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A proposed methodology to determine the sensory quality of a fresh goat's cheese (Cameros cheese): application to cheeses packaged under modified atmospheres

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Abstract

A sensory profile was proposed, together with a methodology which permited the quality control of a fresh goat's cheese (Cameros cheese) from the sensory standpoint. Samples of Cameros cheese from four different cheesemakers were evaluated by a jury of 10 members. All panelists attended five tasting sessions to define an agreed lexicon of sensory characteristics of Cameros cheese. In order to quantify each one of the sensory attributes, a scorecard was elaborated. The intensity of the attributes selected was quantified on a scale from 1 to 7 according to the indications given in the sensory description. For each attribute the optimum score was established by the panelists to obtain the numerical score of samples. Using the proposed system, the sensory quality of Cameros cheeses packaged under modified atmospheres was evaluated. Five different modified atmosphere conditions were studied (carbon dioxide/nitrogen mixtures and vacuum) and compared to control cheeses packaged in air. The product stored at 3–4°C was evaluated periodically. After 14 days of storage, the sensory characteristics of the control cheeses were unacceptable in all the parameters studied. However, the overall score for cheeses stored in 40 and 50% CO_2 did not change substantially, retaining a reasonable acceptability until the end of the storage period. The 100% CO_2 atmosphere had a very negative effect on the sensory quality specially in taste. Cheeses packaged under vacuum showed a fast deterioration of surface appearance and texture. The proposed methodology allowed the quantification of the sensory differences between the packaging conditions investigated. With regard to Cameros cheese, packaging in 50%CO_2/50%N_2 and 40%CO_2/60%N_2 were the most effective for retaining good sensory characteristics specially in taste and odour. However, texture and appearance were negatively affected by these conditions.

Keywords: Sensory evaluation; Fresh goat's cheese; Modified atmospheres; Vacuum

1. Introduction

Cameros cheese is a fresh cheese made from pasteurized goat's milk. It takes its name from the Cameros geographical area in the province of La Rioja (Spain). Although its manufacture and consumption underwent a major decline in the Sixties, it is at present in a period of recovery due to the support of programmes for the development of the rural environment, promoted by regional and European goverments.

At the current stage of its recovery, characterization of Cameros cheese is approached in terms of defining its physical, chemical and sensory characteristics. Sensory characteristics are of the utmost importance in cheese, especially for its quality control (Bertozzi & Panari, 1993; González Mendoza & Díaz Rodríguez, 1993; Roberts & Vickers, 1994). Some methods for assessing sensory attributes in European cow's milk cheeses have been published recently as texture guidelines (Lavanchy et al., 1994) and flavor-taste guidelines (Berodier, Lavanchy, Zannoni, Adamo, Casals & Herrero, 1997). Other quantitative descriptive analysis methods (Casiraghi, Lucisano & Pompei, 1989; Chen, Larkin, Clark & Irwin, 1979; Dacremont & Vickers, 1994; Hough et al., 1996; Jack, Piggott & Patterson, 1993; Piggott & Mowat, 1991; Wium, Gross & Qvist, 1997) have been applied to hard and semi-hard cheeses but none on fresh cheeses.

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The production of Cameros cheese is very limited because of the special characteristics involved: the lack of goat's milk in some periods of the year and the situation of the producing area, which makes its distribution especially difficult. Moreover, the physicochemical characteristics of this fresh cheese mean that its shelf-life is very short (Olarte, Sanz, González-Fandos & Torre, 1999). Given the presence of oxygen, high water activity and the high pH of fresh cheese, the microorganisms responsible for spoilage can grow easily. Thus, the shelf-life of fresh cheese is only seven days.

The increased consumer demand for fresh, preservative-free foods has led to the use of modified atmosphere packaging (MAP) as a technique to improve product image and extend the quality shelf-life of various foods. The gases normally used for MAP include carbon dioxide (CO_2), oxygen (O_2) and nitrogen (N_2). The most important gas from a microbiological standpoint is CO_2, used alone or in mixtures with nitrogen and/or oxygen, which inhibits the growth of many microorganisms including spoilage bacteria (Daniels, Krishnamurthi & Rizvi, 1985). In general, it is recognised that carbon dioxide in combination with chilled storage is particularly effective at delaying spoilage by Gram-negative aerobic bacteria and molds (Clark & Takacs, 1980; Enfors & Molin, 1980).

The use of MAP may reduce contamination levels, but the sensory characteristics and their evolution throughout the storage time are very important. Some authors have pointed out the adverse effects of CO_2 on sensory characteristics (Daniels et al., 1985; Scott and Smith, 1971). However, although there are some studies on cheese packaging, only a few study sensory aspects (Fava, Pergiovanni, Galli & Polvara, 1993; Hong, Wendorff & Bradley, 1995; Maniar, Marcy, Bishop & Duncan, 1994; Pergiovanni, Fava & Moro, 1993; Vercelino, Gricoli de Luca, Gimenes & Fonseca, 1996).

In this study the effect of modified atmosphere conditions on the sensorial characteristics of Cameros cheese is evaluated using a scorecard and the methodology proposed.

2. Material and methods

2.1. Panelists selection and training

The panelists were selected based on interest, time available and a liking for cheeses, and according to the criteria established by Costell and Durán (1981), Costell (1983) and Piggott (1984). The group originally included 35 volunteers, between 23 and 48 years old, connected in some way with the Department of Agriculture and Food at the University of La Rioja, 20 were female and 15 were male. As a first step, the subjects' ability to discriminate among the four basic tastes was established and 5 subjects were eliminated. A second selection stage determined the subjects' aptitude for describing the sensory characteristics of food products; and 10 further subjects were eliminated. Remaining subjects received about 50 h of training over the course of 4 months, during which they developed and defined descriptors and reduced between-panelist variation.

During the training, the panelists were presented with an array of commercial dairy products (goat's and cow's fresh cheese, fermented milks, butter) to aid in development of terms, which included: firmess, consistence, springiness, cohesiveness, smoothness of the mass and odour. The panelists marked the responses on 7 points numerical intensity scales anchored on the left with "not" or "low" and on the right with "very"or "high" according with the attribute evaluated. The panelist chose references from the array of dairy products that they used in order to develop intensities for each attribute.

A jury of 10 members was finally chosen, with the help of which the sensory definition of Cameros Cheese was made and the scorecard was established (Damasio & Costell, 1991).

2.2. Development of the scorecard

All the panelists attended five tasting sessions to define specific and appropriate sensory characteristics of Cameros cheese. In each session, samples from four different cheesemakers were used. In order to quantify each one of the sensory attributes, a scorecard was elaborated. The intensity of the attributes selected was quantified on a scale from 1 to 7 (from less to more) according to the indications given in the sensory description. For each attribute the optimum score was established by the panelists.

Samples were tested as follows: each panelist was given a whole cheese (pieces of 250–500 g) and a smooth bladed knife. External appearance attributes were assessed first. The knife was used to evaluate consistency and resistance to cutting. With two incisions from the center of the cheese, a wedge of approximately 45° was obtained which was used to evaluate odour, taste and texture. Samples were allowed to equilibrate at room temperature for around 10 min before their assessment, so they could be presented to the panelists at about 10–12°C.

The cheeses were presented in three-digit coded plastic sample dishes sealed with plastic wrap. Tasting sessions were conducted under normal light conditions (ISO/DIS 8589). The panelists were presented with water and expectoration cups to cleanse the palate between samples. The panelists were allowed to swallow the cheeses, if desired. Order of presentation of samples was randomized.

2.3. Preparation of cheeses packaged under MAP

The sample cheeses were manufactured in our pilot plant from pasteurized (72°C/15 s) goat's milk, following the same procedure used by the commercial producers. After pasteurization, salt, $CaCl_2$ and rennet were added. Curd formation was achieved at 32–33°C after 45 min. Next, the curd was cut, the whey was removed and the molds were filled (Olarte, Sanz, Torre & Barcina, 1995). After 12 h of refrigeration, the cheeses were removed from the molds and the control samples were packaged in air. The other cheeses were packaged under different modified atmosphere conditions: 20%CO_2/80%N_2 (Batch M20), 40%CO_2/60%N_2 (Batch M40), 50%CO_2/50%N_2 (Batch M50), 100%CO_2 (Batch M100) and vacuum packaged. The plastic films used were provided by Dixie (Dixie, Bern) with a CO_2 permeability of less than 13 $cm^3/m^2/24$ h at 1 atm and O_2 permeability of 5 $cm^3/m^2/24$ h at 1 atm. The packages were evacuated, flushed and sealed in a Vaessen-Schoemake machine with gas injection. The gases used were industrial mixtures provided by Carburos Metálicos (Spain).

All the cheeses were stored at 4°C for up to 28 days. Samples were evaluated on day 0 and after 7, 14, 21 and 28 days of storage.

The experiment was carried out under the same conditions a month later.

2.4. Cheese samples evaluation

Due to rapid evolution of the sensory characteristics of the cheeses, on the days of test (days 0, 7, 14, 21 and 28) the six cheese samples were evaluated in two tasting sessions (morning, afternoon). Testing sessions were carried out in the same conditions explained before. In each session, three out of the six samples choosen at random were evaluated.

2.5. Statistical analysis

Variance analysis of two ways (samples and panelists) was carried out using the SYSTAT program for Windows; Statistics version 5.0 (Evanston, Illinois, 1992). Tuke's test was performed for comparison of means using the same program. Those means bearing different

Table 1
Definitions, parameters and optimum scores for sensory evaluation of Cameros cheese

Attribute	Definition	Optimum	Optimum score
Appearance			
Surface		No rind	
Marking	Surface mark on sample	Surface marked with "cillas" Deep marks on upper side Shallow marks on lower side	7
Colour	Visual sensation varying from white to green.	Even colour. White or ivory-like Shiny surface	3
Fissures	Visible cracking or splitting	Nonexistent or low number	1
Shape	External configuration of sample	Cylindrical form. Even upper face Uneven lower face. Convex sides	7
Interior	All the visible attributes once the cheese sample had been sliced by a knife	Even colour. White. Flat surface. Without eyes	7
Odour	Attribute perceptible by olfatory organ	Smooth. Weak whey odour	1
Taste			
Typical	Oral sensation comparable to traditional taste.	Refreshing. Smooth. Goat milk taste. Weak acidity	7
Salt distribution	Oral sensation produced by salt	Greater saltiness on the outer zone than the inner	7
Texture			
Springiness	Attribute relating to the rapidity of recovering initial thickness after a deforming pressure with the fingers	High	7
Firmness	Attribute relating to the force required to achieve a given deformation in the mouth	Moderate	4
Graininess	Attribute relating to the perception of the size and shape of particles in a sample in the mouth	Moderate	4
Friability	Attribute relating to the force necessary to break a sample into crumbs in the mouth	Moderate	4
Consistency	Attribute relating to the deformability detected by manual handling	Does not deform on handling	6

letters in the same line of Table 4a–c differed significantly ($P < 0.05$).

3. Results and discussion

Table 1 gives the specific and appropriate sensorial characteristics for this cheese, such as the external appearance, shape, consistency, cutting aspects, odour, taste and texture. It should be noted that cheese surfaces display the imprint of the sterilizable plastic molds in which they are made, which aim to reproduce the marks produced by the traditional "cillas" (wicker baskets used as molds). The score given by the panelists for an optimum cheese was also included.

Table 2 shows the scorecard proposed. This scorecard must be used together with the description given for each sensory attribute (Table 1). However, in the evaluation of each sample by the panelists in the testing sessions, the column "optimum score" was not included in Table 1.

The criterion adopted for the scorecard design was the evaluation of all the attributes according to a scale from 1 to 7 (always increasing). This criterion were adopted in order to facilitate the panelists' work. However, in order to obtain the numerical score of the samples, the panelists established the optimum score for each attribute. Thus, the optimum score given by the panelists for

Table 3
Score adjustment table for judged attributes

Attribute	Score given by judge	Final score
Colour	3	7
	1 and 2	5
	4 and 5	3
	6 and 7	1
Fissures	1	7
Odour	2 and 3	5
	4 and 5	3
	6 and 7	1
Firmness	4	7
Graininess	3 and 5	5
Friability	2 and 6	3
	1 and 7	1
Consistency	6	7
	5 and 7	5
	3 and 4	3
	1 and 2	1

Table 2
Scorecard for Cameros cheese

Appearance							
Surface							
Marking	1 □ Nonexistent	2 □	3 □	4 □ Weak	5 □	6 □	7 □ Strong
Colour	1 □ White	2 □	3 □	4 □ Yellowish	5 □	6 □	7 □ Greenish
Fissures	1 □ Nonexistent	2 □	3 □	4 □	5 □	6 □	7 □ Numerous
Shape[a]	1 □ Incorrect	2 □	3 □	4 □	5 □	6 □	7 □ Correct
Interior[a]	1 □ Incorrect	2 □	3 □	4 □	5 □	6 □	7 □ Correct
Odour							
Odour[a]	1 □ Weak	2 □	3 □	4 □	5 □	6 □	7 □ Strong
Taste							
Taste[a]	1 □ Incorrect	2 □	3 □	4 □	5 □	6 □	7 □ Correct
Salt distribution	1 □ Even	2 □	3 □	4 □	5 □	6 □	7 □ Uneven
Texture							
Springiness	1 □ Low	2 □	3 □	4 □ Moderate	5 □	6 □	7 □ High
Firmness	1 □ Low	2 □	3 □	4 □ Moderate	5 □	6 □	7 □ High
Graininess	1 □ Low	2 □	3 □	4 □ Moderate	5 □	6 □	7 □ High
Friability	1 □ Low	2 □	3 □	4 □ Moderate	5 □	6 □	7 □ High
Consistency	1 □ Low	2 □	3 □	4 □ Moderate	5 □	6 □	7 □ High

[a] According to the definition given (Table 1).

Table 4
Results obtained from the sensory evaluation of Cameros cheeses packaged under different conditions, over 28 days of refrigerated storage. Means bearing different superscripts in the same line differ significantly ($P < 0.05$)[a]

a

		Control	Vacuum	M20	M40	M50	M100
Marking	0 D	7.00 ± 0.00	7.00 ± 0.00	7.00 ± 0.00	7.00 ± 0.00	7.00 ± 0.00	7.00 ± 0.00
	7 D	6.20 ± 1.02^{b}	2.10 ± 0.32^{a}	6.30 ± 0.80^{b}	5.50 ± 0.99^{b}	5.90 ± 1.01^{b}	4.80 ± 0.97^{ab}
	14 D	3.30 ± 0.54^{b}	1.80 ± 0.60^{a}	3.00 ± 0.99^{b}	3.20 ± 0.46^{b}	3.30 ± 0.97^{b}	2.90 ± 0.63^{b}
	21 D	1.30 ± 0.46^{a}	1.70 ± 0.80^{a}	2.90 ± 0.96^{b}	3.00 ± 0.62^{b}	2.90 ± 0.85^{b}	2.30 ± 0.58^{b}
	28 D	1.00 ± 0.00^{a}	1.50 ± 0.72^{a}	2.40 ± 0.74^{b}	2.60 ± 0.53^{b}	2.70 ± 0.49^{b}	2.20 ± 0.54^{b}
Colour	0 D	7.00 ± 0.00	7.00 ± 0.00	7.00 ± 0.00	7.00 ± 0.00	7.00 ± 0.00	7.00 ± 0.00
	7 D	6.50 ± 0.56	6.40 ± 0.68	6.40 ± 0.70	5.60 ± 0.80	5.80 ± 0.64	5.10 ± 0.67
	14 D	3.70 ± 0.80^{a}	5.90 ± 0.99^{b}	5.90 ± 0.48^{b}	5.30 ± 0.69^{b}	5.50 ± 0.59^{b}	4.90 ± 0.98^{b}
	21 D	1.50 ± 0.73^{a}	5.90 ± 0.86^{b}	5.80 ± 0.58^{b}	5.10 ± 0.44^{b}	5.30 ± 0.85^{b}	4.70 ± 0.84^{b}
	28 D	1.00 ± 0.00^{a}	5.80 ± 1.14^{b}	5.60 ± 0.44^{b}	5.00 ± 0.46^{b}	5.10 ± 0.42^{b}	4.60 ± 0.73^{b}
Fissures	0 D	6.80 ± 0.34	6.80 ± 0.84	6.80 ± 0.84	6.80 ± 0.84	6.80 ± 0.84	6.80 ± 0.84
	7 D	6.30 ± 0.92^{b}	4.10 ± 0.98^{a}	6.20 ± 0.70^{b}	5.50 ± 0.85^{b}	5.60 ± 0.48^{b}	4.90 ± 0.66^{ab}
	14 D	3.50 ± 0.48^{b}	1.10 ± 1.03^{a}	3.10 ± 0.69^{b}	3.00 ± 0.40^{b}	3.20 ± 0.86^{b}	3.102 ± 0.83^{b}
	21 D	1.60 ± 0.64^{a}	1.10 ± 0.85^{a}	3.00 ± 0.88^{b}	2.80 ± 0.51^{b}	2.90 ± 0.75^{b}	2.50 ± 0.64^{b}
	28 D	1.00 ± 0.00^{a}	1.00 ± 0.00^{a}	2.20 ± 0.47^{b}	2.40 ± 0.46^{b}	2.50 ± 0.63^{b}	2.40 ± 0.53^{b}
Shape	0 D	6.30 ± 0.98	6.30 ± 0.98	6.30 ± 0.98	6.30 ± 0.98	6.30 ± 0.98	6.30 ± 0.98
	7 D	5.90 ± 0.90^{b}	4.30 ± 0.90^{a}	5.90 ± 1.06^{b}	5.20 ± 0.56^{b}	5.30 ± 0.42^{b}	4.90 ± 0.97^{ab}
	14 D	3.30 ± 0.60^{b}	2.00 ± 0.47^{a}	2.70 ± 0.74^{b}	2.70 ± 0.92^{b}	2.80 ± 0.75^{b}	2.70 ± 0.69^{b}
	21 D	1.40 ± 0.52^{a}	2.00 ± 0.68^{b}	2.50 ± 0.62^{b}	2.40 ± 0.75^{b}	2.30 ± 0.58^{b}	2.10 ± 0.50^{b}
	28 D	1.00 ± 0.00^{a}	1.30 ± 0.70^{a}	2.10 ± 0.55^{b}	2.10 ± 0.59^{b}	2.00 ± 0.48^{b}	2.00 ± 0.50^{b}
Interior	0 D	6.60 ± 0.52	6.60 ± 0.52	6.60 ± 0.52	6.60 ± 0.52	6.60 ± 0.52	6.60 ± 0.52
	7 D	6.30 ± 0.86^{b}	3.30 ± 0.93^{a}	6.20 ± 0.72^{b}	5.30 ± 0.71^{b}	5.40 ± 0.68^{b}	4.80 ± 0.72^{b}
	14 D	3.00 ± 0.58^{b}	1.10 ± 0.40^{a}	2.10 ± 0.83^{b}	2.10 ± 0.58^{b}	2.20 ± 0.87^{b}	2.60 ± 0.38^{b}
	21 D	1.30 ± 0.70^{a}	1.20 ± 1.05^{a}	1.90 ± 0.79^{b}	2.00 ± 0.50^{b}	2.00 ± 0.57^{b}	2.10 ± 0.40^{b}
	28 D	1.00 ± 0.00^{a}	1.00 ± 0.00^{a}	1.60 ± 0.48^{b}	1.90 ± 0.42^{b}	1.90 ± 0.46^{b}	2.00 ± 0.42^{b}
Total appearance	0 D	33.70 ± 0.95	33.70 ± 0.95	33.70 ± 0.95	33.70 ± 0.95	33.70 ± 0.95	33.70 ± 0.95
	7 D	31.20 ± 0.92^{b}	20.30 ± 1.42^{a}	31.00 ± 1.15^{b}	27.10 ± 1.29^{b}	28.00 ± 1.16^{b}	24.40 ± 1.27^{ab}
	14 D	16.80 ± 1.14^{b}	11.90 ± 1.10^{a}	16.70 ± 0.82^{b}	16.30 ± 1.06^{b}	17.00 ± 1.05^{b}	16.20 ± 1.14^{b}
	21 D	7.10 ± 0.99^{a}	11.80 ± 1.23^{b}	16.10 ± 1.10^{b}	15.30 ± 1.42^{b}	15.40 ± 1.27^{b}	13.70 ± 1.16^{b}
	28 D	5.00 ± 0.00^{a}	10.60 ± 0.84^{b}	13.90 ± 1.29^{b}	14.00 ± 1.16^{b}	14.20 ± 1.14^{b}	13.20 ± 0.92^{b}

b

Springiness	0 D	6.80 ± 0.84	6.80 ± 0.84	6.80 ± 0.84	6.80 ± 0.84	6.80 ± 0.84	6.80 ± 0.84
	7 D	5.60 ± 0.90^{c}	3.70 ± 0.96^{b}	2.70 ± 0.95^{a}	4.10 ± 0.93^{b}	4.20 ± 0.96^{b}	2.70 ± 0.90^{a}
	14 D	1.90 ± 0.78^{b}	1.30 ± 0.52^{a}	1.20 ± 0.47^{a}	2.70 ± 0.91^{c}	2.80 ± 0.48^{c}	1.60 ± 0.75^{a}
	21 D	N.D.	1.30 ± 0.52^{a}	1.10 ± 0.38^{a}	2.60 ± 0.69^{b}	2.70 ± 0.76^{b}	1.00 ± 0.00^{a}
	28 D	N.D.	1.00 ± 0.00^{a}	1.00 ± 0.00^{a}	2.50 ± 0.84^{b}	2.40 ± 0.84^{b}	1.00 ± 0.00^{a}
Firmness	0 D	6.90 ± 0.80	6.90 ± 0.80	6.90 ± 0.80	6.90 ± 0.80	6.90 ± 0.80	6.90 ± 0.80
	7 D	5.80 ± 0.60^{c}	1.30 ± 0.48^{a}	2.60 ± 0.93^{a}	4.30 ± 0.95^{b}	4.00 ± 0.92^{b}	2.50 ± 0.85^{a}
	14 D	1.50 ± 0.66^{a}	1.30 ± 0.52^{a}	1.30 ± 0.42^{a}	2.80 ± 0.73^{b}	2.70 ± 0.58^{b}	1.40 ± 0.60^{a}
	21 D	N.D.	1.20 ± 0.42^{a}	1.10 ± 0.36^{a}	2.70 ± 0.48^{b}	2.60 ± 0.63^{b}	1.00 ± 0.00^{a}
	28 D	N.D.	1.00 ± 0.00^{a}	1.00 ± 0.00^{a}	2.60 ± 0.93^{b}	2.10 ± 0.76^{b}	1.00 ± 0.00^{a}
Graininess	0 D	6.80 ± 0.84	6.80 ± 0.84	6.80 ± 0.84	6.80 ± 0.84	6.80 ± 0.84	6.80 ± 0.84
	7 D	4.20 ± 0.76^{c}	1.20 ± 0.42^{a}	2.80 ± 0.94^{a}	3.20 ± 0.89^{b}	3.50 ± 0.93^{b}	2.70 ± 0.87^{a}
	14 D	1.20 ± 0.47^{a}	1.20 ± 0.44^{a}	1.00 ± 0.00^{a}	2.20 ± 0.54^{b}	2.40 ± 0.98^{b}	1.30 ± 0.60^{a}
	21 D	N.D.	1.10 ± 0.35^{a}	1.20 ± 0.40^{a}	2.10 ± 0.38^{b}	2.60 ± 0.86^{b}	1.00 ± 0.00^{a}
	28 D	N.D.	1.00 ± 0.00^{a}	1.00 ± 0.00^{a}	1.90 ± 0.64^{b}	2.20 ± 0.73^{b}	1.00 ± 0.00^{a}
Friability	0 D	6.90 ± 0.80	6.90 ± 0.80	6.90 ± 0.80	6.90 ± 0.80	6.90 ± 0.80	6.90 ± 0.80
	7 D	4.30 ± 0.55^{c}	1.10 ± 0.32^{a}	2.60 ± 0.77^{a}	2.90 ± 0.88^{b}	3.10 ± 0.98^{b}	2.50 ± 0.91^{a}
	14 D	1.40 ± 0.58^{a}	1.30 ± 0.53^{a}	1.10 ± 0.36^{a}	2.00 ± 0.94^{b}	1.90 ± 0.43^{b}	1.20 ± 0.50^{a}
	21 D	N.D.	1.30 ± 0.54^{a}	1.20 ± 0.44^{a}	1.80 ± 0.82^{b}	1.70 ± 0.87^{b}	1.00 ± 0.00^{a}
	28 D	N.D.	1.00 ± 0.00^{a}	1.00 ± 0.00^{a}	1.70 ± 0.56^{b}	1.50 ± 0.67^{b}	1.00 ± 0.00^{a}
Consistency	0 D	6.90 ± 0.80	6.90 ± 0.80	6.90 ± 0.80	6.90 ± 0.80	6.90 ± 0.80	6.90 ± 0.80
	7 D	4.90 ± 0.41^{c}	3.30 ± 0.83^{b}	2.40 ± 0.73^{a}	3.30 ± 0.91^{b}	3.20 ± 0.96^{b}	2.50 ± 0.86^{a}

(*continued on next page*)

Table 4 (*continued*)

		Control	Vacuum	M20	M40	M50	M100
	14 D	1.50 ± 0.66[a]	1.10 ± 0.33[a]	1.30 ± 0.50[a]	2.10 ± 0.78[b]	2.20 ± 0.72[b]	1.30 ± 0.51[a]
	21 D	N.D.	1.00 ± 0.00[a]	1.20 ± 0.44[a]	1.80 ± 0.43[b]	2.30 ± 0.86[b]	1.00 ± 0.00[a]
	28 D	N.D.	1.00 ± 0.00[a]	1.00 ± 0.00[a]	1.60 ± 0.55[b]	1.90 ± 0.57[b]	1.00 ± 0.00[a]
Total texture	0 D	34.30 ± 0.82	34.30 ± 0.82	34.30 ± 0.82	34.30 ± 0.82	34.30 ± 0.82	34.30 ± 0.82
	7 D	24.80 ± 0.92[c]	10.60 ± 0.96[a]	13.10 ± 0.74[a]	17.80 ± 0.91[b]	18.00 ± 0.94[b]	12.90 ± 0.88[a]
	14 D	7.50 ± 0.97[b]	6.20 ± 0.92[a]	6.10 ± 1.05[a]	11.80 ± 0.78[c]	12.00 ± 0.81[c]	6.80 ± 0.91[a]
	21 D	N.D.	5.80 ± 0.63[a]	5.80 ± 0.78[a]	11.00 ± 1.05[b]	11.90 ± 1.10[b]	5.00 ± 0.00[a]
	28 D	N.D.	5.00 ± 0.00[a]	5.00 ± 0.00[a]	10.30 ± 0.95[b]	10.10 ± 0.90[b]	5.00 ± 0.00[a]
c							
Taste	0 D	6.90 ± 0.32	6.90 ± 0.32	6.90 ± 0.32	6.90 ± 0.32	6.90 ± 0.32	6.90 ± 0.32
	7 D	5.80 ± 0.58[b]	3.30 ± 0.82[a]	5.10 ± 0.99[b]	5.20 ± 1.13[b]	4.10 ± 0.57[ab]	2.00 ± 0.47[a]
	14 D	1.80 ± 0.63[a]	3.20 ± 0.63[ab]	4.80 ± 0.78[b]	4.90 ± 0.74[b]	4.30 ± 0.67[b]	2.10 ± 0.57[a]
	21 D	N.D.	3.10 ± 0.74[b]	3.20 ± 0.63[b]	4.10 ± 0.86[b]	3.30 ± 0.48[b]	1.00 ± 0.00[a]
	28 D	N.D	1.00 ± 0.00[a]	1.00 ± 0.00[a]	3.50 ± 0.53[b]	2.80 ± 0.79[b]	1.00 ± 0.00[a]
Salt distribution	0 D	6.40 ± 0.52	6.40 ± 0.52	6.40 ± 0.52	6.40 ± 0.52	6.40 ± 0.52	6.40 ± 0.52
	7 D	1.70 ± 0.96[a]	1.50 ± 0.53[a]	2.80 ± 0.63[b]	2.80 ± 0.63[b]	2.20 ± 0.57[b]	2.10 ± 0.57[b]
	14 D	1.50 ± 0.52	1.50 ± 0.71	1.50 ± 0.71	1.50 ± 0.71	1.90 ± 0.88	2.10 ± 0.74
	21 D	N.D.	1.40 ± 0.70	1.20 ± 0.48	1.40 ± 0.52	1.20 ± 0.42	1.00 ± 0.00
	28 D	N.D.	1.00 ± 0.00	1.00 ± 0.00	1.30 ± 0.48	1.10 ± 0.32	1.00 ± 0.00
Total taste	0 D	13.30 ± 0.82	13.30 ± 0.82	13.30 ± 0.82	13.30 ± 0.82	13.30 ± 0.82	13.30 ± 0.82
	7 D	7.70 ± 0.82[b]	4.80 ± 0.64[a]	7.90 ± 0.99[b]	8.00 ± 0.81[b]	6.30 ± 0.48[ab]	4.10 ± 0.87[a]
	14 D	3.30 ± 0.95[a]	4.70 ± 0.82[ab]	6.30 ± 0.82[b]	6.40 ± 0.70[b]	6.20 ± 0.42[b]	4.20 ± 0.92[a]
	21 D	N.D.	4.50 ± 0.85[b]	4.40 ± 0.97[b]	5.50 ± 1.25[b]	4.50 ± 0.74[b]	2.00 ± 0.00[a]
	28 D	N.D.	2.00 ± 0.00[a]	2.00 ± 0.00[a]	4.80 ± 0.92[b]	3.90 ± 0.99[b]	2.00 ± 0.00[a]
Odour	0 D	6.90 ± 0.32	6.90 ± 0.32	6.90 ± 0.32	6.90 ± 0.32	6.90 ± 0.32	6.90 ± 0.32
	7 D	6.60 ± 0.51	6.70 ± 0.48	6.70 ± 0.48	6.80 ± 0.42	6.90 ± 0.32	6.90 ± 0.32
	14 D	3.10 ± 0.88[a]	6.60 ± 0.51[b]	6.60 ± 0.51[b]	6.80 ± 0.42[b]	6.70 ± 0.48[b]	6.90 ± 0.32[b]
	21 D	1.00 ± 0.00[a]	6.50 ± 0.53[b]	6.50 ± 0.71[b]	6.60 ± 0.51[b]	6.70 ± 0.48[b]	6.80 ± 0.42[b]
	28 D	1.00 ± 0.00[a]	3.20 ± 0.63[ab]	5.10 ± 0.74[b]	5.90 ± 0.57[bc]	6.70 ± 0.48[c]	6.60 ± 0.51[c]
Overall score	0 D	112.50 ± 3.26	112.50 ± 3.26	112.50 ± 3.26	112.50 ± 3.26	112.50 ± 3.26	112.50 ± 3.26
	7 D	86.25 ± 3.58[c]	54.30 ± 3.09[a]	74.60 ± 3.77[b]	75.10 ± 3.81[b]	71.90 ± 2.72[b]	57.05 ± 3.43[a]
	14 D	36.90 ± 3.81[a]	40.70 ± 3.30[ab]	48.30 ± 3.27[b]	53.40 ± 2.95[c]	54.70 ± 3.43[c]	43.20 ± 4.05[ab]
	21 D	R.	38.20 ± 3.64[a]	42.70 ± 4.45[b]	49.50 ± 2.80[c]	49.20 ± 3.26[c]	R.
	28 D	R.	R.	R.	45.55 ± 3.27	**44.25 ± 3.44**	R.

[a] The data are the average ± standard deviation values of the scores given by 10 judges in two experiments. Means having different letters in the same line differ significantly ($P < 0.05$). N.D., not determined; R., refused.

most of the parameters was 7, but was only 3 for colour, 1 for fissure and odour, 4 for firmness, graininess and friability and 6 for consistency. Thus, the use of a score adjustment table was necessary to calculate the overall score (Table 3).

According to the panelists' criteria, the parameters studied had differing levels of influence on the overall score. Judges gave 30% of the overall score to the assessment of external appearance, other 30% to taste and other 30% to texture. Odour was the parameter considered of lower influence, with only 10% for cheeses in good conditions. However, odour was a determinant in the evaluation of the cheeses packaged in MAP since in those with a score over 5, the parameters of texture and taste were not determinated. It must be noticed that a score over 5 matches to a value below 3 after applying the adjustment table (Table 3).

Taking into account the different level of influence of each sensory category evaluated and the number of attributes identified under each category of sensory variable, the overall score was obtained by addition to the score for texture and appearance, the score for odour multiplied by 1.5 and the score for taste by 2.5. The maximum score a sample could reach was 115.5 points. Cheeses with an overall score below 35 were refused.

Using this methodology, the evolution of the sensory quality of Cameros cheese packaged under modified atmospheres was evaluated. In Table 4a–c are shown the results obtained after applying the adjustment table (Table 3). No significant differences were found when scores given by the panellists for the same sample were compared. This fact can be explained by the concise sensory description and the scoring criteria established

in the scorecard. Thus significant differences found (expressed as letters in Table 4a–c) corresponds to significant differences among cheese samples.

Sensory quality decreased throughout the storage in all the cheeses studied, and a general deterioration of appearance and texture was observed. A loss of the greater saltiness on the outer zone of the optimum cheeses was also noticed as the storage time increased.

The sensory analysis results revealed that the highest score on day 7 was awarded to the control batch. However, control cheeses were refused by day 21. These cheeses were received unfavourably by the tasting panel and obtained the lowest score for odour (1.00 ± 0.00); it was not possible to estimate taste and texture parameters. Moreover, defects in colour (greenish) were detected after day 14, giving a score color of 1.50 ± 0.73.

Cheeses packaged under vacuum showed a fast deterioration of surface appearance, caused mainly by the loss of surface markings (2.10 ± 0.32 day 7) and shape (2.00 ± 0.47 day 14). However, the color was acceptable until the end of the period studied (5.80 ± 1.14 day 28). The texture also showed a rapid deterioration over the storage time, with an increase in the graininess (1.20 ± 0.42 day 7) and friability (1.10 ± 0.32 day 7) and a decrease in the firmness (1.30 ± 0.48 day 7). Neither off-odour, nor off-tastes were described by the panelists until day 28, when cheeses were refused.

The colour of the cheeses packaged in CO_2 atmospheres received very favourable scores during the period studied. The odour also received very favourable scores, except for day 28 in batch M20. The texture was of reasonable quality, with the highest score obtained by batches M40 and M50 (10.30 ± 0.95 and 10.10 ± 0.90, day 28, respectively). In addition, batches M40 and M50 received acceptable values for taste (4.80 ± 0.92 and 3.90 ± 0.99 day 28 respectively).

Authors have reported that CO_2 has some negative effects on milk products in general, with respect to the color and aroma (Scott & Smith, 1971). However, Maniar et al. (1994) found that CO_2 did not affect the sensory characteristics. These different results can be explained by the CO_2 concentrations used and the type of products studied. In contrast, in the present study, colour and odour were not affected in cheeses packaged in 100% CO_2, but taste and texture were very negatively affected.

Structural losses at high CO_2 concentrations could be explained by the high solubility of CO_2 in cheese aquose phase. On the other hand, high concentrations of CO_2 are known by their antimicrobiological effect, thus the structure deterioration of cheeses packaged in 20% CO_2 could be due to the microbiological growth.

The conclusion of this study is that the methodology proposed permits a simple and effective quantification of the sensory quality of Cameros cheese. With regard to the packaging conditions, it is concluded that 40%CO_2/60%N_2 and 50%CO_2/50%N_2 are the most effective for retaining good sensory characteristics, particularly in taste and odour. However, these packaging conditions affected negatively texture and appearance, it would be necessary to carry out a consumer acceptability study to determinate the applicability of this packaging conditions.

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