

The Cause of Trichinosis and its Prevention Through Safe Food Handling Practices¹

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This is one in a series of fact sheets discussing common foodborne pathogens of interest to food handlers, processors, and retailers.

What is Trichinosis?

Trichinosis is an infection caused by roundworms in the genus *Trichinella*, with infection resulting entirely from food sources. Illness occurs as a result of ingesting *Trichinella* larvae from undercooked meat, typically pork, and the resultant activity of adult worms in the intestines as well as larvae encysted in host tissue (Crompton and Savioli, 2006).

What is *Trichinella*?

Trichinella is a genus of roundworms that are unique in their extremely low degree of host specificity; they can infect a wide range of mammals and some birds. The main two species of *Trichinella* associated with human infection in the United States (US) are *T. spiralis* and *T. murrelli*, though *T. spiralis* is responsible for the most human infections. The intermediate hosts of most concern to humans are swine (Despommier, 2005).

Incidence of Trichinosis

According to the most recent data from the Centers for Disease Control and Prevention (CDC), there were 72 reported cases of trichinosis for the years 1997–2001. Of these 72 cases, the consumption of pork was responsible for 21; the rest were caused by the consumption of improperly cooked wild game (CDC, 2003). Other animals known to carry *T. spiralis* include horses, rats, foxes, wolves, bears, seals, and wild boars (WSDOH, 2008).

How do humans get infected with *Trichinella*?

When a human consumes raw or undercooked meat infected with *Trichinella* larvae, the ingested larvae establish residency in the small intestine, where they typically grow to maturity in less than a week (Redman, 2007). Adult worms within the small intestine will mate, and the females will give birth to live larvae that will subsequently penetrate the mucous membrane of the small intestine. Upon penetrating the mucous membrane, larvae can gain

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All chemicals should be used in accordance with directions on the manufacturer's label. Use pesticides safely. Read and follow directions on the manufacturer's label.

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access to the bloodstream, the lymphatic system, or both.

Once in the bloodstream or lymphatic system, larvae can then travel to most areas of the human body. Larvae indiscriminately infect host cells, and can infect any type of tissue. However, larvae prefer to infect skeletal muscle cells, where they end up encysting themselves, thus allowing the disease to spread when that infected muscle tissue is consumed (Despommier, 2005).

Disease and Onset Time of Trichinosis

Most damage to the body occurs during the invasion of extraintestinal host cells by larvae (which may invade and kill brain, kidney, liver, heart, and most other types of cells), or the encysting of larvae in skeletal muscle tissue (Despommier, 2005). Symptoms associated with trichinae in the intestines can begin as early as 1–2 days following infection, and further symptoms associated with larvae colonizing extraintestinal tissue will occur between 2–8 weeks after ingestion of the contaminated food (CDC, 2004).

What are the symptoms of Trichinosis?

The severity of symptoms is directly related to how many larvae are ingested, with a larger amount producing more symptoms of greater severity. If very few larvae are ingested, the patient may be completely asymptomatic, or may experience very general flu-like symptoms that may never be properly diagnosed (Despommier, 2005). In more serious infections, the patient may initially experience nausea, vomiting, diarrhea, and muscle pain (CDC, 2004), possibly followed by secondary diseases, such as neuro-trichinellosis, myocarditis, and dyspnea, if larvae migrate to brain, heart, or other vital tissues (Despommier, 2005).

What is the treatment for Trichinosis?

Many antihelminthic drugs are available for use in the treatment of trichinosis, including albendazole and mebendazole (WSDOH, 2008). The efficacy of

treatment is dependent upon how soon the infection is caught and how severe the infection is. Some mild infections are never diagnosed or treated, but resolve themselves after several weeks (Despommier, 2005).

Prevention of Trichinosis before Slaughter

Trichinosis is spread to intermediate hosts such as pigs in the same way it is spread to humans: through food. *Trichinella* worms typically infect less than 0.2% of grain-fed hogs, but tend to infect hogs fed on uncooked garbage much more frequently (McWilliams, 1974). If a hog is fed uncooked meat that is contaminated with *Trichinella*, that hog may become infected, leading to possible infections in humans who consume the meat from that hog. Because of the risks associated with uncooked garbage, all states in the US are required to cook garbage thoroughly before it is fed to swine (McWilliams, 1974). [See EDIS document AS143/AN143 *Feeding Food Wastes to Swine* at <http://edis.ifas.ufl.edu/an143> for more on the treatment of food waste intended for use as a source of feed for swine.]

Swine and other livestock should also be kept from eating the carcasses of dead animals, such as rats, that may have died on the premises and may also carry disease (CDC, 2004). All swine should be adequately and responsibly fed, to reduce their tendency to root for food sources that may be unsafe (Meyer and Brendemuhl, 2003).

In addition to the proper feeding of hogs and cooking of garbage, certain methods of animal husbandry may be used to prevent trichinosis in livestock. One method is total isolation, in which domestic animals are raised entirely indoors, leaving little to no opportunity for parasitic infection. However, this method is not economically feasible for most domesticated animals, and it is likely to be considered by some as objectionable from a holistic point of view. Alternatively, the regular rotation or renovation of pastures may serve to limit the amount of exposure of swine to trichinae passed through the feces of other swine (Meyer and Brendemuhl, 2003).

Many de-worming chemicals have been shown to safely control internal parasites in swine, as long as the manufacturer's instructions are strictly followed. Some of the most effective include Dichlorvos, Levamisole, and Pyrantel (Meyer and Brendemuhl, 2003).

Government Inspection and Testing for Trichinosis

The United States Department of Agriculture (USDA) is responsible for verifying the wholesomeness of meats sold in the United States. However, trichinae are not typically discovered during USDA inspection due to their microscopic size, so no pork sold in the US should be assumed to be safe from trichinae. The European Union (EU) tends to be more rigorous in its inspection of pork for trichinae, employing several techniques not typically used in the US. Tests used by the EU include the following:

- **Compression method.** In the compression method, samples from the diaphragms of hogs are tested for the presence of worms by being pressed between two glass slides and then examined with a microscope. This method has a sensitivity of about 3 larvae per gram of sample tissue (Gamble, 2001).
- **Trichonscopy.** Trichonscopy involves taking muscle samples from hogs post-slaughter. Those samples are then magnified and projected onto a screen, allowing for constant visual surveillance for infected tissue (Cox, 1982).
- **Pooled Sample Digestion Method.** In the pooled sample digestion method, tissue samples are retrieved from areas of the hog which traditionally have high concentrations of larvae, and are digested using acidified pepsin, which releases the larvae from their capsules and allows them to be microscopically quantified (Gamble, 2001).

Destruction and Prevention of Trichinae in Industry

To prevent cross-contamination of uninfected meat with infected meat, it is highly recommended that the equipment used to process meat, particularly grinders, be regularly cleaned and sanitized. This decreases the likelihood that infection from one source will subsequently contaminate another (CDC, 2004).

Performed under very carefully controlled conditions, the food industry may attempt to destroy trichinae through curing and smoking, pickling, freezing, or cooking and canning (Dresser and Bellenir, 1995). However, the International Commission on Trichinellosis (ICT) only recognizes three methods for reducing the number of larvae in meats to safe levels—freezing, irradiating, or cooking (ICT, 2007).

Prevention of Trichinosis through Freezing

The following describes USDA's guidelines for commercial freezing of pork products.

- After preparatory chilling to a temperature of 40°F or below, or preparatory freezing, all parts of the product must be subjected continuously to temperatures at or below those in Table 1, for the specified time (USDA, 2001):

Table 1.

Temperature °F	Group 1 (Days)	Group 2 (Days)
5	20	30
-10	10	20
-20	6	12

- Group 1 includes products comprised of separate pieces not exceeding 6 inches in thickness, products arranged on separate racks with respective layers not exceeding 6 inches in thickness, products stored in crates or boxes not exceeding six inches in depth, or stored as solidly frozen blocks not exceeding 6 inches in thickness (USDA, 2001).

- Group 2 includes products in pieces, layers, or within containers, whose thicknesses are greater than 6 inches but less than 27 inches (USDA, 2001).

Alternatively, the USDA allows the treatment of pork products to consist of commercial freeze-drying or controlled freezing processes according to Table 2 (USDA, 2001):

Table 2.

Minimum Internal Temperature		Minimum Time
°F	°C	
0	-17.8	106 hours
-5	-20.6	82 hours
-10	-23.3	63 hours
-15	-26.1	48 hours
-20	-28.9	35 hours
-25	-31.7	22 hours
-30	-34.5	8 hours
-35	-37.2	1/2 hour

Prevention of Trichinosis through Irradiation

Irradiation has been used to inactivate trichinae in industry. Studies show that treatment of pork with 0.3 kGy of irradiation with Cobalt-60, or irradiation with high energy X-rays are completely effective against *Trichinella* (Gamble, 2001). The ICT considers irradiation to be an effective method for reducing larvae in meat to levels safe for human consumption. The ICT finds that irradiation of products at 0.3 kGy effectively inactivates trichinae, but recommends that irradiation only be used on food that is packaged and sealed (ICT, 2007).

Prevention of Trichinosis through Cooking Techniques

The following describes USDA's guidelines for commercial cooking of pork products:

- One of the time and temperature combinations from Table 3 must be used in the heat treatment of all pork muscle tissue (USDA, 2001)

Table 3. Minimum time and temperature combinations for the heat treatment of all pork muscle tissue, per USDA mandate

Minimum Internal Temperature		Minimum Time
°F	°C	
120	49.0	21 hours
122	50.0	9.5 hours
124	51.1	4.5 hours
126	52.2	2 hours
128	53.4	1 hour
130	54.5	30 minutes
132	55.6	15 minutes
134	56.7	6 minutes
136	57.8	3 minutes
138	58.9	2 minutes
140	60.0	1 minute
142	61.1	1 minute
144	62.2	Instant

- If the product is not cured or fermented, the time to raise the product temperature from 60°F to 120°F should not take more than two hours (USDA, 2001).
- All parts of the product should be heated to the appropriate internal temperature. Products heated through submersion in water must remain submerged throughout the heating process (USDA, 2001).

The following are effective home-cooking guidelines and recommendations to protect against trichinosis:

- Fresh pork, uncured pork chops greater than or equal to one inch in thickness, and cured picnic shoulders should be heated to an internal temperature of 170°F (McWilliams, 1974).
- The most effective method for cooking pork greater than one inch in thickness is the use of moist heat, such as in braising, as unpalatable damage to or burning of the surface of the meat may occur if an attempt is made to fry thick pork to the necessary internal temperature (McWilliams, 1974).

- All hams that have not been heated during processing should be cooked to an internal temperature of 165°F–170°F. Heat-cured hams and tenderized hams, which are only partially cooked during processing and are labeled "cook before eating," should be cooked to an internal temperature of 160°F. Those hams labeled "ready-to-eat" have been cooked to doneness during processing and may generally be cooked according to the preference of the consumer (McWilliams, 1974).
- While cooking meat, it is better to use a well-calibrated meat thermometer instead of a doneness timetable, as such timetables don't take into account the varying amounts of bone and fat in the product, which affect cooking time (McWilliams, 1974).
- Trichinae are not always killed by microwaving, smoking, curing, or drying (CDC, 2004).

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