Interview: Dr. Eugen Wierbicki

Food irradiation expert tells how breakthrough was achieved

Dr. Eugen Wierbicki is one of the pioneers in food irradiation. A meat scientist, he worked at the U.S. Army program at the Natick, Massachusetts laboratory from 1962 until it was disbanded in 1980. Since then, he has continued his work at the U.S. Department of Agriculture, Eastern Regional Research Center in Philadelphia as research leader for the Food Irradiation Research Group in the Food Safety Laboratory.

He was interviewed by Marjorie Mazel Hecht, managing editor of Fusion *magazine, in February 1984.*

Hecht: You have been in the food irradiation research area for 22 years, starting with the U.S. Army program in Natick, Massachusetts. Were you there when the Army program was established?

Wierbicki: No, the Army program was officially established in 1953 at the Quartermaster Food and Container Institute in Chicago. This institute conducted high-dose and low-dose irradiation research until 1962. In that year, the Army set up special food-irradiation facilities on a pilot-project basis, using cobalt-60 and an electron beam accelerator. They asked me to join this outfit, particularly to take care of the product development division, manufacturing processes, packaging, and food acceptance, utilizing my chemistry and industrial knowledge to get better quality irradiated foods. I joined the Natick staff in August 1962.

Hecht: What was the aim of the Natick laboratory, and what was the full scope of its work?

Wierbicki: The U.S. Army Natick Laboratories provided research and development mainly on food and clothing—in reality, support to military personnel on everything except guns. The Quartermaster program was moved to Natick because they had unique laboratories, excellent microbiology and chemistry laboratories, which we needed to establish radiation sterilizing doses and to establish the effects of the radiation in killing micro-organisms and identification of radiolysis products, if any. They also had an excellent packaging group—packaging is essential in high-dose radiation of foods. In addition, Natick also had a consumer-testing group, about 800 volunteers recruited from the employees to test foods in the program.

While I was there, the number of people at the lab ranged from 1,100 to 1,200 civilians and about 100 to 300 military. About 40 people were employed directly in the food irradiation work, and, in addition, we used 16 people in the chemistry, microbiology, and nutrition labs at Natick.

Hecht: What were your accomplishments—how would you summarize your work between 1962 and 1980?

Wierbicki: In 1962, there was a big problem in regard to the acceptability of radiation-sterilized meat, particularly in terms of its eating quality—mainly flavor. Some foods, like cured meat, bacon, and ham resulted in a relatively acceptable product, but beef, in particular, had an unpleasant odor, and beef is a very big item.

My specialty is meat. I went from a doctoral program to the meat industry, and became a manager of a meat research company. I also had a good background in chemistry. Therefore, I really took a very thorough approach to developing high-quality irradiated foods, starting with control of the raw material: I used only federally inspected meat and I knew its age.

Then I worked on the preparation of the meat for irradiation; for example, determining what was the best method of blanching the meat to inactivate enzymes. I investigated the electric oven to do this, dry cooking, water cooking, and other conditions. Then I worked on packaging. In packaging the product, we had to take into account the degree of vacuum during the sealing of the container. If you leave a little oxygen, it will be converted to ozone by irradiation, and ozone causes rancidity or oxidation of lipids.

Next came the question of indirect additives to irradiated foods; for example, from the enamel on the can. Also we worked on developing special flexible packaging, a plastic aluminum-foil laminated system so that we could use this packaging for individual ready-to-eat precooked meals or irradiation of packaged foods by electrons. We had to find out what irradiation does to the packaging and the foods, what changes irradiation causes in the composition of food, what food components are produced and their amounts, whether these components were desirable or undesirable, and how we could eliminate or reduce them drastically.

Our achievement was really a great one: We developed a technology for producing high-quality radiation-sterilized meats, ranging from cured meat like ham, corned beef, and bacon to uncured meat like beef steak, roast beef, pork roast, chicken, etc.

Hecht: Did you solve the problem of the beef flavor?
Wierbicki: Yes. There were real breakthroughs in our work. One, of course, was vacuum packaging—eliminating the oxygen by the highest possible vacuum before the can collapses and then removing the residual oxygen or air using nitrogen gas before sealing, which is now common practice. Also, we developed six plastics approved as food containers for irradiated foods. Because of our work, the Food and Drug Administration has no packaging problem with packaging irradiated foods.

Hecht: Has the FDA already approved the type of packaging you developed?
Wierbicki: Right. Now, in regard to the flavor, our work was very important. First of all, the previous work in food irradiation in Chicago was conducted using commercial irradiators of small capacity, no temperature control during irradiation, and a low dose rate; sometimes foods were irradiated for days, and the high-temperature would scald the food or make the food rancid. At the Natick lab, we could irradiate using an electron beam in a matter of a few seconds, and we could process a product in only 20 minutes.

With the cobalt-60 source at Natick, about 3 million curies, we could irradiate with a sterilizing dose of 3.0 to 5.0 megarads in about 45 to 70 minutes. We could also control the time after closing the cans and irradiation, which is important. However, the main breakthrough in regard to flavor and quality of irradiation-sterilized products was irradiation in the frozen state.

The chemistry data accumulated at that time showed that the production of radiolytic products, particularly in fat of meats, is intensified by the presence of oxygen. This is eliminated by vacuum-closing of the cans or flexible packaging. The other problematic factor was the radiolysis products of water—hydroxyl radicals, hydrogen radicals, electrons, and hydrogen peroxides. They were short-lived, but they attacked proteins, lipids, and sulphur containing amino acids like methionine, creating sulphur and rancid odors in the irradiated foods.

However, if we froze the freshly prepared meat (for example, frozen steaks) after vacuum packaging and then irradiated it, there were many fewer free radicals produced. In addition, these free radicals stay immobilized in the ice crystals of frozen water. Then, when food is defrosted, they react with each other to form water back again. Thus, we eliminated the problem of odor; for instance, such foods as cured meats taste the same as non-irradiated cured meats. With beef, we were able to get a much better quality than thermally preserved items have; the texture, odor, and flavor are at acceptable levels. This was a big breakthrough.

Hecht: So the process you developed for sterilization is to package the beef, quick-freeze it, then irradiate it. What is its shelf life then?
Wierbicki: After irradiation at a sterilizing dose, the meat can be kept for years without refrigeration.

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Hecht: For years?
Wierbicki: Oh yes. The stability just depends on the durabilty of the packaging materials—how long it is before they corrode or break. We have some items that are 10 years old.

Hecht: Were these tested for taste and so forth.
Wierbicki: Yes, by military consumers and consumer volunteers at the Natick laboratory. Now, of course, with irradiation-sterilized foods, the main prerequisite is microbiological safety, so that there are no bacteria remaining in foods that can cause problems when the food is stored at room temperature. The microbiologists established that anaerobic spores of *clostridium botulinum,* which cause botulism poisoning if they survive, are the most radiation-resistant. Therefore, we had to study the effect of irradiation on these spores.

We found that irradiating in a frozen state requires only a slightly higher dose of irradiation to get rid of the botulism spores than irradiating in the nonfrozen state. This is because the spores of *c. botulinum* are relatively dry in themselves and therefore are not affected indirectly by the free radicals of water, but by the direct effect of absorbing the ionizing energy. Of course, this means that by irradiating foods in a frozen state, there is a great improvement in quality, and this study was really a big breakthrough.

Hecht: When did this happen?
Wierbicki: I was already thinking about this problem when I was working under a research contract with the Army in 1960. At that time, I was reading about the radiolysis of water, which was one of the first experiments done by the Argonne Laboratory. I thought that if we could immobilize these radiolytic products in water crystals we might overcome the problem with beef. So I took beef steak, froze it, and irradiated it frozen. I was surprised at how terrific an improvement in quality it was, both in smell and taste. Then, in 1963, others at Swift and Company working under a research contract with me made the same observations, as well as researchers in England. So really, this improvement was slowly coming from several different sources. I just applied the best processing parameters to get good products.

Hecht: When you came into the Natick program, then, you had already been working on some of the problems of food irradiation?
Wierbicki: Yes. Of course, by then, there was much published on food irradiation. It was not entirely new to me.

The next step in our research was to have the determination of quality—which we obtained by testing the product with consumers for odor, flavor, color, texture, and general acceptance. We did this using the food acceptance group at Natick and the military consumer testing group at Fort Lee, Virginia, where they used different irradiated foods as components of regular meals in mess halls, having the participants rate the food on a 9-point scale. On this scale, a rating of 9 means "like extremely" while a rating of 1 is "dislike extremely"; 5 is borderline, "neither like nor dislike." Foods rated 5 or above were considered in the acceptable range.

Hecht: How did your irradiated food rate?
Wierbicki: On meats and poultry that were served without any condiments—steaks and roasts, for example—we saw a range of 6 to 8. With casseroles, it ranged from 5 to 6. So in any case, there was either no difference in acceptance of irradiated and nonirradiated food or there was just a ½-point to at most a 1-point difference.

Next, we tested for wholesomeness, the nutritional quality. It is interesting here that the irradiation processing of the frozen meat decreased drastically the destruction of vitamins. For example when we irradiated meat at $-40°$, we got only a 30% destruction of thiamine, as opposed to 80% or 90% destruction for thermally processed food. Now, if irradiation-sterilized foods were your *only* food source, you would need a vitamin supplement for thiamine; but, of course, a diet of only irradiated food will never be the case.

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Wholesomeness was a big problem. Any testing had to show that irradiation did not create any decomposition products that might be harmful. The usual testing process with animals is to take a normal dose, multiply it by 100 times or more, and study what happens with animals. But you can't do that with food, because animals physiologically can't take more than 35% of meat in their diet. You can poison them by nitrogen and ammonia from metabolized proteins.

Hecht: How did you set up your study with animals?
Wierbicki: We had to study what happened with animals when they were fed a maximum of 35% of their diet as irradiated meat. We used mice, dogs, and rats in the study. In addition, when we started in 1976, there were other basic methodologies developed to test for wholesomeness; for example, the effect of a 25% irradiated meat diet on the embryos, mutagenicity, etc. This became a tremendous project.

First we started with beef in 1971. This went well, and in 1975, the secretary of the Army gave us the green light to go with other foods: pork, ham, and chicken. We also used contractors in private industry for this work, to prepare for the industrial development of the technology. The contractor for beef, pork, and ham was Industrial Biotest Labs in Northbrook, Illinois. Unfortunately, they became disqualified in 1977, and then the study continued with only chicken remaining. The chicken study was contracted to Raltech Scientific Services, a division of the Ralston Purina Company in St. Louis, Missouri. They did an excellent job. They completed all studies in 1982, and a final report was submitted to us in 1983.

Hecht: When was the final report submitted to the Food and Drug Administration?
Wierbicki: It still has not been submitted. The report has been evaluated by an independent contractor, Tracor Fitco,

Incorporated in Rockville, Maryland, which completed its evaluation in June 1983 and submitted a recommendation to us. At this point, USDA is still evaluating their recommendations.

Hecht: Are these animal tests the only ones you can use to test for wholesomeness and long-term effects?
Wierbicki: After the abortion of the beef, pork, and ham studies, we were rather desperate, thinking that high-dose radiation would probably collapse. However, by 1977, the idea developed in the minds of the scientists that testing of foods with animals is not the only approach to wholesomeness. Another approach is through chemical studies.

Therefore, we developed extensive studies at the Natick labs, using computers to determine qualitatively and quantitatively the kinds and amounts of radiolytic products that might be produced by the irradiation. Now, based on this, we developed the so-called chemi-clearance principle—FDA calls this *generic clearance*. This means that if we have one food approved, like chicken, with completed wholesomeness studies with animals and supplemented by chemical data, then we can use these data for the clearances of beef, pork, ham, and bacon, based on the chemical data only if they are identical with the chemistry data for chicken—and they are.

Therefore, I believe that after some short-duration animal studies that might be required by FDA, it may be possible to clear other foods by extrapolation. With the present technique of gas chromatography and computers, we can really determine what components are present and we can predict to a high correlation—a prediction value around 0.99. A report on chemistry studies on irradiated chicken, beef, pork, ham, and bacon by Dr. Charles Merritt from Natick is available for for use by industry.

Hecht: Has the FDA accepted this chemi-clearance principle?
Wierbicki: The FDA speaks of the chemi-clearance principle in their July 1980 report, "Recommendations for Evaluating the Safety of Irradiated Foods," calling it "generic clearance."

Hecht: What are you working on now that this meat study is completed?
Wierbicki: My main activity is now low-dose radiation to extend the shelf life of fresh meats and poultry and to destroy spoilage-causing microorganisms and certain pathogens. Certain pathogens are sensitive to radiation: *Salmonella* in poultry and *Yersinia* or *Campylobacter* in meats and poultry. *Campylobacter* is a new pathogen, recently discovered, that causes more food-borne discomforts in humans than *Salmonella*.

In Canada, they are undertaking a thorough testing of low-dose radiation of poultry and fresh fish to test for *Campylobacter* and *Salmonella* as well as shelf-life extension. Canada accepted the November 1980 recommendation of the joint committee of the Food and Agriculture Organization, International Atomic Energy Agency, and World Health Organization regarding the wholesomeness of irradiated foods, which states that all foods irradiated up to 1,000 kilorads (or 1 megarad) are wholesome and therefore do not require any more toxicological testing.

In this country, the FDA is more conservative about doses, so they intend to permit only one-tenth this dose, 100 kilorads. Of course, the FDA permitted the irradiation of spices in July 1983 by up to 1 megarad.

However, in the 100-kilorad dose range that is expected to be approved by the FDA, all kinds of insects can be destroyed, including insect eggs, which is a big opportunity for the grain industry. Chemical fumigation, you know, cannot destroy the insect eggs; these can hatch and turn up as worms in the flour you buy. Grain can be irradiated when it is loaded on boats, or on delivery, for instance. Fresh fruits can be disinfested by radiation, instead of using chemical fumigants.

Of course, radiation has to be very carefully used. Radiation is energy. If you give too much, you will have side effects, such as softening of skin in fruits and other cytotoxic effects. But studies show that if you irradiate at between 20 and 60 kilorads and if you use properly matured fruits and avoid unnecessary bruises by radiating in crates, it can be done without any problems. It is estimated that you do not need more than 20 kilorads for many fruits, at a cost of about 6¢ per shipping carton, which is in the same cost range as fumigation. And this is only the beginning. With the development of experience, I'm sure the cost will be brought down.

Hecht: The new FDA regulation apparently applies only to grains, fruits, and vegetables. What is stopping the FDA from approving low-dose irradiation for meats and fish?
Wierbicki: Here it is a question of microbiological sensitivity in low-dose irradiation. You see, the low dose kills only some bacteria, not others. In the low-dose irradiation of fresh meat, poultry, and fish, there is a delicate balance between how high a dose we can use before off-odors and off-flavors develop.

By all available information, this is somewhere between 200 and 500 kilorads, depending on the food. Of course, one could shift 100 kilorads upwards if one applied proper technological parameters like good temperature, refrigerating properly while irradiating, and maybe vacuum packaging. This is the subject of the technology and research I am conducting.

Now, by applying, for example, the low dose of 200 to 300 kilorads, what will happen? You eliminate completely spoilage micro-organisms of a sacrophilic nature, *Pseudomonas* that cause a sliminess and putrid odor in foods, but you decrease *Salmonella* by only about 4 to 6 logarithmic cycles; some *Salmonella* survives. The question is, could some *Salmonella* recover from the energy of radiation absorbed and develop without the food appearing spoiled because the spoilage bacteria have been destroyed? If this were so, the consumer might therefore be in danger.

Here, microbiological safety is of primary importance. In the case of fish, I believe this problem has been solved. The studies conducted under the International Project on Food Irradiation recommend that the maximum dose of 220 kilorads for fish should be used. With 220 kilorads, some spoilage bacteria remain that make the fish smelly and spoiled before the botulism type E, which is present particularly in fish, can grow and develop toxins.

We found that when 300 kilorads were used with chickens, some bacteria remain, so that in three to four weeks, irradiated chickens develop spoilage (without radiation, spoilage develops in seven days). But this spoilage occurs before *Clostridium botulinum* type E, which can grow above 3° Celsius, can develop toxins. More of this kind of research has to be conducted, extending the dose to 500 kilorads, before we can safely recommend or petition FDA for low-dose irradiation of fresh meat and poultry. However, the microbiology experts of the Codex Alimentarius Commission consider that the doses up to 1,000 kilorads cause no microbiological safety problems as long as the fresh irradiated meats, poultry, and fish are stored at ice temperature (0° to 5° Celsius).

I want to stress that this problem does not exist in frozen foods, those which are kept frozen until consumption, going from frozen to cooked, and which are generally highly contaminated with *Salmonella*—like frog legs, shrimp, and frozen beef. You know, we have a problem of *Salmonella* contamination with defrosted beef, particularly imported ones. Here radiation can be used, and there will be no problem with flavor and no problem with some bacteria remaining and developing spoilage and toxins, because these foods are distributed frozen.

This is one thing that I really hope the FDA will regulate without any further petition; namely, irradiation of frozen foods for *Salmonella* control—frozen beef, frozen frog legs, frozen shrimp, and so on. To destroy *Salmonella* in frozen foods requires only 500 kilorads. With this dose in the frozen state, there are no effects on flavor at all, no effects on quality.

Also, as a meat scientist, I see big opportunities for controlling micro-organisms in low-salt meats. Low salt today is important, and if you reduce salt you increase bacteria spoilage; you can counteract this with low-dose irradiation. With processed meats, you can use higher doses than for fresh meats. We can go to about 300 to 500 kilorads before you can detect off-odor. Therefore, here is a big opportunity. I ran a few preliminary tests, but I do not yet have the final results. However, as a meat scientist I believe it would work.

Of course, we should not forget irradiation of pork for trichina control; we need only 30 kilorads for this purpose.

Hecht: From what you have said, it seems as though there is no scientific reason for the FDA to exclude meat, poultry, and fish from its proposed regulations for food irradiation.

Wierbicki: I have just received the *Federal Register* for Feb. 14, 1984, with the new proposed rule by the FDA for "Irradiation in the Production, Processing, and Handling of Food"—for which we all have been waiting since March 1981. I am surprised that FDA apparently limits the 100-kilorad applications to fruits, vegetables, and grains only. There is no scientific justification not to use this low dose on fresh meats, poultry, and fish.

Whereas there might be some concern for the microbiological safety of meats and poultry irradiated with a dose higher than 100 kilorad (200 to 500 kilorad), there is *no* microbiological safety problem for 100-kilorad-irradiated fresh meats and poultry. This low dose will leave a sufficient number of lactic acid bacteria, yeasts, and molds that spoil the meats during extended storage before pathogenic bacteria may develop toxins.

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The 100-kilorad dose can do much good for fresh meats, poultry, and fish: a) It extends the shelf-life under refrigeration by 4 to 8 days; b) it eradicates *Campylobacter*, *Yersinia*, and other pathogenic bacteria; c) it reduces the *Salmonella* by two log cycles (that is, by 99.9%); d) it destroys trichina in pork; e) it allows elimination of chlorine from poultry water chilling tanks, the wholesomeness of which is questionable; and f) it has no significant or measurable effect on nutritional quality (vitamins) or radiolysis products in the irradiated items. I hope that FDA clears the 100-kilorad dose as safe across-the-board in their final regulations.

Hecht: I'd like to go back to some history. Why did the Army disband the Natick laboratory, just as it seemed as though you had made major breakthroughs?

Wierbicki: The Department of the Army, of course, was very much interested in high-dose irradiated food—shelf-stable meat, poultry, fish that can be stored for a long time without refrigeration and be of good quality. The Army program developed the packaging, developed the technology, and solved the problem of wholesomeness. It came to the point where the program was ready for consumer education, and the military thought, "This is not our job," and I think they were right.

The program was initially the U.S. Army Food Irradiation Program. In 1975, it was changed to the National Food Irradiation Program, and then it became the International Food Irradiation Program, with visiting scientists from all over the world coming to the Natick lab for education. There were no secrets involved. We published everything we did.

But in 1978, the Army suggested that some other agency should take over. In June 1980, the program was transferred to the U.S. Department of Agriculture, and I was the only one of 56 people who were at the Natick lab who transferred to continue the work. My children were grown up, and I was very dedicated; I had worked over 20 years, and I wanted to see it through. Nobody is indispensable, but I thought that if no one from Natick moved to USDA, food-irradiation research progress in the United States would die, and it would be a shame.

Hecht: It really surprised me that they would break up such a successful laboratory and not move the USDA to Natick. When you have
years it seems very destructive to break them up.
Wierbicki: Oh, yes. . . .

Hecht: When did you come to this country?
Wierbicki: I was born in Byelorussia, White Russia, in the western part. It was eastern Poland until 1939. In 1939, I was "liberated from the Polish yoke," as the Communists called it. As a result of this liberation, my father was sent to Siberia and our property destroyed.

In 1941, in June, Nazi Germany liberated me from the Russian yoke. As a result of this liberation, I was arrested in September 1943 because I was suspected of dealing with partisans. I moved to Germany as a forced laborer, working in Potsdam near Berlin. Then, in February 1945, the Russians came too close for my liking. Even though I was sent to Germany by force, I didn't want to go back to the Soviet Union, where my mother was murdered and our property confiscated. So, I moved farther west to Austria and then to Bavaria. There I was liberated for the third time by French Moroccan troops.

So now I say to my children, I'm a very free man because I was liberated three times. Then in 1946, in Munich, an American occupation zone of Germany, I went to a university for refugee students, UNRA University, and later transferred to the Technical University of Munich. There I got a degree in agriculture, then a doctor's degree in agricultural chemistry. I married there, and came to the United States in 1949. Because I didn't know the language, I couldn't find a job. I worked in a factory first, then Ohio State offered me a fellowship. The university acknowledged my doctor's degree from Germany, and I got another doctor's degree in agricultural biochemistry in 1953. Then I worked for the meat industry for seven years before moving to the Natick project in 1962.