

# Mite Control in Dry-Cured Ham Aging Facilities



Dry-cured, or country-cured, ham is an American value-added ham with unique, aged flavors. The finished product is a treasured tradition, mainly in the southern United States. There are regional variations in the curing, smoking, and aging processes that result in small differences in the final flavor of the product (Pham et al., 2008).

American dry-cured hams are aged for a minimum of 3 months and a maximum of 2 years. Long-aged hams (18–24 months) are premium products with a minimum value of \$10.40 per pound for bone-in ham, \$17.50 per pound for boneless ham, and \$39.95 per pound for sliced ham.

Ham aging rooms are maintained at temperatures ranging from 65 to 86°F and relative humidity values from

60 to 80 percent. These conditions are necessary for the characteristic flavor of the hams, but they are also optimal environmental conditions for ham mites to increase in numbers and potentially infest dry-cured hams.

The ham mite is a tiny relative of spiders that can reproduce into large populations and become a serious pest (Figure 1). The mite is adapted to feeding on aged meats, cheeses, semi-moist pet foods, and grain products that are between 15 and 45 percent moisture content. The ham mite can live on foods in cracks, crevices, and walls in food-processing buildings. In heavy mite infestations, mites can easily be seen crawling on hams and physical structures in the aging rooms (Figure 2).



Photo by Eric Erbe, USDA Agricultural Research Service, Bugwood.org



Figure 1. (Left) Scanning electron micrograph of ham mites. (Right) An aggregation of mites on a food surface.



Figure 2. (Left) An aging ham infested with mites (small, white dots). (Right) Mites on a wooden aging rack.

Ham mite infestations may lead to product losses of \$1.4 million a year or more for facilities without proper pest management practices. Regulatory guidelines (USDA Title 9 Code of Federal Regulations 301.2) state that filth on a meat product that may “render it injurious to health” is adulteration, and many inspectors assess mites on dry-cured ham to be adulteration.

Losses can be mitigated if a mite infestation is discovered early and treated with fumigants. Methyl bromide has commonly been used to control visible infestations of mites on dry-cured hams or racks, but the gas has been banned as an atmospheric ozone-depleting chemical. After several years of 1-year emergency-use exemptions to the ban, the U.S. Environmental Protection Agency (EPA) stopped allowing its use. The only source of methyl bromide available to dry-cured ham producers is in existing stocks held by ham or pest-control companies and is very expensive (more than \$20 per pound in 2014; Zhao et al., 2016).

Research has been conducted on the efficacy of potential methyl bromide alternatives to control ham mite infestations in the U.S. At the time of this publication, no alternatives have been discovered that are as effective at controlling mites as methyl bromide. However, some fumigants have the potential to control mite infestations. Therefore, a combination of these recently studied alternatives to methyl bromide can contribute to establishing an effective integrated pest management (IPM) program that will minimize the potential for infestations and financial loss. IPM programs have three components: pest prevention, pest monitoring, and mitigation.

This publication summarizes recent findings as well as currently available practices to help control ham mite infestations in dry-cured ham facilities.

## **Good Manufacturing Practices and IPM for Ham Mites**

### ***Sanitation***

It is important to establish and follow good sanitation routines and Sanitation Standard Operating Procedures (SSOPs). Strictly follow your facility’s SSOPs, good manufacturing practices (GMPs), and Hazardous Analysis and Critical Control Points plan. Below are additional recommendations for your plant:

- Replace wooden racks with metal racks. Wooden racks may harbor grease and residues; metal racks are easier to clean. If using wooden racks, minimize cracks in the wood by sealing with a USDA-approved substance.
- Clean floors with hot water (131°F or hotter) and alkaline cleaner and sanitize with quaternary ammonium weekly (or on an established regular basis)

to avoid grease and/or food buildup that can harbor ham mites. Use the manufacturer’s recommendations for cleaner and sanitizer concentrations. It is best to use low-pressure water. If cleaning is necessary while product is in the room, be extremely careful not to splatter floor water onto the products hanging above. After cleaning, dry the room with fans and then adjust the relative humidity to the proper aging room level.

- Thoroughly clean and sanitize the entire aging room, including racks, walls, floors, ceilings, and equipment at the end of each aging period and before hanging the next batch of hams. Cleaning should be completed at least twice a year (spring and fall). Long-aged hams that are still in the aging room can be rotated to a temporary room during cleaning and moved back to the rack once cleaning and sanitizing is completed and the room is dry.
- Limit employee/personnel access to the aging house, and require foot baths, hairnets, hats, and lab coats at each entrance to the aging rooms. Lab coats can be frozen for 24 hours before cleaning to kill any pests that may be present on the clothing.

### ***General Pest Control***

Insects and rodents are serious pests of food-processing buildings and can be carriers of ham mites. Keep buildings free of any weeds, turf grasses, trees, shrubs, or debris close to the exterior walls. A 1- to 2-foot gravel or solid surface “dead zone” is recommended to eliminate a harbor zone for insects, rodents, and mites. Additionally, inspect the building’s exterior and seal any openings.

## **Developing an Effective IPM Program**

### ***Ham Pests and Their Environment***

There is no known effective biological control for ham mites in aging facilities. Ham mite treatment is needed when the infestation level exceeds the critical limit observed by a government meat inspector (such as one mite per one to two observations during an inspection, or a certain number of mites in a mite trap).

In addition to the ham mite, other insect pests that may infest dry-cured ham facilities include red-legged ham beetles (RLHB), cheese skippers, and larder beetles (Figure 3). These pests can be effectively controlled with proper sanitation and commonly used insecticides and fumigants.

Typical mold growth on hams fosters and promotes mite growth and reproduction. Ham aging rooms are the ideal temperature and indoor humidity level for the development of molds, mites, and insects. Proper airflow and good HVAC/air system filtration are crucial to



Photo by Michael C. Thomas, Florida Department of Agriculture and Consumer Services, Bugwood.org



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Figure 3. (From left) Red-legged ham beetle, cheese skipper, and larder beetle.

controlling mold and mite growth in ham aging rooms. Mold grows best on hams with a water activity ( $A_w$ ) above 0.9; therefore, reducing the water activity below 0.9 will minimize mold growth (Asefa et al., 2011) and possibly reduce mite populations (if water activity goes below 0.7). It is also important to ensure that incoming raw products are free from fungal contamination.

### **Physical Control**

#### *Light*

Ham mites prefer darkness and tend to avoid light, especially red or white incandescent, fluorescent, or LED lights. It is recommended to use lights continuously (24/7) if possible. Use red LED lights at doors and entrances and inside aging rooms and buildings. Use white lights when employees are working in an aging room. To prevent off-flavors and off-colors, be sure the light does not constantly come in close contact with the hams.

#### *Temperature*

Ham mites cannot withstand high heat. After removing all of the hams from the aging room, use heat

as a treatment to kill mites: hold each room at 104°F for 4 days, 108°F for 2 days, or 113°F for 1 day (Abbar et al., 2016b). Thoroughly clean and sanitize the rooms before bringing mite-free hams back into the room.

Additionally, ham mites are not able to tolerate cold temperatures. To use cold to kill ham mites, chill the facility (with freezing units) at -4°F for 12 hours, 14°F for 1 day, 19°F for 40 hours, or 23°F for 2 days (Abbar et al., 2016b). If you are not able to lower the entire aging room temperature, move infested hams to a walk-in freezer at -4°F for 24 hours.

#### *Monitoring with Traps*

Traps (Figure 4) are often used in product storage facilities to monitor pest populations year-round. Traps can detect the presence of mites and also monitor their relative numbers before a serious infestation occurs. Traps can also help determine the size of the mite population and when to take corrective action. Some mite traps are available commercially (Wakefield and Dunn, 2005).

When trap captures suggest the mite population is high and observation samples exceed a critical limit

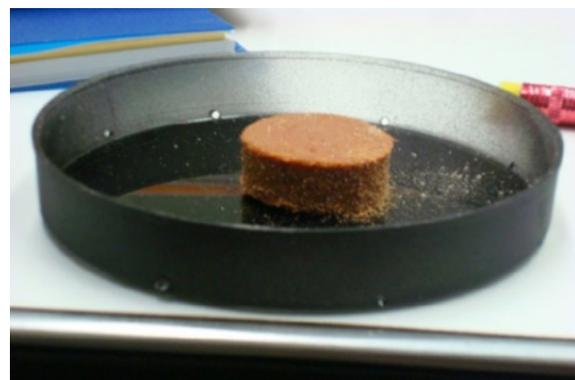
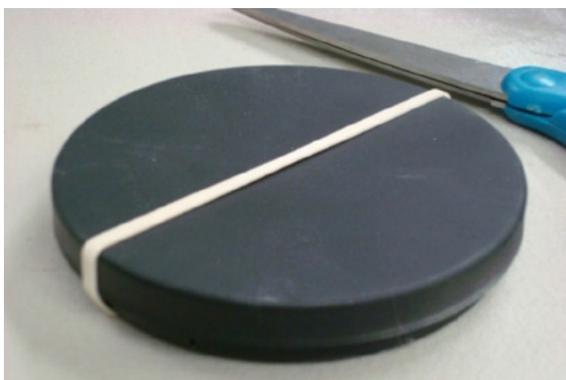


Figure 4. (Left) A food-baited trap with the lid held on by a rubber band and tiny holes (not visible) around the side to allow mites to enter. (Right) Moist food bait inside the trap with mites feeding.

(perhaps one mite per one to two sample units or 10 or more sample units per inspection), plan to take immediate corrective action (Amoah et al., 2017). These actions may include:

- fumigation with methyl bromide (if available) or a registered alternative fumigant
- removing hams and conducting a commercial heat treatment
- freezing hams at a tolerable temperature and treating the whole aging room with an effective, legal process

A good IPM program for ham mites should include:

- a monitoring system
- traps or systematic visual inspections
- good records of mite population levels
- an understanding of the relationship between ham age and mite population levels
- good records of corrective actions taken when critical mite infestation limits are exceeded

### ***Chemical Control***

#### *Food-Safe Compounds as Mite Deterrents*

Multiple food-grade coatings are effective at inhibiting mite population growth. These coatings include propylene glycol, lard, ethoxyquin, BHT, BHA, carrageenan, propylene glycol alginate, and xanthan gum with propylene glycol (Abbar et al., 2016; Campbell et al., 2018; Campbell et al., 2020). Research indicates that nets coated with some of these food-grade coatings can be used on hams during aging to prevent mites. Ham mites do not reproduce on these coatings and are likely to avoid contact with them. These nets could be part of an IPM plan to control mites through prevention.

#### *Fumigation*

Phosphine is a common grain fumigant that is readily available and allowed for use on aged meats and cheeses. Phosphine fumigation at 2,000 parts per million at 75°F or warmer is effective at killing all life stages of ham mites in 48 hours or less (Hasan et al., 2020). However, a significant limitation of phosphine fumigation is that it corrodes copper and other metals. This can cause costly damage to most electrical equipment such as telephones, lighting systems, and HVAC systems. If phosphine is used, all electrical appliances and metal equipment in the aging house must be effectively sealed or ventilated (Zhao et al., 2015).

Alternatively, if it is feasible to move hams out of an aging room, they could be taken to one or more metal shipping containers on-site to be safely fumigated with phosphine. The aging room and other buildings could then be given a thorough cleaning followed by heat treatment to control existing pests (Abbar et al., 2016b).

The fumigant sulfuryl fluoride (ProFume), which is registered in the U.S. for use on stored commodities like country hams, can control mobile mite stages, but some eggs may survive (Phillips and Schilling, 2013). Nevertheless, a sulfuryl fluoride fumigation is legal and relatively effective; a small population resulting from any surviving eggs could be kept low with proper sanitation and prevention measures.

Recent research shows the fumigants ethyl formate and propylene oxide can control mites. Commercial products of these two chemicals are used in other countries, but they are not yet registered for use as pesticides in ham facilities in the U.S.

## Combination of Control Plans

A good IPM plan incorporates a combination of sanitation, monitoring, controlling other pests, physical control, and chemical control (Table 1).

**Table 1. Combination of control plans.**

Control category	Practices
Sanitation	<ul style="list-style-type: none"> <li>• Provide foot baths and hand-washing stations at the entrances to all processing rooms.</li> <li>• At the end of spring and the end of the aging cycle,               <ul style="list-style-type: none"> <li>▪ clean with 131°F or hotter water and alkaline cleaner.</li> <li>▪ sanitize with a quaternary ammonium compound.</li> </ul> </li> </ul>
Monitoring	<ul style="list-style-type: none"> <li>• Use a device like the Kansas State University mite trap or a commercially available mite trap with distribution throughout the plant, and monitor regularly for the presence of mites.</li> <li>• Inspect mite activities on hams, ham racks, and floors regularly.</li> </ul>
Other pest control	<ul style="list-style-type: none"> <li>• Use proper sanitation, insecticides, and fumigants to control red-legged ham beetles, cheese skippers, and lard beetles.</li> <li>• Control mold growth at 75.2–89.6°F and 76–85% RH with good ventilation and air filtration systems.</li> </ul>
Physical control	<ul style="list-style-type: none"> <li>• Control temperature (75.2–89.6°F) and relative humidity (76–85%) in aging rooms (when using nets treated with food-grade coatings).</li> <li>• Use red LED or regular white lights for aging facilities, and keep them on continuously (use white lights when working in the aging room).</li> <li>• Use freezing treatment for aging rooms (if feasible) and infected hams (-4°F for 12 hours, 14°F for 1 day, 19°F for 40 hours, or 23°F for 2 days).</li> <li>• When aging rooms are empty, use heat to treat rooms (104°F for 4 days, 108°F for 2 days, or 113°F for 1 day).</li> </ul>
Chemical control	<ul style="list-style-type: none"> <li>• Spray chlorphenapyr (Phantom) around the building exterior every 2–3 months to keep other pests away.</li> <li>• After properly sanitizing the aging rooms, spray chlorphenapyr (Phantom) or short-chain fatty acids on cracks and crevices, and, if allowed, on the racks, floors, and walls (Abbar et al., 2016c).</li> <li>• Use stocking nets treated with a food-grade coating that contains propylene glycol instead of the traditional stocking nets.</li> <li>• Fumigate with methyl bromide as a last resort (if you have existing stock) or with legal alternatives (phosphine, sulfuryl fluoride) using proper methods, or conduct a controlled heat treatment with hams removed from the room.</li> </ul>

## Personnel Training

Designate an IPM manager/technician who is trained in identifying and monitoring mite populations in the plant. This employee should establish and maintain the IPM program to control mite populations and infestations in aging houses. They should make sure sanitation and HACCP procedures are followed, review mite monitoring/control records monthly, and address any issues.

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By **Yan Campbell**, PhD, Research Associate, Food Science, Nutrition, and Health Promotion; **William Rogers**, Research Assistant, Food Science, Nutrition, and Health Promotion; **Courtney Crist**, PhD, Assistant Extension Professor, Food Science, Nutrition, and Health Promotion; **J. Byron Williams**, PhD, Associate Extension Professor, Central Mississippi Research and Extension Center; **Thomas Phillips**, PhD, Professor of Entomology, Kansas State University; and **M. Wes Schilling**, PhD, Professor, Food Science, Nutrition, and Health Promotion.



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