Developing methods for prolonged storage of avocado fruits by using modified atmosphere

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Abstract:

The effect of modified atmosphere packaging (MAP) on the keeping quality of 'Hass' and 'Fuerte' avocado fruits during storage was studied, in order to understand the physiological basis of MA storage, and to examine the possibility of commercial application of the method for prolonged avocado storage. In addition, we have examined the effect of MAP storage conditions on the following factors:

(a) Physiological parameters of fruit ripening, such as firmness and rates of respiration and ethylene production;

(b) Fruit weight-loss that stems from water evaporation and its physiological significance;

(c) Increase of storage temperature (from 5 to 7ºC) for alleviation of chilling injury, assuming that fruit ripening will be retarded by MAP also at the elevated storage temperature;

(d) The possible correlation between polyphenol oxidase (PPO) activity and chilling injury associated with tissue browning following storage;

(e) The possible correlation between fruit water loss and changes in concentration of Ca^{2+} ions in various fruit regions during storage and shelf life.

The effects of the thickness of polyethylene (PE) liner, storage temperature and fruit quantity on maximal storage duration of 'Hass' and 'Fuerte' fruits without appearance of chilling injury symptoms, were examined. Additionally, the effect of $CaCl_2$ treatments (applied in various concentrations and methods) on improving MAP storage of 'Fuerte' fruits was examined. Experiments were performed at 5 and 7ºC, using 2400 cm^2 PE liners of 30, 40 or 50 µ thickness.

Results show that neither the PE thickness nor the tested storage temperatures affected significantly the atmosphere composition created within the package. On the other hand, the concentrations of oxygen and CO_2 obtained at equilibrium within the package and the time required to reach this equilibrium were strongly dependent on the quantity of sealed fruits.

Elevated (5-7%) concentrations of CO_2, combined with reduced (3-5%) oxygen concentrations, created within the packages by 3.5-4 kg of 'Fuerte' or by 2.2-3.5 kg of 'Hass' avocado fruits, made possible their prolonged storage at low temperatures for 8

and 9 weeks, respectively. Hence, MA retarded fruit softening, prevented color changes (in 'Hass' fruits), and enabled subsequent normal fruit ripening at 20ºC without development of chilling injuries. Additionally, the MAP storage reduced significantly weight loss of fruits, which did not exceed 1% after 9 weeks (compared to 6-7% in control fruits after 6 weeks). Ethylene concentrations accumulated within the packages were around 0.3-2 µl/l and did not affect fruit ripening. Therefore, addition of ethylene absorbers to the packages was not necessary. Only when oxygen concentrations within the package dropped to 2-3% during the first week of storage (with 4-4.2 kg 'Hass' fruits), symptoms typical to low-oxygen damage were detected.

During storage no significant differences in PPO activity could be found between fruits stored under MAP or in perforated bags. However, following complete softening in shelf life, an increased PPO activity could be observed in MAP stored fruits as compared with fruits stored without packaging. No correlation between PPO activity and pulp discoloration associated with chilling injury could be found, since packaging treatments that reduced significantly these chilling injury symptoms did not affect PPO activity.

Dipping 'Fuerte' fruits in $CaCl_2$ prior to MAP storage did not affect the gas composition within the package, nor the rate of fruit softening during shelf life. A decrease in the Ca^{2+} ion concentration in the pulp, accompanied by a corresponding increase in Ca^{2+} ions in the peel region, was observed during fruit ripening in shelf life, when water loss reached 6-7%. Similar results were obtained during regular storage, whereas MAP storage, which reduced water loss, abolished these differences in Ca^{2+} ion concentration within fruit regions. These variations in Ca^{2+} ions concentration may stem from the evaporating water movement that carry the Ca^{2+} ions from the fruit center towards the peel. Since chilling injury symptoms appear mainly in the pulp, these results may indicate that the reduction in Ca^{2+} ion concentration may play a significant role in the chilling susceptibility of the pulp. These results further show the advantage of MAP storage in preventing chilling injury of avocado fruits.

The results of this study show for the first time that MA in a commercial packaging is beneficial in extending storage durations of avocado cultivars while maintaining fruit quality, and therefore offers potential advantages for commercial use. In addition, prevention of fruit weight loss by MAP may represent another advantage of this simple method, compared with avocado storage under controlled atmosphere.