Proc. of Second World Avocado Congress 1992 pp. 463-466

Long-Distance Controlled Atmosphere Transport of Avocados

G.J. Eksteen
PPECB, P O Box 15289, Panorama 7506, Republic of South Africa

A.B. Truter
FFTRI, Private Bag X5013, Stellenbosch 7600, Republic of South Africa

L.L. Vorster
Westfalia, P O Box 14, Duivelskloof 0835, Republic of South Africa

Abstract. **Low temperature storage is essential for long-distance transport of avocados but results in chilling injury if the temperature is too low and physiological disorders and waste, if a the temperature is too high. Controlled atmosphere (CA) storage can extend storage life, maintain quality, drastically reduce chilling injury and allow storage at lower temperatures.**

Controlled Atmosphere Applications

Optimum CA conditions for avocado fruit. Best results are obtained by storing avocados at 2% to 5% oxygen and up to 10% carbon dioxide (Eksteen and Truter, 1983; Kader, 1989). Optimum storage temperatures vary between 4.4C and 13C (Hardenburg *et al.,* 1986). The average optimum for South African grown avocados is 5.5C but Vorster *et al.* (1990) have found that a temperature management system whereby the transit temperature is reduced from 7.5C to as low as 3.5C gives best results for long-distance transport.

The relative humidity in the storage atmosphere should preferably be in the 90% to 95% range because it was found that moisture loss may increase chilling injury (Bower and Cutting, 1987). The avocado being a climacteric fruit should be stored and transported at very low ethylene levels in the atmosphere to reduce early softening. Efficient ethylene removal systems are, however, still under development (Heap, 1989).

Reason for CA storage. The following advantages can be obtained with CA storage of South African grown avocados (Eksteen and Truter, 1983):

1. Storage and shelf life can be increased considerably;
2. Chilling injury can be drastically reduced; and
3. Physiological disorders such as vascular abnormalities and mesocarp discoloration can be reduced to an absolute minimum.

Practical Application. CA storage must be cost-effective and must result in less quality losses and increased storage and shelf life. It must also be practical, easy and safe to apply and must not require very sophisticated expensive equipment.

These above mentioned benefits were applied in practice when 'Hass' avocados were shipped from Australia to France. This was a six-week journey and the fruit arrived in a very good condition (McGlasson, 1989).

With an 8-day shipping schedule (16- to 19-day voyage), from South Africa to Europe, it is important that all the fruit should be sold by the time the next vessel arrives. Extended CA storage life is therefore not that important, but the better external and internal quality and extended shelf life that can be obtained with CA transport stabilizes the market and builds consumer confidence.

Extension of storage life without quality loss may, however, be to the advantage of production areas or countries situated close to the market (e.g. Israel) since the marketing period of a specific cultivar or the marketing season can be extended by at least two to three weeks with CA storage.

CA storage and distribution systems. CA cold stores have little practical benefit in a long distance marketing system except that it may be utilized to extend storage life. In such a situation, the fruit can be CA-stored prior to regular atmosphere (RA) air freight to a distant market or to shipping under CA (longer distances) or RA (shorter distances). In this case, it is of absolute importance to apply the CA treatment as soon as possible after harvest.

CA containers combine the CA concept with a practical and economical transport system. It has been proven (McGlasson, 1989) that avocados can be shipped successfully for six weeks (Australia to France) in CA containers. This concept allows for in-transit application of CA storage, but problems with RH and temperature control and gas tightness were experienced (Little *et al.,* 1989). CA containers can be used as a door to door system, provided an economical and reliable infrastructure exists. Electronic programmable CA containers make it possible to change storage atmosphere and temperature en route. Most optimum carrying conditions can be pre-selected and applied without further manual interference (Eksteen and Truter, 1989). Another very important feature is that the container can change from a storage condition into an atmosphere conducive for fruit ripening by changing to the normal atmospheric situation, introducing ethylene and increasing the temperature at a pre-programmed time. This concept, if all functions operate correctly, will result in reduced losses, better quality and ready-to-eat fruit when required.

Cost and reliability of the container, shipping and transport cost and an effective supporting infrastructure are factors to be considered before venturing into long distance transport of avocados in CA containers.

CA vessels or decks. CA decks or chambers on ships can be regarded as floating CA cold stores. The same results can be expected as with CA stores if the storage conditions are kept optimum. One of the major problems, however, is to maintain a gas-tight seal in a structure with relative movement between different components. For best results, CA must be applied soon after harvest. This may be a problem in countries such as South Africa where the major production areas are approximately 30 hours by refrigerated truck from the port.

Another aspect that needs very careful consideration is that big volumes have to be shipped to make the operation economically viable. Such large volumes may not be readily available within a few days or may create marketing problems where large volumes have to be sold within a limited period. CA-shipments may, however, combine the benefits of CA storage with a relatively low cost transport system. This can make long distance transport very feasible in supplying a sophisticated market with good quality fruit.

Modified Atmosphere Applications

Modified atmosphere (MA) conditions are achieved by enclosing the fruit in a polyethylene bag or wrapping it in a permeable film or container. Various gas pre-treatments can also, for the purpose of this discussion, be regarded as MA storage. These systems, however, may not always have the same or consistent end results when compared to CA. Reasons for this are that the optimum conditions cannot always be maintained at desired levels for prolonged periods. Another problem is that the normal atmosphere must be restored after a certain period of pre-treatment or prior to ripening.

MA Packaging. Avocado fruit individually packed in polyethylene or cellophane bags were previously exported from South Africa to Europe. The polyethylene bags reduced chilling injury as well as internal physiological disorders (Eksteen and Truter, 1983). (This concept was replaced by fruit waxing). Under this system there was a tendency to develop more anthracnose and other fruit rots when packed in bags.

Pre-conditioning atmospheres. Avocado fruit respond very well to treatment with 20% to 25% carbon dioxide immediately after harvest. Best results are obtained with a 48 to 72 hour exposure to these conditions at 5.5C. The physiological effects on the enzyme systems (ABA, PPO etc.) are very similar to the effects of CA storage (Truter *et al.,* 1991). A CO_2 shock treatment prior to RA shipping may therefore be a very practical and economical consideration.

Possible Handling And Long-Distance Transport Systems

The application of CA in any transport system is dictated by many factors of which economical considerations, logistics and availability of suitable equipment are only a few. The transport chain may be divided into three distinct areas; i.e. packhouse cold store to port of export, port of export to port of import, and port of import to market.

On land CA store followed by CA container road and/or sea transport or CA deck shipping. This concept may be less feasible because of no or little off-season utilization of cold store and loss of valuable storage/transport time to distant markets. On land CA storage, however, allows for immediate preconditioning of fruit prior to MA or RA shipping where CA shipping is not available.

Door to door CA container followed by CA container road and/or sea transport or CA storage post shipping. This concept may be the ideal because it allows for immediate and continuous CA shipping. Cost and logistics are, however, important considerations especially where the production area is far from the port and if CA containers are not readily available.

Immediate CA shipping. This can be done by either port-to-port CA shipping or CA storage post-shipping. This concept can be utilized if CA conditions can be applied very soon after picking. The production area must be close to the port and CA vessels must be scheduled to avoid delays. On-land CA storage may be implemented after discharge provided that the optimum storage period is not exceeded.

Gas pre-conditioning of the fruit followed by CA container or CA deck shipping or RA road and/or sea transport. This concept may be more practical, economical and quality effective and can be done at the packhouse or during road transport to the port. It does not require expensive equipment and can combine immediate pre-conditioning followed by RA shipping.

MA packaging followed by RA storage and transport only. MA packaging should never be combined with CA because of the restriction of gas movement caused by the MA film or membrane. Although it allows for longer storage and long distance transport, the MA film should be removed prior to marketing to avoid fermentation and to trigger ripening.

RA shipping with either gas preconditioning or MA packaging. Actual RA shipping period should not exceed 21 days unless the fruit is preconditioned or some sort of MA is applied. Both treatments have a limited effect and are not really designed for long distance transport and marketing.

Conclusions

A controlled atmosphere environment for long distance transport should only be considered if it is economically and practically feasible. CA vessels can only be used for port to port transport and decks must be filled rapidly requiring fast packing of big volumes. The latter may create marketing pressure. CA containers make a door to door concept possible and allow for much more flexibility in picking, shipping and marketing. Pre-treatment with various gasses with or without MA procedures do not really extend storage life of avocados, but may result in less quality loss during transport and marketing. CA pre- or post-shipping storages do not contribute towards long distance transport, but may extend the marketing season.

Literature Cited

Bower, J.P. and J.G.M. Cutting. 1987. Some factors affecting post-harvest quality of avocado fruit. S. A. Avocado Growers' Assn. Yrbk. 10:143-146.

Eksteen, G.J. and A.B. Truter. 1983. Controlled atmosphere storage and polyethylene bag packing of avocados. Proceedings XVIth International Congress of Refrigeration, (Paris, 1983) C2-424:307-311.

Eksteen, G.J. and A.B. Truter. 1989. Transport simulation test with avocados and bananas in controlled atmosphere containers. S. A. Avocado Growers' Assn. Yrbk. 12:26-32.

Hardenburg, R.E., A.E. Watada, and C.Y. Wang. 1986. The commercial storage of fruits, vegetables and florist and nursery stocks. United States Department of Agriculture Handbook 66.

Heap, R.D. 1989. Long distance transport of tropical fruit. Aspects of Applied Biology 20:33-40.

Kader, A.A. 1989. A summary of CA requirements and recommendations for fruits other than pome fruits. Fifth Proceedings, International Controlled Atmosphere Research Conference, Wenatchee, Washington, USA, 2:303-328.

Little, C.R., R.B. Tomkins, and G.R. Rigby. 1989. Controlled atmosphere transport of horticultural produce. International Controlled Atmosphere Research Conference, Wenatchee Washington, 1:429-439.

McGlasson, W.B. 1989. MA packaging a practical alternative to CA shipping containers. Fifth Proceedings, International Controlled Atmosphere Research Conference, Wenatchee, Washington USA, 2:235-240.

Truter, A.B., J.G.M Cutting, J. Bower, and S. Van Eeden. 1991. Effect of modified atmospheres on internal physiological browning of 'Fuerte' avocados. S. A. Avocado Growers' Assn. Yrbk. 14:50-52.

Vorster, L.L., J.C. Toerien, and J.J. Bezuidenhout. 1990. Temperature management of avocados - an integrated approach. S. A. Avocado Growers' Assn. Yrbk. 13:43-46.