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Effect of CA-storage on the Physical and Sensorial Quality of ‘Rocha’ Pear

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Abstract

The effect of several storage factors (storage time, time in the open air at room temperature, and concentrations of O₂ and CO₂) were evaluated for the pear cultivar ‘Rocha’ following CA and NA storage. Colour was affected by the time in the open air and the concentrations of O₂ and CO₂, via their linear, quadratic and cross interaction effects. Firmness was affected by all factors tested. Sensorial evaluation confirmed the results pertaining to colour and firmness, and permitted detection of the influence of storage conditions upon juiciness and sweetness.

INTRODUCTION

‘Rocha’ pear (Pyrus communis L.), a native Portuguese pear cultivar, possesses excellent storage capacity and unique sensory properties; it is indeed characterized by a white, smooth, granular, sweet, not acid and very juicy pulp (Soares et al., 2001). Pears are usually harvested between August and mid-September, so appropriate postharvest storage conditions are required in order to preserve fruit quality attributes over a period of up to nine months. Scarce information is yet available on recommended CA-storage gas composition for this cultivar, and on the factors that may influence quality decay. Recommendations for CA-storage are varied, and depend on such factors as cultivar and period of storage (Yang and Lee, 1997).

The goals of this study were thus to experimentally determine the effects of storage time, time of exposure to open air at room temperature, and overhead storage gas composition (in terms of O₂ and CO₂) on selected quality parameters of ‘Rocha’ pear.

MATERIALS AND METHODS

Experimental Conditions

Pears (cv. ‘Rocha’) were harvested in Portugal at a stage of commercial maturity, in August 1998; they were then stored at 0 - 0.5 °C and 90 - 95 % RH in air (NA) or under CA. Four CA storage conditions were tested: 2 % (v/v) O₂ + 0.5 % (v/v) CO₂; 2 % (v/v) O₂ + 1.5 % (v/v) CO₂; 3 % (v/v) O₂ + 0.5 % (v/v) CO₂; and 3 % (v/v) O₂ + 1.5 % (v/v) CO₂. After 4, 7 and 9 month of storage, fruits were removed from each storage condition, and allowed to ripen in air at room temperature (19 - 20 °C). After 1 and 6 days in air at room temperature, 10 pears from each storage condition were selected at random, and duly evaluated in terms of colour (by the L° a° b° reflectance system) and firmness (by maximum force at puncture). Sensorial analysis was performed after 6 d of exposure to open air at room temperature, via a rating test; panelists were asked to score, in a 9 cm-unanchored scale, yellow colour, firmness, juiciness and sweetness of pear samples, corresponding to each storage condition.

Statistical Analyses

The influences of the four factors tested (Table 1) were empirically modelled according to a second order polynomial, using as dependent variables Hunter’s b° value (Y₁) and firmness (Y₂):

\[ Y = b_0 + b_1 X_1 + b_2 X_2 + b_3 X_3 + b_4 X_4 + b_{11} X_1^2 + b_{12} X_1 X_2 + b_{13} X_1 X_3 + b_{14} X_1 X_4 + b_{22} X_2^2 + b_{23} X_2 X_3 + b_{24} X_2 X_4 + b_{33} X_3^2 + b_{34} X_3 X_4 + b_{44} X_4^2 \] 

(1)
where \( b_i \) is a constant, the \( b_i' \)s (in \( i = 1, 2, 3, 4 \)) are linear effect parameters, the \( b_i'' \)s (in \( i = 1, 2, 3, 4 \)) are interaction effect parameters, and the \( b_i''' \)s (in \( i = 1, 2, 3, 4 \)) are quadratic effect parameters, and where the \( X_i \)'s (in \( i = 1, 2, 3, 4 \)) are the processing parameters in the coded form. An analysis of variance (ANOVA) was performed, so as to evaluate the influence of the storage factors on the sensorial attributes.

**RESULTS AND DISCUSSION**

When pears were exposed to air at room temperature, the \( b^* \) value decreased as apparent by the negative value for \( b_1 \) (Table 2). The values of \( b^* \) were positively influenced by the concentration of \( O_2 \) (\( b_1 \)) and by the interaction of the concentration of \( O_2 \) with the time of exposure to the open air at room temperature (\( b_{13} \)); however, there was a negative effect associated with the square of the concentration of \( O_2 \) (\( b_3 \)). The regression analysis showed that there were positive effects associated with the square of the concentration of \( CO_2 \) (\( b_4 \)) and the interaction of the concentration of \( CO_2 \) with the time of exposure to the open air at room temperature (\( b_{14} \)), whereas a negative effect was associated to the interaction of the concentrations of \( O_2 \) and \( CO_2 \) (\( b_{13} \)). The sensorial results confirmed the positive effect of the concentration of \( O_2 \); pears stored in air were rated as more yellow than those stored under any of the CA composition considered (Fig. 1A).

Analysis of results of the firmness test indicated that its changes were influenced by storage time via linear (\( b_1 \)) and quadratic (\( b_2 \)) effects, and by time in the open air at room temperature, via the quadratic effect (\( b_2 \)). Firmness changes were influenced positively by the interaction between time of exposure to the open air at room temperature and concentration of \( O_2 \) (\( b_{13} \)), and negatively by the interaction between the time of exposure to the open air at room temperature and concentration of \( CO_2 \) (\( b_4 \)). The influence of the storage time and of the gas composition were detected by the panel (Fig. 1B); pears stored under the two CA conditions with 2 % (v/v) \( O_2 \) and under 3 % (v/v) \( O_2 \), 0.5 % (v/v) \( CO_2 \) were rated firmer after 9 month of storage than those stored under air, or under 3 % (v/v) \( O_2 \) + 1.5 % (v/v) \( CO_2 \).

Juice content and sweetness are important attributes in consumer perception of fruit quality (Wang and Mellerthain, 1975). The sensorial results indicated that panelists were able to detect differences in terms of juiciness among pears stored under the various storage conditions (Fig. 1C); fruits under the two CA conditions corresponding to 1.5 % (v/v) \( CO_2 \) were reported to be between moderate and strong in terms of juiciness. The content of soluble solids may thus be influenced by the storage conditions (Drake and Eisele, 1999). Sweetness was not apparently affected by storage time; however, panelists perceived differences in sweetness between pears stored under distinct gas compositions; fruits stored under 2 % (v/v) \( O_2 \) + 1.5 % (v/v) \( CO_2 \) were sweeter than those stored under air, or under 3 % (v/v) \( O_2 \) + 0.5 % (v/v) \( CO_2 \) (Fig. 1D), after 7 and 9 month of storage.

**ACKNOWLEDGEMENTS**

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**Literature Cited**


**Tables**

**Table 1. Storage factors tested with regard to quality parameters of 'Rocha' pear**

<table>
<thead>
<tr>
<th>Factor tested</th>
<th>Notation</th>
<th>Levels</th>
</tr>
</thead>
<tbody>
<tr>
<td>Storage time (month)</td>
<td>( X_1 )</td>
<td>4, 7 and 9</td>
</tr>
<tr>
<td>Time in open air (d)</td>
<td>( X_2 )</td>
<td>1 and 6</td>
</tr>
<tr>
<td>% (v/v) ( O_2 )</td>
<td>( X_1 )</td>
<td>2, 3 and 7</td>
</tr>
<tr>
<td>% (v/v) ( CO_2 )</td>
<td>( X_1 )</td>
<td>0, 0.5 and 1.5</td>
</tr>
</tbody>
</table>

**Table 2. Second order polynomial model for the \( b^* \) value and the firmness of 'Rocha' pears, as a function of the relevant independent (coded) variables, and associated estimators of parameters**

<table>
<thead>
<tr>
<th>Variable</th>
<th>Model</th>
<th>Parameter</th>
<th>Estimated value ± 95% confidence interval</th>
<th>Units</th>
<th>( R^2_{adj} )</th>
</tr>
</thead>
<tbody>
<tr>
<td>( b^* ) value</td>
<td>( Y_1 = b_0 + b_1 X_1 + b_2 X_1^2 + b_3 X_1 X_3 + b_4 X_1^2 + b_5 X_2^2 + b_6 X_1 X_4 + b_7 X_4^2 )</td>
<td>( b_0 )</td>
<td>10.2 ± 1.7</td>
<td>dimensionless</td>
<td>0.75</td>
</tr>
<tr>
<td></td>
<td></td>
<td>( b_1 )</td>
<td>-0.5 ± 0.2</td>
<td>( d^1 )</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>( b_2 )</td>
<td>3.3 ± 0.9</td>
<td>(vol/vol)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>( b_3 )</td>
<td>0.01 ± 0.01</td>
<td>(vol/vol)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>( b_4 )</td>
<td>0.02 ± 0.01</td>
<td>(vol/vol)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>( b_5 )</td>
<td>-0.15 ± 0.04</td>
<td>(vol/vol)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>( b_6 )</td>
<td>-2.4 ± 0.7</td>
<td>(vol/vol)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>( b_7 )</td>
<td>1.6 ± 0.9</td>
<td>(vol/vol)</td>
<td></td>
</tr>
<tr>
<td>Firmness</td>
<td>( Y_2 = b_0 + b_1 X_1 + b_2 X_1^2 + b_3 X_1 X_3 + b_4 X_1^2 + b_5 X_2^2 + b_6 X_1 X_4 + b_7 X_4^2 )</td>
<td>( b_0 )</td>
<td>14 ± 7</td>
<td>N</td>
<td>0.93</td>
</tr>
<tr>
<td></td>
<td></td>
<td>( b_1 )</td>
<td>15 ± 2</td>
<td>N x month</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>( b_2 )</td>
<td>-1.4 ± 0.2</td>
<td>N x month</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>( b_3 )</td>
<td>-0.96 ± 0.03</td>
<td>N x ( d^2 )</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>( b_4 )</td>
<td>0.08 ± 0.02</td>
<td>N x ( d^2 ) x (vol/vol)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>( b_5 )</td>
<td>-0.3 ± 0.2</td>
<td>N x ( d^2 ) x (vol/vol)</td>
<td></td>
</tr>
</tbody>
</table>

* Including only the statistically significant parameters
Fig. 1. Sensorial evaluation of pears (cv. Rocha) stored under air (■), 2 % (v/v) O₂ + 0.5 % (v/v) CO₂ (□), 2 % (v/v) O₂ + 1.5 % (v/v) CO₂ (◆), 3 % (v/v) O₂ + 0.5 % (v/v) CO₂ (□), and 3 % (v/v) O₂ + 1.5 % (v/v) CO₂ (●), in terms of yellow colour (a) and firmness (b) throughout storage.

Fig. 1. (cont.) Sensorial evaluation of pears (cv. Rocha) stored under air (■), 2 % (v/v) O₂ + 0.5 % (v/v) CO₂ (□), 2 % (v/v) O₂ + 1.5 % (v/v) CO₂ (◆), 3 % (v/v) O₂ + 0.5 % (v/v) CO₂ (□) and 3 % (v/v) O₂ + 1.5 % (v/v) CO₂ (●), in terms of juiciness (c) and sweetness (d) throughout storage.