PAPER

CREMOSO CHEESE: PREDICTION OF RIPENING TIME USING PHYSICOCHEMICAL PARAMETERS AND MULTIVARIATE STATISTICAL TECHNIQUES

PREDIZIONE DEL TEMPO DI MATURAZIONE DI FORMAGGI CREMOSI IMPIEGANDO PARAMETRI CHIMICO-FISICI E TECNICHE STATISTICHE MULTIVARIATE

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ABSTRACT

Physicochemical parameters were used to study the ripening evolution in Cremoso cheese. Twenty-eight cheeses manufactured in different seasons and ripened for 30 days were obtained from two nearby factories. Using principal components analysis (PCA), cheese samples were grouped by ripening time, mainly according to PC_1. The high loading values of %pH4.6-SN/TN, %TCA-SN/TN, %PTA-SN/TN and the α_{S1}-I-casein/(α_{S1}-casein + α_{S1}-

RIASSUNTO

Per lo studio della evoluzione della maturazione del formaggio Cremoso sono stati impiegati parametri chimico-fisici. 28 forme di formaggio stagionati per 30 giorni e prodotti in differenti epoche dell'anno sono stati ottenuti da due caseifici vicini. L'analisi per componenti principali (PCA) ha evidenziato un raggruppamento tra campioni in funzione del tempo di maturazione, principalmente su PC_1. Gli elevati loadings trovati per %pH4,6-SN/TN,

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I-casein) ratio on factor 1 indicate that these variables are the most important for grouping cheeses according to ripening time. Using Partial Least Squares Regression (PLS) based on physicochemical parameters selected by PCA, a good model for predicting the ripening time of Cremoso cheese was developed. This model includes parameters of moderate, simple, and fast analyses and has an error of estimation of 2 days.

%TCA-SN/TN, %PTA-SN/TN e per la relazione α_{s1}-I-casein/(α_{s1}-casein + α_{s1}-I-casein) sul fattore 1, hanno mostrato che queste variabili sono le più importanti per riunire i formaggi in relazione al loro tempo di maturazione.

Impiegando la Partial Least Squares Regression (PLS) basata in parametri chimico-fisici selezionati per il PCA, è stato svilupato un buon modello per la predizione del tempo di maturazione del formaggio Cremoso. Il modello si basa su parametri analitici semplici e rapidi. Il modello, inoltre, indica un errore di valutazione pari a due giorni.

INTRODUCTION

Proteolysis is of great importance in most cheese varieties and is carried out by various enzymes during cheese ripening. It is thought to have a profound impact on the development of cheese texture, taste and aroma.

In soft cheese, proteolysis is responsible for the softening of the cheese mass and the consequent development of a typical creamy texture. In this type of cheese, the main proteolytic agent is the residual milk-clotting enzyme because the high moisture content as well as the absence of cooking enhance its retention in the curd and its activity on proteins. The hydrolysis of α_{s1}-casein in the Phe_{23}-Phe_{24} bond by this enzyme is a very important transformation during the ripening of this cheese (HYNES *et al.*, 1999). The α_{s1}-I-casein peptide is more hydrophilic than the original α_{s1}-casein and, for this reason, the cheese has a greater water retaining capacity and this allows the creamy texture typical of this variety to develop.

The analytical methodologies used to evaluate proteolysis have been described in depth and include both classical physicochemical methods (pH, Kjeldahl, moisture, dry matter, etc.) and more sophisticated approaches such as electrophoresis and chromatography.

For most cheese, proteolysis is commonly used as an index of maturity. Most, if not all, nitrogenous compounds that contribute to cheese flavour are soluble in aqueous solvents. Solubility at pH 4.6 is widely used for the initial fractionation of cheese nitrogen (N) or as a crude index of proteolysis. Values for nitrogen which is also soluble in both 12% tricloroacetic acid and 2.5% phosphotungstic acid are also used as indices of maturity, but secondary proteolysis is not very important in soft cheese. Polyacrylamide gel electrophoresis (PAGE) is widely used to monitor primary proteolysis in cheese and is mostly related to the activities of residual coagulant and plasmin. Residual α_{s1}-casein is a good index of the level of general proteolysis in relatively young cheeses (FOX, 1993).

The results from proteolysis analysis are often rather complicated and multivariate in their nature. Multivariate statistical techniques have therefore been successfully used to analyse proteolysis data.

Ripening time can be determined by applying multivariate regression analysis to physicochemical and proteolysis data obtained during cheese ripening.

GARCIA-RUIZ *et al.* (1998) and POVEDA *et al.* (2004) predicted the ripening time of Manchego cheese with an error close to 11 days by using PLS regression on the results from classical analysis. Peptides and amino acid profiles obtained by HPLC and PLS regression have been successfully used to differentiate the age of Ragusano cheese (FALLICO *et al.*, 2004). DOWNEY *et al.* (2005) predicted the maturity and sensory attributes of Cheddar cheese using near-infrared spectroscopy with an accuracy sufficient for industrial use. MARTIN-DEL-CAMPO *et al.* (2007) determined the ripening stages of Camembert cheese with an error of 1 day by applying mid-infrared spectroscopy and PLS.

Soft cheese is very important among the Argentinean cheeses with Cremoso being the most important. According to the Código Alimentario Argentino (CAA), Cremoso is a cow milk cheese produced with a thermophilic starter. It is enzymatically-coagulated and has a creamy aroma and taste, neutral white color, with no holes and a slight elastic texture. The minimum ripening time is 30 days; however, cheeses with different ripening times are available on the market.

Currently, there are no analytical procedures for determining the ripening time of Argentinean cheeses. Given the major effect that ripening has on the final quality of cheese, information about the progress of proteolysis would be useful to the cheese-maker in order to be able to check the ripening process. Moreover, the determination of the degree of ripening is an important part of cheese quality evaluation and is currently done by trained sensory panellists. This approach is time-consuming and expensive. Consequently, there is considerable interest in developing instrumental techniques that would enable more objective, faster and less expensive assessment of cheese quality.

In the present study the physicochemical characteristics of Cremoso cheese were used to develop statistical models for predicting the ripening time.

MATERIALS AND METHODS

Cheese samples

Twenty-eight cheeses from different seasons (8 in autumn, 6 in winter, 14 in spring) were supplied by two nearby dairy plants in Santa Fe, Argentina (two brands). These cheeses were produced according to standard Cremoso technology (ZALAZAR *et al.*, 1999). Ripening was carried out at 7°C and 80% relative humidity over 30 days in the Instituto de Lactología Industrial (INLAIN-FIQ) located in Santa Fe (Argentina). Considering that proteolysis indices are influenced by factors other than ripening time, such as temperature of ripening, moisture content of the cheese and the milk coagulant and starter used, these conditions were held strictly constant in the production of these cheeses and throughout the present study.

Cheeses were sampled (IDF, 1995) for individual analysis at different ripening times (Table 1). The physicochemical parameters were determined at all the ripening times, whereas the overall composition was only performed after 30 days of ripening.

Cheese composition

The overall composition was assessed by determining moisture (IDF, 1982), fat (BRADLEY *et al.*, 1993) and protein content (IDF, 1993).

Cheese analysis

The physicochemical parameters analysed were: moisture content, pH, soluble nitrogen at pH 4.6 (pH 4.6-SN), in 12% tricloroacetic acid (TCA-SN), in 2.5% phosphotungstic acid (PTA-SN) and the α_{S1}-I-casein/(α_{S1}-casein + α_{S1}-I-casein) ratio. Cheese ripening was monitored for 30 days because the sensory characteristics of this cheese decrease significantly after this length of time.

pH. Grated cheese (10 g) was thoroughly blended with 10 mL H_2O using a mortar and pestle. The pH of the resulting slurry was measured with a pH meter (ES16 Titriskop, Metrohn Herisau, Switzerland).

Soluble nitrogen. Cheese samples were treated to obtain a crude citrate extract (HYNES *et al.*, 2001). This extract was obtained by adding 20 mL of 0.5M sodium citrate to 10 g of cheese and grinding to homogeneity using a pestle. Deionised water was added to ~90 mL and the pH was adjusted to 4.6. After centrifugation (3,000 g/15 min), the volume of the soluble fraction was adjusted to 100 mL. 12% TCA and 2.5% PTA soluble fractions were obtained from the pH 4.6 soluble fraction (GRIPON *et al.*, 1975). Nitrogen contents were determined in duplicate by the macro-Kjeldahl method (IDF, 1993). These values are expressed as percentage of total nitrogen.

α_{S1}-I-casein/(α_{S1}-casein + α_{S1}-I-casein) ratio. Samples of cheese caseins were prepared by precipitation at pH 4.6, purification and lyophilisation. The insoluble residue at pH 4.6 was analysed by Urea-PAGE in a Mini Protean II cube (Bio-Rad Laboratories, California, USA) using the method of ANDREWS (1983) with 7.5% acrylamide (HYNES *et al.*, 1999). Proteins were stained with Coomassie Blue G-250. The protein bands were quantified by densitometric analysis using a Minidensit densitometer (SEAC, Firenze, Italy) at 632 nm.

Sensory evaluation

Sensory examination was performed on all cheeses at the end of ripening to establish if their general characteristics were typical of Cremoso cheese, according to Argentinean Regulations (CAA, 2007).

Statistical analysis

Analysis of variance (ANOVA) with Statgraphics Plus 3.0 (Manugistics, Inc., Rockville, MD, USA) was used as a first step to determine whether treatment (ripening time, season and brand) had a significant impact on the physicochemical parameters. When differences were found ($p \leq 0.05$), means were compared by the least significant difference (LSD) test using the same statistical tool.

Table 1 - Number of cheeses sampled at each ripening time.

Days	0	9	15	22	30	Total
Cheeses sampled	8	4	4	4	8	28

Subsequently, the data matrix was analysed with multivariate techniques (Principal component analysis-PCA and Discriminant analysis-DA) using the software SPSS 10.0 (SPSS Inc., Chicago, USA) in order to evaluate the evolution of the physicochemical parameters. PCA was performed after standardising the variables (mean = 0; SD = 1).

Multiple linear regression (MLR), principal component regression (PCR) and PLS are the conventional statistical methods used for modelling quantitative relationships between two blocks of variables Y and X. MLR delivers the optimal fit according to the least-squares criterion when there is no multicollinearity between the X variables. PCR and PLS may be used when multicollinearity is present among the variables in the X block or when the number of samples is small (CARPINO *et al.*, 2002; HAIR *et al.*, 1999). PCR finds components (t_i) that capture the greatest amount of variance in the predictor variables of the X block without using the information contained in the response variables. However, PLS calculates components (t_i) which capture the maximum variance of block X and simultaneously achieves maximum correlation with response variables (MARTENS and NAES, 1993).

In this study, MLR could not be used because there was a strong correlation (multicollinearity) between the predictor variables, thus violating one of the main assumptions of MLR. With regard

to PCR and PLS, the latter was chosen because of its emphasis on predicting the responses and not necessarily on trying to understand the underlying relationship between the variables.

PLS regression (Unscrambler 7.6, Camo, ASA, Olso, Norway) was applied to the cheese samples (n = 28). This procedure typically uses cross-validation, a method of internal validation using the original data set, to test for the optimal number of principal components to be used. The data matrix was divided into calibration samples (n = 19) and validation samples (n = 9); this latter set was chosen by random selection. Calibration samples were used to study the relationship between ripening time and physicochemical parameters in order to obtain a prediction model using the following equation:

$$t = b_0 + \sum_{j=1}^{n} b_j x_j$$

where t was the ripening time, x_j were the physicochemical parameters and b_0 and b_j were the regression coefficients in the models.

The validation samples were used to test the predictive ability of the models obtained. The quality of the regression models was evaluated by the coefficient of regression (R) and the root mean square error of prediction (RMSEP) defined as follows:

$$RMSEP = \left(\sum_{i=1}^{n} (t_i - t_{i0})^2/n\right)^{1/2}$$

Table 2 - Overall composition values obtained at the end of ripening.

	Moisture content	Protein content	Fat content
X	48.6%	20.6%	25.5%
SD	1.3	1.3	1.6

where, t_i is the real ripening time, t_{i0} the predicted ripening time obtained with the model for the *i*th validation sample and *n* the number of cheese samples of the validation set.

RESULTS AND DISCUSSION

Physicochemical parameter evolution

Table 2 shows the gross composition values obtained for all cheeses at 30 days of ripening. These values were within the normal ranges established by the Argentinean Regulations for Cremoso cheese (CAA, 2007). Furthermore, all of the cheeses showed a satisfactory and typical sensory quality for this cheese variety. Therefore, it was valid to use these cheeses to develop a prediction model.

Electrophoretic urea-PAGE patterns of pH 4.6 insoluble fractions for some calibration cheeses at 0, 9, 22 and 30 days are presented in Fig. 1. The α_{s1}-casein degradation was extensive and showed a concomitant increase of the α_{s1}-I-casein fraction, a peptide resulting from the breakdown of casein by residual chymosin. For this reason, the α_{S1}-I-casein/(α_{S1}-casein + α_{S1}-I-casein) ratio is expected to increase significantly with cheese age.

The ANOVA and LSD analysis showed that all the variables studied, with the exception of moisture content, changed significantly with ripening time ($p \leq 0.05$) over the ripening period (Table 3). Changes in the values of these variables with ripening time were evaluated. For example, %pH4.6-SN/TN and the α_{S1}-I-casein/(α_{S1}-casein + α_{S1}-I-casein) ratio in cheese sampled at 0, 9, 15, 22 and 30 days is shown in Figs. 2A and 2B and is used to describe the changes throughout ripening. The %pH4.6-SN/TN shows a strong linear progression (R = 0.95) with the ripening time for all the studied ripening periods (Fig. 2A). The α_{S1}-I-casein/(α_{S1}-casein + α_{S1}-I-casein) ratio showed a similar evolution over the

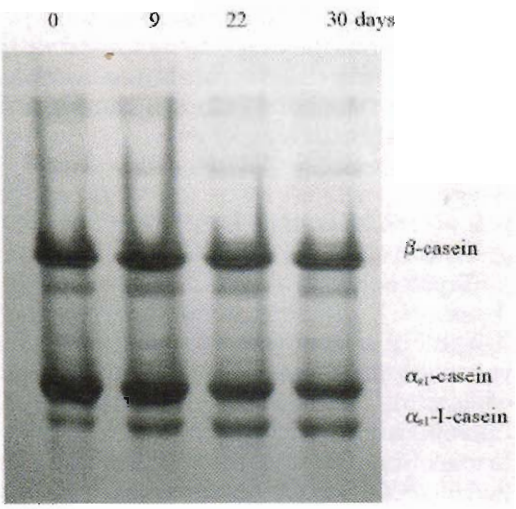

Fig. 1 - Urea polyacrylamide gel electrophoresis of 0- 9- 22- and 30-days-old Cremoso cheeses.

ripening period (Fig. 2B). These changes are in agreement with the fact that the hydrolysis of α_{s1}-casein in the Phe_{23}-Phe_{24} bond is the most important transformation of this cheese variety during ripening and consequently these fractions increase with the cheese age. Increase of the α_{S1}-I-casein/(α_{S1}-casein + α_{S1}-I-casein) ratio with ripening is, however, limited to the first days of ripening because the α_{s1}-I-casein peptide is usually hydrolysed for longer periods. Since Cremoso cheese has a very short ripening period (30 days), the relationship between the α_{S1}-I-casein/(α_{S1}-casein + α_{S1}-I-casein) ratio and ripening time can be considered linear. This statement however may not be true for cheeses with longer ripening times. The %TCA-SN/TN increased slowly up to day 9 and then more quickly to the end of ripening (result not shown). An important increase in %PTA-SN/TN was observed up to day 22 (result not shown). These two nitrogen fractions contain medium- and small-size peptides and free amino acids which appear at the end of ripening as products of secondary proteolysis. The pH showed a weak progression throughout ripening (result not shown).

The ANOVA analysis of all the studied variables with seasons (data not shown) showed that Cremoso cheeses manufactured in different seasons differed significantly in moisture content ($p=0.03$), %TCA-SN/TN ($p=0.02$) and %PTA-SN/TN ($p=0.01$); however, these differences may not be practically significant because the p-values were very close to the significance level. The %TCA-SN/TN and %PTA-SN/TN values from spring were slightly higher than those from winter and autumn; these results may have been related to the higher psychrotrophic bacterial counts found in raw milk in Argentina during the hotter seasons (REINHEIMER *et al.*, 1985). The endo- and exo-enzymes of the psychrotrophic bacteria may survive normal pasteurisation and sterilisa-

Table 3 - Physicochemical parameter values of cheeses during ripening (Means and SD).

Parameters	*p-value*	Ripening time (days)				
		0	9	15	22	30
%Moisture	0.27	49.82±0.96	49.17±1.03	49.27±1.58	48.56±1.18	48.57±1.25
pH	0.02	5.18±0.07^{a}	5.24±0.07^{a-b}	5.21±0.07^{a-b}	5.34±0.05^{b-c}	5.26±0.09^{b-c}
%pH4.6-SN/TN	0.00	5.06±0.34^{a}	6.72±0.55^{b}	7.26±0.18^{b}	8.81±0.42^{c}	10.01±0.70^{d}
%TCA-SN/TN	0.00	2.38±0.38^{a}	2.96±0.20^{a}	3.59±0.68^{b}	4.58±0,75^{b}	5.28±0.46^{c}
%PTA-SN/TN	0.00	0.81±0.26^{a}	1.00±0.14^{a-b}	1.21±0.38^{b}	1.24±0.17^{b}	1.65±0.25^{c}
α_{S1}-I-Cn/(α_{S1}-Cn + α_{S1}-I-Cn)	0.00	0.05±0.04^{a}	0.16±0.07^{b}	0.18±0.01^{b}	0.31±0.09^{c}	0.44±0.10^{d}

$^{a-d}$ Means in rows with different superscripts differ ($P \leq 0.05$) according to the LSD test.

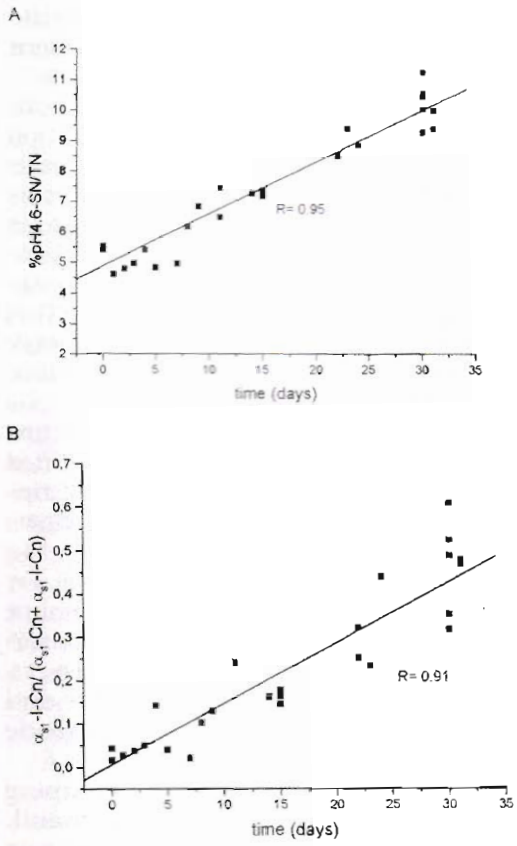

Fig. 2 - Changes in physicochemical parameters in cheese samples during ripening: (A) %pH4.6-SN/TN and (B) α_{S1}-I-Cn/(α_{S1}-Cn + α_{S1}-I-Cn) ratio.

tion temperatures, and are likely to remain active in cheeses throughout the ripening period (ZALAZAR *et al.*, 1986). Significant differences in moisture content with seasons could be attributed to differences in manufacturing technology.

The ANOVA results of all variables studied showed no significant differences between brands (data not shown).

Multivariate data analysis: PCA and DA

The results of the physicochemical parameters of the twenty-eight cheese samples were used in the construction of the multivariate data matrix, resulting in a data matrix of 28 samples and 6 variables. Exploratory data analysis of physicochemical parameters was performed to evaluate the influence of age, season and brand on ripening of Cremoso cheese. The Kaiser-Meyer-Olkin value of sampling adequacy obtained was > 0.5 (0.823), therefore, the application of PCA on the data matrix was justified (HAIR *et al.*, 1999). The number of required components according to the Kaiser criterion (eigenvalue ≥ 1) was 2 but three factors were chosen because the information regarding pH was contained in PC_3. These three components accounted for 94% of the total variability (PC_1 66.7%, PC_2 16.7% and PC_3 10.6%). All variables studied were considered in the PCA analysis.

Fig. 3 shows the score plot, defined by PC_1 and PC_2, and the samples identified by ripening time. The factorial map shows the differentiation of cheese samples based on ripening time, mainly according to PC_1. In this factor, the highest loading values belonged to the three nitrogen fractions and the α_{S1}-I-casein/(α_{S1}-casein + α_{S1}-I-casein) ratio; the grouping of cheeses on this axis indicates that it was largely on the basis of these variables.

The score plot of PC_2 vs PC_3 (results not shown) showed that the cheese samples were loosely grouped by season along PC_2 and PC_3. Regarding the PC_2 and PC_3 loadings, moisture content and pH had medium loading values, so the information about these variables was divided between these two PCs.

No grouping of cheese samples was observed in relation to brand.

In order to maximise the loading of each variable in only one factor, the rotated solution (VARIMAX) was performed. This rotation only affects the distribution of the proportions of the total variance explained by each factor; the cumulative proportion of the total variance explained for all factors does not change. The factorial map of rotated factors shows that the cheese samples were again grouped along PC_1 on the basis of ripening time (results not shown). The three nitrogen

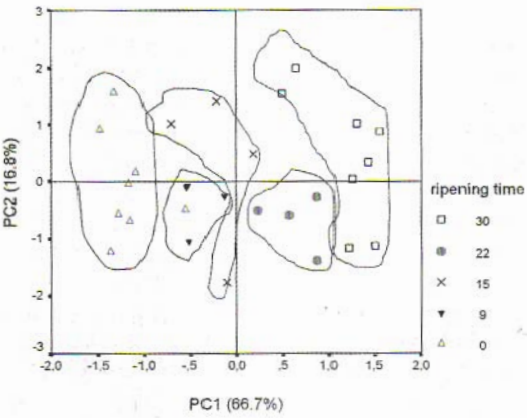

Fig. 3 - 2-dimensional representation of scores on PC1 and PC2 after PCA of the physicochemical parameters.

fractions and the α_{S1}-I-casein/(α_{S1}-casein + α_{S1}-I-casein) ratio had the highest loadings in this PC (Fig. 4) and were positive. This means that these variables increased during ripening.

It can be observed that cheeses tended to cluster on the basis of production season along the rotated PC_2 and only moisture content had a high loading value in this PC (Fig. 4). Therefore, according to multivariate analysis, moisture content was the most important variable in grouping the samples based on seasons. These results were in accord with the univariate analysis even though the differences in moisture content observed between seasons were weak.

No grouping by brand was observed.

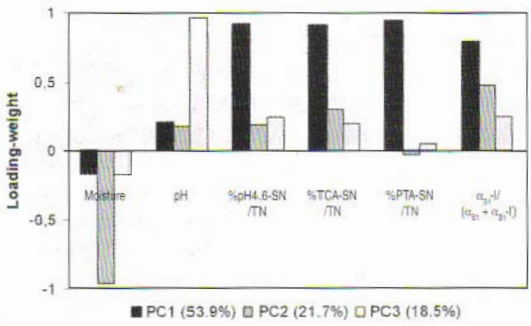

Fig. 4 - Loading weight values of rotated PC_1, PC_2 and PC_3 after PCA of the physicochemical parameters.

pH had a high loading in PC_3 which did not give information on any treatment studied (Fig. 4).

In order to validate the previous conclusion based on the visual observation of scores, the discriminant model was applied using PC_1, PC_2 and PC_3 scores as predictors. Ripening time and seasons were used as classification factors. Samples were classified according to the group for which they had the best match. This was expressed in terms of the percentage of samples assigned to the correct class. A significant discriminant function ($p \leq 0.05$) was found with respect to the time factor. This function allowed 5 pre-defined groups (0, 9, 15, 22 and 30 days of ripening) to be classified; 86% of the cases were classified correctly.

The situation was not the same for the seasons. No significant discriminant function was observed; it was not possible to distinguish between the 3 pre-determined seasons (autumn, winter and spring) when a PCA analysis was made for all the samples.

In summary, there was no grouping of cheese samples according to brand. The grouping of samples by seasons was poor and did not influence differentiation based on ripening time. Consequently, cheese samples of different brands and seasons could be used to obtain only one more robust ripening time prediction model. Moreover, this multivariate analysis allowed appropriate variables to be selected for subsequent application to other statistical method. These variables were the three nitrogen fractions and the α_{S1}-I-casein/(α_{S1}-casein + α_{S1}-I-casein) ratio which grouped the samples according to cheese age on the basis of the biochemical processes that occur during the ripening of this cheese variety.

Prediction of ripening time by PLS regression

PLS regression was applied to the calibration sample set (n = 19) to get a rip-

ening time prediction model for Cremoso cheese. The moisture content, pH, %pH4.6-SN/TN, %TCA-SN/TN, %PTA-SN/TN and the α_{S1}-I-casein/(α_{S1}-casein + α_{S1}-I-casein) ratio were used as predictor variables to obtain the full model. A reduced model based on the last four variables was studied. These models were then applied to the validation set (random selection validation).

Table 4 reports the statistical parameters from the PLS regression. These results include the intercept (b_0), standardised regression coefficients (b_j), the non-standardised regression coefficients (b_{wj}), the correlation coefficient (R), and the root mean squares error of prediction (RMSEP). As can be seen, the reduced model had a higher correlation and lower error (RMSEP) than the full model. This result was in agreement with the PCA in that the three nitrogen fractions and the α_{S1}-I-casein/(α_{S1}-casein + α_{S1}-I-casein) ratio were the variables that grouped the cheese samples according to ripening time.

A plot of the real cheese age and that predicted from the reduced model is shown in Fig. 5, there is a high correlation between the real and predicted ripening time (R = 0.99).

In the reduced PLS model, %pH4.6-SN/TN and the α_{S1}-I-casein/(α_{S1}-casein + α_{S1}-I-casein) ratio were the variables with the highest non-standardised regression coefficients. These variables were the most important for predicting the ripening time

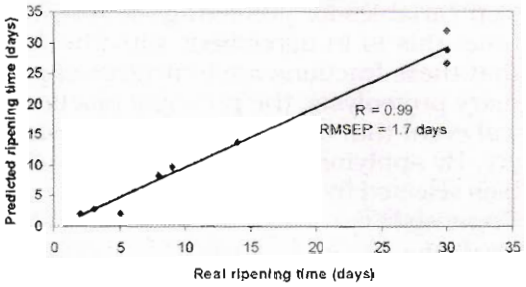

Fig. 5 - Correlation between the predicted ripening time, obtained using a reduced PLS model, and the real ripening time in the cheese samples (n = 9).

of Cremoso cheese, in agreement with the fact that these fractions are indicators of primary proteolysis, the principal event that occurs in this cheese variety. %TCA-SN/TN and %PTA-SN/TN were the next most important factors; this is in accord with the previously obtained results. Moreover, the regression coefficients were positive, which indicated that these variables increased during the ripening process.

CONCLUSION

ANOVA and PCA of the physicochemical parameters changed during ripening time; this was due to the previously described biochemical changes that occur in Argentinean soft cheeses. The %pH4.6-SN/TN and the α_{S1}-I-casein/(α_{S1}-casein + α_{S1}-I-casein) ratio were the most impor-

Table 4 - Statistical parameters from full and reduced PLS models.

	b_j (b_{wj})								
	b_0	Moisture	pH	%pH 4.6-SN/ TN	%TCA-SN/ TN	%PTA-SN/ TN	α_{S1}-I/(α_{S1} + α_{S1}-I)	R	RMSEP
full model	-75.3	0.23 (0.28)	9.31 (0.86)	1.82 (3.54)	1.78 (2.33)	6.22 (2.44)	16.36 (2.75)	0.98	2.4
reduced model	-14.61	-	-	2.48 (4.82)	1.45 (1.91)	0.68 (0.27)	24.10 (4.05)	0.99	1.7

b_0: intercept; b_j: standardised regression coefficients; b_{wj}: non-standardised regression coefficients; R: correlation coefficient; RMSEP: root mean squares error of prediction.

tant variables for predicting the ripening time; this is in agreement with the fact that these fractions are indicators of primary proteolysis, the principal biochemical event that occurs in this cheese variety. By applying PLS regression to variables selected by PCA, the ripening time of Cremoso cheese could be predicted with a prediction error of 2 days. These parameters can be measured rather simply and quickly so the ripening time of the cheeses is very easy to calculate. The models suggested in this study were developed for two specific local products of Argentina; their applicability for similar cheeses made in other processing plants has yet to be established.

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