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EVALUATION OF BROWNING RATE OF QUINCE AT AMBIENT EXPOSURE

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ABSTRACT: Since quince is a fruit relatively susceptible to browning, in the present work it was evaluated the colour of the quince over time of exposure to the atmospheric air. The colour of the fresh pulp was assessed using a handheld tristimulus colorimeter using the CIELab colour coordinates: L*a*b*. These Cartesian coordinates were then used to calculate the polar or cylindrical coordinates: value, hue angle (º) and chroma. At each instant, ten measurements of colour were made, and to evaluate the colour change, measurements were repeated in the same samples after every 5 minutes, over a period of two hours. The results obtained for the medium values of the cylindrical coordinates in the freshly cut quince were found to be: value = 7.80, chroma = 31.78 and Hue = 92.28º, being these values determined right after cutting. Total colour difference (TCD) was calculated having the values of the Cartesian coordinates of the freshly cut quince as reference. In relation to the colour change, the values for TCD were 0.00, 26.35, 30.41, 31.81 and 32.39, respectively for times 0, 30, 60, 90 and 120 minutes, indicating a faster rate initially and a tendency for stabilization towards the end of the period analyzed.
Key words: *quince, browning, colour, browning kinetics*

INTRODUCTION

The Quince (*Cydonia oblonga*) is a relatively small tree, the only member of the gender *Cydonia*, from the Rosaceae family. The fruit is called quince, and resembles a cross between an apple and a pear. Quince is rich in dietary fibre, vitamins, like vitamin C, and minerals, such as copper or potassium, while being low in saturated fat, cholesterol and sodium. In the raw form, the flesh is hard and unpalatable, with an astringent, acidulous taste. However, quince is rarely used in the raw form, being instead commonly made into preserves and jellies. Once cooked and sweetened, it turns red, with a pleasant taste and strong fragrance.

Colour is one of the most important appearance attributes of foods and it has a major influence on the reaction of the consumer, contributing to determine the acceptability or rejection of the food. However, the colour of food products is quite susceptible, and may be affected in a high extent by processing, in particular thermal processing. Nevertheless, some degradation also occurs during transportation and storage. Among the alterations that can occur are those resulting from pigment degradation, browning reactions like Maillard reactions, enzymatic browning or oxidation of ascorbic acid (Maskan, 2001, 2006; Suh et al., 2003).

Because colour is such an important attribute of food quality, it has been the object of study by many researchers, in many foods: pomegranate juice concentrate (Maskan, 2006), tofu (Baik and Mittal, 2003), kiwi (Maskan, 2001), spinach (Nisha et al., 2004), watercress (Cruz et al., 2007), carrots (Koca et al., 2007), bananas (Chua et al., 2001) or pears (Quevedo et al., 2009).

Tristimulus colorimetry has been widely accepted as a rapid and simple instrumental method for measuring the colour of food products, and CIELab Cartesian coordinates (L*, a*, b*) can be used to quantify that colour. There are other parameters derived from Hunter L*, a*, b* coordinates, such as the total colour difference (TCD), which aims at quantifying the overall colour difference between a sample and a reference material. Furthermore, the Cartesian coordinates can be used to calculate the cylindrical coordinates: value, chroma and Hue

angle (Maskan, 2001). Data about the kinetics of change in quality attributes in foods, like for example colour, provide valuable information for understanding and predicting changes that occur during processing and storage, and thus allow improving quality and minimizing losses (Kumar et al., 2006).
Although many studies can be found about the kinetics of colour change during processing of foods, studies about the kinetics of degradation of colour of quince just by exposure to the atmospheric air are lacking, and this is a product that is very susceptible to browning and quite rapidly too. In this way, the present study aimed at investigating the variation along time of colour of quince during exposure to atmospheric conditions.

MATERIAL AND METHODS

Sampling

The samples of quince (*Cydonia oblonga* Mill.) cultivar Gamboa were cut into slices and colour measurements were done right after cutting. After that, the slices were left exposed to atmospheric conditions, and colour measurements were made every five minutes until two hours.

Colour measurements

The colour was measured using a handheld tristimulus colorimeter (Chroma Meter - CR-400, Konica Minolta), calibrated with a CIE standard illuminant D65. The colour coordinates L*a*b* of the CIELab colour space were determined, where L* denotes lightness, and varies from zero (black) to 100 (white), a* varies from -60 (green) to +60 (red) and b* veries from -60 (blue) to +60 (yellow) (Kumar et al., 2006). From the Cartesian coordinates (L*a*b*) the total colour difference (TCD) was calculated by equation (1) (Chen and Ramaswamy, 2002):

$$\mathrm{TCD} = \sqrt{(L*_0 - L*)^2 + (a*_0 - a*)^2 + (b*_0 - b*)^2} \qquad (1)$$

considering the colour of the freshly cut product as reference. The Cartesian colour coordinates were then used to calculate the cylindrical coordinates, value, chroma and hue angle, by the following equations (Maskan, 2001):

$$\mathrm{Value} = L*/10 \qquad (2)$$

$$\mathrm{Chroma} = \sqrt{a*^2 + b*^2} \qquad (3)$$

$$\mathrm{Hue}\,(^{o}) = \tan^{-1}\left(\frac{b*}{a*}\right) \qquad (4)$$

According to Maskan (2001) the browning index (BI) can be calculated from the Cartesian colour coordinates by the following equation:

$$\mathrm{BI} = \frac{[100\,(x - 0.31)]}{0.17} \qquad (5)$$

where

$$x = \frac{(a* + 1.75\,L*)}{(5.645\,L* + a* - 3.012\,b*)} \qquad (6)$$

For the colour determinations ten samples were analysed at each time instant and the mean values and standard deviations were calculated for each set.

Mathematical modelling

One of the many models cited in literature to describe the kinetics of change of a certain attribute, P, of a food product is the logistic model reported by Chen and Ramaswamy (2002) as:

$$P = U_0 + \frac{U_e}{1 + \exp[\pm k(t - t_0)]} \qquad (7)$$

where k is the kinetic constant, U_0 and U_e are constants related to P_0 and P_e, respectively, and t_0 is the half-life time, i.e., the time at which the value of the property P increases/decreases to half/double of the U value. P_0 represents the initial value of the property while P_e is the final equilibrium value, and the signs (+) or (-) indicate increase or degradation of the property P, depending on the case.

RESULTS AND DISCUSSION

Table 1 shows the results of the fittings made with the logistic model in Equation (7) to the experimental data of the different variables analysed (Cartesian colour coordinates, cylindrical coordinates, total colour difference and browning index). For the fittings, the software SigmaPlot V8.0 (SPSS, Inc.) was used. In Table 1 the values of all four parameters in the model are presented, along with the value of the correlation coefficient, R, which allows evaluating the quality of the fit, i.e., how good does the fit describe the experimental set of data for each case. The values for R in table 1 indicate that in all cases the model adjusts quite well the experimental data, being the fit for a* the best, with higher value of R, 0.9968, and the fit for b* the less good, with the lowest value, 0.9282. Still, since the value of R is quite close to 1, even in this case the fitting was quite successful. The values of the kinetic constant, k, are positive for L* and Hue and negative for all other cases, thus indicating that the variables L* and Hue decrease with time, whereas all other increase.

Table 1. Fitting of the experimental data with the kinetic model from Equation (7)

	L*	a*	b*	Chroma	Hue	TCD	BI
U_0	54.6055	-21.421	29.1377	27.3189	290.72	-36.138	15.2884
U_e	58.1742	39.1257	10.9047	16.27523	-1020.1	67.1939	124.178
t_0	-325.23	-25.239	317.35	402.94	-2328.8	-96.508	626.87
k (s^{-1})	1.04e-3	-1.29e-3	-3.55e-3	-2.34e-3	65.781	-1.25e-3	-1.58e-3
R	0.9918	0.9968	0.9282	0.9784	0.9963	0.9953	0.9920

To better understand how these different colour variables change along exposure time, Figures 1 to 4 show the experimental points of the variables along time, together with the corresponding fits obtained with SigmaPlot. In all cases, each point at a given instant results from the data measured in that instant, i.e., is the mean value between 10 measurements.

Figure 1 shows the different Cartesian colour coordinates, lightness (L*) and the two opposing colour coordinates (a* and b*). The graph evidences the decrease in L* along time, thus indicating that the quince samples become darker. As to the colour coordinate a* the freshly cut quince presents a value for a* lower than zero, thus indicating a slight prevalence of the green colour. However, very rapidly this vanishes giving place to positive values of a*, corresponding to the appearance of the reddish colour, as a result of the development of the brown compounds. As to b*, this is always positive, thus indicating that yellow prevails over blue (negative values of b*), and by increasing with time it shows that the yellowish colour is intensified, this also in result of browning. Furthermore, it is visible from all curves that colour change is faster at the initial moments (until 2000 sec, that is the first half hour), tending to stabilize thereafter.

Figure 2 shows the cylindrical colour coordinates as well as the corresponding fits obtained for each variable. Chroma, which indicates colour saturation, increases along exposure time, thus meaning that the colour is becoming more intense. The hue angle, which is used to characterise the colour of foods, diminishes from around 90º to about 70º. An angle of 0° or 360° represents red Hue, while angles of 90°, 180° and 270° represent yellow, green and blue Hue, respectively.

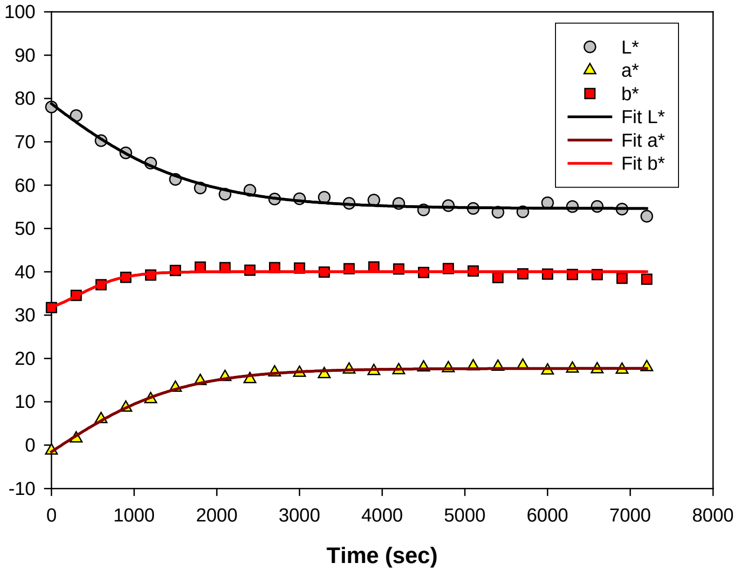

Figure 1. Variation along time of the Cartesian colour coordinates of quince

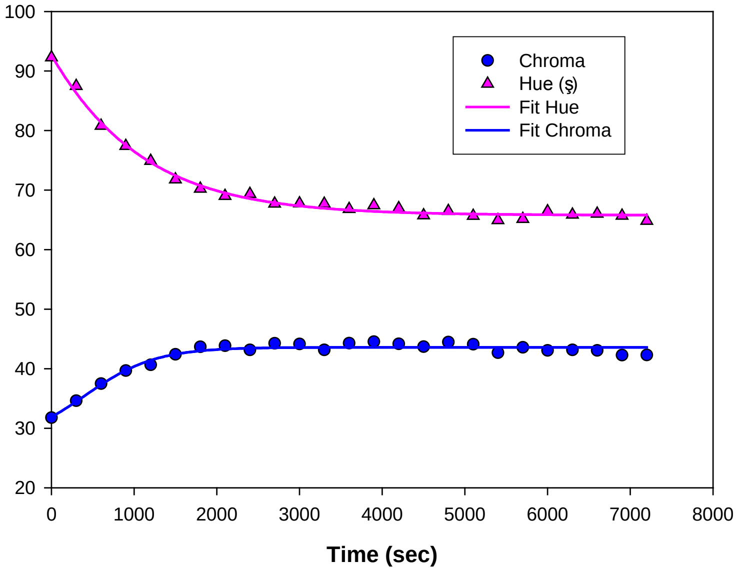

Figure 2. Variation along time of the polar colour coordinates of quince

Figure 3 shows the variation along exposure time of the total colour difference, which was calculated according to Equation (1), and that quantifies the deviation of colour in relation to the reference colour. In this case the freshly cut product was the reference and the corresponding Cartesian coordinates were: L* = 78.02(±0.86), a* = -1.27(±0.23) and b* = 31.75(±1.68). As the graph shows, the values of TCD increase along time, thus indicating a higher difference from the reference, i.e., from the freshly cut quince. This results, as previously said, from brown compounds formed during reactions that take place at the surface of the product that is exposed to the atmospheric air, and in particular oxygen.

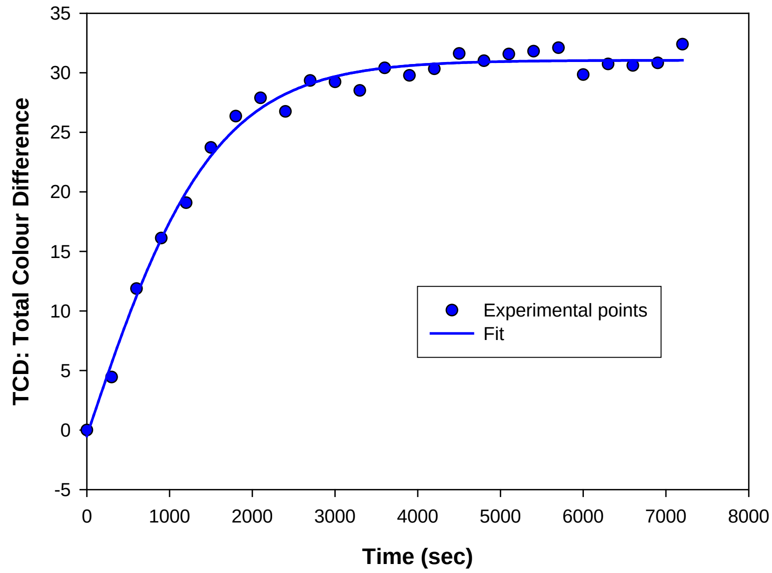

Figure 3. Variation along time of the total colour difference of quince

Figure 4, which represents the variation of the browning index along exposure time, shows a quite similar trend to that observed earlier in Figure 3. In fact, these two variables are different ways of quantifying the same type of phenomena, i.e., the development of darker colours as a result of browning. Once again is visible that the first half hour is critical for the darkening of the cut quince, and that in fact the degree of browning is quite important, given the high values of BI obtained towards the end reaching 140.

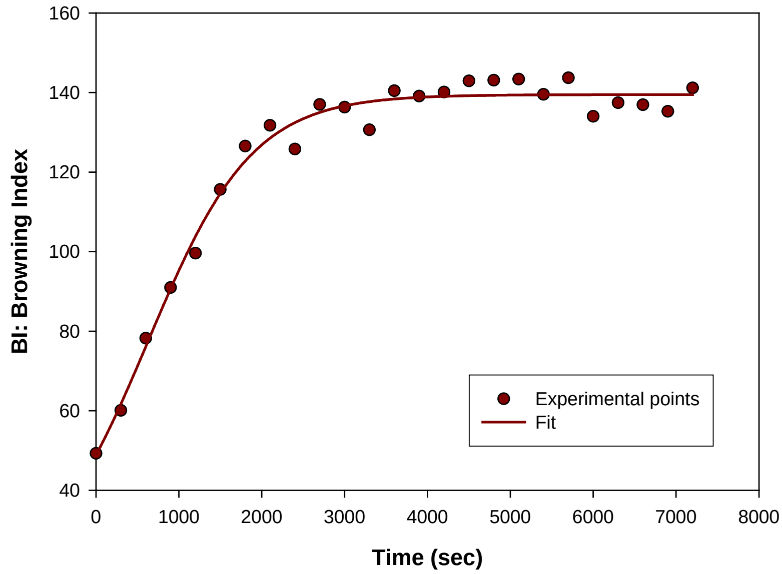

Figure 4. Variation along time of the browning index of quince

CONCLUSIONS

From the present work it was possible to confirm that quince is in fact very susceptible to the exposure to the atmospheric oxygen, which allows the development of an intense degree of browning. All the colour parameters analysed prove the appearance of brown compounds in result of the reactions undertaken at the surface of the quince. Furthermore, total colour difference and browning index were quantified and they revealed that the major colour deterioration happens in the first half hour, and in the following 1 hour and a half the colour stays approximately constant. Furthermore, the experimental data were fitted to a kinetic model found in literature to describe browning in foods, the logistic model, and in all cases this proved to be very adequate to describe the kinetic behaviour of all variables along time, given the very high values of the regression coefficients.

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