Not all viruses harm people. The Food and Drug Administration has approved a mixture of viruses as a food additive to protect people. The additive can be used in processing plants for spraying onto ready-to-eat meat and poultry products to protect consumers from the potentially life-threatening bacterium *Listeria monocytogenes* (*L. monocytogenes*).
The viruses used in the additive are known as bacteriophages. Bacteriophage means “bacteria eater.” A bacteriophage, also called a phage (pronounced fayj), is any virus that infects bacteria.

Consuming food contaminated with the bacterium *L. monocytogenes* can cause an infectious disease, listeriosis, which is rarely serious in healthy adults and children, but can be severe and even deadly in pregnant women, newborns, older people, and people with weakened immune systems. Pregnant women are about 20 times more likely than other healthy adults to get listeriosis, according to the Centers for Disease Control and Prevention (CDC). Listeriosis can cause miscarriage, stillbirth, premature delivery, or death of a newborn baby.

People with listeriosis have fever and muscle aches, and sometimes an upset stomach, nausea, and diarrhea. If the infection spreads to the nervous system, headache, stiff neck, confusion, loss of balance, or convulsions can occur.

The CDC estimates that about 2,500 people become seriously ill with listeriosis each year in the United States. Of these, about 500 die.

Cooking can kill *L. monocytogenes*, but many ready-to-eat foods, such as hot dogs, sausages, luncheon meats, cold cuts, and other deli-style meats and poultry, may become contaminated within the processing plant after cooking and before packaging. Unlike fresh meat and poultry, the ready-to-eat products can be consumed without reheating, so the *L. monocytogenes* survive and are ingested.

"*L. monocytogenes* can continue to thrive even in refrigerated conditions," says Capt. Andrew Zajac, a food safety expert and acting director of the Division of Petition Review within the FDA's Center for Food Safety and Applied Nutrition (CFSAN). "If a food product contaminated with *L. monocytogenes* is bought by a consumer and brought home and refrigerated, the bacteria can continue to multiply."

**How Bacteriophages Work**

Bacteriophages are found in the environment. "We're routinely exposed to bacteriophages," says Zajac. "They are found in soil and water, and they are part of the microbial population in the human gut and oral cavity."

Bacteriophages infect only bacteria, says Zajac. "They don't infect plant or mammalian cells." Thousands of varieties of phages exist, and each one infects only one type or a few types of bacteria. The particular phages approved as a food additive are very specific to *Listeria*, says Zajac. "They'll only thrive if *Listeria* are present."

The type of phage that was approved is lytic, which means that the phage destroys its host during its life cycle without integrating into the host genome. This type of phage works by attaching itself to a bacterium and injecting its genetic material into the cell. The phage takes over the metabolic machinery of the bacterium, forcing it to produce hundreds of new phages and causing the bacterial cell walls to break open. This process kills the bacterium and releases many new phages, which seek out other bacteria to invade and repeat the cycle.

"The process continues until all host bacteria have been destroyed," says Zajac. "Then the bacteriophages cease replicating. They need a host to multi-

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### Bacteriophage

The head (blue) stores genetic material, which is released through the corkscrew-like tail (pink) into a bacterium, forcing the bacterium to produce hundreds of new bacteriophages. The bacterial cell walls break open, killing the bacterium and releasing many new bacteriophages that seek out other bacteria to invade and repeat the cycle.
ply and will gradually become inactive when they lose the host."

**Approval Process for Food Additives**

To market a new food additive, a manufacturer must petition the FDA for its approval. The petition must provide convincing evidence that the proposed additive performs as it is intended and will not cause harmful effects when consumed.

If an additive is approved, the FDA issues a regulation that includes information on the types of foods in which the additive can be used and maximum amounts to be used. The regulation also provides the additive's identity and specifications on purity, which will ensure that the additive used in food is the same substance that was evaluated and approved by the FDA.

Once a food additive is approved, any company can use the additive, says Zajac, as long as it meets the conditions in the regulation.

In response to a petition submitted by industry, the FDA published a regulation in August 2006 permitting the use of a Listeria-specific bacteriophage preparation on ready-to-eat meat and poultry products.

The preparation combines six different phages that have been shown to be effective against 170 different strains of *L. monocytogenes*. Multiple phages are used so that if the *L. monocytogenes* develop resistance to several phages, the remaining ones can still destroy the bacteria.

The FDA must approve any additive before it can be used in food. When an additive is to be used on meat or poultry products, as with this one, both the FDA and the U.S. Department of Agriculture (USDA) are involved in the approval. The FDA evaluates the safety of the ingredient for its intended use. At the same time, the USDA evaluates the ingredient's suitability.

The FDA's food additive regulations define safety as "a reasonable certainty that the substance is not harmful under the intended conditions of use." The FDA's CFSAN determined that the phage preparation does not pose any safety concerns based, in part, on published reports submitted by the petitioner on the results of the use of phages in animal and human studies.

The USDA's Food Safety and Inspection Service (FSIS) evaluated the bacteriophage preparation's suitability. "Suitability establishes that the use of a substance is effective in performing the intended purpose of use and at the lowest level necessary for particular types of products," says Robert C. Post, Ph.D., director of the FSIS' Labeling and Consumer Protection Staff. In addition, suitability is an assurance that the use of the additive will not result in a product that is unfit for human consumption (adulterated) or one that misleads consumers. Consumers would be misled, for example, if the additive makes a product "appear to be a better value than it actually is or it masks spoilage," says Post.

The FSIS evaluated data submitted by the petitioner to ensure suitability for a number of ready-to-eat products, such as sausages, turkey, soups, stews, hot dogs, bologna, Vienna sausage, and cooked ham and turkey.

**Labeling**

Under the Federal Meat Inspection Act and the Poultry Products Inspection Act, both administered by the USDA, the use of the phage preparation must be declared on labeling as an ingredient. Consumers will see "bacteriophage preparation" on the label of meat or poultry products that have been treated with the food additive.

If consumers have any concerns about what they're getting at the deli counter, says Post, "they always have the ability to ask for the label of the product being prepared or sliced to see what it contains."

**A Phage First**

This approval marks the first time that the FDA has regulated the use of a phage preparation as a food additive. Phages are currently approved in the United States for pesticide applications, such as spraying on crops.

Scientists continue to be interested in other uses for phages, such as to prevent food products from contamination with other types of harmful bacteria and to act as possible treatments for bacterial infections in people.

**For More Information**

FDA Bacteriophage Questions and Answers

[www.cfsan.fda.gov/~dms/opabacqa.html](http://www.cfsan.fda.gov/~dms/opabacqa.html)