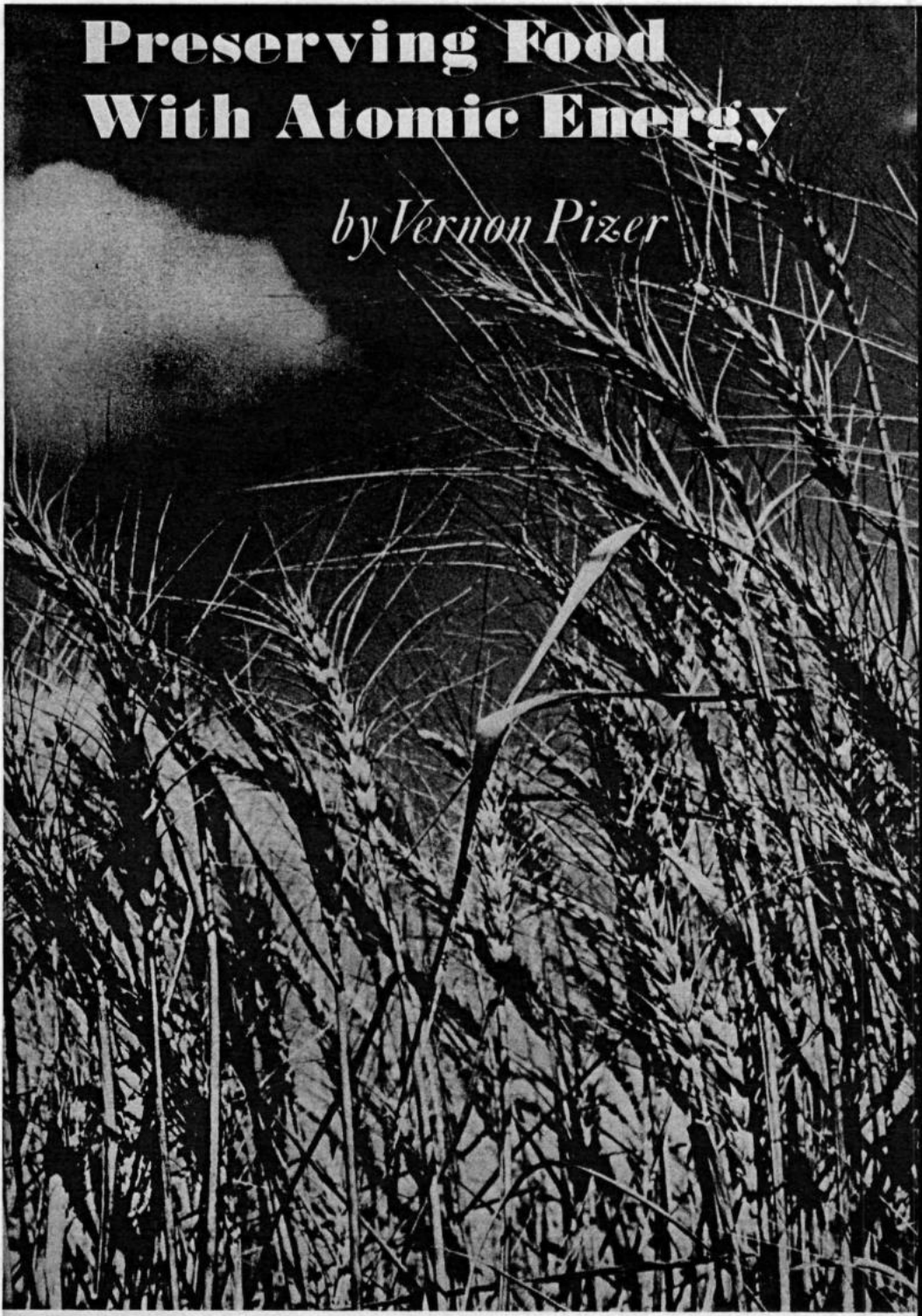
Preserving Food With Atomic Energy

by Vernon Pizer



A WORLD OF THE ATOM SERIES BOOKLET

The Author

Vernon Pizer is a professional writer who has contributed over 200 articles to such magazines as *Reader's Digest*, *Esquire*, *Saturday Evening Post*, and *This Week*, as well as to various foreign publications. Among his published books are *Glorious Triumphs: Athletes Who Conquered Adversity*, Dodd, Mead and Company, 1968; *The World Ocean: Man's Last Frontier*, World Publishing Company, 1967; *The United States Army*, Frederick A. Praeger, Inc., 1967; *The Useful Atom* (with William R. Anderson), World Publishing Company, 1966; and *Rockets, Missiles, and Space*, J. B. Lippincott Company, 1962. Mr. Pizer has also written numerous books and pamphlets for the Department of State and the Department of Defense. Though he writes on a wide range of subjects, Mr. Pizer's area of primary interest is the sciences.

THE WORLD OF THE ATOM SERIES

This is one in a series for junior high school science students and their teachers. The series describes the many exciting fields of nuclear energy.

This booklet tells how atomic radiation is used to safely preserve foods for long periods of time.

I hope you enjoy reading this booklet.

Edward J. Brunenkant, Director
Division of Technical Information

Preserving Food With Atomic Energy

by Vernon Pizer

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United States Atomic Energy Commission
Division of Technical Information

Library of Congress Catalog Card Number: 70-609232

1970

Man, the Hunter

More than anything else, early man was a hunter. His most important activity was his constant hunt for food. If the hunting was good, he found the food he needed in order to live. If the hunting was poor, he faced starvation and death.

Many amazing changes have occurred in the world since those faraway days in the distant past, but one thing has not changed: Food is still a life or death matter for man. In fact, the world's population is growing faster than its food supply; so the problem of providing enough food to meet human needs is even more serious now than it was a million years ago.

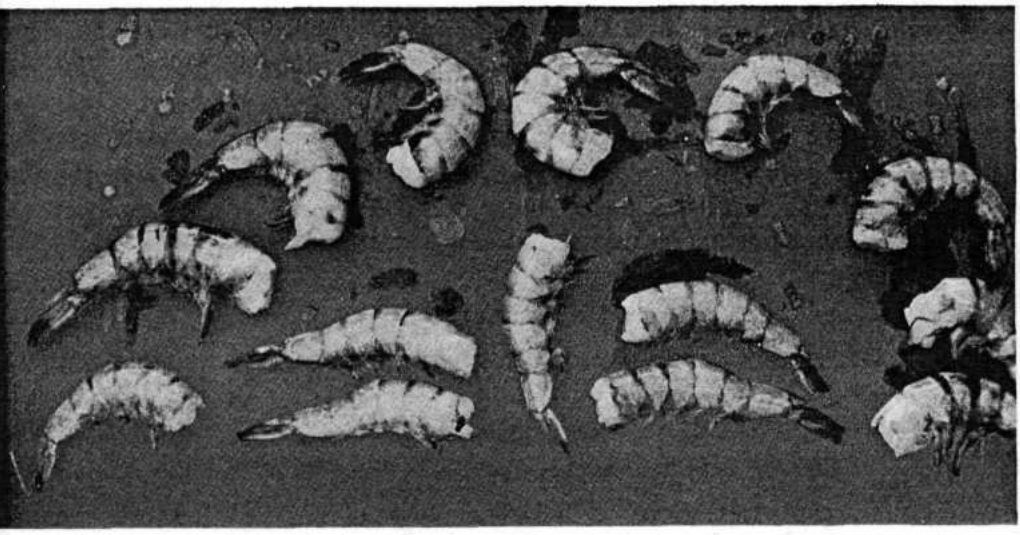
One lesson that early man quickly learned was that he could never be sure that the hunting would be good tomorrow just because it happened to be good today. This made him realize that in order to remain alive he had to save part of his food in times of plenty to tide him over the times when the hunting was poor. So it became the custom to set aside a portion of the food supply to eat when game was scarce. But this created a new and serious problem because often the stored food spoiled and could not be eaten when it was needed most. As a result, man was forced to search for ways to prevent food from spoiling.

As time passed, ways were found to stop food from spoiling as rapidly as before. Man did not yet know *why* these methods worked; he only knew that they helped preserve food

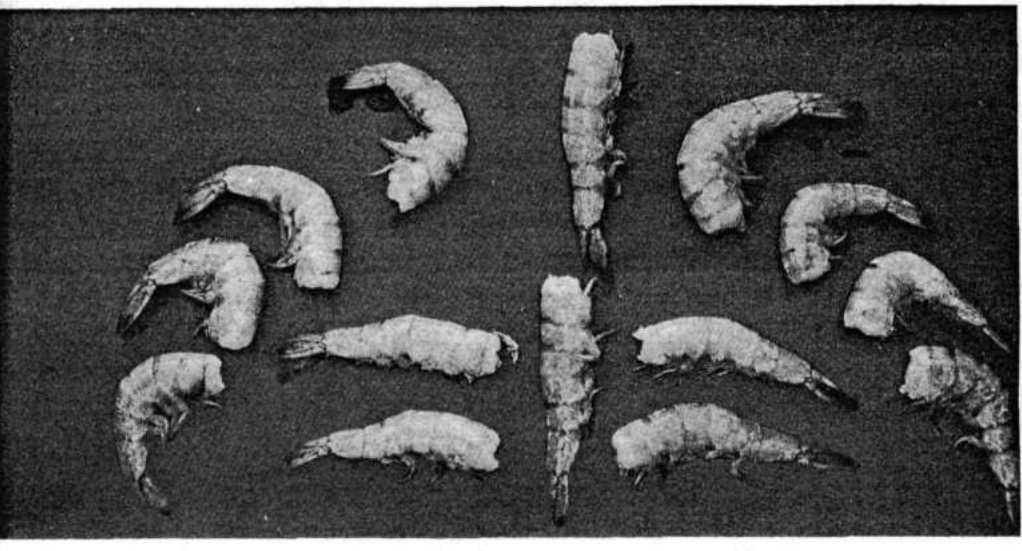
for longer periods. As man slowly began to understand why foods spoil, he was able to improve food preservation methods and to create new methods. Each way of preserving food had its good points and its bad points. Some worked well with certain kinds of foods but not with others. Some were too expensive or too complicated to be used widely. So the search continued.

This search has now brought food scientists and atomic scientists together to create a way to use atomic energy as a means of preserving food. This new method is called *radiation preservation. Nuclear radiation has demonstrated that it can preserve food safely, effectively, and quickly.* This does not mean that the older ways of protecting food from spoiling are no longer practical and necessary. But it does mean that now, thanks to atomic science, certain foods can be preserved better and longer than by other methods. However, public health authorities approve the introduction of irradiated food into the commercial market only after it has been proven to be wholesome and free of possible cancer-causing substances as well as demonstrating that the irradiation does, in fact, do what the petitioner claims it does.

The best way to understand how radiation preservation works is to learn why foods spoil.



The shrimp in both pictures are the same age. The seafood below was preserved with nuclear radiation and that above was not.



Food Spoilage

All foods begin to spoil in one way or another almost from the moment they are harvested by the farmer, caught by the fisherman, or processed by the butcher. The longer the spoilage is allowed to continue, the greater are the changes that take place in the food. One change is a loss in the amount of nourishment that the food gives to those who eat it. Another change is the development of a smell, an appearance, or a flavor that is disagreeable to humans. A third change may be the development of poisons in the food that can be harmful if they are eaten; at times

these poisons may even be harmful enough to cause death.

Often spoilage is caused by unsanitary conditions that allow the food to come in contact with dirt or with insects. While it is very important to handle food in a sanitary manner at all times, sanitation alone is not enough to prevent spoilage. This is because most foods contain within themselves certain "spoilers". These "spoilers" are *microorganisms* and *enzymes*.

Microorganisms

The microorganisms that cause food to spoil are bacteria, molds, and yeasts. These tiny substances are alive and growing everywhere all the time. They exist in and on plants and animals, in the air, in water, and in the soil. So even when food is treated to halt the growth of the microorganisms it already contains, it will continue to spoil when other microorganisms reach it. This means that continuous protection is necessary to prevent food from spoiling.

Let's take a closer look at microorganisms to see how they affect food. While the food is still alive in its plant or animal form, it grows because it is able to combine certain chemicals and minerals into molecules that form its tissue. As soon as the plant is harvested or the animal is butchered this growth of new molecules comes to a halt.

It is now the turn of the microorganisms to take over since the delicate balance between the host and the microorganisms has been upset. They go to work on the mole-

cules, reversing the process of growth that had been occurring earlier when the food was still alive. They cause this reversal by forcing the complex molecules of the food to break down into the chemicals and minerals from which they had been formed earlier. This breakdown of molecules is known as decay. All microorganisms do not function in exactly the same way, but all of them have the same objective: To break down the molecules to a size which they can use as nourishment.

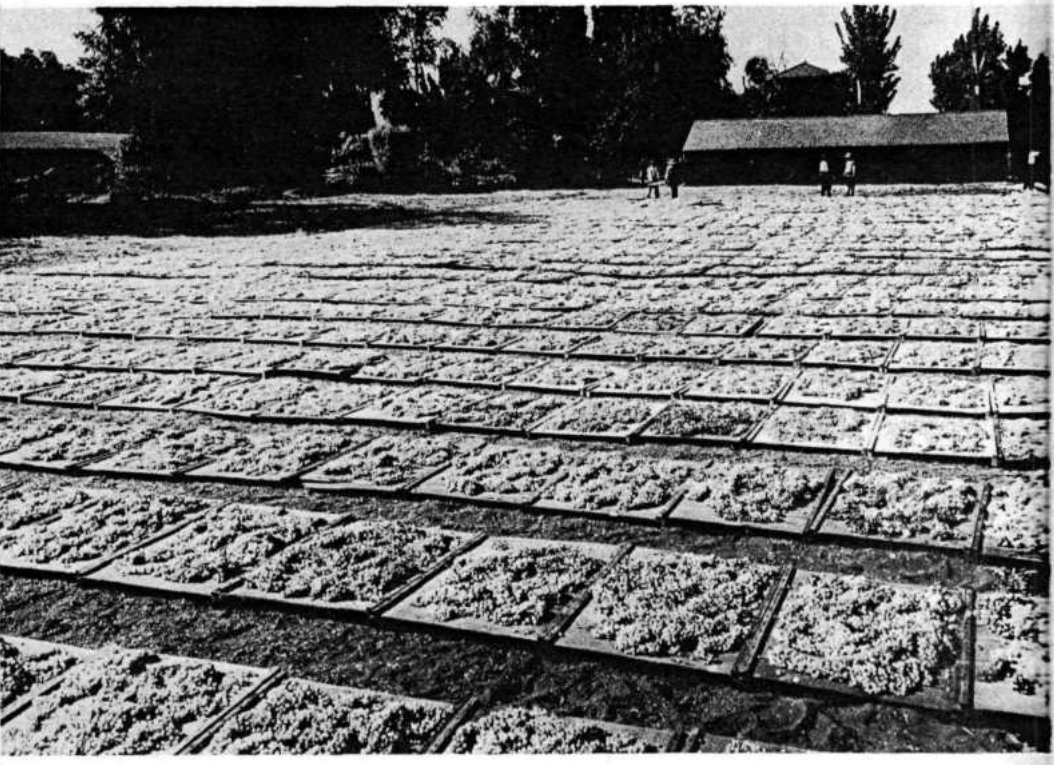
Enzymes

Enzymes are proteins that act as *catalysts,* which are simply substances that help rapid chemical reactions take place while they themselves are not changed by the reaction. In a way, a catalyst might be thought of as something like an incubator on a chicken farm. The incubator causes the eggs to hatch into chicks, but the incubator itself is not affected or changed by the hatching process. In the same way, the catalysts—the enzymes—that are present in food are not changed or "used up" by the chemical reactions they cause in the food. This means that a little enzyme can go a long way.

Enzymes and microorganisms can cause two different chemical reactions in food. One is known as *fermentation.* The second is called *oxidation.* Fermentation is a process that partially breaks down glucose, a natural sugar found in plants and animals. This partial breakdown produces carbon dioxide in addition to releasing a small amount of energy. Alcohol is also produced. Oxidation, like

fermentation, breaks down glucose but it causes a more complete breakdown. Oxidation, which must have oxygen in order to take place, produces carbon dioxide and water and releases a greater amount of energy than does fermentation.

A great effort is necessary to prevent spoilage between the time the food is harvested or butchered in a distant place and the time it is bought in a supermarket. So many dangers lie in wait along the way—dirt, insects, microorganisms, enzymes, unfavorable temperatures, and even just plain air that can make fats and oils become stale and rancid. Man's long history of war against these dangers has been one of the most difficult of all his struggles because he was fighting enemies that he understood very poorly and that he could seldom see.



These grapes are being dried by the sun. Drying is an age-old technique used to preserve food for future use.

Combatting Food Spoilage

Long before man had any clear understanding of the mechanics of the bright rays of the sun shining down upon the earth, he discovered that he could avoid discomfort and a possible skin burn if he provided himself with shade on a very sunny day. In much the same manner, long before he understood *why* or *how* food spoilage occurs, he found several ways to help guard against it. He discovered some of these by simple good luck. Others he

found by intelligent observation, just as he had been intelligent enough to observe that shade would protect him from sunburn.

Early man learned, for instance, that many foods would keep for longer periods if the moisture was removed from them. He spread grains, vegetables, fruits, and strips of meat to dry in the sun. He also used the heat of a fire to parch such foods as corn and beans. As more time passed, man found other ways to improve his ability to preserve his food, although he still knew very little about why foods spoil.

We can see how man made progress from one method of preservation to another. For example, it is not difficult to trace modern dehydration all the way back to the ancient techniques of drying and parching. Freezing can be seen as an outgrowth of mechanical refrigeration. In turn, the refrigerator can be recognized as simply a better and easier way of doing what the Romans did when they sent slaves into the mountains to bring down blocks of ice.

Several other so-called "modern" techniques are even closer to ancient practices; some of these are smoking, pickling, salting, and the making of sugar concentrates such as jams. And in some parts of the world, the old methods of drying and parching are still used just as they were thousands of years ago.

As he experimented, man even found that he could turn the tables on nature by using to good advantage one of the ways in which foods spoil. Wandering herdsmen in Asia and Europe originated the practice of fermenting

milk into cheeses. These cheeses could be eaten long after the milk in its liquid state would have spoiled. At about the same time, others were learning that honey and water could be fermented into mead, an alcoholic drink. Later, mead gave way in popularity to two other fermented alcoholic products: Wine and beer.

The first real breakthrough in preservation came early in the 19th century when Nicolas Appert, a Frenchman, invented canning. Up until that time, every known method of preservation depended upon a natural action, such as drying, fermenting, or icing. But canning was completely different because it was the first method that did not rely on a natural action. It was truly a man-made technique.

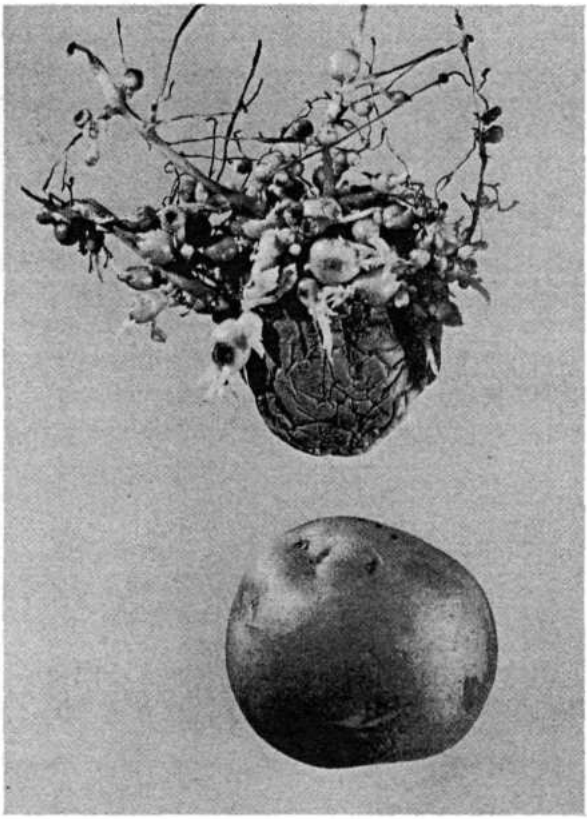
The first canners used glass bottles for their processing. The food to be processed was bottled, sealed, and then heated in kettles of water. This system presented problems because the bottles broke easily and were expensive. These troubles were partially overcome in 1810 by an Englishman who invented a tin can that was strong and easy to handle. Later other inventors developed ways to manufacture the cans quickly and cheaply. After that, the use of canned foods expanded rapidly.

Everyone agreed that canning preserved foods very well, but nobody knew *why*. A French chemist, Louis Pasteur, wanted to know why canning was effective. In 1864, after a long series of tests in his laboratory, Pasteur found the answer. He discovered that when food is sealed in an airtight container and then heated sufficiently, the heat kills a large percentage of the microorganisms in the food that would otherwise cause spoiling. In honor of Pasteur, the practice of reducing the number of microorganisms in foods by the application of heat is called *pasteurization*.

Louis Pasteur

More than a half century after Pasteur's discovery, the stage was set for the second breakthrough in developing a preservation technique that did not depend upon a natural action. The actors on the stage were the scientists who were exploring the mysteries of the atom.

Pioneers who settled in the West used canning, drying, and fermenting techniques to preserve foods that they raised. On the left is a farm family in Custer County, Nebraska, around 1887.



The bottom potato was preserved with gamma radiation; the top one was not treated. Both were stored for 16 months and then these photos were taken. The irradiated potato was still firm, fresh-looking, edible, and had no sprouts.

How Radiation Affects Food

By the middle of the 1940s, scientists had learned enough about the atom to understand how they could use it to preserve food. They planned to do this by making use of one part of the nuclear phenomenon: Radiation.

The principle of preserving food by radiation is not as complex as one might imagine. It is based on the fact that if, under proper safeguards, the gamma rays given off (or emitted) from a radiation source are allowed to pass through food, the rays will kill or reduce the number of the microorganisms in the food.

We have already seen that one of the major causes of spoilage is the action of microorganisms that break down the molecules of the food. So we can readily understand that when the rays kill or reduce the number of microorganisms they are preventing or delaying spoilage. Let's take a close look at exactly what happens during the irradiation of food.

As the rays pass through the food, they collide with some of the atoms in their path. Atoms contain a tiny core known as a nucleus. They also contain small particles known as electrons. The electrons are in constant orbit around the nucleus, much as weather satellites orbit the earth. The nucleus is electrically positive, but the orbiting electrons have a negative electrical charge. The positive charge of the nucleus balances the negative charge of the electrons so that the atom as a whole is neither positive nor negative, but is electrically neutral.

But during irradiation, the rays change this situation when they collide with the atoms. They do this because the rays strike some of the electrons within the atoms, knocking them out of orbit just as a swinging bat striking a flying baseball will slam it out of

the park. This means that the atom has lost a portion of the negative charge that had been balancing the positive charge of its nucleus. As a result, that atom as a whole is no longer electrically neutral but now becomes positive. The atom is now said to be *ionized.* It has become an *ion* by the action of *ionizing* radiation.

These fish fillets are placed in the research irradiator at the Massachusetts Institute of Technology for radurization.

Ionizing radiation at the level intended for the irradiation of food does not make it radioactive. Neither does it cause the microorganisms within the food to become radioactive. But ionization does have a most important effect on the microorganisms, and it is this effect that is the key to understanding why irradiation preserves food.

A low radiation dose, called *radurization,* destroys most of the microorganisms in the food, just as the low heat used in pasteurization destroys most of the microorganisms in milk. In fact, radurization is sometimes known as radiation pasteurization.

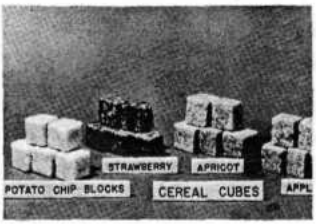
A higher dose of radiation, called *radappertization,* destroys all the microorganisms in the food, just as high heat processes canned goods. Because of this, radappertization is sometimes known as radiation sterilization.

In other words, ionizing radiation acts as a brake on the spoilage microorganisms in food by slowing their rate of growth with the radurization process or by destroying them completely by the radappertization process. In either case, the result is the same: The usefulness of the food is increased depending on the strength of the dose.

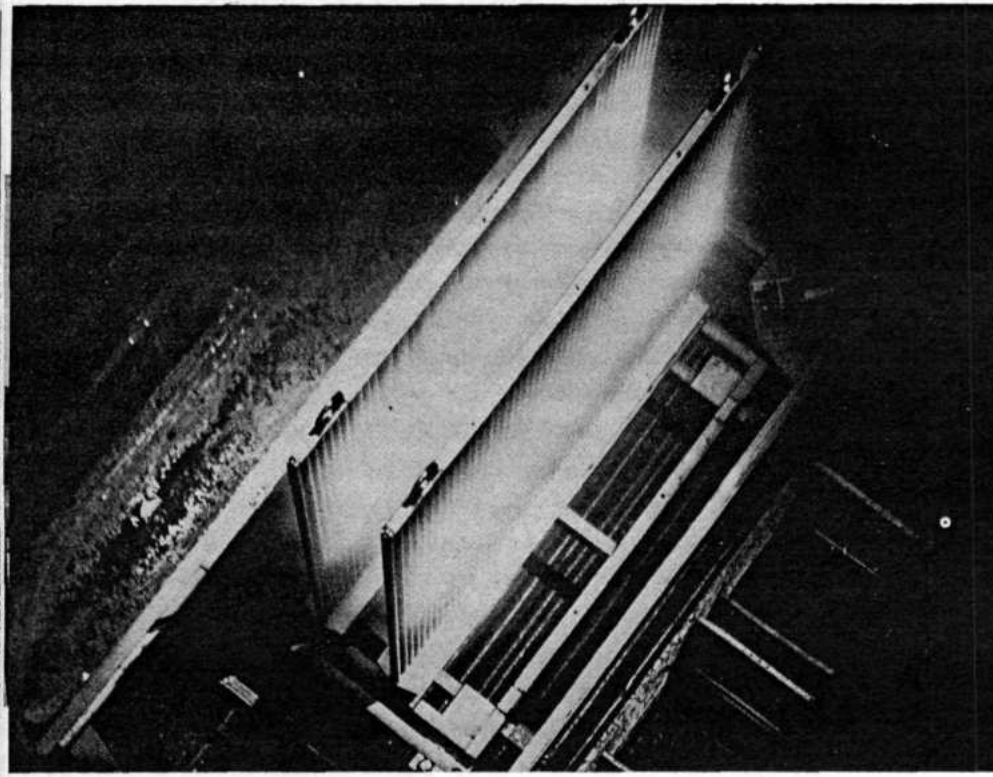
There is also another way in which irradiation is important in preserving food. It can reduce the damage that insects cause in wheat and other grains. A number of different chemicals can be used to get rid of insects that attack grain. However, the chemicals do not rid the grain of the eggs that the insects have laid. These eggs later hatch into new insects that damage the grain. But irradiation can prevent this by destroying the eggs so that they cannot hatch. This method of preserving grain is called *radiation disinfestation.*

Most of the older ways of preserving foods change the normal appearance of the food. For instance, canned corn is quite different from fresh corn on the cob; dehydrated eggs are a powder that does not look at all like eggs in the shell; and frozen spinach does not look like fresh spinach. Very often, the taste of a food is also changed when it is preserved by one of the older methods. On the other hand, *one of the great advantages of irradiation is that it causes little or no change in the normal appearance of the food.*

Research scientists have not yet discovered all there is to know about why ionizing radiation should affect food the way it does. However, they have learned enough to make it very clear that the process is a giant step forward in man's long search for ways to protect his food supply.



Freeze-dried food cubes used by astronauts sometimes have a waxy, artificial taste.



The cobalt-60 source at the Army's Radiation Laboratory in Natick, Massachusetts, glows like a neon sign at the bottom of a 25-foot storage pool of water.

Sources of Radiation

Two different kinds of radiation sources may be used for food preservation. One is a *radioisotope* (or radioactive isotope). The other is an *accelerator.*

A radioisotope is an atom that emits radiation. There are three different types of radiation emitted by radioisotopes: Alpha, beta, and gamma. Only radioisotopes that emit gamma rays are used for preserving food.

This is because gamma rays will penetrate deeply without being stopped by the outer layers of the food. The radioisotopes most often used for preserving food are cobalt-60 and cesium-137.*

An accelerator is a complex machine that employs electricity and magnetism to increase the speed at which atomic particles move and then discharges the particles at a high velocity. In a way, an accelerator might be thought of as somewhat like a pitcher going into a "wind-up" to put more speed into his fast ball. The particular kind of accelerator that is used for the radiation preservation of food is an electron accelerator.

The electrons are speeded up in the machine and then are beamed from it to the food that is to be processed. The electrons act in the food like gamma rays, however they do not have as much penetrating ability as gamma rays. The beam of electrons can be aimed from the accelerator to the food just as a beam of light can be aimed from a flashlight. Gamma rays cannot be aimed in one direction, but fan out in all directions from the radioisotope that is emitting them.

The food irradiation research that has been conducted in the United States has been carried out mainly under the direction of the Atomic Energy Commission and the U. S.

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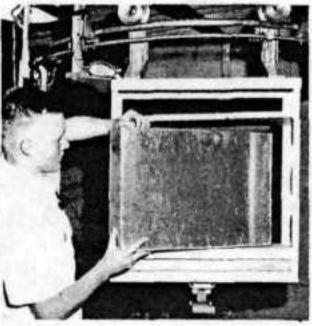
*The numbers following these radioisotopes are the sums of the neutrons and protons in their nuclei. Neutrons and protons are elementary particles that form the nucleus of an atom.



A food container is loaded into a conveyor for processing in the Army's accelerator.

Army. The AEC is interested in food irradiation because it is the Government agency that has the major responsibility for the peaceful uses of the atom. The Army is interested in the subject because it must feed large numbers of soldiers stationed in many different places all over the world. Radiation preservation promises to provide the Army with a way to feed its forces better regardless of their location.

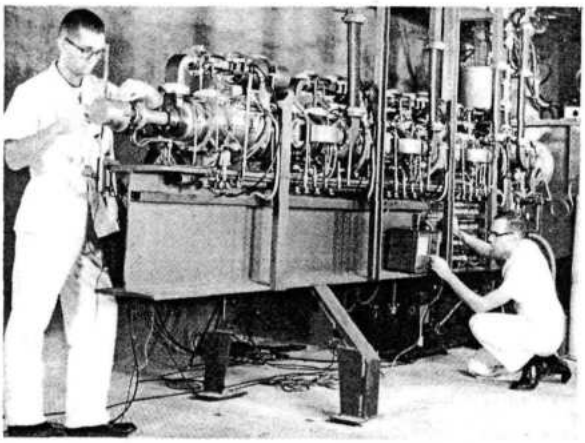
Most of AEC's research has been performed with low-dose radiation. After being irradiated the food is maintained and displayed in the appearance normally seen by the consumer. The aim has been to develop both radurization and disinfestation because the AEC believes these can bring benefits to the most people in the shortest time. The particular kinds of foods involved in the AEC program have been fruits, vegetables, finned fish and shellfish, and wheat. In conducting its research, the AEC has used two different radioisotopes as radiation sources: Cobalt-60 and cesium-137.

The Army's research efforts have been mainly in the field of radappertization. The object has been to preserve foods indefinitely without refrigeration. This is because the Army needs to store troop rations for long periods, often under conditions where refrigeration is difficult or even impossible. The foods involved in the Army's program have been mainly ham, pork, beef, and chicken. In this program a pretreatment, such as cooking, smoking, etc., is usually required prior to irradiation. This pretreatment destroys the

natural enzymes that would cause endogenous breakdown of the food product in question. In conducting its research, the Army has used both radioisotopes and electron accelerators as radiation sources.

So far, radioisotopes have been used more often than accelerators as radiation sources in the numerous food preservation development programs. This was partly because there was a good supply of radioisotopes at a time when accelerators were still scarce. Now, however, accelerators can be purchased with no difficulty from commercial manufacturers.

Several different things are considered in deciding which radiation source is best for a particular irradiation program. One fact that comes into consideration is cost. At present, accelerators are more expensive to use as radiation sources than are radioisotopes, because accelerators have to be serviced regularly and the servicing is costly. (Radioiso-



The accelerator at Natick.

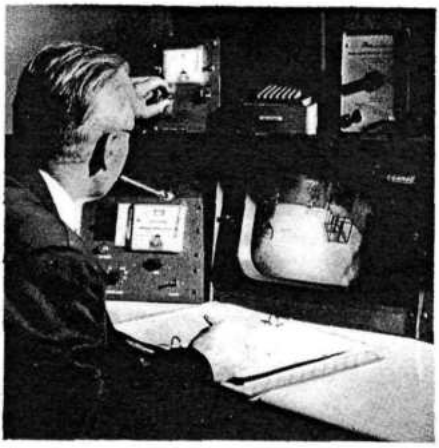
topes do not need servicing.) However, as accelerators are improved they will need less servicing so that expense will be reduced.

Although radioisotopes do not need servicing, they do have to be replaced by adding a new supply of the same radioisotope after a certain period. This is because a radioisotope gradually weakens just as a flashlight battery eventually becomes too feeble to do its job well. (The rate at which a radioisotope weakens is determined by its *half-life,* which is the length of time it takes for half of a radioisotope's atoms to lose their radioactivity. The half-life of cobalt-60 is 5.3 years. The half-life of cesium-137 is 29 years.)

Another point that must be considered in selecting a radiation source for a particular program is how easily it can be operated. An accelerator can be turned off and on like an electric switch. However, a radioisotope emits its rays continuously. In other words, it is always "on".

This means that safety precautions must be taken at all times to make sure that the rays do not accidentally strike the people who work with radioisotopes. One important safety measure is provided by placing a shield around the radioisotope to stop the rays from reaching the operators. Various types of material are used for these shields. Some of these are concrete, lead, and pools of water.

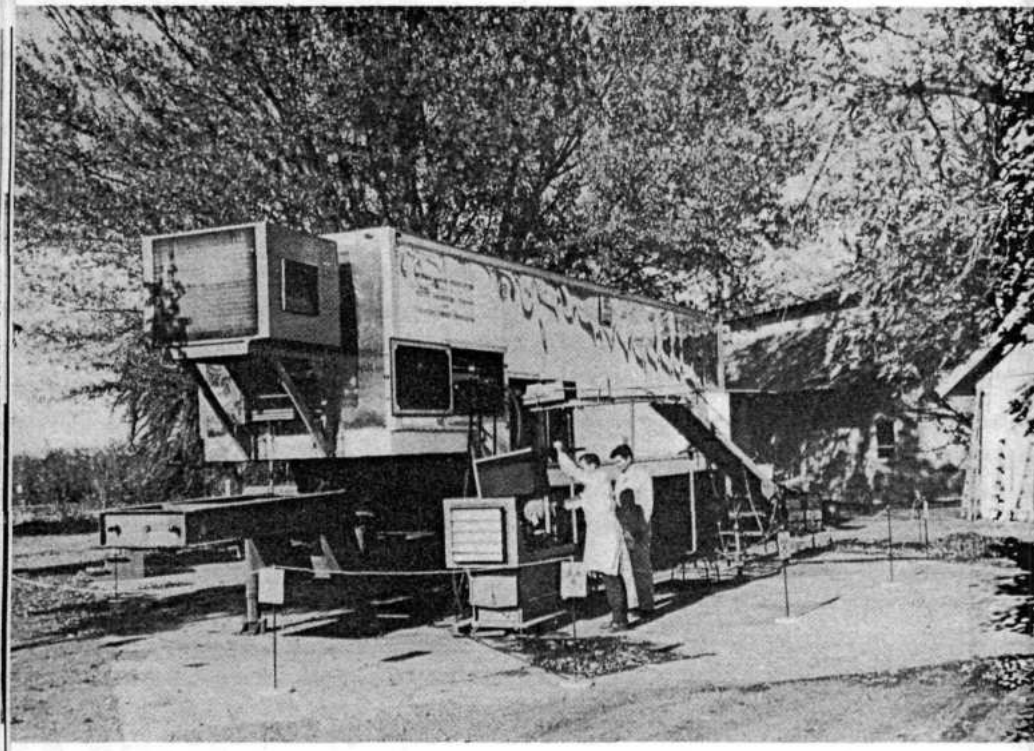
A final fact that must be taken into consideration in selecting a radiation source is the nature of the food that is to be irradiated. A thick product such as a ham or a beef roast needs the deep penetrating ability of the gamma rays emitted by a radioisotope. How-



Closed-circuit television is used to supervise experimental food processing at the Army's Radiation Laboratory.

Radappertization of bacon is viewed through a heavy lead-glass window at the Brookhaven National Laboratory in Upton, New York.

ever, surface irradiation of a thin item, such as a steak or a slice of fish, can be handled very well by an electron accelerator.



A box of fruit (above the men) moves on a conveyor belt into the Mobile Gamma Irradiator. This device is being used in an orchard to radurize fruit immediately after harvest.

The Irradiators

After the radiation source has been selected, something else is still needed before the irradiation of food can take place. This is a structure to contain the source in such a way that the food can be exposed to a carefully measured dose of the radiation under conditions that are safe for the operators. This structure is called an *irradiator.*

A number of irradiators of different design have been built and placed in operation in test programs. The differences in design give the operators an opportunity to compare one kind of irradiator with another. In this way they can find out which design works best and which are the easiest and cheapest to operate. In addition, they can pick the one that is best suited to the kind and the amount of the food they wish to process.

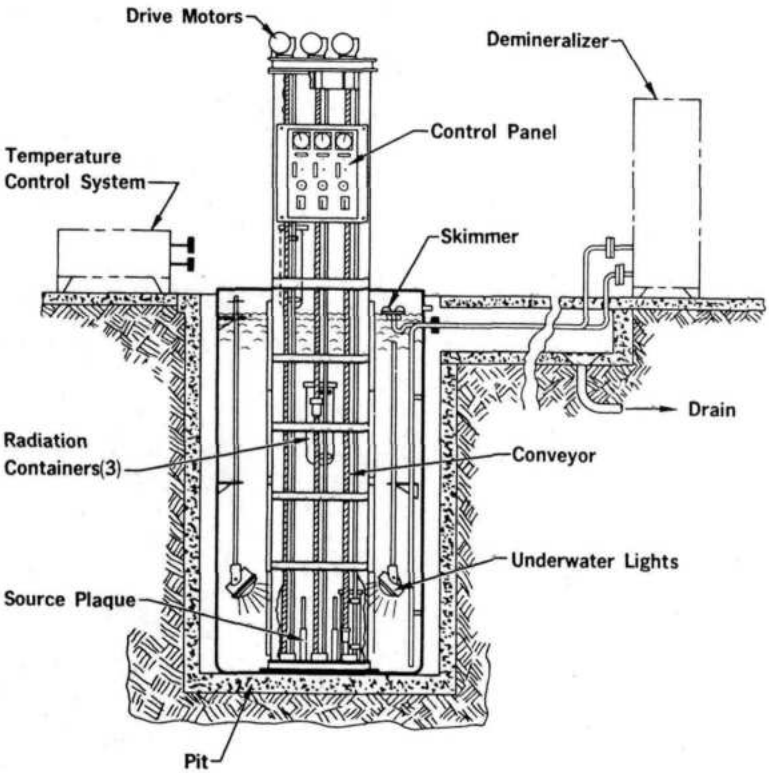
The **Marine Products Development Irradiator (MPDI)** is located in Gloucester, Massachusetts, and has been performing successfully since 1964. As its name indicates, the MPDI is used for processing fish products. It was built by the AEC and is operated by the Fishery Products Technology Laboratory of the Department of Commerce.

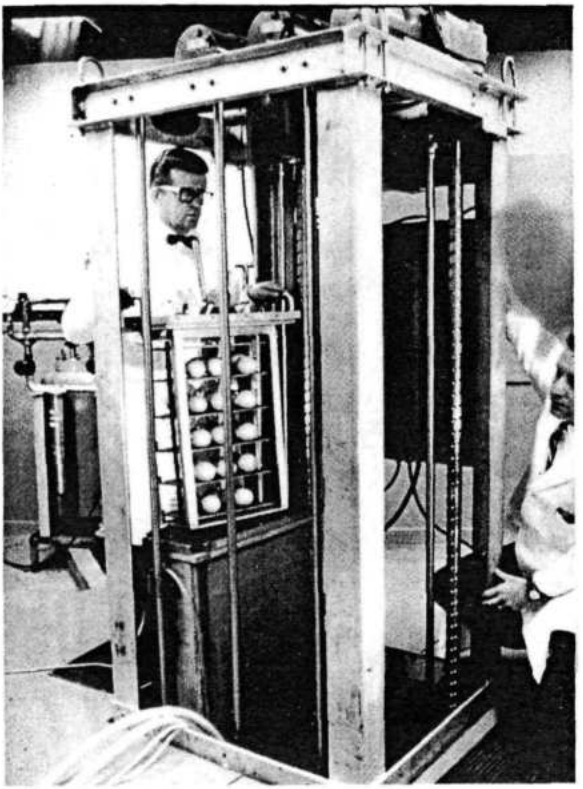
The MPDI provides on a small scale all the facilities—radiation source, apparatus for remote handling of the source, shielding, food preparation and work areas, conveyor system to move the food mechanically, laboratory and offices—that a commercial plant would need for a large-scale operation.

The heart of the irradiator is its cobalt-60 radiation source. The source is shaped in the form of a rectangle that is called a *plaque.* When it was installed in 1964, the MPDI source plaque had a strength of 225,000 curies. (A curie is the basic unit of measure of radiation intensity, just as a volt is the basic unit of measure of electrical intensity, and a degree on a thermometer is the basic unit of measure of the intensity of heat.)

When the MPDI is not in use, the source plaque rests at the bottom of a pool of water that serves as a shield for its radiation. When the MPDI is to be placed in operation, the plaque is raised from the pool by remote control and is guided into position between the lower and upper levels of a continuous conveyor belt. Packages of fish are carried along on the conveyor.

The conveyor belt passes the packages under and then over the plaque. On each pass the packages are exposed to a carefully calculated dose of radiation from the plaque.





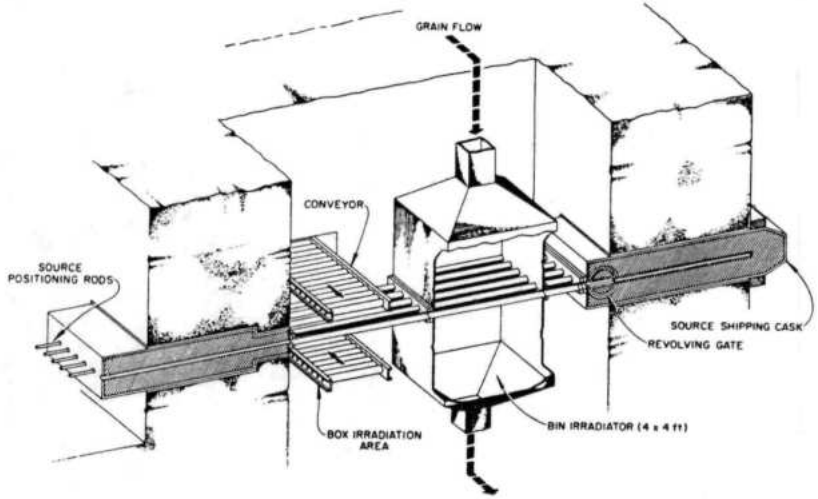
The diagram on the opposite page illustrates the main parts of a research irradiator. Above, scientists load fruit into the research irradiator at the University of California.

This dose is determined by the timing or speed of the conveyor belt as well as the strength of the isotopic source. By the time the packages of fish have completed their round trip on the conveyor they are radiation pasteurized (or radurized). The MPDI can treat 1000 pounds of fish per hour at 100,000 rads.

There is another type of irradiator, the **research irradiator,** that eliminates the step of

raising the source plaque from its shielding pool of water. In the research irradiator the source remains stationary at the bottom of the pool and the product is lowered to the plaque. The product is first placed in a watertight container and then is lowered so that the rays from the plaque can pass through the container to irradiate the item it contains.

The amount of exposure time for the product is controlled with great care so that it will receive the exact amount of radiation that has been selected for it. Irradiators of this type are used in research programs at the University of California, the University of Florida, the University of Hawaii, the University of Washington, and the Massachusetts Institute of Technology.



A special purpose irradiator (above), the **Grain Products Irradiator (GPI)**, is located in Savannah, Georgia. The GPI, which operates

under the supervision of the Department of Agriculture, uses cobalt-60 as a source and is intended for the radiation disinfestation of insects in wheat and other grains. However, the GPI can also be used to irradiate packaged mixes, cereals, and flours.

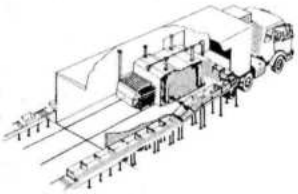
The GPI is housed in a thick-walled, concrete structure called a cell. In the middle of the cell is a metal bin into which loose grain is poured from above. The radiation source is shaped into 11 separate, rod-like cylinders that had a strength of 25,000 curies when they were installed. When the GPI is not in use, the source cylinders rest in a shielding cask that is built into the cell wall.

To irradiate loose grain, the cylinders are pushed out into pipes that crisscross through the bin. Then the grain is poured into the bin at a precise rate of speed. As the grain passes through the crisscrossed pipes it is irradiated by the source cylinders within the pipes. The grain then leaves the bin through a chute in the bottom. The capacity of the GPI is 2000 pounds of grain per hour.

The method is a little different if packaged or sacked products are to be irradiated in the GPI. From a platform built outside the cell, a continuous conveyor belt passes through the cell wall into the space between the wall and the metal bin on the inside. The pipes that contain the source cylinders run between the upper and lower levels of the conveyor belt.

To irradiate packaged products the source cylinders are not pushed all the way into the bin. Instead, they are stopped when they are

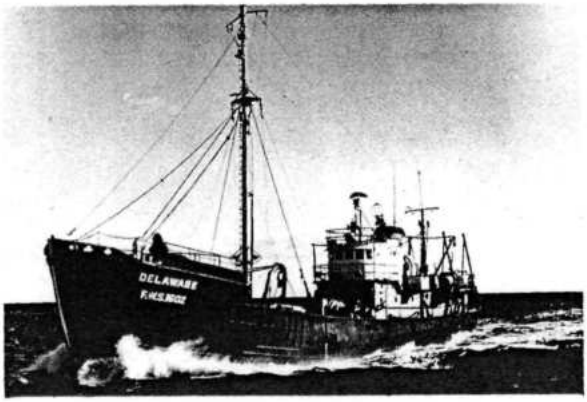
in the portion of the pipes between the two levels of the conveyor belt. Then the packages are carried on the belt from outside the cell, in over the pipes, and back out under the pipes. As they pass over and then under the pipes, the packages are irradiated by the source cylinders within the pipes. The GPI has a capacity of 2800 pounds of packaged products per hour.



Unlike the irradiators we have discussed so far, the AEC's **Mobile Gamma Irradiator (MGI),** is on wheels and can be moved. This makes it possible to take the MGI right into the fields to irradiate crops at the height of their just-picked freshness. (See drawing on left and picture on page 22.) In operation, boxes of fruit or vegetables are placed on a moving belt outside the MGI. The belt carries the boxes through the MGI where they are exposed to the radiation source, and then the boxes are brought back out on the opposite side of the MGI. The radiation source of the MGI is cobalt-60 that had a strength of 100,000 curies when it was installed. The capacity of the MGI is 1000 pounds per hour.

Another movable unit is the AEC's **cesium-137 irradiator.** The unit weighs 35 tons and is mounted in a trailer. Its radiation source is cesium-137 that had a strength of 170,000 curies when it was installed. The unit was used to irradiate food products from about 50 different companies on a test basis. The irradiator can handle from 200 to 300 pounds per hour, depending upon the type of food that is being processed and the dose required.

Movable in a quite different way is the **shipboard irradiator** developed by AEC. Three such irradiators have been in operation aboard different Department of the Interior vessels.



The Delaware, *a Department of the Interior fishing vessel, contains an irradiator for preserving fish.*

Each of the irradiators weighs 17 tons and contains a 30,000-curie, cobalt-60 radiation source. Because the units can go to sea, it is possible to irradiate fish immediately after they are caught. Fish processed in this way and then refrigerated can be kept in a fresh condition two to three times longer than fish not irradiated but caught at the same time and placed under refrigeration. Each seagoing irradiator can process 150 pounds per hour. These irradiators can also be used in land-based operations.

The **Hawaii Development Irradiator (HDI)** was designed specifically for tropical fruit product irradiation and contained 220,000 curies of cobalt-60 in June 1967 when it was dedicated. This irradiator is one of the most

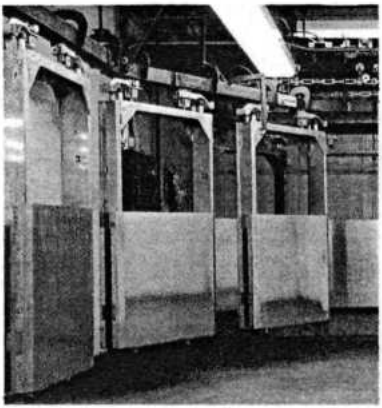
versatile pilot plant irradiators within the AEC program. It is operated under contract to the AEC by the State Department of Agriculture of Hawaii and the facility is primarily used in developing the technology of radiation disinfestation to meet quarantine requirements. (See pages 38-40 for more information about this irradiator.)

The most complete food irradiation research center in the United States is the Army Radiation Laboratory in Natick, Massachusetts. Here there are two separate radiation facilities. One uses a radiation source with a strength of 1.3 million curies at the time it was installed. The second uses an electron accelerator as its radiation source. The accelerator produces 24 million electron volts. The

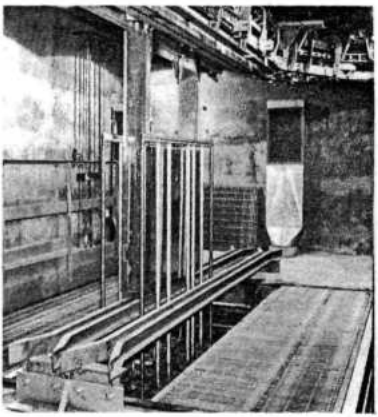
(1) Steaks are partially cooked to destroy enzymes prior to processing at the Natick Laboratory.

(2) The precooked steaks are sealed in cans.

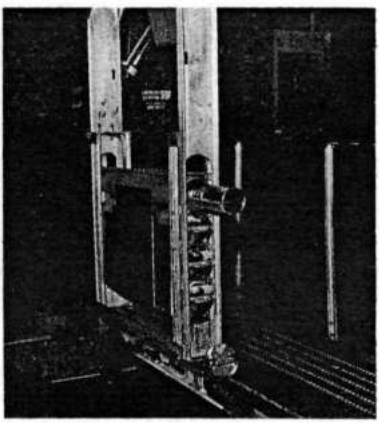
program at Natick has been devoted mainly to the radappertization (or radiation sterilization) of pork, smoked ham, beef, and chicken.



(3) The cans are placed in aluminum boxes that are conveyed into the radiation cell.



(4) Conveyor racks pass between raised cobalt-60 rods. (See picture on page 16.)



A dietician prepares radappertized baked ham for taste testing by volunteers at the Army's Quartermaster Food and Container Institute.

Safety First

From the beginning, the entire United States effort in food irradiation research has been based on providing complete safety for those who eat the food. It was not enough for the research scientists to prove that the size of the radiation dose used in food irradiation will not under any circumstances cause the food itself to become radioactive. They also

wanted to know two other important things: (1) Would irradiated food lead to any harmful effect on those who ate it? (2) Would radiation processing cause any change in the nutritional value of the food?

Even after the investigators are fully satisfied that a particular food, irradiated at a certain dose level by a particular radiation source, is completely safe and wholesome for human use, it still cannot immediately be offered to the public. Before that can happen, the food must first be cleared officially by the Food and Drug Administration (FDA).

In addition, meat and meat products must also be cleared by the Meat Inspection Division of the Department of Agriculture. These clearances are given *only* after thorough testing to demonstrate to the clearing authorities that the particular irradiated food is indeed safe for human use.

Radiation preservation has been more thoroughly tested than any other method of food preservation. The basic tests were designed in cooperation with FDA officials. These tests require the feeding of irradiated products to animals over a long period of time. In addition, during research and development of a particular irradiated food, volunteer human tasters have been used to sample the food and give their opinion as to its quality.

The animal testing program uses mainly dogs, rats, mice, and chickens, but it has also included monkeys and pigs. Two or three different species of animals are used for each test food for a 2-year period. In the AEC

program, three species are used. Each species used in a study is divided into four separate groups. One group receives the animal's normal diet. A second group receives unirradiated test food. The two remaining test groups receive test food which has been irradiated at a different dose level for each group. When rats, mice, or chickens are used, the study also includes three generations of their young during the 2-year period. When dogs are used, the tests also include one litter of their young during the 2-year testing period.

The total number of animals in each study depends upon the particular species used, the number of different species used, and the quantity of young they bear. If dogs are used in the test, the starting number is 32. For rats the starting number is 400; for mice, it is 600; and for chickens, it is 240. So if a study uses all four of these species it begins with 1272 animals, and this number becomes larger as the young are born. Throughout the testing period, each animal is continually examined to determine how it is affected by the food it eats. So far, nearly 500,000 animals have been used in the long-term testing programs of the AEC and the Army.

Samples of cooked fish preserved by radiation are tasted and compared with cooked but nonirradiated fresh fish.

Thousands of human volunteers have taken part in taste-testing of irradiated foods. These volunteers are a cross-section of the American people—professional tasters, scientists, technicians, representatives of government and industry, soldiers, sailors, and airmen. Their opinions of the foods they taste-test are important since it would be useless to develop an irradiated food if people disliked it and would not eat it. In these

studies the tasters have indicated that they find irradiated foods to be acceptable.

Research scientists have also been deeply interested in another part of the food irradiation process—the packaging materials for irradiated food. During the processing, the radiation obviously must pass through the packaging material on its way to the food inside. This raises a number of questions. Does the irradiation have any effect on the material? Does the material in any way affect the irradiation of the food itself? Is the packaging material strong enough to resist damage during storage or shipment?

To learn the answers to these and other important questions, investigators have conducted thorough tests on a wide variety of packaging materials. As a result of the facts learned in these studies, the FDA has already approved the use of more than a dozen different materials for packaging of food that is to be radiation processed. *As for the food itself, the FDA has approved irradiated wheat and wheat products and irradiated white potatoes for general public use.*

In 1963, the FDA also approved irradiated bacon for unlimited human use but, in 1968, withdrew its approval to await the results of new feeding tests.

Those who are involved in developing radiation preservation of food are encouraged by the results they are obtaining in their continuing test programs. They expect these results to lead to the approval of additional foods for general public use.

Fish fillets are wrapped and sealed before radiation exposure at the Massachusetts Institute of Technology.

Nonirradiated (left) and radurized strawberries.

The Future

It is believed that within the next 10 years a number of irradiated foods will appear on supermarket shelves. This does not mean that foods preserved in other ways will be crowded off the shelves. *There will always be a need for canning, freezing, and other familiar methods because they will continue to be the best ways to process many foods. But irradiation will become the preferred way to preserve a number of foods because it will offer advantages that other methods do not have.*

Radappertization (radiation sterilization) holds great promise for special purposes, such as supplying the needs of military personnel. However, it seems likely that the food processing companies will devote their first

efforts to producing radurized (radiation pasteurized) foods for general public use. Radurization is especially helpful for foods that spoil easily and are shipped in large quantities on a regular basis.

Wheat is a good example of food of this kind. Before wheat is shipped overseas, it is usually fumigated to kill insects. However, fumigation does not affect the insect eggs in the wheat. While the grain is being transported in the cool hold of a ship, the eggs remain at rest. When the wheat is unloaded in a hot-weather country, the eggs grow into insects that multiply rapidly. These insects sometimes destroy as much as one-quarter of the shipment.

Radiation disinfestation before leaving the home port will prevent this tremendous loss by eliminating the insects and their eggs without reducing the nutritional value of the wheat. For countries that have serious food shortages, preventing such losses may be a life-or-death matter.

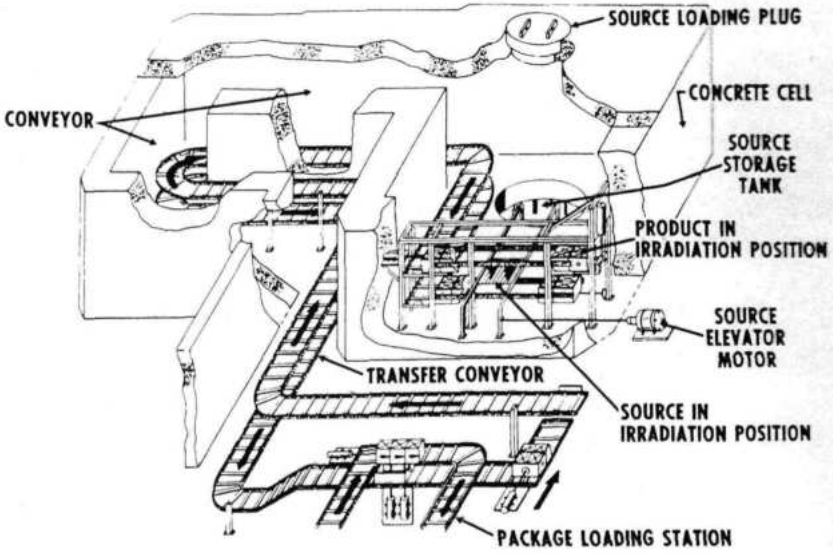
Other foods that are especially suitable for radiation pasteurization are marine products. Irradiation can make fish last one or two weeks longer without affecting flavor or fresh appearance. This is enough time to make it possible to ship unfrozen ocean fish far inland and in this way open up new markets for the coastal fishing industry. It would bring to those living far from the ocean a fresh food which had previously been scarce and expensive. Irradiation can be performed on central "factory ships" sailing with the fishing fleet, or in irradiators on shore in fishing ports.

Radiation pasteurization is also attractive for processing many fruits. Fresh strawberries usually last no more than 10 days after they are picked. However, if they are irradiated when they are picked, the strawberries will last about 15 days. Even more important, strawberry growers usually lose berries because of spoilage during shipment and irradiation can cut this loss. Many other fruits show similar reduction of spoilage and an increase of shelf life* after irradiation without noticeable change in flavor.

Irradiation seems particularly well suited to the papaya, a high-priced, melon-like fruit. Papayas are an important crop in Hawaii, which ships much of its harvest to the mainland United States. An insect known as

Grove of papaya trees.

*This is a period of time during which a material may be stored and remain suitable for use.



Hawaii Development Irradiator

the Hawaiian fruit fly attacks papayas and causes spoilage.

At present, only papayas that have been chemically fumigated to get rid of fruit flies can be sent to the mainland. However, the chemicals used for fumigation are becoming less and less effective in getting rid of fruit flies. A higher dose of these chemicals could do a better job. But higher doses cannot be used until there are additional 2-year feeding tests to show that the higher doses cannot harm those who eat the papayas.

Radiation disinfestation of the papayas seems to be the best answer to the problem. Research work done by the AEC, the Hawaii State Department of Agriculture, the University of Hawaii, and the Plant Quarantine Division of the Department of Agriculture has

shown that irradiation disinfests the papaya effectively. It is also faster than fumigation. By irradiating instead of fumigating, the time between harvest and shipment can be reduced by about 24 hours; spoilage can be reduced; and the shelf life of the papayas can be increased.

Actually, many irradiated foods have already been placed on sale in other countries. Potatoes and onions, irradiated to delay sprouting, have been offered for sale to the general public in Israel. The products were clearly labeled as being radiation processed. The purchasers rated the potatoes and onions highly as to flavor. They were especially pleased that the vegetables did not sprout during storage in their pantries, as unirradiated potatoes and onions had in the past.

In the Soviet Union, it is reported that the public health authorities there have approved unlimited public use of a number of irradiated foods. These foods include certain grains, dried fruits, dry food concentrates, and fresh fruits and vegetables irradiated at specified doses.

The most recent clearance obtained was in The Netherlands. The public health authority there cleared for unlimited human consumption irradiated fresh mushrooms. The irradiation can be by gamma ray or electrons up to 250 kilorads.* This is the first new clearance in the Free World since potatoes. The whole-

*A rad (*r*adiation *a*bsorbed *d*ose) is a unit of measure of absorbed dose of ionizing radiation. A kilorad is 1000 rads.

someness program was conducted on rats and dogs that were fed both gamma- and electron-irradiated mushrooms.

In a sense, it is really not so unusual to think of eating irradiated foods as a part of a normal diet. As a matter of fact, people have been eating irradiated foods for centuries. After all, grilling meat over a fire is simply a way of using the infra-red rays emitted by the fire. This makes the popular backyard barbecue a kind of "hamburger irradiator".

Of course, from "irradiation" in a backyard barbecue to the ionizing radiation of a nuclear irradiator is a truly giant step. Because it is such a big step, the researchers are leaving nothing to chance. *At present, in over 50 nations around the world, scientific and technical staffs are hard at work developing radiation preservation of foods.* This means that a great number of nations containing more than half of all the people on earth are trying to speed the day when irradiated foods will be a routine part of man's diet.

Motion Pictures

Available for loan without charge from the AEC Headquarters Film Library, Division of Public Information, U. S. Atomic Energy Commission, Washington, D. C. 20545, and from other AEC film libraries.

Farm Fresh to You, 13½ minutes, color, 1966. Produced for the AEC's Division of Isotopes Development by the Army Pictorial Center. Radiation pasteurization of fresh fruits and vegetables is illustrated with live action and animation.

The Fresher the Better, 13½ minutes, color, 1966. Produced for the AEC's Division of Isotopes Development by the Army Pictorial Center. Preservation of seafood with irradiation is described. Explanation of the process is achieved through animation and sequences of actual research. The Marine Products Development Irradiator is shown in use.

Photo Credits

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Author's photo courtesy Harris & Ewing

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1, 4, 7, & 8	USDA
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15	USDA
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21	Top, USANL; bottom, BNL
29 & 30	BNL
31	Top, left, USANL; top, right, BNL; bottom, USANL
32	U. S. Army
34 & 35	BNL
37 & 42	USDA

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