

## Status of the USDA Food Irradiation Programs

□ THE U.S. DEPARTMENT of Agriculture (USDA) has conducted studies of food irradiation as a quarantine treatment for fruits for at least 25 years (Burditt, 1981). The numerous studies were reviewed by Burditt (1981). The recent medfly crisis in California and the proposed action of the U.S. Environmental Protection Agency (EPA) to restrict the use of ethylene dibromide as a fumigant starting in July 1983 (EPA, 1981) has renewed interest in the possibilities for the use of irradiation in quarantine control of insects. As a result of these events, the USDA held conferences in Fresno, Calif., on July 16, 1981, and Orlando, Fla. on September 10, 1981, and participated in a workshop on low dose radiation treatment of agricultural commodities, which was held April 19-21, 1982, in Washington, D.C. The general conclusion of the USDA conferences in 1981 was that there is a critical need for data on the relationship of irradiation dose to phytotoxic damage to the fruit. However, it was also recognized that additional information is needed on the effects of radiation on the Caribbean fruit fly (*Anastrepha suspensa* [Loew]).

USDA scientists are considering the use of irradiation with a great deal of caution because of the results of previous studies indicating that phytotoxic damage to the fruit occurs during the irradiation of fruits even at the very low dose rates required for insect quarantine purposes. Burditt et al. (1981), as an example, reported that though doses of 25 krads prevented the development of adult Caribbean fruit flies in irradiated grapefruit, the irradiated fruits had increased skin pitting, scald, decay, and, in some cases, changes in the taste of both sections and juice.

The Agricultural Research Service (ARS) is currently conducting research on the use of radiation for insect disinfestation at three sites.

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In Miami, Fla., at the USDA-ARS Subtropical Horticulture Research Laboratory, and in Winter Haven, Fla., at the USDA-ARS Citrus and Subtropical Products Laboratory, research is being conducted on commodity treatments for the Caribbean fruit fly and on the composition of products from chemically treated and irradiated citrus fruits. In Honolulu, Hawaii, fruit fly infestation and disinfestation in tropical and subtropical fruits are under investigation. New research is planned at Yakima, Wash., at the Yakima Research Laboratory, on the Codling moth. In the Plant Science Laboratory at the Eastern Regional Research Center (ERRC) in Philadelphia, the biochemical and physiological basis for radiation-induced softening and other manifestations of phytotoxicity will be studied in blueberries, tomatoes, and other selected fruits. In addition, new approaches involving the combination of low-dose irradiation with other treatments, such as storage under controlled atmospheres, hypobaric storage, and use of chemical fungistats, will be investigated with regard to alleviation of radiation-induced defects and extension of storage life.

In August of 1980, the U.S. Department of Defense and the USDA signed a memorandum of understanding, which transferred lead agency role for the food irradiation program from the Army's Natick Laboratories to the ERRC in Philadelphia. It was agreed that

some key scientists and equipment would be transferred from the Army's Natick irradiation facility to the USDA to achieve a smooth transition and completion of the Army's high-dosage meat sterilization program. USDA agreed to complete the animal feeding studies of the irradiation sterilized chicken and the related chemical research needed to support a petition to the Food and Drug Administration (FDA) for approval of sterilized chicken products. USDA indicated that it would concentrate its research on a long range program using low levels of irradiation to prevent marketing losses and to improve the safety and quality of fruits, vegetables, and grains as an alternative to present methods used for food preservation and insect disinfestation. Of particular interest was the use of irradiation as an alternative to the use of nitrite in preservation of meats, especially bacon.

As a result of the agreement, a large amount of equipment and one scientist were transferred from the Army to ERRC in 1980-1981. The transfer of equipment was completed in late 1981. The USDA was unable to accept transfer of the cobalt source, but the 158,000 curie cesium-137 self-contained irradiation source was transferred to ERRC in November of 1981. This source was installed at the ERRC and became operational in March 1982. Several changes were made during installation to better protect the operating controls from the ozone generated by the radiation.

The second major facility that is assigned for use of the food irradiation program is a controlled access meat laboratory, which was originally intended for studies of meats inoculated with *Clostridium botulinum* before processing. The laboratory complex contains a refrigerated processing room, a laboratory, and an animal room. The food irradiation group also has a processed meats laboratory

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and smoke house available for their use. An electron-spin resonance spectrophotometer was installed in a separate laboratory during 1982.

The Food Irradiation Research Unit has a staff of five. However, the food irradiation program within the Food Safety Laboratory is a cooperative effort supported by all four of the laboratories' research units. Scientists within each of the other groups provide expertise in directing microbiological, analytical, or biochemical studies of irradiated foods. The Food Safety Laboratory cooperates with other laboratories in food irradiation studies both at ERRC and other sites.

Research in food irradiation was initiated before the transfer of either equipment or personnel to the ERRC in 1980. This was accomplished by initiating a cooperative research project with the Natick Laboratory to determine the efficacy of gamma or electron irradiation as a substitute for nitrite and to reduce use of nitrite for the preservation of bacon. Fiddler et al. (1981) reported the results of investigations of nitrosamines in irradiation-sterilized bacon. The data obtained by these investigators suggested that irradiation sterilization with cobalt-60 (3.0 Mrad at  $-40^{\circ}\text{C}$ ) significantly reduced residual nitrite in bacon prior to frying, thereby reducing volatile nitrosamines to considerably below the 10 ppb violative level after frying. Irradiation sterilization further destroyed volatile nitrosamines intentionally added to the bacon.

A large scale cooperative study was initiated in 1980 to determine the effect of irradiation (0.5, 1.0, and 1.5 Mrad) on the microbiological safety and stability of bacon cured with reduced amounts of nitrite. The microbiological studies were completed and are currently under review for publication. A series of experiments was initiated recently to determine the importance of sugar to the microbiological safety of low-nitrite (40 ppm) irradiated bacon. The Food Contaminants Research Unit is conducting further studies to determine the effect of irradiation on nitrosamine formation, residual nitrite, and preformed nitrosamines in bacon.

The National Research Council Committee on Nitrite and Alterna-

tive-Curing Agents in Food recommended that the use of irradiation in combination with low concentrations of nitrite be studied (NAS, 1982). The Food Irradiation Research Unit initiated studies during 1982 of irradiated polyunsaturated lipids with emphasis on lipid peroxide formation. It also initiated research during 1982 on low-dose (100 to 700 krad) irradiation of fresh and processed meats and of fresh poultry to extend shelf life and to improve food safety. The Food Additives Research Unit plans to initiate research on the effect of low-dose irradiation of meat on proteolytic activity and cell structure.

The toxicological studies to determine the wholesomeness of chicken parts sterilized with ionizing radiation (4.5 to 6.75 Mrad) at  $-40^{\circ}\text{C}$  were initiated by the Army in 1976 by a contract to Research 900 (Raltech Scientific Services, A Division of Ralston Purina Co.) in St. Louis, Mo. This study represents one of the most exhaustive wholesomeness studies ever undertaken on any food product. Supporting studies were undertaken by the Army. A similar study on beef, which was initiated by the Army in 1971, was inconclusive because of problems with the contractor's conduct of the study (Brynjolfsson, 1978; GAO, 1978).

The protocol for the studies at Research 900 required the testing of five diets: (1) 100% laboratory rodent ration (rats and mice) or dry dog food (dogs); (2) 35% enzyme-inactivated chicken, stored frozen; (3) 35% thermally-sterilized chicken; (4) 35% gamma-sterilized, enzyme-inactivated chicken; and (5) 35% electron-sterilized, enzyme-inactivated chicken. The studies were designed to provide toxicity, carcinogenicity, mutagenicity, teratogenicity, and antimetabolite data on the diets. Included within these goals were food consumption, growth, feed efficiency, longevity, reproduction, breeding performance throughout a life span, clinical chemistry, and gross and microscopic pathology of selected tissues. The mutagenicity series of experiments was based on a three tiered system including in vitro testing with the Ames plate test, a sex-linked recessive lethal test in *Drosophila*, a heritable translocation assay in mice, and dominant lethal tests in both mice and rats.

Responsibility for these studies was accepted by the USDA as part of the transfer of the food irradiation program in 1980. Draft copies of all but one of the final reports are now under review. The review of these documents will not be completed for several months because of the complexity of the studies and the length of the reports. The report of the multi-generation study of mice fed the irradiated chicken is typical in that it contains 14 volumes with a total of 10,328 pages. The USDA is supporting the analysis of the volatile compounds in irradiated chicken by C. Merritt at the Natick laboratories. This study will be completed during 1982 and is considered to be an essential part of the proposed petition to the FDA.

Final reports have been accepted for a number of the wholesomeness studies. No final conclusions on the wholesomeness of irradiation sterilized chicken can be made until all of the reports, including supporting studies, are completed and the information evaluated in its entirety by both USDA and FDA reviewers.

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