Australian Postharvest Technologies for Fresh Fruits and Vegetables

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Abstract

General postharvest handling systems and technologies used in Australia for broccoli and other fruits and vegetables from harvest to wholesale market are presented to contrast with those in China. With production areas usually a considerable distance (e.g. 100 to 3500 km) from the major markets in the capital cities, appropriate systems and technologies are needed to minimise losses and maintain product integrity and quality while ensuring food safety. Aspects covered include field harvest (harvest aids, packing), packing houses (handling, grading, sorting, packing, cooling, pallet/unitisation), storage and transport (refrigeration, mixed loads), and wholesale markets.

WHILE Australia and China are of comparable areas, their horticultural production, storage, and distribution systems are markedly different. In China, the average horticultural farm holding is relatively small — around 0.2 to 0.8 ha (Beijing Vegetable Research Center and Hangzhou University of Commerce, pers. comm.). Produce is sold directly from the farm to collectors (wholesalers) who organise transport to the major markets, for export and retail distribution. Australian farms are considerably larger (at least 100-fold) with many growers operating their own packing houses and coolrooms. Distances from major production areas to the principal markets in the capital cities range from less than 100 km to over 3000 km. Australian systems are designed to minimise expensive labour costs while maintaining product quality throughout the transport, distribution, and marketing systems, as the grower may receive no return for his produce until it passes through the wholesale market.

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Harvest Aids

The most common harvest aid is the bulk bin (Figure 1). Many fruits and vegetable are harvested directly into bulk bins (capacity 0.5 t, external dimensions 116 × 116 cm × 70–80 cm high) or via smaller harvest packs which are emptied into bins in the field. Bins are usually transported promptly to the packing house when filled. More sophisticated systems for lettuce, celery, and Chinese cabbage include conveyor belts, shading, and packing into cartons in the field (Figure 2). In these cases, full pallets of packed produce go directly to the packing house coolrooms.

Occasionally, harvest aids are developed to overcome specific harvest problems. For example, the Australian 'Kensington Pride' mango is sensitive to the sap exuded when the stem is cut. Fruit may stain or develop a more serious 'burn' injury which significantly reduces fruit quality. The mango harvest aid allows mangoes to fall onto a tarpaulin sprayed with a detergent solution (Figure 3). The tarpaulin causes no impact damage from the drop while the detergent disperses any mango sap, preventing fruit injury.

Highly mechanised harvest aids used in the tomato industry allow cost-effective large volume harvesting while reducing the physical strain (to humans) of

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picking. Blocks of tomatoes may be picked 15–30 times every 2–3 days over 4–12 weeks. Labour costs are minimised using a tomato harvester (Figure 4).

Packing House

The general operations in a packing house might include: a preliminary inspection to remove excess field trash and damaged produce when the bulk bins are emptied onto the packing line; washing, fungicide or insecticide application, waxing and drying (as applicable); quality grading, size grading, labelling and packing; palletising of packed cartons; and cooling to appropriate holding or carriage temperatures.

The use of postharvest chemicals in the packing house (fungicides, insecticides) is regulated by appropriate health or food authorities and individual treatments will depend on the horticultural produce. While the processing equipment used will be specific for the treatment, the systems used are relatively standard. The packing house must also comply with regulations governing water hygiene and disposal of used chemicals.

The shelf life of broccoli is shortened considerably at ambient compared with storage (1–2°C) temperatures. Consequently, broccoli is cooled (in the bulk bin) as soon as possible after harvest and is refrigerated before packing. The packing house may also be refrigerated (10°C) to minimise temperature rises during sorting, grading, and packing. Broccoli heads are inspected for quality and defects before packaging and return to the coolroom. Chinese cabbage, lettuce, and celery packed in the field go directly to a forced-air coolroom in the packing house.

Figure 1. Harvesting broccoli into bulk bins.

Figure 2. Harvesting, trimming, and packing Chinese cabbage in the field.

Figure 3. Mango harvest aid reduces sap injury.

Figure 4. Tomato harvester for high-volume, labour-intensive picking.

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Many fruits and some vegetables are labelled with a small sticker indicating the brand name and/or packing house number. This previously manual operation is now done routinely by modern processing equipment. Similarly, while older style belt and roller size graders are still used (Figure 5), modern equipment uses computer-controlled size graders (either by weight or optically) to channel produce to the appropriate packing lines (Figure 6). Many of these systems also colour-grade produce as it passes through the line. The final packing into cartons is mostly a manual operation but it may be done mechanically (Figures 7 and 8). Generally, only packing houses with a very high throughput can afford this system.

Cooling

Temperature is the most important factor in maintaining product quality and maximising shelf life through the marketing chain. The higher a product's respiratory heat, the more critical it is to rapidly remove field heat and hold the product at its optimal storage temperature.

Broccoli and sweet corn have a high respiratory heat. Apart from refrigeration for initial cooling, ice may also be added to ensure temperature rises are minimised. When produce is 'top-iced', it is packed in a suitable waterproof package, usually polystyrene cartons fitted with a lid. The product must also be tolerant of prolonged exposure to wet conditions at 0°C.

Another simple cooling method is hydro-cooling. Bulk bins may be hydro-cooled before packing, either by immersion in cold water or by showering cold water over them. After packing, pallets of produce in open-top waterproof cartons may be hydro-cooled by showering with cold water. Water is recirculated through a refrigeration system, and again the produce must be tolerant of wet conditions.

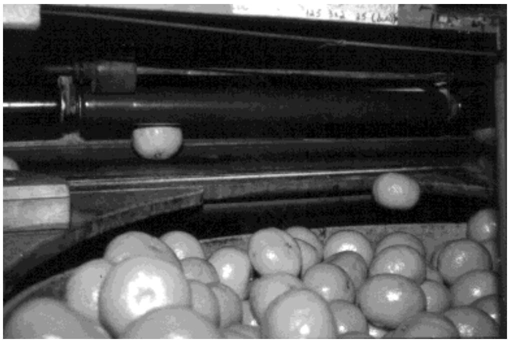

Figure 5. A common belt and roller size-grader for mandarins.

Figure 7. Manually labelling and packing oranges.

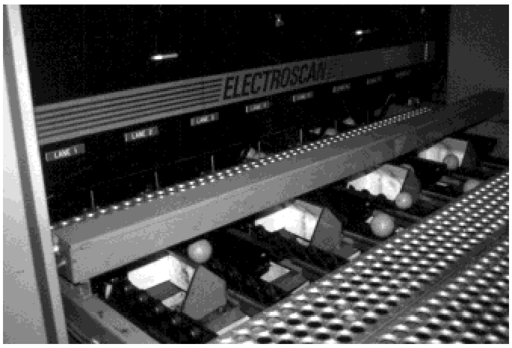

Figure 6. Computer-controlled orange size-grader.

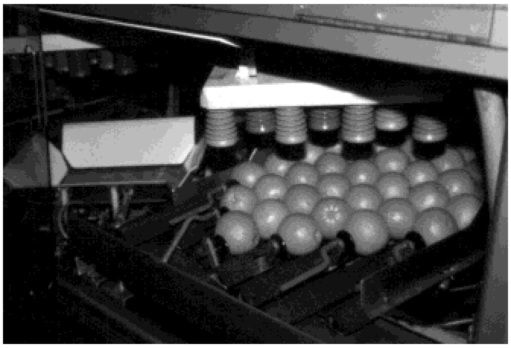

Figure 8. Mechanised orange packing.

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Refrigerated room cooling is the most common form of cooling for fruits and vegetables. However, cooling of packed, palletised produce can be quite slow in a static coolroom system, as very little cold air penetrates the stow and makes contact with the produce. Forced-air systems considerably improve the rate of cooling and make more efficient use of refrigeration (Figure 9).

Vacuum cooling is another, but less common, cooling method suitable for leafy vegetables such as lettuce. Applying a vacuum to the produce causes evaporation of water and associated cooling. Every 6°C of cooling is accompanied by a 1% moisture loss but this can be reduced by spraying produce with water before or during the cooling process. Vacuum and hydro-cooled produce should be transferred to an appropriate coolroom as soon as possible after cooling to maintain the desired temperature.

Packaging

The most common packages for fruits and vegetables are made of fibreboard, sometimes waxed to increase strength, especially where free moisture may be encountered. Polystyrene packages are also common although disposal of used packages can be a problem. Various inserts (fibreboard dividers, paper wraps, plastic or fibreboard trays, plastic containers, plastic films) may also be used, depending on the produce. Most fibreboard cartons are used only once, occasionally twice, while polystyrene cartons may be used a little more often. At $1 to $2 each, depending on design and construction, carton cost is a significant expense, especially with lower-value produce.

Plastic crates have been introduced periodically but have not proven popular to date. The major carton manufacturers are currently trialing returnable plastic packages for fruits and vegetables. These would be rented rather than bought, as is currently the case for fibreboard and polystyrene cartons. Multiple use of the same package could reduce packaging costs to around 10–20% of those at present.

Attempts have also been made to introduce a small range of standard-size packages. Again, this has not proven popular and many carton designs are currently used. The common features of most packages are that they fit reasonably efficiently on the standard Australian pallet, ventilation is designed to allow forced-air cooling, and the package is strong enough to protect its contents throughout the handling systems, though damage does sometimes occur (Figure 10).

The Australian pallet is 1165 × 1165 mm. Pallets are hired from local depots, used for transport to markets, and returned to the market depot. Most cartons are designed so that an integral number of carton widths and lengths equals 1165 mm (allowing for some bulge in the carton). For example, a carton 580 mm long by 385 mm wide would efficiently fit three across (1155 mm) and two along (1160 mm) a standard pallet. Other designs accommodate a pin wheel pattern, e.g. a carton 480 × 335 mm would fit two across and one along (2 × 335 + 480 = 1150 mm) with the stow rotated around the pallet and a central chimney in the middle (Figure 11). This stow is less efficient but is very widely used.

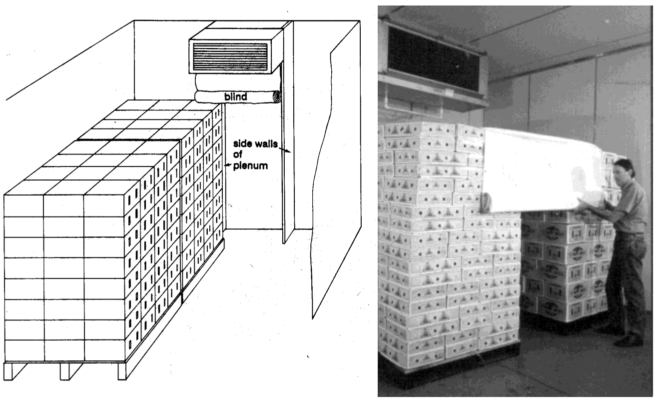

Figure 9. Forced-air cooling principles and operation. Cold air from the refrigeration unit is drawn through the aligned carton ventilation slots producing rapid cooling.

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Figure 10. Possible causes of carton collapse: under strength, wet, too high, poorly secured, rough handling.

Figure 11. An 8 per layer pin wheel stow with metal corner posts and strapping to stabilise the load. Alignment of ventilation slots allows forced-air cooling.

A pallet of packed cartons will usually be stabilised by corner posts (heavy fibreboard or metal) and strapping (plastic strap or netting). Bulk bins (timber or very heavy grade fibreboard) are also used as are bags (e.g. for onions and potatoes). Again, these are designed to palletise so that fork lifts and standard storage systems can be used throughout the handling chain.

Transport

The majority of fruit and vegetables is transported by road but rail is also used. Over short distances, non-refrigerated systems are used; over longer distances, refrigerated systems predominate. Loads are palletised and major packing houses and transport company premises are designed to allow fork lifts to drive directly into large, refrigerated trucks. Refrigerated packing houses or distribution centres allow road vehicles to back up to an air lock for loading and unloading. This allows fork lifts to move from packing house to truck under controlled temperatures, maintaining the cool chain.

Refrigeration systems used in road and rail transport do not have the capacity to cool the several tonnes of produce in the load which should therefore be cooled (preferably by forced air) to the appropriate carriage/storage temperature before loading. To minimise transport damage, loads are packed as tightly as possible into trucks. Unfortunately, this also tends to reduce penetration of refrigerated air through the stow and temperatures in the centres of pallets may rise, especially in produce that generates high respiratory heat.

To maximise air circulation, the refrigeration unit should have a plenum to ensure that cold air delivered by the unit can return only via the floor and plenum (Figure 12). The vehicle should also have a suitable air delivery ducting system to deliver cold air along the entire length of the load. Ducted flooring also assists in providing air a clear passage back to the refrigeration unit. Even with good systems, the majority of the air passes over the top layers and side cartons (against the wall), with little air penetrating the centre of the pallet.

Market

The Brisbane wholesale market has a central covered unloading area where produce can be unloaded from trucks. On three sides of this area are the stands of wholesale market agents where produce is sold. Most agents have small coolrooms within their selling area.

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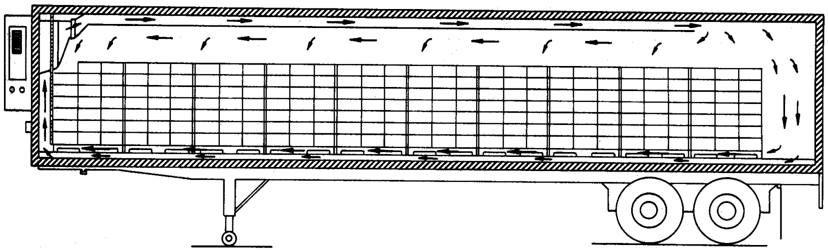

Figure 12. Airflow around palletised load in a refrigerated truck.

They also have larger warehouse storage and coolroom facilities within the market complex. Some also operate ripening rooms, usually forced-air systems with ethylene control.

Some supermarket distribution centres within the market are large refrigerated (15°C) warehouses containing lower temperature coolrooms. Produce received at the centre is held, collated, and distributed as required to the supermarket stores.

When produce is sold (either by agents or distribution centres), pallets are disassembled and restacked with mixed loads. The stability of these loads depends on the degree of similarity between the different cartons/packages purchased. The cool chain is often broken as these loads are transported to local (say up to 100 km) retailers.

A significant difference between the Australian and Chinese systems is that in China, produce is sold many steps back in the market chain, i.e. on farm to the collector (wholesaler). In Australia, the produce is sold (with respect to the grower) as it passes through the wholesale market.

Recommended Reading

Hardenburg, R.E., Watada, A.E. and Wang, C.Y. 1990. The commercial storage of fruits, vegetables, and florist and nursery stocks. United States Department of Agriculture, Agriculture Handbook, No. 66.

Kader, A.A. ed. 1992. Postharvest technology of horticultural crops. Davis, California. University of California Publication 3311. ISBN 0-931876-99-0.

Watkins, J.B. and Ledger, S. 1990. Forced-air cooling, 2nd ed. Brisbane, Queensland Department of Primary Industries Information Series QI88027.

Wills, R.B.H., Lee, T.H., Graham, D., McGlasson, W.B., and Hall, E.G. 1982. Postharvest. An introduction to the physiology and handling of fruits and vegetables. Sydney, University of New South Wales Press. ISBN 0-86840-009-2.