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CHARACTERIZATION OF MATURITY PARAMETERS IN ESTHER AVOCADO *(Persea americana* Mill.) FRUITS DURING POSTHARVEST COLD STORAGE

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The evolution of different quality parameters during avocado cold storage was determined for different harvest days, storage temperatures and storage periods. Twelve 8-year-old trees were used, with three samplings being performed every month as of January 18th, 2006. Harvested avocado samples were stored for 10, 20 and 30 days at 4, 6 and 9ºC and evaluated after a storage period at 20ºC, once the fruit reached 0.5-0.9 k-f firmness. The evaluated parameters were dehydration, ripening time and skin and flesh colour (tristimulus colorimeter MINOLTA, model CR-300). The results of the evaluated parameters were analyzed through ANOVA according to a factorial randomized design of 3 x 3 x 3 (harvest dates x storage periods x storage temperatures). The results obtained indicate that for dehydration no differences were detected among treatments, with storage temperature and harvest date as determining factors. Ripening time showed differences attributable to harvest dates, storage periods and storage temperatures, and the determining factor was storage period. Skin and pulp colour presented differences attributable to harvest date.

CARACTERIZACIÓN DE PARÁMETROS DE LA MADUREZ EN FRUTOS DE PALTO (*Persea americana* Mill.) VARIEDAD ESTHER, DURANTE EL ALMACENAJE REFRIGERADO EN POSTCOSECHA

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El objetivo del estudio fue determinar la evolución de distintos parámetros de calidad durante el almacenaje refrigerado de la palta para distintas fechas de cosecha, temperaturas de almacenaje y períodos de guarda. Se utilizaron 12 árboles de 8 años de edad, efectuándose tres muestreos cada un mes a partir del 18 de enero de 2006. Las muestras de palta cosechadas, fueron almacenadas por 10, 20 y 30 días a 4, 6 y 9℃, y evaluadas luego de un período de almacenaje a 20℃, una vez que la fruta alcanzó 0,5 - 0,9 kg-f de firmeza. Los parámetros a evaluar fueron la deshidratación, tiempo de maduración, color de piel y color de pulpa (colorímetro triestímulo MINOLTA modelo CR-300). Los resultados de los parámetros evaluados fueron analizados mediante ANDEVA de acuerdo a un diseño al azar con estructura factorial 3 x 3 x 3 (fechas de cosecha x períodos de almacenaje x temperaturas de almacenaje). Los resultados obtenidos indican que para la deshidratación hubo diferencias entre tratamientos, y los factores determinantes fueron la temperatura de almacenaje y la fecha de cosecha. El tiempo de maduración arrojó diferencias atribuidas a la fecha de cosecha, período de almacenaje y temperaturas de almacenaje, siendo el período de almacenaje el factor preponderante. El color de piel y de pulpa mostró diferencias atribuidas a la fecha de cosecha.

Introduction

It is necessary to know and characterize the evolution of the metabolic processes involved in the maturation period, in order to determine the acceptability parameters of the fruit. Among them oil accumulation, size and fruit form, skin color and dehydration can be mentioned (Kader and Arpaia, 2002).
The dry matter percentage has a high degree of correlation with the oil content and is used as maturity index in California and in the main avocado producing areas. According to Covarrubias and Lizana (2006), the oil percentage of cv. Esther fruit harvested at mid December is of 4,5% with a 13,5% of dry weight, reaching a 13,6% of oil with a 23,3% of dry weight in the middle of March, for the Cabildo zone, V region of Chile. Besides, a high relation (R^2= 0,96) between the oil content and the dry weight percentage of fruits was found.
The temperature for the long term storage must be as low as possible, but not able to cause physiological disorders neither fruit freezing. Avocados, in general terms, are stored at temperatures between 6 and 8ºC, depending on the cultivar (Berger et al., 1978; Luza et al., 1979; Lizana et al., 1991 and 1993; Lizana and Figueroa, 1997). There is no evidence for Esther cultivar. According to Gardiazabal and Rosemberg (1991), the best temperatures for avocado maturation is between 15,5 and 23,5ºC. Higher temperatures than 25,5ºC produce an accelerated softening and a fast dehydration, discoloration and flavor loss.

Objective

The objective of this study was to determine the evolution of different quality parameters during cold storage in avocado cv. Esther for different harvest dates, storage temperatures and storage periods.

Materials and Methods

The fruit was obtained from 12 trees selected according to growth uniformity, 8 years old, from a monthly sampling starting on January 18, 2006, during 3 months. The harvested avocado samples were stored for 10, 20 and 30 days at 4, 6 and 9ºC and were evaluated after a maturation period at 20ºC, once the fruit reached a firmness between 0,5-0,9 kg-f (measured with manual penetrometer, 7,9mm diameter probe). Also fruit maturated at 20ºC without previous cold storage was evaluated.
The parameters under evaluation were dehydration, maturation time after storage, skin and flesh color (measured with a Minolta Triestimulus Chromameter model CR-300). The color component analyzed was the hue angle value (H_{ab}).

For each storage temperature, 3 boxes of 12 fruits each, originating from different plants were used. The experimental unit was a box. In each evaluation, 3 fruits per box were analyzed. A completely randomized design was used, with a factorial structure 3x3x3 (harvest dates x storage periods x storage temperatures). The results were analyzed by ANOVA and Tukey's multiple range test with significance $P<0.05$.

Results and Discussion

Time for maturation after cold storage removal

In this parameter, there were two interactions. The first, between the date of harvest and temperature factors, and the second, between the harvest date and storage period factors.

In the first interaction, the statistical indicators show that harvest date had an incidence in the answer near to 66%. The results showed significant differences between the fruit harvested on February and March and stored at 6 and 9ºC and the fruit harvested in January and stored at 4ºC. The rest of the treatments showed results that situate in an intermediate position between the two groups mentioned above.

The fruit harvested in March presented a similar behavior to the range obtained for fruit harvested in February. The fruit harvested in January took in average 10 days to reach consumption maturity after its removal from cold storage, while the fruit harvested in February took 6,9 days and the one harvested in March 7 days, independent of the cold storage period (Figure 1).

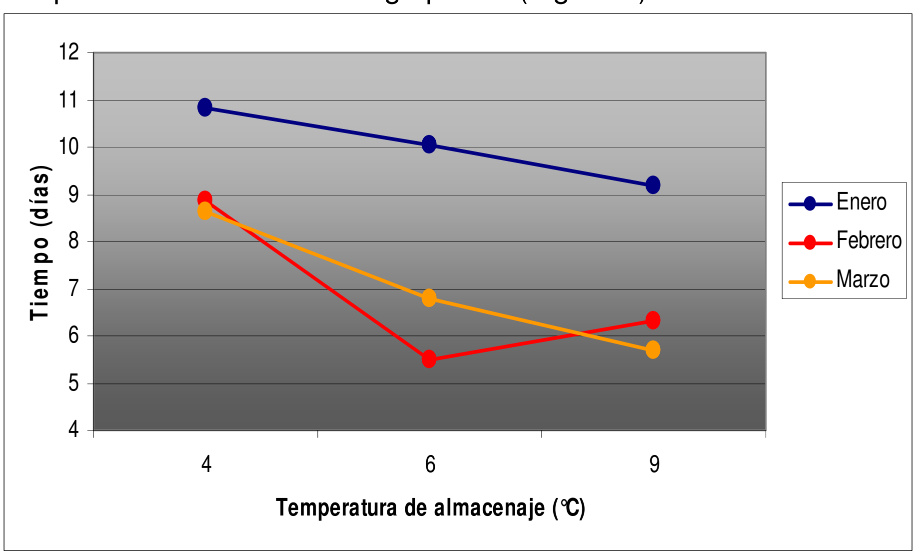

Figure 1. Time in reaching consumption maturity after cold storage removal, for the interaction of the storage temperature and harvest date factors for fruit stored up to 30 days.

For temperature, while lower the storage temperature, more time is necessary for the fruit to reach consumption maturity after cold storage removal. Fruit stored at 4ºC took in average 9,4 days, at 6ºC took 7,4 days and at 9ºC took 7,1 days, independent of the cold storage period.

The phenomenon observed for the storage temperature could be attributed to the fact that while the storage temperature is higher, the metabolic rate of the maturation process integrated by the different maturity parameters is greater, so the fruit leaves the cold storage with a higher maturity degree.

Inside the second interaction, the cold storage period had an incidence in dehydration near to 77%. Those fruits harvested in January, February and March and stored for 30 days in cold storage and the fruits harvested in February and stored for 20 days, showed significant differences with respect to the rest of the treatments of the interaction (Figure 2).

The results allow to affirm that while the fruit was stored longer in cold storage, it took less time to reach consumption maturity after removal from the cold storage. The fruit that was cold stored for 10 days, took 10,7 days in average to reach consumption maturity, while the fruit cold stored for 30 days, took 4,5 days in average.

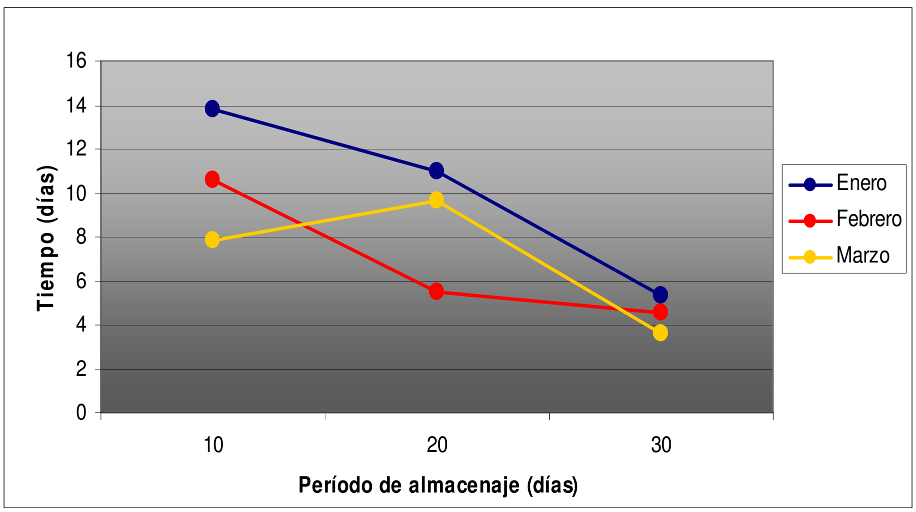

Figure 2. Time to reach the consumption maturity from the cold storage removal, for the interaction between the factors storage periods and harvest dates for fruits stored at 4, 6 and 9ºC.

Dehydration

For this parameter, interaction between the factors harvest date and storage period was observed. The statistical indicators point out that the harvest date has an incidence on dehydration near to 72%. In Figure 3, it can be observed that fruit that was harvested in March and stored for 10 and 30 days was the less dehydrated (8,4 and 8,2%, respectively) and presented statistical differences with respect to fruit harvested in January and stored for 10 and 20 days (18,1 and 14,1%, respectively).

The water loss affects the appearance of the fruits from this specie if it is greater than 10% (Luza et al., 1979), event that occurred in some treatments in this experiment.
Studies carried out by Covarrubias and Lizana (2006) indicated that the humidity percentage inside the fruit is greater while lower is the degree of maturity, therefore this could be a cause for the greater water loss in the fruit harvested earlier.
In general terms, it can be affirmed that the earlier the fruit is harvested, the dehydration percentage is greater.
On the other hand, the cold storage period plus its maturation at 20ºC, affects dehydration. The fruit that was stored for a shorter period of time dehydrated in a higher percentage when reaching consumption maturity, than the fruit that was stored for a longer period of time.

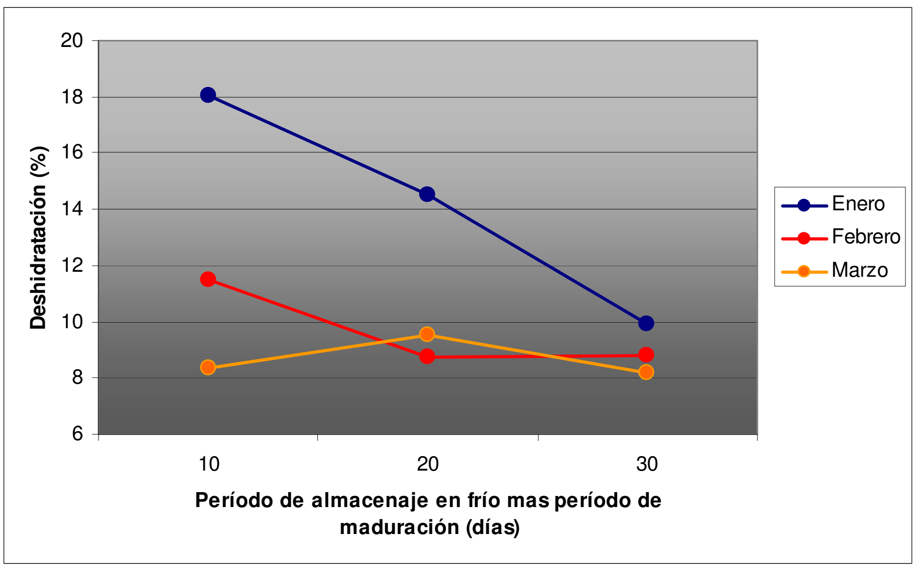

Figure 3. Dehydration percentages for the interaction between the storage periods and harvest date factors, for the fruit stored at 4, 6 and 9ºC.

The greatest dehydration in the fruit that was cold stored during shorter periods of time (10 days) could be due to the fact that at the moment the fruit was harvested and at the moment in which the fruit reaches consumption maturity, it passed a longer maturity time at room temperature than at the cold storage. On the other hand, the fruit that was cold stored for a longer time, passed the most part of its maturation within storage, what could have caused that this fruit dehydrated less.
The temperature factor showed significant differences between the treatments that compose it, in an independent way from the rest of the factors. The results show that fruit stored at 9ºC obtained a dehydration percentage significantly lower (9,6%) than fruit stored at 6ºC (12,1%). The fruit stored at 4ºC obtained a dehydration percentage of 10,1% (Figure 4).

Skin Color

In the skin color, storage temperature and storage period factors did not show an interaction between them, neither with the harvest date factor. They did not show significant differences as independent factors, nevertheless the harvest date factor presented differences in its results.
The fruit harvested in January and February, showed significant differences in hue angle values with respect to fruit harvested in March, independent of temperature and storage period (Figure 5).
It can be affirmed that fruit harvested in March (116,2) obtained a lower hue value than fruit collected in January (120,9) and February (121,3). According to this, the fruit harvested in March obtained a darker skin hue angle value, similar to the original.

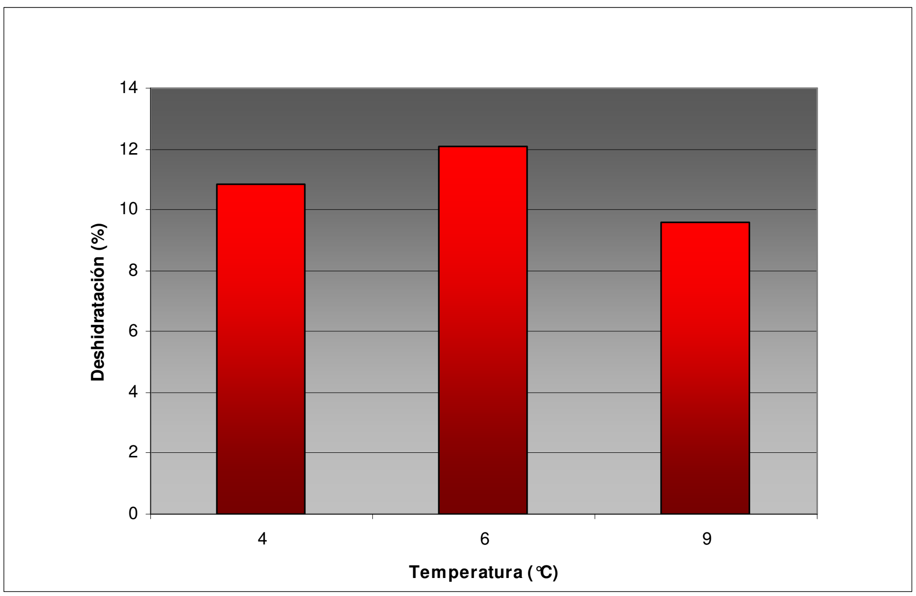

Figure 4. Dehydration percentages for the different cold storage temperatures of the fruit harvested in three dates and stored up to 30 days.

Flesh Color
With respect to the flesh color, the storage temperature and storage period factors did not show interaction between them, neither presented significant differences as independent factors, nevertheless the harvest date factor presented differences in its results.
The fruit harvested in February and March showed significant differences in hue angle values with respect to the fruit harvested in January, independent of the temperature and the storage period (Figure 6).

Figure 5. Hue angle values (H_{ab}) in the fruit stored for three periods and three temperatures, for three harvest dates.

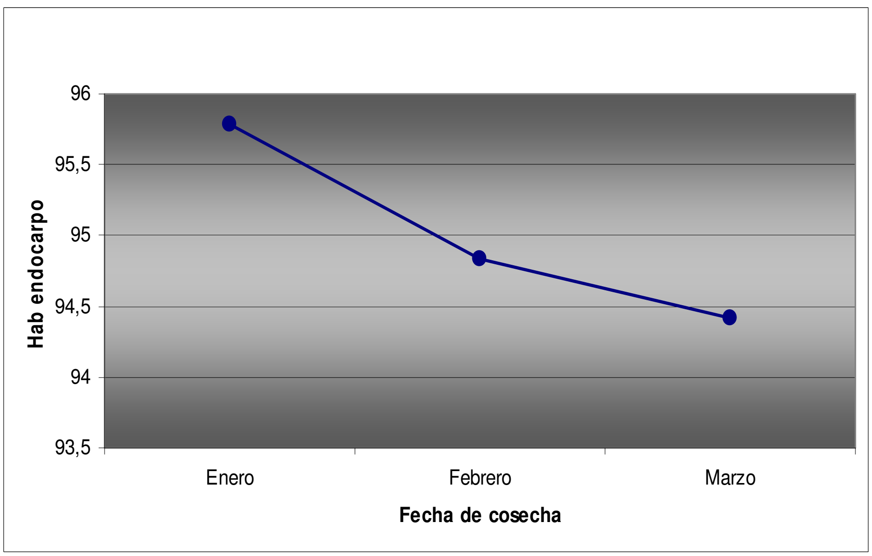

Figure 6. Hue angle values (H_{ab}) in the endocarp of fruit stored for three periods and three temperatures, for three harvest dates.

It can be affirmed that the fruit harvested in the month of January (95,8) obtained a higher hue angle value than fruit collected in February and March (94,8 and 94,4, respectively). According to this, avocado fruit harvested in January presented a lighter hue angle value compared to the rest of the treatments.

The mesocarp hue angle value did not show interaction between the harvest date, storage temperature and storage period factors, neither presented significant differences among the factor levels in an independent form.

Conclusions

The harvest date, cold storage period and storage temperature factors, cause variations in the commercial aspect of some maturity parameters of avocados cv. Esther, after its storage.

According to the obtained values, the fruit harvested in the month of March and stored for a period of 30 days, suffer the lowest dehydration.

Fruit collected in March, stored at 9ºC and for a period of 30 days, take the shortest time to reach consumption maturity, after removal from cold storage.

Skin color of fruit collected in January and February is different to the color of the fruit harvested in March after cold storage, being the fruit collected in March the one that maintains in the best way its original hue angle value.

Flesh color of fruit collected in January, presents a lighter color compared to the fruit harvested in February and March after cold storage, being this last the ones that maintain in the best way its original hue angle value.

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