Sensory and Textural Properties of Queso Blanco-Type Cheese Influenced by Acid Type

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ABSTRACT

The influence of acetic, citric, or lactic acids on textural properties and sensory attributes of Queso Blanco-type cheese during refrigerated storage (7 wk at 5°C) was evaluated. Hardness, fracturability, chewiness, and gumminess were highest for cheese made with acetic acid and lowest for that made with lactic acid. Springiness or cohesiveness of cheese was not dependent on acid type. All of the textural parameters except cohesiveness increased with age of cheese. The cheeses were evaluated at 3 or 7 wk, respectively, by 63 or 40 consumer panelists. About 60 or 80% of the panelists awarded cheese scores of 6 to 9 (on a nine-point scale) for 3- or 7-wk-old cheeses, respectively. Chi-square tests for preferences of tasters showed no significant differences between acid types for 3-wk-old cheeses, but 7-wk-old cheeses made with acetic or citric acid were preferred over those made with lactic acid.
(**Key words**: Queso Blanco, texture, sensory, acid)

Abbreviation key: **ACA** = acetic acid, **CA** = citric acid, **LA** = lactic acid, **TPA** = texture profile analysis.

INTRODUCTION

Queso Blanco is a fresh, soft Latin American variety produced by direct acidification of hot milk. Several food-grade acids (20, 21), citrus fruit juices (14), or acid whey (12) are used as coagulating acids for the manufacture of Queso Blanco. Most research on Queso Blanco-type cheese has focused on improvement of manufacturing methods, but studies are limited on the sensory and textural properties of the cheese made with different acids. Differences in chemical properties of the acids used for manufacture may influence sensory and physicochemical properties of the cheese because different acids produce structural differences in skim milk gels (10). The objective of this study was to determine the influence of different acids on the sensory and textural properties of Queso Blanco-type cheese.

MATERIALS AND METHODS

Manufacture of Queso Blanco

Queso Blanco-type cheese was manufactured by adding three different acids to sublots of different whole milks as previously described (4, 11, 14, 17). The mean fat and protein contents of the milk were 3.5 and 3.2%, respectively. Each lot of milk was divided into three batches (≈45 kg per batch) and coagulated by addition of dilute (2%) solutions of food-grade citric (CA), acetic (ACA), or lactic (LA) acids. The CA and LA were from Archer Daniels Midland Co. (Decatur, IL), and ACA was from Integrated Ingredients (Montebello, CA). Following whey drainage, the curd was salted at the rate of 2% (wt/wt) and pressed in 4.54-kg blocks. After pressing, each block was divided into six 800-g blocks, vacuum-packaged separately in Cryovac® (W. R. Grace & Co., Duncan, SC) bags, and stored at 5°C.

Compositional Analysis

Cheeses were sampled after 1 wk of storage for compositional analysis. Fat was determined

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by the modified Babcock procedure (18). Moisture was by microwave drying (18) (CEM AVC™-80 moisture-solids analyzer, CEM Corporation, Matthews, NC). Salt was determined by chloride analysis (Corning 926 Salt Analyzer; Corning Medical and Scientific Glass Works, Medfield, MA). Protein (total N × 6.38) was determined by the semi-macro-Kjeldahl method (1) using an autoanalyzer (Kjeltec® 1030 analyzer; Tecator AB, Högamäs, Sweden), and pH was measured directly in cheese with a puncture-tip combination electrode (Ag/AgCl Xerolyt®; Ingold Electrode, Inc., Wilmington, MA) and pH meter (pHI™ 12; Beckman Instruments, Inc., Fullerton, CA).

Texture Profile Analysis

A fresh block of the cheese was taken after 1, 3, 5, or 7 wk of storage for texture profile analysis (**TPA**) by the method of Bourne (2). For each replicate, ten samples (2 × 2 × 2 cm) were cut across a diagonal cross-section of each cheese block. The samples were placed separately in an airtight Ziploc® (DowBrands L. P., Indianapolis, IN) bag, which was placed on a styrofoam plate in an incubator at 35°C for 1.5 h. Then, the samples were transferred to an airtight chamber for no more than 20 min before textural analysis.

The TPA of the samples was by a Universal testing machine model T5K (J. J. Lloyd Instruments, Warsash, England) with a load of 50 N and a crosshead speed of 7.5 cm/min. Each sample was subjected to 50% compression (1 cm), and response curves were recorded on a strip chart recorder with chart speed of 2 mm/s. Textural parameters (hardness, cohesiveness, springiness, chewiness, fracturability, and gumminess) were calculated from textural profile curves using a digitizer interfaced with a computer (3).

Sensory Evaluation

After 3 and 7 wk of storage, the cheeses were evaluated by a consumer panel of 63 (32 males and 31 females) or 40 (21 males and 19 females) volunteers, who were identified from a cooperative respondent base maintained at California Polytechnic State University (San Luis Obispo) as bona fide cheese lovers and users. Because a majority of consumers at the university know very little about Latin American cheeses (9), a consumer acceptance study of the cheese was chosen over a trained taste panel.

Each block of cheese was cut into several cubes (2 × 2 × 2 cm) that were held at room temperature (22°C) for 1 h in Ziploc® bags before their presentation to participants. The samples were coded with three-digit random numbers and presented to participants using the monadic sequential method (23) in which samples are presented one at a time in a different order. Sensory attributes (flavor, body and texture, and overall acceptability) of the cheese were scored on a nine-point hedonic scale (9 = like extremely to 1 = dislike extremely).

Statistical Analyses

The TPA data were analyzed statistically by randomized complete block split-plot design using the computer software package of SAS (19). The model was

$$Y_{ijk} = \mu + \beta_i + \alpha_j + \epsilon_{ij} + \omega_k + \alpha\omega_{jk} + \delta_{ijk}$$

where

μ = the overall mean,
β_i = block i effect,
α_j = acid j effect,
ϵ_{ij} = the whole plot error,
ω_k = age k effect,
$\alpha\omega_{jk}$ = interaction of acid × age, and
δ_{ijk} = the split-plot error.

Whole plot error was used for testing acid or block effects. Split-plot error was used for testing the effects of age and the interaction of acid × age. Compositional data were analyzed by two-way ANOVA using Minitab Release 7 (Minitab Inc., State College, PA) computer software package. Significance of differences among means for composition and TPA data were determined by Fisher's least significant difference test at $P < .05$.

Statistical Analysis of Sensory Attributes

Scores for sensory attributes for the cheeses made with the different acid types were analyzed by chi-square 3 × 3 contingency tables. The scores were grouped into three categories:

TABLE 1. Composition and yield of Queso Blanco-type cheese made from whole milk with different acids.

Cheese component	Acid			LSD[1]
	Acetic	Citric	Lactic	
Moisture, %	51.38	51.35	53.03	2.13
Fat, %	20.7[a]	20.2[a]	19.2[b]	.65
Protein, %	21.82[a]	21.51[a]	19.85[b]	.91
Salt (NaCl), %	1.94[a]	1.89[a]	1.79[b]	.06
pH	5.28	5.28	5.27	.05
Yield,[2] %	13.54[a]	13.67[a]	14.20[b]	.42

[a,b]Means within the same row with different superscripts differ ($P < .05$).

[1]Least significant difference ($P = .05$).

[2]Yield calculated on 52% moisture basis.

1 to 4, dislike extremely to unsatisfactory; 5, neither like nor dislike; or 6 to 9, satisfactory to like extremely. There were 63 respondents for the wk-3 sensory analysis and 40 for the wk-7 analysis. Both Pearson's chi-square and the likelihood-ratio tests (7) were performed. In each analysis the test statistics agreed very closely, and thus only Pearson's chi-square statistic was reported. To determine preferences of the cheeses due to acid type, the following analyses were planned a priori:

1. Analysis of 3 × 3 contingency tables using scores grouped into 1 to 4, 5, or 6 to 9.
2. Sensory scores for the cheeses made with ACA or CA were compared using the chi-square test on the portion of the table involving those acids only.
3. If the test in step 2 was not significant, then the ACA and CA data were pooled and compared with the LA data using a chi-square test.
4. If the test in step 2 was significant, then the Bonferroni approach (7) was used, i.e., paired comparisons between acid types using α of .0167 (i.e., α of .05 divided by n comparisons, where n = 3).

The tests were performed using Minitab Release 7 (Minitab Inc.).

RESULTS

Composition of Cheese

The means, standard errors, and least significant differences for moisture, fat, protein, salt, pH, and yield of Queso Blanco-type cheese made from whole milk (3.5% fat and 3.2% protein) using ACA, CA, or LA as

TABLE 2. Analysis of variance summary for textural parameters of Queso Blanco-type cheese made with different acids.

Factor	df	MS					
		Hardness	Fracturability	Springiness	Cohesiveness	Gumminess	Chewiness
Block (replicates)	2	.227	.016	.995	.044*	.775	42.92
Acid	2	16.788****	9.663****	.708	.001	14.621***	467.32**
Error A (whole plot)	4	.045	.124	.567	.006	.315	25.89
Age of cheese	3	3.776****	3.491****	7.613****	.033	3.515	342.29****
Acid × age	6	.270	.384	.209	.041	1.338	58.83
Error B (split-plot)	18	.411	.136	.504	.069	1.122	53.00

*$P < .05$.

**$P < .01$.

***$P < .005$.

****$P < .001$.

coagulants are presented in Table 1. Mean moisture content was consistently higher in Queso Blanco-type cheese made with LA than in that made with ACA or CA; however, the differences were not significant ($P > .05$). Amounts of protein, fat, or salt were significantly ($P < .05$) lower in the LA cheeses than in the CA or ACA cheeses. The pH values of the cheeses were between 5.22 and 5.32 and were not dependent on the type of acid used for manufacture.

Textural Properties

Table 2 shows the ANOVA mean squares for the textural parameters of Queso Blanco-type cheese. Hardness, fracturability, gumminess, and chewiness of the cheese were influenced significantly ($P < .05$) by acid type, but springiness and cohesiveness of the cheese were not dependent on acid type. In addition, hardness, fracturability, springiness, and chewiness were affected significantly by the age of the cheese, but cohesiveness and gumminess were not (Table 2). There was no interaction between acid and age for any of the textural parameters (Table 2).

Overall mean hardness, fracturability, gumminess, or chewiness values were highest for ACA cheeses and lowest for LA cheeses (Table 3). However, the differences between ACA and CA cheeses for fracturability or chewiness were not significant ($P > .05$). Also, there were no significant ($P > .05$) differences in springiness or cohesiveness among the cheeses (Table 3).

Changes in textural properties of Queso Blanco-type during storage at 5°C for 7 wk are shown in Figure 1. Cheese hardness was significantly ($P < .001$) dependent on age, increasing from 2.77 ± .89 N at 1 wk to 4.33 ± 1.42 N after 7 wk of refrigerated storage (Figure 1A). Similarly, fracturability of Queso Blanco-type cheese increased significantly ($P < .001$) with age of cheese (Figure 1B).

Mean cohesiveness of the cheeses ranged from .76 ± .17 to .78 ± .23 and were not influenced by acid type (Table 3) or by age of cheese (Figure 1C). Any differences in cohesiveness of the cheeses were due to variations between replicates (Table 2). Mean springiness of the cheese increased significantly ($P < .001$), from 5.42 ± .51 mm at 1 wk to 7.25 ± .57 mm after 7 wk (Figure 1D).

Chewiness (i.e., hardness × cohesiveness × springiness) increased significantly ($P < .001$) with cheese age (Figure 1E). Gumminess (hardness × cohesiveness) also followed the same trend as chewiness (Figure 1F). The magnitudes of change in chewiness and gumminess during storage were largest for ACA cheeses (Figures 1E and F).

Sensory Evaluation

Table 4 shows the statistical analysis of the sensory data. A significant chi-square test indicates that the frequencies of scores in the three score categories (1 to 4, 5, or 6 to 9) were different for the different acid types. The chi-square tests for scores for sensory attributes for the 3-wk-old cheeses were not significant ($P > .05$), suggesting that flavor, body and texture, or overall preferences for the cheeses at 3 wk of age were not dependent on acid type. For example, the percentage of tasters who

TABLE 3. Textural properties of Queso Blanco-type cheese made with different acids.

Textural parameter	Acid			LSD[1]
	Acetic	Citric	Lactic	
Hardness, N	4.37[a]	4.00[b]	2.16[c]	.24
Fracturability, N	3.02[a]	2.64[a]	1.31[b]	.40
Springiness, mm	5.95	6.01	6.43	.85
Gumminess	3.96[a]	3.30[b]	1.81[c]	.64
Cohesiveness	.76	.76	.78	.09
Chewiness	24.18[a]	20.24[a]	11.96[b]	5.76

[a,b,c]Means within the same row with different superscripts differ ($P < .05$).

[1]Least significant difference ($P = .05$).

awarded scores from 6 to 9 for cheeses made with ACA, CA, or LA were, respectively, 63, 67, or 73%.

However, the chi-square tests for the sensory scores for 7-wk-old cheeses were significant at P = .014, P = .002, or P = .004, respectively, for flavor, body and texture, and overall acceptability. Although the chi-square test for flavor of the 7-wk-old cheeses was dependent on acid type (P = .014), an addi-

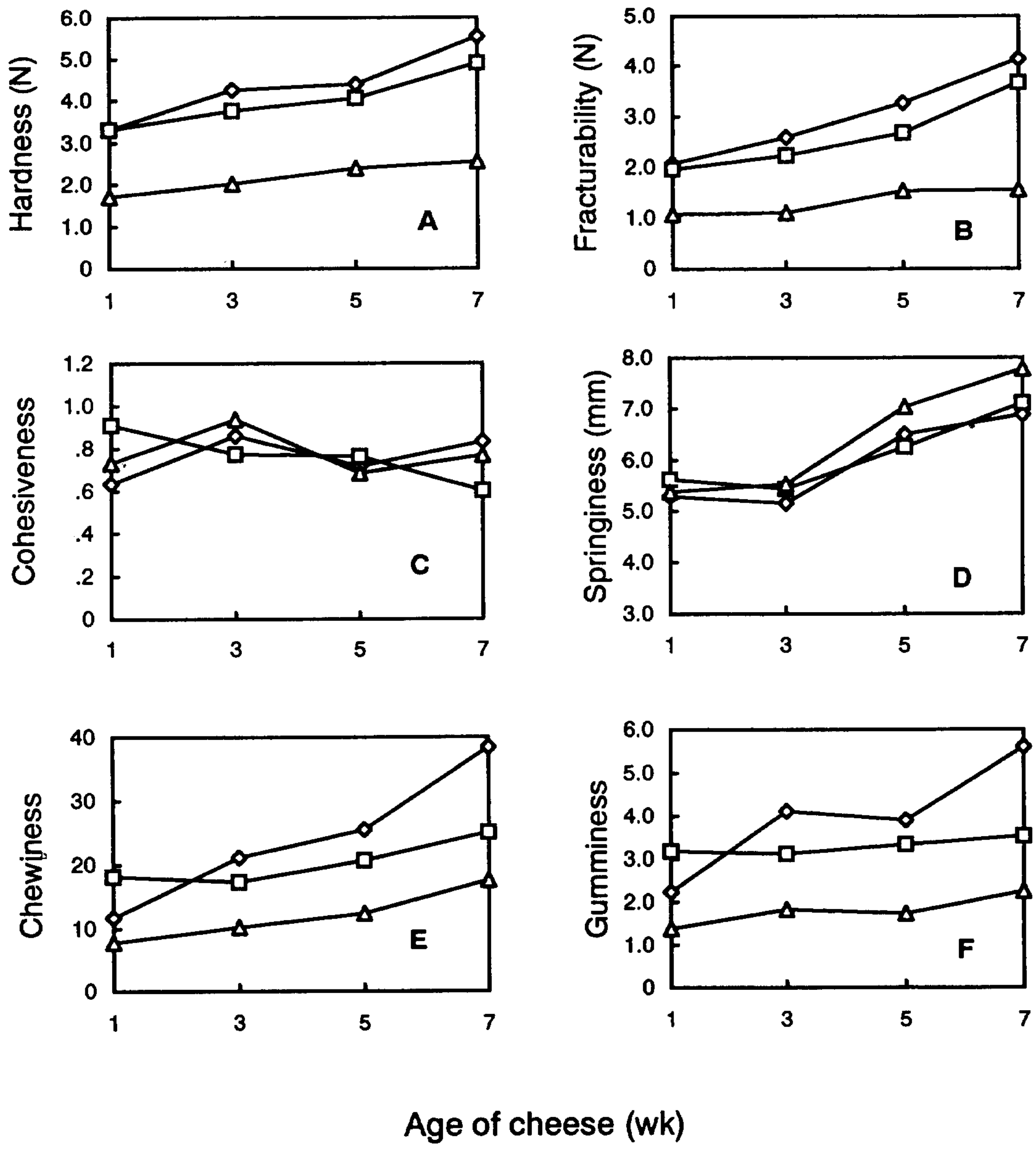

Figure 1. Textural parameters for Queso Blanco-type cheese during storage (1 to 7 wk). Cheeses were made with acetic (◊), citric (□), or lactic (△) acids. Charts shown are for hardness (A), fracturability (B), cohesiveness (C), springiness (D), chewiness (E), and gumminess (F). Standard errors for age points for the respective charts are .14, .05, .02, .17, 17.66, and .37.

tional chi-square test using flavor scores in the category 6 to 9 was not statistically significant ($P > .05$). This result suggests that the tasters who liked the cheese had no preference for a particular acid type. The body and texture scores of the 7-wk-old cheeses depended significantly ($P = .002$) on acid type. In-depth chi-square analysis showed that the body and texture of cheeses made with ACA were preferred significantly over those made with CA ($P = .0004$) or LA ($P = .04$), but the tasters' preferences for body and texture of cheeses made with CA or LA were not significant ($P = .06$). For overall acceptability scores, the differences between the acid types were ACA = CA > LA.

Generally, scores for overall acceptability of the cheeses correlated more with those of flavor ($r = .818$) than with those of texture ($r = .718$). Sensory scores of the cheeses did not depend on the age or sex of the cheese tasters.

DISCUSSION

The Queso Blanco-type cheese studied can be readily manufactured by acid coagulation of hot milk. The composition of milk and acid type influence the final composition of resultant cheese. A wide range (47 to 61%) of moisture content of Queso Blanco has been reported (4, 11, 12) in the literature. Variations in cheese moisture were attributed to difficulty in whey drainage, resulting from clogging of the drainage screen by fine curd particles (11). Whey drainage was adequate during the

TABLE 4. Summary of statistics for sensory data of Queso Blanco-type cheese made with different acids.

Acid	Range of scores[1]	Percentage of tasters scoring			Statistical summary			
		1 to 4	5	6 to 9	n	χ^2	df	P
				Flavor, 3 wk				
Acetic	2–9	24	13	63				
Citric	3–9	13	20	67				
Lactic	3–9	11	16	73				
					63	13.189	14	.5117
				Body and texture, 3 wk				
Acetic	2–9	24	22	54				
Citric	2–9	27	13	60				
Lactic	2–9	25	14	60				
					63	11.375	14	.6564
				Overall acceptability, 3 wk				
Acetic	3–9	19	22	59				
Citric	3–9	10	22	68				
Lactic	3–9	11	13	76				
					63	12.542	12	.4032
				Flavor, 7 wk				
Acetic	4–8	8	12	80				
Citric	4–8	10	0	90				
Lactic	4–8	20	5	75				
					40	19.165	8	.0140
				Body and texture, 7 wk				
Acetic	5–8	0	10	90				
Citric	4–8	28	0	72				
Lactic	3–8	15	10	75				
					40	28.093	10	.0017
				Overall acceptability, 7 wk				
Acetic	4–8	3	7	90				
Citric	5–8	0	18	82				
Lactic	4–8	10	22	68				
					40	22.699	8	.0038

[1]Scores on a nine-point hedonic scale (1 = "dislike extremely" to 9 = "like extremely").

manufacture of Queso Blanco-type cheese in the present study. Improved whey separation may be due to the use of dilute acids (8, 16) and improved curd handling during manufacture (8).

Textural properties of Queso Blanco-type cheese were influenced significantly by the type of acid used for manufacture. Chen et al. (5) analyzed textural properties of several cheeses and found that cheese hardness increased with protein content but increased fat, moisture, and salt reduced hardness. Similarly, the higher moisture content in the LA cheese than in the ACA or CA cheeses reduced hardness of the LA cheese. Parnell-Clunies et al. (16) found a highly significant ($P < .0001$) inverse relationship between cheese moisture and hardness. Also, results of the present study agree with those of Parnell-Clunies et al. (16), who found that hardness of Queso Blanco increased with age. Fracturability, the force with which the cheese breaks, was at least twice as great for ACA or CA cheeses than for LA cheeses. Also, fracturability increased significantly with age. This difference may be related to the increase in hardness of the cheese during storage. Springiness, a measure of the elastic or plastic behavior (15), was similar for cheese, regardless of acid type used for manufacture, suggesting that Queso Blanco-type cheeses made with different acids have similar physicochemical properties (B. B. Prasad and N.Y. Farkye, 1993, unpublished data).

Differences in the hardness, fracturability, and springiness of Queso Blanco-type cheese made with different acids may be due to microstructural differences. Queso Blanco has a granular structure consisting of protein particles with an ultrastructure of core and lining, the nature of which is dependent on coagulation temperature (13). Earlier research (11) showed differences in the ultrastructure of core and lining in skim milk gels produced with different acids. In addition, higher hardness values of the ACA or CA cheeses than of LA cheeses may be due to increased compaction of the caseins and a firmer matrix in the former.

Unlike rennet-coagulated cheeses (e.g., Cheddar), for which proteolysis during storage reduces hardness (6), little or no proteolysis occurs in Queso Blanco (22) to reduce hardness during storage. Because no visible whey expulsion occurred during storage, the increase in hardness with age cannot be explained and needs further investigation. Also, differences in textural properties of Queso Blanco-type cheese may relate to functional properties such as shreddability and sliceability because both properties involve the application of force.

Results of the sensory evaluation of the cheese showed that ≈60 or 80% of the tasters awarded scores of 6 to 9 for the 3- or 7-wk-old cheeses, respectively, suggesting that most tasters liked the cheese. General comments were that the cheeses, especially at 3 wk, were bland. The increase in the number of tasters who liked the cheese after 7 wk storage was possibly due to the development of mild flavor. Therefore, the cheese must be ripened for consumption as table cheese, or enzymes or condiments may be added to the fresh cheese to enhance flavor and increase consumer acceptability (4, 22).

CONCLUSIONS

Instrumental analysis of texture showed that Queso Blanco-type cheese made with ACA or CA had higher hardness or fracturability than that made with LA. Gumminess or chewiness of ACA cheeses were not significantly different from CA cheeses but differed significantly from LA cheeses. Springiness or cohesiveness of the cheese was not dependent on acid type. After 3 wk of storage, the sensory attributes of the cheese were not dependent on acid type. However, after 7 wk storage, the distribution of sensory scores of the cheese was dependent on acid type. Therefore, manufacturers may select acids for the manufacture of Queso Blanco-type cheeses to meet specific qualities desired by consumers.

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