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An attempt for producing low-sodium Feta-type cheese

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A study has been undertaken to produce ultrafiltrated Feta-type cheese with a low sodium content. This study includes two trials. In the first trial, Feta-type cheese was manufactured from ultrafiltrate retentate and salted with sodium chloride at levels of 1, 2 or 4% (control). The resultant cheeses were stored at 7 ± 1°C for 30 days. Results showed that cheese of good quality containing 7·4 mg Na/g cheese could be made with 2% sodium chloride. Lowering sodium chloride concentrations did not greatly affect the gross chemical composition but significantly increased the contents of acidity, water-soluble N and bacterial counts during storage. There was no significant difference in the concentrations of total volatile fatty acids between the different treatments. In the second trial, Feta-type cheeses were salted at a rate of 2% with various mixtures of sodium chloride + potassium chloride. The results indicated that substitution of sodium chloride by potassium chloride did not significantly influence the moisture, fat, total N, pH and proteolysis but significantly decreased the acidity of cheese throughout the storage at 7 ± 1°C. Cheese containing potassium chloride showed significantly higher total volatile fatty acids, bacterial counts, moulds and yeasts during storage. Acceptable quality Feta-type cheese could be successfully manufactured using 2% of a mixture of sodium chloride : potassium chloride (1 : 1) which gave 4·1 mg Na/g cheese.

INTRODUCTION

Sodium ingestion by humans has become associated with hypertension, and some foods, including cheese, have been listed as important sources of sodium (Albernethy, 1979; Anon. 1980).

The cheese industry is responding to the needs of some consumers by manufacturing some cheeses with no NaCl or with a substitute for NaCl. Lindsay *et al.* (1982) found that Cheddar cheese acceptable to consumers could be made with substantially reduced concentrations of NaCl or mixtures of KCl and NaCl. Cheddar cheese with low NaCl has been made from milk concentrated by ultrafiltration (UF) (Kosikowski, 1983). Low-sodium Cottage cheese of acceptable quality could be manufactured using a salt substitute (Demott *et al.*, 1984, 1986). Rapacci *et al.* (1990) reported that the use of 70% NaCl + 30% KCl did not change the intrinsic characteristics of Prato cheese.

Feta-type cheeses are manufactured now in Egypt on an industrial scale by UF techniques, and have received quite variable consumer acceptability. They contain higher, about 4%, salt (Moussa *et al.*, 1990).

The present study was carried out as an attempt to produce UF Feta-type cheese with low sodium content.

MATERIALS AND METHODS

Materials

Fresh cow's milk was obtained from the collection centre of the International Dairy and Foods Company (Milky Land) (Al-Asher-men-Ramadan City, Egypt). Fromase 200 (microbial rennet from *Mucor miehi* obtained from Rapidase Co., France) was used. A starter culture of *Lactobacillus delbrueckii* subsp. *bulgaricus* and *Streptococcus salivarius* subsp. *thermophilus* was obtained from Chr. Hansen Laboratory (Copenhagen, Denmark). The cultures were activated in sterilised skimmed milk before being used. NaCl and KCl (BDH Chemicals Ltd, Poole, UK) were used in cheese salting. Glucono-Delta-Lactone (GDL) was obtained from the Sigma Chemical Company, (St Louis, MO, USA), as a coarse powder containing essentially 100% GDL.

Methods

Preparation of milk retentate

Retentate was prepared at the International Dairy and Foods Company (Milky Land). Cow's milk (3% fat and 8·5% SNF) was heated at 75°C for 10s, cooled to 50°C

and ultrafiltered using a UF unit (Model 37-18-5 GR 6, PP-2228-81, Pasilc, Denmark) to 35% total solids. Retentate was heated to 85°C for 2 min, homogenised at 150 kg/cm^2 and cooled to 35°C.

Cheese manufacture

Feta-type cheese was made according to the procedure described by Tamime and Kirkegaard (1991), with some modifications. Two trials were carried out.

The first trial. The retentate obtained was mixed with 0·5% starter (*L. delbrueckii* subsp. *bulgaricus* and Str. *salivarius* subsp. *thermophilus*, 1:1) and 0·02% calcium chloride. GDL was used in an amount that decreased the pH of retentate to around 5·2, then the mixture immediately renneted at a rate of 3 g per 100 kg. The mixture was mixed well and directly divided into three equal parts. NaCl was added at concentrations of 1, 2 and 4% (w/w) for the first, second and third parts, respectively, and then each part distributed in 500 g cans and left to complete coagulation.

The second trial. In the light of the results obtained from the first trial, it was found that Feta-type cheese of good quality could be made using 2% NaCl. Feta-type cheese was manufactured as described previously and salted as follows:

A: 2·0% NaCl (control)
B: 1·5% NaCl + 0·5% KCl
C: 1·0% NaCl + 1·0% KCl
D: 0·5% NaCl + 1·5% KCl

In each trial, the cans were hermetically sealed after the fresh samples had been taken, and then the cans were stored at 7 ± 1°C for 30 days. Three replicates were made for each treatment. Cans were opened, and samples were taken and examined at 15 and 30 days.

Cheese analysis

Cheeses were analysed for moisture, fat, total N (TN), water-soluble N (WSN), acidity and pH according to Ling (1963). Total volatile fatty acids (TVFA) were determined by the method of Kosikowski (1978). Concentrations of sodium in cheese were determined by atomic absorption spectrometry (Horowitz, 1970).

The microbiological quality of the cheese samples was also examined by determining the total bacterial counts, coliform and moulds and yeasts as described by the American Public Health Association (APHA, 1978).

Organoleptic evaluation

Cheeses were evaluated for flavour (scale 0—40) and body and texture (scale 0—20) by a panel of five judges according to Vafopoulou *et al.* (1989).

Statistical analysis

Data were statistically analysed according to Steel and Torrie (1980).

RESULTS AND DISCUSSION

Trial I: Effect of low NaCl concentrations on the quality of UF Feta-type cheese

Cheese composition

Table 1 shows that the different salt concentrations added did not greatly affect the moisture, fat or total N contents of cheeses. However, the moisture after all treatments slightly decreased during storage and this was associated with a slight increase in fat content of the cheese. This could be due to exudation of a slight quantity of cheese serum.

Acidity of cheese has been found to increase significantly with decreasing NaCl added. The corresponding data for pH values of cheeses had the opposite trend. These results indicate that acid development by starter bacteria was stimulated during the storage of cheese.

It is also evident from Table 1 that the fresh Feta-type cheeses from all treatments had higher levels of WSN which was mainly due to the retention of whey proteins in the curd (Abd El-Salam *et al.*, 1981). The increases in WSN of the cheeses throughout the storage period could be attributed to the microbial and enzyme activities. Cheeses salted with 1 or 2% NaCl showed significantly higher WSN than did the control cheese. Darwish *et al.* (1989), indicated that the rate of protein breakdown in Domiati cheese during storage at 10°C increased as the salt content of the cheese decreased.

Table 1. Effect of low NaCl concentrations on the composition of UF Feta-type cheese, during storage

NaCl level (%)	Storage period (days)	Moisture (%)	Fat/DM (%)	Total N/DM (%)	Acidity (%)	pH	Water-soluble N, as % of TN	Total volatile fatty acids[a]	Na (mg/g)
1	Fresh	61·0	41·49	5·50	2·62	4·75	17·0	5·6	3·9
	15	60·0	42·00	5·48	2·96	4·60	20·3	7·8	
	30	56·6	43·26	5·47	3·15	4·43	23·5	10·9	
2	Fresh	60·3	41·76	5·53	2·46	4·82	16·1	5·2	7·4
	15	59·7	42·17	5·52	2·82	4·71	19·0	6·7	
	30	59·2	43·51	5·51	3·00	4·53	22·2	9·2	
4	Fresh	60·2	41·91	5·52	2·14	4·92	15·0	4·0	15·4
(control)	15	59·5	42·47	5·51	2·40	4·80	17·3	5·2	
	30	59·0	43·90	5·51	2·64	4·71	20·7	7·0	

[a]Expressed as ml 0·1 M NaOH per 100 g cheese.

Table 2. Effect of low NaCl concentrations on the microbiological and organoleptic properties of UF Feta-type cheese, during storage

Properties	Storage period (days)	NaCl level (%) 1	2	4 control
Total bacterial count (cfu/g)	Fresh	25×10^6	25×10^6	21×10^5
	15	144×10^6	52×10^6	30×10^5
	30	191×10^6	95×10^6	39×10^5
Moulds and yeasts (cfu/g)	Fresh	62	50	13
	15	160	112	25
	30	185	154	48
Coliform (cfu/g)	Fresh	9	8	5
	15	14	10	6
	30	17	12	8
Flavour[a] (0–40 point scale)	Fresh	32·0[a]	32 2[a]	32·5[a]
	15	30·2[a]	34·0[b]	34·5[b]
	30	28·3[a]	35·0[b]	36·4[b]
Body and texture (0–20 point scale)	Fresh	15·0	15·2	15·3
	15	16·2	16·3	16·5
	30	16·7	16·8	17·0

[a]Flavour scores in each line with different following letters are significantly different ($P < 0.05$).

TVFA concentrations in Feta-type cheese salted with 1 or 2% NaCl were slightly higher than those for the control one. Also the present results showed that the TVFA increased gradually during storage in a refrigerator. Similar results were obtained by El-Neshawy *et al.* (1988) in Domiati cheese with low fat and salt contents during storage.

Statistical analysis (see Table 5 below) showed that the differences in TVFA levels due to different treatments and storage periods were not significant.

The sodium contents found in the test samples are shown in Table 1.

Microbiological properties

The results in Table 2 illustrate the changes in the microbiological characteristics of UF Feta-type cheese salted with low NaCl concentrations. There was a significant increase in the total bacterial count in the cheeses with 1 or 2% NaCl compared with the control. This may be attributed to the low salt and/or the high moisture content of the cheese. However, the total bacterial count slightly increased throughout the storage of cheeses in a refrigerator. The differences in total bacterial count due to storage were not significant.

The number of moulds and yeasts was found to be significantly increased ($P < 0.05$) with decreasing amounts of NaCl and with advancing storage time. This may be attributed to the encouraging effect of the resultant acidity on the growth of moulds and yeasts.

The coliform counts of all cheese samples (fresh or stored) were < 20 cfu/g and such results reflect the hygienic standards and sanitary condition during production. Higher counts were found in cheeses salted with 1% than in those with 2 or 4%. This could be attributed to the low NaCl used.

Sensory evaluation

Organoleptic scoring of UF Feta-type cheese produced from different treatments are demonstrated in Table 2. There was no significant difference in the body and texture scores of cheeses made with various levels of NaCl. Also, the data reveal that the fresh cheeses of all treatments had nearly the same flavour score points. After 15 or 30 days of storage, cheese salted with 1% NaCl gained significantly lower ($P < 0.05$) scores for flavour than the other cheeses. Bitter flavour was detected in 1% NaCl-cheese after 15 and 30 days of storage, whereas, during storage, the differences in the flavour scores between cheeses salted with 2 and 4% NaCl were insignificant. El-Neshawy *et al* (1988) found that the addition of 2% salt to Domiati cheese milk gave a product with acceptable quality.

From the results obtained in this trial, it was found that UF Feta-cheese of good quality with low-sodium content (= 7·6 mg/g cheese) could be made using 2% NaCl for salting of cheese.

Table 3. Effect of substitution of NaCl by KCl on the composition of UF Feta-type cheese, during storage

Salt treatments	Storage period (days)	Moisture (%)	Fat/DM (%)	Total N/DM (%)	Acidity (%)	pH	Water soluble N, as % of TN	Total volatile fatty acids[a]	Na (mg/g)
2·0% NaCl	Fresh	61·5	44·2	5·81	2·40	4·70	16·8	5·8	7·8
	15	61·0	45·4	5·81	2·98	4·64	18·9	6·7	
	30	60·5	46·0	5·80	3·24	4·48	23·0	9·3	
1·5% NaCl + 0·5% KCl	Fresh	61·4	43·9	5·82	2·42	4·76	16·7	6·6	5·7
	15	61·0	45·1	5·81	2·60	4·72	18·8	8·4	
	30	60·6	45·9	5·81	2·83	4·54	22·9	11·0	
1% NaCl + 1% KCl	Fresh	61·2	44·2	5·83	2·51	4·75	17·0	6·9	4·1
	15	60·8	44·9	5·83	2·70	4·73	19·1	8·7	
	30	60·4	46·2	5·82	2·90	4·60	23·1	11·5	
0·5% NaCl + 1·5% Kcl	Fresh	61·7	44·3	5·82	2·48	4·78	17·0	7·0	2·0
	15	61·3	45·1	5·82	2·64	4·69	19·0	9·0	
	30	60·8	46·0	5·81	2·90	4·56	23·1	12·5	

[a]Expressed as ml 0·1 M NaOH per 100 g cheese.

Trial II: Effect of substitution of the NaCl by KCl on the quality of UF Feta-type cheese

Cheese composition

The results presented in Table 3 show that substitution of the NaCl by KCl did not affect the moisture, fat or total N contents of cheese. The stored cheese containing KCl had significantly lower ($P < 0.01$) acidity than did the NaCl—salted cheese, probably due to the low bacterial counts in the former cheese (Table 4). On the other hand, KCl cheeses had somewhat higher pH values than did the cheese containing NaCl alone; however, no statistical significant difference was found. Lindsay *et al.* (1982) found that Cheddar cheeses containing KCl showed slightly higher pH than those with NaCl.

The present data in Table 3 indicate that the use of KCl instead of NaCl for salting of Feta-type cheese did not significantly influence the WSN levels of cheese throughout the storage period. This is in agreement with results obtained with Cheddar cheese by Rasmussen and Barbano (1987).

The concentrations of TVFA as shown in Table 3 increased significantly ($P < 0.01$) in Feta-type cheese by replacing NaCl with KCl. Lindsay *et al.* (1982) showed that the Cheddar cheese containing KCl had higher contents of free fatty acids than those with only NaCl.

Table 3 indicates that Feta-type cheese salted with 2% NaCl, 1·5% NaCl + 0·5% KCl, 1% NaCl + 1% KCl or 0·5% NaCl + 1·5 KCl had Na levels of 7·8, 5·7, 4·1 and 2·0 mg/g cheese, respectively.

Microbiological properties

Table 4 shows that UF Feta-type cheese salted with various mixtures of NCl and KCl had significantly lower ($P < 0.05$) bacterial counts than that salted with NaCl alone. It is possible that the K^+ was partly responsible for the inhibitory effect of the KCl/NaCl mixture as compared to NaCl. Koenig and Marth (1982) showed that Cheddar cheese salted with KCl/NaCl had lower bacterial counts than did the cheese salted with NaCl.

During the storage period, the yeast and mould counts of Feta-type cheese containing KCl were nearly similar to the NaCl-cheese. Similar results were obtained by Demott *et al.* (1986) for Cottage cheese.

Statistical analysis (Table 5) indicated that the differences in total bacterial or mould and yeast counts due to storage were found to be significant.

Table 4. Effect of substitution of NaCl by KCl on the microbiological and organoleptic properties of UF Feta-type cheese, during storage

Properties	Storage period (days)	Salt treatments			
		2% NaCl	1·5% NaCl + 0·5% KCl	1% NaCl + 1% KCl	0·5% NaCl + 1·5% KCl
Total bacterial count (cfu/g)	Fresh	$14·0 \times 10^6$	$88·0 \times 10^5$	$56·0 \times 10^5$	$52·0 \times 10^5$
	15	$25·0 \times 10^6$	$16·5 \times 10^6$	$98·0 \times 10^5$	$86·0 \times 10^5$
	30	$65·3 \times 10^6$	$29·2 \times 10^6$	$14·2 \times 10^6$	$11·2 \times 10^6$
Mould and yeast (cfu/g)	Fresh	72	80	78	75
	15	108	102	100	106
	30	145	136	140	150
Flavour[a] (0–40 point scale)	Fresh	33·5[a]	32·8[a]	33·0[a]	29·2[b]
	15	35·2[a]	35·0[a]	34·8[a]	30·5[b]
	30	36·8[a]	36·2[a]	36·0[a]	30·8[b]
Body and texture[a] (0–20 point scale)	Fresh	15·5[a]	15·2[a]	15·0[a]	13·5[b]
	15	16·8[a]	16·4[a]	16·5[a]	14·2[b]
	30	17·0[a]	16·8[a]	16·7[a]	14·5[b]

[a,b]Flavour or body and texture scores in each line with different following letters are significantly different ($P < 0.05$).

Table 5. Statistical analysis of some chemical, microbiological and organoleptic properties of Feta-type cheese

Source of variances	Degree of freedom	*F*-value								
		Acidity	pH	Water-soluble N	Total volatile fatty acids	Total bacterial count	Coliform	Mould and yeast	Flavour	Body and texture
Effect of NaCl level	2	46·2**	76·5**	59·8**	2·55^{NS}	24·8**	19·1**	13·1*	6·98*	0·41^{NS}
Storage period	2	45·7**	44·7**	32·9**	5·87^{NS}	4·05^{NS}	9·75*	8·47*	0·49^{NS}	11·3*
Effect of substitution of NaCl by KCl	3	41·9**	0·48^{NS}	0·02^{NS}	15·1**	6·80**	—	1·25^{NS}	39·5**	22·3**
Storage period	2	107**	5·38**	20·3**	114**	6·25*	—	506**	11·3**	17·4**

* = $P < 0.05$; ** = $P < 0.001$; NS = not significant.

Sensory evaluation

Table 4 illustrates the scoring points of UF Feta-type cheese containing NaCl and KCl at the fresh stage or after 15 and 30 days of storage in a refrigerator. Cheeses containing 0·5% KCl + 1·5% NaCl or equal quantities (1% of each) had similar flavour and body and texture properties as that containing NaCl alone; while the flavour, body and texture scores for cheeses containing 1·5% KCl + 0·5 NaCl were significantly lower ($P < 0·01$) than those for cheese from the other treatments. This treatment led to cheese with slightly less salty and slightly more bitter taste. The general trends of results are in agreement with those found by Lindsay *et al.* (1982), Demott *et al.* (1984, 1986) and Rapacci *et al.* (1990) in their studies on the effect of KCl on Cheddar, Cottage and prato cheese, respectively.

It was concluded that low-sodium Feta-type cheese of acceptable quality without defects in flavour could be made from UF retentate salted with 1% NaCl + 1% KCl.

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