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Composition and Microstructure of Domiati Cheese made from Reconstituted UF Milk

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ABSTRACT

The quality of Domiati cheese made from reconstituted UF milk was improved, compared with that made from reconstituted milk by the conventional method. The clotting time decreased, the coagulum strength and the protein and fat retention increased, and this resulted in a firmer coagulum and smoother body.

UF cheese had higher moisture, fat in DM, protein in DM, proteolysis of proteins and pH value than conventional cheese. The accumulation of free amino acids was significantly different between the control and the experimental cheeses and increased throughout the ripening period.

The liberation of Free Fatty Acids showed the same trend in both cheeses except for a small increase of free Volatile Fatty Acids in UF cheese which had a good finish and appearance, better consistency and flavour than the control cheese.

The microstructures of the cheeses were quite similar and the protein matrix was in a loose and porous structure. The casein network was still recognizable after four months of ripening.

INTRODUCTION

Domiati cheese of acceptable quality has been made from 100% recombined milk using the same principles and standard as apply to the production of Domiati cheese from fresh milk. A few technological problems were found, e.g. the rate of coagulation was slower, the coagulum strength was reduced, the rate of syneresis of the curd during cheese making slightly decreased and

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the ripening of cheese was slower than in fresh milk cheese (Omar *et al.*, 1983).

Reconstituted milk of 20% Total Solids was used in making soft brine cheese by Omar & Buchheim (1983). They obtained a satisfactory curd firmness and body characteristics as compared with the conventional product.

Recombined milk was concentrated to 20% Total Solids by the ultrafiltration techniques to eliminate the necessary amount of water and lactose before coagulation and to obtain the retentate, which has the same composition as drained cheese. The quality of Domiati cheese made by this method was improved (Abd El-Salam *et al.*, 1983).

The quality and flavour of cheese are influenced by the concentration of free amino acids and Free Fatty Acids in cheese during ripening (Webb & Johnson, 1965). Therefore, the microstructure and chemical composition of Domiati cheese made from ultrafiltered fresh milk was studied by Omar (1987*b*).

The objective of the present work was to study the effect of ultrafiltration on the composition and microstructure of Domiati cheese made from reconstituted ultrafiltered milk.

MATERIALS AND METHODS

Cheese making

Reconstituted skim milk was prepared at the rate of 9% dry matter and concentrated 4-fold by UF at a pressure of 0·10 to 0·15 MPa at a temperature of 50°C using an Amicon DC 30E ultrafilter and H10PIO membranes. Butter oil (melted at 70°C) was added to the retentate, well mixed then homogenized. The mixture was inoculated with 4 g NaCl and 3 g rennet/100 kg retentate. Control cheese was made by the conventional method (Fahmi & Sharara, 1950) from recombined milk of 20% Total Solids, including the addition of NaCl (to 10%) to the recombined milk before renneting. The young cheese was pickled in salted whey (14% NaCl) at room temperature (20 to 25°C) for 4 months. Treatments were conducted in triplicate and cheese samples were analyzed when young and after 2 and 4 months.

Free amino acid composition

Ten grams of cheese were dissolved in 90 ml 0·5M tris-sodium citrate solution. The mixture was then heated to 75°C in a water bath and

homogenized at 10 000 rpm for 3 min using a laboratory homogenizer (Aid type 309). The samples were deproteinized by 5% sulphosalicylic acid and filtered. The filtrate was adjusted to pH 2 by the addition of 5N NaOH and to pH 2·2 using freshly prepared 0·2N sodium citrate buffer (pH 2·2) followed by filtration (Mondino *et al.*, 1972). Free amino acids were determined on 0·8 ml of the filtrate using an amino acid analyzer JLC/6AH JEOL/Japan.

Free Fatty Acid composition

Sodium soaps of the Free Fatty Acids were released from cheese by the method of Kuzdzal & Kuzdzal-Savoie (1966). Free Volatile Fatty Acids (C_2 to C_8) were prepared as in the method described by Roos *et al.* (1963). The methyl esters of (C_{10}–C_{18}) Free Fatty Acids were prepared by the method of Kuzdzal-Savoie & Kuzdzal (1967). Free Fatty Acids were separated on a Pye Unicam 104 gas–liquid chromatograph using a 1·5 m glass column, inner diameter 3 mm, packed with 10% dimethyl glycol succinate on Chromosorb AW/80/100, with 2% H_3PO_4 added. The carrier gas was argon, at 40 ml/min, the column was at 150°C, and the detector was at 250°C.

Chemical composition of cheese

The cheese samples were analyzed for pH, moisture, fat and total nitrogen contents according to the AOAC methods (Horwitz *et al.*, 1970). The protein breakdown was measured as water-soluble nitrogen (Sode Mogensen, 1948), non-protein nitrogen (Schrober *et al.*, 1961) and amino acid nitrogen (Garnier, 1962). The nitrogen in each fraction was determined by the Kjeldahl method and the results were expressed as percentage of total nitrogen content in the cheese.

Sensory evaluation

All cheese samples were subjected to sensory evaluation using a scale with 50 points for flavour, 30 points for body and texture and 20 points for finish and appearance (Bruncke, 1968). Statistical analysis was carried out according to Steel & Torrie (1960).

Electron microscopy

Cheese samples were prepared for electron microscopy by application of the freeze-fracturing technique according to Buckheim (1982) and Prokopek *et al.* (1976). Small pieces (1 to 2 mm^3) of cheese were mounted on specimen holders using glycerol as intermediate layer to increase mechanical stability.

The specimens were quickly frozen by immersion in melting Freon 22 (−160°C) and stored under liquid nitrogen. Freeze-fracturing was carried out in a Balzers BA 360 M unit at an object temperature of −120°C. For replication, the freshly freeze-cleaved surface was immediately shadowed with 2 nm platinum/carbon under an angle of 45° and further stabilized by 20 nm of pure carbon. The replicas were floated onto distilled water and then transferred to 5% sodium hypochlorite for 2 h and passed again to distilled water. Electron microscopy was carried out with a Siemens ELMISKOP Iat 80 KV.

RESULTS AND DISCUSSION

It was observed, during the manufacture of Domiati cheese from reconstituted UF milk, that the clotting time decreased, the coagulum strength increased and no fat or curd particles were lost, resulting in a firmer coagulum and smoother body compared to cheese made from recombined milk by the conventional method.

The retention of total nitrogen and protein was significantly higher ($P < 0{\cdot}1$) in UF milk cheese than in the control cheese (Table 1) which may account for the higher yield in cheese made by UF (Goncharov *et al.* 1977; Veinoglou *et al.*, 1978; Mottar *et al.*, 1979; Omar *et al.*, 1986; Omar, 1987*a*, *b*).

The gross composition elements of the resultant cheese were within the

TABLE 1
Protein Retention in Domiati Cheese made from Recombined Milk

Index	*Number*	*Conventional method*	*Ultrafiltration method*
Nitrogen in milk (%)	1	0·882	1·25
	2	0·890	1·31
	3	0·905	1·24
	$\bar{x}$	0·892	1·27
	σ_x	0·012	0·04
Nitrogen in whey (%)	1	0·210	0·095
	2	0·225	0·091
	3	0·219	0·106
	$\bar{x}$	0·218	0·098
	σ_x	0·016	0·005
Retention (%)	$\bar{x}$	70·6	90·2

$\bar{x}$ = Mean value; σ_x = standard deviation.

TABLE 2
Chemical Analysis of Domiati Cheese made from Recombined Milk

Index	*Age of cheese*					
	Conventional method			*Ultrafiltration method*		
	Young	*2 months*	*4 months*	*Young*	*2 months*	*4 months*
Moisture (%)	63·58	57·52	55·18	71·99	62·74	58·76
Fat in DM (%)	49·42	44·73	45·64	67·83	52·27	50·92
Total N (TN) in DM (%)	7·83	7·02	6·89	10·6	8·45	7·86
Soluble N (% of TN)	4·49	11·6	21·8	6·16	15·4	25·5
Non-protein N (% of TN)	3·95	6·87	11·4	5·12	9·71	16·9
Amino acid N (% of TN)	0·55	1·98	3·87	0·81	2·56	5·23
Free amino acids (mg/100 g cheese)	58·1	150	328	69·4	173	430
Volatile Fatty Acids (C_2–C_{10}) (μg/g cheese)	4·79	12·7	27·7	6·16	16·9	42·7
Non-volatile Fatty Acids (μg/g cheese)	140	249	381	139	242	390
pH	5·01	4·89	4·75	6·15	5·75	5·60

legal limits (Table 2). The fat in dry matter, the moisture, nitrogenous substances and pH values changed during the ripening.

The moisture and fat in dry matter contents of UF cheese were higher than that of the control cheese. This could be attributed to the higher water-binding capacity of proteins and the higher fat retention in UF milk cheese (Maubois & Mocquot, 1975; Goncharov *et al.*, 1977; *Omar*, 1987*a*, *b*). The pH value was higher in UF cheese because of the increase of buffering capacity in the retentate, elimination of lactose and the reduction of clotting time in ultrafiltered milk cheese (Green *et al.*, 1981).

The breakdown of protein in cheese made from dried milk is slower than that in cheese made from fresh milk (Omar & Buchheim, 1983; Omar *et al.* 1983). In this study the breakdown of proteins in UF cheese was slightly higher than in cheese made by the conventional method (Table 2).

The pattern distribution of the free amino acids was similar in both treatments (either young or matured cheese) and revealed 16 free amino acids (Table 3). The accumulation of free amino acids was significantly different ($P < 0·1$) between cheeses made by UF and control procedures and the UF cheese contained 71·8, 14·9 and 30·9% more amino acids than the control cheese when young and after 2 and 4 months of ripening, respectively. This variation could account for the better flavour of UF cheese. Glutamic acid, leucine, proline, arginine and alanine represented half of the free amino acid concentration in 4 months-matured UF cheese, while

TABLE 3
Free Amino Acid Composition of Domiati Cheese made from Recombined Milk (mg/100 g cheese)

Amino acid	*Age of cheese*					
	Conventional method			*Ultrafiltration method*		
	Young	*2 months*	*4 months*	*Young*	*2 months*	*4 months*
Lysine	0·70	3·50	23·5	4·77	8·49	29·5
Histidine	0·80	1·58	16·3	1·10	2·08	17·9
Arginine	3·63	11·4	15·6	4·51	16·5	36·5
Aspartic acid	12·6	16·2	36·2	13·1	17·2	23·2
Threonine	0·30	1·91	3·32	1·50	6·80	13·6
Serine	1·13	3·52	9·80	0·38	2·90	1·50
Glutamic acid	14·1	36·5	66·6	15·2	31·3	76·2
Proline	6·08	17·0	34·9	8·12	17·3	42·0
Glycine	2·41	5·13	11·6	2·89	5·46	16·8
Alanine	1·33	5·16	20·0	2·80	13·7	36·5
Valine	3·45	7·22	18·2	4·01	10·3	16·4
Methionine	0·80	2·53	6·36	4·40	7·04	15·1
Iso-leucine	3·36	6·56	9·32	1·42	5·36	17·5
Leucine	5·06	18·2	32·6	4·47	17·2	43·4
Tyrosine	1·13	7·64	18·4	2·52	6·11	30·0
Phenylalanine	1·28	6·35	13·8	1·32	5·24	14·0
Total	58·1	150	328	69·4	173	430

TABLE 4
Scoring of Domiati Cheese made from Recombined Milk after Four Months of Ripening

		Treatment number								
		Conventional method				*Ultrafiltration method*				
		1	*2*	*3*	$\bar{x}$	*1*	*2*	*3*	$\bar{x}$	*T ratio*
Finish and appearance	(20)	17	17	17	17	19	19	19	19	—
Body and texture	(30)	24	25	24	24·3	27	28	27	27·3	2·12
Aroma	(25)	18	19	18	18·3	20	21	20	20·3	4·24
Taste	(25)	18	17	17	17·3	21	19	18	19·3	2·12
Total	(100)	77	78	76	77	87	87	84	86	6·93

Fig. 1. Micrograph of young Domiati cheese made from recombined milk by the traditional method. Cheese matrix consists of casein micelles (C), fat globules (F) and whey phase (W). Bar: 0·5 μm.

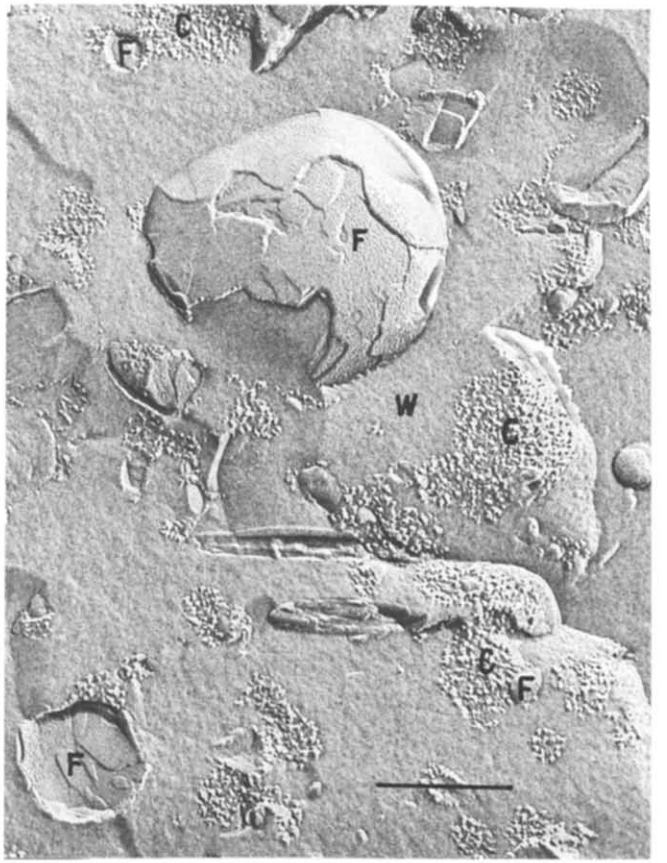

Fig. 2. Micrograph of young Domiati cheese made from recombined milk by the ultrafiltration method. The small fat globules (F) are in association with the casein (C) and the whey phase (W). Bar: 0·5 μm.

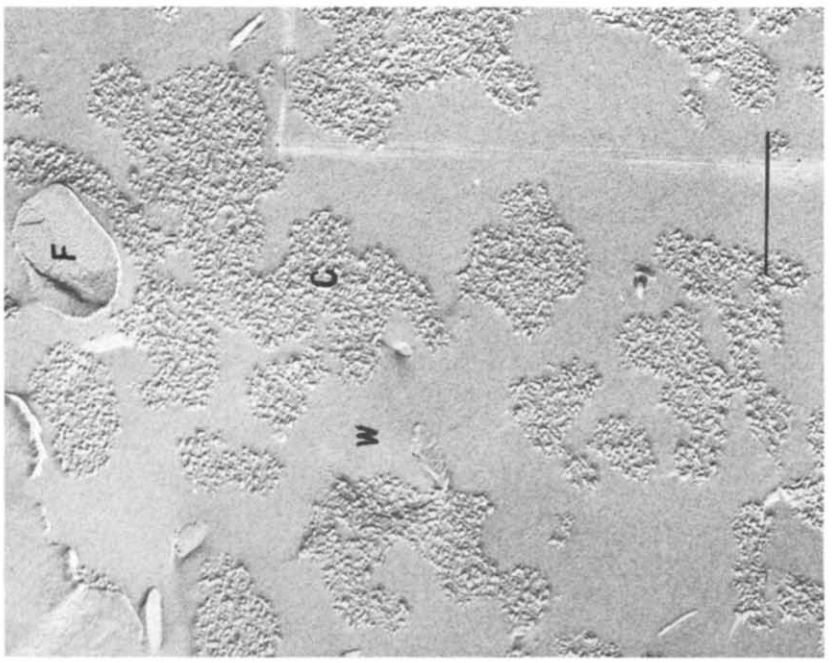

Fig. 4. Micrograph of four months. Domiati cheese made by the ultrafiltration method. The casein (C) network is still recognizable and the fat globules (F) are embedded in the casein aggregates with the whey phase (W). Bar: 0·5 μm.

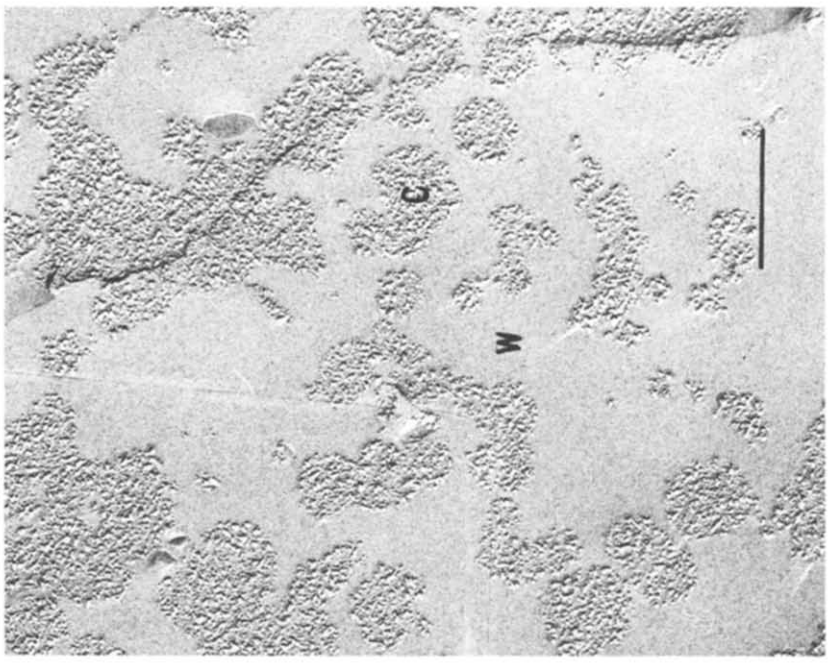

Fig. 3. Micrograph of four months Domiati cheese made by the traditional method, showing the disintegration of the casein (C) into a uniform matrix and the penetration of the whey (W) into the disintegrated casein mass. Bar: 0·5 μm.

the same value in control cheese resulted from glutamic acid, aspartic acid, proline and leucine.

The Free Fatty Acid pattern revealed 24 Free Fatty Acids in young and matured cheese; also, no significant differences were recorded between the two cheeses in their contents of the non-volatile Free Fatty Acids (C_{12}–$C_{18:3}$). This could be attributed to the use of the same pasteurized cream fat during the manufacturing process. The lipolysis of cheese fat and the liberation of Free Fatty Acids showed the same trend in all treatments, except for a small increase of the Free Volatile Fatty Acids (C_2–C_{10}) in 4 months matured UF cheese to 42·7 μg/g cheese, as against 27·7 μg/g in control cheese (Table 2). This may be the cause of improved flavour in UF cheese.

The significant differences ($P < 0{\cdot}1$) in cheese scoring (Table 4) are related to proteolysis, lipolysis and production of acetic and propionic acids which interact with the other components to determine the final flavour of the resultant cheese (Biede & Hammond, 1979). UF cheese of 4 months of age had a good finish and appearance, smooth body, soft consistency and pure to slight salty flavour, while the control cheese had a porous or brittle body and distinct salty flavour. Thus the organoleptic properties of cheese were improved by using reconstituted UF milk in cheese making.

The microstructure of young Domiati cheese is shown in Figs 1 and 2. Casein network chains are clearly similar in both cheeses. The degradation of casein micelles after four months is shown in Figs 3 and 4, resulting in the disintegration of casein into a uniform matrix and the penetration of the whey into the disintegrated casein mass; the small fat globules are embedded in the casein aggregates. The protein matrix had a loose and porous structure and the casein network was still recognizable.

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