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CHARACTERIZATION OF COLOMBIAN QUESILLO CHEESE BY SPECTROCOLORIMETRY

CARACTERIZACIÓN DE QUESILLO COLOMBIANO POR ESPECTROCOLORIMETRÍA

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ABSTRACT

Rationale: The colour of food is one of the major attributes which affect a consumer's perception of its quality, and it is also a powerful tool for quality control and marketing. The Quesillo cheese is a typical Colombian cheese. The observed colour in Quesillo cheese is a composite of many contributing factors. **Objectives:** The objective of the current work was to characterize the colour of Quesillo cheese using parameters L^*, a^* and b^* of the CIE (Commission Internationale d'Eclairage) system by spectrocolorimetry. **Methods:** The collection of data with colorimeters was used for the instrumental characterization of colour in Quesillo cheese. Colour parameters L^*, a^* and b^* were measured in triplicate using CIE-LAB space for fourteen commercial Quesillo cheese and seven manufactured cheeses. Using the mean values of colour in the analysed cheeses, parameters of chroma metric (C^*), hue (H^*), colour differences (ΔE), whiteness index (WI) and yellowness indix (YI) were determined. **Results:** The general mean values obtained were, $L^* = 78.13$, $a^* = -0.96$, $b^* = 22.95$, $C^* = 22.97$ and $H^* = 92.38°$. These can be estimated as the reference values for Quesillo cheese, which could be used in quality control in the manufacturing process. Different factors are discussed that can change or influence the colour in the final product. **Conclusions:** The colour variations of this type of cheese are principally due to the initial composition of milk, composition of acid whey and manufacturing technology.

Keywords: Milk, pasta-filata, colombian quesillo cheese, colour, colorimetry.

RESUMEN

Antecedentes: El color de los alimentos es uno de los mayores atributos que afecta la percepción de la calidad por parte de los consumidores y también es una potente herramienta para el control de calidad y mercadeo. El quesillo es un queso típico colombiano. El color que se observa en el quesillo es una combinación de muchos factores. **Objetivos:** El objetivo del presente trabajo fue caracterizar el color del quesillo utilizando los parámetros L^*, a^* y b^* del sistema CIE (Comisión Internationale d'Eclairage) mediante espectrocolorimetría. **Métodos:** Los datos del color del quesillo fueron obtenidos con un colorímetro. Se determinó los parámetros de color L^*, a^*, b^* por triplicado, utilizando el espacio CIE-LAB, para catorce quesillos comerciales y siete quesillos fabricados para este estudio. Utilizando los valores medios del color de los quesos analizados se determinó los parámetros de croma métrico (C^*), tonalidad (H^*), diferencia de color (AE), índice de blancura (WI) e índice de amarillo (YI). **Resultados:** Los valores medios generales obtenidos fueron: $L^* = 78{,}13$, $a^* = -0{,}96$, $b^* = 22{,}95$, $C^* = 22{,}97$ and $H^* = 92{,}38$. Éstos pueden ser estimados como valores de referencia para el quesillo y podría emplearse en control de calidad la fabricación. Se discutelos diversos factores que pueden cambiar o influir en el color del producto final. **Conclusiones:** Las variaciones de color de este queso se deben, principalmente, a la composición inicial de la leche, la composición del suero ácido y la tecnología de fabricación.

Palabras clave: Leche, pasta-hilada, quesillo colombiano, color, colorimetría.

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INTRODUCTION

Quesillo cheese, Doble Crema cheese, Trenza cheese and Pera Cheese are typical Colombian cheeses that are members of the pasta-filata cheese family. It is believed that the technology to produce this cheese was developed by Italian immigrants (1). From Colombia, Quesillo cheese has reached other Latin American countries, among which are: Guatemala, Honduras, El Salvador and Nicaragua. Quesillo and Doble Crema cheese have become the most popular cheese varieties in Colombia because of their functional properties which are of utmost importance for pizza and other foods, like sandwiches, burgers, and others that use them (2). Colombia produces approximately about 23000 tons per year of Doble Crema cheese and Quesillo. Quesillo is an acid fresh unripened cheese that can be classified as semi-soft cheese with a medium to high content of fat (1, 3, 4).

Quesillo is manufactured from raw whole cow's milk, which is slightly heat-treated at 50°C for 15 – 30 min and thereafter coagulated at 35 – 37°C by using acid whey and rennet as adjuvants (50% of the amount normally used). Acid whey fermented in the same cheese, making plant to pH 4.5, providing a natural whey culture. Natural whey starters are preferred as they contribute to the typical flavour and aroma of the final cheese product (5). The curd is placed on tables specially designed for removal of whey (for 10 min or more if necessary), until the pH reaches about 5.3 suitable enough for stretching. The stretching process is performed in a hot bowl, without water or liquid, at a temperature higher than 75°C for about 25 min. The cheese curd is salted at the beginning of the stretching process. The physical structure of casein by the action of lactic acid and accelerated by the high temperature is transformed from dicalcium paracaseinate to monocalcium caseinate, increasing its elasticity and strength. After stretching, the cheese is moulded into 1 – 2.5 kg sample sizes and ventilated, so that the cheese becomes bright, and cooled at 4°C. Normally, it has a rectangular shape.

An important factor to consider is that several craft industries, working in the manufacturing process, use a curd stretching step done in a bowl at the end of cheese production whereby the heat of the fire is reduced but the curd is allowed to stretch for a few more minutes to give the cheese more consistency, making the final colour a more intense yellow. Also, in some craft industries they leave the moulded cheese on shelves for at least 12 hours before being packed and stored in cold rooms (6). Several studies have evaluated the browning in cheese and the factors involved, such as temperature of storage in warm climate, of cooling and heating (7 - 10). This allows understanding the appearance of a more intense yellow colour in the surface of Quesillo cheese.

The aspect of foodstuffs is one of the acceptable ways to appreciate quality and desirable on-sale food products (11). A product will be accepted if it has an attractive appearance (texture and colour). This parameter is often the primary consideration of consumers when making purchase decisions (12, 13). Colour of food is one of the major attributes that affect the consumer's perception of quality (14), also is included the flavour, odour, origin, naturalness and ripeness. This makes a potent tool for quality control and marketing. Colour is qualitatively distinguished by the human eye but not quantified; however, colour can be measured using a colorimeter, which has greater sensitivity and higher reproducibility than the human eye. The information obtained from colorimeters correlate well with human perception (15).

Colour is an important factor when it comes to consumer choice and selection of cheese. For most cheeses produced in the world, the quality of milk affects the final product. The observed colour in Quesillo cheese is a composite of many contributing factors. Several studies on the colour characterization of cheeses have shown that colour is closely related to the initial composition of milk, the manufacturing technology and the addition of food additives, among other findings (10, 16 - 19). Table 1 summarizes the information about colour attributes for different cheese varieties.

Table 1. Colour attributes for different type of cheeses (15).

Cheese	L^*	a^*	b^*	C^*	H^*	WI	YI
Brie (interior)	90.20	2.70	26.50	26.64	84.18	71.62	41.97
Camembert (interior)	85.00	3.30	26.90	27.10	83.01	69.02	45.21
Crottin de Chavignol	92.40	-1.90	10.00	10.18	100.76	87.30	15.46
Edam	79.80	4.20	32.20	32.47	82.57	61.76	57.65
Feta	93.50	-1.10	11.00	11.05	95.71	87.18	16.81
Gouda	82.60	3.60	27.10	27.34	82.43	67.59	46.87
Gouda (Egyptian)	76.57	9.99	35.05	36.45	74	56.67	65.39
Roncal	60.00	-4.25	13.50	14.15	107.47	57.57	32.14
Fresh cheese (HPP)	79.9	-1.25	8.45	8.54	98.41	78.16	15.11
Molido Nariñense cheese	94.16	-0.33	11.00	11.00	91.72	87.54	16.69
Processed cheese	91	3	18.6	18.84	80.84	79.12	29.20
Semi-hard Cheese	80.00	-7.55	27.50	28.52	105.35	65.17	49.11
Reggianito	73 a 79			29 a 33	71 a 76		
Roquefort	92.80	-1.40	14.50	14.57	95.51	83.75	22.32
Tilsit	77.20	3.10	28.80	28.97	83.86	63.14	53.29

Hunter L*, a* and b* values for light to dark, red to green, and yellow to blue respectively.

Chroma (C*), hue (H*), Whiteness index (WI) and Yellowness index (YI) were calculated from data collected from reference.

Attributes of colour are chroma metric or saturation (C^*), and hue (H^*) (also found as tonality or tone). C^* represent the radial distance and describes the extent to which a colour is separated from the neutral gray colour which is closer to a pure spectrum between vividness and dullness. H^* is defined by its angular position in a cylindrical colour space and corresponds to the dominance of Radiation specific wavelengths over others (colours: red 0 °, 90 ° yellow, 180 green and 270 ° blue).

Colour indexes are Whiteness index (WI) and Yellowness index (YI). WI is widely used in the textile and paper industries, although recently its use has been extended to food, drugs, plastic and ceramic industries. A WI value of 100 indicates an ideal white surface (16). Any differences to these values indicate a deviation from ideal white. YI value indicates the grade by which the sample surface is different to the ideal white in terms of yellowness. The YI increases when the difference in ideal white increases. However, if these values grow on the positive scale YI (+) they will indicate a difference in the yellowness. It also indicates a difference in blueness if it decreases on the negative scale YI (-).

Colombian cheeses have not been classified according to their colour, but it could be said that the Molido Nariñese cheese and Quesito Antioqueño have white colour, Pera cheese and Trenza cheese have a colour from white to pale-yellow, Costeño cheese and Campesino cheese has a pale-yellow colour surface, Doble Crema cheese and Quesillo cheeses are more yellow than the previous ones but not as much as Paipa cheese (1). Most of the Colombian population know and differentiates among each of these cheeses. Although there is no formal ranking of the colour of them, the Colombian population relate the colour with the composition and quality. The Quesillo cheese produced from a low fat milk, less than 3% fat, resulting in much whiter colour than the normal colour of Quesillo cheese. Consumers consider this product as a dietary cheese, although it is not yet fully accepted by the entire population. Another incidence occurs in the department of Nariño, where Molido Nariñense yellow cheese is considered as stale or old, and it is not desired (20).

The colour variations of Quesillo are due principally to: the initial milk composition and acid whey used in the production of cheese. The fat and indigenous microflora, the manufacturing technology including the time of stretching, holding time before packaging and temperature of storage also affect the final colour of the product.

The objective of the current work is to characterize the colour of Quesillo cheese using parameters L^*, a^* and b^* of the Commission Internationale d'Eclairage (CIE) system.

MATERIALS AND METHODS

Cheeses samples

Seven Quesillo cheese samples were produced (6), with raw milk at pH 6.7 ± 0.1 and acid whey at pH 4.5 ± 0.3. The procedure for the production of Quesillo cheese is presented in flowchart as shown in Figure 1. Fourteen commercial samples of Quesillo cheeses from different regions of Colombia were procured from local supermarkets in Cali-Colombia and used for comparative purposes. Quesillo cheese samples were cut as cylinders of approximately 2 cm in height and 5 cm in radius, packed in plastic bag and stored at 4°C for 24 h before the colour test analysis.

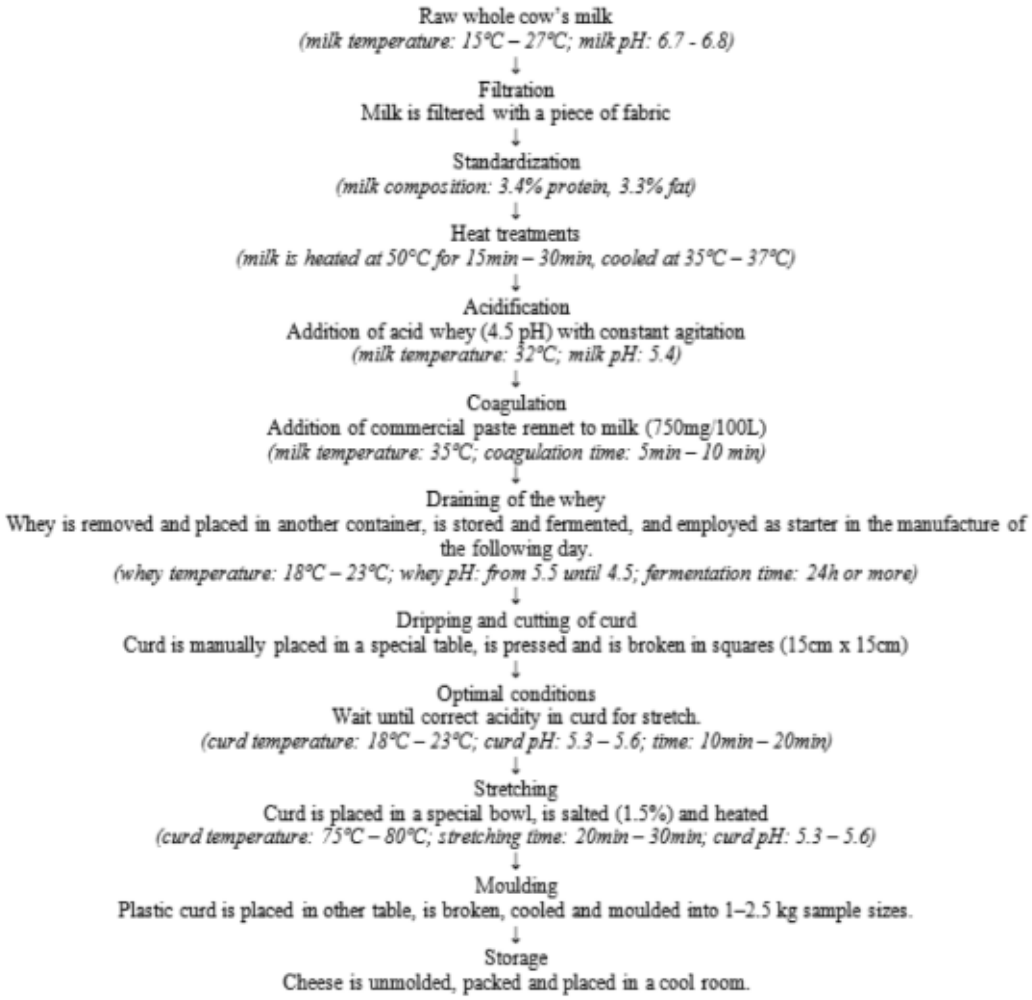

Figure 1. Manufacture process of Quesillo cheese.

Colour measurements

Colour measurements were performed in a spectrocolorimeter (Colour flex® – HunterLab). The reference illuminant used was D65 (standard daylight). The colour parameters of L^*, a^* and b^* of samples were determined. A glass plate was placed over the light port of the Hunter colorimeter and was standardized using black and white reference plates. Samples were placed in Petri dishes for analysis. All of the samples were large enough to cover the entire light port, and they were placed on the glass plate over the light port and covered with a black glass to prevent that stray light interferes with the readings. Surface colour of each sample was measured. After the colour parameters were read for a sample, it was rotated 145 ° and read again. This procedure was triplicate.

Colour parameters were obtained using the CIE-LAB space, where L^* corresponds to lightness/darkness (colour change ranges from 0% dark to 100% light), a^* to green/red chromaticity (from −60 green to 60 red), and b^* to blue/yellow chromaticity (from −60 blue to 60 yellow). Colour parameters were averaged for each of the commercial Quesillo cheeses, 3 samples per cheese for Quesillo cheese were analysed. For manufactured Quesillo cheese 3 samples per 7 cheeses were analysed. The colour parameters calculated were C^*, H^*, ΔE^* and the indexes WI and YI were calculated from the average values of L*, a*, b*.

The attributes of colour which are; chroma metric or saturation (C*), hue, tonality or tone (H*), were calculated according to equations 1 and 2; and the colour indexes which are: WI and YI were determined according to (16) in equation 3 and (15) in equation 4, respectively, as shown below:

$$C^* = \sqrt{(a^*)^2 + (b^*)^2} \qquad \textbf{Equation 1.}$$

$$H^* = \text{arctg}\left(\frac{b^*}{a^*}\right) \qquad \textbf{Equation 2.}$$

$$WI = 100 - \sqrt{(100 - L^*)^2 + a^{*2} + b^{*2}} \qquad \textbf{Equation 3.}$$

$$YI = 142.86 \cdot \left(\frac{b^*}{L^*}\right) \qquad \textbf{Equation 4.}$$

Colour differences (symbolized as ΔE*), in the CIE-LAB space, numerically represents the perception of difference of colour for the human eye between two food samples. Also ΔE* represents an overall index of colour variation. ΔE* was calculated using equation 5, shown below:

$$\Delta E_{r,s} = \sqrt{(L^* - L^*_{ref})^2 + (a^* - a^*_{ref})^2 + (b^* - b^*_{ref})^2}$$

$$\Delta E_{r,s} = \sqrt{(\Delta L^*)^2 + (\Delta a^*)^2 + (\Delta b^*)^2} \qquad \textbf{Equation 5.}$$

Statistical Analysis

Data were reported in the CIE L*a*b* colorimetric system and analysed using Microsoft Excel® (version 2010) and SPSS® (version 18.0.0). Significant differences in composition for commercial and manufactured Quesillo cheeses were tested using a one-way analysis of variance (ANOVA) and included a Tukey's Studentized multiple comparison test at the 5% level.

RESULTS

Table 2 shows the physicochemical composition of manufactured Quesillo cheese for this study.

Table 2. Composition and pH of manufactured Quesillo Cheeses.

Characteristic	Range[1]
Moisture (%)	50 – 55
Fat (%)	26 – 30
Protein (%)	22 – 25
Salt (%)	1.1 – 1.7
pH	5.2 – 5.4

[1] Range of seven manufactured Quesillo cheeses for this study.

The mean values and standard deviation of L* a* b*, C*, H*, ΔE*, WI and YI are shown in Table 3. Colour analysis of commercial and manufactured cheeses indicated that, in general, L* and b* values are not significantly different from each other, only a* values showed significant differences. Also, It shows that this type of cheese is located in sector yellow (+ b*) with slight tones of green (-a*), H* greater than 90° and C* greater than 20. The a* (-0.96) and b* (22.95) values of manufactured cheese is close to the values of commercial cheeses, except for one that moves away from the set of data (a * -1.47, b * 23.14) that have higher yellowness and greenness than the others. As for the white, the manufactured cheese was much whiter than most of the samples. The average values obtained for L*, C* and H*, can be characterized by the colorimetric region, in which the samples fall within a pale-yellow colour to yellow colour, and a bright surface.

Table 3. Colour values of Quesillo.

Cheeses	Sample	Experimental Parameters[3]			Calculated Parameters[4]		
		L*	a*	b*	C*	H*	ΔE*
Commercial[1]	1	77.58[a]	-1.47[a]	23.14[a]	23.19	93.64	1.01
	2	79.02[a]	-0.37[b]	22.05[a]	22.06	90.97	1.29
	3	77.71[a]	-0.24[b]	21.68[a]	21.68	90.63	0.78
	4	77.11[a]	-0.34[b]	21.42[a]	21.42	90.91	1.18
	5	77.81[a]	-0.64[a b]	21.93[a]	21.94	91.67	0.40
	6	77.49[a]	-0.40[b]	22.81[a]	22.81	91.01	0.62
	7	78.45[a]	-0.57[b]	22.78[a]	22.79	91.44	0.80
	8	77.62[a]	-0.52[b]	22.26[a]	22.27	91.35	0.22
	9	77.53[a]	-0.74[a b]	22.57[a]	22.59	91.88	0.36
	10	77.60[a]	-0.43[b]	21.73[a]	21.73	91.14	0.67
	11	78.32[a]	-0.72[a b]	22.08[a]	22.09	91.88	0.59
	12	76.85[a]	-0.72[a b]	23.21[a]	23.22	91.79	1.29
	13	77.64[a]	-0.83[a b]	22.01[a]	22.03	92.15	0.39
	14	77.99[a]	-0.91[a b]	22.31[a]	22.33	92.34	0.32
Manufactured[2]	15	78.13[a]	-0.96[a b]	22.95[a]	22.97	92.38	1.01
Average		77.79 ± 0.53	-0.66 ± 0.31	22.33 ± 0.56	22.34 ± 0.56	91.68 ± 0.76	0.71 ± 0.35
		Confidence Interval 99.99%					
Max		77.05	-1.09	21.56			
Min		78.53	-0.23	23.10			

[a b] Values in a column with a common superscript letter do not differ significantly (P > 0.05).

[1] Each result shown for the commercial cheeses (1-14) represents the mean of 3 samples.

[2] The result for the manufactured cheese (15) is the mean of 7 cheeses). They do not differ significantly (P > 0.05).

[3] Hunter L*, a* and b* values for light to dark, red to green, and yellow to blue.

[4] Calculated values for attributes of colour C* and H*, and Colour differences ΔE*.

The relationship between whiteness and yellowness is shown in Figure 2. In figure 2a, it could be observed that at least three commercial cheeses are whiter and two are yellower than manufactured cheese. Figure 2b shows that as WI decreases, YI increases. YI value determines only the level of yellow (+) or blue (-) of samples, in this case, the yellowing of the cheese.

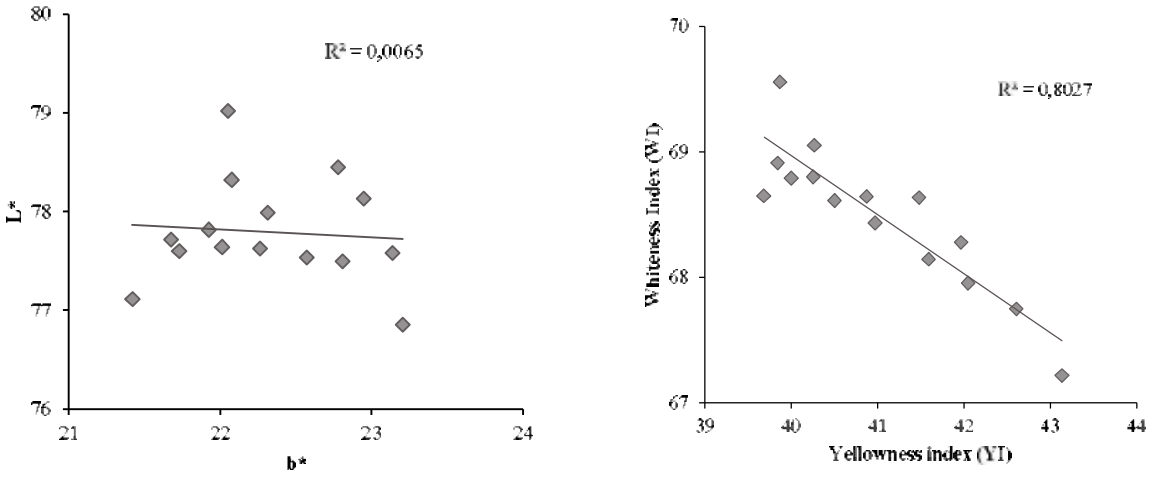

Figure 2. Graphical representation of whiteness – yellowness: a) L* vs b* (R^2=0.0065) and b) WI vs. YI (R^2=0.8027) for the 15 cheeses.

DISCUSSION

Milk composition

The fat content of raw milk in Colombia is variable; it may range between 3.1% and 4.8% (21). From the results as indicated in Table 2 and Table 3 the colour of manufactured Quesillo cheese is closely related to the initial composition of milk which is 3.3% fat, and final composition of the cheese which is 28% fat approximately. Carpino *et al.*, 2004 (22) found that compounds from pasture plants are transferred to cheese and they also may transfer flavour and colour. Doan (1924) indicated that the yellow fat globules are responsible primarily for the yellowish tints, where the size of these fat globules from milk probably influences the composite colour of the cheese as well as the colour of the globules themselves (23). The pigments in milk fat globules which are β-carotene and related carotenoid compounds (22, 24) are associated with a small amount of *xanthophylls* and that these pigments are the same as those found in green and yellow vegetation (23). In Colombia, the cattle usually have access to pasture or are fed with considerable quantities of green feeds (25 - 27) which contain comparatively large amounts of carotenoids (28). In traditional cheese production, milk used to produce Quesillo cheese did not receive extensive pre-treatment, except only a brief heat treatment (6); allowing probably the fat globules to retain their integrity and size in the final cheese product. This is a very important factor in the final colour of the manufactured cheese.

From the results as indicated in Table 3, the mean value calculated for L* is comparable with values reported in the literature, indicated in Table 1, i.e. Edam, Fresh cheese, Egyptian, Gouda, Reggianito Argentino and Tilsit; a* is similar for Feta and Molido Nariñense cheese, while b* differs from them.

Quesillo cheese technology

Also an appreciation of the manufacturing procedure of Quesillo cheese is crucial to understand its peculiar colour. Many small-scale enterprises do not use standardized milk in cheese manufacturing (1), which explains why artisan-produced cheeses are more yellow in colour intensity than the commercial types which use standardized milk in cheese preparation (29).

Quesillo cheese is made with acid whey, which contains indigenous microflora that eliminates the need for a starter culture (6). In some traditional pasta filata cheeses, such as Caciocavallo, Ragusano (30, 31), Provolone, Mozzarella, and Pizza cheeses (32), the whey is stored and employed as starter in the manufacturing process the following day. The culture contained in the whey may change the colour of the cheese, as observed by Chamba, 2004 (33), who reported the modifications in colour of cheese due to the activity of the culture.

Colour difference

From the results as indicated in Table 3, there are no significant colour differences between the samples and general mean value, confirming the impossibility of the visual perception of the human eye. Can be explained the relationship between the opinion of the observer and the values of ΔE*, which were below 2.70 that are not noticeable to the human eye (none 0 - 0.7, lightly 0.7 – 2.5, remarkable 2.5 - 3.0, appreciable 3.0 - 6.0, considerable 6.0 - 12.0, and biggest 12.0).

Colour indexes

The calculated Index was used to study the changes in colour over time. Although Quesillo belongs to the fresh-cheese category that is intended for consumption within 25 days, they have variations in colour. The mean value of WI = 68.28 is an indication that the cheese colour, which is yellowish in appearance, is due to its composition. A mean of YI = 41.97 suggests that Quesillo does not have an intense yellow colour, but it is possible to see yellow tones in it. From the data calculated for WI and YI and compared to data from several workers, indicated in Table 1, it is possible to place Quesillo cheese between other cheese, it could be inferred that Quesillo cheese is more white than Edam, Tilsit or Gouda and it is more yellow than Crottin de Chavignol, Feta, Queso de Roncal, Fresh cheese, Molido Nariñense cheese, Processed cheese or Roquefort. Colour indexes may be served for categorizing the cheese on the scale of white (WI) or yellow (YI), better than only L* or a* (Figure 3).

CONCLUSIONS

The mean values and ranges calculated from a set of data could serve as information for quality control and colour characterization of these chee-

ses. The general mean values obtained for Quesillo cheese were, L*= 78.13, a*= -0.96, b*= 22.95, C*= 22.97 and H*= 92.38°.

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