Interview: Dr. Martin Welt

Feeding the Third World with astronauts' food

The following are excerpts from an interview with Dr. Martin Welt, conducted Aug. 2, 1986 by Fusion *magazine managing editor Marjorie Mazel Hecht. At the time of the interview, Dr. Welt was affiliated with Radiation Technology, Inc.*

Hecht: Your company is one of the few in the world that is exporting food irradiation plants. What is the total cost for building a large-scale plant in West Africa, for example?
Welt: To build a very versatile pallet irradiator, like Radiation Technology's Model RT 4101, would take an investment of probably about $4.5 million, depending on the amount of cobalt-60 put into the facility. Most of the initial work in a plant in West Africa, for example, would be for relatively low-dose application, requiring a relatively small amount of cobalt-60; you could probably have the entire turnkey operation, including money set aside for a warehouse, land acquisition, and site preparation, for approximately $4.5 million. If the same site were built in the United States, it might be less, but shipping costs and other contingencies might move the cost up to $5 million.

Hecht: How long would it take to build the plant?
Welt: Once a site has been chosen and all the permits are obtained, you could figure approximately 12 to 14 months to get it into operation. That is a little bit longer than in the United States.

Hopefully, we would be dealing with a nation that had a vested interest in getting the permits and everything else done. In some countries, we have to get special permits for bringing in even steel, since they want as much as they can to be indigenous. If the government gets behind the project, then they will give you exemptions, so you can bring in whatever is needed to get the project done.

We have done several firm proposals for West Africa, but building the first plant will tell a lot. One of the advantages is that during the last four or five months of construction we would bring over four or five people who would be trained to supervise the operations and we would train them in our plant in Salem, New Jersey, so that by the time the plant was built in West Africa, they would be able to go back and operate it.

Their plant would be a mirror image of what we have in Salem, the computer, the entire system. This is a big advantage, because very often when you build a plant, it is basically doing nothing for four or five months while you are training your staff. This way they can get into operation immediately.

Hecht: What will the West African countries be processing?
Welt: We are doing a lot of exploratory work now on some of their indigenous crops, and we had excellent results. For example, on the yams, you could see how the tubers were able to be maintained in very good condition with a good starch to sugar ratio. The unirradiated yams started sprouting like the potato food crops do, and the product deteriorates as the starches are converted to sugar and the value of the product is lost. . . .

The facility I designed, and which Radiation Technology now operates, is the only irradiation facility in the world capable of irradiating pallet loads of food at the rate of up to 2,500 pounds per minute. Yet, it will permit the country, or user, to do any type of irradiation—sterilize food at very high doses or irradiate yams at very, very low levels—because the computer-controlled system allows the pallet to be positioned at some distance from the source so that you can develop either low dose rate or high dose rate processing and be able to get through the irradiation chamber with the required dose. . . .

This is a big advantage, because the other systems in the world today, by and large, only allow the product to go in one path by the source, at one distance, which means that the only way you can control the dose to the product is by adding or removing cobalt to the source or the speed of the product by the source.
Hecht: Could the irradiation plant also be used to provide fresh water?
Welt: Basically, if you are going to provide people with food, you also have to contemplate maintaining their health. And one of their biggest problems is dysentery. The irradiation processing of sanitary sewage is one of the things, in my view, that could be solved without a huge expenditure of money—just education and rather simple devices. Irradiation facilities can also serve to purify filtered water by irradiating it while the plant is doing something else, because so much radiation simply bypasses the target. You can intercept the leakage radiation with a pipe with water flowing at the

proper rates, and you can purify the water supply without using chlorination. . . .

We have taken the 4101 design and modified it for this purpose. You can simply put helical pipes, carrying water at a relatively low flow rate, going either above or below the conveyors that carry the pallets of food being processed. The water has to circulate until any unit volume of water gets a sufficient dose to give reasonable assurance that the water is going to be free of contamination.

What's happening now in the United States, unfortunately, is that, with our bent on overregulation, we've basically destroyed the nuclear industry.

Most of the contamination is due to coliform bacteria, and fortunately these organisms are extremely sensitive to radiation. . . . With just one-tenth of a megarad of radiation, you can reduce the original bacteria population by a factor of about 10^{-10}. So it doesn't take very much radiation to knock out the coliform. . . .

Hecht: Has there been any consideration of irradiating fish in Africa? The coastal countries certainly have an enormous source of protein in fish.

Welt: We have talked to several African nations about fish and of course they are interested. We try to encourage them to locate the plants in coastal ports so that shelf-life-extended product would be provided for their own use, and also for export. However, the food-producing areas tend to be in the central parts of these West African nations, away from the coast.

Their present thinking is to take care of the grain-producing areas or the root crops by providing insect disinfestation and sprout inhibition. If that is successful, then they would build a second plant on the coast. We are trying to encourage them to confederate somewhat, so that several smaller nations could make use of the technology on a larger, more efficient scale. We've proposed using the first plant as a training station for other African nations and are hoping to have that funded.

Hecht: What about the idea of a floating irradiator that could be moved around the coast from country to country?

Welt: Of course. The Russians supposedly have a fisheries irradiator at sea on some sort of a mother-ship type of thing. The United States had one years ago, a barge-mounted type of affair, actually used by the Icelanders under contract with the U.S. Atomic Energy Commission back in the 1960s. (That mobile irradiator, by the way, ended up "lost" somewhere in California and the Israelis purchased it and shipped it to Israel. . . .)

Hecht: Could your plant design fit on a big barge?

Welt: Sure. The best results with shelf-life extension of fresh seafood occur if you can irradiate the seafood very soon after you catch it, and the way to do that is at sea.

These are all feasible things and I believe that in the future, if these countries take their resources and put them in the right place, the machines will basically be available to do that. In harvesting fresh fish, you gut it, ice it, and it goes down a conveyor line. You can design a materials handling system which would lend itself very nicely to running under either a bremsstrahlung x-ray type beam or an electron beam. . . .

The designs for ship-mounted irradiators exist; a lot of the design work goes back to the 1960s. In the Atoms for Peace days, we were thinking bigger than today, and perhaps rightly so. What's happening now in the United States, unfortunately, is that, with our bent on overregulation, we've basically destroyed the nuclear industry. . . . I can't believe that the nation that was so instrumental in getting nuclear power going and licensing our technology overseas, is now seeing foreign governments become so smart that they can do things much better than we! You know, we haven't had any new domestic reactor sales since 1978.

The food irradiation program has made some progress, but we haven't really gotten into the marketplace.

Hecht: The Food and Drug Administration (FDA) has accepted for filing in the Federal Register your petition for high-dose irradiation to sterilize food. What will this mean?

Welt: In my view, the culmination of the entire food-irradiation program is the production of the shelf-stable food item similar to the products we have been preparing for the U.S. Space Shuttle astronauts since about 1980-81. These products are whole meals that are prepackaged. We radiation-sterilized the food in such a manner that the meals could be kept at room temperature for extended periods—many years if need be—without freezing or refrigeration.

Radiation Technology worked on a petition to the Food and Drug Administration, which was submitted on Feb. 26, 1986. We were informed on July 8, that the data we had submitted had been deemed sufficient in depth and content to permit its being filed in the Federal Register as a formal petition. . . .

We feel reasonably confident that we have submitted a rather complete petition. Radiation Technology is the only company, the only group, that has succeeded in petitioning the FDA since 1964, and we've had five separate food-additive petitions that have been approved by the FDA and become regulations. I think that our petition effort helped move the entire field forward—a process that culminated in the FDA's issuance of their own regulation on April 18, 1986. This now permits the 100 kilorad irradiation of fresh fruits and vegetables in the United States, and extends the maximum dose that we could sanitize spices or herbs or spice blends from the 1 megarad or 10 kilogray level up to 30 kilogray. This essentially will now permit us to provide a commercial, sterile spice or herb product that can be used in prepared food items such as sauces, salad dressing, or what have you. By providing an essentially commercially sterile spice, we provide a much healthier product because there is no bacteria entering into the food product which could cause food poisoning.

If you were to take broccoli from harvest to the table for consumption, it would take 6,500 kilowatt hours per ton for canning, 4,500 kilowatt hours for freezing, and approximately 1,400 kilowatt hours for radiation sterilization. That's a very significant energy saving.

Now, back to the high dose issue: The United States and countries fortunate to have very rich reserves of food or agricultural potential, can have a problem of oversupply, such as we have now with our grain. Grain is not an item that necessarily has to be sterilized for long-term storage; it will store for long periods if it is kept free of insect infestation and mold. But, unfortunately, other types of products—vegetables, fruits, meat, poultry, seafoods, fish products—have a very short shelf life. They are extremely perishable, and to preserve them for long periods of time you have to either freeze the product—which takes a great deal of energy that is typically unavailable to Third World developing nations—or can the product. Canning again requires a great deal of energy. Also, the canning process uses high temperatures that essentially cook out the nutrients and change the taste and texture of the food. It is also very energy-intensive and expensive on a comparative basis.

Radiation sterilization is another, very efficient option. We have shown through our own experimentation and very successful work that we can use radiation sterilization to preserve a surplus of fresh vegetables—for example, cauliflower, broccoli, brussel sprouts, and carrots that are harvested after the farmer has been able to meet the demands of the fresh vegetable markets and that are an oversupply, which tends to depress the fresh product prices. Rather than wreaking havoc on the pricing structure and hurting the farmer himself who can hardly afford to harvest the crop at the low prices he gets for it, we have shown that we can take the surplus crop of fruit or vegetables, blanch them so that the enzymes are inactivated, vacuum pack them, and irradiate them at a high enough dose to permit long-term storage at room temperatures.

Blanching is a low-temperature heating process, also used before foods are frozen, that slows down but does not shut off the enzymatic process. That's why there is a shelf life of frozen foods of about nine months; because after that period, the enzyme breakdown—the degradation of the vegetable, fruit, or meat—tends to make the product lose a lot of nutrients, lose some of the wholesomeness in the process. Blanching is simply a low-temperature steaming or heating process well below the normal cooking temperatures, that does not cook out the nutrients. Typically it is a temperature of 65 to 70° Centigrade. To have something totally shelf stable, would require blanching it for about 2 minutes at 80° Centigrade. If you wanted something to have a six-month to a year shelf life, it might require a temperature of 65° Centigrade for perhaps 10 or 12 minutes. The time/temperature relationship determines the extent of the destruction of the enzyme activity that can break down the tissue.

Once the vegetables or fruits are blanched, they are vacuum packed. If we are talking about overseas shipment, the food would not necessarily be packaged in individual containers, which is expensive. Instead it would be put into 50-kilo plastic bags that would then be vacuum sealed. These bags could then be put into drums, and then the filled drums would be irradiated with doses high enough to assure a sterilization level, so that the probability of finding one viable clostridium botulinum organism would be 10^{-12}. This is the same safety margin normally used in canned foods.

This irradiation processing gives you a much better taste because the food is not cooked at high heat. Not only that, but the cost is very, very much lower than the cost of canning or freezing. It is difficult to say exactly what the cost is, but I've used some numbers that tend to give a reasonable approximation. For example, if you were to take broccoli from harvest to the table for consumption, it would take 6,500 kilowatt hours per ton for canning, 4,500 kilowatt hours for freezing, and approximately 1,400 kilowatt hours for radiation sterilization. That's a very significant energy saving.

If every other cost is the same—the packaging cost, the food cost, the transportation cost—then just in terms of energy alone there will be a very significant savings in cost to the recipient nation or the consumer. I proposed just such a methodology to the secretary of agriculture. . . . For example, you could take surplus strawberries or raspberries and preserve them with low cost, and then use them for bakery products or sherbets or jams or what have you, months after their harvest season. We've done that also.

Hecht: This is the same method that's used to produce the food that the astronauts eat in space?

Welt: That is correct. For example, we would take a beef steak and cook it just the way the astronauts order it, rare, medium, or well-done. Then the steak is individually placed in a laminated, aluminum, polyester nylon, or polyprophylene trilaminate pouch, which is vacuum sealed. That pouch is then radiation-sterilized, making the product shelf stable. We guarantee the space agency that the astronaut food has a shelf life of at least eight years, but there is really no reason to believe that in eight years and a month or nine years or ten years the food is going to be bad. If you can eliminate the enzyme action, which we definitely do, and irradiate the food to eliminate all microbial contamination, and use packaging that assures elimination of oxygen permeation, then you have a shelf-stable food; there is nothing else that is going to break down the food.

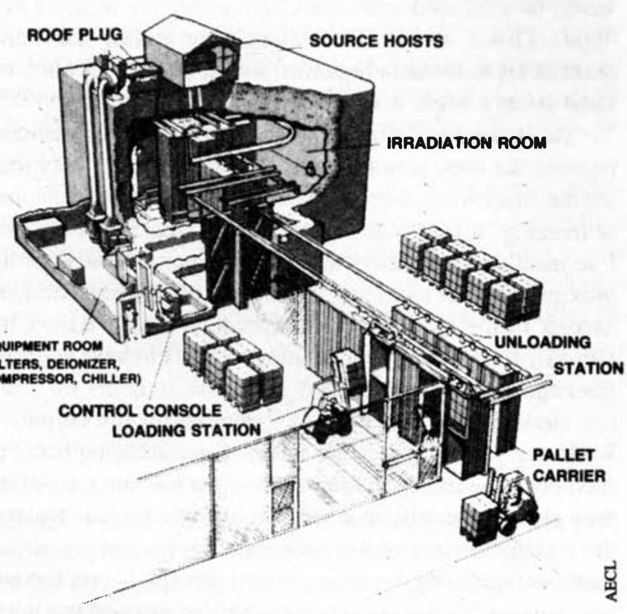
Hecht: It seems to me that one of the advantages is that you bag the food first and then irradiate it, so you are ensuring that nothing will contaminate it after it is processed.

Welt: It is total sterilization. Years ago, the FDA had a problem with this. They felt that if such a technology became

Food irradiation: how it works

Food processed with gamma irradiation is perfectly safe, tastes good, and is as wholesome as it is when fresh. Irradiation processing can eliminate insect infestation, retard spoilage, prolong shelf life, kill trichina and salmonella in pork and chicken, ensure purity, and permit the shipping and storage of meats without refrigeration.

Cobalt-60 is the most frequent source for the ionizing radiation (or ionizing energy). The very short wavelength gamma rays from the decaying radionuclide penetrate inside solid particles and kill microorganisms by breaking down the cell walls or destroying the metabolic pathways of the organism so that the cell dies. At higher doses, all microorganisms are killed, sterilizing the processed food.



There is no radioactivity induced in the processed food. The chemical reaction caused by the gamma rays does not involve the atomic nuclei of the food, and therefore, the atomic structure of the molecules is not changed. Some natural radiation, called background radiation, is present in all foods, but irradiation processing does not add to this.

Contrary to the cries of the anti-nuclear environmentalists, the gamma rays do not change the chemical structure of the food, or produce unique radiolytic products that might prove harmful. More than 30 years of testing have determined that 90% of the radiolytic products produced in radiation processing are the same as those in non-irradiated food, while the remaining 10% are chemically similar to natural food components and constitute only 3 parts per million of the processed food.

As the FDA put it, the difference between irradiated and non-irradiated foods is "so small as to make the foods indistinguishable in respect to safety."

A typical radiation facility consists of the radiation source with its shielding (see illustration), an automatic conveyor system that transports the produce to and from the source, various control systems to manage the processing, and storage facilities.

In the typical facility shown here, the cobalt-60 source is embedded in thin rods, which are submerged in a well of water that serves as a shield to protect the personnel from the radiation when the source is not in use. The dose of radiation received depends on the time of exposure and the product's distance from the source. The area housing the gamma irradiation source is shielded with 6 to 8 feet of concrete.

commonplace, that the food industry would essentially be sterilizing filth, as they put it. I think they have come around over the years, and they have seen that by and large industry is not really out to package filth. The industry, in fact, tends to use very good manufacturing practice procedures. . . . The old saying is that if you put garbage in you get garbage out. Even though we sterilize the product and it is totally sterile, if you have dirt, insect parts, or whatnot in your product, these will all be sterile when it comes time to eat it, but it will still be a filthy product.

Hecht: One of the problems now in the food industry seems to be that they are not inspecting food producing plants the way they used to because of budget cuts, and so there is an increase in gastroenteric outbreaks of various sorts—from listeria in milk products to salmonella in meats. I would much rather eat irradiated food where you would be assured that there would not be that bacteria.

Welt: I agree 100% and I think so do most of the scientific community that has any knowledge or experience with irradiated food.

On the listeria question, the FDA issued a report in which it indicated that 29% of the listeriosis cases are fatal. The listeria organism is a very insidious organism. It gets into the casein in the milk, which protects it from the heat used in the pasteurization process, but not from the irradiation, which is at a high enough dosage to kill the bacteria.

And even going up a little bit higher with the dosage that we use would still not affect the quality of the product. A lot of people ask me about the irradiation of milk. One of the old wives' tales is that milk and dairy products are not good candidates for irradiation. Now that is true and false. It is true because when most people do their irradiation work, they tend to go in at a somewhat higher dosage based on a comparison with the work they have done on meat and poultry or fruit and vegetables. Therefore, you can get an off taste because of the high butterfat content and the radiation oxidation process. We have found that the dosages required to render the milk totally safe from listeria is extremely low, and at these dosages there is no off taste whatsoever.

I remind a lot of people that the first doctoral thesis done in the United States on the subject of food irradiation was done at Columbia University in 1950 . . . radiation sterilization of whole milk with 2 MeV x-ray. This dissertation reported good organoleptic results; they had no problems with what they did back in 1950.

Hecht: That is so amazing. After 35 years of research, the pessimists are still complaining that food irradiation won't work or is dangerous.

Welt: It is really unfortunate because the United States could really do wonders with this technology and really help people overseas. We're not doing it, and I don't know why it is not being done. We have the surplus, we have the food, we have the technology, and we have the low-cost transportation.

I was once invited to a meeting with the former scientific adviser to the president, George Keyworth, to explore the use of this technology. . . . One of the questions discussed was the poor image of the United States in Third World nations. The administration was trying to say, look, we want to do the right thing, but it is not as simple as some people believe. Especially with food, we do want to get our farm surpluses to the Third World nations, but at the beginning of a budget process you don't simply set aside dollars for the transportation and handling of a product that is going to be shipped to wherever it is going. The question always comes up, not that we don't want to ship this surplus, but who is going to pay to ship it, because typically the surplus is perishable; it has to go in a refrigerated shipment.

Hecht: But radiation sterilization eliminates this problem.

Welt: That's what we discussed in Keyworth's office one evening several years ago. But as with many things, you can discuss something and nothing ever comes of it. We still had to go through all of the regulatory nightmares. As you know, we paid a terrible price, just trying to go through a minefield of regulations, with no beacons, no lights, no help. You do what you believe is right, and very often you get struck by lightning.

Hecht: With radiation sterilization, a developing country that has a good crop year could use this not only against spoilage, but to stockpile what it produces in good years. In those countries that have almost no transportation, very little infrastructure, and no means of refrigeration, an irradiator at the harvest site could save all that produce from spoiling or being eaten by insects and rodents.

Welt: This is correct. The only problem is from a technical point of view, using radioactive sources simply does not lend itself to any kind of an economically viable transportable device. It may be that in coming years one can set up a mobile device, an electron-beam device that could generate bremsstrahlung radiation, or an x-ray device in which the bremsstrahlung would be a form of an x-ray. That would have a reasonable chance of being viable and economically feasible as a portable device. Of course, in going to Third World nations you are not going to be able to plug your device into the 220 or 110 outlet; you are going to have to have your own diesel generator and everything else.

These things are certainly within the realm of today's technology. What really bothers me—and it has bothered me since years and years ago when I worked for the Atomic Energy Commission and spent time with nuclear reactors: We sometimes have the best resources of government but we don't use these resources on projects that really don't require huge sums of money, but that can accomplish a lot in a hurry. As a result, we never quite solve those simple, solvable problems. . . .