Food Irradiation: Unresolved Issues

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Food-associated diarrheal disease is a major problem in the United States. One approach offered as virtually a panacea is food irradiation. Irradiating our food would have some unequivocal benefits, but there are some important unresolved issues that must be addressed before we commit our society to a technology that could be harmful.

Proponents of food irradiation cite the prevalence of diarrheal episodes in the United States as the major rationale for immediately adopting the technique. They note that ~200 million episodes of significant diarrhea occur annually. That figure undoubtedly is reasonably accurate, but, in probably the best study of its kind, Mead et al. [1] point out that, of those 200 million cases, only approximately one-third (76 million) can be ascribed to foodborne disease. Of that number, ~14 million are caused by recognized agents, most of which are viruses. Of the 1800 deaths resulting from infection with known foodborne agents, the majority are caused by *Salmonella*, *Listeria*, and *Toxoplasma*.

Food irradiation would certainly have some benefit, but it is not the single best solution to the problem of diarrhea in the United States. Its likely benefit relates to the 2.25% (4.5 million) of all diarrheal episodes and ~18% of foodborne diarrheal episodes caused by known bacterial and parasitic pathogens. Potentially, food irradiation could markedly lessen the number of severe cases of foodborne disease caused by *Salmonella*, *Listeria*, and *Escherichia coli* O15:H7.

Given the likelihood of clear benefits in regard to foodborne diarrhea caused by several important pathogens, the possibility of a beneficial effect against viral pathogens at very large radiation doses, and the probability of some effect on foodborne disease of unknown etiology, why would any infectious diseases clinician or epidemiologist oppose irradiating our food supply?

I am not opposed to the concept of sterilizing food by irradiation. I am strongly opposed to adoption of such technologies (using cobalt 60, cesium 137, or linear acceleration) before several issues are resolved.

First is the potential for chromosome damage in people who consume irradiated foods. Many in vitro and experimental studies have been performed, but there are only 2 relevant human studies, one carried out in India [2] and one in China [3]. In the Indian study, which was conducted in the mid-1970s, malnourished children were fed traditionally processed wheat or fresh or stored irradiated wheat; after a relatively short period of time, those fed fresh irradiated wheat showed chromosome breaks that were not found in children who were fed wheat that had not been irradiated or irradiated wheat that had been stored.

This study has been harshly criticized because of the small number of children it included and the methods that were used in conducting the study. These criticisms are valid, but the study still raises disturbing questions about possible genetic damage. A decade later, a larger study was carried out in China. The subjects were healthy adults, most of them between the ages of 18 and 23 years, who were fed irradiated foods for 3 months. The Chinese investigators found no chromosome abnormalities. The Chinese study was published, in part, in the *Chinese Medical Journal* in September 1987 [3]. My colleagues in the Department of Preventive Medicine at the New Jersey Medical School examined the data, reanalyzed it, and found that subjects who consumed irradiated foods did have increased chromosome breaks at borderline statistical significance ($P = .07$) [4]. Moreover, most of the foods used in the study were treated with small amounts of radiation.

These studies are inconclusive, but they are still worrisome. It would not be a good idea for billions of people around the planet to consume food that might cause chromosome damage. Moreover, suppose the risk is greater for those who are under-
nourished to begin with, as are ∼2 billion people on this planet. Think of food irradiation as the equivalent of a new antimicrobial agent. Would any new drug be accepted for general use in the United States if the only 2 relevant studies, both conducted in other countries, suggested the possibility of potentially dangerous adverse effects? We need a meticulous study conducted by an impeccable scientific group in which young and older adults and children of different ethnic groups and different socioeconomic status are given irradiated foods for 2–3 months, with regular examination of their chromosomes. If changes are found, the chromosome analyses should continue for a few additional months after subjects have stopped consuming irradiated foods, to make sure that the abnormalities disappear (as almost certainly they would).

This would not be a difficult, lengthy, or expensive study. I have urged this on proponents of irradiation for the past 7 years. My own prediction is that the study’s results would be negative, thus supporting proponents’ claims, but no one has been willing to conduct such a study. If chromosome abnormalities do occur with short-term consumption of irradiated foods, what might happen to the chromosomes of people who consume irradiated foods for years or decades?

Second is the issue of nutritional damage to irradiated foods. Proponents of food irradiation say that this is a nonissue and should be ignored. They are wrong. There are many studies that have found vitamin loss in food that has been irradiated. The following is a quotation from a report prepared for the director of the Bureau of Foods of the US Food and Drug Administration in July 1980:

There is ample published evidence that a number of vitamins are labile to some degree when irradiated. Particular attention should be focused on vitamin A and carotene, vitamin E, vitamin C, vitamin B-12, thiamin, and vitamin B-6. Although other vitamins and essential nutrients must not be ignored, the aforementioned vitamins are noted because of published studies that demonstrate losses in irradiated products. [5]

Many data indicate the potential for nutrient loss after irradiation [6, 7]. A US Department of Agriculture study showed that not only did irradiated pork lose some thiamin content, but, when the pork was cooked, there was greater additional thiamin loss than occurred in cooked pork that had never been irradiated [8].

The evidence is clear. Irradiation can destroy some vitamins. Its effect differs from food to food and also depends on the amount of irradiation used. The larger the dosage, the greater the nutrient loss. Advocates of irradiation either issue a blanket denial or say, “Why worry? Our food supply has redundant vitamins, so some loss in irradiated foods is inconsequential.” Others suggest that vitamin supplements can make up for losses.

But what about the 35 million people who live in poverty in the United States? They have enough trouble getting adequate nutrition without having their access to food limited to foods with deliberately reduced vitamin content. And what about the 36 million Americans who are older than 65 years? Approximately 25% of older people have abnormally low blood levels of ≥1 major vitamin [9]; that is why older people need a daily vitamin supplement. Should they consume vitamin-damaged foods? And what about the billions of undernourished people on this planet? Should we tell them we will provide them with foods that have longer shelf lives and less contamination but are less nutritious? For many people, that would be an unacceptable trade-off.

Proponents argue that cooking also causes vitamin loss, so why castigate irradiation? Certainly it is true that cooking causes vitamin loss. However, most fruits and an increasing proportion of vegetables are eaten raw, and comparison with cooked foods is inappropriate in those cases. In addition, as I have indicated, irradiated foods, when further processed (by cooking or freezing), may have an excessive vitamin loss compared with that in nonirradiated foods.

There is another problem. We do not know which of the hundreds of substances that fruits and vegetables contain are responsible for offering some protection against some cancers, heart disease, and stroke. If we cannot yet identify the beneficial components of fruits and vegetables, how can we tell whether irradiation will damage these health-promoting components? Irradiation could damage such components more than it does certain vitamins, less than it does certain vitamins, or not at all. We simply do not know. In addition, the information about potential nutrient loss relates to bombardment with gamma rays. The nutritional effects of the increasingly popular linear acceleration process are virtually unexplored.

I have proposed that, before irradiation is generally implemented, a food—for example, strawberries—be tested by an outside, impartial group to determine the extent of the loss of vitamins from the irradiation itself and then from the usual processing (in the case of strawberries, this might include freezing and thawing). The results of testing would then be included on the label accompanying each packet of the food. For meats, nutrient content would be tested before irradiation, after irradiation, and then after cooking, and the results would be compared with the nutrient content after cooking alone. At least the public would know that the specific food had been treated with irradiation and that some measurement had been made of nutrient loss, if any, during irradiation and then during further processing. This suggestion has not been accepted.

Proponents of irradiation also argue that if a food does not show significant nutrient loss after undergoing irradiation with 500,000 rad, then irradiation with 5 million rad should be acceptable without further nutrition testing. That is erroneous; nutrition loss after irradiation is dose dependent. There is in-
creasing evidence that nutritional deficits increase susceptibility to or progression of some infections and can damage the immune system. Could irradiating foods actually promote certain infections?

I want to make it clear that I am not an implacable foe of food irradiation. Indeed, I think that, used judiciously, it may be a useful technology for protecting people from contamination by microorganisms in some of the food items (especially fruits and vegetables) that are imported from around the world, and it may be needed for deli meats that are eaten cold. However, it should be used only under well-defined circumstances.

Irradiated foods might be useful for severely immunocompromised people, particularly those with major deficits in delayed-type immunity or acute neutropenia. However, if this is undertaken, there should be meticulous efficacy assessment. Only after determination of microbe-specific effectiveness should expansion to whole subpopulations with potential immunosuppression (e.g., older people) be considered.

Also to be considered in the dialogue is the availability of alternative approaches and newer technologies. Inspections by the Food and Drug Administration and the Department of Agriculture are increasingly effective. Recently, water electrolysis has been suggested as a potentially useful method of decontaminating fruits and vegetables.

In the last few years, the debate has been joined by increasing numbers of infectious disease experts. They have, in general, glibly advocated the benefits and dismissed the potential dangers associated with irradiation of food. Yet, the debate is far from over. The infectious disease and epidemiology experts who are proponents of irradiation should now do the following:

1. Be specific about the extent of the benefits of such procedures.
2. Provide information about the microbe-specific impact on disease burden. For example, will food irradiation reduce intestinal carriage of *Listeria monocytogenes*? Will it affect the sporadic cases of *Listeria* infection or infection during pregnancy that may be related to increased intestinal carriage of *L. monocytogenes*?
3. Provide information about which foods should be irradiated and what dosage is required to achieve the anticipated benefits.

I will continue to oppose the irradiation of foods with large amounts of radiation until questions about chromosome damage and nutrient loss are answered and until the food industry agrees to full disclosure by prominent labeling of each irradiated food item sold to the public.

References