World Journal of Dairy & Food Sciences 8 (2): 118-130, 2013
ISSN 1817-308X

DOI: 10.5829/idosi.wjdfs.2013.8.2.1124

Compositional, Rheological and Organoleptic Qualities of Camel Milk Labneh as Affected by Some Milk Heat Treatments

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Abstract: The present study was carried out to investigate the chemical, rheological and microstructure properties of camel milk Labneh. Labneh samples were manufactured from camel milk thermally treated at 63° (T1), 85° (T2) and 95°C (T3) for 30 min, whereas the control sample was manufactured from camel milk pasteurized on 72°C for 15 sec. Chemical composition of resultant Labneh samples showed that total solids, protein and fat contents were only significantly increased in Labneh samples which manufactured from camel milks thermally treated at 85° and 95°C for 30 min., while the lactose content was decreased by increasing the thermal treatment of camel milk. The pH ranged from 4.90 to 4.78 during 1 to 9 days of the study and titratable acidity ranged from 0.82 to 1.02% as percentage of lactic acid. The differences in acidity and pH values in response to the applied thermal treatments were only significant in highest treatment (95°C/30 min). The changes in the apparent viscosity were increased linear with the increase in the thermal treatment of camel milk and also increased with storage time. The control sample has presented a higher index of syneresis than the other treatments and this index was decreased as storage time progressed (9 days) in all samples. Scanning electron microscopy (SEM) revealed that the protein matrices of the high thermally treated Labneh samples (T2 and T3) appeared to be relatively more intensive than the control. In these treatments, the casein micelles were predominantly linked by particle to particle attachment in chains with comparatively small interspaced voids (T2), rather than by particle fusion into big aggregates (T3). However, the control exhibited a more open, loose and less dense protein network than experimental treatments. The overall acceptability scores of the sensory evaluation revealed that T3, fresh as well as, stored was the significantly most accepted, while the control sample was the least. As storage progressed the organoleptic scores insignificantly decreased in all treatments. The obtained results showed that the thermal treatment of camel milk at 95°C for 30 min had good significant impact on the physiochemical, texture and sensory properties of resultant Labneh.

Key words: Camel milk Labneh · Chemical composition · Microstructure · Milk heat treatments · Rheological properties · Sensory evaluation

INTRODUCTION

The interest of both food producers and consumers for functional foods has been exponentially increasing during the last decade. The use of milk with particular nutritional properties such as camel milk, in combination with bacterial strains having probiotic properties and/or producing physiologically active metabolites, represents one of the technology options for manufacturing dairy functional products. Camel milk and its products are a good nutritional source for human diet in several parts of the world as they contain all essential nutrients [1]. It has been reported that camel milk has potential therapeutic properties, such as anticarcinogenic [2], antidiabetic [3] and antihypertensive [4] and has been recommended to be consumed by children who are allergic to bovine milk

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[5]. Camel milk is somehow different from cow milk in its chemical composition but it contains all essential nutrients as cow milk, also its high whey proteins such as lactoferrin and immunoglobulin confer to it the high antimicrobial properties. The quantity of whey proteins is higher in camel milk than cow's milk, at 0.9 to 1.0 percent and 0.7 to 0.8 percent, respectively. This is primarily due to the higher content of albumin and lactoferrin [6, 7]. Compared to cow, buffalo and ewe milk fat, camel milk fat contains less short-chained fatty acids [8]. Some researchers claim that the value of camel milk is to be found in the high concentrations of linoleic acid and the polyunsaturated acids, which are essential for human nutrition; cholesterol in camel milk is lower than cow or goat milk [9]. The heat stability of camel milk whey proteins was found to be considerably higher than in cow's milk. The average lactose content of camel milk is slightly lower (4.62%) than cow's milk (4.80%). Close analysis of camel milk does show some medicinal potential. The milk protein lactoferrin, which present in large quantities in camel milk (ten times higher than in cow milk), does have some anti-viral and anti-bacterial properties. Furthermore, camel milk has greater contents of vitamin C, ash and sodium, potassium, phosphorus, zinc, iron (10 times as rich in iron as cow's milk) and manganese than cow's milk [10]. In Russia, Kazakhstan and India as much as a Liter a day being prescribed to hospital patients to aid recovery from tuberculosis and diabetes. Camel milk has positive effects in controlling high blood pressure and helps in the management of arteriosclerosis and osteoporosis. Also, camel milk contains high insulin and insulin-like protein, which can help in regulating the blood glucose levels in the diabetic patients [11, 12]. Moreover, camel milk lacks β-lactoglobulin and contains α-lactalbumin, a similar situation to that in human milk. Previous research has recommended the potential use of camel milk in the manufacture of infant formula [13].

Products made from camel milk include the traditionally fermented products garris and koumiss, Domiati cheese, fresh soft white cheese, hard cheese and ice-cream [10]. The consumption of camel's milk, especially in fermented form, is a very old tradition in different regions of the world such as Africa and Middle Eastern countries [14]. Fermented camel milk is high in lactic bacteria, which have been shown to be effective against pathogens including *Bacillus, Staphylococcus, Salmonella* and *Escherichia* [12]. Camel milk was shown to have greater resistance to bacterial growth leading to less active cultures and thus causing quality problems in its fermented products. The proteolysis rate in fermented camel milk has been reported to be greater compared with cow's milk [15]. Mohamed *et al.* [16], observed that camel milk failed to form gel like structure after 18 h incubation with lactic acid culture, this was attributed to the presence of antibacterial factors such as lysozymes, lactoferrin immunoglobulin in camel milk. These antimicrobial factors were present at significantly greater concentrations in camel milk and were more heat stable compared with those in cow and buffalo milks [17]. Farah *et al.* [18] studied the preparation and consumer acceptability tests of fermented camel milk. They found that the consistency of fermented milk (under lab conditions) was thin and a precipitate in the form of flacks was formed rather than a coagulum after fermentation. These reports clearly show the difficulty of producing fermented camel milk products with high consistency due to the problem associated with milk coagulation. Concentrated yogurt is popularly known as "Labneh" in the Middle East or as strained yogurt in Greece and rest of Europe. Labneh is a semisolid fermented dairy food produced by removing part of the whey from yogurt to reach total solid levels between 23 and 25 g/100 g, of which 8–11 g/100 g is fat [19]. Labneh made from camel milk has not been given such attention in researches compared with that made from cow milk.

Therefore, the objectives of this study were to develop Labneh from camel milk, in addition to study the effect of various thermal treatments of camel milk on the physiochemical properties and the microstructure of resultant Labneh.

MATERIALS AND METHODS

Materials: Camel milk batches were collected from the herd of Desert Research Center, Marriott Station, Egypt. All animals were kept under the same conditions. Every bulk milk batch was analyzed for chemical composition and divided into 4 lots for manufacturing subsequent Labneh treatments. The approximate composition of used camel milk is shown in Table 1. Commercial yogurt starter culture (YC-087) was from Chr. Hansen, Inc., Milwaukee, WI and consisting of *Streptococcus thermophilus* and *Lactobacillus delbrueckii* ssp. *bulgaricus*. Commercial stabilizer (Grindstred ES 255) was from Emulsifier and Stabilizer System, Danisco Ingredients, Brabrand, Denmark.

Table 1: Chemical composition (%) and pH of camel milk used in the manufacture of Labneh

	Chemical composition (%) and pH					
Sample	Fat %	Protein %**	Ash %	Carbohydrates %***	Total solids %	pH
Camel milk*	3.5±0.141	3.44±0.113	0.81±0.045	4.3±0.082	12.05±0.868	6.7±0.028

*: Bulk camel milk samples **Protein%=N× 6.38 ***Calculated by the difference

Manufacture of the Experimental Camel Milk Labneh (Concentrated Yogurt): The manufacture of Labneh from camel milk was done based on the results of the preliminary trials in an attempt to increase firmness of Labneh. Three percentages of commercial stabilizers (0.5, 0.75 or 1%) [10] and starter culture (2, 3 or 4%) has been added to the camel milk to prepare Labneh. Basing on the sensory results of Labneh (*i.e.*, with the highest intensities), the best results were 1.0% commercial stabilizer and 4 % yogurt starter culture. Labneh was manufactured by procedure similar to that reported by Al-Otaibi and El-Demerdash [20]. Camel 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° (T1), 85° (T2) and 95°C (T3) for 30 min in thermostatically-controlled water bath and were gently stirred during heating, then cooled immediately to 43°C using a running tap water and then 1.0% commercial stabilizer was added. All treatments were inoculated with 4% yogurt starter culture, then agitated and dispensed in plastic cups and incubated at 43°C for 14 h ± 0.5 until it was completely coagulated. The resultant Labneh samples were then put into cheese cloth bags and mixed thoroughly with 0.5% NaCl, which were hung in the refrigerator at 5° ± 1°C for 18 h, to allow drainage of the whey. Labneh treatments were stored at 5°C over night and then tested at different periods of cold storage (fresh, 3, 6 and 9 days).

Methods of Analyses: Labneh treatments were tested for protein, fat, ash, total solids (TS) and acidity (expressed as grams of lactic acid/100 g of Labneh) as given in the AOAC [21]. The pH values were determined electrometrically with a pH meter (model Cole-Armer Instrument Co., USA). Synersis was measured as mentioned by Farooq and Haque [22] as the amount of spontaneous whey (ml/100g) drained off after 2 h at 7°C when fresh and during storage of all Labneh treatments. Firmness was measured in fresh and stored Labneh as described by Amatayakul *et al.* [23] using a penetrometer (Kochler Co. Inc., USA). The speed of penetration was set at 2 mm/s and the depth of penetration was set at 10 mm. Viscosity was measured as formerly described by Djurdjevic *et al.* [24] using a Brookfield DV-E viscometer (Brookfield Engineering Laboratory Inc., Stoughton, MA) with spindle size 0.15cm that rotated at different rpm ranged from (20-200) at shear rates ranging from 4.2 to 42.1/s. Data were collected Using Wingather soft ware (Brookfield Engineering Laboratory Inc., Stoughton, MA). Viscosity was monitored during storage at 5°C during storage after 1, 3, 6 and 9 days.

Scanning Electron Microscopy (SEM) Examination: Labneh samples were prepared for SEM according to the method of Brooker and Wells [25]. The specimens were viewed in a scanning electron microscope (JXA-840A Electron Probe Microanalyzer-JEOL-Japan) after dehydrated using Critical Point Dried instrument and coating with gold using S150A Sputter Coater-Edwards-England.

Sensory Evaluation: Camel milk Labneh samples were subjected to organoleptic evaluation by 10 panelists of the Stuff member of Animal Production Division, Desert Research Center, Cairo, Egypt. Organoleptic evaluation was carried out according to scheme of Salem *et al.* [26]. Samples were organoleptically scored for flavor (60 points), consistency (30 points) and appearance (10 points) when fresh and after storage for 9 days at 5±1°C.

Statistical Analysis: All data were expressed as mean values. Statistical analysis was performed using one way analysis of variance (ANOVA) followed by Duncan's Multiple Range Test with $P \leq 0.05$ being considered statistically significant using SAS program (SAS) [27].

RESULTS AND DISCUSSION

Chemical Composition of Camel Milk Labneh: The chemical composition of Labneh samples manufactured from camel milk subjected to different thermal treatments is shown in Table 2. The values of Labneh total solids content reflect clearly the effect of the milk thermal treatments. The significantly ($P \leq 0.05$) highest values of total solids were found in Labneh samples manufactured

Table 2: Gross chemical composition (%) of fresh camel milk Labneh as affected by milk heat treatments

	Chemical composition (%)				
Labneh treatments	Total solids	Protein	Fat	Ash	Lactose*
Control	22.14^{c}	9.15^{b}	8.21^{b}	1.03^{b}	3.75^{a}
T1	22.99^{bc}	9.32^{ab}	8.91^{ab}	1.12^{ab}	3.64^{a}
T2	23.55^{ab}	9.56^{ab}	9.43^{a}	1.14^{ab}	3.42^{b}
T3	24.10^{a}	9.88^{a}	9.65^{a}	1.22^{a}	3.35^{b}

^{a,b,c} Means not followed by the same lower case letter in each row are significantly different ($p \leq 0.05$).

*Calculated by the difference

Control: Labneh made from heated milk at 72°C / 15 sec. T1: Labneh made from heated milk at 63°C/30min.

T2: Labneh made from heated milk at 85°C/30min. T3: Labneh made from heated milk at 95°C/30min.

from milk treated to 85°C or 95°C for 30 min compared with control (manufactured from pasteurized milk at 72°C for 15 sec.). The protein content was only significantly 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 camel milk with the exception in Labneh samples from thermally treated camel milk more than 85°C for 30 min (Table 2); the differences in this respect were significant. The highest ash content (1.22%) was significantly achieved in the Labneh from thermally treated milk at 95°C for 30 min, followed by the average value of 1.14% in milk treated by heating at 85°C for 30 min. The control showed the lowest average value (1.03%) for ash content. The hydrolysis of lactose was significantly highest in the camel milk thermally treated for ≥ 85 °C for 30 min than the other treatments. This may be due to the effect of thermal treatment on camel milk proteins by antimicrobial factors [17, 28]. Also, Djurdjevic *et al.* [24] reported that during heat treatment of milk, pH decreased, while titratable acidity increased and lactose content decreases during heat treatment.

The obtained results showed that the thermal treatment of camel milk for 85°C or 95°C for 30 min before the manufacture Labneh led to products with different chemical composition. This confirms that heat-treatments affected the chemical composition of the milk. Similar results were obtained by El-Agamy [17] and Hattem *et al.* [29], who reported that for thermal treatment of camel milk ≥ 80°C/30 min, had significant impact on milk composition, in terms of the content of total solids, protein and ash. On the other hand, the thermal treatment at 63°C for 30 min of camel milk did not differ significantly in gross composition of Labneh than control one. This means that the normal pasteurization method do not affect the chemical composition of camel milk Labneh and these results are in agreement with that result given by Farah [30] who indicated that the thermal treatment at 63°C for 30 min did not affect the chemical composition of camel milk.

pH and Acidity (%) Values of Camel Milk Labneh: The change in pH and acidity in Labneh during storage at 5°C for 9 days as affected by thermal treatments of camel milk prior to the manufacture are illustrated in Table 3. The pH and acidity values for the entire Labneh samples were similar. The pH ranged from 4.90 to 4.78 during 1 to 9 days of the study and titratable acidity ranged from 0.82 to 1.02% as percentage of lactic acid. Previous study, Hashim *et al.* [10] indicated 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). As the storage period advanced the acidity in all Labneh treatments increased gradually with a very slow rate. The differences in acidity in response to the applied thermal treatments were only significant in highest treatment and 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 [29] and this in agreement with the findings of Hassan *et al.* [31] for camel milk. These results are in agreement with those obtained by Oliveira *et al.* [32] and Lucas *et al.* [33] who reported that *L. delbrueckii subsp. bulgaricus* produces lactic acid during refrigerated storage, known as postacidification. Also, these results are in agreement with those obtained by Sulieman *et al.* [34] in *Garris* (Sudanese traditionally fermented camel milk).

An opposite trend was recorded concerning pH values which decreased gradually as the storage period advanced reaching minimum values at the end of storage period. However, the slow development of acidity, despite addition of sufficient amounts of active yoghurt starter may be ascribed to the presence of antibacterial substances in camel milk which inhibited the activity of yoghurt culture and the effect of thermal treatment on camel milk proteins by antimicrobial factors [17, 28]. Generally, the decrease in pH was greater in camel milk than in bovine milk, which could have been due to the low buffering capacity of camel milk [35]. The difference in buffering capacity between bovine and camel milks is

Table 3: Changes in pH values and acidity (%) of camel milk Labneh during storage at 5°C as affected by milk heat treatments.

	pH values				Acidity (% lactic acid)			
Storage period (days)	Control	T1	T2	T3	Control	T1	T2	T3
Fresh	4.90^{Aa}	4.87^{Aa}	4.86$^{A\ a}$	4.86^{Aa}	0.82^{Bb}	0.85^{Bb}	0.87^{Bab}	0.91$^{B\ a}$
3	4.85^{Ab}	4.82^{ABb}	4.80^{Bb}	4.79^{Bb}	0.86^{ABb}	0.88^{ABb}	0.91^{Bab}	0.95$^{B\ a}$
6	4.81^{Ab}	4.80^{Ab}	4.79^{Ab}	4.79^{Ab}	0.88^{ABb}	0.91^{ABb}	0.95^{ABab}	0.97$^{AB\ a}$
9	4.81^{Ab}	4.79^{Ab}	4.79^{Ab}	4.78^{Ab}	0.89^{Ab}	0.92^{Ab}	0.98^{Aab}	1.02^{Aa}

^{a,b,c} Means not followed by the same lower case letter in each column are significantly different ($p \leq 0.05$).

^{A,B,C} Means not followed by the same lower case letter in each row are significantly different ($p \leq 0.05$).

Control: Labneh made from heated milk at 72°C / 15 sec. T1: Labneh made from heated milk at 63°C/30min.

T2: Labneh made from heated milk at 85°C/30min. T3: Labneh made from heated milk at 95°C/30min.

related to the differences in the proportion of proteins and certain salts in both milks [36]. The obtained results for pH and acidity are consistent with that of Abu-Tarboush *et al.* [37] who reported that pH reached 4.6 to 4.8 in camel milk incubated with Bifidobacteria and the acidy reached 0.95 %. By the same way, Nanda e*t al.* [38] found that the acidity reached 1.1% lactic acid in camel cheese.

Rheological Properties of Camel Milk Labneh

Viscosity: The effect of the different thermal treatments of camel milk on the apparent viscosity of Labneh is depicted in Fig. 1. The apparent viscosity decreased as the shear rate increased in all samples, so Labneh exhibited a shear thinning behavior. This shear thinning behavior is due to the progressive breakdown of aggregates formed between milk caseins by the action of the decrease in pH [39]. It can be seen that the change in the apparent viscosity was linear with the increase in the thermal treatment of camel milk, where the highest treatment (95°C/30 min) increase in the solids concentration led to highest apparent viscosity. The fall in viscosity with shear rate might be due to the destruction of the interactions within the Labneh network structure. These interactions are electrostatic and hydrophobic ones, which are considered as weak physical bonds [40]. As shown experimentally by Ozer *et al.* [41], the preparation of Labneh using a cloth bag had the highest protein and fat content, since the cloth bags allow, mainly, the separation of lactose and minerals into the whey and thereby decrease in the porosity. Also, during heat treatment whey protein associated with casein micelles alters properties of micelles, so they become more hydrated than natural casein micelles [42].

Whey proteins participate in gel structure due to formed coaggregates and in this way contribute to the flow behavior of gels. Corredig and Dalgleish [43] 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 sample T3 with the highest thermal treatment also had the highest protein content and consequently T3 had the highest apparent viscosity, as shown in Fig. 1. The obtained results in accordance with that of Sömer and Kýlýç [44], who reported that heat treatment promotes protein denaturation, which increases water binding and viscosity. Moreover, Ozer *et al.* [45] indicated that different manufacturing techniques led to differences in the rheology of concentrated yogurts and that rheological behavior of Labneh depended on the protein concentration, samples with high protein contents had greater gel strengths. In this sense, Cayot *et al.* [46] reported that the consistency index of stirred acid gels, calculated from the Ostwald model, increased as milk heating temperature increased from 70° to 100°C. An increase in milk heating temperature resulted in an increase in apparent viscosity of stirred yogurts [47]. Furthermore, as the storage period advanced the viscosity in all Labneh samples increased gradually with a slow rate as shown in Fig. 1. These results are compatible with Nsabimana *et al.* [48], who found that at constant shear rate, the apparent viscosity of Labneh increased with storage time and storage time had a negligible effect on flow properties of destructured Labneh. Similar observation was reported also by Abu-Jdayil *et al*. [49]. The same trend was founded in the stirred yogurt by Beal *et al.* [50], who found that, the longer the storage time was, the higher the viscosity was, especially between d 1 and 7 days of cold storage.

Firmness: An important criterion for quality assessment of set-style cultured milk products is the texture of the gel, so the texture of Labneh is an important characteristic that

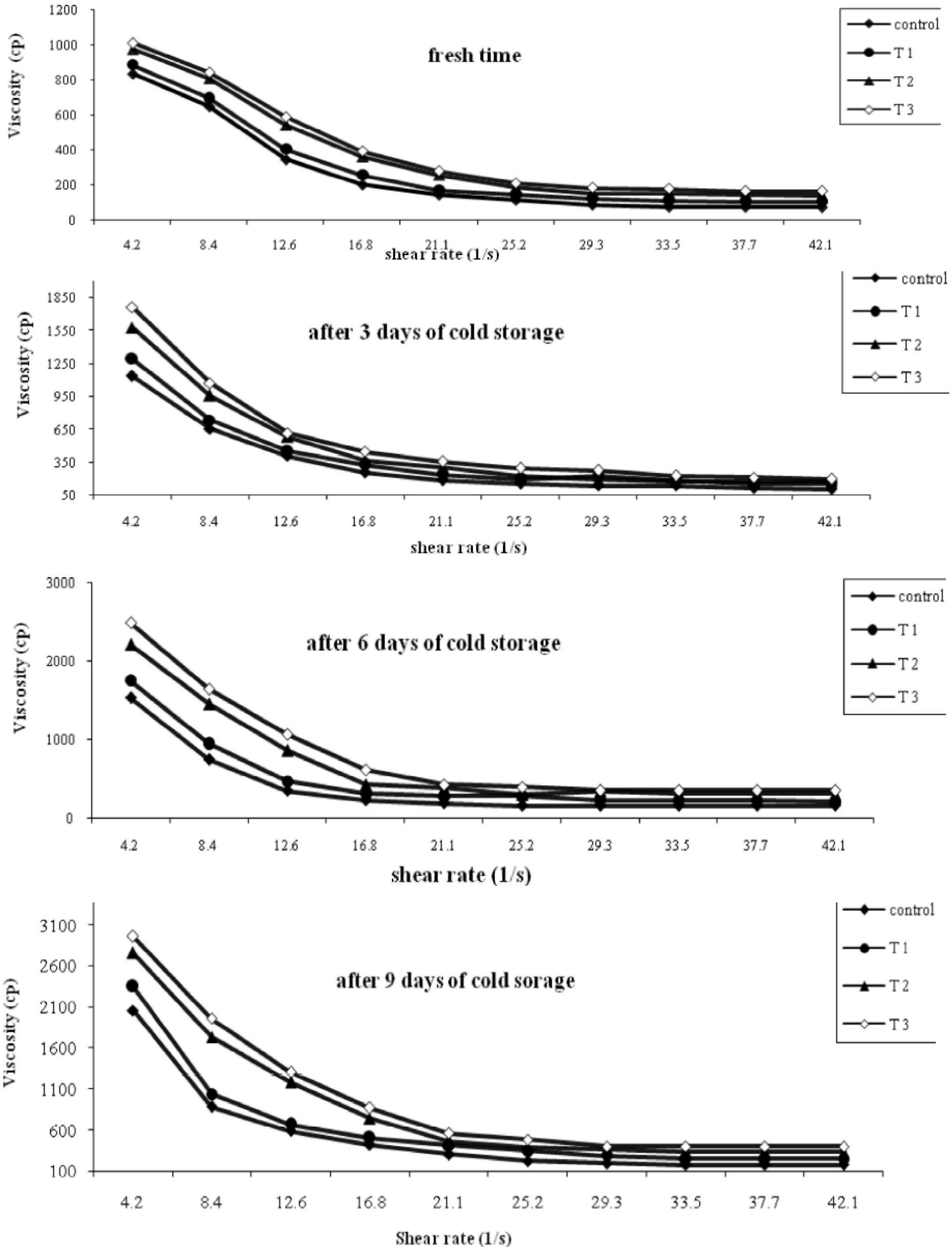

Fig. 1: Apparent viscosity of camel milk Labneh during storage at 5°C as affected by milk heat treatments. Control: Labneh made from heated milk at 72°C / 15 sec. T1: Labneh made from heated milk at 63°C/30min. T2: Labneh made from heated milk at 85°C/30min. T3: Labneh made from heated milk at 95°C/30min.

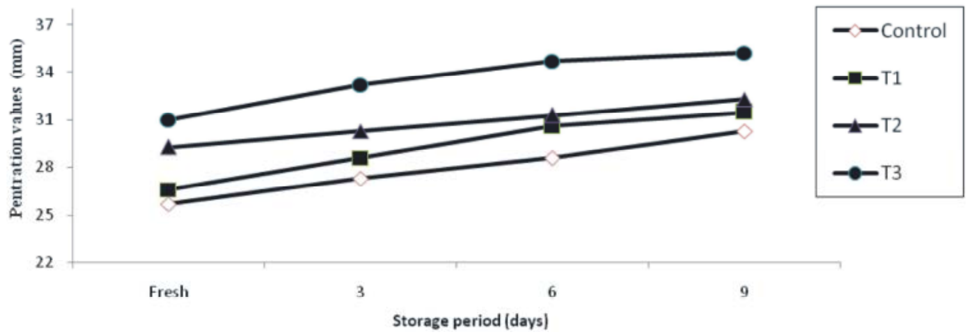

Fig. 2: Changes in the penetration values (mm) of camel milk Labneh during storage at 5°C as affected by milk heat treatments.

Control: Labneh made from heated milk at 72°C / 15 sec. T1: Labneh made rom heated milk at 63°C/30min.
T2: Labneh made from heated milk at 85°C/30min. T3: Labneh made from heated milk at 95°C/30min.

determines the acceptability of the product. Ideally, it should have smooth and pasty texture with semisolid mass. Penetrometer values of all Labneh samples are given in Fig. 2. Higher penetrometer values indicated higher firmness. High thermally treatment resulted in an increase in gel strength of Labneh samples. In terms of penetrometer values, significant increases ($P < 0.05$) in penetrometer values were observed only in the samples with highest thermally treated camel milk Labneh (T2 and T3). Theses obtained results are in accordance with Lee and Lucey [51], 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.* [52] 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 [53]. On the other hand, during cold storage, the firmness of each sample increased until day 9. This increased in the penetration values are in agreement with that of Barrantes *et al.* [54], who found that during storage, the firmness of each yoghurt increased until day 8, but remained relatively constant thereafter until day 20. In the same line, Farooq and Haque [22] reported that the penetration significantly increased in all samples between d 0 and 7, but not *(P* >.05) during 7 to 14 d of storage.

Whey Separation: Whey separation (wheying-off) is defined as the expulsion of whey from the network which then becomes visible as surface whey. Yogurt manufacturers use stabilizers, such as, pectin, gelatin and starch, to try to prevent wheying-off. Another approach is to increase the total solids content of yogurt milk, especially the protein content, to reduce wheying-off. Spontaneous syneresis, which is contraction of gel without the application of any external force, is the usual cause of whey separation [55]. The drainage method is useful in products that have a serum separation step through screen, such as, traditionally manufactured concentrated yogurt (Labneh). In this test, surface whey that is expelled from acid milk gels is gently poured off and quantified. This test has been used to evaluate whey separation in set-type yogurt gels [47]. Changes in syneresis rate of camel milk Labneh during the cold storage of control and different thermal treatments are shown in Fig. 3. It can be seen that the control Labneh has presented a higher index of syneresis than the other treatments. However, significant rate was only recorded in the highest thermally treated Labneh (T2 and T3). This might be related to the greater protein concentration in these samples, because of intensified water retention by the protein matrix. Also, it can be observed that the whey separation in each sample decreased as storage time progressed (9 days) in all samples and this is compatible

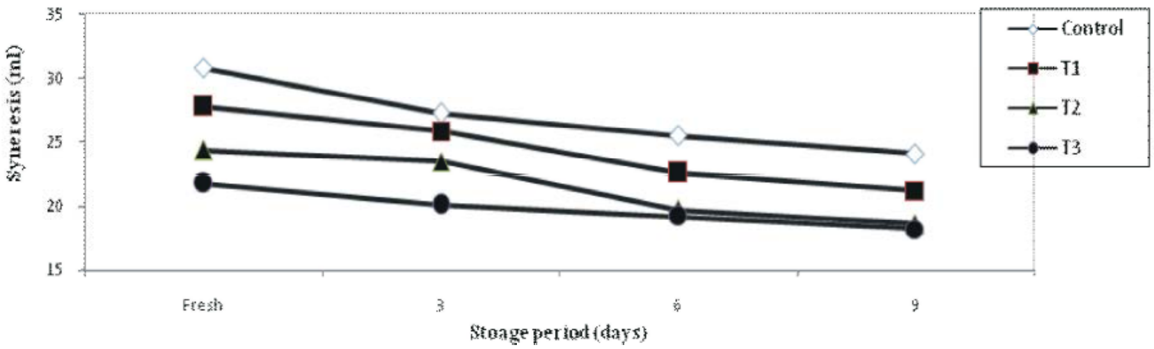

Fig. 3: Changes in whey separation of camel milk Labneh during storage at 5°C as affected by milk heat treatments. Control: Labneh made from heated milk at 72°C / 15 sec. T1: Labneh made from heated milk at 63°C/30min. T2: Labneh made from heated milk at 85°C/30min. T3: Labneh made from heated milk at 95°C/30min.

with the results of Al-Kadamany *et al.* [56], who attributed that to the whey separation in acid milk gels has been linked to rearrangements of particles making up the casein gel network. These results are in agreement with those obtained by Djurdjevic *et al.* [24], who reported that heat treatment plays very important role in yogurt manufacture and quality. During heat treatments, complex between casein and whey protein is formed, which directly influences hydration of casein micelles. It is generally accepted that set-style yogurt produced from unheated milk has weak gel, with worse rheological and sensory characteristics and pronounced syneresis. Also, as a result of insufficient heat treatments weak gel is formed. By the same way, Trachoo [57] mentioned that yogurt made from UHT-treated milk (138°C/3-6 sec) had lower viscosity and firmness but less syneresis than that made from vat-treated milk (82°C/20 min). Whey protein denaturation was believed to be responsible for this phenomenon. Also, Sömer and Kýlýç [44] reported that heat treatment promotes protein denaturation, which increases water binding and viscosity. Hashim *et al.* [10] and Mehaia [58] found that the coagulum obtained from camel milk is softer than that from cow milk. Therefore, the draining of acid curd made from camel milk is characterized by rapid syneresis compared with cow's milk. Moreover, the low water retention capacity of the gel made from camel milk may be attributed to the low kappa fraction, which is very hydrophilic [59].

Microstructure of Camel Milk Labneh: Microstructure has a major impact on the texture and other physical properties of acid milk gels. Thus, scanning electron microscopy (SEM) was performed for control and high thermally treated camel milk Labneh treatments and corresponding micrographs are shown in Fig. 4. In general, the microstructures of the Labneh thermal treatments were similar in protein matrices composed of casein micelle chains and clusters. However, SEM revealed that the protein matrices of the high thermally treated Labneh samples (T2 and T3) appeared to be relatively more intensive than the control (Fig. 4c & d). In these treatments, the casein micelles were predominantly linked by particle to particle attachment in chains with comparatively small interspaced voids (Fig. 4c), rather than by particle fusion into big aggregates (Fig. 4d). However, for control protein structure characterized by short casein micelles chains and no appreciable casein micelle fusion were observed. The control exhibited a more open, loose and less dense protein network than thermal treatments. These SEM observations reinforce conclusion already drawn concerning firmness difference between control and high thermally treated camel milk Labneh gels. Similar observations were reported by Tamime *et al.* [60] during the manufacture of Labneh. This structure develops in milk which had been heated to a minimum of 85°C, at this temperature; β-lactoglobulin forms a complex with κ-casein at the casein micelle surface. This complex gives the casein micelles the form of minute globular particles in replicas of cryofixed micelles [54]. Also, Lee and Lucey [61] reported that yogurt gels made from milk heated at high temperature (>80°C) had a more cross-linked and branched protein structure with small pores compared with milk heated at low temperature. On the other hand, Tamime *et al.* [62] demonstrated that concentrated yogurt (Labneh) from camel milk exhibited more homogeneous and compact microstructure in comparison to the microstructure of products from goat and sheep milk.

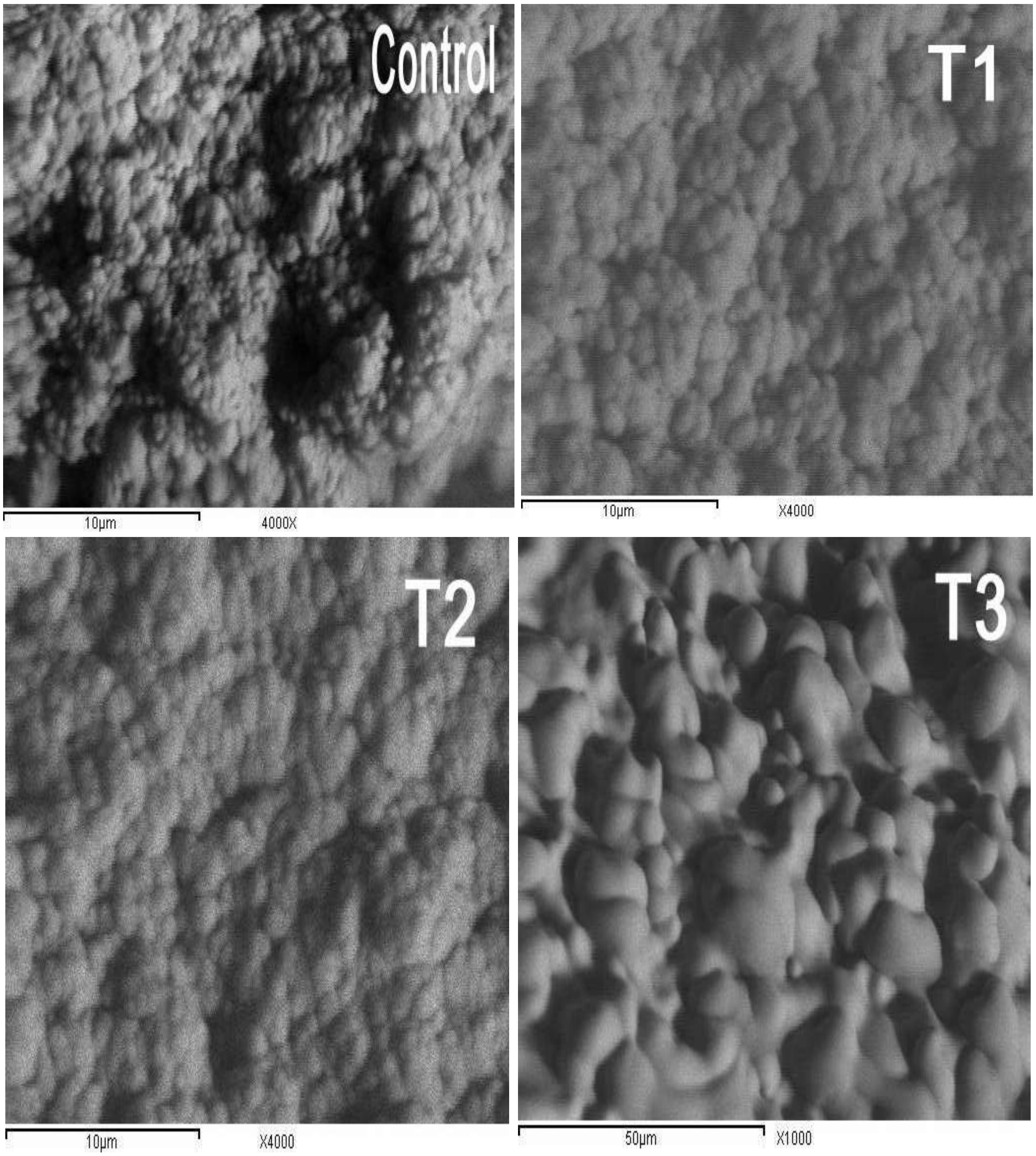

Fig. 4: Scanning electron microscopy (SEM) micrographs of camel milk Labneh as affected by milk heat treatments Control: Labneh made from heated milk at 72°C / 15 sec. T1: Labneh made from heated milk at 63°C/30min. T2: Labneh made from heated milk at 85°C/30min. T3: Labneh made from heated milk at 95°C/30min.

Organoleptic Properties of Camel milk Labneh: Camel milk Labneh of different thermal treatments were evaluated for flavor, consistency and appearance. Data pertaining to the overall evaluation and preference of Labneh when fresh and at the end of storage at 5°C are depicted in Table 4. The overall acceptability scores of the sensory evaluation revealed that T3 fresh as well as stored were the significantly most accepted and gained higher scores, while the control sample was the least. As storage progressed the organoleptic scores insignificantly decreased in all treatments and these results are in agreement with Salem *et al.* [26]. The obtained results

Table 4: Organoleptic properties of camel milk Labneh during storage at 5°C as affected by milk heat treatments

		Labneh treatments			
Organoleptic properties	Storage period (days)	Control	T1	T2	T3
Flavor (60)	Fresh	52.55 ^{Ab}	52.68 ^{Ab}	55.30 ^{Aab}	57.82 ^{Aa}
	9	50.21 ^{Ab}	51.50 ^{Aab}	53.63 ^{Aab}	54.52 ^{Aa}
Consistency (30)	Fresh	24.20 ^{Ab}	26.34 ^{Aab}	26.90 ^{Aab}	28.22 ^{Aa}
	9	24.80 ^{Ab}	27.12 ^{Aab}	27.15 ^{Aab}	28.80 ^{Aa}
Appearance (10)	Fresh	8.42 ^{Ab}	8.55 ^{Aab}	8.86 ^{Aab}	9.19 ^{Aa}
	9	8.12 ^{Ab}	8.32 ^{Aab}	8.60 ^{Aab}	9.06 ^{Aa}
Total (100)	Fresh	85.17 ^{Ab}	87.57 ^{Aab}	91.06 ^{Aab}	95.23 ^{Aa}
	9	83.13 ^{Ab}	86.94 ^{Aab}	89.38 ^{Aab}	92.38 ^{Aa}

^{a,b,c} Means not followed by the same lower case letter in each row are significantly different ($p \leq 0.05$).

^{A,B,C} Means not followed by the same lower case letter in each column for each score are significantly different ($p \leq 0.05$).

Control: Labneh made from heated milk at 72°C / 15 sec. T1: Labneh made from heated milk at 63°C/30min.

T2: Labneh made from heated milk at 85°C/30min. T3: Labneh made from heated milk at 95°C/30min.

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 mouthfeel in the sensory evaluation. These results are in agreement with Cayot *et al.* [46], who reported that the consistency index of stirred acid gels, increased as milk heating temperature increased from 70° to 100°C. An increase in heat treatment r esulted in an increase in oral viscosity and perceived mouth coating attributes, as well as, a decrease in the chalkiness attribute of stirred yogurt [47, 63].

CONCLUSION

Labneh from camel milk with good texture and acceptable sensory quality could be obtained. The main factors that govern the success of the manufacture of the camel milk Labneh is the thermal treatment of the milk at 95°C for 30 min with the use of 1.0% commercial stabilizer and 4 % yogurt starter culture. This thermal treatment appears to play an important role in the enhancement of curd firmness and subsequently whey separation rate. Moreover, the obtained Labneh had good viscosity, more dense and closed protein network.

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