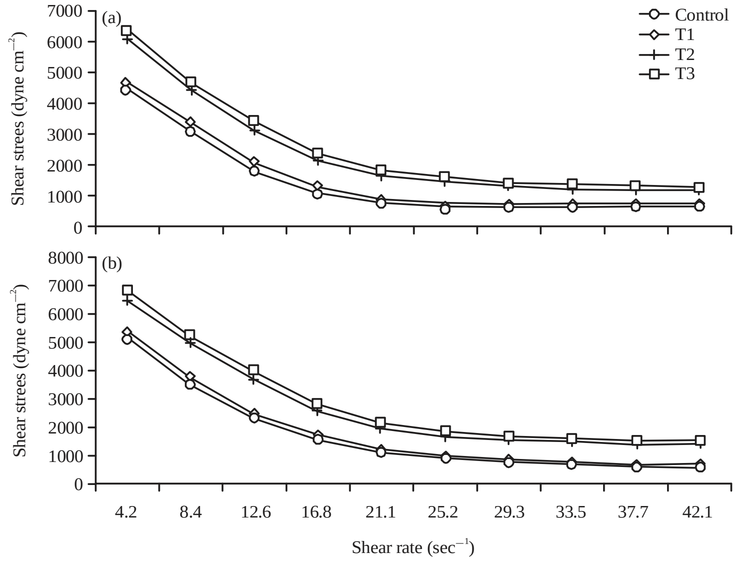

Fig. 7(a-b): Flow behaviour goats' milk yogurt as affected by some heat treatments and fermented by (a) Yogurt and (b) Probiotic starter cultures, respectively during the storage period at 6±0.5°C/9 days. Control: Yogurt made from heated milk at 72°C/15 sec, T1: Yogurt made from heated milk at 63°C/30 min, T2: Yogurt made from heated milk at 85°C/30 min, T3: Yogurt made from heated milk at 95°C/30 min, (a) Bacterial starter culture containing of *Lactobacillus delbrueckii* ssp., *bulgaricus* and *Streptococcus thermophilus* (as commercial yogurt starter) and (b) Bacterial starter culture containing of *Lactobacillus acidophilus*, *Streptococcus thermophilus* and bifidobacteria (with potential probiotic properties)

of the flow curve as compared with that made by probiotic starter (ABT-2). Our result are in according with Folkenberg *et al.*[55] and Lazaridou and Biliaderis[67]. In addition, the increase in the viscosity values of fermented milk products could be due to some strains of LAB used in the manufacture produce EPS[55]. Also, Moreira *et al.*[68] mentioned that, it is generally accepted that the viscosity of coagulum depends both on the amount of EPS produced and on the pH. In addition, this decrease in flow curve indicated that there was decrease in the viscosity of yogurt samples prepared with the yogurt starter than that made with ABT-2 culture.

Moreover, some strains of lactic acid bacteria used in the manufacture of fermented milks produce exopolysaccharides[48], that increased the viscosity of fermented milks[55]. The fall in viscosity with shear rate might be due to the destruction of the interactions within the yogurt netstudy structure. These interactions are electrostatic and hydrophobic ones, which are considered as weak physical bonds[69]. From Fig. 4-7 show that during the investigated time of shearing, It can be seen that the change in the viscosity was linear with the increase in the thermal treatment of goats' milk, where yogurt samples made with milk previously thermally treated at 95°C for 30 min (T3) was characterized with 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 during storage at 5°C till the 9th day (Fig. 4). It could be due to its firmness, strong protein netstudy and firm curd (Fig. 3) which is affected the increase in viscosity values. Also, viscosity is correlated with the firmness of yogurt[70,71]. Furthermore; during heat treatment whey protein associated with casein micelles alters properties of micelles, so they become more hydrated than natural casein micelles. Whey proteins participate in gel structure due to formed co-aggregates and in this way contribute to the flow behavior of gels. Corredig and Dalgleish[72] found that not only time and temperature of heating but also the amount of whey protein present in skim milk affect the quantity of formed complex; as well as that casein micelle possess only a certain number of sites which are available for the interaction with β-lactoglobulin. Therefore, the yogurt samples T3 with the highest thermal treatment also had the highest protein content and consequently T3 had the highest dynamic viscosity as shown in Fig. 4. The obtained results in accordance with that of Somer and Kilic[46] who reported that heat treatment promotes protein denaturation, which increases water binding and viscosity. In this sense, Cayot *et al.*[73] reported that the consistency index of stirred acid gels, calculated from the Ostwald model, increased as milk heating temperature increased from 70-100°C. An increase in milk heating temperature resulted in an increase in apparent viscosity of stirred yogurts[74].

On the other hand, the control treatment (73°C for 15 sec) resulted in yogurt with low viscosity values (downward shifting of the viscosity). A possible explanation of the decrease in the viscosity values 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[50]. On the other hand, viscosity of yogurt might be associated with the strength of the gel resistant to breaking[75].

Furthermore, as the storage period advanced the viscosity in all goats' milk yogurt treatments increased gradually with a slow rate being the highest values with T3 treatments either fermented with yogurt or probiotic starter as shown in Fig. 7, it could be related to a strong protein netstudy and firm curd (Fig. 3). The same trend was founded in the stirred yogurt by Beal *et al.*[76] who reported that, the longer the storage time was, the higher the viscosity was especially between 1 and 7 days of cold storage. It was also found that, viscosity is correlated with the firmness of yogurt[70,71]. Similar observation was reported also by Abu-Jdayil *et al.*[77].

Organoleptic properties of goats' milk yogurt: The scores for organoleptic properties, overall evaluation and preference of goats' milk yogurt as affected by both the thermal treatments of milk used in yogurt manufacture and yogurt (Yo-Fast 1) or probiotic (ABT-2) starter cultures used in the fermentation process during storage at 6±0.5°C for 9 days are depicted in Table 4.

All goats' milk yogurt treatments were acceptable with significant differences ($p \leq 0.05$) among each other, where the milk heat treatment and starter used, as well as time of the storage were the principle factors ($p \leq 0.05$) influencing on the organoleptic properties. It is clear that no marked change occurred in colour and appearance either in fresh or in stored treatments. Moreover, all treatments characterized by specific taste which is due to the type of milk and starters used. The resultant products had a good general appearance, body and texture (soft, smooth and lubricity texture) and pleasant creamy flavour.

Concerning the type of starter used, the treatments fermented with yogurt culture ranked lower flavour scores than that fermented with probiotic 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), same finding reported by Hussain *et al.*[37].

The overall acceptability scores of the sensory evaluation revealed that yogurt samples made with milk previously thermally treated at 95°C for 30 min (T3) either fresh or stored were the significantly most accepted and gained higher scores; especially when probiotic culture (ABT-2) used in the fermentation process and were characterized with perfect flavour, body and texture as well as whiteness appearance and color followed by yogurt samples made with milk previously thermally treated at 85°C for 30 min (T2) while the control (73°C for 15 sec) treatment was the least, ranked the lowest organoleptic scores throughout the storage period (6±0.5°C for 9 days), possible explanation could be due to the pronounced of small amount of free whey.

As storage progressed to the 9th day, the decrease in quality (flavour, body and texture and appearance) started to be seen after the 6th day of storage and all treatments scored the lowest values at the end of storage period, as observed also by Bonczar *et al.*[41]. Akin *et al.*[61] and Guler-Akin and Akin[62] indicated that the organoleptic evaluation of the bio-yogurts received higher scores than the yogurts and appeared to be more acidic than the bio-yogurt after 14 days, so it received lower organoleptic scores than the bio-yogurts. The decrease in total quality during storage was more marked in control treatments. While, treatments of T3 possessed the highest score until the end of storage period followed by T2. Also, the whey separation in white color appeared to be decreased during storage in all treatments (Fig. 2). Vijayalakshmi *et al.*[78] mentioned that, during storage of low fat fruit yogurt, acidic or mal flavour, firm or ropy body and texture, shrunken or free whey appearance, fermented milk products at the end of storage. Also, Salmeron *et al.*[79] found that, inoculation with the probiotic lactic acid bacteria caused a significant change in the aroma profile of all goats' milk yogurt treatments either when fresh or during the storage period.

These obtained results revealed that there was reasonable agreement between the rheology results of the tested samples as previously shown and its sensory scores. Whereas, the increase in penetration and apparent viscosity seem to be the reasons for improved texture in this sample that was evidenced by smooth body and mouth feel in the sensory evaluation. These results are in agreement with Cayot *et al.*[73] who reported that the consistency index of stirred acid gels, increased as milk heating temperature increased from

Table 4: Sensory evaluation scores of goats' milk yogurt during storage at 6±0.5°C/9 days

		Treatments			
Type of starter/parameters	Storage period (days)	Control	T1	T2	T3
Yo-Fast 1*					
Flavour (1-10 points)	0	7.55 ± 0.11^{Fd}	8.69 ± 0.15^{Ec}	8.80 ± 0.12^{Db}	9.25 ± 0.14^{Aa}
	3	7.50 ± 0.18^{FGc}	8.65 ± 0.17^{Eb}	8.74 ± 0.16^{DEb}	9.22 ± 0.19^{Aa}
	6	7.46 ± 0.20^{Gd}	8.55 ± 0.09^{Fc}	8.71 ± 0.18^{Eb}	9.15 ± 0.16^{ABa}
	9	7.35 ± 0.14^{Hd}	8.48 ± 0.16^{GcF}	8.66 ± 0.21^{Eb}	9.00 ± 0.17^{Ca}
Body and texture (1-5 points)	0	3.51 ± 0.17^{Lb}	4.33 ± 0.12^{Gc}	4.58 ± 0.14^{CDb}	4.79 ± 0.13^{Aa}
	3	3.45 ± 0.23^{LMd}	3.78 ± 0.18^{Jc}	4.53 ± 0.19^{CDEb}	4.74 ± 0.18^{Aa}
	6	3.43 ± 0.19^{LMd}	3.74 ± 0.22^{Jc}	4.50 ± 0.20^{DEb}	4.66 ± 0.20^{Ba}
	9	3.36 ± 0.08^{Md}	3.68 ± 0.14^{JKc}	4.46 ± 0.15^{Eb}	4.61 ± 0.10^{BCa}
Appearance and colour (1-5 points)	0	3.65 ± 0.10^{Kd}	3.77 ± 0.20^{Jc}	4.22 ± 0.16^{Hb}	4.56 ± 0.17^{CDa}
	3	3.61 ± 0.12^{Kd}	3.73 ± 0.15^{JKc}	4.17 ± 0.10^{Hb}	4.53 ± 0.09^{CDEa}
	6	3.53 ± 0.19^{Kd}	3.66 ± 0.17^{Kc}	4.08 ± 0.09^{Ib}	4.50 ± 0.17^{DEa}
	9	3.44 ± 0.22^{LMd}	3.61 ± 0.13^{Kc}	4.00 ± 0.12^{Ib}	4.48 ± 0.15^{DEa}
ABT-2**					
Flavour (1-10 points)	0	8.42 ± 0.14^{Hd}	8.77 ± 0.09^{Fc}	9.22 ± 0.16^{Db}	9.66 ± 0.11^{Aa}
	3	8.36 ± 0.17^{Hd}	8.72 ± 0.15^{FGc}	9.19 ± 0.10^{Db}	9.55 ± 0.16^{Ba}
	6	8.22 ± 0.16^{Id}	8.66 ± 0.19^{Gc}	9.05 ± 0.20^{Eb}	9.51 ± 0.13^{BCa}
	9	8.15 ± 0.10^{Id}	8.61 ± 0.11^{Gc}	8.99 ± 0.17^{Eb}	9.45 ± 0.15^{Ca}
Body and texture (1-5 points)	0	3.56 ± 0.18^{Gd}	4.54 ± 0.17^{DEFc}	4.65 ± 0.19^{Cb}	4.88 ± 0.14^{Aa}
	3	3.53 ± 0.20^{Gd}	4.51 ± 0.14^{EFc}	4.62 ± 0.17^{CDb}	4.84 ± 0.16^{Aa}
	6	3.49 ± 0.17^{GHd}	3.97 ± 0.13^{Fc}	4.58 ± 0.11^{DEb}	4.75 ± 0.19^{Ba}
	9	3.44 ± 0.16^{Hd}	3.92 ± 0.10^{Fc}	4.53 ± 0.15^{DEb}	4.68 ± 0.20^{BCa}
Appearance and colour (1-5 points)	0	3.75 ± 0.14^{EFd}	3.85 ± 0.18^{Ec}	4.55 ± 0.21^{BCb}	4.71 ± 0.17^{Aa}
	3	3.72 ± 0.11^{FGd}	3.80 ± 0.15^{Ec}	4.52 ± 0.18^{BCb}	4.66 ± 0.16^{Aa}
	6	3.66 ± 0.21^{GHd}	3.76 ± 0.19^{EFc}	4.48 ± 0.16^{CDb}	4.62 ± 0.14^{ABa}
	9	3.62 ± 0.19^{Hd}	3.72 ± 0.12^{FGc}	4.43 ± 0.17^{Db}	4.55 ± 0.18^{BCa}

Control: Yogurt made from heated milk at 72°C/15 sec, T1: Yogurt made from heated milk at 63°C/30 min, T2: Yogurt made from heated milk at 85°C/30 min, T3: Yogurt made from heated milk at 95°C/30 min, *Bacterial starter culture containing of *Lactobacillus delbrueckii* spp., *bulgaricus* and *Streptococcus thermophilus* (as commercial yogurt starter), **Bacterial starter culture containing of *Lactobacillus acidophilus*, *thermophilus* and bifidobacteria (with potential probiotic properties), $^{A,B,C,......}$Means with the different capital superscript letters within the same raw indicate significant ($p\leq0.05$) differences between type of starter/storage period and milk heat treatments, $^{a,b,c,......}$Means with the different small superscript letters within the same column and property are significantly ($p\leq0.05$) different between storage period (days) and milk heat treatments

70-100°C. An increase in heat treatment resulted in an increase in viscosity and perceived mouth coating attributes as well as, a decrease in the chalkiness attribute of stirred yogurt[74,80].

CONCLUSION

From the economical point of view there is a possibility for enhancement the use of goats' milk for processing functional yogurt using either yogurt or probiotic starters with improved nutritional, functional values and also with good organoleptic properties during storage at 6±0.5°C for 9 days. The highest thermally treated goats' milk used in the manufacture yogurt treatments had good significant impact on the physiochemical properties, with higher dynamic viscosity values, lowest whey separation and strong curd compared with other treatments as well as the control throughout storage period especially when fermented with probiotic starter and could be considered as product with functional properties and health benefits especially in desert areas in Egypt which is consider a new product. Further studies are needed to determine the effect of goats' milk yogurt as fermented products on the microflora of gastrointestinal tract of human.

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