Colour evolution in Roncal Cheese during the first minutes of exposure to air

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ABSTRACT

We have measured the spectral reflectance and computed the CIELAB colour coordinates of 42 Roncal cheese at 0, 1.5, 3, 5, 10, 20 and 30 minutes after cutting the samples and exposing the cheese interior to air. L*, a* and b* change significantly during this 30 minutes and colour changes are noticeable for visual colour evaluation of this product in quality control processes. A simple first order kinetics model has been used to determine the time scale of these changes. CIE a* and b* evolve faster with time with time constants 3.8 ± 0.5 minutes and 5.5 ± 0.8 minutes respectively while L* time constant is 12 ± 2 minutes. In order to ensure colour stability a time delay of at least 30 minutes is recommended between cutting the sample and the visual colour evaluation.

1. INTRODUCTION

Visual colour evaluation of food products plays an important role in quality control processes in food industry. Trained panellists usually do this evaluation with or without the aid of colour standards. Panel training, physical conditions in the evaluation booths and product preparation must be considered to obtain reliable results. Respect to the product itself, it is obvious that its colour should be stable during the evaluation, at least within the visual discrimination capabilities of the panellists. Some food products, like cheese, are cut to show their interior in order to be evaluated. The resulting exposure to air and oxygenation/oxidation processes may result in colour changes thus affecting the visual evaluation scores. Information is needed about the magnitude of these colour changes and the time scale in which these changes may affect the visual evaluation. This information can not be obtained from visual estimates and therefore instrumental colour measurements at this stage are necessary to determine the correct methodology in the visual evaluation procedure.

Although visual colour appraisal is a quite common practice, there are relatively few works on instrumental colour measurements on cheese varieties. In these works however it is not analysed colour evolution or colour stability. In fact these works do not provide detailed information specifying the precise moment when colour measurements were performed. Colour information is obtained to characterize specific cheese varieties or to trace the effects of colorants and other additives. Colour is typically referred to the Hunter Lab[1, 2] and CIELAB[3, 4, 5] colour spaces.

Roncal cheese is an important food product in the Spanish region of Navarre. It belongs to the guarantee of protected origin “Queso del Roncal” and visual colour assessment is a part of the quality control processes established by the Regulation Body. In this work we study the time evolution of colour coordinates in Roncal cheese during the first 30 minutes of exposure to air and its implications respect the visual evaluation procedures in the quality control of this product.

2. METHOD

Forty-two cheeses from the guarantee of protected origin “Queso del Roncal” (Roncal cheese) were studied. Roncal cheese is a traditional, farmhouse, unpasteurized hard cheese made from sheep's milk. It is wheel-shaped having a hard natural rind covered with a velvety-smooth layer of blue-grey mould. The firm elastic interior is slightly grainy, with small irregular holes.

Cheeses used in this work were aged for four months in the cheese farms and then transported to the university laboratories, where they were cut in quarters. The colour of one of these quarters was measured with a portable spectrocolorimeter Spectro-Color Dr Lange, calibrated with the white and black calibration tiles supplied with the apparatus. Spectral reflectance data provided by the apparatus cover the range 400-700 nm at 10 nm intervals. CIELAB colour coordinates where calculated referred to the D65 standard illuminant and 10º standard observer. Each measurement corresponds to the average of five different readings in five points of the cheese surface. Measurements were made at several time intervals after cutting the sample. The first measurement was made immediately after been cut (minute 0) and the following measurements were made after 1.5, 3, 5, 10, 20 and 30 minutes.

3. RESULTS AND DISCUSSION

Figure 1 shows the mean spectral reflectance of all measured samples. Each spectrum corresponds to a specific time interval since the cheese was cut and its interior exposed to air. For a given time, Roncal cheese reflectance spectra exhibit a depression between 400 nm and 500 nm where reflectance values slowly increase and reach a rather flat region, between 500 nm and 700 nm. This spectral shape is partially related with the presence of carotenoids that enter the product through the animal's diet.

Maximum reflectance values are obtained immediately after the sample has been cut (t=0). As the time of exposure to air increases reflectance values decrease for all wavelengths. The percentage reflectance decrease is more important at short wavelengths (notice the vertical scale limits). If data at t=0 min and t=30 min is compared, the relative reflectance decrease it is about 17-19% between 400 nm and 500 nm and 10-11% between 500 nm an 700 nm

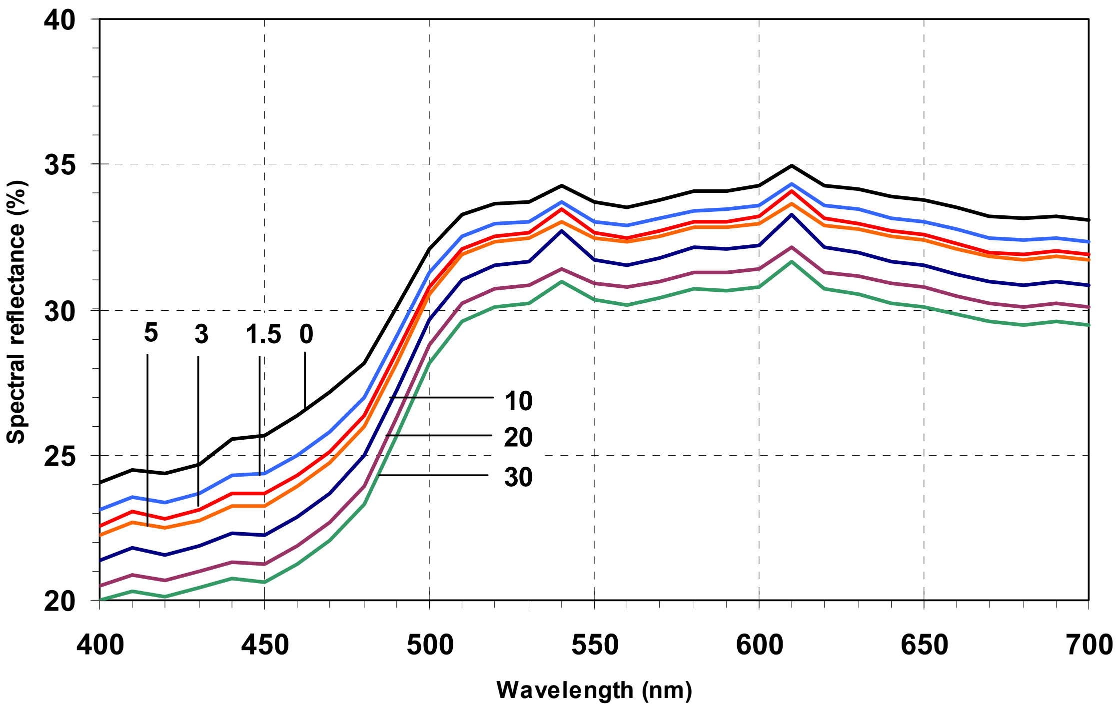

Figure 1. Mean spectral reflectance (%) during the exposure of the cheese surface to air. Labels refer to the measurement time in minutes.

Since we are here interested in the possible effects of colour evolution and colour stability related with the visual colour evaluation of the product we have computed, from these reflectance spectra, CIELAB L*, a* and b* colour coordinates. As expected from reflectance data, all colour coordinates change significantly once a fresh cut of cheese is exposed to air. Some of them decrease with time (L*, a* and h*) while others (b* and C*) increase. Just after been cut, visual colour of Roncal cheese is whitish and inhomogeneous. In fact colour changes from white to yellow can be discerned by careful visual inspection as cheese surface becomes more homogeneously coloured during the first minutes.

However each colour coordinate evolves at different rate. Mean CIE L*, a* and b* colour coordinates are plotted versus measurement time in figure 2 where experimental values are represented by open triangles. It is apparent that a* and b* change faster than L*. As a result a* and b* approximately reach stable values in 30 minutes while L* seems to decrease for a longer period. Changes in colour coordinates during these 30 minutes are large enough to produce discernible colour changes during the visual evaluation of this particular product. It is therefore necessary to wait until colour becomes stable before its evaluation.

This colour evolution depends on the chemical processes during the oxygenation once the interior is exposed to air. For Roncal cheese this information does not exists and then it is not possible to model the time behaviour of colour coordinates on a chemical base.

For this reason and in order to determine the time scale at which colour become stable we have used a simple approach. Data points in figure 1 suggest some kind of exponential decay in the colour coordinate values. Exponentially decaying solutions are frequently found in chemical reactions, specifically in those reactions that obey a first order kinetics[6]. In the absence of detailed knowledge of the chemistry during the oxygenation of the cheese surface we have assumed that each colour coordinate varies exponentially with time according to the expression:

$$C.C. = P_f + (P_f - P_0)\exp(-t/\tau) \quad (1)$$

This is the solution of first order kinetics. Here C.C. represents any colour coordinate (L*, a*, b*), P_0 and P_f are its initial and final values respectively and τ is the decay constant. Table 1 show the parameter estimation after fitting observed colour coordinate values to equation (1).

In figure 2 we can compare measured L*, a* and b* values (open triangles) and predicted values (lines). From this figure and from R^2 values in table 1 we can conclude that equation (1) is a good approximation to the observed time evolution of colour coordinates.

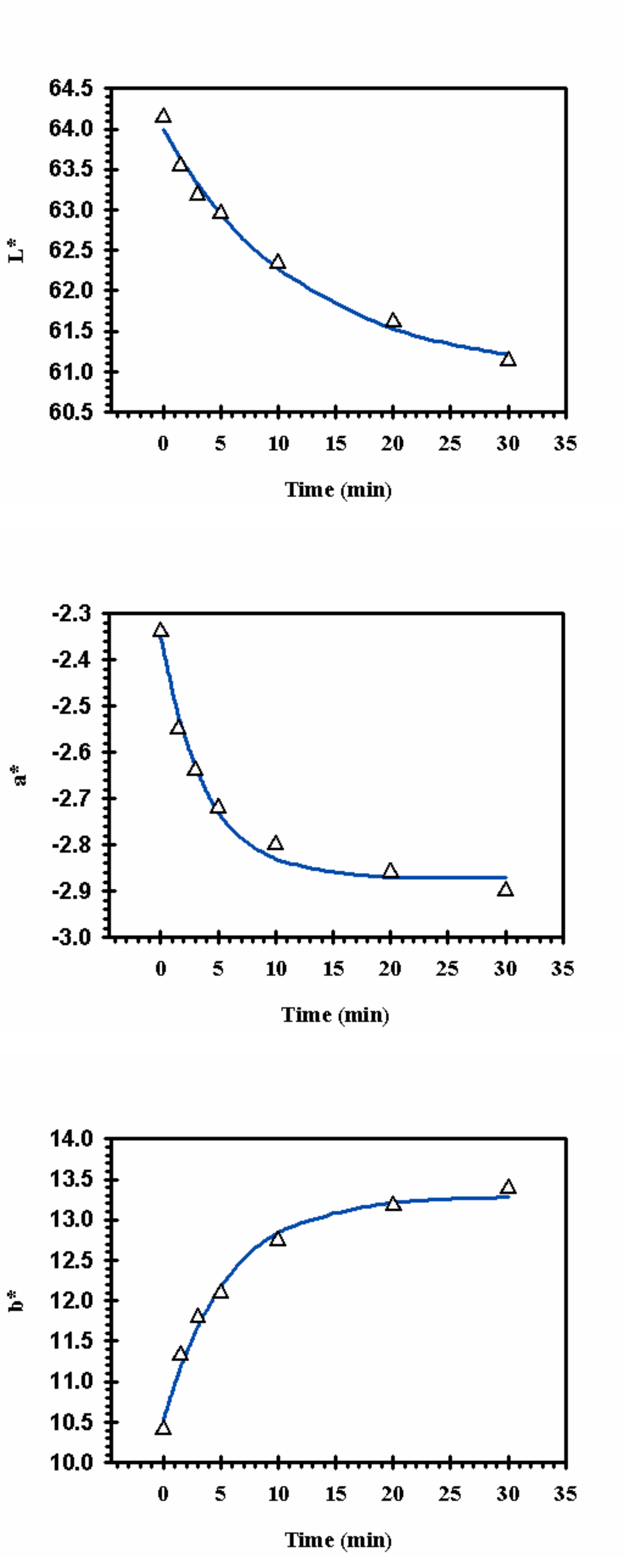

Figure 2. Time evolution of CIE L*, a* and b* colour coordinates in the first 30 minutes after cutting. Triangles are experimental values. Lines are predicted values using equation (1)

Table 1: Parameter estimates after fitting data to eq (1)

C.C.	P_0	P_f	τ (min)	R^2
L*	64.0±0.1	61.0±0.2	12±2	0.990
a*	-2.35±0.03	-2.87±0.02	3.8±0.5	0.987
b*	10.52±0.12	13.28±0.11	5.5±0.8	0.989

As expected from the experimental data, a* and b* change faster than L* and therefore L* is the most restricting parameter in order to recommend a time delay between preparing the samples and the visual evaluation of its surface colour. For this product waiting about three or four times the decay time (30-40 minutes) is required to ensure colour stability in the evaluated samples. This however can not be considered a general recommendation since this time will depend on the characteristics of each cheese variety and should be determined in each case.

Notice finally that the mathematical model used to describe the time behaviour of each colour coordinate and expressed in equation (1) does not intend to represent the detailed nature of the chemical reactions in the oxygenation process. It is a simple and accurate way, at least for this product, to determine the time scale in the colour changes. Different decay time constants for each colour coordinate are expected by their mathematical definitions and do not have to resemble the time constants related with the chemical reactions in the cheese surface, even in the case that only one pigment is involved.

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