



Know-how for Horticulture™

**Heat treatment of
tomatoes for New
Zealand - commercial
prototype
development**

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QLD Department of Primary
Industries

Project Number: VG98136

VG98136

This report is published by Horticulture Australia Ltd to pass on information concerning horticultural research and development undertaken for the vegetable industry.

The research contained in this report was funded by Horticulture Australia Ltd with the financial support of Queensland Fruit and Vegetables.

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ISBN 0 7341 0770 6

Published and distributed by:
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Heat Treatment of Tomatoes for New Zealand

Commercial Prototype Development

Project VG98136

Final Report

June 2003

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Department of Primary Industries
Agency for Food and Fibre Sciences

Heat treatment of tomatoes for New Zealand – Commercial prototype development.
Project No. VG98136 Final report (June 2003).

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The work described here continues the work completed in Project HG97019 'Preliminary investigation of simplified heat treatment systems for disinfestation of vegetables for New Zealand'. It was designed to identify a commercial partner, to refine and evaluate the design features of the system, and to demonstrate to the tomato industry that it was suitable for commercially treating tomatoes for export.

Funding for the work was provided by the Tomato Committee of the Queensland Fruit and Vegetable Growers organisation. Some evaluation work was also performed as part of the Australian Centre for International Agricultural Research Project PHT 93/877 'Low cost disinfestation systems for fruit'.

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Media summary

Many fruit and vegetables which are hosts of fruit flies are excluded from markets with quarantine barriers unless they have received an approved disinfestation treatment. Until relatively recently, the cheapest and most effective treatments have been chemical insecticides or fumigants. For a variety of reasons these have been banned, are being phased out or under threat. Heat treatment (called vapour heat treatment or high temperature forced air treatment in some countries) has seen a moderate level of experimental development and commercial use. One impediment to its commercial expansion is the capital cost of the treatment equipment.

A previous project HG97019, 'Preliminary investigation of simplified heat treatment systems for disinfestation of vegetables for New Zealand', contributed to the development of a prototype low cost commercial heat treatment unit.

This project has thoroughly tested and refined the design of the prototype system, and has demonstrated that tomatoes, including four 'gourmet' cultivars can be successfully treated.

The prototype system was based around the use of vented 'half-height' plastic bins of nominal 250kg capacity. A stack of bins, when covered by a specially fabricated vented cover allowed air to flow from one side of the bin to the opposite side without leakage from top, bottom or other sides. Using this configuration the air path remained a constant one metre, and independent of load. The unit is designed to operate up to 50°C, with a relative humidity in the range of 50-95 percent.

A fully commercial system of 20 bin size and based on the developments of the project, has now been installed, commissioned and tested for treatment of mangoes. An application has been submitted to the Ministry of Agriculture Forestry and Fisheries, Japan for approval for this unit to be used for export to Japan. Additional work is being planned to use the commercial unit to demonstrate the performance of the unit for tomato treatment.

Technical Summary

Access to a specific market with quarantine barriers against fruit flies for a particular crop, using heat treatment requires multiple factors to be successfully overcome. For New Zealand, quarantine authorities require the identification of the most tolerant fruit fly species for the product, as well as the in-vitro determination of most tolerant stage. Based on this information, a demonstration of treatment efficacy at the level required has to be performed using the product and the most tolerant stage of the most tolerant species under the treatment conditions shown to be both effective and non-injurious to the product.

Project HG97019 developed a prototype heat treatment using design principles different from those used in the systems that have been available commercially. The system was based around 250kg plastic bins through which heated and humidified air could be pulled horizontally. A fabricated cover of polypropylene sheeting with openings opposite the air ventilation slots on two sides of the bin ensured all of the circulating air was forced through the beds of product. Consistent with the objective of achieving the required high performance while maintaining the cost as low as possible, the electronic monitoring and control hardware and software has been refined to the point where it can be incorporated into commercial systems with only limited effort.

Following a public 'expressions of interest', York Refrigeration Australia was chosen to be the commercialisation partner. This company has extensive experience in high humidity cold room development and fabrication so is ideally situated to take the QHI concepts to the market.

To demonstrate to the tomato industry that the process was commercially viable, the 'gourmet' varieties 'Mercedes', 'Isabella', 'Petula' and 'Redcoat' were treated at the conditions shown to be effective for the fruit fly disinfestation procedure developed to satisfy New Zealand import requirements.

The final objective and major output of the project was the design and development of a commercial prototype treatment unit. However, before this work could be commenced, an opportunity arose for the commercial partner to install a fully commercial 20-bin size unit for mango treatment, superseding the need for a prototype stage. This commercial unit was more expensive than the cost envisaged in the project plan, due at least in part to the refrigerated cooling capability included. Since the design was based on reverse cycle refrigeration heating, it followed logically that substantial refrigerated cooling capacity could be simply built in. The ability to cool without using water provides a significant advantage over other commercial systems, as it has been demonstrated that water-cooling is detrimental to quality.

Introduction

The application of heat to horticultural crops as a fruit fly disinfestation treatment has been known for many years. It is usually referred to as vapour heat treatment (VHT).

The process was used in only a limited way until about 1984, when the banning of ethylene dibromide (EDB) encouraged a Japanese company to develop equipment that could apply the treatment at an accelerated rate, thereby reducing the treatment time from about 18 hours to less than 6 hours. Other design improvements included the replacement of steam with recirculating heated water as the main heat transfer and humidification medium. However the equipment, while being of high quality and performance, is also expensive to purchase and somewhat difficult to operate.

The Japanese built units have been used successfully in a number of locations throughout the world, for example Hawaii (papaya), Philippines (mango and papaya), Taiwan (lychee and mango), Thailand (mango) and Okinawa (squash, eggplant). In each of these localities, central packing operations are used, allowing efficient and cost-effective use of the very expensive equipment.

Another system, somewhat cheaper, but still fairly expensive, is based on work done by US engineers. This system follows the 'American' approach of maintaining reduced humidity to minimise condensation on the surface of the fruit. This system is usually described as the high temperature forced air (HTFA) system.

In Queensland, the growing and packing of horticultural crops occurs over a very wide area. Chemical-based disinfestation treatments are the most common types of treatments and are applied in individual packing sheds. This is the cheapest and least complex approach for most shed operators. The introduction of heat treatment is expensive and more complex, consequently cost minimisation is a high priority as is operational simplicity and the ability to integrate into existing shed practices with minimal disruption.

This project was designed to use the pilot scale system developed as part of project HG97019 "Preliminary Investigation of Simplified Heat Treatment Systems for Disinfestation of Vegetables for New Zealand" as the starting point of a commercial design, to fulfil a range of requirements for making available the heat treatment process as widely as possible throughout Australia.

Treatment chamber design

Design concepts

There are two fundamental requirements which have to be met in a commercially viable treatment system. The first, and most important, is that the treatment can be applied in a way which complies with the quarantine regulatory requirements of the importing country. The second is that the treatment can be applied in a way which does not produce a degradation of product quality. Any time X temperature combination in excess of the minimum will satisfy the quarantine requirement. However for minimal product impact, the time and temperature above the quarantine threshold has to be minimised. This is achieved by producing uniform airflow and efficient heating to

minimise the temperature difference between the products heating fastest and those heating slowest.

The system was designed to meet or exceed the following major technical features -

- Temperatures to be measurable to a resolution of 0.1°C, with short term measuring accuracy and stability 0.1°C over the duration of a treatment and long term temperature stability $\pm 0.1^\circ\text{C}$ or better in 1 week
- Relative humidity controllable in the range 50-95%
- High level of temperature uniformity through the product bed
- Sufficient capacity to complete treatment in 4-6 hours

Product container selection

The decision was taken to focus attention on treatment of product in bulk. The plastic bin was chosen as the most suitable container for the following reasons

- Handling unit size more convenient than crate
- Standard size and readily available
- Easy to clean
- Available with vented sides

Three companies were identified as suppliers of ventilated plastic bins. However only two could supply the shallow depth size (1130 mm X 1130 mm X 480 mm external) with an internal volume of 460 L and nominal capacity of 250Kg. One of the two had characteristics which would contribute to reduced and non-uniform air flow, in particular solid corners and a solid section in the centre of each side, and reduced side slot ventilation. The bin from F&T Industries (model BB) was chosen as being the most suitable (Fig 1 a,b,c).

The chosen bin had a side ventilation open area of 11 percent as standard. This was modified to provide a more uniform ventilation pattern by drilling 10 mm holes in the blank sections of two sides. This increased the open area to 15 percent (Fig 2).

Modified and unmodified bin characteristics are shown in the Appendix.

Bin positioning

Several issues have an impact on how the bins might be positioned in the chamber.

i. *Stacking height.* The standard version of the BB bin can be stacked fully loaded to six high at temperatures above the expected upper limit in this application of 50°C. This means that the bottom bin would be able to support at least 1.25t. However, with the additional air flow holes drilled, particularly at the corners, it was decided that a four high stack (750 Kg load) would provide a conservative margin of safety. Such a decision would have been better made using objective compression test data. This is not available and not easily generated.

Stack height, which also affects air distribution, will be addressed below.

ii. *Path length of air through product bed.* In many commercial treatment chambers, the standard treatment container is the plastic crate. These are typically stacked

approximately 2m high. As a result, air must flow vertically either up or down, travelling through a product bed which is close to 2 m long.

In a bin configuration with the air flowing horizontally, the product bed is only 1.1m. Figures 6a and 6b show possible configurations for short path lengths. It is reasonable to expect that such a shorter path will lead to improved heat exchange and reduced temperature differences. It would have been possible to place bins in line to achieve a path length of 2.2m (Fig. 6c). In this configuration, alignment and sealing between bins becomes critical and probably could not be achieved with sufficient reproducibility to satisfy regulatory requirements. It was decided that, because of the inter-bin sealing problems and the long path length, this option would not be pursued further.

iii. *Product temperature and air flow uniformity.* The system design uses a configuration widely encountered in conventional forced-air cooling. This uses a plenum wall to isolate the outlet and inlet air flows of the fan system. The product containers are positioned around openings cut in the plenum wall through which the air flows.

Two configurations are possible, either the bin is butted up against the plenum opening which is almost the full width of the bin (Fig 6b); alternatively bins could be placed on either side of a plenum opening (Fig 6a).

In the configuration shown in Figure 6a, a polypropylene sheet is used to cover the top of the bins and the ends to force the air to travel the path shown. Air must travel into the channel formed by the sides of the bins, through the product bed and into the channel between the bins and through the plenum wall.

Airflow management

Maximum efficiency and maximum heating rate is achieved by ensuring that all of the circulating air passes through the product bed and does not travel through any leakage points. To ensure that this occurred, the top and all sides of the bin stack was covered by polypropylene sheeting. A panel the size of the bin ventilation panel was removed from the sheeting on the air entry and exit faces of the stack. The direction of the air was such that negative fan pressure pulled the sheeting tightly against the bins, creating a highly effective seal.

Monitoring and control

i. Hardware

All devices used for the monitoring and control functions were connected to the control computer using EIA RS-485 serial communication. This interface provides the capability to have a remote computer up to 1200 m from the treatment system in an electrically hostile environment, while using a single pair cable connection.

Temperature measurement uses Class A, 100 ohm RTD sensors connected as 4-wire devices. The uncalibrated sensors have an accuracy of $\pm 0.25^{\circ}\text{C}$ which when calibrated through the software have an accuracy of better than 0.1°C . Humidity measurement uses RTD wet bulb and dry bulb sensors in the air circulating system, with software calculation of RH and dew point.

ii. Software

The entire system is monitored and controlled by a single standard computer. The software platform used is Citect version 5.2 SCADA system, running on a 133MHz Pentium based PC computer with Windows NT as the operating platform[#]. Within this software, separate screens have been developed for specific tasks

- Operator sign on
- Full system control for technician maintenance
- Sensor calibration
- Trend display
- Routine operation for commercial treatment application

Data is logged to disk for archiving purposes. Data from the treatment is also sent to a dot matrix line printer for monitoring and supervisory purposes.

Treatments are setup in the system as 'recipes', which an operator need only select to start the automatic operation, stopping when the treatment has been completed. The development and modification of the recipes is a simple process, requiring only addition, deletion or modification of records in a database.

The use of the Citect software provides a very high level of flexibility, as it based around the OPC (OLE* for Process Control) interface specification. This means that, should it be necessary in the future to redesign any of the monitoring and control circuitry, only minimal changes will be required in the software. Maintenance and upgrading will be relatively straightforward.

Performance

Figure 4 shows temperature and relative humidity data plots for a typical treatment run for treating tomatoes.

Technology transfer - commercial unit

As the project was originally developed, the final output was to be the design and building of a small commercial prototype unit. This plan was overtaken by actual commercial development activity.

This unit described below was designed and built as a commercial activity by York Refrigeration Australia for the treatment of mango. Although its design is based on work done within this project, it is not an output of the project and is included for reference only.

The chamber uses a conventional cool room design with 100mm thick expanded polystyrene panels 6.5 metres X 5.5 metres X 3.6 metres, with a sliding door at each end for product entry and exit. (Fig 5a). The chamber is fitted with a modified York Thermfresh® unit inside a plenum with 20 openings, one for each bin (Fig 5b). Openings are externally lined with foam cushions to act as air seals against the bins.

[#] Windows 95/98 can be used but performance is superior using Windows NT.

^{*} Microsoft's object-based technology for sharing information and services across process and machine boundaries

The standard configuration uses stacks of four bins of product, each stack being fitted with a cover as shown in Fig 5c. Nominal capacity, based on the specifications of the bins is 5t, although actual capacity is below this and product dependent.

The original prototype design was based on gas heating, with heated water circulated as the heat exchange medium. Accurate temperature control was achieved by mixing hot and cold water using solenoid valves. It was always considered that reverse cycle refrigeration would present substantial advantages. However the project budget was insufficient to follow this path. In the design of the commercial unit, reverse cycle refrigeration was used because its use provided additional functionality in the form of in-chamber air cooling immediately after treatment. This capability is believed to be unique in the world, with other types of systems capable only of water cooling, which we have shown to be injury-inducing in related work.

The total treatment cycle from ambient temperature, through treatment and back to ambient temperature takes about six hours.

Commercial Quality Issues

The objective of the project was to gain access to market in New Zealand for Queensland tomatoes using heat treatment. This requires not only an effective quarantine treatment, but also a treatment which does not reduce the quality of the fruit. The Queensland tomato industry required a demonstration that fruit after receiving a full quarantine treatment in the prototype treatment chamber would retain the quality required for sale in New Zealand.

As originally conceived during project design, the demonstration was to consist of at least two treatment runs using a range of commercial cultivars, followed by evaluations of the treated fruit by industry and other stakeholders at a central location in the vicinity of the treatment site. After repeated attempts over several months to coordinate both the supply of suitable fruit and the participation of at least part of the group for evaluation, it became clear that the strategy would fail, and that a different approach would be required.

The logistics of a realistic commercial simulation of a treatment process is more complex than would seem with fruit handling* a major factor, in particular

- Fruit should be at least at 'breaker' stage when treated which is consistent with commercial practice
- It would be expected that commercial treatment would commence not more than 12 hours after harvest
- No pre-treatment cooling can be used to prevent further ripening after harvest, because of the effect on injury susceptibility
- Efficient post-treatment cooling is required for maximising shelf life and quality

* The organisational relocation of project staff from Hamilton in Brisbane to Gatton had a major detrimental impact on the ability to deal with these important factors affecting the operation of the work. Since sourcing fruit, transporting and storing treated fruit all became substantially more difficult, the range of options in undertaking trials was limited and far from ideal.

Following are several selected experiments where objective quality evaluations were performed in the laboratory to illustrate the performance of the unit.

Experimental method

The minimum quantity treatable in the prototype system exceeds 200 Kg, which is one full bin. To overcome the need to use such a large quantity of expensive fruit, a system was devised to allow the quantity of test fruit to be minimised, as well as providing the flexibility to treat multiple samples while maintaining them separately from the bulk of fruit in the bin. Cylinders of open plastic mesh (gardening trellis mesh with 50 mm openings), 250 mm diameter and the depth of the product bed were placed as required in the bin and the remaining space was packed with low quality 'filler' fruit (Fig 3). Test fruit were placed into each cylinder. In this way the bin was uniformly filled, there was no disruption to air flow and sample integrity was maintained. A maximum of nine cylinders, each able to contain approximately 10 Kg was used in a bin. Two bins were routinely used with one or two filled depending on the number of samples to be treated. Air flow uniformity is only slightly affected by the use of either one or two filled bins.

For Trial 1 and 2 the treatment consisted of

- 2 hours at 40°C air temperature at 50-60% RH (conditioning phase)
- 46.5°C air temperature at 90% RH until fruit centre temperature at 45°C
- 1 hour with all fruit temperatures at 45°C
- air cooling to ambient temperature

For Trial 3 the treatment consisted of

- temperature ramped to 40°C over 4 hours, followed by 2 hours at 40°C
- temperature ramped to 45°C over 2 hours
- temperature held at 45-46°C and 70-80 %RH for 5 hours (fruit centres at 45°C for 1 hour)
- air cooling to ambient temperature

Results and discussion

Trial 1

The objective of this trial was to test the system and to confirm that the equipment could apply the treatment as required and with minimal fruit injury. Fruit of the 'gourmet' type, was sourced from three growers (G1,G2,G3) in the Gatton area. No other information about particular cultivars was obtained, as the treatment is required to be generic and non-cultivar specific. The fruit of predominantly backward colour were sorted immediately before treatment to remove both mature green and one-quarter colour and beyond. Sufficient fruit of one-quarter to one-half colour (ripe) was available from two of the growers to also investigate quality responses for this ripeness stage.

After treatment as described above, fruit were held at 22°C until ripe. Ripe fruit were held at 8°C to allow all ratings to be completed simultaneously. Quality evaluations for

internal and external colour, internal and external injury were performed and brix determined.

Tables 1(a-e). Quality evaluation rating scores for external colour (1 = green, 7 = full red), external injury (0 = nil, 4 = very severe), internal colour (1 = green, 7 = full red), internal injury (0 = nil, 4 = very severe), and for brix (as percent sucrose) following quarantine heat treatment. Fruit from growers (G1, G2, G3) treated at breaker stage and at half colour were assessed 1 day (T+1) and 10 days (T+10) after treatment following holding at 22°C.

(a) External colour

		Breaker				Ripe		
		G1	G2	G3	Mean	G1	G2	Mean
Untreated		7.0	6.9	7.0	6.96	7.0	6.9	6.95
Days after	T + 1	7.0	7.0	6.9	6.96	7.0	7.0	7.0
treatment	T + 10	7.0	7.0	6.8	6.93	7.0	7.0	7.0

(b) External injury

		Breaker				Ripe		
		G1	G2	G3	Mean	G1	G2	Mean
Untreated		0.33	0	0.1	0.14	0.33	0	0.16
Days after	T + 1	0.25	0.3	0.21	0.25	0.3	0.1	0.20
treatment	T + 10	0.46	0.08	0.12	0.22	0.58	0.29	0.87

(c) Internal colour

		Breaker				Ripe		
		G1	G2	G3	Mean	G1	G2	Mean
Untreated		7.0	7.0	6.3	6.76	7.0	7.0	7.0
Days after	T + 1	7.0	7.0	6.1	6.70	7.0	7.0	7.0
treatment	T + 10	6.9	7.0	6.25	6.71	7.0	7.0	7.0

(d) Internal injury

		Breaker				Ripe		
		G1	G2	G3	Mean	G1	G2	Mean
Untreated		0.12	0	0.71	0.27	0.12	0	0.06
Days after	T + 1	0.1	0.12	0.1	0.10	0.2	0.2	0.20
treatment	T + 10	0.5	0.41	0.87	0.59	0.1	0.58	0.34

(e) Brix

		Breaker				Ripe		
		G1	G2	G3	Mean	G1	G2	Mean
Untreated		4.35	4.65	4.25	4.41	4.35	4.65	4.50
Days after	T + 1	4.35	4.2	4.45	4.33	4.1	4.70	4.40
treatment	T + 10	4.1	4.45	4.2	4.25	4.0	4.75	4.37

No significant differences were found between untreated and heat treated fruit for any of the quality parameters determined. Fruit from Grower 3 had slightly weaker external and internal colour, and slightly more external and internal injury but responded similarly to the heat treatment as the other fruit. Fruit treated at a more advanced stage of ripeness exhibited similar behaviour.

Trial 2

The object of the trial was to further test the performance of the treatment unit, to make a preliminary comparison between some common commercial cultivars and to check the fruit handling system for its suitability for simulating commercial practice.

Fruit for the trial were obtained from a commercial grower located in the Bundaberg area of South-east Queensland. Fruit cultivars were the trellis-grown ‘gourmet’ types ‘Mercedes’, ‘Petula’ and ‘Isabella’. Carton packed fruit on a pallet and over-wrapped with multiple layers of plastic film were transported overnight by refrigerated truck set at 10°C. Arrival temperature of the fruit was 20-25°C.

Fruit were treated using the same schedule as Trial 1. Quality parameters of ripened fruit are shown in Table 2.

Tables 2(a-e). Quality evaluation rating scores for external colour (1 = green, 7 = full red), external injury (0 = nil, 4 = very severe), internal colour (1 = green, 7 = full red), internal injury (0 = nil, 4 = very severe), and for brix (as percent sucrose) following quarantine heat treatment of three ‘gourmet’ type tomato cultivars.

(a) External colour

	Untreated	Treated
Mercedes	7.0	6.9
Petula	6.5	6.1
Isabella	6.8	6.1

(b) External injury

	Untreated	Treated
Mercedes	0	0
Petula	0	0
Isabella	0	0

(c) Internal colour

	Untreated	Treated
Mercedes	7.0	6.9
Petula	6.5	6.0
Isabella	6.5	6.0

(d) Internal injury

	Untreated	Treated
Mercedes	0.3	0.7
Petula	0.1	0.8
Isabella	0.4	1.1

(e) Brix

	Untreated	Treated
Mercedes	4.1	4.2
Petula	4.35	4.7
Isabella	4.6	4.55

In ‘Petula’ and ‘Isabella’ cultivars, both external and internal colour development was slightly behind that of the untreated fruit. This was only in the nature of a retardation of development as the same final colour was eventually reached.

No external injuries were detected in treated fruit. Internal injuries were found in untreated fruit and the level increased in treated fruit. This suggests some predisposition to injury development that is exacerbated by heat treatment.

Overall the quality of the fruit remained good.

Trial 3

The trial was designed to continue the evaluation of the treatment system by determining any differences in injury development between upper and lower bins. It

also was used to determine the impact on injury development of reduced humidity air treatment and slow temperature ramping.

It is widely accepted by those working in the field of disinfestation heat treatment that reduced humidity treatment for all or part of a treatment cycle is beneficial for reducing injury development. This has rarely been investigated because equipment is not generally been available to undertake a well-designed experiment. The authors have shown (Jordan et al, 2001, unpublished) that there is a small but significant reduction in internal injury symptoms in tomatoes by using reduced humidity heating (< 60%) compared with high humidity heating.

Tables 3(a-e). Quality evaluation rating scores for external colour (1 = green, 7 = full red), external injury (0 = nil, 4 = very severe), internal colour (1 = green, 7 = full red), internal injury (0 = nil, 4 = very severe), and for brix (as percent sucrose) following quarantine heat treatment of four 'gourmet' type tomato cultivars

(a) External colour

	Untreated	Treated	
		Rep 1	Rep 2
Mercedes	7.0	6.8	7.0
Isabella	7.0	6.7	6.8
Petula	7.0	6.6	6.5
Redcoat	7.0	7.0	7.0

(b) External injury

	Untreated	Treated	
		Rep 1	Rep 2
Mercedes	0.0	0.9	0.6
Isabella	0.1	0.4	0.6
Petula	0.0	0.5	0.25
Redcoat	0.1	0.6	0.54

(c) Internal colour

	Untreated	Treated	
		Rep 1	Rep 2
Mercedes	7.0	6.0	6.0
Isabella	7.0	6.4	6.3
Petula	7.0	6.3	6.2
Redcoat	6.8	6.6	6.8

(d) Internal injury

	Untreated	Treated	
		Rep 1	Rep 2
Mercedes	0.2	2.0	1.50
Isabella	0.75	2.7	1.66
Petula	0.5	1.5	1.25
Redcoat	0.25	1.5	1.16

(e) Brix

	Untreated	Treated	
		Rep 1	Rep 2
Mercedes	4.65	4.2	4.0
Isabella	4.1	4.15	4.0
Petula	4.35	4.1	4.3
Redcoat	3.85	3.65	3.65

Fruit for the experiment were sourced from a commercial grower in the Bundaberg region and transported to Brisbane by road, arriving at 18-21°C. Holding overnight at ambient temperature before treatment was necessary to reduce predisposition to injury. Quality parameters of ripened fruit are shown in Table 3.

Treated fruit showed a low level of quality deterioration symptoms as retardation of internal and external colour development, and development of low levels of external and internal injury.

This level of injury is not surprising since fruit suffered some pre-treatment cooling in transit, which may not have been overcome by the relatively short over-night holding

period. In addition, because treatment was at reduced relative humidity (60-80%), heating efficiency was low resulting in a total treatment time of 13 hours. Such a long treatment time could also have contributed to the injuries observed.

Commercial evaluation 1

Four gourmet-type cultivars ‘Mercedes’, ‘Petula’, ‘Isabella’ and ‘Redcoat’ were obtained from the commercial grower in Bundaberg, moved to Brisbane overnight and heat treated using the standard schedule. Partially ripened fruit were returned to the grower for quality assessment.

The returned fruit were subjected to the standard packing shed quality evaluation which is directed to the assessment of fruit after packing. Hence, the system will automatically downgrade forward coloured fruit as unacceptable for export regardless of other quality attributes. This trial was designed to only demonstrate freedom from heat-induced injuries and other defects, and was not designed to minimise ripening behaviour, because of unavoidable constraints in the handling system. As a result, fruit of otherwise good quality were assessed as being commercially unacceptable.

Commercial evaluation 2

In an effort to overcome the delays in handling the fruit, a modified approach to sourcing, treating and returning fruit was attempted. By collecting fruit directly from the farm and driving them to Brisbane, treating over-night and returning the fruit by commercial road service, it was possible to have them available for assessment in approximately two days. Although not ideal, it was adequate to demonstrate that loss of green life as a result of the heat treatment process was only slight.

Export quality fruit of cultivars ‘Redcoat’ and ‘Mercedes’ were obtained from the commercial packing shed in the Bundaberg region and driven to Brisbane, arriving about six hours after harvest. Fruit was subjected to a standard heat treatment process and cooled in air to ambient temperature. Test fruit were removed from the treatment chamber, packed into open-top fibreboard cartons and placed into a cool room at 10°C until the following afternoon. Cartons were delivered to the depot of the transport company and were returned to the packing shed the following day. Assessment was performed three days after treatment.

The quality assessment demonstrated problems that could be regarded as only minor and which could be managed during sorting prior to packing. The most obvious of these was the presence of green fruit, as well as some ‘blemish’ and ‘wounds’, occurring in ‘Redcoat’ but not in ‘Mercedes’.

The presence of unripe fruit in a treated batch is to be expected, as it is well known that heat treating mature green tomato fruit will prevent or severely retard the ripening process. While much of this fruit was removed during pre-treatment sorting (as it would be in a commercial operation), it is easier, and preferable to allow fruit of uncertain ripeness level to be treated. After treatment, ripening fruit will have coloured slightly, allowing easy removal of the fruit remaining green.

It is known that heat treatment will accelerate, and possibly worsen, the development of symptoms of physical damage caused prior to treatment, so this explanation for the damage detected in 'Redcoat' can not be discounted. In any event, most of the external symptoms could be eliminated in a thorough grading process.

Conclusions

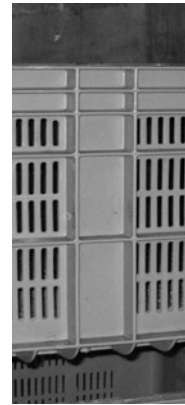
A prototype heat treatment unit capable of treating up to 500 Kg of product at high and low humidity at up to 50°C has been built, tested and used to routinely treat fruit.

Based on the prototype unit design characteristics, a commercial partner has jointly designed and installed a 20 bin size unit for treating mangoes. This unit has been tested and is currently waiting for acceptance of the Japanese Ministry of Agriculture, Forestry and Fisheries for treating fruit for export to Japan.

Experimental and commercial evaluations of heat-treated fruit showed a slight degradation in quality for some fruit of some cultivars, and also a failure to ripen when mature green fruit are treated. This is in line with previous experimental work. It is expected that fruit with treatment induced defects will be able to be removed by sorting during the packing operation, allowing a product of the required commercial export quality to be produced. There is also scope for optimising the treatment process by manipulation of times, temperatures and humidity outside the regulatory quarantine treatment period, to further minimise the risk of quality loss.



(i)



(ii)

Figure 1a. Centre of bin side panel showing blank areas. ((i) Everhard Perstorp bin; (ii) F&T Industries model BB bin)



(i)



(ii)

Figure 1b. Corner posts of bins showing blank areas (external view)



(i)



(ii)

Figure 1c. Bin corners – inside view

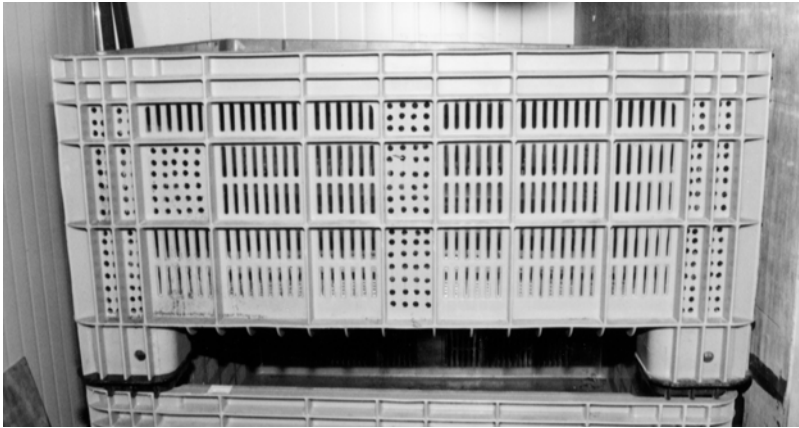


Figure 2. Side view of modified bin showing additional drilled ventilation holes.



Figure 3. Mesh cylinders containing tomato fruit under test, positioned inside bin prior to filling the remaining space with low value filler fruit.

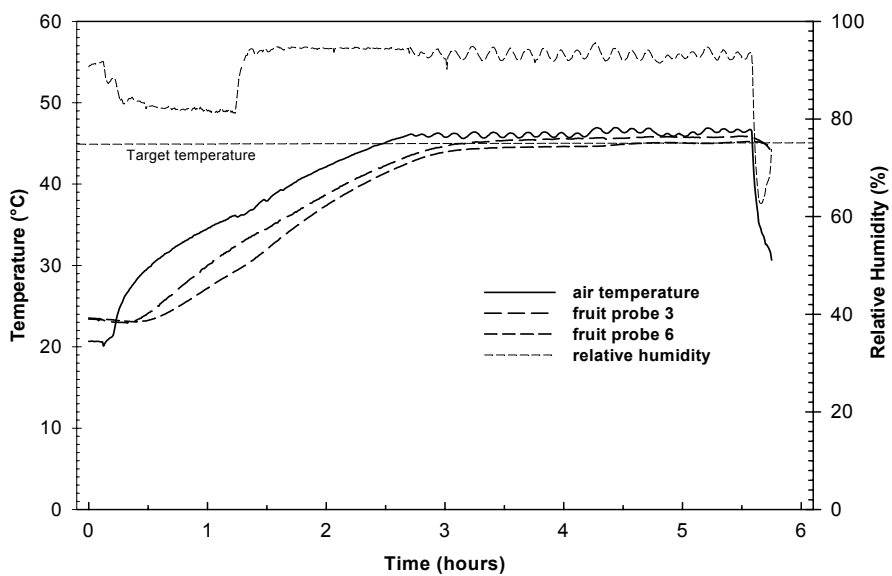


Figure 4. Typical heat treatment run profile showing air temperature, relative humidity and typical fruit temperatures

Commercial Treatment Unit



Figure 5a. External view of chamber



Figure 5b. Internal view of empty chamber



Figure 5c. Bin stack with cover in place



Figure 5d. Mango fruit in a treatment bin

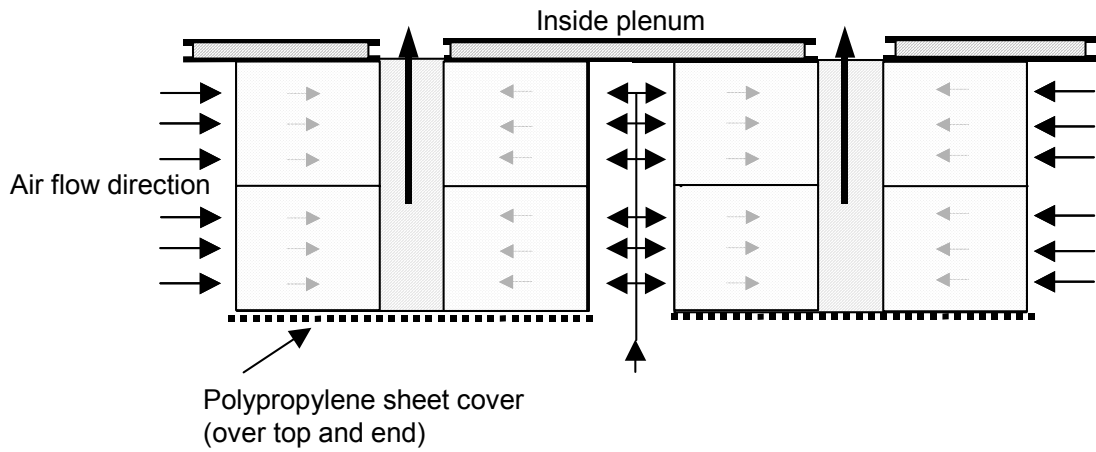


Figure 6a. Bin position - double bin configuration

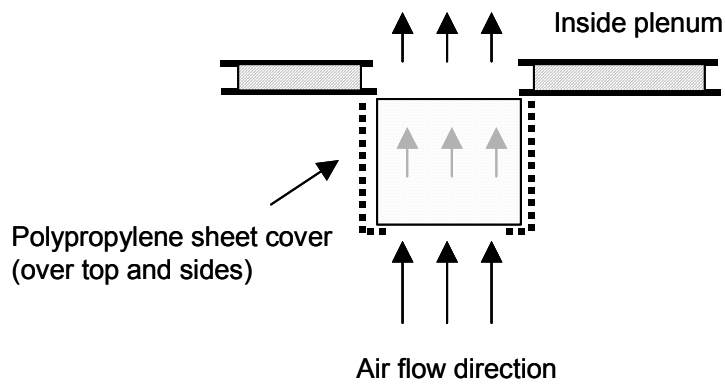


Figure 6b. Bin position - single bin configuration

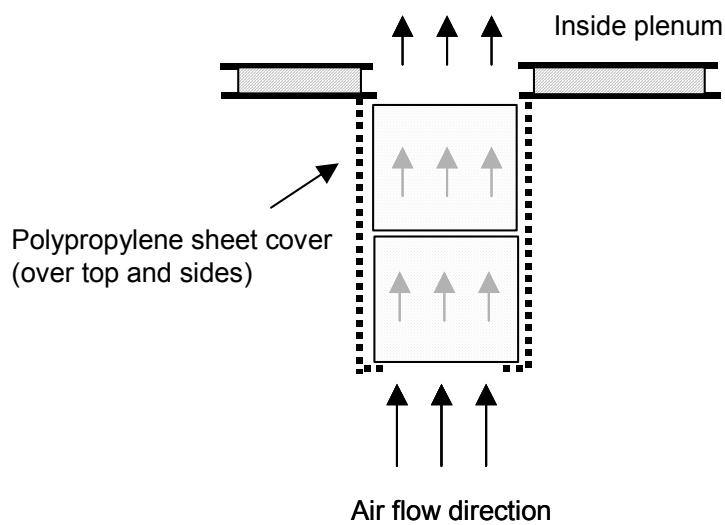


Figure 6c. Bin position – two bin in-line configuration