Irradiation of U.S. Poultry—Benefits, Costs, and Export Potential

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Along with the potential to give perishable food products a longer shelf-life and to substitute for chemical fumigants, irradiation may offer consumers safer poultry by destroying microbial pathogens which cause foodborne illnesses.

Last fall, USDA's Food Safety and Inspection Service (FSIS) approved irradiation of uncooked poultry to control bacteria that cause diseases, such as salmonellosis and campylobacteriosis. Each year, about 4 million Americans contract these diseases primarily from foods, and suffer a variety of symptoms ranging from diarrhea and vomiting to blood poisoning. These diseases can be especially serious for the very young, the elderly, and people with compromised immune systems.

Although irradiation of poultry could reduce the number of foodborne illnesses caused by eating undercooked or improperly handled chicken or turkey, producers will not use the technology until they believe that consumers will buy irradiated poultry.

But, poultry producers' interest in irradiation is mixed. The National Broiler Council says it is neutral toward irradiation—that commercial viability depends on consumer acceptance. The National Turkey Federation favors experimentation with irradiation to determine public acceptance. The USA Poultry and Egg Export Council favors offering irradiated poultry products in export markets.

Poultry Irradiation Approved To Combat Foodborne Disease

On September 21, 1992, FSIS published a final rule which allows irradiation of fresh or frozen uncooked poultry and mechanically separated poultry products to kill micro-organisms that cause dis-

USDA chemist Bill Obermeyer places a plastic bag containing chicken into position for irradiation—now approved for poultry to reduce spoilage and illness caused by bacteria.

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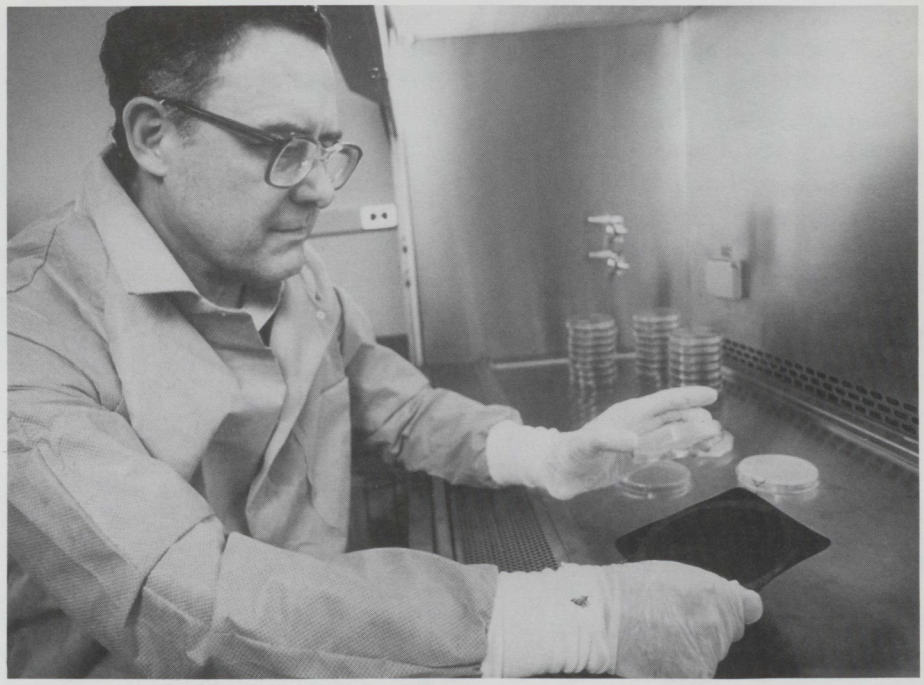
eases, such as salmonellosis, campylobacteriosis, and listeriosis. The U.S. Food and Drug Administration (FDA) had approved irradiation of uncooked poultry in May 1990. Now that both FDA and FSIS have issued final approvals, irradiation may be used on poultry.

FSIS' rule would allow the use of FDA-approved ionizing radiation sources to treat poultry at a dose of 1.5-3.0 kilograys (kGy). (Ionizing radiation is radiation with sufficient energy to remove electrons from atoms, thereby creating ions.) Products that may be irradiated include fresh or frozen uncooked whole carcasses and parts, including ground, boneless, and skinless poultry, as well as mechanically separated poultry products. Cooked, cured, or poultry products with added ingredients may not be irradiated.

To reduce the possibility of recontamination, poultry must be packaged for sale prior to irradiation. Such packaging must be approved by FDA, which last amended the list of packaging materials approved for use during irradiation in 1989. Newer combination materials, such as pads that absorb poultry juices and water, would need approval. The packaging material must allow oxygen—but not moisture or micro-organisms—to enter and leave the package.

Labels for irradiated poultry must display the international radiation logo in green along with the statement "Treated with Radiation" or "Treated by Irradiation." The labels would also carry the handling statement "Keep Refrigerated" or "Keep Frozen" as appropriate. Statements about the purpose of irradiation, such as "Irradiated to control foodborne disease," may be included, as long as FSIS rules that the information is not false or misleading.

FSIS must approve a poultry packing plant's or irradiation plant's quality-control program before the plant will be permitted to irradiate poultry. Quality controls include facility licensing by appropriate Federal and State agencies, radiation processing and safety training for plant supervisors, procedures and equipment for measuring the amount of radiation absorbed by the products, and appropriate handling and sanitation practices.



USDA microbiologist Donald Thayer uses various growth media to replicate Salmonella—the primary bacterium contaminating poultry.

Foodborne Illnesses Are Costly

Salmonellosis and campylobacteriosis are the two human diseases most frequently associated with chicken consumption. (This article focuses primarily on chicken, because Americans consume four times as much chicken as turkey.)

These two diseases cause symptoms and illnesses ranging from a day or two of mild diarrhea and vomiting to hospitalization for dehydration and diarrhea, blood poisoning, or sometimes even death. The severity of the symptoms depends, in part, on how many bacteria are consumed and how well the body can fight off the bacteria. Therefore, the most vulnerable are people with weak immune systems, such as some of the elderly and patients with cancer, AIDS, or other diseases treated with immunosupressing drugs.

People place themselves at risk of contracting these foodborne illnesses by eating undercooked poultry and by improperly handling uncooked poultry. Risks of contamination can be reduced by cooking the poultry thoroughly; washing all surfaces and utensils touched by raw poultry in hot, soapy water before reusing; refrigerating leftovers promptly in small containers; and thawing frozen raw poultry in the refrigerator—not at room temperature.

Salmonellosis

Centers for Disease Control (CDC) researchers estimate that 2 million cases of salmonellosis occur each year—96 percent of which

are caused by food—and that 1,000 to 2,000 end in death. Most cases go unreported.

During 1983-87, 170 salmonellosis outbreaks with identifiable causes were reported to the CDC (each of these afflicted, on average, 84 people). Eaten as a separate item, chicken was identified by the CDC as the cause of 15 of these outbreaks.

Salmonellosis outbreaks are increasingly caused by combination food dishes (which may or may not contain chicken), such as poultry, fish, or egg salads; Chinese or Mexican dishes; or casseroles. During 1983-87, 80 of the 170 salmonellosis outbreaks were attributed to such combination food dishes.

Researchers with USDA's Economic Research Service (ERS) assumed that 30 percent, or 24 of the outbreaks from mixed foods, were caused by chicken. Using this assumption, chicken could have been responsible for 39 of the 170 salmonellosis outbreaks, or 23 percent. ERS researchers assumed chicken was responsible for the same percentage of unreported cases. Therefore, chicken is estimated to have been responsible for 23 percent of the 2 million cases of salmonellosis estimated by the CDC.

ERS estimates medical costs and productivity losses due to food-caused salmonellosis are $1.1 billion to $1.6 billion each year. Using the assumptions explained above, $260 million to $363 million of these estimated costs were attributable to chicken. Medical costs include expenses for doctor visits, medicine, and hospital care. Productivity losses refer to earnings lost from work due to illness or death.

These estimated medical and lost productivity costs do not include pain and suffering, the value of lost leisure time due to illness, or the time consumers take for preventive actions, such as cleaning hands and utensils after handling raw chicken. Costs would increase even more if chronic complications of salmonellosis, such as arthritis and colitis, could be estimated.

Campylobacteriosis

The CDC estimates that 2.1 million campylobacteriosis cases occur each year, of which 120-360 result in death. A 1984 study by the Seattle-King County Health Department found that 48 percent of the cases in that area could be traced to chicken consumption or cross-contamination of other foods by raw chicken. If this percentage is applied to the 2.1 million cases nationally, the medical costs and productivity losses due to campylobacteriosis caused by chicken would be $390-$452 million per year.

Irradiation Prevents Diseases

Irradiating chicken with doses of 1.5-3 kGy will greatly reduce the potential for foodborne illnesses. For example, Dutch researchers estimate that irradiation at 2.5 kGy will leave 93 percent of chicken packages free from *Salmonella*. According to USDA scientists, in the remaining 7 percent of packages, *Salmonella* levels would be reduced by 99.9 percent, the *Salmonella* would be injured and their growth would be reduced, and the remaining *Salmonella* would be more susceptible to heat reduction. This same dose would kill 100 percent of *Campylobacter*.

Irradiation kills other pathogens that sometimes contaminate chicken, such as *Listeria*. However, *Listeria* was not included in the benefit/cost analysis because the percentage of human illnesses associated with chicken could not be determined. Therefore, the public health benefits are underestimated somewhat.

Irradiation Costs Pennies Per Pound

In 1988, ERS estimated the costs of irradiating chicken at a dose of 2.5 kGy in hypothetical irradiators of various sizes. Estimated 1991 operating and annualized investment costs range from 1 to 1.5 cents per pound, depending on irradiator size (table 1).

At the time of the study, there were no U.S. irradiators built specifically to irradiate fresh poultry. The investment and operating costs for irradiating chicken were based on information from commercial plants using irradiation mostly to sterilize medical supplies and equipment.

The irradiators were assumed to use radioactive cobalt-60 as their radiation source. For some applications, an irradiator could use high-energy electrons or x-rays as the radiation source, such as one in France which treats mechanically deboned chicken (see box).

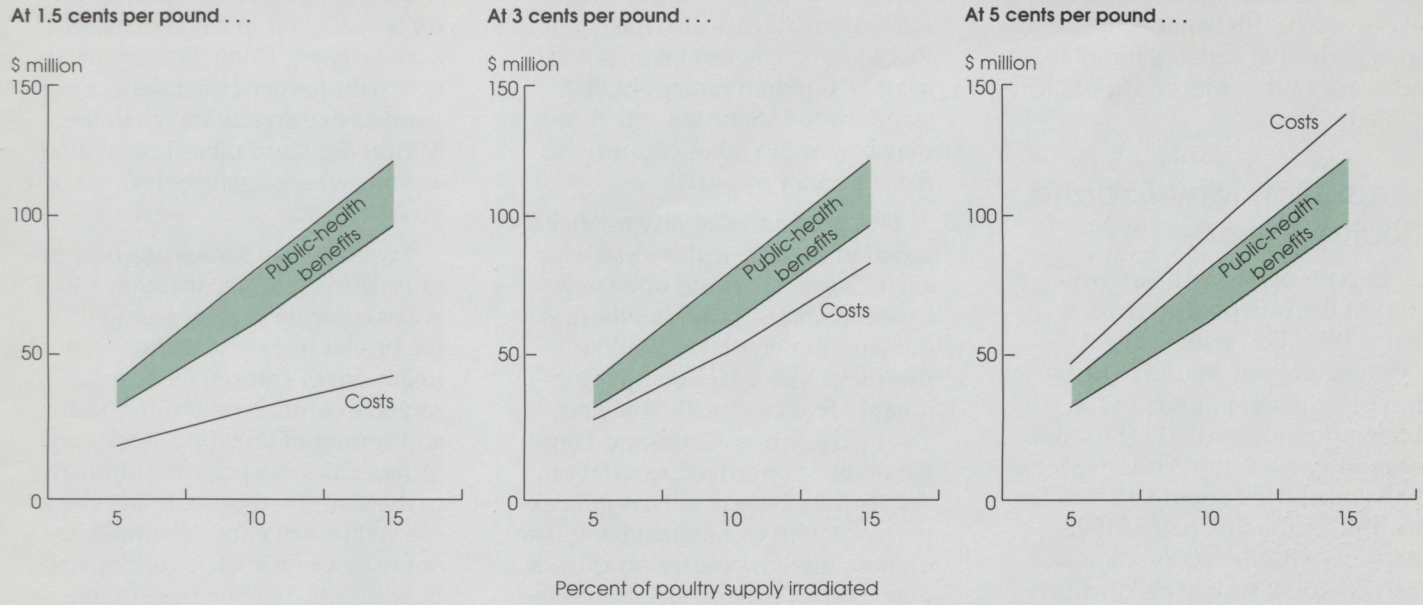
The irradiators in table 1 reflect the processing capacities of medium and large U.S. chicken pack-

Table 1
Costs of Irradiating Chicken Decrease as Plant Size Increases[1]

Annual amount of chicken irradiated	Initial investment	Treatment cost
Million pounds	*Million dollars*	*Cents per pound*
52	2.6	1.50
104	4.4	1.30
208	7.5	1.02
416	14.5	.99

[1]Assumes cobalt-60 irradiator integrated into packing plant.

Figure 1
Public-Health Benefits Can Outweigh the Costs of Irradiating Chicken



ing plants. Irradiators treating smaller volumes would have higher treatment costs per pound.

These costs are for the treatment alone and do not include the expense of a possible educational campaign to acquaint consumers with irradiation, research efforts needed to support industry petitions to FSIS or FDA, or disposal of the cobalt-60 when its radioactivity is too low to be useful for processing. In addition to the costs incurred by the company, various Federal and State government agencies must commit resources for license approval and other forms of inspection.

The irradiators in table 1 were assumed to be physically integrated into existing chicken packing plants, which eliminates the need to build additional refrigerated storage space, loading docks, and offices.

However, an irradiator does not have to be located in the packing plant. Contractors handling a variety of products could do the job instead. For instance, Sam Whitney, president of Vindicator, Inc., a contract irradiator specializing in treating food, said their charge to irradiate poultry at a dose of 1.5-3 kGy will be 3 cents per pound. Customers must pay for transportation.

Public-Health Benefits Can Exceed Costs

Irradiated poultry will enter the marketplace very slowly for many reasons, including uncertainty over consumers' interest in purchasing irradiated chicken and the lack of approved facilities to irradiate the products.

ERS has estimated and compared the public-health benefits with the irradiation treatment costs if 5, 10, and 15 percent of U.S. chicken were irradiated (fig. 1).

If 5 percent of the 18.5 billion pounds of chicken consumed in the United States in 1991 were irradiated, between $31.6 million and $39.5 million would have been saved in terms of reduced medical costs and lost productivity from salmonellosis and campylobacteriosis illnesses and deaths. If 10 percent of the chicken were irradiated, between $63.2 million and $79 million would have been saved. If 15 percent of the chicken were irradiated, public-health protection benefits would have been $94.8 million to $118.5 million.

Assuming a cost of 1.5 cents per pound for an irradiator integrated into a chicken packing plant, irradiating 5 percent of the chicken consumed in 1991 would cost $13.9 million. Irradiating 10 percent of the chicken supply would cost $27.8 million, and irradiating 15 percent would cost $41.6 million. In these three examples, the estimated benefits to public health are more than double the estimated costs, thus yielding positive net benefits.

Higher costs for irradiation lessen the net benefits. For example, a charge of 3 cents per pound (Mr. Whitney's estimated charge at the contract irradiator) for the irradiation treatment yields smaller, but still positive, net benefits under these assumptions. However, a

charge of 5 cents per pound would raise the irradiation treatment costs above the health benefits, resulting in negative net benefits for all three amounts of the chicken supply irradiated.

Irradiation May Expand Poultry Exports

Exports are a small but growing part of the U.S. poultry market. Since 1985, U.S. poultry meat exports steadily increased from below 500 million pounds to 1.4 billion pounds by 1991. The value of poultry meat exports is expected to have reached about $930 million in 1992. In the first half of 1992, 6.4 percent of broiler production and 3.0 percent of turkey production was exported.

Some countries are increasing testing requirements for bacteria in imported foods. In 1991, Indonesia began enforcing a zero-tolerance standard for *Salmonella* on poultry, which has largely excluded U.S. exports to that growing market. Greece also has insisted that chicken be free of *Salmonella*, but does not apply that standard to U.S. turkey. Such tests may be used in other countries to reject poultry imports.

U.S. producers' ability to offer irradiated poultry with reduced levels of *Salmonella* could open new export markets, provided there is demand for irradiated poultry products. Major U.S. competitors—notably France, Brazil, Thailand, The Netherlands, Chile, and Hungary—have approved irradiation. As firms in these countries gain experience with commercializing irradiation, foreign poultry producers may gain an edge over U.S. producers in offering irradiated poultry.

Irradiating poultry with doses of 1.5-3 kGy and using proper refrigeration doubles the current shelf-life of about a week. This may make it possible to ship some products now frozen as fresh. Exports could expand because fresh poultry is preferred in some markets, such as Hong Kong. Poultry products with reduced bacteria counts would have an advantage in the Middle East and other hot-weather regions where spoilage is more of a problem.

Swedish companies produce *Salmonella*-free poultry through a variety of controls in each segment of the broiler industry, including heat treatment of chicken feed, strict sanitary controls on poultry farms, and testing of breeding stock and grown chickens prior to shipment to the slaughterhouse. If any chickens test positive for *Salmonella*, the entire stock or flock is condemned. In addition, Sweden has surveillance programs to determine the food source of infection for patients hospitalized with salmonellosis.

These controls, however, come at a price as chicken is consider-

Table 2
Among Countries Permitting Irradiation of Poultry, the Former Soviet Union Is the Largest Importer of U.S. Poultry

Country	Poultry products approved for irradiation	Imports of U.S. broiler meat, 1991
		Million pounds
Bangladesh	Chicken	*
Brazil	Poultry	.13
Chile	Chicken	.55
France	Poultry (ground, chopped, or cut), mechanically deboned poultry meat, egg whites (liquid, dried, or frozen)	6.14
Hungary	Frozen chicken	.09
Israel	Poultry and poultry sections	*
Netherlands	Poultry	6.99
South Africa	Chicken	.80
Syrian Arab Republic	Chicken	.01
Thailand	Chicken	.04
United Kingdom	Poultry	7.10
Former Soviet Union	Poultry, eviscerated	183.09
Yugoslavia	Fresh poultry, egg powder	5.22
Total		210.16

* No U.S. poultry meat imports.

Machine-Produced Radiation Used on Poultry in France

Alternatives to cobalt-60 as the radiation source include high-energy electrons or x-rays.

A French food processing company uses high-energy electrons to reduce *Salmonella* in mechanically deboned poultry. The company uses the irradiated poultry in a variety of processed foods, such as sauces, gravies, and soups. The mechanically deboned poultry is made into 2-1/4-inch-thick cakes, which are then packaged, deep-frozen, and carried on a conveyor through a stream of high-energy electrons.

High-energy electrons and x-rays are produced by electron accelerator machines powered by electricity. With this technology, no radioactive materials are shipped or disposed of.

However, electrons at the maximum energy levels allowed by FDA cannot penetrate more than 1-3 inches, depending on the food's density, when irradiated from one side. Therefore, electrons could be used only with thin packages or if the *Salmonella* contamination were just on the surface.

Although x-rays have the same penetrating ability as cobalt-60, producing x-ray power is very inefficient. No industrial accelerator presently operates in the x-ray mode for a significant portion of time.

For further information on electron accelerators' potential for treating food, see R.M. Morrison's *An Economic Analysis of Electron Accelerators and Cobalt-60 for Irradiating Food,* TB-1762. USDA, ERS, June 1989.

ably more expensive in Sweden than in the United States. In June 1992, the retail price of whole broilers in Stockholm was $3.55 per pound, compared with $0.87 in Washington, DC.

Swedish companies are selling chicken with "*Salmonella*-free" labels in Sweden and Denmark. Denmark is examining ways to change their production and inspection systems to meet this competition. Norway is producing chicken that seems to be free of *Campylobacter*, although no label declarations appear on chicken packages.

Irradiation might provide an alternative product with safety features at a cheaper cost. It will be interesting to see if European customers will accept this product.

Exports of irradiated poultry would require approval by the importing country. Currently, 13 countries permit irradiation of chicken or poultry (table 2), and 11 import U.S. poultry. In 1991, about 15 percent of U.S. broiler meat exports went to these countries, a large portion of which went to the former Soviet Union. However, the four largest U.S. export customers—Japan, Hong Kong, Mexico, and Canada—have not approved irradiation of poultry (they receive about 60 percent of U.S. poultry exports).

Alternatives to Irradiation Explored

Other techniques may offer some public benefits as well. For example, FSIS has just approved (on a case-by-case basis) a trisodium phosphate (TSP) wash for poultry that reduces *Salmonella*. (Whether TSP is also effective in reducing *Campylobacter* is being investigated.)

USDA is working on farm-management strategies to control *Salmonella enteritidis* in eggs, which may also reduce Salmonella levels in chicken.

Poultry producers will compare the costs and benefits of irradiation with alternative techniques to reduce *Salmonella* contamination.

Marketplace Will Decide Use

Potential niche markets might include supermarkets serving individuals at high risk from foodborne illnesses and foodservice operations in nursing homes.

But whether irradiated chicken and turkey have a place in the U.S. poultry marketing system depends on actions by consumers, producers, and marketers. Poultry processors and marketers will decide whether to use irradiation based on a variety of factors, including the cost of irradiation and consumers' acceptance of this technology and interest in its benefits.

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