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INCIDENCE OF COLD STORAGE OF ESTHER AVOCADO (*Persea americana* Mill.) FRUIT ON THE OCCURRENCE OF POSTHARVEST PHYSIOLOGICAL DISORDERS

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The effect of avocado cold storage on the occurrence of post-harvest physiological disorders was determined for different harvest dates, 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. Evaluated parameters were fibre browning, internal browning intensity, percentage of flesh with internal browning, percentage of external spots and seriousness of grey spots. For the different parameters, avocado fruits were evaluated by means of a grading scale. The results were analyzed by ANOVA according to a factorial randomized design of 3 x 3 x 3 (harvest dates x storage periods x storage temperatures) and by the Kruskall-Wallis test when the data did not comply with the assumptions of normality and equality of variance. The results obtained indicate that for fibre browning differences were detected among treatments, attributed to harvest dates, storage periods and storage temperatures, with harvest dates as determining factors. Regarding the intensity of internal browning, percentage of pulp with internal browning, percentage of outer spots and seriousness of grey spots, no statistically significant differences among treatments were found.

INCIDENCIA DEL ALMACENAJE REFRIGERADO DE FRUTOS DE PALTO (*Persea americana* Mill.) VARIEDAD ESTHER, EN LA MANIFESTACIÓN DE DESÓRDENES FISIOLÓGICOS DE POSTCOSECHA

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El objetivo del estudio fue determinar el efecto del almacenaje refrigerado de la palta, en la manifestación de desórdenes fisiológicos de poscosecha para distintas fechas de cosecha, temperaturas de almacenaje y períodos de guarda. Se utilizaron 12 árboles de 8 años de edad, efectuándose tres muestreos por 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°C, y evaluadas luego de un período de almacenaje a 20°C, una vez que la fruta alcanzó 0,5 - 0,9 kg-f de firmeza. Los parámetros a evaluar fueron el pardeamiento de fibras, intensidad de pardeamiento interno, porcentaje de pulpa con pardeamiento interno, porcentaje

de manchas externas y severidad de manchas grises. Para los distintos parámetros, la fruta fue evaluada mediante una escala de clasificación. Los resultados 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) y mediante la prueba de Kruskal Wallis, cuando los datos no cumplieron con los supuestos de igualdad de varianzas y normalidad. Los resultados obtenidos indican que para el pardeamiento de fibras hubo diferencias entre tratamientos, atribuibles a la fecha de cosecha, período de almacenaje y temperatura de almacenaje, siendo la fecha de cosecha el factor preponderante. Para la intensidad del pardeamiento interno, el porcentaje de pulpa con pardeamiento interno, porcentaje de manchas externas y severidad de manchas grises, no hubo diferencias estadísticamente significativas entre los tratamientos.

Introduction

Among the parameters that influence fruit quality and acceptability, the presence of defects, such as the physiological disorders that develop during fruit storage, can be mentioned (Kader and Arpaia, 2002). On the other hand, if fruit is harvested in a development period in which it is physiologically immature, the results would indicate an irregular maturation, lack of flavors and physiological disorders (Lizana *et al*., 1992).

Considering that the fruit is a living product, and as such it respires, this process may be accelerated or retarded depending on temperature. In the avocado specific case, high temperatures accelerate respiration, producing a fast flesh softening and posterior decomposition of the harvested fruit (Barrientos, 1993).

A fruit such as avocado, original from tropical regions, is sensible to low temperatures and the damage is presented as physiological disorders. A physiological disorder constitutes an alteration in the fruit tissue that is not caused by pathogens neither by mechanical damage, being able to develop because of nutritional deficits or as an answer to an adverse environment, such as temperature or atmospheric composition. Chilling injury is a physiological alteration produced in fruit exposed during storage to temperatures higher to the freezing point, but lower than the critical range of the cultivar. The damage magnitude depends on how low the temperature is and the time the fruit is exposed to it. In avocado, low temperature damages may be present during cold storage or may be expressed or /and intensified after transferring the fruit to room temperature (Aguirre *et al*., 1994).

Generally, different browning problems are associated to chilling injury. External browning is the clearest symptom in those cultivars that in a normal maturity stage have green colored skin. In cases of low damage it is presented as necrotic punctuations and in severe damage it is expressed as irregular spots that darken with time until turning brown or almost black. Flesh browning corresponds to delimited spots, brown colored or light gray to dark brown (Berger *et al*., 1992), sometimes its presence can be visualized immediately after the cut, increasing the browning intensity with air exposition time (Lizana *et al*., 1992; Aguirre, 1994).

Vascular or fiber browning is when the vascular tissue changes color, from yellowish light green to light brown or black presented more intensely in the basal and distal fruit zone. The first symptoms appear in the distal portion of the fruit, as dots, being capable of extending across the flesh in extreme cases (Lizana *et al.*, 1992). This disorder is expressed in fruit that matures at harvest, reason why it can be affirmed that it is not a low temperature induced damage, but it accentuates during cold storage (Barrientos, 1993).

Objective

The objective of this study was to determine the effect of cold storage in the expression of postharvest physiological disorders in avocados cv. Esther for different harvest dates, storage temperatures and storage periods.

Material 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 evaluated parameters were physiological disorders whose damage was classified through a classification scale from 1 to 5. Fiber browning (Table 1), intensity of internal browning (Table 2), percentage of flesh with internal browning (Table 3), percentage of external spots (Table 4) and severity of gray spots (Table 5), were evaluated.

Table 1. Classification scale according to the percentage of fruit affected with external spots used in the trials.

Degree	% of affected fruit
1	0
2	Less than 25% of the surface
3	Between 25 and 50% of the surface
4	More than 50% of the surface

Table 2. Classification scale according to the intensity of internal browning used in the trials.

Degree	Intensity	Color
1	Healthy	Natural
2	Low	Very light brown
3	Moderated	Light brown
4	Severe	Dark brown
5	Very severe	Very dark brown

Table 3. Classification scale according to the percentage of internal browning used in the trials.

Degree	% of affected flesh
1	Does not exist
2	Zone adyacent to the seed
3	Less than 25%
4	Between 25 and 50%
5	More than 50%

Table 4. Classification scale according to the severity of gray spots used in the trials.

Degree	Clasification	N° of spots
1	Does not exist	0
2	Low	1
3	Moderated	2 - 4
4	Severe	5 - 10
5	Very severe	> 10

Table 5. Classification scale according to the intensity of fiber browning used in the trials.

Scale	Intensity
1	Healthy
2	Low, browning as spots in the base of the fruit
3	Moderated, browning across the flesh
4	Severe, dark brown fibers in the flesh
5	Very severe, dark brown across all the flesh

For each storage temperature three 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

External spots. The results did not show significant differences between the different factors. In general, fruit with spot damage was not observed.

Internal browning. In this parameter, the trial results did not show significant differences between the different factors. In general, fruit with internal browning was not observed.

Gray spots. In this parameter, the trial results did not show significant differences between the different factors. In general, fruit with spot damage was not observed.

Fiber browning. The fruit harvested in the three dates did not show symptoms of this disorder in its maturation at 20ºC, without previous cold storage. Interaction between harvest date and temperature factors was observed. Also interaction was registered between the periods of storage, storage temperature and harvest date factors.

For the data obtained from the interaction between the harvest date and storage temperature factors, the harvest date has an incidence near 96% in the fiber browning. In this way, the fruit harvested in March and stored at 4 and 6ºC, presented the least damage and showed statistical differences with respect to the fruit harvested in January and stored at 6 and 9ºC and the fruit harvested in February and stored at 4ºC (Figure 1).

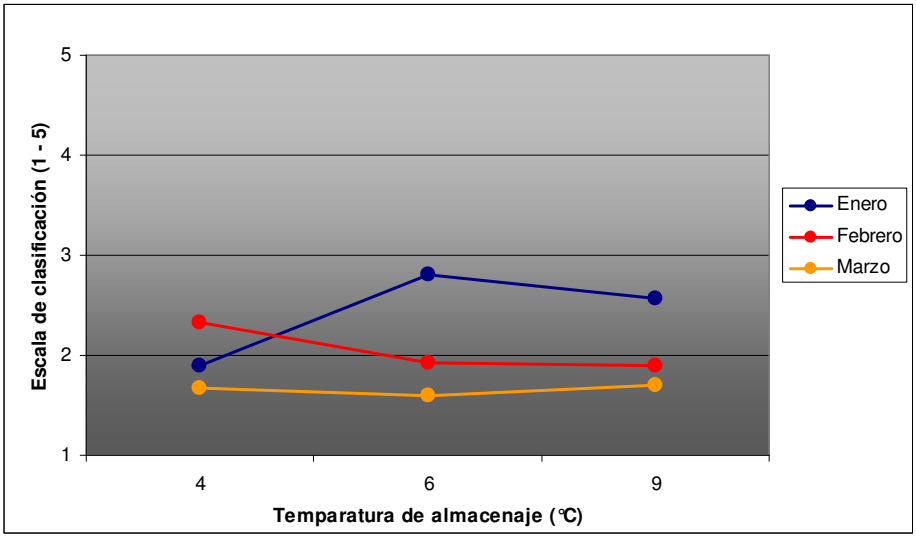

Figure 1. Fiber browning level for the interaction between storage temperature and harvest date, for fruit held in cold storage up to 30 days.

It can be affirmed that while earlier the fruit is harvested, the incidence of fiber browning is greater.

The fruit that was stored at 4ºC obtained a lower damage level that the fruit stored at 6 and 9ºC. Nevertheless, the fruit stored at 6ºC obtained a greater level of fiber browning that the one stored at 9ºC, phenomenon that could be due to the irregular conditions of the chamber that stored fruit at 6ºC.

It is important to mention that the fruit harvested in January presents an increase in the damage level as the fruit is stored at higher temperatures. Nevertheless, the fruit harvested in February and March, decreases the damage levels as the storage temperature is increased. The fruit harvested in March showed a constant behavior in its damage levels, with respect to the temperature.

It may be that the answer of fiber browning to the storage temperatures has a relationship with the degree of development or fruit maturity. According to Covarrubias and Lizana (2006), the oil percentage of fruits cv. Esther harvested on mid December is of 4,5% reaching a 13,6% in the middle of March, for the Cabildo zone, V region of Chile. It may be affirmed that while more advanced the development degree, the damage incidence is lower and the different storage temperatures have less responsibility in the answer to this physiological disorder.

In respect to the interaction between the storage period and storage temperature factors, the storage period has an incidence in the fiber browning near to 84% (Figure 2).

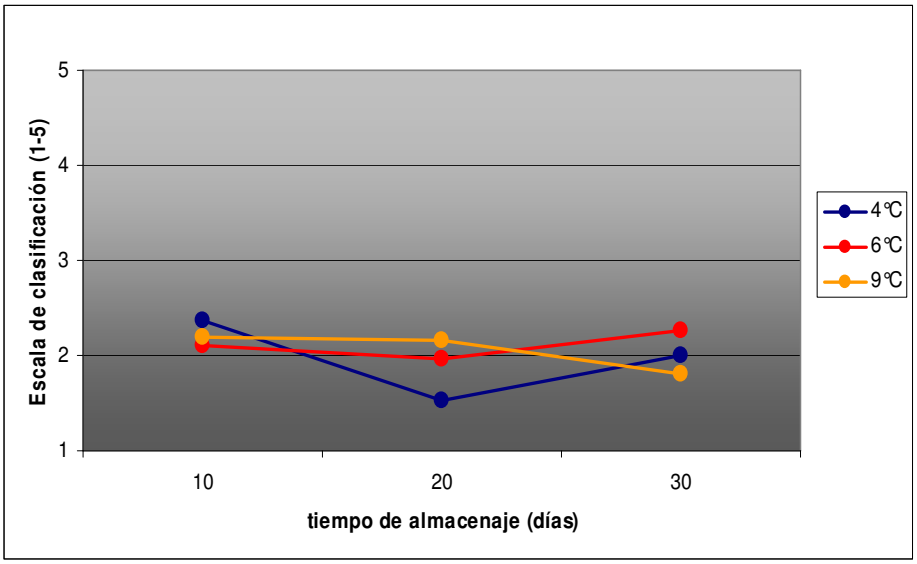

Figure 2. Fiber browning level for the interaction between storage time and storage temperature, for fruit harvested in three dates.

The fruit stored for 10 days in cold storage obtained a higher damage level than the fruit stored for 20 and 30 days. Nevertheless, the fruit cold stored for 20 days obtained a damage level lower than the fruit stored for 30 days. The interaction does not show a clear tendency of the factor effects in the fibers browning.
For the data obtained in the interaction between the storage period and harvest date factors, the harvest date has an incidence in the fiber browning near to 83%. In this way, the fruit that was harvested in March and cold stored for 10, 20 and 30 days, obtained lower damage incidence levels with respect to the fruit that was harvested in January and stored during 10 and 30 days in cold storage (Figure 3).

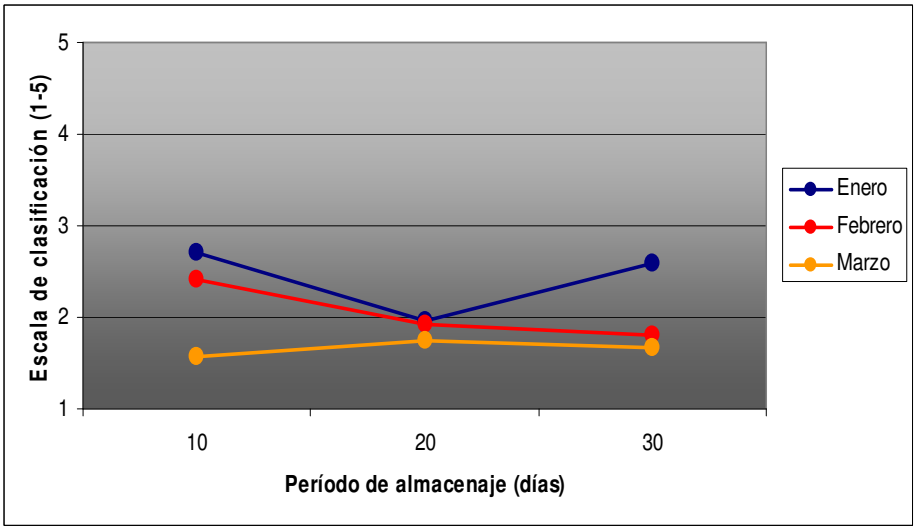

Figure 3. Fiber browning level for the interaction between storage period and harvest date, for fruit stored at three temperatures.

The interaction shows, as well as in the previous case, that the fruit harvested in March presents a constant answer to the fiber browning damage, independent of the cold storage period. The fruit harvested in February tends to diminish the damage as the cold storage period increases. The fruit harvested in January did not show a regular tendency in its behavior, therefore the answer cannot be attributed to any factor.

Conclusions

The harvest date, cold storage period and storage temperature, do not influence in the physiological disorders of external spots, internal browning and gray spots, nevertheless it does influence the fiber browning, after cold storage.
According to the values obtained in the different evaluated parameters, a greater benefit of storage at low temperatures exists in fruit harvested in March and stored at 4ºC.

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