Exporting vegetables in bulk: reducing supply chain costs without compromising quality

Helen Ramsey
Dennis Phillips

Follow this and additional works at: https://researchlibrary.agric.wa.gov.au/bulletins

Part of the Agronomy and Crop Sciences Commons, and the Marketing Commons

Recommended Citation
Exporting vegetables in bulk
Reducing supply chain costs without compromising quality
Acknowledgments

We wish to thank Horticulture Australia Limited and the Australian Vegetable Industry for funding this project through their national levy as well as the Department of Agriculture and Food, Western Australia for support through salaries and infrastructure. Support for infrastructure was also kindly provided by The Sea Freight Council of Western Australia as well as GSF Australia. ‘In-kind’ support was provided by growers including Sumpec vegetables, G & T East and P Rose as well as exporters, AiSMIK and North East Equity (Sumich).

This research was conducted by Dennis Philips, Aileen Reid and Shane Trainer with technical support from David Gatter and the staff at the Medina and Manjimup Horticultural Research Stations.

Contact

For further information, please contact project leader Dennis Phillips  
P: (08)9368 3319  F: (08) 9368 2985  E: dphillips@agric.wa.gov.au

Disclaimer

The Chief Executive Officer of the Department of Agriculture and Food and the State of Western Australia accept no liability whatsoever by reason of negligence or otherwise from use or release of this information or any part of it.

Copyright © Western Australian Agriculture Authority, 2009

Quick Reference: Recommendations based on test shipments

<table>
<thead>
<tr>
<th>Product</th>
<th>Bin depth (internal)</th>
<th>Bin floor</th>
<th>Bin lid</th>
<th>Pre-cooling method</th>
</tr>
</thead>
<tbody>
<tr>
<td>Broccoli</td>
<td>1100 mm</td>
<td>Waxed cardboard</td>
<td>Wax cardboard—44 holes x 40 mm diameter</td>
<td>FAC to 1 °C</td>
</tr>
<tr>
<td>Celery</td>
<td>1100 mm</td>
<td>Unwaxed</td>
<td>Unknown</td>
<td>FAC to 1 °C</td>
</tr>
<tr>
<td>Cabbage</td>
<td>1100 mm</td>
<td>Optional</td>
<td>Optional</td>
<td>FAC to 1 °C</td>
</tr>
<tr>
<td>Chinese cabbage</td>
<td>1100 mm</td>
<td>Unwaxed</td>
<td>Pre-wet waxed or unwaxed solid or perforated, 24 holes x 60 mm diameter</td>
<td>FAC to 1 °C</td>
</tr>
<tr>
<td>Iceberg Lettuce</td>
<td>1100 mm</td>
<td>Optional</td>
<td>Solid pre-wet waxed or unwaxed</td>
<td>FAC to 1 °C</td>
</tr>
<tr>
<td>Cauliflower</td>
<td>625 mm or less</td>
<td>Optional</td>
<td>Leaves or waxed cardboard, 44 holes x 20 mm diameter</td>
<td>FAC to 1 °C</td>
</tr>
<tr>
<td>Cos lettuce</td>
<td>625 mm or less</td>
<td>Waxed</td>
<td>Optional</td>
<td>FAC to 1 °C</td>
</tr>
<tr>
<td>Sweet corn</td>
<td>1100 mm</td>
<td>Optional</td>
<td>Unknown</td>
<td>Vacuum cooling only to 1 °C</td>
</tr>
</tbody>
</table>

FAC: forced air cooling
Exporting vegetables in bulk

Reducing supply chain costs without compromising quality

Compiled by Helen Ramsey and Dennis Phillips
Department of Agriculture and Food Western Australia, South Perth

Contents

Bulk-handling technique ................................................................. 3
Steps in the Bulk-handling technique ........................................... 4
Requirements for conversion to bulk-handling method .................. 8
Bin design .......................................................... 8
Bin dimensions ............................................................. 9
Pre-cooling ........................................................................ 10
Temperature control in transit .................................................. 10
Crop-specific guidelines ............................................................ 12

Other treatments

<table>
<thead>
<tr>
<th>Storage period tested</th>
<th>Unknowns</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stems cut short to 1st floret junction No large or over-mature heads</td>
<td>22–32 days Other lid ventilation patterns</td>
</tr>
<tr>
<td>No wetting before packing No plastic sleeves Trimming required at destination</td>
<td>20–26 days Effect of bin lids</td>
</tr>
<tr>
<td>Firm heads to resist squashing</td>
<td>15–18 days Optimal lid ventilation</td>
</tr>
<tr>
<td>Moisture Control Technology liner encouraged rots</td>
<td>21 days Gomasho can develop in storage</td>
</tr>
<tr>
<td>Heads in the bottom quarter of the bed flattened but suitable for processing</td>
<td>21 days Importer needs both fresh and processing outlets for lettuce. Bulk shipping is best suited to processing for iceberg</td>
</tr>
<tr>
<td>Heads must be very firm but not over-mature. Variety differences—Toronto very good</td>
<td></td>
</tr>
<tr>
<td>Moisture Control Technology liner OK</td>
<td>15–21 days Biosecurity aspects of leaves on top</td>
</tr>
<tr>
<td>Heads flattened in bins making produce suitable for processing only</td>
<td>21 days</td>
</tr>
<tr>
<td>Optimum crop maturity is important Trimming is required at destination Bin rails need to be strengthened</td>
<td>20 days Still many unknowns</td>
</tr>
</tbody>
</table>
Increased competition, a strong Australian dollar and increased production costs have seen Australian grown vegetables steadily lose their share in traditional export markets.

As competition increases, we need to investigate production and handling techniques that improve our price and quality competitiveness.

Improving the efficiency of the supply chain to export markets is one way Australian growers can reduce production and shipping costs and improve product quality.

Traditionally, preparation of vegetables for export in Western Australia has been a two-stage process. Produce is harvested and cooled in bulk bins then repacked into smaller cartons at an export packing facility. Cartons are then individually loaded into sea containers by hand or onto pallets that are loaded into the container with a forklift.

This practice is costly because of the labour involved in repackaging and the individual handling of cartons into sea containers. Costs associated with staffing and maintaining export packing facilities are also high.

**What is wrong with current practices**

Repackaging is also detrimental to product quality. Additional physical damage often occurs during packing and some degree of heating is inevitable during the time produce is unrefrigerated. Such breaks in the cold chain increase the risk of postharvest diseases and shorten the shelf life of produce.
**Bulk-handling technique**

Harvesting vegetables directly into disposable bulk bins in the field and shipping direct to export markets in these bins eliminates double handling and the need for packing facilities. Costs associated with handling and repacking (if required) are shifted to the export destination.

The design of bulk bins allows more efficient pre-cooling of produce and better ventilation and temperature control in the sea container. Higher sea container weights are also achievable with bulk bins compared to cartons, lowering export costs per kilogram of produce.

**Higher sea container weights reduce shipping costs**

Table 1 shows average shipping weights in tonnes that can be achieved in a 20-foot sea container comparing bulk bins to traditional cartons. Broccoli offers the greatest potential with the elimination of polystyrene packaging and ice. Further export efficiencies can be gained with the use of 40-foot sea containers.

<table>
<thead>
<tr>
<th>Crop</th>
<th>Traditional cartons</th>
<th>Bulk bins</th>
</tr>
</thead>
<tbody>
<tr>
<td>Broccoli</td>
<td>3.6 (polystyrene with ice)</td>
<td>6.7</td>
</tr>
<tr>
<td>Cauliflower</td>
<td>8.4</td>
<td>9.75</td>
</tr>
<tr>
<td>Cabbage</td>
<td>8.5 (bags)</td>
<td>8.5</td>
</tr>
<tr>
<td>Chinese cabbage</td>
<td>5.6</td>
<td>6.4</td>
</tr>
<tr>
<td>Celery</td>
<td>8</td>
<td>8.4</td>
</tr>
<tr>
<td>Lettuce</td>
<td>5.6</td>
<td>7.5</td>
</tr>
</tbody>
</table>

“Elimination of packing costs in Australia offers the greatest potential for cost savings”

*Broccoli packed in a bulk bin for export.*
Steps in the Bulk-handling technique

This technique has been demonstrated to lower production and shipping costs and improve end-product quality for a variety of vegetable crops.

**Step 1**
Vegetables are harvested and graded into bulk export bins in the field.

**Step 2**
Bins are pre-cooled on-farm using forced air or vacuum cooling.

**Step 4**
Sea containers are shipped to the overseas port.

**Step 5**
Bins are unloaded at a pre-packer or processor’s premises at the export destination, bypassing the wholesale market in the destination country.
Step 2

Pre-cooled bins are loaded directly into refrigerated sea containers on-farm.

Step 3

Bin design allows for easy handling with a forklift and makes the most efficient use of space inside a sea container.

Step 6

Produce is processed or repacked according to the requirements of the end user and distributed to the retail level.

“Shifting labour costs associated with repackaging and trimming offshore takes advantage of lower labour costs in the destination country”

Examples of how produce can be processed and packed in the destination country.
Requirements for conversion to bulk-handling method

- Reliable in-field sorting of produce
- On-farm forced air or vacuum cooling system for pre-cooling bins
- Sufficient produce to fill whole sea containers
- Facilities to load sea containers on-farm
- Direct supply contacts with a pre-packer or retail distribution centre in the destination country

Bin design

The department has tested a range of bin designs and configurations. Packing efficiency—both in the bin and within a sea container—was assessed along with impacts on vegetable quality. The resulting prototype is a lightweight but strong pinewood bin, designed and costed for single use. Bins are lined with a plastic pallet bag, secured to the floor with a thin cardboard sheet. Holes are cut into the base of the pallet bag and cardboard sheet to allow ventilation.

Basic bulk bin design. Bearers for forks are 75 mm in width (height off the ground), 100 mm if a palet jack is to be used. The five floor rails sitting above the bearers are 25 mm thick and 100 mm wide. Side rails are 15 mm thick and 150 mm wide. Triangular corner posts are 60 mm by 60 mm. A 100 micron pallet bag, 1850 mm long and 1220 mm wide is used to line the bins. Twenty four holes each 40 mm in diameter are cut into the base of the pallet bag, aligning with those in the cardboard floor. Overall dimensions of the bin vary with shipping container and produce being shipped. See Tables 2 and 3 and crop specific recommendations for specific design recommendations.
Bin dimensions

Bins are modular (made in two interlocking parts - see step 1 photo on page 6) and designed to be stacked two high in the sea container, minimising damage to produce and allowing for easy handling. Actual bin dimensions depend on the dimensions of the sea container. The wooden construction makes them easily and cheaply re-sized to fit sea containers of different internal dimensions. Internal bin depths of up to 1100 mm were found to have no negative impact on produce quality compared to shallower bins.

“Matching bin size with sea container dimensions allows for more efficient filling of the space inside a sea container, maximising sea container weights and lowering shipping costs per kilogram of produce”

Table 2 shows examples of the internal dimensions of refrigerated sea containers in Western Australian ports. Table 3 shows the recommended bin dimensions for use in each of these sea containers.

<table>
<thead>
<tr>
<th>Shipping line</th>
<th>Internal length</th>
<th>Internal width</th>
<th>Load line height</th>
</tr>
</thead>
<tbody>
<tr>
<td>PIL – HC</td>
<td>5506</td>
<td>2304</td>
<td>2520</td>
</tr>
<tr>
<td>MAERSK</td>
<td>5451</td>
<td>2290</td>
<td>2156</td>
</tr>
<tr>
<td>MAERSK – 40’</td>
<td>11578</td>
<td>2280</td>
<td>2425</td>
</tr>
<tr>
<td>K Line – KKTU 604/607</td>
<td>5454</td>
<td>2273</td>
<td>2170</td>
</tr>
</tbody>
</table>

Table 3 Recommended bin dimensions in millimeters (external dimensions)

<table>
<thead>
<tr>
<th>Shipping Line</th>
<th>Length</th>
<th>Width</th>
<th>Height</th>
</tr>
</thead>
<tbody>
<tr>
<td>PIL – HC</td>
<td>1050</td>
<td>1115</td>
<td>1225</td>
</tr>
<tr>
<td>MAERSK</td>
<td>1040</td>
<td>1110</td>
<td>1040</td>
</tr>
<tr>
<td>MAERSK – 40’</td>
<td>1100</td>
<td>1110</td>
<td>1080</td>
</tr>
<tr>
<td>K Line – KKTU 604/607</td>
<td>1040</td>
<td>1110</td>
<td>1040</td>
</tr>
</tbody>
</table>
Pre-cooling

The bulk bin design allows for quick and efficient pre-cooling on-farm using Forced Air Cooling (FAC). FAC is a cheap and effective method of cooling large volumes of produce with low capital and operating costs.

After packing, bulk bins are transported to a cool room with a plenum wall, exhaust fan and humidifier. Bins are stacked two high and pushed hard against the plenum wall with the fork gap of the top bin aligned with the opening in the wall (see Figure 1). A sheet of plastic is secured over the exposed rear and side fork gaps between the bins, sealing off all sides.

When the fan is turned on, the pressure difference between the outside of the bins and the opening in the plenum wall draws cold air down through the top bins and up through ventilation holes in the bottom bins. This method allows rapid cooling of large volumes of produce. Cooled produce can be loaded directly into refrigerated sea containers. It is recommended that produce is cooled to 1°C.

“Air follows the path of least resistance from air inlets to air outlets. The absence of air vents in the base of traditional cartons and the way in which cartons are stacked inside in a sea container limits airflow to the edges of the stack. This results in limited temperature control and uneven produce temperatures during transit.”
Temperature control in transit

In transit, air inside a sea container is circulated, starting from the floor at the refrigerated end of the container. Airflow moves toward the filling end, then vertically up through the container and back to the refrigerated end. Warm air is released from a vent at the top of the refrigerated end of the container (see Figure 2).

Ventilation holes in the base of bulk bins take advantage of the cool airflow along the floor of the sea container. As air flows along the floor it is forced up through the ventilation holes and released from the open tops of the bins. This creates continual airflow through the bins, maintaining produce at a constant low temperature throughout transit.

Crop-specific guidelines

The following guidelines are based on the findings of research trials and test shipments to Malaysia and Dubai conducted by the department between 1999 and 2006.

**Broccoli** offers the best prospect for successful shipping in bulk bins by sea as demonstrated by a successful out turn in Dubai of a trial shipment 32 days after loading in the field. Bulk handling has the potential to eliminate high costs associated with airfreight, polystyrene packaging and ice. Harvesting broccoli at optimum maturity and cutting heads with short stems to minimise damage to heads are essential to a good out-turn in bulk bins. Deep bins stacked two high in a standard sea container are recommended to maximise transport efficiencies. Bins should have a ventilated waxed cardboard floor and lid to minimise product dehydration.

**Celery** is the next best prospect for shipping. Heads must be packed dry and preferably unsleeved in deep bins to maximise the freight advantage. Trimming and sleeving will be required at the destination to maximise returns.

**Cabbage and Chinese cabbage** also offer good prospects for shipping in bulk. Packing and shipping methods are the same as for broccoli. However, the potential saving in freight costs is not as good as broccoli. Chinese cabbage out-turns better with a pre-wet perforated or solid cardboard lid on top of the bin.

**Iceberg lettuce** is more difficult to ship than the products mentioned above. However, with attention to detail in the field and in transportation, a system could be perfected, particularly for markets accessible within 15 days of harvest. Lettuce maturity is critical to good out-turn. Heads need to be firm but not over-mature. Average head weights around 700–800 g are considered best. The economics of lettuce are more favourable when shipped in deep bins. Bins should have a loosely fitted solid pre-wet unwaxed cardboard lid to minimise product dehydration. The best destination market for iceberg lettuce is processing as wilted wrapper leaves need to be removed at the destination for fresh markets.

**Cauliflower** offers potential for bulk shipping. Indications are that shallow bins may be better suited to cauliflower, reducing the potential freight advantages of shipping in bulk. A waxed cardboard lid perforated with 20 mm ventilation holes offers the best means of minimising damage from dehydration.

**Cos lettuce** is not well suited to bulk shipping for fresh markets as it becomes compressed and flattened during transit. There may be potential for processing at the end destination within 15 days from harvest as very little crushing was observed in shallow bins.

**Sweet corn** offers potential for shipping in deep bins. However, vacuum cooling is required for the best out-turn. A stronger bin than tested in this project may be needed as rails on the standard bin bulged significantly under the weight of the corn.