

Fumigation of dried vine fruit for export

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Abstract

Methyl bromide is currently used extensively for quarantine fumigations and for fumigating dried fruit prior to export. Recent studies have been conducted to develop a modern code of practice for the use of this fumigant by the dried fruit industry. This work has led to improved fumigation techniques and safety procedures. It has also demonstrated that it can take up to 12 days to completely ventilate large stacks (200 t) of boxed sultanas so that concentrations of methyl bromide are at or below the occupational exposure standard or threshold limit value (TLV) of 5 ppm.

The construction of large stacks can be modified by splitting stacks and introducing ducts to improve ventilation but, in the absence of direct monitoring, 10 days of ventilation are necessary before stacks are broken down. This necessitates a change in regulations for ventilation.

There are now concerns about the ozone depleting properties of methyl bromide, and the phasing out of its use has been proposed under the Montreal Protocol. Improved codes of practice for the use of methyl bromide will only meet short-term requirements for industry, and there is an urgent need to develop alternative treatments for control of insects in export produce.

Introduction

Methyl bromide is a fumigant which can kill insect pests rapidly (within a few hours) and is used extensively for quarantine and export fumigations. The dried fruit industry in Victoria, Australia uses methyl bromide for fumigating stacks of cartons of processed fruit to control insect infestations in fruit for export. Fruit is fumigated approximately every month and three days before export in accordance with the Dried Fruit (Export) Orders, using as a standard for fumigation the National Health and Medical Research Council (NH&MRC) 'Code of Practice for the Fumigation of Dried Fruit with Methyl Bromide' (1971). This document has provided the industry with useful operational guidelines, but it has become outdated since it uses Imperial units and contains insufficient information on bromide residues, personal protection and safe ventilation procedures. This paper is concerned with obtaining information required to modernise the code of practice. It is also concerned with more general implications of some of the findings, e.g. in relation to worker safety.

Before the current study, the only detailed data on fumigations of large stacks of processed sultanas (174 t) were in reports on two fumigations conducted by the Department of

Primary Industries and Energy (DPIE). The reports expressed concern that workers required to break down stacks a few hours after removal of fumigation sheets could be exposed to unacceptable levels of fumigant. The use of fan-forced aeration was endorsed, since no fumigant was detected after 22 hours of fan forced ventilation of a 174 t stack. However, it was stated that 'due to the limit of accuracy of the gas analyser used, 'not detected' should be interpreted as meaning that there was no more than 100 ppm present'.

More precise information on methyl bromide concentrations during ventilation was required for a modern code of practice because, the short-term exposure standard, or short term-exposure limit (STEL), for methyl bromide is 15 ppm and the occupational exposure standard or threshold limit value (TLV) for prolonged exposure is 5 ppm.

Materials and Methods

Methyl bromide fumigations of 200 t stacks of 15 kg boxes of sultanas were monitored at the Mildura Co-operative Fruit Company Ltd packing sheds at Red Cliffs and Irymple, Victoria. The sultana boxes were of corrugated cardboard with polythene bag liners. Fumigations all lasted 24 hours with fumigant dosages ranging from 18 to 48 g/m³. The stacks were built on aluminium sheeting (ACI Vapastop) placed over the concrete floor to reduce gas leakage.

Each stack was built with flexible ducting laid around its base in such a way that it could be connected to an extraction fan on conclusion of the fumigation. At first, fumigations were carried out on solid stacks of boxes, but for later fumigations stacks were split into two 100 t stacks about 50 mm apart. In the split stack fumigations, T-pieces were introduced connecting the ducting around the stacks with weldmesh ducts, with cross sectional areas the same as the end of a sultana box (0.0459 m²), built into the bases of stacks. Each duct was linked to a chimney, with a cross-sectional area the same as the top of a sultana box (0.108 m²), running vertically through the stack (Fig. 1).

The gas-proof sheets used to cover the stacks were made of nylon fabric, proofed on both sides with PVC and ca. 0.37 mm thick. The sheets were tailored to fit over metal frames fitted with wheels. Sheets were raised to allow the frame to be wheeled over a stack and were then lowered to cover the stack and surrounding ducting. Sand snakes were used to hold the edges of the sheeting down onto the Vapastop sheets at the base of the stack to form a seal. Piping to deliver methyl bromide to the stack was fitted to the top of the frame and down one side, where a gas fitting, running through the fumigation sheet, was connected to a methyl bromide vaporiser for introduction of the fumigant. Before fumigation commenced, a risk area was delineated with ropes and warning signs 15 m from the stack in accordance with AS 2476 (ASA 1981).

Initially, fumigation staff were equipped with canister respirators, overalls and gloves in accordance with the NH&MRC Code of Practice. Following a review of safety procedures, they were equipped with self-contained breathing apparatus, the compressed air cylinders for which were carried on a

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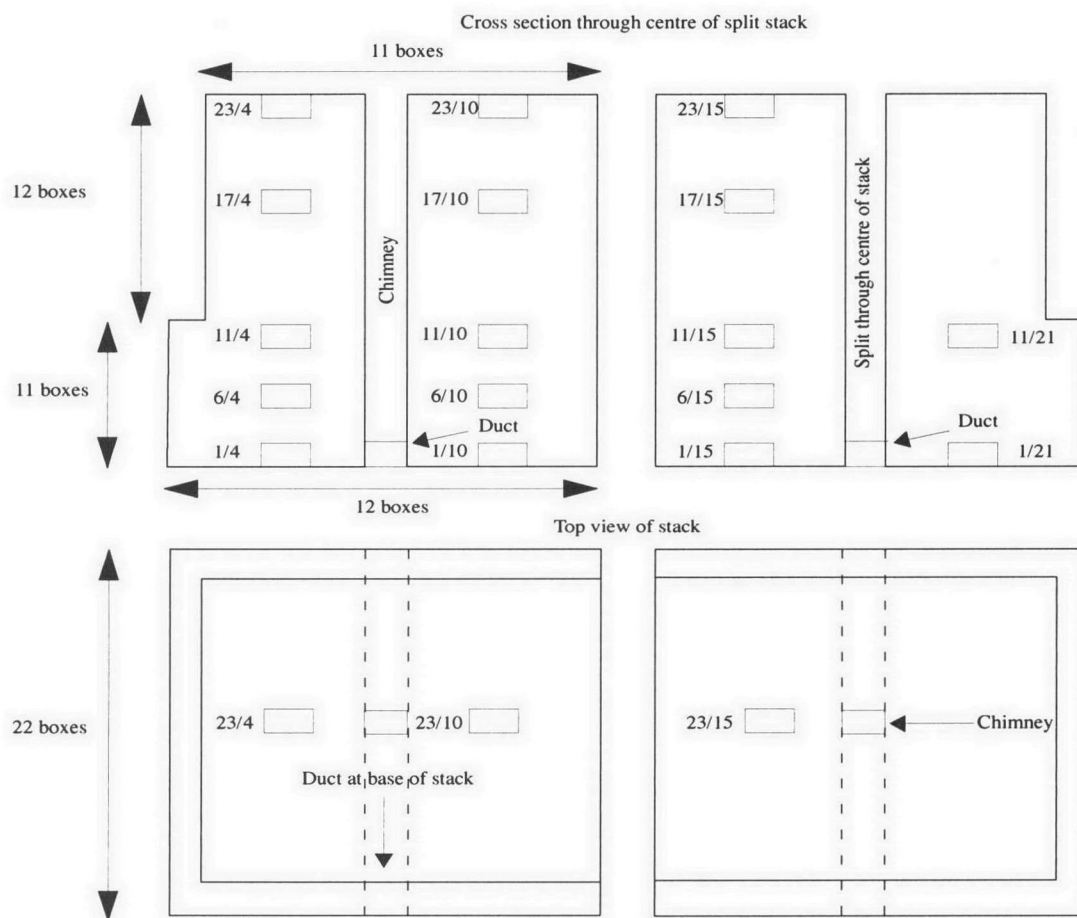


Fig. 1. Diagram of stack of 15 kg boxes of sultanas showing a split stack with basal ducts and chimneys to improve ventilation following fumigation. Boxes identified by vertical/horizontal numbers. All boxes had external gas lines; boxes 1/4, 6/4, 11/4, 17/4, 23/4, 11/10 and 17/10 had internal gas lines; boxes 1/4, 6/4, 11/4, 17/4, 23/4, 11/10, 23/10, 17/15 and 23/15 had external thermocouples; and boxes 1/4, 11/4 and 23/4 had insect cages.

trolley. Flexible air lines linked the cylinders to full face respirator masks. The cylinders were fitted with audible warning devices to indicate when the air level was low.

Methyl bromide concentrations were determined using either a gas chromatograph (GC) fitted with an electron capture detector, or by gas detector tubes (Dräger). The GC was fitted with a J&W Scientific DB-624 fused silica column 30 m × 0.53 mm ID with a film thickness of 0.3 μm; operating temperatures were oven 50°C, injection port 250°C and detector 300°C. Gas sampling lines were placed at different locations within stacks both outside and within boxes of sultanas. Gas samples for analysis were taken from the lines during fumigation and ventilation periods. Stack and ambient temperatures were recorded using an electronic data logger (Datataker) attached to T-type thermocouples located with some of the gas lines and outside stacks. In most fumigations, insect bioassay cages were inserted into some of the boxes of sultanas and into ducts at the bases of stacks (Fig. 1). The insect species used were *Tribolium castaneum* (Herbst) (Tenebrionidae, Coleoptera), *Oryzaephilus surinamensis* (L.) (Silvanidae, Coleoptera), and *Plodia interpunctella* (Hubner) (Pyralidae, Lepidoptera).

To commence ventilation, an extraction fan was connected to a chimney pipe through which gas was exhausted above the packing shed roof. The intake of the fan was connected to the ducting around the stack. The fan was switched on and the fumigation sheet was raised on the side opposite the fan. This enabled the fan to draw fresh air through the stack to flush out the methyl bromide. After ca. 20 hours, the extraction fan was

switched off and disconnected. The sand snakes were removed and the fumigation sheet was either removed completely, or the sides were raised, and the stack was subjected to fan-forced ventilation from either one large or two smaller fan units for a further 24 hours after which the fumigation sheet was removed, if it was still in place, and the stack was left under natural ventilation.

After fan-forced ventilation was completed, the atmosphere in the shed in the vicinity of the stack was tested for methyl bromide by a fumigator wearing a respirator. A halide lamp was used as a check for significant contamination and if there was no indication of methyl bromide then gas detector tubes were used in the immediate vicinity of the stack to confirm that concentrations in the area were at or below the TLV of 5 ppm.

Results and Discussion

The NH&MRC Code of Practice (NH+MRC 1971) recommends the use of full facepiece canister respirators in accordance with the Australian Standard Z18 of 1968. However, under the current standard, Australian Standard AS 1716-1991 'Respiratory protective devices' (ASA 1991), the maximum gas concentration for which canister filters can be recommended is 50 times the TLV, i.e. 250 ppm for methyl bromide. Also, WorkCover Authority of N.S.W. (1991) recommends that canister filter respirators should never be used for protection against highly toxic gases such as methyl bromide. Consequently, it was recommended to the industry

that fumigators be equipped with self-contained breathing equipment. Industrial response was hastened by a ban on use of canisters (which incorporated a phase-in period) imposed by trade unions.

As previously reported (Williams and Henderson 1993), a solid 200 t stack with a temperature of ca. 21°C was fumigated with 18 g/m³ of methyl bromide. During ventilation concentrations of ca. 100 ppm of methyl bromide were detected at the base of the stack 8 days after ventilation commenced and it took nearly 12 days before concentrations throughout the stack were reduced to 5 ppm or less. This result prompted the use of split stacks and the introduction of ducts and chimneys to facilitate ventilation (Fig. 1).

The results of monitoring methyl bromide concentrations during ventilation of a split stack with ducts and chimneys and a stack temperature of ca. 19°C are given in Table 1. Despite the improved ventilation it still took 9.5 days before methyl bromide concentrations were at or below 5 ppm at the base of the stack. The zero or low concentrations of methyl bromide recorded after 7 days ventilation in the outer and upper regions of the stack indicate the potential for lowering methyl bromide concentrations more rapidly by reducing stack size. However, reducing stack size means that the floor space required to house the fruit must be increased and this presents most packing sheds with major storage problems.

Location of a stack in a well-ventilated part of a packing shed, e.g. with open doors on either side of the stack, and high temperatures, can aid removal of methyl bromide. A 200 t split stack in a well-ventilated location was fumigated with 24 g/m³ of methyl bromide when the ambient temperature was 40°C. It took only 6 days of ventilation before methyl bromide concentrations were reduced to 5 ppm or less.

The caged insects used in all of the trials were dead when examined. Many insects caged in unfumigated boxes of sultanas were alive and live insects were also found amongst the sultanas in some of these boxes. Thus, it appeared that the fumigations were successfully controlling infestations.

Gas detector tube readings for methyl bromide taken immediately around stacks (including readings taken with detector tubes touching the boxes) on completion of fan-forced ventilation never exceeded the occupational exposure standard of 5 ppm, in accordance with DPIE findings. However, analysis by GC and/or detector tubes of gas samples from within stacks at this time always showed methyl bromide concentrations in excess of both the TLV and STEL, demonstrating the danger of relying on the DPIE findings (Table 1).

Information gained in this study indicates the importance of checking fumigant concentrations within bulks of produce after an initial ventilation period, to ensure that concentrations do not exceed the occupational exposure standard before people are required to handle the produce.

There are now concerns about the ozone-depleting properties of methyl bromide, and the phasing out of its use has been proposed under the Montreal Protocol. Consequently this study will only meet short-term requirements for industry. Work on developing and testing alternative fumigants and fumigant mixtures for control of insect pests in a variety of products is planned to meet future requirements. The Stored Grain Research Laboratory, Division of Entomology CSIRO, and the Division of Horticulture CSIRO, have already conducted some trials on the use of carbon dioxide as an alternative treatment for the dried fruit industry. The carbon dioxide treatments proved successful when stacks of fruit were enclosed in tailor made gas-proof covers, which enabled toxic concentrations of carbon dioxide to be maintained for a minimum 15 day treatment period (Tarr et al., these proceedings).

Conclusions

Monitoring ventilation of large stacks of dried fruit showed that, on completion of fan-forced ventilation, concentrations of methyl bromide in the immediate vicinity of stacks were below the TLV of 5 ppm and that consequently it was safe to work within the area. However, concentrations of methyl bromide persisting within the stacks made it unsafe to break them down. In all circumstances, there was a need to extend the current maximum 2-day period allowed before breaking down of stacks. In general, a 12-day ventilation period would be needed for a solid 200 t stack and a 10-day period for a split stack with ducts and chimneys. Only if a stack was fitted with gas sampling lines to enable methyl bromide concentrations to be monitored would it be reasonable to take advantage of favourable conditions to reduce the ventilation period required.

It is important that organisations undertaking fumigations of produce conduct some monitoring to check that their fumigations comply with current health and safety standards as well as existing fumigation schedules. It is also important that fumigators be equipped with appropriate protective respirators and clothing that meets current standards.

Table 1. Concentration of methyl bromide (ppm) in a 200 t split stack in boxes of sultanas at different times after commencement of ventilation. Ventilation of both sub-stacks was aided by a chimney and basal duct as in Figure 1.

Vertical location in stack		1.5 days				2.5 days				7 days			
Top	Box 23	52	35	30		36	37	26		0	0	0	
	Box 17	51	50	86		63	63	45		0	0	0	
Middle	Box 10	128	850	212	288	91	330	118	119	0	8	2	0
	Box 6	356	1497	418		139	666	171		0	3	5	
Base	Box 1	1059	2118		2163	476	1091		861	18	75	35	60
Vertical location in stack		8 days				8.5 days				9.5 days			
Top	Box 23	0	0	0									
	Box 17	0	0	0									
Middle	Box 10	0	3	0	0		0						
	Box 6	0	12	0			2				2		
Base	Box 1	10	35	16	30	3	7	0	5	0	4	0	3
Horizontal location in stack		Box 4	Box 10	Box 15	Box 21	Box 4	Box 10	Box 15	Box 21	Box 4	Box 10	Box 15	Box 21

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