Irradiation Pasteurization of Solid Foods: Taking Food Safety to the Next Level

In the 19th century, milk from diseased cattle produced in unsanitary surroundings and distributed under filthy conditions to an increasingly urbanized population sickened and killed consumers by the thousands (1,2). Wide acceptance of the germ theory and the sanitary awakening that followed led to vast improvements in animal health and hygiene, and the safety of dairy products improved substantially. Dairy farmers in northern Europe discovered that heating milk fed to their calves further reduced the risk for tuberculosis in their herds, and after overcoming concerns that the new thermal pasteurization technology would corrupt the dairy industry, destroy the nutritional value of milk, and lead to serious public health problems, the same level of protection was offered to human consumers a few decades later (3,4). More recently, thermal pasteurization has been suggested for eliminating low level contamination of juice by foodborne pathogens (5,6). However, for the safety of solid foods that enter kitchens as raw agricultural commodities, including meat, poultry, and seafood, we continue to rely solely on animal health programs and sanitation. Therefore, as we approach the 21st century, preventable illness and death caused by vegetative bacterial and parasitic foodborne pathogens remain substantial public health problems (7,8).

Irradiation pasteurization of solid foods with low doses of gamma rays, X-rays, and electrons will effectively control vegetative bacterial and parasitic foodborne pathogens (9-11). Public concerns, similar to those raised against thermal pasteurization of milk, have been advanced in opposition to irradiation pasteurization, and it has been claimed that if we but paid more attention to sanitation and proper cooking, these products could be safely consumed without introducing new technologies.

Perhaps. However, the residual risk for infection that remains after state-of-practice sanitation during production, harvest, processing, distribution, and preparation yields an unacceptable level of illness and death. In addition, the admonition to properly cook works only if culturally acceptable food preferences do not include undercooked and raw foods. Increased interest (encouraged by the public health and nutrition community) in fresh produce as part of a high fiber, low fat diet, further reduces the effectiveness of proper cooking as a disease control strategy (12).

Recent outbreaks of foodborne illness associated with undercooked meat and uncooked fresh produce, and the emergence of the previously unrecognized foodborne hazards that spawned the conference whose proceedings are reported in this issue of Emerging Infectious Diseases, have stimulated interest in methods of pasteurizing solid food without altering its raw appearance and characteristics. Research is under way on a variety of promising approaches, including pulsed energy, bright light, high pressure, and other nonthermal technologies, but few are ready for immediate application (13,14; Fed Reg 61:42381-83, 1997). Irradiation pasteurization, on the other hand, is a well-established process with clearly documented safety and efficacy that can be put into widespread use as quickly as facilities can be sited and built (15).

Good practice guidelines and Hazard Analysis and Critical Control Points programs (HACCP) can result in raw meat, poultry, seafood, and produce with sufficiently low levels of pathogen contamination that irradiation doses as low as 1 to 3 kGy yield adequate margins of safety for common foodborne pathogens such as *Campylobacter*, *Cryptosporidium*, *Escherichia coli*, *Listeria*, *Salmonella*, and *Toxoplasma* (9). No other control for *Campylobacter* contamination of poultry meat is apparent, and other approaches to ground beef safety have proven inadequate to prevent intermittent low level contamination with *E. coli* O157:H7. Likewise, no other solutions are immediately available to control pathogen contamination of produce intended for raw consumption, and irradiation doses used appear adequate for the bacterial and parasitic pathogens involved in recent outbreaks (Donald Thayer, pers. comm.)

The food industry appears reluctant to fully embrace irradiation pasteurization despite the obvious and painful failure of alternative approaches to prevent foodborne infections. Much of this reluctance stems from the perception that consumers reject the process and will refuse to buy irradiated food. Indeed, surveys have shown considerable consumer confusion and ignorance about food irradiation (16), and reports on public antipathy toward things radioactive abound. However, consumer surveys also demonstrate profound and growing public concern about microbial food safety, and decreasing concerns about the safety of irradiated food (17). Knowing as little about it as they appear to, approximately half of the consumers surveyed have expressed willingness to try irradiated food if it will decrease their risk for illness (16). In addition, when educated about food irradiation, 90% of survey participants expressed interest in purchasing irradiated foods; sampling such food increased interest to 99% (18).

Irradiation pasteurization is not the cure for all food safety ills. Pasteurization of any sort is no match for bad sanitation and substandard practices, and irradiation pasteurization can be overwhelmed by large numbers of pathogens. Just as obviously, foods produced and processed under appropriate conditions that are then properly packaged and irradiated are subject to postpasteurization contamination. In addition, the doses of irradiation used to pasteurize fresh meat and poultry are not sufficient to kill bacterial spores. Thus, if anaerobic packaging is the method used to protect irradiated foods from postpasteurization contamination, *Clostridium botulinum* could pose a risk if the cold chain is disrupted.

Vibrio infections associated with consumption of raw molluscan shellfish can be prevented with irradiation pasteurization, but the Norwalk-like viruses also frequently associated with raw shellfish appear to be more radioresistant than vegetative bacterial pathogens. Levels of irradiation an order of magnitude greater than pasteurizing doses for meat and poultry also are necessary to inactivate hepatitis A virus. To reduce the risk for foodborne hepatitis A and Norwalk virus infections, it will be necessary to reduce the level of exposure of food to human feces. This is true regardless of whether or not foods are to be pasteurized. Although irradiation pasteurization will not eliminate all seafoodborne pathogens, it will reduce the potential of seafood to cause illness. Seafood HACCP and advances in viral diagnostics and environmental virology will help ensure that prepasteurization conditions are sufficient to yield seafood appropriate for irradiation pasteurization (19,20). Just as thermal pasteurization works well for liquid foods like milk and juice, but not for solid foods for which raw characteristics are desired, irradiation pasteurization works well for meat, poultry, seafood, and soft fruit, but wilts leafy vegetables and sprouts. That irradiation pasteurization does not work for every food and every pathogen is poor justification for not applying it for those food/pathogen combinations for which it has been shown to work so well.

Consumer surveys have demonstrated public concerns over worker and environmental safety that have also contributed to the reluctance of some to build and use food irradiation facilities. These concerns are appropriate and addressable. Because food irradiation and irradiation sterilization of nonfood items like medical supplies are so well established, proper facilities design and operating characteristics are well known. The relatively short half-life of Cobalt 60 and its insolubility in water reduce environmental concerns, which can be eliminated altogether by using electricity-generated X-rays and electron beams instead of a radioactive source. Proper education and training has protected employees of irradiation sterilization facilities; employees of food irradiation facilities should not be qualitatively different from other employees in similar industries.

Thus, a broadly applicable solution to many of our food safety problems exists and has existed for a number of decades. It is disappointing that the public health community has been so silent for so long on this issue. Faced with the liability of marketing hazardous foods, it is puzzling why the food industry has not stepped into the vacuum created by this lack of leadership from public health. Presentations at the Conference on Emerging Foodborne Pathogens make it clear that new foodborne hazards are being stacked on top of old, unresolved food safety problems—broadly applicable solutions are desperately needed. Just as thermal pasteurization of milk protected us from *E. coli* O157:H7 before we knew it was in raw milk, irradiation pasteurization can protect us from tomorrow's emerging foodborne pathogen.

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