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Manufacture of yoghurt from stored frozen sheep's milk

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Abstract

The effects of long-term deep-frozen storage of sheep's milk on its physicochemical, microbiological and physical stability characteristics, as well as on the corresponding characteristics and the sensory attributes of the yoghurt manufactured from the stored frozen milk after thawing were examined. Bulk whole sheep's milk, after clarification and pasteurisation (72° C for 15 s), was sampled for analysis and then poured into plastic bags, frozen in a moving-air freezer at −25° C in thin blocks (21 cm long, 21 cm high and 2.7 cm thick) weighing about 1.2 kg, and stored at −20° C for up to 6 months. At 2, 4 and 6 months of storage, samples were removed, thawed and analysed. Moreover, set type yoghurts were manufactured from these samples and examined. The results indicated that there were no significant ($P>0.05$) differences between fresh (control) and stored frozen milk samples in pH, acidity, acid degree value, peroxide value, protein sediment, apparent viscosity or coliform counts. The frozen samples had significantly ($P<0.05$) lower total bacterial counts than the fresh milk. No significant ($P>0.05$) differences in pH, acidity, lactose, appearance and colour, body and texture, flavour, overall acceptability, consistency, apparent viscosity or syneresis were observed between the control milk yoghurt and the yoghurts made from milk stored frozen for up to 6 months.

Keywords: Yoghurt; Sheep's milk; Frozen storage

1. Introduction

Greece ranks fifth in the world regarding the number of sheep. Total sheep's milk production was 652,000 t in 1993 and this represents about 35% of the total milk production of the country (Voutsinas, Katsiari, Pappas, & Mallatou, 1996). The availability of sheep's milk is highly seasonable, since the lactation period of sheep lasts only 6 months. In addition, the majority of sheep's milk is produced during the spring months, so the possibility of producing sheep's milk products all year round relies on the ability to freeze large quantities of milk while maintaining the quality of fresh milk (Rauschenberger, Swenson, & Wendorff, 2000).

Many consumers in Greece have a preference for yoghurt made from sheep's milk (Anifantakis, Kehagias, Kotouza, & Kalatzopoulos, 1980). To develop a regular supply of yoghurt for this market sector all year long, sheep's milk produced during the season of high milk production (April–May) is frozen and stored for later thawing and yoghurt manufacture (summer–autumn). It should be mentioned that, in a previous paper, we reported (Voutsinas et al., 1996) the successful long-term (8 months) deep-frozen storage of reverse osmosis (RO) concentrates of sheep's milk and their use in the production of high quality yoghurt. However, it is obvious that the RO technique can be used only by big dairy industries; all small dairies use normal milk instead of concentrates, since they cannot afford the high cost of a RO unit or hiring the technical personnel required for processing the milk and maintaining the RO unit.

Efforts at freezing to preserve milk date back to the 1930s, but research in this field really only got into its stride after World War II. Samuelsson, Thome, Borgstrom, and Hjalmdahl (1957a) published an excellent review on the manufacture and stability in storage of frozen milk and cream from the cow. According to this paper, the most important defects of frozen milk are generally related to one or several of the following factors: (1) the disturbance of the fat emulsion, (2) the flocculation of the protein, (3) the development of flavour defects and (4) the bacteriological status after defrosting.

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Very little information (Anifantakis et al., 1980; Giangiacomo & Messina, 1991; Young, 1987) has been reported on the effects of long-term frozen storage on the physicochemical, microbiological and physical stability characteristics of sheep's milk. These effects were found to depend mainly on the freezing rate (fast vs slow freezing), storage temperature, thickness of frozen milk blocks (thin vs thick) and duration of storage, but there is no consent among these studies. Moreover, no thorough investigation has been conducted on the effects of deep-frozen storage of sheep's milk on the physicochemical, sensory and physical stability characteristics of yoghurt made from thawed milk, apart from the note (no data reported) of Anifantakis et al. (1980) that yoghurt made from defrosted sheep's milk was generally of good quality and that, in most cases, their consumer type panel was rather insensitive to the oxidized flavour of yoghurt.

The objectives of the present research were to study the effects of long-term deep-frozen storage of sheep's milk on its physicochemical, microbiological and physical stability characteristics and, especially, on the corresponding characteristics and the sensory attributes of the yoghurts manufactured from the stored frozen milks after thawing.

2. Materials and methods

2.1. Packaging, freezing, storage and thawing of milk

Bulk whole sheep's milk, originating primarily from the Boutsiko breed, was obtained from a local dairy industry after clarification, pasteurisation (72 °C for 15 s) and cooling to 4 °C. The milk was packaged in 1.5 l plastic bags (25×26 cm, type PA1PE 5070 SKL, Dixie Union, Germany), which were heat-sealed with a special machine (type TISF-450, Tew Electric Heating Equipment Co. Ltd, Germany). Then, 10 bags were placed in a rectangular metal basket in which the bags were separated by wire screens to produce frozen milk blocks of standard thickness. The bags were frozen in a moving-air freezer at −25 °C and then stored in a still-air freezer at −20 °C for up to 6 months. Each frozen milk block weighed about 1.2 kg and was 21 cm long, 21 cm high and 2.7 cm thick. No free space was left in the bag. Blocks were thawed by placing plastic bags in a circulating water bath at 40 °C. Three trials were carried out and the reported results are the means of these trials.

2.2. Chemical analyses of milk

Samples of milk were examined for pH (pH-meter Metrohm, AG, Switzerland), fat (Gerber method; British Standards Institution, 1955), titratable acidity (Dornic method; Tamime & Robinson, 1985), total solids (IDF, 1987), lactose (IDF, 1974), ash (AOAC, 1984), total N (IDF, 1986), calcium (Pearce, 1977) and lipolysis by measuring the acid degree value (ADV) (Deeth & Fitz-Gerald, 1976). The Kjeldahl method was carried out by using the Kjeldatherm digestion system KT 20S and Vapodest-5 system equipped with a micro-processor for automatic distillation and titration (C. Gerhard, Bonn, Germany).

The oxidation of milk was determined as follows: 0.5–1 kg of sample was heated to 40 °C, and then centrifuged (1540 × ***g***, 30 min) to give a firm cream layer. The cream was transferred into a Funke-Gerber whipped cream tester (Berlin, Germany), cooled to 10–12 °C and churned for 5–10 min at 50–60 rpm intermittently (5 s on–10 s off). After the buttermilk had been drained off (5–10 min), the butter granules were washed four times with cold water (2–4 °C), and then transferred to 100 ml centrifuge tubes. A clear butterfat was obtained from butter by melting slowly in a water-bath at 40 °C, centrifuging (1900 × ***g***, 5 min) and filtering through Whatman No. 1 paper. The peroxide value (PV) of extracted fat was then determined according to the AOAC (1984) and expressed as meq peroxide kg^{-1} fat.

2.3. Apparent viscosity

The apparent viscosities of fresh (control) and freshly thawed milk samples were measured in duplicate at 20 °C using a Brookfield Synchro-Lectric viscometer, Model RVT (Brookfield Engineering Laboratories, Inc., Stoughton, MA, USA), fitted with a UL Adapter. The speed was set at 50 rpm, and the sample was sheared for 1 min.

2.4. Sedimentation

Samples (40 ml) of control and freshly thawed milks were centrifuged (1540 × ***g***, 10 min) and the mass of the sediment was estimated after drying at 105 °C for 3 h (Anifantakis et al., 1980). Protein stability was expressed as g of sediment per 40 ml of sample, and a value of dry weight greater than 1.0 was regarded as indicative of instability (Koschak, Fennema, Amundson, & Lee, 1981).

2.5. Microbial analyses of milk

The total bacterial and coliform counts in milk samples were determined using the pour-plate method (APHA, 1967). Total bacterial counts were determined on plate count agar (Merck) incubated at 32 °C for 3 days. Coliform counts were estimated using desoxycholate lactose agar (Merck) incubated at 32 °C for 1 day.

2.6. Yoghurt manufacture

Yoghurt of set type was made, using the heating temperature–time parameters followed by the dairy factories. The milk was heated to 90 °C for 15 s in an open kettle dipped in boiling water, cooled rapidly by tap water to about 45 °C, inoculated with 2% commercial yoghurt culture of *Lactobacillus delbrueckii* subsp. *bulgaricus* and *Streptococcus thermophilus* (Visbyvac Joghurt 4, Laboratorium Wiesby GmbH & Co. KG, Niebull, Germany), and stirred well to ensure uniform distribution of the culture. Aliquots (200 g) were poured into plastic containers, which were then closed with plastic covers and incubated at 43 °C until the pH decreased to about 4.5. This normally required 2.5–2.75 h. The containers were then transferred carefully to a force-air storage at 3 °C to cool the product and terminate acid development. After 20 h some of the samples were analysed and judged, while the remaining samples were stored cool (3 °C) for 14 or 21 days before examination.

2.7. Chemical analyses of yoghurt

The yoghurts were analysed for pH (pH-meter Metrohm, AG, Switzerland), fat (Gerber method; British Standards Institution, 1955), acidity (Dornic method; after mixing 10 g of yoghurt with an equal mass of distilled water), total solids (IDF, 1958), ash (IDF, 1964) and lactose (IDF, 1974). Total N was determined by the Kjeldahl method (IDF, 1986). The calcium content was determined by the complexometric method of Pearce (1977).

2.8. Microbial analyses of yoghurt

The coliform, and yeast and mould counts of yoghurts were determined using the pour-plate method (APHA, 1967). Coliform counts were estimated using desoxycholate lactose agar (Merck) incubated at 32 °C for 1 day. Yeast and mould enumeration was carried out on Chloramphenicol Yeast Extract Glucose Agar (IDF, 1990) incubated at 25 °C for 4 days.

2.9. Sensory evaluation of yoghurt

The yoghurts were subjected to sensory evaluation after 1 and 14 days of storage at 3 °C by a five-member trained panel familiar with dairy products. Panel members evaluated yoghurt for (1) appearance and colour, (2) body and texture, and (3) flavour using a five-point scale, with 1 being poor, 2 fair, 3 good, 4 very good, and 5 excellent. Dominating importance was given to the attribute of flavour over the other two, as recommended by Pearce and Heap (1974). Thus, the score obtained for this attribute was multiplied by two. The total score (over-all acceptability) was obtained by adding the scores for the three attributes. An excellent yoghurt received a total score of 20. Panel members were also instructed to report any defects in appearance and colour (e.g. wheying-off, fat separation, gassiness, unnatural colour, lack of uniformity, extraneous matter, surface discolouration), body and texture (lumpy or granular, slimy, gelatinous, too thin) or flavour (excess acid, yeasty, unclean) (Pearce & Heap, 1974).

2.10. Consistency of set yoghurt

The consistency (firmness) of the unbroken yoghurt coagulum was measured on samples (4 °C) contained in 600-ml glass beakers by means of a Brookfield Synchro-Lectric Viscometer, model RVT, set up on a Brookfield Helipath Stand. A T-bar type spindle (T-D) with 20.4 mm crossbar length was rotated at 2.5 rpm. The spindle was set so that the crosspiece was 6.5 mm below the surface of the yoghurt. The reading was taken 1 min after the spindle started to be lowered into the sample. Two readings were recorded on each yoghurt. The Helipath Stand allowed the spindle to be lowered slowly (2.5 rpm) while rotating into the sample, eliminating the channelling effect normally experienced with highly viscous materials.

2.11. Viscosity of stirred yoghurt

Stirred yoghurt was made by standard stirring of the set yoghurt. The apparent viscosity was determined at 4 °C using a second Brookfield Synchro-Lectric Viscometer, model RVT with a No. 4 spindle at a speed of 2.5 rpm. The apparent viscosity was derived from the maximum deflection of the needle on the viscometer scale after 1 min of shearing under the above conditions.

2.12. Syneresis of set yoghurt

The yoghurt coagulum was separated from the container by means of a thin-bladed sharp knife rotated around the edge. Then, the plastic container was cut along two opposite sides and its content (200 g) was inverted on a 40-mesh stainless steel screen, placed on the top of a long-stemmed funnel, and cut crosswise in four pieces. After 2 h of draining at 3 °C, the quantity of free whey (ml) collected in a 100-ml graduated cylinder was read and taken as an index of syneresis (Modler, Larmond, Lin, Froehlich, & Emmons, 1983).

2.13. Statistical analysis

The results were analysed by one-way analysis of variance using Statgraphics (Statistical Graphics Corp., Rockville, MD, USA). When significant ($P \leqslant 0.05$) differences were found among storage times, the means were separated by Tukey's test (Steel & Torrie, 1960).

3. Results and discussion

3.1. Composition of milk and yoghurt

The composition of fresh (control) milk and the resultant yoghurt is shown in Table 1. The composition of control milk was typical of the standardised milk composition normally used for yoghurt manufacture in the dairy industry. Moreover, the composition of yoghurt complies with Greek standards in force (Codex Alimentarious, 2000).

3.2. Physicochemical characteristics of milk

The effects of frozen storage on some physicochemical characteristics of sheep's milk are presented in Table 2. As indicated, frozen storage did not affect ($P>0.05$) the pH and acidity of sheep's milk, which remained nearly constant throughout storage. This finding is in agreement with the results of Young (1987) who reported that pH and titratable acidity values of all sheep's milk samples remained essentially the same during 12 months frozen storage. Table 2 shows that fat lipolysis, expressed as acid degree value (ADV), of sheep's milk, gradually increased during frozen storage. Thus, the frozen samples had slightly higher, but not significantly ($P>0.05$), ADVs than the control milk. The low ADVs of the frozen samples, as compared to that of control milk, can probably be attributed to the pasteurisation of milk before freezing. Anifantakis et al. (1980) reported that the free fatty acid values in frozen whole sheep's milk increased with increasing storage time, because milk lipases were not completely inactivated during frozen storage. However, these authors did not compare the ADVs of the stored frozen samples with that of the control milk to determine whether frozen storage affected (or not) the fat lipolysis of sheep's milk. Needs (1990) suggested that the lipids of raw sheep milk can be frozen for up to 6 months without marked deterioration. Moreover, Needs (1992) found a gradual but significant ($P\leqslant 0.001$) increase in the free fatty acids of raw sheep's milk during frozen storage, although after 6 months storage at −20 °C the residual lipase activity was only 11% of the initial activity in fresh milk.

Table 1
Composition (%) of fresh sheep's milk[a] and produced yoghurt[a]

Component	Milk	Yoghurt
Total solids	17.80	18.10
Fat	6.44	6.70
SNF	11.38	11.40
Protein	5.88	5.85
Lactose	4.72	4.87
Ash	0.89	0.86
Calcium	0.22	0.22

[a] Means of three batches with duplicate determinations.
SNF, solids non fat.

The degree of fat oxidation, expressed as peroxide value (PV), of sheep's milk was not influenced ($P>0.05$) by the frozen storage (Table 2), although a gradual increase in the PV of samples was observed during storage. This finding is in contrast to the results of Anifantakis et al. (1980), who observed that the PV of sheep's milk increased greatly from 0.05 in the original sheep's milk to 0.487 meq kg^{-1} fat in milk frozen in thin (2 cm) blocks and stored at −20 °C for 5 months. With regard to frozen milk it is essential that access of air (oxygen) is prevented. Air causes oxidation, rancidity or changes in colour and/or flavour. Of equal importance are effective closure and permeability of the packaging material (Samuelsson et al., 1957b). Table 2 indicates that the packaging (material and procedure) of sheep's milk used in the present study was effective in maintaining the quality of the fat during frozen storage.

3.3. Physical stability characteristics of milk

Table 2 shows some physical stability changes in sheep's milk as a result of the frozen storage. The values for protein sediment and apparent viscosity, which are indices of protein stability, in the frozen samples were slightly higher ($P>0.05$) than in fresh milk. These results indicate that the stored frozen samples of sheep's milk exhibited excellent protein stability throughout storage. This finding is in accordance with the results of Anifantakis et al. (1980) who reported that the protein precipitate remained practically the same throughout the frozen storage (11 months) of sheep's milk. Giangiacomo and Messina (1991) also reported that the physical stability of the thawed ewe milk was excellent, even after 6 months storage at −18 °C. Moreover, Rauschenberger et al. (2000) found that, in the samples of raw sheep's milk stored at −15 °C, protein precipitated between 6 and 9 months, while no precipitation occurred in the samples stored at −27 °C. However, Young (1987) reported that, after 3 months storage at −12 and −20 °C, the samples of raw ewe's milk showed signs of separation, bittiness on the surface and a green shiny deposit at the base (of plastic cartons). The appearance of samples stored at these temperatures continued to deteriorate over the subsequent storage for 9 months.

3.4. Microbiological characteristics of milk

The effects of frozen storage on the total bacterial and coliform counts of sheep's milk are shown in Table 2. As seen, the number of total bacteria in sheep's milk

Table 2
Physicochemical, physical stability and microbiological characteristics[a] of fresh and frozen sheep's milk

Duration of frozen storage (months)	pH	Acidity (°D)[b]	ADV (meqKOH 100 g^{-1} fat)	PV (meq kg^{-1} fat)	Sediment (g dry wt. 40 ml^{-1})	Apparent viscosity (cp)	TVC (cfu ml^{-1})	Coliforms (cfu ml^{-1})
0	6.53	24.5	0.40	0.07	0.01	2.93	25,300a	1
2	6.52	24.0	0.46	0.08	0.04	2.95	13,900b	0
4	6.54	23.5	0.47	0.14	0.06	2.97	11,600b	0
6	6.52	24.0	0.54	0.16	0.06	3.28	10,200b	0

[a] Means of three batches with duplicate determinations. Means in each column without a letter or bearing a common letter did not differ significantly ($P > 0.05$).
[b] 1° D = 0.01% lactic acid. ADV, acid degree value; PV, peroxide value; TVC, total bacterial count.

decreased significantly during the first 2 months of frozen storage and slightly thereafter. This finding is in agreement with the statement of Samuelsson et al. (1957b) that, during the first 24 h of frozen storage more bacteria are killed than during any later period. Babcock, Roerig, Stabile, Dunlap, and Randall (1947) established that there was a certain tendency for bacterial counts in cow milk to decline during frozen storage. A lethal effect of frozen storage (−20.5 °C) on the bacterial count of pasteurised cow milk has been observed by Samuelsson et al. (1957b). Moreover, Rauschenberger et al. (2000) reported that samples of sheep milk stored at −15 and −27 °C showed a decrease in coliform and standard plate counts during the experiment. Anifantakis et al. (1980) found that practically there were no alteration in the bacterial counts (standard plate counts, coliforms and psychrophiles) of sheep's milk during frozen storage. Young (1987) also reported that little change was noted in total bacterial counts and presumptive coliforms in raw sheep's milk throughout the 12 months frozen storage.

3.5. Physicochemical characteristics of yoghurt

The pH and acidity values of the produced yoghurts, after storage at 3 °C for 1, 14 and 21 days, are shown in Table 3. There were no significant ($P > 0.05$) differences in either pH or acidity between the control milk yoghurt and the yoghurts made from stored frozen milks. It is also obvious, from Table 3, that the pH values of all yoghurts decreased and acidity values increased as cold storage increased from 1 to 21 days. Similar observations have been reported for cow's and goat's milk yoghurts by Abrahamsen and Holmen (1980, 1981). This is attributed to the acid production in yoghurt during the cold storage (after-acidification) as a result of lactose catabolism by the bacterial cultures (Rasic & Kurmann, 1978), which is obvious in Table 3.

3.6. Microbiological characteristics of yoghurt

No coliforms were detected in the yoghurts made from fresh or frozen milks. The presence of yeasts and moulds in some yoghurts (1 cfu g^{-1}) could be attributed to post-production contamination, since the processing temperature (90 °C) used in this study was high enough to inactivate them. It should also be mentioned that container filling was not performed aseptically.

3.7. Sensory characteristics of yoghurt

Table 4 shows the mean values for the sensory attributes of yoghurts made from fresh or stored frozen sheep's milk. As seen, there were no significant

Table 3
Mean values for pH, acidity and lactose in yoghurts[a] made from fresh or frozen sheep's milk during cold storage (1, 14 and 21 days)

Duration of frozen storage (months)	pH			Acidity (°D)[b]			Lactose (%)	
	1	14	21	1	14	21	1	14
0	4.25	4.10	4.00	135	144	151	4.87	4.58
2	4.30	4.18	4.08	130	140	144	4.97	4.71
4	4.25	4.10	4.04	132	141	147	4.95	4.60
6	4.26	4.09	4.03	130	143	150	4.90	4.52

[a] Means of three batches with duplicate determinations.
[b] 1 °D = 0.01% lactic acid.

Table 4
Sensory characteristics of yoghurts[a] made from fresh or frozen sheep's milk during cold storage (1 and 14 days)

Duration of frozen storage (months)	Appearance and colour (5)[b]		Body and texture (5)[b]		Flavour (10)[b]		Overall score (20)[b]	
	1	14	1	14	1	14	1	14
0	4.50	4.60	4.85	4.90	9.70	9.90	19.05	19.40
2	4.50	4.60	4.69	4.80	9.65	9.70	18.84	19.10
4	4.72	4.53	4.54	4.90	9.69	9.80	18.95	19.23
6	4.65	4.59	4.55	4.60	9.60	9.73	18.80	18.92

[a] Means of three batches with duplicate determinations.
[b] Values in parentheses are maximum attainable scores.

($P > 0.05$) differences in appearance and colour, body and texture, flavour, and overall score, after 1 and 14 days of storage at 3 °C, between control and frozen milk yoghurts. Anifantakis et al. (1980), observed that yoghurt made from stored frozen sheep's milk was generally of good quality. It should be mentioned that, in the present study, no off-flavour was noted by any member of the trained panel in the yoghurts made from stored frozen milks. On the other hand, Anifantakis et al. (1980) reported that their consumer-type panel, in most cases, was rather insensitive to the oxidised flavour of yoghurt and did not complain about it.

In general, small differences in the sensory attributes of yoghurts were observed between 1 and 14 days of cold storage (Table 4). The body and texture, the flavour and the overall acceptability scores of all yoghurts increased slightly during their cold storage for 14 days. A similar trend was observed by Abrahamsen and Holmen (1980) for control cow's milk yoghurt.

3.8. Consistency of set yoghurt

The mean values for the physical characteristics of sheep's milk yoghurts made from fresh or frozen samples are presented in Table 5. After cold storage for 1 and 14 days, set yoghurts made from stored frozen milk had consistency values similar to the control milk yoghurt. These results indicate that frozen storage of sheep's milk, even for 6 months, did not have any adverse effect on the consistency of the yoghurts made after thawing. Table 5 also shows that the consistency values increased slightly during the cold storage of all yoghurts. This finding agrees with the results of Abrahamsen and Holmen (1980) for yoghurt made from control cow's milk. In addition, O'Neil, Kleyn, and Hare (1979) reported that the acidity and objective consistency, measured with a Brookfield viscometer equipped with a Helipath stand accessory, of three brands of commercial yoghurt did increase slightly during 2 weeks of cold storage. As acidity increased with storage, the consistency also increased. An increase in acidity with the cold storage of yoghurts was also observed in the present study (Table 3).

3.9. Viscosity of stirred yoghurt

Apparent viscosities of stirred yoghurts made from all milk samples are shown in Table 5. As seen, the yoghurts made from the stored frozen milks had apparent viscosity values equal to the control milk yoghurt, indicating that frozen storage of sheep's milk had no adverse effect on the apparent viscosity of the yoghurts prepared from it.

Yoghurts stored for 14 days at 3 °C had higher apparent viscosities than yoghurts examined after 1 day (Table 5), a finding in accordance with the results of Abrahamsen and Holmen (1980) for control cow's milk yoghurt and Parnell-Clunies, Kakuda, Mullen, Arnott, and Deman (1986) for yoghurt prepared from vat-heated cow's milk.

Table 5
Physical characteristics of yoghurts[a] made from fresh or frozen sheep's milk during cold storage (1 and 14 days)

Duration of frozen storage (months)	Consistency of set yoghurt (cps × 10^4)		Apparent viscosity of stirred yoghurt (cps × 10^3)		Syneresis (ml 200 g^{-1})	
	1	14	1	14	1	14
0	49.10	49.20	59.60	61.20	18.4	18.5
2	48.80	49.30	60.80	61.30	19.1	19.6
4	49.40	49.60	60.00	60.60	20.0	20.1
6	47.80	48.20	58.80	59.10	20.5	20.9

[a] Means of three batches with duplicate determinations.

3.10. Syneresis of yoghurt

Table 5 shows that the yoghurts made from stored frozen sheep's milk had higher syneresis values than the control milk yoghurt, but these differences were not statistically significant ($P > 0.05$). Syneresis slightly increased in all yoghurts over the cold storage period (Table 5). Kehagias, Komiotis, Koulouris, Koroni, and Kazazis (1986, pp. 167–169) also found that the separated serum of sheep's milk set-type yoghurt slightly increased during cold storage. In addition, Farooq and Haque (1992) reported that syneresis in plain non-fat-low calorie set-type yoghurt significantly increased during cold storage.

4. Conclusions

There were no significant ($P > 0.05$) differences between the physicochemical, microbiological and physical stability characteristics of fresh and stored frozen (at -20 °C for up to 6 months) sheep's milks. The yoghurts manufactured from the frozen milk, after thawing by immersing in a water bath at 40 °C, had physicochemical, sensory and physical stability characteristics similar to those of the yoghurt prepared from fresh milk, indicating that yoghurt manufactured from stored frozen sheep's milk can be of as high quality as that made from fresh milk.

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