# BEYOND
# Methyl Bromide

***The search intensifies for safe, effective alternatives.***

Cheap, fast, and easy to use, methyl bromide has been "a chemical for all reasons." Exterminators use it to protect your home from termites that would like to make lunch of your back porch.

Museum curators rely on it to keep tiny beetles, moths, and other small insects from gnawing precious relics.

Exporters of shiny brassware in the Far East fumigate shredded packing material so pests like khapra beetles can't stow away inside and make their way from the warehouse to your house.

Around the farm and in the packinghouse, methyl bromide performs a host of fumigation chores. Pumped into soil, it kills weeds, insects, fungi, and bacteria that could weaken or kill crop plants.

Inside dark warehouses and silos, the chemical protects a cornucopia of produce and grain from voracious insects. What's more, some crops targeted for export—juicy cherries from California and the Pacific Northwest, for example—can be routinely fumigated with this chemical to meet rigorous quarantine requirements of importing nations.

But by the end of the century, this picture will likely change. That's because the United States has signed an international accord, known as the Montreal Protocol, to reduce or eliminate production or use of chemicals thought to damage the ozone layer—the natural shield that protects the Earth's atmosphere. Methyl bromide was put on the list with other compounds similarly linked to ozone depletion.

In addition, the U.S. Clean Air Act calls for halting manufacture of ozone-depleting compounds by the year 2001.

These events have sent ARS scientists at labs around the country scurrying to find alternative ways to disinfect soils and stored crops. And they're scrutinizing the chemical's escape from soil, known as outgasing, when it's used as a fumigant.

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**Insect pathologist Pat Vail (left) and entomologist Charles Curtis ascertain the distribution of Indianmeal moths in a sample of walnuts. (K5720-4)**

Here's a look at what scientists at three labs are doing to help lessen reliance on methyl bromide.

### Atmospheres: Hot, Cold, and Modified

Nothing quite matches the rich flavor and crunchy texture of walnuts for fudge, brownies, pies, quick breads, and a host of other treats. But this nut is also a favorite with insects like the navel orangeworm, codling moth, and Indianmeal moth, which find its nutmeat tasty and its sturdy shell a cozy home for their wormlike offspring.

Today, growers zap these pests with a dose of methyl bromide where walnuts are stored.

Walnuts sometimes stay as long as a year in cavernous warehouses, giant steel canisters, or other storehouses stuffed with thousands of tons of nuts.

In a test launched in the spring of 1994 with 8,000 pounds of unshelled walnuts, researchers at the ARS Horticultural Crops Research Laboratory in Fresno, California, are trying to trounce the moths by either making life inside the storeroom too cold, infecting them with a virus, or changing the air around them into a mix of gases they can't tolerate. Also, the researchers are juggling combinations of these tactics.

Importantly, any strategy that protects stored walnuts could likely guard several other commodities as well, like almonds and pistachios. Some of these same moves might be readily applied to fending off pest attacks on sun-dried fruits, like raisins, apricots, prunes, and perhaps

others, says laboratory director Patrick V. Vail.

California leads the nation in producing these tree nuts and fruits. The 1993 crop had a farm value of about $2 billion.

To wipe out any navel orangeworms that may have been hiding in the walnuts when they came in from the orchard, the scientists stashed field bins full of walnuts in a small, airtight storeroom, then pumped in nitrogen until the air had only four-tenths of 1 percent oxygen. The air we breathe, notes Vail, has about 21 percent oxygen. After 7 days in this inhospitable atmosphere, no navel orangeworms survived.

Next, to deter any Indianmeal moths lurking in the storeroom, Vail and colleagues separated the bins into groups that were either chilled to 50°F, surrounded by air containing only 5 percent oxygen, or dusted with a natural virus that infects Indianmeal moth but is harmless to humans and other organisms.

Vail is doing the work with entomologists Charles E. Curtis, Judy A. Johnson, and Edwin L. Soderstrom at Fresno.

For the next several weeks, the scientists routinely set Indianmeal moths loose in the chamber. When checked 2-1/2 months later, all the treatments "looked pretty promising," reports Vail. "There was some slight insect damage to the virus-treated walnuts, but those held at 5 percent oxygen or at 50°F remained undamaged."

The team used another 8,000 pounds of walnuts last fall for a second round of tests and is now scrutinizing the results and tabulating

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**A chromameter enables biological technician Joel Jenner to determine the rind color of lemons. Plants will be moved into greenhouses to see how preharvest growing temperatures affect the postharvest response of fruit to quarantine treatments. (K5715-2)**

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**Technician David Brandl prepares to roll a 500-pound bin of walnuts into a controlled atmosphere chamber. (K5718-16)**

costs. "We'll probably have to give processors a cluster of treatments," says Vail, "that are likely to be more expensive than simply fumigating with methyl bromide."

The team will try some similar tricks with raisins this year. For another crop—prunes—a mix of heat and cold might keep moths out of the tender, moist fruit.

"Today," says entomologist Judy A. Johnson, "prune packers give the whole processing plant a good fumigation with methyl bromide, once the harvest is brought indoors.

"We're testing an alternative: convert the large methyl bromide chambers to heating and cooling rooms. Use heat instead of methyl bromide for a quick kill of insects that might be concealed in prunes. Then, throughout the fall and winter, use cool night air to keep the prunes at about 50°F until they're ready to pack and ship."

To streamline cooling and keep energy costs low, Johnson is collaborating with agricultural engineer James F. Thompson of the University of California, Davis.

"Processors already know that low temperature is a really good way to prevent infestation," says Johnson. "But it takes a long time to kill the insects. So if you use heat first, you have a fairly quick treatment, followed by the night air recirculation, which uses little energy and should keep the prunes insect-free.

"We're trying to fine-tune this strategy. We know that we can kill Indianmeal moth eggs in 3 weeks at 50°F and that it may take more than 5 weeks to kill off the adults. We need to find out exactly what happens to the moths if we use heat for a few days and then low temperatures for a few months."

Meanwhile, co-researcher Ed Soderstrom is testing a range of controlled atmosphere environments, to find the precise mix of gases that harms warehouse marauders but not the stored harvest. In his laboratory, Soderstrom uses hundreds of glistening white Indianmeal moth eggs, each no bigger than a pinhead.

"Atmospheres with 5 or 6 percent oxygen are less expensive to use for long-term storage than those with four-tenths of a percent, for example," says Soderstrom. "Since controlled atmosphere storage—what we call CA—is more costly than methyl bromide, we're trying to determine the least expensive way to use it."

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**To lessen environmental disturbances inside special walnut storage rooms, entomologist Judy Johnson (left) and technician Karen Valero use tubes to insert pests. During storage tests, they gently blow mated pairs of Indianmeal moths into the closed chambers. (K5717-18)**

Johnson is pursuing yet another pest control strategy. She's following the lead of ARS researchers elsewhere who have had remarkable success in recruiting helpful insects to patrol silos.

The beneficial bugs seek out and kill troublesome ones. What better place to find candidates for this natural warfare than the "fig dump," a mountain of figs that, while rejected at a nearby packinghouse as not perfect enough for humans, make a nutritious addition to cattle feed.

"The fig dump is a very entertaining place, if you're an entomologist," says Johnson, "because it's teeming with both pests and beneficial insects." The beneficials, she says, could search out unwanted insects that may be hiding in crevices or cubbyholes at the warehouse.

She has her eye on a little black wasp called *Habrobracon hebetor*. "The females," she says, "sting and parasitize Indianmeal moth larvae, later laying eggs on these immobilized worms. Wasp offspring then hatch from the eggs and kill the larvae by feeding on them."

Further foraging at the fig dump, says Johnson, may reveal other promising protectors.

## Another Breed of CATTS

Besides mothproofing dried fruits and nuts, methyl bromide is used for fresh produce like apples, and even highly perishable soft fruits like nectarines and cherries. In the Pacific Northwest, growers fumigate about $35 million worth of sweet cherries every year for export to Japan.

To discover the best mix of new options for exporters, Lisa G. Neven at Yakima and colleague Elizabeth J. Mitcham at the University of California at Davis developed what surely are two of the world's most sophisticated fruit treatment boxes. They've dubbed them "CATTS," for controlled atmosphere/temperature treatment system.

"You can adjust temperature, humidity, atmospheric gases, or air speed from your office or lab computer," says Neven. "Our CATTS are saving us months of time because we can scrutinize more possibilities faster than ever."

These research prototypes, which resemble overgrown home freezers, are perfectly sized to accommodate

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**Investigating the persistence of methyl bromide residues in fruit, chemist Charles Sell inserts probes that will register the temperature of apple pulp. (K5745-2)**

standard field boxes from neighboring farms.

A study by Neven and Mitcham with 1,400 pounds of cherries compared two different temperatures, 113°F and 117°F, with and without the specially altered atmospheres.

"We found that heating the fruit to 117°F—and simultaneously using CA—kills all of the codling moths in only 44 minutes," says Neven. "That's about half as long as it takes to kill them if you use heat alone. Heat makes the insects breathe faster and need more oxygen, but the CA doesn't have enough oxygen to keep them alive."

"This treatment," Mitcham points out, "isn't perfect, because there was some softening of the fruit. But the combination of heat and CA seems really promising. And we haven't even begun to look at all of the different heat-plus-CA combinations that we could try."

## Emissions Check

While some researchers probe for alternatives to methyl bromide's indoor uses, ARS soil scientist Scott R. Yates at Riverside, California, is exploring its outdoor work as a fumigant. He's looking for ways to reduce emissions into the atmosphere.

Soil fumigation now accounts for about 85 percent of the methyl bromide used in U.S. agriculture.

Without methyl bromide, producers of crops like strawberries, tomatoes, peppers, and eggplant might lose a portion of their harvest. Those crops and others, including grapes, citrus, nuts, forest tree seedlings, and ornamental trees are usually planted only after soil has been sterilized with methyl bromide.

Kenneth W. Vick, ARS national program leader for stored product insects and plant quarantine, says it is estimated that unless viable alternatives are found, losses to U.S. agriculture could total as much as $1.5 billion annually.

Collecting data on how much methyl bromide actually gets into the atmosphere is important to gaining an understanding of its atmospheric effects, Vick says.

According to a preliminary study by Yates, who is in the ARS Pesti-

**In the soil, methyl bromide degrades at varying rates, depending on factors such as soil type, moisture level, pH, and microbial activity. To determine the gas' underground movement, soil scientist Scott Yates measures its concentration at several depths. He will remeasure at the end of the experiment to see how much of the gas remains.**

cide and Water Quality Research Unit, soil fumigation appears to release less of the compound into the air than was previously thought.

"Our findings suggest that only 40 percent of the methyl bromide that's injected into the soil escapes," he says. His estimate contrasts with those from some sources, which have been as high as 90 percent. The Montreal Protocol assumed emissions were 50 percent, based on a computer model.

For his experiment, Yates copied growers' procedures. He injected the chemical into the soil with tractor-borne nozzles, where it quickly vaporizes. On two 10-acre plots near the ARS Salinity Laboratory in Riverside, he applied the chemical 10 inches below the soil surface, just like strawberry growers do, then sealed the surface with a clear plastic tarp for 5 days. On a second, untarped, 10-acre plot, he pumped the chemical down 27 inches—the tactic growers use when replacing an old vineyard or orchard with young trees.

To capture and measure escaping methyl bromide, Yates used three different techniques, requiring some 60 different probes or other instruments.

"This may be the first time," says Yates, "that anyone has accounted for 100 percent of methyl bromide fumigant under real farming conditions."

Next, Yates and colleagues at the University of California at Riverside will compare different ways to apply the chemical.

"We'll find the one that minimizes emissions," he says, "and then we'll make it even better."—By **Marcia Wood** and **Kathryn Barry Stelljes,** ARS. **Dennis Senft,** ARS, contributed to this article.

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