

Illness Associated with Exposure to Methyl Bromide–Fumigated Produce — California, 2010

Methyl bromide (MeBr) is a toxic gas used to fumigate agricultural fields and some produce. The U.S. Department of Agriculture (USDA) requires MeBr fumigation of grapes imported from Chile to prevent invasion by the Chilean false red mite, *Brevipalpus chilensis*. In 2010, two workers were exposed intermittently to MeBr over several months as part of their job inspecting produce at a cold-storage facility in Carson, California. Both workers had disabling neurologic symptoms (e.g., ataxia, memory difficulties, and dizziness) and elevated serum bromide concentrations. An environmental investigation revealed the potential for MeBr to accumulate in enclosed areas during the transportation and storage of fumigated grapes. Some MeBr air concentrations measured at a single point in time exceeded current 8-hour exposure limits, suggesting that exposure in confined areas could result in poisoning. Possible measures for facilities managers to consider to reduce postfumigation MeBr exposures include 1) increased aeration time, 2) reduction of packaging that might absorb MeBr or limit aeration, and 3) changes in the stacking of pallets to improve air flow. Facilities should monitor air MeBr levels if they store MeBr-fumigated commodities in enclosed spaces entered by workers. Clinicians should consider occupational and environmental exposures in their differential diagnosis, and workers who might become exposed to fumigants should be informed of the health hazards related to these pesticides.

The California Department of Pesticide Regulation (CDPR) was notified of MeBr exposure in one worker (patient A) after the treating physician contacted the California Poison Control System on March 19, 2010. Investigation by staff members of the Los Angeles County Department of Agriculture and CDPR confirmed that patient A had elevated serum bromide concentrations and that he had learned that a coworker (patient B) had similar symptoms. During April 13–21, 2010, CDPR conducted industrial hygiene testing, measuring MeBr concentrations at single points in time with samples obtained at several locations, using colorimetric indicator tubes sensitive to air concentrations ranging from 0.4 ppm to 80 ppm.* Sampling was conducted at three sites: the Port of Long Beach (PLB), where the imported grapes were fumigated

with MeBr and then aerated; a cold-storage facility in Carson (facility A), where the two patients inspected produce, 6 miles from PLB; and a second cold-storage facility 215 miles from PLB in Tulare County (facility B), which was chosen to assess the effect on MeBr concentrations of transporting a shipment a long distance.

Case Reports

Patient A was a man aged 22 years with an unremarkable medical history who was employed as a quality inspector by a wholesale produce shipping company and was assigned to facility A from late December 2009 through the middle of March 2010. He worked long work shifts 3–4 days per week. In late January 2010, he began experiencing gradually increasing difficulty walking (i.e., ataxia). Additionally, he described gradual onset of problems with concentration, dizziness, and visual disturbances (i.e., decreased visual acuity and peripheral vision). On March 13, after speaking with a coworker (patient B) and learning they had similar symptoms, patient A began to suspect that a workplace exposure was responsible.

Patient A obtained a medical evaluation by his primary-care provider and an occupational medicine specialist. Major findings included a positive Romberg sign, difficulty maintaining balance while standing on one leg, and difficulty with tandem gait. The pertinent negatives on examination were as follows: no nystagmus, normal extraocular movements, normal funduscopic examination, cranial nerves 2–12 intact, muscle strength and control intact, fingertip-to-nose intact, deep tendon reflexes equal and active (2+), and intact perception of light touches (<0.5 mm apart). Patient A's serum bromide concentration on March 18 was 4.4 mg/dL.† Assuming first-order elimination kinetics and a 12-day half-life for inorganic bromide, his serum bromide was estimated to have been 58.7 mg/dL on March 13, his last day working in cold storage. When interviewed in April, the patient stated that his symptoms had lessened and that he was hoping to return to work shortly. By September 2010, he appeared fully recovered, had left his job as a produce inspector, and had enrolled in graduate school.

Patient B was a previously healthy man, aged 52 years, who worked as an independently contracted quality inspector for customers in the produce shipping and packing industry. From December 2009 to February 18, 2010, he worked 8 hours or more, 4 to 5 days per week, inside the refrigerated storage

*The exposure limit for MeBr set by the American Conference of Governmental Industrial Hygienists and the Cal/OSHA Permissible Exposure Limit (PEL) is a time-weighted average concentration for up to an 8-hour workday with exposure of 1 ppm. The U.S. Environmental Protection Agency has noted that short- and intermediate-term (1 day to 6 months) exposures to MeBr concentrations of 0.15 ppm for an 8-hour time-weighted average are of concern. Additional information available at <http://www.epa.gov/oppsrrd1/REDs/factsheets/methylbromide-fs.pdf>.

† The laboratory reference range for serum bromide is <0.5 mg/dL (5 ppm).

space at facility A. In January and February he noticed the gradual onset of lightheadedness and difficulty with speech. On February 22, 2010, he sought treatment for respiratory symptoms, decreased libido, feeling mentally “slow,” and trouble speaking. He also experienced symptoms of nausea, vomiting, lightheadedness, ataxia, and memory difficulty. Abnormal findings on physical examination by a physician included blood pressure of 170/120 mm Hg, difficulty with tandem gait, drift of his right hand with supination, and inability to remember three words (e.g., apple, book, and pencil) communicated to him 5 minutes earlier. He refused hospitalization to rule out a cerebrovascular incident. Magnetic resonance imaging of the brain and head was normal except for bilateral sinusitis. Routine screening tests of his blood and his complete blood count were normal except for borderline blood urea nitrogen elevation and mildly increased nonfasting blood glucose. He was treated with a sulfa antibiotic for sinusitis and lisinopril for high blood pressure.

Patient B visited his physician for follow-up on February 24, 2010, when he was noted to have continuing lightheadedness and referred to a neurologist. Laboratory testing during March 1–12, 2010, was negative or normal for rheumatoid arthritis, systemic lupus, coccidiomycosis, and several other inflammatory or infectious diseases. An echocardiogram was normal, and evaluation for pheochromocytoma and carcinoid tumor were negative. After learning that patient A had similar symptoms, a serum bromide test was obtained on March 20, 2010, that showed a bromide level of 1.5 mg/dL, which was estimated to have been a level of 85 mg/dL on patient B's last work day (February 18). On March 24, because of his continued lightheadedness, patient B was restricted from activities that could endanger himself or others (e.g., driving), which precluded him from working. When contacted in September 2010, he felt he had fully recovered and had returned to work as an independently contracted produce inspector in cold-storage facilities.

Both patient A and patient B told investigators that their working conditions at facility A were unusual. Typically, they worked outside refrigerated storage areas, not inside, but at facility A they were required to work inside the refrigerated area. Forklift drivers and other facility A employees entered intermittently, but only patient A and patient B worked for prolonged periods inside the refrigerated area. No other coworkers reported illness; however, CDPR did not conduct an illness survey or measure serum bromide in other potentially exposed workers.

Environmental Investigation

During April 13–21, environmental sampling was conducted 1) at the semi-enclosed dockside buildings where imported produce is fumigated at PLB, 2) inside loaded semitrailers ready for departure from PLB, 3) inside the semitrailers on

What is already known on this topic?

Some imported produce must be treated with methyl bromide (MeBr), a toxic gas that can cause severe illness. Such illness principally has been observed in workers conducting MeBr applications.

What is added by this report?

In 2010, two produce inspectors working in a California cold-storage facility where MeBr-treated grapes were stored developed severe neurologic illness believed to have resulted from prolonged MeBr exposure. These are the first illnesses in the United States arising from MeBr exposure occurring in produce storage areas remote from the site of application.

What are the implications for public health practice?

The evidence suggests that proposed U.S. Environmental Protection Agency requirements to prevent illness associated with MeBr exposure were not being followed. Facilities should monitor air MeBr levels if they store MeBr-fumigated commodities in enclosed spaces entered by workers. In addition, clinicians should consider occupational and environmental exposures, especially when diagnosing patients with unusual illnesses, and workers who might become exposed to fumigants should be informed of the health hazards related to these pesticides.

arrival at cold-storage facilities A and B, 4) at the loading docks at facilities A and B, and 5) inside the refrigerated area at facility A. When produce is fumigated with MeBr, stacks of tarped pallets are injected with MeBr gas and after a few hours the fumigated commodities are aerated. After aeration, MeBr concentrations must be <5 ppm, based on single point in time measurements, before the commodity can be released for commercial distribution (1,2).

Results of the environmental investigation demonstrated that PLB had aerated grapes fumigated with MeBr according to current USDA standards.[§] Beginning April 9, after PLB became aware of the two workers' symptoms, aeration time was extended from 4 to 9 hours, reducing short-term MeBr concentrations in semitrailers sampled before their departure from PLB. When packaged produce was shipped in enclosed semitrailers, however, offgassing of the fumigant from the produce caused levels to increase to potentially hazardous concentrations. The 15 samples collected from the semitrailers after they arrived at facility A and facility B from PLB showed significantly[¶] higher concentrations of MeBr (median 10 ppm and geometric mean 5.0 ppm) than the 10 samples taken inside the loaded semitrailers before departure from PLB (median 0.75 ppm and geometric mean 0.68 ppm) (Table).

[§] Available at http://www.aphis.usda.gov/import_export/plants/manuals/ports/downloads/treatment_pdf/02_03_chemicaltreatmentsmb.pdf.

[¶] Mann-Whitney/Wilcoxon two-sample test, $p < 0.01$.

To reduce MeBr levels, the small vent door on one trailer was left open to continue ventilation throughout the 215-mile trip from PLB to facility B. On arrival, no MeBr (<0.4 ppm) could be detected in this load. However, 10 minutes later, despite having the main rear doors open, the MeBr concentration was 4 ppm, above the recommended 8-hour exposure limits of 1 ppm. In addition, MeBr concentrations on the loading docks at facilities A and B and in the refrigerated area at facility A where patients A and B inspected produce (median 2.0 ppm and geometric mean 1.9 ppm) also exceeded 1 ppm (Table). These observations were consistent with predictions that a large volume of commodity that is offgassing MeBr, handled in conditions of low ventilation, has the potential to generate MeBr exposures above permissible exposure limits during an 8-hour work shift (3).

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Editorial Note

MeBr is a colorless and odorless multisystem toxicant, producing severe and sometimes permanent nervous system effects (4). Most use of MeBr ceased by 2005 to protect stratospheric ozone, but it is still used to treat commodities

TABLE. Results of testing for methyl bromide (MeBr) concentrations at the Port of Long Beach (PLB) and cold-storage facilities in Carson (facility A) and Tulare County (facility B) — California, April 2010

Location of sampling (dates)	No. of samples	Range of results (ppm MeBr*)	Median (ppm MeBr)	Geometric mean (ppm MeBr [†])
PLB: in semi-enclosed dockside buildings containing produce after fumigation and aeration (April 13, 19, and 21)				
After 4 hrs of aeration	8	<0.4–8.0 [§]	1.9	1.7
After 9 hrs of aeration	19	<0.4–5.0	1.0	1.0
Total in semi-enclosed dockside buildings at PLB	27	<0.4–8.0	1.4	1.3
PLB: inside loaded semitrailers ready to depart				
After produce aerated 4 hrs (April 19 only)	3	2.0–5.5	2.5	3.0
After produce aerated 9 hrs (April 13, 19, and 21)	7	<0.4–1.0	<0.4	0.4
Total for semitrailers ready to depart PLB	10	<0.4–5.5	0.75	0.68
Facility A: semitrailers on arrival after driven with trailers fully closed (April 13 and 19)				
Sample collected through small vent door immediately on arrival	6	10.0–20.0	13.5	13.5
Sample collected beside load (with doors open) after 19–25 min aeration	3	<0.4–4.0	2.5	1.3
Facility B: semitrailer on arrival after driven with vent doors open the entire 215-mile trip (April 21)				
Sample collected through small vent door immediately on arrival	1	<0.4	—	—
Sample collected beside load (doors open) after 10 min aeration	1	4.0	—	—
Facility B: semitrailer on arrival after driven with vent doors closed the entire 215-mile trip (April 21)				
Sample collected through small vent door immediately on arrival	2	10.0–20.0	15.0	14.1
Sample collected beside load (doors open) after 10 min aeration	2	4.0	4.0	4.0
Total in semitrailers at facilities A and B	15	<0.4–20	10.0	5.0
Facilities A and B: indoor areas (April 13, 19, and 21)				
Loading dock (enclosed to retain cold air)	3	<0.4–7.0	2.0	1.4
Inside facility A refrigerated area (April 13 and 19)	2	2.0–4.0	3.0	2.8
Total at loading dock and inside refrigerated area at facilities A and B	5	<0.4–7.0	2.0	1.9

* All results obtained from detector tubes with a minimum level of detection of 0.4 ppm and a variability of $\pm 15\%$.

[†] All results below the limit of detection were assigned a value of 0.2 ppm.

[§] The highest value (8.0 ppm) could not be replicated. Excluding that value, the range for the remaining seven samples in this grouping was <0.4–3.5 ppm, with a median value of 1.8 ppm and a geometric mean of 1.4 ppm. According to U.S. Environmental Protection Agency regulations, after aeration, MeBr concentrations must be below 5 ppm before the commodity can be released for commercial distribution.

potentially contaminated with a recognized quarantine pest, and to treat certain agricultural items (e.g., soil and seedlings) when no feasible alternative exists (4). Fatalities and serious poisonings principally involve workers conducting structural and commodity fumigations (5–9). However, at least one report describes toxicity in a warehouse worker exposed to imported produce fumigated with MeBr under circumstances similar to those described in this report (10). MeBr poisoning is becoming rare. CDPR identified one such case in 2007, which involved an agricultural worker applying MeBr.

Cold-storage facilities on the East Coast and West Coast of the United States have recently adopted measures to increase dissipation of MeBr and to prevent MeBr overexposure. These measures include creating well-ventilated fruit inspection stations separate from chiller rooms, reconfiguring airflow and improving ventilation to increase air exchange where fumigated commodities are stored, and increasing the frequency of air monitoring of MeBr levels.

The illnesses in the two workers described in this report are consistent with prolonged indoor exposure to fumigated produce. These findings suggest that other workers with similar exposures might be at risk for serious poisoning. The U.S. Census Bureau estimated that in 2002 a total of 877 cold-storage facilities were in operation in the United States. Commodity groups and cold-storage facility operators in the western United States, USDA, the U.S. Environmental Protection Agency, and representatives of the Chilean produce industry have been notified of these findings.

The findings in this report are subject to at least two limitations. First, because of the delay in reporting and confirming the two cases, CDPR did not have an opportunity to survey the workplace at the time the exposures occurred; staffing limitations also precluded industrial hygiene sampling beyond PLB and two offsite cold-storage facilities. Second, existing exposure standards are based on 8-hour time-weighted averages; CDPR performed only single point in

time measurements of MeBr air concentrations to maximize the number of sites sampled.

Additional investigation is needed to identify effective measures to prevent MeBr overexposure among persons who spend prolonged periods inside cold-storage facilities (2). The industry is evaluating the effectiveness of recently adopted measures to prevent MeBr overexposure. In addition to exploring modifications to packaging and aeration, studies of the dissipation kinetics of fumigated fruit and lower rates of application are needed to guide development of fully protective procedures.

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