Lait (1996) 76, 513-522

Original article

Accelerated ripening of reduced fat semi-hard cheese from a mixture of cow's, goat's and ewe's ultrafiltrated milk by using a Lac⁻ Prt⁻ strain of lactococci

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(Received 13 May 1996; accepted 6 August 1996)

Summary – The technological process for a reduced fat (360 g/kg total solids) semi-hard cheese, based on a mixture of cow's, ewe's and goat's milk concentrated by ultrafiltration, was assayed using starter cultures designed to accelerate proteolysis and improve flavour and aroma development. The proteolytic fractions studied (noncasein nitrogen, nonprotein nitrogen and amino nitrogen) were significantly higher in the cheeses elaborated with the selected starter (IFPL) towards a commercial starter (Flora Danica). The addition to the IFPL starter of a *Lactococcus lactis* subsp *lactis* Lac⁻ Prt⁻ strain (T1) caused, at the end of the cheese ripening time (3 months), a two-fold increase in the amino nitrogen content, when compared to the cheeses elaborated with the commercial starter. The reduced fat ultrafiltrated (UF) milk cheeses elaborated with IFPL starter achieved an adequate proteolysis together with the right balance of flavour and aroma. By using a starter culture previously selected for semi-hard cheeses, and enhanced by addition of Lac⁻ Prt⁻ lactococci, it was possible to accelerate in 1 1/2 months the ripening time required for the UF cheeses made with a commercial starter.

reduced fat cheese / ultrafiltrated milk / accelerated cheese ripening / mutant lactococci / starter

Résumé – Affinage accéléré de fromage à pâte demi-dure, à teneur en matière grasse réduite, obtenu à partir d'un lait de mélange vache-chèvre-brebis ultrafiltré, à l'aide de lactocoques Lac⁻, Prt⁻. *La technologie de fabrication d'un fromage à pâte demi-dure, à teneur en matière grasse réduite (360 g/kg d'extrait sec) obtenu à partir d'un mélange de lait de vache, de chèvre et de brebis ultrafiltré (UF) a été expérimentée. Des levains destinés à accélérer la protéolyse et à améliorer le développement de la flaveur et de l'arôme ont été utilisés. Les teneurs en azote des fractions protéolysées étudiées (azote non caséique, azote non protéique, azote aminé) étaient significativement plus élevées dans les fromages élaborés avec le levain sélectionné (IFPL) que dans les fromages élaborés avec un levain commercial (Flora Danica). L'addition d'une souche de* Lactococcus lactis *subsp* lactis *Lac⁻ Prt⁻ (T1) au levain IFPL provoquait à la fin de l'affinage (3 mois) un doublement de l'augmentation*

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du taux d'azote aminé des fromages, comparativement à ceux élaborés avec le levain commercial. Les fromages à teneur en matière grasse réduite élaborés à partir de lait ultrafiltré avec des levains IFPL, parvenaient à une bonne protéolyse, tout en ayant un juste équilibre de flaveur et d'arôme. L'utilisation de levains choisis pour des fromages à pâte demi-dure et améliorés par l'addition de lactocoque Lac⁻ Prt⁻ réduisait d'un mois et demi le temps nécessaire à l'affinage des fromages ultrafiltrés fabriqués avec un levain commercial.

fromage à matière grasse réduite / lait ultrafiltré / accélération de l'affinage des fromages / lactocoque Lac⁻ Prt⁻ / levain

INTRODUCTION

Low fat cheeses made under conventional conditions normally present defective sensory characteristics, for example weak aroma, unwanted flavours and over-firm or rubbery texture (Jameson, 1994). There may be a number of causes to these defects: low fat levels (which are a factor in dissolution of aroma compounds and masking of flavours, such as a bitter taste), lower degree of lipolysis, altered protein matrix density and too little or too much proteolysis depending on the characteristics of the manufacturing process. Moreover, in this kind of product, bitter peptides, which form as caseins break down under the action of the rennet and the proteases from the microorganisms in the starter culture, are more evident owing to the smaller proportion of the aroma compounds which grow in the presence of fats (El Soda, 1993).

In an effort to achieve products with acceptable characteristics, proposals have been made for modified cheesemaking techniques and the introduction of technological innovations, with the following objectives: to retain more moisture in the three-dimensional casein network, so as to compensate for the reduction in fat; and to control the salt/moisture ratio and improve the aroma through the use of lactic bacteria either as part of or in addition to the starter culture (Ardö, 1994; Emmons, 1994). Fat substitutes such as modified starch, structured lipids, sucrose polyesters, and so on have also been used as fat replacers in cheeses (Quiblier et al, 1990; Drake and Swanson, 1995).

A variety of alternatives have been tried to control cheese moisture, but it is not known by how much the moisture in low fat cheeses needs to be increased for the product to be as similar as possible to a traditional cheese in terms of firmness and texture (Emmons, 1994). A number of authors have proposed the use of ultrafiltrated (UF) milk concentrate to retain more moisture in low fat cheeses (Boer and Nooy 1980; De Koning et al, 1981; Ardö, 1994). However, there are problems to be solved arising from the slowdown of ripening due to lower levels of residual rennet, the presence of protease and peptidase inhibitors and the ability of whey proteins to link with some aroma compounds (Lelievre and Lawrence, 1988; Bech, 1993).

A number of proposals have been made to improve aroma and flavour in low fat cheeses: the use of enzymes such as commercial aminopeptidases (Coulson et al, 1992; Skeie et al, 1995), mixtures of proteases and lipases (McGregor and White, 1990), the addition of heat-treated microorganisms (Ardö et al, 1989; Ardö and Mansson, 1990; El Soda et al, 1991) or the use of modified starter cultures. Lactococci Prt⁻Lac⁻ (Grieve and Dulley, 1983; Kamaly et al, 1989), Lac⁻ (Birkeland et al, 1992) or Prt⁻ (Broome et al, 1991) have been used as adjuncts to the starter to improve the organoleptic characteristics of cheeses.

A specific starter culture for industrial production of semi-hard goat's milk cheese has been developed at our laboratory

(Requena et al, 1992). In addition, the acidifying and proteinase activity of the strain *Lactococcus lactis* subsp *lactis* IFPL 359 in the new starter culture has been successfully eliminated, through loss of the plasmid where the genetic determinants that encode for these activities are located, while maintaining peptidase activity (Requena and McKay, 1993). It has been found that high concentrations of *L lactis* subsp *lactis* IFPL 359, variant Lac^-Prt^-, accelerate proteolysis and hence flavour development in cheese slurries (Rodríguez et al, 1996).

The production of ewe's and goat's milk is growing in Spain. An important part of this production is used for the elaboration of semi-hard cheeses in a mixture with cow's milk. The production of these types of cheeses in Spain was approximately 140 000 t (50% of the total cheese production) in 1994 (Federación Nacional de Industrias Lácteas [FENIL], 1996, personal communication).

The aim of the present work was to study the manufacturing process for a reduced fat semi-hard cheese based on a mixture of cow's, ewe's and goat's milk concentrated by ultrafiltration, using starter cultures designed to accelerate proteolysis and improve flavour and aroma.

MATERIALS AND METHODS

Ultrafiltration process

Approximately 190 kg of semi-skimmed milk (2.3% fat content) made from skimmed cow's milk mixed with ewe's and goat's milk (55/15/30) was pasteurized (4 s at 92 °C) in an ACTIJOULE apparatus (Actini, Maxilly, Évian-les-Bains, France), at a flow rate of 500 L/h. After pasteurization, the milk was cooled to 50 °C then put through the ultrafiltration process. A Tech Sep tubular apparatus was used (Tech Sep, Saint-Maurice de Beynost, Miribel, France); its characteristics are described in an earlier paper (Goudédranche et al, 1980). The equipment consisted of two mineral-type subunits in zircone oxide (ZrO_2) which gave a total unit membrane area of 0.815 m^2 (cut off 150 000 Da). The process conditions were as follows: input pressure 4.4 bar, output pressure 3.0 bar, temperature 50 °C, flow rate 15 000 L/h. Once a threefold concentration was attained, diafiltration was carried out, with the addition of sufficient water at 50 °C, to reduce lactose content in the retentate (down to 1.7%).

Ultrafiltration was continued until total protein content in the retentate reached 226 g/kg, equivalent to a six-fold concentration.

Preparation of cheeses

Cheeses were made following the procedure described by Goudédranche et al (1980). Upon completion of ultrafiltration, the concentrate was cooled to 30 °C. When this temperature was reached, the various freeze-dried starter cultures were added directly to the vat to produce counts in the region of 10^{10} cfu/kg in the retentate.

Three batches of cheese were made using the following starter cultures: the commercial starter (Flora Danica MSP, Chr Hansen, Denmark), consisting of a mixture of *L lactis* subsp *cremoris*, *L lactis* subsp *lactis*, *Leuconostoc mesenteroides* subsp *cremoris* and *L lactis* subsp *diacetylactis;* the IFPL starter, previously described by Requena et al (1992), consisting of a mixture of *L lactis* subsp *lactis* IFPL 359 (80%), *Lactobacillus casei* subsp *casei* IFPL 731 (5%), *L plantarum* IFPL 935 (5%), *L mesenteroides* subsp *dextranicum* IFPL 709 (5%) and *L paramesenteroides* IFPL 705 (5%); and the IFPL starter, to which a concentrate of the Lac^-Prt^- derivate of *L lactis* subsp *lactis* IFPL 359, strain T1, (approx 10^{10} cfu/kg retentate) was also added.

The freeze-dried cultures were re-dissolved in permeate 3 h before they were added to the retentate at 30 °C. Following starter addition, the pre-cheese (pH 6.58) was left to acidify for 3 h at 30 °C. In this time pH dropped to 6.4, at which point salt (1.1%;w/w) and rennet (0.4 mL/kg precheese; rennet contained 520 mg/L of chymosin) were added.

Approximately 600 g of cheese were placed in moulds and left to acidify overnight in a chamber at 30 °C, until pH reached approximately 5. The moulds were then placed in ripening chambers at 13 °C and 90% relative humidity. After 3 h in these conditions, the cheeses were removed from their moulds and treated with a solution of 3 g/L of Delvocid® (Gist-brocades nv, Seclin, France) to prevent growth of fungi during ripe-

ning, which took place over 3 months. Cheese samples were taken in triplicate at 0, 15, 30, 45, 60 and 90 days of ripening.

Physicochemical analysis

Dry matter, total protein, fat and lactose content of milk in permeates and serum were determined using a MULTISPEC apparatus (Föss Electric, Nanterre, France). The pH was measured directly in milk and cheeses using a Schott CG-837 pH meter.

Total solids (TS) and fat were determined according to the International Dairy Federation standards (IDF, 1982 and 1986, respectively). Nitrogen and total protein were determined by the Kjeldahl procedure (Official Methods of Analysis, 1975). Noncasein nitrogen (NCN) and nonprotein nitrogen (NPN) were determined by the procedure described by Kuchroo and Fox (1982), and the amino nitrogen fraction ($N.NH_2$) by the method described by Kuchroo et al (1983).

Ca and Mg contents were determined by atomic absorption spectrophotometry following precipitation with trichloroacetic acid (De la Fuente and Juárez, 1995b). P was determined colorimetrically following the method described by De la Fuente and Juárez (1995a).

Microbiological analyses

Sample-taking and the necessary dilutions were carried out in accordance with the International Dairy Federation standards (IDF, 1985). Total viable counts of lactobacilli and leuconostocs were performed following the procedures previously used by Gómez et al (1989). Lactococcal differentiation was carried out on agar plates using bromocresol purple as lactose fermentation indicator (McKay et al, 1970).

Sensory analysis

Cheeses were subjected to periodic sensory analysis throughout ripening (15, 30, 45, 60 and 90 days), following the recommendations of the International Dairy Federation (IDF, 1987). The attributes assessed were: general appearance, aroma, flavour/taste, texture and general acceptability, for each of which the cheeses were awarded points on a scale of 1 (very poor) to 5 (very good). Defects in flavour or aroma were also evaluated.

Statistical analysis

Statistical study consisted of a two-way analysis of variance carried out using BMDP programs

Table I. Composition of cow's, ewe's and goat's milk and the mixture used in the ultrafiltration process and of the permeates and the retentate.
Composition des laits de vache, brebis et chèvre, et du lait de mélange soumis à l'ultrafiltration, ainsi que des perméats et du rétentat.

	Fat (g/L)	*Protein (g/L)*	*Lactose (g/L)*	*Dry matter (g/L)*	*pH*
Milk					
Cow (C)	0.9	36.6	48.1	93.5	–
Goat (G)	32.9	30.4	45.9	114.7	–
Ewe (E)	79.5	60.9	46.1	196.6	–
Mixture C/E/G (55/15/30)	22.7	38.5	48.6	116.6	6.7
Permeate					
Before diafiltration	0.0	2.2	50.7	54.9	–
At the end of UF	0.0	2.1	25.3	27.3	–
Mixture permeate	0.0	1.9	37.3	40.1	–
Retentate	132.0	226.0	17.0	399.0	6.6

2D, 2V and 7D (version 1994) on an ALPHA 2100 under VMS computer (CTI CSIC, Madrid, Spain).

RESULTS AND DISCUSSION

Ultrafiltration process

The characteristics of milk, permeate and retentate composition are shown in table I. The milk mixture used to make the cheeses contained 2.3% fat, 3.8% protein, 4.9% lactose and 11.7% total solids.

From an initial 190 kg of milk, total permeate after ultrafiltration was 228 kg. This gives a yield for the process of 16.3%, since the volume of whey left after making the cheeses was approximately 2%. Total protein content in the whey was 5.6% and total solids 11.2%.

Total Ca, Mg and P contents in the milk were 1 184 ± 20, 134 ± 1 and 1 040 ± 20 mg/kg, respectively, and in the permeate 204 ± 4, 64 ± 1 and 210 ± 25 mg/kg, giving a percentage of retention in the retentate of 85.00, 58.50 and 82.45%, respectively. Percent retention of Ca in the retentate was higher than that reported by Brulé et al (1974) in UF milk and Qvist et al (1987) in Havarti cheese made with UF milk, probably because the milk was not acidified prior to the ultrafiltration process, so that less Ca entered the soluble phase (Holt, 1985).

Evolution of physicochemical characteristics of cheeses in the course of ripening

Fat and protein contents (as a proportion of TS) did not change to any appreciable extent during ripening of all batches, nor were they affected by the different starters used. Mean values were (g/kg TS) fat 360.4 ± 1.68 and protein 533.3 ± 2.99. Protein content (%TS) was higher than that reported by Goudédranche et al (1980) for UF Saint-Paulin cheese, by El-Shibiny et al (1991) for UF Ras cheese and by Qvist et al (1987) for UF Havarti cheese, owing to the reduced fat content in the milk used. Fat content was around 40% lower than in a traditional semi-hard ewe's or goat's milk cheese (Martín Hernández et al, 1992; Fontecha et al, 1994).

Figure 1 shows the evolution of pH and total solids in the course of ripening for all three cheese batches. The mean pH value of the cheeses at the outset of ripening was 5.0, approximately 1.5 pH units lower than the original milk, and was similar to that

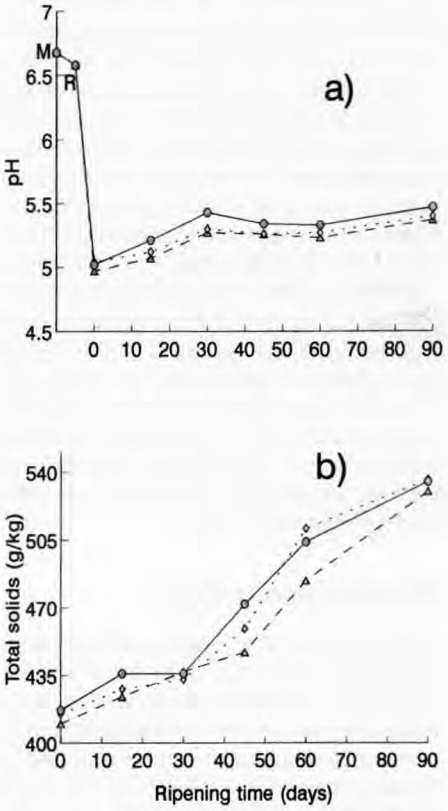

Fig 1. Evolution of (a) pH and (b) total solids in cheeses elaborated with the Flora Danica starter (○), IFPL starter (◊) *and IFPL + T1* (Δ) during ripening. M: milk; R: retentate.
Évolution a) du pH et b) de la matière sèche totale de fromages élaborés avec des levains Flora Danica (○), IFPL (◊) et IFPL + T1 (Δ) durant l'affinage. (M) lait. (R) rétentat.

reported by Delbeke (1987) for UF Saint-Paulin cheese, Spangler et al (1989) for UF Gouda cheese and McGregor and White (1990) for low fat Cheddar cheese. The pH during the first 45 days of ripening was significantly lower in the IFPL batches ($P < 0.01$). The addition of *L lactis* Lac$^-$ Prt$^-$ (T1) again produced no lowering of pH, as might have been expected as a result of loss of phospho-β-galactosidase activity (Requena and McKay, 1993). At the end of the ripening period, the pH in all batches was 5.4. Evolution of pH was similar to that found in UF Saint-Paulin and UF Camembert cheeses (Goudédranche et al, 1986).

Figure 1 also shows the evolution of total solids in the three batches in the course of ripening. Total solids at the outset of ripening were low (mean value for the three batches was 41.4%) as compared to other cheeses made with ultrafiltrated milk (Qvist et al, 1987; Spangler et al, 1989; McGregor and White, 1990). This could be due to both the low fat content of the cheeses and the high temperature treatment of the original milk and hence high levels of moisture were retained, even after 3 months' ripening (mean value 53.3%). Total solids increased during cheese ripening and the evolution was not significantly affected by the different types of starter used.

Microbiological analyses

Figure 2 shows the evolution of total microorganisms, lactococci, lactobacilli and leuconostocs over the ripening period in the three cheese batches. The evolution of total counts was similar to that reported by Goudédranche et al (1986) in UF Saint-Paulin cheese. Lactococci were the predominant flora in all batches and at all stages of the assay, although counts were lower in cheeses made with Flora Danica than those made with IFPL starter. Lactococci counts declined over the storage period, and by the end were either two logarithmic units (cheeses with Flora Danica) or one logarithmic unit (IFPL starter) lower than the initial values. Over the same period, counts of *L lactis* subsp *lactis* T1 fell by two logarithmic units (results not shown). Hi-

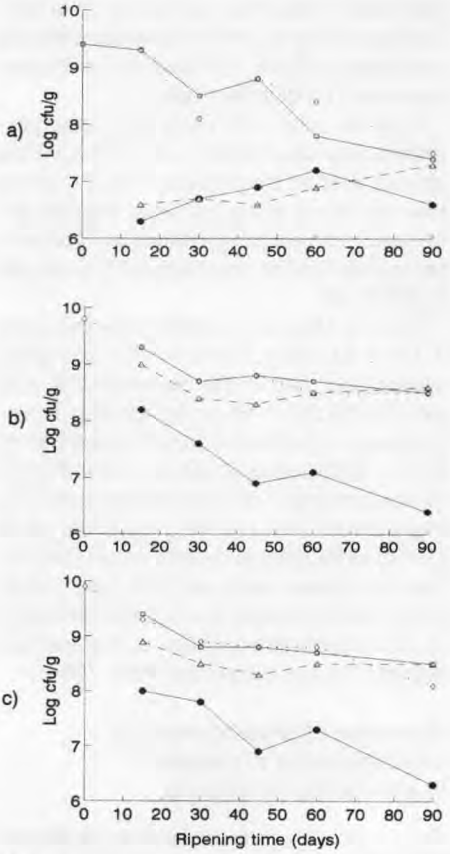

Fig 2. Evolution of the total viable microorganisms (□), lactococci (◊), lactobacilli (Δ) and leuconostoc (●) in cheeses elaborated with (a) Flora Danica starter, (b) IFPL starter and (c) IFPL starter + T1 during ripening (0, 15, 30, 45, 60 and 90 days).
Évolution de la flore mésophile aérobie revivifiable (□), lactocoque (◊), lactobacille (Δ) et leuconostoc (●) dans les fromages élaborés avec des levains (a) Flora Danica, (b) IFPL et (c) IFPL + T1, durant l'affinage (0, 15, 30, 45, 60 et 90 jours).

gher levels of lysis have been found for this variant Lac⁻ Prt⁻ (Rodríguez et al, 1996).

At the end of the ripening period, lactococci and lactobacilli counts were similar in cheeses made with IFPL starter or Flora Danica. In the latter case, these were probably originated by milk contamination during manufacturing and were significantly lower than in IFPL cheeses. Leuconostoc levels were higher in IFPL cheeses than in those made with Flora Danica at all stages of the assay (fig 2).

Nitrogen fractions

Evolution of the nitrogen fractions (NCN, NPN and $N.NH_2$) in the three cheese batches is shown in table II. NCN content in the three batches increased significantly ($P < 0.05$) over the first 2 weeks of ripening, and slightly thereafter. The highest NCN values were obtained in the cheeses elaborated with *L lactis* T1 in the starter culture (table II). Evolution of NPN was comparable to that of NCN in all three batches.

The most significant differences between batches were found in the $N.NH_2$ fraction, which increased more sharply ($P < 0.05$) during ripening of cheeses made with IFPL starter than with Flora Danica (table II). By the end of the ripening period, the level of amino nitrogen was higher ($P < 0.001$) in the IFPL batches than in the Flora Danica (2.83 and 3.22% as compared to 1.62%). Moreover, the amino nitrogen content of cheeses after 90 days of ripening increa-

Table II. Mean values and standard deviation (in parenthesis) for the nitrogen fractions: noncasein nitrogen (NCN), nonprotein nitrogen (NPN) and amino nitrogen ($N.NH_2$) in cheeses during ripening. *Teneurs moyennes et écarts types (entre parenthèses) des fractions azotées : azote non caséique (NCN), azote non protéique (NPN) et azote aminé ($N.NH_2$) des fromages au cours de l'affinage.*

Cheese batch	*Ripening time (days)*	*NCN (% TN)*	*NPN (% TN)*	*$N.NH_2$ (% TN)*
	0	11.7 (0.0)[a]	5.1 (0.0)[a]	0.08 (0.0)[a]
	15	18.4 (0.0)[b]	11.0 (0.5)[a]	0.12 (0.0)[b]
Flora	30	18.1 (0.1)[b]	14.9 (0.6)[a]	0.31 (0.1)[b]
Danica	45	22.3 (0.2)[a]	14.5 (0.1)[a]	1.07 (0.1)[c]
starter	60	25.1 (0.3)[b]	16.3 (0.2)[a]	1.51 (0.3)[b]
	90	25.2 (0.2)[b]	16.5 (0.3)[b]	1.62 (0.1)[c]
	0	11.3 (0.1)[a]	3.6 (0.1)[b]	0.09 (0.0)[a]
	15	19.5 (0.1)[a]	12.4 (0.5)[a]	0.34 (0.0)[ab]
IFPL	30	20.6 (0.3)[ab]	14.6 (0.8)[a]	0.94 (0.1)[a]
starter	45	24.3 (0.2)[a]	17.8 (0.3)[a]	1.52 (0.4)[b]
	60	25.6 (0.2)[ab]	17.6 (0.7)[a]	2.62 (0.5)[a]
	90	25.7 (0.1)[ab]	20.4 (0.2)[a]	2.83 (0.2)[b]
	0	11.5 (0.1)[a]	4.0 (0.0)[b]	0.08 (0.0)[a]
	15	19.4 (0.1)[a]	13.7 (0.5)[a]	0.38 (0.1)[a]
IFPL	30	22.0 (0.3)[a]	16.1 (0.7)[a]	1.27 (0.3)[a]
starter +	45	24.1 (0.2)[a]	17.5 (0.7)[a]	1.86 (0.2)[a]
T1	60	27.5 (0.2)[a]	17.4 (0.5)[a]	2.49 (0.4)[a]
	90	27.3 (0.2)[a]	21.2 (0.3)[a]	3.22 (0.1)[a]

[a, b, c] Means at the same time ripening time not followed by the same letter differ significantly ($P < 0.05$). Mean values are means of nine cheese samples.

[a,b,c] *Les moyennes à un même temps d'affinage suivies de lettres différentes sont significativement différentes (p < 0,05). Les teneurs moyennes représentent la moyenne de neuf échantillons de fromage.*

sed significantly ($P < 0.05$) when *L lactis* subsp *lactis* T1 was added to the IFPL starter. Cheeses made with UF milk generally require longer ripening times to achieve maximum grading scores, which is attributed to the lower degree of proteolysis (Bech, 1993). The use of starter strains selected for increasing secondary proteolysis (IFPL starter, Requena et al, 1992), together with the addition of Lac^- Prt^- lactococcal strains, produced a significant increase ($P < 0.05$) in amino nitrogen levels from the first month of ripening. Comparison of the results in these cheeses and the results in cheeses made with a commercial starter (Flora Danica) shows that ripening can be accelerated by approximately 1 1/2 months. This finding bears out the results of a previous experiment on evolution of proteolysis in slurries of cheese made from the same milk mixture with a concentrate of the strain T1 (Rodríguez et al, 1996).

Sensory analysis

The results of sensory analysis of the three cheese batches are shown in table III. The appearance of the cheeses was considered good throughout ripening, with no significant differences between batches ($P < 0.05$). The IFPL cheeses further exhibited remarkably well-distributed interior openings, which have been shown to be the result of growth of the leuconostocs in the cheeses and considered as a valuable characteristic in the appearance scores (Requena et al, 1992). Cheese aroma increased during ripening in all batches, and cheeses made with IFPL starter awarded the best final scores on both aroma and flavour. From 45 days on, the tasting panel found flavour stronger in cheeses made with the IFPL starter and strain T1 than in those made with Flora Danica, the difference becoming more pronounced as ripe-

Table III. Mean values and standard deviation (in parenthesis) for the sensory characteristics of the cheeses during ripening.
Valeurs moyennes et écarts types (entre parenthèses) des caractéristiques sensorielles des fromages au cours de l'affinage.

	Cheese batch	*Ripening time (days)*				
		15	*30*	*45*	*60*	*90*
Appearance	Flora Danica	3.4 (0.8)	3.5 (0.9)	3.4 (0.5)	4.1 (0.8)	3.6 (0.7)
	IFPL	3.9 (0.5)	3.8 (0.5)	3.8 (0.5)	4.3 (0.7)	3.7 (0.7)
	IFPL + T1	3.6 (0.8)	3.8 (0.5)	4.0 (0.5)	4.6 (0.5)	3.9 (0.9)
Aroma	Flora Danica	3.3 (1.0)	3.7 (1.1)	3.6 (0.5)	4.5 (0.8)	3.8 (0.8)
	IFPL	2.4 (1.0)	3.0 (1.0)	3.6 (0.5)	4.1 (0.7)	4.4 (0.5)
	IFPL + T1	2.9 (1.4)	3.1 (0.9)	3.6 (0.8)	4.1 (0.7)	4.0 (0.7)
Flavour	Flora Danica	3.4 (0.9)	4.2 (0.7)	3.9 (0.4)	4.2 (0.8)	3.6 (0.7)
	IFPL	3.0 (1.0)	3.3 (0.8)	3.4 (0.6)	4.3 (0.5)	3.9 (0.8)
	IFPL + T1	2.5 (1.0)	3.4 (0.8)	3.3 (0.7)	4.5 (0.5)	3.8 (0.8)
Texture	Flora Danica	3.3 (0.8)	3.8 (0.7)	3.9 (0.6)	4.0 (0.8)	3.9 (0.7)
	IFPL	3.5 (0.7)	3.6 (0.6)	3.7 (0.5)	4.1 (0.6)	3.9 (0.6)
	IFPL + T1	3.4 (0.9)	3.9 (0.7)	3.7 (0.5)	4.5 (0.8)	3.9 (0.5)
General acceptance	Flora Danica	3.5 (0.9)	4.0 (0.8)	3.9 (0.9)	4.3 (0.9)	4.3 (0.9)
	IFPL	2.9 (0.9)	3.5 (0.7)	3.4 (0.7)	4.3 (0.4)	4.3 (0.4)
	IFPL + T1	2.9 (0.7)	3.6 (0.6)	3.3 (0.5)	4.4 (0.5)	4.4 (0.5)

ning progressed. However, the strong taste of the cheeses was less appreciated by some panel tasters, who made no significant differences between the batches (table III). The texture of all three batches was considered smooth, thanks largely to greater moisture retention, and the panel found this a positive change from the typically hard consistency of low fat cheeses (Drake and Swanson, 1995).

Given optimum flavour development in 2 months and an adequate level of proteolysis, acceptable ripening could be achieved in this time. Some tasters thought that cheeses with the IFPL starter were overripe after 3 months, and even more so where *L lactis* subsp *lactis* T1 had been added.

CONCLUSION

A reduced fat cheese of acceptable sensory characteristics was successfully made from UF milk concentrate. Moreover, by using a starter culture previously selected as ideal for semi-hard cheese and enhanced by the addition of Lac$^-$ Prt$^-$ lactococci, it was possible to shorten the ripening time required in cheeses made with a commercial starter to ensure adequate proteolysis while achieving the typical appearance of such cheeses, with the right balance of flavour and aroma.

ACKNOWLEDGMENTS

The authors would like to acknowledge financial support for this study from the Comision Interministerial de Ciencia y Tecnología (Project ALI 95-0046-CO2-01). J Rodríguez is the recipient of a scholarship from the Spanish Council for Scientific Research (CSIC).

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