**Irradiation and the Reduction of Pathogens**

**Objective:**
The purpose of this lesson is to show that the use of irradiation of food and food products can reduce and/or eliminate food borne pathogens from the food supply and thus, reduce the incidence of foodborne illness.

**The Big Picture:**
While the food supply in the United States is the safest in the world, increasing number and severity of foodborne illnesses have increased public awareness. Emergence of a new category of foodborne pathogens such as *Escherichia coli* O157:H7 and *Listeria monocytogenes* has contributed to the public debate on the safety of the food supply. The use of ionizing radiation treatments such as: high-energy electrons (E-beam), X-rays, and Gamma rays (γ-rays) can significantly reduce the numbers of pathogens in food and thus reduce the occurrence of foodborne illness. Evidence suggests that low dose irradiation would affect food quality just as pasteurization does. To date, the biggest problem with food irradiation is gaining consumer acceptance.

**The lesson:**
Preservation of food by irradiation has been around for decades and most of the safety issues have been resolved. The U.S. Army developed food irradiation during the 1950’s, and since that time, both soldiers and astronauts have been feasting regularly on irradiated food.

Irradiation works by making electrically charged pairs of ion particles that kill disease-causing pathogens by affecting their DNA. The larger the DNA structure of the organism, the easier it is to kill them. Parasites and insects have large DNA structures and are easily killed. Bacteria have smaller DNA structure and are harder to kill. Viruses have small amount DNA-type material and are not affected by irradiation at levels that are normally used for food irradiation. Prion particles, which are responsible for Mad-Cow disease, are also resistant to irradiation levels considered safe.

The U.S. Army considers food irradiated (zapped) with 56 kiloGrays of irradiation safe. At this exposure, packaged food can remain intact and safe without refrigeration for an indefinite amount of time. A Gray is equal to 100 Rads. A (Gy) is the S.I. unit for radiation exposure or absorbed radiation dosage. One Gray equals one Joule of energy absorbed per kilogram of absorbing material (1 Gy = 1 J/kg), or about one-quarter calorie of energy per half-pound of absorbing material.

Currently there are three ways to produce irradiation:
One way is to send a stream of high-speed electrons (E-beams) into the material to be irradiated. A device like a TV without a screen is used. A TV works by sending E-beams toward the viewing screen. When the E-beams hit the viewing screen, certain color sectors become electronically excited and begin to glow, producing the picture. The E-
beam machine targets food items instead of color sectors on a screen, and is destructive to organisms whose DNA is altered by the E-beams. This method can be turned off and on just like a TV and requires little shielding to protect individuals and workers in the irradiation facility. However, it does not penetrate deeply into foodstuffs and its best use is for near surface treatment.

A second way is to use metal radio-isotypes that are made in nuclear reactors. Cobalt-60 and Cesium-137 are the choices. Both of these substances send deep penetrating nuclear ($\gamma$-rays) into the food and sterilizes to any depth. However, this method cannot be turned off and requires a great amount of shielding to protect workers, while being the most effective and powerful method. Note, these radioisotopes do not produce neutrons and therefore, do not make things radioactive.

The third method and the latest technology, is the use of X-rays that are millions of times more powerful than medical X-rays. This method penetrates deeply into food and it can be turned on and off easily. However, it does require a great amount of shielding to protect workers.

None of the three methods produce any radioactive waste or make food radioactive. Both X-rays and E-beams produce non-radioactive waste. The used products of Cobalt and Cesium decay are recyclable; they can be sent back to the nuclear reactor and recharged for reuse.

Many foods have been approved for irradiation. The World Health Organization (WHO), Center for Disease Control (CDC), U.S. Department of Agriculture (USDA), and the Food and Drug Administration (FDA) have endorsed irradiation of many foods as being safe.

Some examples of approvals for use of irradiation of food products from 1963 to 1999:

<table>
<thead>
<tr>
<th>Approved Year</th>
<th>Food</th>
<th>Dose</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td>1963</td>
<td>Wheat flour</td>
<td>0.2-0.5 kGy</td>
<td>Control mold</td>
</tr>
<tr>
<td>1964</td>
<td>White potatoes</td>
<td>0.05-0.15 kGy</td>
<td>Inhibit sprouting</td>
</tr>
<tr>
<td>1986</td>
<td>Pork</td>
<td>0.3-1.0 kGy</td>
<td>Kill Trichina parasites</td>
</tr>
<tr>
<td>1986</td>
<td>Fruits and vegetables</td>
<td>1.0 kGy</td>
<td>Insect control, increase shelf life</td>
</tr>
<tr>
<td>1986</td>
<td>Herbs and spices</td>
<td>30 kGy</td>
<td>Sterilization</td>
</tr>
<tr>
<td>1990 FDA</td>
<td>Poultry</td>
<td>3.0 kGy</td>
<td>Bacterial pathogen reduction</td>
</tr>
<tr>
<td>1992 USDA</td>
<td>Poultry</td>
<td>1.5-3.0 kGy</td>
<td>Bacterial pathogen reduction</td>
</tr>
<tr>
<td>1997 FDA</td>
<td>Meat</td>
<td>4.5 kGy</td>
<td>Bacterial pathogen reduction</td>
</tr>
<tr>
<td>1999 USDA (pending)</td>
<td>Meat</td>
<td>4.5 kGy</td>
<td>Bacterial pathogen reduction</td>
</tr>
</tbody>
</table>

Cf [www.cdc.gov](http://www.cdc.gov)

It is important to note that irradiation cannot be used universally on all foods. Irradiation kills live shellfish like oysters and reduces their shelf life. Irradiated alfalfa seeds are killed too, reducing alfalfa sprout shelf life. The whites of shelled eggs become milky.
and liquidy when irradiated. When opened, they look and act like eggs, yet this factor could affect their performance in recipes.

It is believed that irradiation will affect most foods like pasteurization affects milk. Pasteurization does change the taste of milk, but makes it much safer to drink. Like pasteurization, irradiation causes little harm to the nutritional value of the food. However, it does change the vitamin thiamine, certain amino acids and fatty acids. These changes do not seem to be nutritionally significant though.

Irradiated foods are labeled with a green radiation label that is internationally known as a “Radura”. Presently, surveys suggest that 50% of consumers will buy irradiated food if there is no added cost, and that more would buy irradiated food if they knew the full scoop. However, it is not reasonable to expect 100% acceptance anytime. Present scientific evidence overwhelmingly favors the use of irradiation to kill disease-causing microbes in food. However, there is a body of anecdotal evidence from groups like the Stop Irradiation Project and the Organic Consumers Association (OAC) that oppose irradiation of food and cite many reasons for their beliefs. Presently, they do not accept any hard evidence that disfavors their opinions or beliefs. They make the claim that irradiated (nuked) food suffers changes in flavor, texture, odor, nutritional integrity and chemical composition [www.organicconsumers.org].

There is little doubt that irradiation decreases the number of food borne pathogens like: *Campylobacter*, *Cyclospora*, *E. coli* 0157:H7, *Shigella*, *Salmonella* and *Listeria* for the U.S. Military and NASA. Today, there are few commercial irradiation facilities in use and only a few foods are actually getting irradiated. More needs to be done so that consumers can make safer choices.

**Late notes:** On May 13, 2002 both the House and Senate passed the farm bill HR 2646, which supports irradiation of foods. President Bush has signed it into law. Irradiation is also being used by the Post Office to stop Anthrax in the wake of 9/11. The OAC is outraged and is complaining that the Post Office is destroying digital data that is sent through the mail.
**Activities:**

I) Two days of lecture and discussion.

II) Two days: one day of media/computer research by students and one day of student team oral reporting. Each student team needs to look up three pathogens listed in the lesson and give a minimum 100-word report on each. Each team will present their report orally and in writing. In addition, each student needs to write a minimum 25-word summary on each pathogen presented by their peer classmates and hand in at the end of day five.

III) One day: Student will take short test and complete their 25-word summaries on each pathogen presented.