ARE THERE VALID CONCERNS ABOUT FOOD IRRADIATION?

Dr. Louria's "Counterpoint on Food Irradiation," presents several questions of the proponents and processors of irradiated foods. The following is a response to those points.

Dr. Louria's first point is that he does not believe that Dr. Steele used the current analysis of food-related illnesses and cites the data of Mead et al.[1] However, upon closer inspection, I note that Dr. Steele mentions "An estimated 76,000,000 cases of foodborne infection...approximately 6000 deaths." Mead estimates 76 million

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foodborne illnesses and 5200 deaths and does indicate that unknown agents account for 62 million of the illnesses. Certainly not all of the unknown causes will be vegetative bacterial, protozoal, or other pathogens easily controlled by irradiation, and they may not be on a food product that is suitable for food irradiation, but many of these pathogens will be sensitive to ionizing radiation. Yes, two-thirds of the 211 million cases of acute gastroenteritis are not foodborne, but that still leaves 76,000,000 cases that are foodborne. Dr. Louria raises the concern of the potential for chromosomal damage and then cites studies performed in India and China. He indicates that his colleagues examined the data from the Chinese study and found borderline statistical significance ($P = 0.07$). Let us discuss these two studies and others that may have been missed in his review of the literature.

Bhaskaram and Sadasivan reported that children suffering from kwashiorkor developed an incidence rate of polyploidy of 0.8% after 2 weeks and 1.8% after 4 weeks of ingesting irradiated wheat.[2] This same research facility also reported increased polyploid cells in mice and rats eating irradiated wheat.[3,4] These reports caused considerable concern in the scientific community but, upon examination, were found to contain mutually contradictory data and to be at variance with well-established knowledge of biology.[5,6] An example of this was the report of 0% polyploidy in controls and test group children after removal of the treated diet, even though polyploidy is not unusual in human populations.[2]

George et al found no evidence for increased polyploid cells in the bone marrow of rats fed irradiated (0.75 kGy) wheat, within 24 hours of irradiation, for 1 to 6 weeks.[7] Tesh et al reported the results of duplicate studies of rats consuming a diet incorporating irradiated wheat that were conducted independently at different laboratories.[8] The diets contained 70% by weight of wheat flour that was irradiated to 0.75 kGy prior to milling. The diets were consumed by the rats within 2, 4, or 8 weeks from the date of irradiation. There were five males and five females in each diet group in each study. The number of polyploid configurations per 500 metaphases was counted for each animal. The authors concluded that there were no treatment-related effects on the number of polyploids per 500 metaphases, food consumption, body-weight change, and incidence of mortality.

Chi et al specifically looked for any evidence of polyploid cells in the human volunteers ingesting irradiated diets without finding such evidence; however, the study design may have been inadequate to detect abnormalities below the 1% level, because only 50 metaphase lymphocytes were examined for each subject.[9] This is the same study to which Dr. Louria refers; however, it is a longer version of the report and published in English.

Renner examined metaphase preparations of chromosomes from bone marrow cells of Chinese hamsters for evidence of mutagenic effects following the ingestion of an unirradiated or a radiation-sterilized diet (45 kGy) for 6 weeks and found incidences of 0.06% and 0.32% polyploid cells, respectively.[10] In the initial investigations, 100 metaphases were counted per animal and 300 in subsequent studies. The incidence of structural chromosomal aberrations did not increase. Further studies revealed that animals ingesting feed immediately after irradiation to doses of 20 kGy or higher developed increased rates of polyploidy. The incidence did not increase when doses of 100 kGy were used, and never exceeded 0.5%. No such effect was found at doses of 10 kGy or less and when the irradiated feed was stored for 6 weeks before use. The ingestion of small amounts of 0.3% H_2O_2 with the unirradiated diet also produced an increased incidence of polyploidy. Because the incidence of polyploidy returned to the control level within a maximum of 6 weeks and because the effect was not dose related, the author concluded that the result was not a mutagenic effect.

The effects of low-dose gamma irradiation on the content of thiamine (B_1), riboflavin (B_2), niacin, pyridoxine (B_6), and cobalamin (B_{12}) in pork chops, and thiamine, riboflavin, and niacin in chicken breasts was studied.[11] Over the range of dose and temperature studied, it was possible to derive a mathematic expression for predicting the losses. A calculation was made of the effect of the loss of thiamine, riboflavin, and niacin due to irradiation on the overall loss of these vitamins in the American diet. The losses of riboflavin and niacin were of the order of a fraction of a percent. Pork is an important source of thiamine, but the calculated loss with irradiation at 1.0 kGy of this vitamin in cooked pork was only 1.5%, if it is assumed that all pork would be irradiated.

Is there the potential for loss of vitamin C in irradiated fruits and vegetables? Yes, but not at the doses that are practical for these products. Some ascorbic acid will be converted to its oxidized dehydro form; however, dehydro ascorbic acid is every bit as usable in humans as its unoxidized form.[12] At doses that are significantly higher than those that are applicable for insect disinfestation or for sprout inhibition in potatoes, some loss in total ascorbate may occur.

On the whole, Dr. Louria's concerns do not seem to be well-founded.

References

1. Mead PS, Slutsker L, Dietz V, et al. Food-related illness and death in the United States. Emerg Infect Dis 1999; 5:607–625.
2. Bhaskaram C, Sadasivan G. Effects of feeding irradiated wheat to malnourished children. Am J Clin Nutr 1975; 28:130–135.

3. Vijayalaxmi. Cytogenetic studies in rats fed irradiated wheat [Letter]. Int J Radiat Biol Relat Stud Phys Chem Med 1975; 27:283–285.
4. Vijayalaxmi. Genetic effects of feeding irradiated wheat to mice. Can J Genet Cytol 1976; 18:231–238.
5. Kesavan PC, Sukhatame PV. Summary of the technical report on the data of NIN, Hyderabad and BARC, Bombay, on the biological effects of freshly irradiated wheat. Report submitted to the Joint FAO/IAEA/WHO Export Committee on the Wholesomeness of Irradiated Food, 1996.
6. Federal Drug Administration. Irradiation in the production, processing, and handling of food. Proposal. Federal Regulation 51:13376–13399. Washington: FDA, 1986.
7. George KP, Chaubey RC, Sundaram K, Gopal-Ay-Engar AR. Frequency of polyploid cells in the bone marrow of rats fed irradiated wheat. Food Cosmet Toxicol 1976; 14:289–291.
8. Tesh JM, Davidson ES, Walker S, Palmer AK, Cozens DD, Richardson JC. Studies in rats fed a diet incorporating irradiated wheat. Technical Report IFIP-R45. International Project in the Field of Food Irradiation. Karlsruhe, Federal Republic of Germany: Institut für Strahlentechnologie, 1977.
9. Chi H, Shiping G, Maoqi W, Wenming L, Wenming C, Yin D. A feeding trial of irradiated diet in human volunteers. Presented at United Nations Food and Agriculture Organization/International Atomic Energy Agency (FAO/IAEA). Seminar for Asia and the Pacific on Practical Applications of Food Irradiation, Shanghai, China, April 7–11, 1986.
10. Renner HW. Chromosome studies on bone marrow cells of Chinese hamsters fed a radiosterilized diet. Toxicology 1977; 8:213–222.
11. Fox JB Jr, Thayer DW, Jenkins RK, et al. Effect of gamma irradiation on the B vitamins of pork chops and chicken breasts. Int J Radiat Biol 1989; 55:689–703.
12. Todhunter EN, McMillan T, Ehmke DA. Utilization of dehydroascorbic acid by human subjects. J Nutr 1950; 42297–42308.

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