About the Guide

ecology center

The Ecology Center welcomes you to Terrain for Schools, a unique current events–based curriculum for colleges and high schools. Lessons in this guide address California State Content Standards for grades 9-12 in three categories: science, social studies, and language arts.

Overviews and applicable standards are found on the first page of each lesson. The lessons are designed to be used with articles in the Summer 2003 issue of Terrain. A few articles are referenced that appear in back issues, available on the web at www.ecologycenter.org.

Teachers: Photocopy this material as needed. Loan the guide to fellow teachers. We welcome your feedback.

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Science

Irradiate Me!

Overview

Students will:
- Learn how irradiation technology works and why it's used.
- Write responses to criticisms after researching critics' arguments.
- Evaluate the different ways a problem such as food poisoning is approached.

Terrain Article: "Hot Lunch" pages 7-8, *Terrain*, Summer 2003.

Introduction

After the bombing of Hiroshima and Nagasaki, nuclear technology was widely associated with weaponry and destruction. In 1953, President Dwight Eisenhower unveiled the "Atoms for Peace" program to promote more peaceful uses for nuclear technology and to find uses for nuclear waste materials. Although most of the ideas spawned by the program – such as nuclear-powered planes, pacemakers, and coffee pots – were scrapped, the idea of irradiating food persisted.

During the 1970s, food irradiation got a boost from another government program, the Department of Energy's Byproducts Utilization Program, also designed to find profitable uses for nuclear waste. At a House Armed Services Committee hearing in 1983, the DOE said, "The utilization of these radioactive materials simply reduces our waste-handling problem." Initially, food irradiation was proposed as a means to prolong shelf-life. At a congressional hearing during the '80s, Army scientist Dr. Ed Josephson ate from a can of 20-year-old irradiated meat to prove his point.

More recently, irradiating food is marketed as a means to minimize spoilage, prolong shelf life, and eliminate pathogens – the disease-causing microorganisms such as E. coli O157:H7, Campylobacter, and Salmonella that cause food poisoining. Irradiation kills insects, parasites, fungi, and bacteria that cause food to spoil. Irradiation can prevent potatoes and onions from sprouting, and it can delay the ripening of certain fruits. By increasing the storage life of some foods, it allows importers and distributors to ship foods further and store them longer. Despite its benefits, controversy still surrounds the technology, and some questions about its safety remain.

Recently, the USDA has begun to make irradiated food available through its school lunch programs. This lesson explains how irradiation destroys food-borne pathogens. It also provides an opportunity to research the concerns of irradiation critics and look at the problem of meat contamination from a broader perspective, as a means to assess problem-solving.

CA CHEMISTRY STANDARDS: Nuclear Processes 11. Nuclear processes are those in which an atomic nucleus changes, including radioactive decay of naturally occurring and human-made isotopes. e. Student know alpha, beta, and gamma radiation produce different amounts and kinds of damage in matter and have different penetrations. Investigation and Experimentation: 1.m. Investigate a science-based societal issue by researching the literature, analyzing data, and communicating the findings. Examples of issues include the irradiation of food.

Irradiation: How It Works

The Process

Food irradiation involves exposing food to controlled amounts of ionizing radiation. The waves of radiation penetrate the food, damaging the DNA molecules of the microbes within it and causing defects in their genetic instructions. This will either kill the microorganisms or make them unable to reproduce.

The waves of radiation can dislodge electrons from atoms and molecules in the cell cytoplasm, creating ions and free radicals. Ions and free radicals can also damage the chemical bonds along the DNA helix.

The effectiveness of irradiation depends upon the amount of DNA in the target organism, the organism's sensitivity to irradiation, and the rate at which it can repair its damaged DNA. Viruses are quite resistant to the effects of irradiation because they contain little DNA. Prions, which are responsible for mad cow disease, are also resistant because they have few chemical bonds to disrupt.

Food is not made radioactive by irradiation. The radiation dislodges electrons, but it does not dislodge neutrons – the subatomic particles that can make something radioactive and cause chain reactions to occur. The radiation energy penetrates the food and its packaging, but most of the energy simply passes through the food. The tiny amount of energy that does not pass through the food is retained as heat.

3 Different Methods

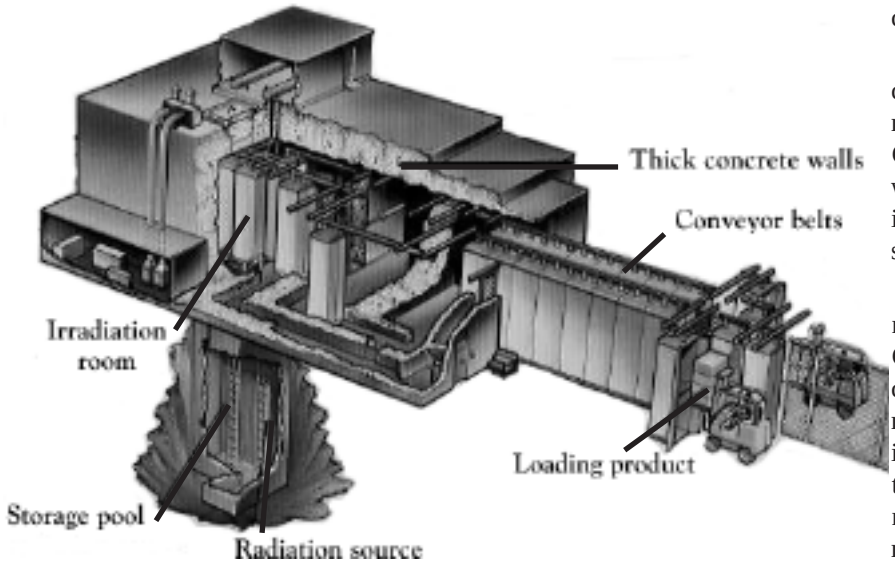
Ionizing radiation used in irradiation comes in three forms:

Gamma rays: Isotopes are atoms of the same element that contain the same number of protons and electrons but different numbers of neutrons. Atoms which have an excess or deficiency of neutrons or protons will be unstable. These atoms – called radioactive isotopes (or radionuclides) – will undergo radioactive decay until they reach a stable state. The decaying process creates gamma rays. Most food irradiated in the US is exposed to the radionuclide Cobalt 60. Gamma rays and X-rays are in the short wave length, high-energy region of the electromagnetic spectrum.

X-rays: The X-ray machines used to irradiate food are similar to X-ray machines used in hospitals. However, irradiated food will receive a radiation dose millions of times greater than that of an ordinary chest X-ray. A beam of electrons is directed at a thin plate of gold or other metal, producing a stream of X-rays. Although X-rays require heavy shielding for safety, no radioactive substances are involved.

Accelerated electrons: The electron beam (or e-beam) is a stream of high energy electrons propelled out of an electron gun. The technology is similar to that of a standard television tube. Radioactive materials are not used in the process. The electrons can penetrate food only to a depth of three centimeters, unlike gamma and X-rays, which can penetrate to a depth of several feet.

One Type of Irradiation Plant



A conveyor belt carries food into an irradiation room, where it passes through a maze of stainless steel rods containing Cobalt 60.

The irradiation room has massive concrete walls that keep any gamma rays from escaping. After it is used, the Cobalt 60 is stored in a pool of water which absorbs the gamma rays. The irradiated food can immediately be stored, packaged or shipped.

Cobalt 60 is produced by exposing naturally occurring non-radioactive Cobalt 59 to intense radiation in the core of a nuclear reactor. When the radioactivity of the cobalt used in an irradiation plant falls to a low level, the cobalt rods are shipped back to the nuclear reactor, where they can be re-activated for further use.

Critics' Concerns

Activity A

Students will evaluate the concerns of food irradiation critics by choosing one of the following statements and writing an initial response to it. They will then research the claim and write a post-research response.

Introduction

Food irradiation offers proven benefits. It protects against foodborne illness by killing 99.9% or more of E. coli O157:H7, Salmonella, Campylobacter, Listeria, and other harmful bacteria. Because it slows ripening and sprouting, it increases the shelf life of several fresh foods. Astronauts have eaten irradiated food since the beginning of the space program. Because it destroys harmful fruit flies, tropical fruits can be shipped to faraway markets without threatening infestation. Yet critics of the technology continue to voice concerns, some of which are listed below.

Concerns

• Irradiation creates chemical by-products in food called "radiolytic products." Some are toxic, and others are known carcinogens. Increasing the levels of mutagens and carcinogens in food now may lead to increased incidence of cancer in the future.

• Irradiation damages amino acids, fatty acids, and vitamins. Normal cooking methods and storage also cause nutritional losses, but irradiation plus cooking and storage decreases the nutritional value even more.

• In food containing certain fats, irradiation produces a unique class of chemicals called cyclobutanones. These chemicals have never been found to naturally occur in any food, and they have been found to cause genetic and cellular damage in rat and human cell cultures. The FDA has never formally examined cyclobutanones.

• Radiation-resistant microbes may grow more rapidly once irradiation kills off competing microbes. For example, the bacteria that cause meat to smell spoiled also control the growth of the bacteria that cause botulism. Irradiation kills the smell-producing bacteria but the botulism bacteria survive to reproduce, unchecked.

• Workers in irradiation plants risk exposure to large doses of radiation due to equipment failure, leaks, and the production, transportation, storage, installation, and replacement of radiation sources. Existing irradiation facilities have poor safety records.

• Irradiation allows the causes of meat contamination in slaughterhouses to continue, while giving the appearance that the problem is being solved. The false sense of safety will lead meat producers, processors, and preparers to be even more lax in their handling and testing of food.

• The FDA claims that irradiated food is safe based upon only 5 toxicity studies out of 441 the agency reviewed. Scientists, including the chair of the 1982 FDA irradiation committee, found those 5 studies flawed. No studies have shown that a long-term diet of irradiated foods is safe.

Problem-Solving: Philosophy and Focus

Activity B

In this activity, students will look at a particular pathogen – E. coli O157:H7 – and how it winds up in beef. They will analyze various solutions to the problem of contaminated meat, including irradiation.

Directions

1. Class reads "Anatomy of a Problem" on page 5.
2. Teacher writes the headings Feedlot, Slaughterhouse, Inspections, Irradiation, Lawmakers, and Kitchen horizontally across the chalkboard.
3. As a class, identify the possible problems that contribute to the spread of E. coli at each stage, from the feedlot to the kitchen.
4. Have students stand under the various headings on the board and express:
   - How could the E. coli contamination problem be remedied at this juncture?
   - What could be the downside to addressing the problem by focusing only on this one link in the process?
5. Post-Activity Opinion Paper Topics:
   - Recommend a program to solve the beef contamination problem. What is the main focus of your program? What is your problem-solving philosophy?
   - Is it more practical to fix the problem of E. coli after the slaughter and packaging of the meat than it is to alter feedlot and meat-packing practices?
   - How important should profit-making be in deciding how to solve this problem?
   - What solution to beef contamination would be the most expensive? The least? Who should pay?
   - Should irradiated food carry a special label?
   - Can you think of an example of a technology that solved one problem, only to create others?

School Lunch

The USDA now offers irradiated food through its National School Lunch Program. Is your school serving the USDA's irradiated food? Share with family, friends, and school officials your knowledge and opinions.

Anatomy of a Problem: E. Coli

The Problem

E. coli O157:H7 is a pathogen that can cause severe illness or death, especially among children, the elderly, and people whose immune systems are depressed. Common symptoms are vomiting and defecating blood. Antibiotics are not effective in treating E. coli. The CDC estimate that about 73,000 Americans are sickened by E. coli O157:H7 every year. An additional 37,000 are sickened by other dangerous strains of E. coli also linked to ground beef.

Feedlot

Feedlots are confined areas where cattle are fed and held before slaughter. E. coli lives harmlessly in the cows' digestive tracts. The animals defecate and drool in shared water troughs, where E. coli replicates. According to the USDA, E. coli is more often found on the hides of feedlot cattle, and may be found in half the animals that are made into ground beef, steaks and other cuts.

If overcrowding at feedlots were reduced, drinking water disinfected, and fly control implemented, the rate of cattle infection would drop. If feedlot cattle were fed hay – rather than the standard feedlot diet of starchy grain and animal by-products – for the week prior to slaughter, the infection rates would drop further.

Slaughterhouse

A study published by USDA in 1996 found that 78.6% of ground beef samples taken at US processing plants contained microbes (such as E. coli) that are spread primarily by feces.

At a slaughterhouse, these pathogens are spread when manure or stomach contents get splattered on the meat during the removal of the hide or the digestive system. If the gutting is not performed carefully, the contents of the digestive system may spill everywhere.

The speed of the production line at meat-packing plants today is faster than ever before. When workers work too fast, more mistakes occur. Contaminated knives can spread pathogens to everything they cut, yet to keep up the pace, workers may skip the required knife disinfecting.

Ground beef, which used to be made at local butcher shops, is now made at the large processing plants, where the meat from dozens or hundreds of cattle is ground together.

Inspections

The U.S. Department of Agriculture (USDA) has two purposes that are sometimes contradictory. It is supposed to promote the sale of American meat *and* protect consumers from unsafe meat.

The USDA monitors E. coli in ground beef by taking 8,000 samples annually at slaughter plants and grocery stores. Much of the inspection at meat-packing plants is done by company employees.

The USDA can recommend that a company recall meat, but they cannot force a recall. If a company distributes contaminated meat, federal law does not require the company to tell state health authorities where the tainted meat was sold. Even if the USDA finds evidence of contamination, the company can still legally sell the meat. The USDA cannot fine companies or shut down plants that violate food safety standards.

Irradiation

If properly applied, irradiation kills any E. coli that has contaminated the meat. Fecal matter may remain on the meat, but the irradiation process will have killed the E. coli in the fecal matter.

Lawmakers

In the last few years, food safety bills – such as the Safer Meat and Poultry Act and the Meat and Poultry Pathogen Reduction Act – have been introduced before Congress. They would have given the USDA greater powers in setting limits on food-borne pathogens, enforcing sanitation requirements at plants, forcing recalls of tainted meat, and fining companies that violate food safety regulations plants. The bills have not passed.

Kitchen

The way that meat is handled and cooked affects the spread of E. coli. For instance, the bacteria will be killed if ground beef is cooked until the internal temperature is at least 160^{o} F and the center is no longer pink.

E. coli can also be passed from one person to another or from one food to another. If the cook doesn't wash his/her hands with soap and water after using the toilet, or if raw meat juices are allowed to mix with cooked food, meat can become contaminated.