



The Health Problems of Irradiated Foods: What the Research Shows

In the course of legalizing the irradiation of beef, chicken, pork, fruit, vegetables, eggs, juice, spices and sprouting seeds – a process that has spanned nearly 20 years – the U.S. Food and Drug Administration has dismissed and ignored a substantial and growing body of evidence suggesting that irradiated foods may not be safe for human consumption. The following is a sampling of research – much of which was funded by government agencies and performed at major universities – that raise questions about the FDA's assertion that people who eat irradiated foods have nothing to worry about.

Health Problems in Humans [I]

Fifteen children suffering from severe protein-calorie malnutrition...receiving freshly irradiated wheat developed polyploid cells and certain abnormal cells in increasing number as the duration of feeding increased... Though the biological significance of polyploidy is not clear, its association with malignancy makes it imperative that the wholesomeness of irradiated wheat for human consumption be very carefully assessed.

- Bhaskaram, C., and G. Sadasivan. "Effects of feeding irradiated wheat to malnourished children." *Amer Journ Clin Nutr*, 28:130-135, 1975.

Health Problems in Humans [II]

[After eating gamma-irradiated potatoes for 14 weeks], it was evident that the haemoglobin values were significantly higher *during* the period than *before*. The values were also significantly higher *during* than *after*. An additional comparison of the values *before* with the values *after* shows that a small effect still remains.

- Jaarma, Maire. "Studies of chemical and enzymatical changes in potato tubers and some higher plants caused by ionizing radiation, including studies on the wholesomeness of γ -irradiated potato tubers and effects on some carbohydrates *in vitro*." Biokemiska institutionen, Kungl. Universitetet i Stockholm, 1967.

Health Problems in Humans [III]

Ten young men served as test subjects for this study, [and were fed] pork loin which had been ground ... and subjected to gamma radiation... It is apparent...that there may very well be differences in the digestibility of the foodstuffs from irradiated or non-irradiated meat, and in the ability of protein in irradiated or non-irradiated meat to maintain nitrogen balance.

- Plough, I.C. et al. "An evaluation in human beings of the acceptability, digestibility and toxicity of pork sterilized by gamma radiation and stored at room temperature." U.S. Army Medical Nutrition Laboratory, Fitzsimons Army Hospital, Denver. Report No. 204, May 1957.

Health Problems in Humans [IV]

Thirteen young men served as test subjects, [and were fed] an irradiated food diet...of 8 different food items... The excretion of indophenol-reducing substances was significantly higher ($p < .005$) during the irradiated food periods... Irradiation decreased the thiamine and ascorbic acid content and increased the "browning reaction" derivatives, fat soluble carbonyl compounds, and thiobarbituric acid reactants.

- Bierman, E.D. et al. "Short-term human feeding studies of foods sterilized by gamma radiation and stored at room temperature." U.S. Army Medical Nutrition Laboratory, Fitzsimons Army Hospital, Denver. Report No. 224, July 1958.

Chromosomal Aberrations in Human Blood Cells [I]

Irradiated sucrose solutions...were extremely toxic to human lymphocytes. Mitoses were inhibited... Degenerated mitoses were observed and the chromosomes were grossly damaged. The chromatin [DNA] material was clumped or the chromosomes appeared shattered or pulverized... In contrast, treatment with unirradiated sucrose at the same concentration had no apparent effect on the mitotic rate and the chromosomes were not visibly damaged.

- Shaw, M.W. and Hayes, E. "Effects of irradiated sucrose on the chromosomes of human lymphocytes in vitro." *Nature*, 211:1254-1255, 1966.

Chromosomal Aberrations in Human Blood Cells [II]

Leukocyte cultures from four different healthy human males [underwent] a considerable inhibition of mitosis and chromosome fragmentation. [Additional] research would be extremely prudent.

- Kesavan, P.C. and Swaminathan, M.S. "Cytotoxic and radiomimetic activity of irradiated culture medium on human leukocytes." *Current Science*, 16:403-404, 1966.

A Summary of Problems

Numerous studies have been carried out to ascertain whether cytotoxic effects occur when unirradiated biological test systems are cultured or fed with irradiated media or food. In such studies, adverse physiological (growth retardation and inhibition), cytological (mitotic inhibition and chromosome aberrations) and genetical effects (forward and reverse mutations) have been observed in a wide range of test systems, ranging from bacteriophages to human cells... The available data suggest that [a variety of free radicals] may act as the toxic and mutagenic agents.

- Kesavan, P.C. and Swaminathan, M.S. "Cytotoxic and mutagenic effects of irradiated substrates and food material." *Radiation Botany*, 11:253-281, 1971.

A Thalidomide Warning [I]

The thalidomide disaster might have been prevented if an easily performed investigation of possible cytotoxic effects in plant cells had been made. It must be acknowledged that any compound causing [cellular] damage must be considered a potential hazard to any living cell or cell system – including man.

- Lofroth, G. "Toxic effects of irradiated foods." *Nature*, 211:302, 1966.

A Thalidomide Warning [II]

Irradiating can bring about chemical transformations in food and food components resulting in the formation of potential mutagens, particularly hydrogen peroxide and various organic peroxides... It is now realized, especially since the thalidomide episode, that [older testing] protocols do not detect the more subtle population hazards such as mutagens and teratogens... In view of the serious consequences to the human population which could arise from a high level of induced mutations, it is desirable that protocols for irradiated food should include in *vivo tests* on mammals for possible mutagenicity.

- Schubert, J. "Mutagenicity and cytotoxicity of irradiated foods and food components." *Bulletin of the World Health Organization*, 41:873-904, 1969. (Co-sponsored by the U.S. Atomic Energy Commission and Food and Drug Administration)

A Cancer Warning

An increase in concentration of a mutagen in food by irradiation will increase the incidence of cancer... It will take four to six decades to demonstrate a statistically significant increase in cancer due to mutagens introduced into food by irradiation... When food irradiation is finally prohibited, several decades worth of people with increased cancer incidence will be in the pipeline.

- Tritsch, G.L. "Food Irradiation." *Nutrition*, 16:698-701, 2000.

Unique, Toxic Chemicals Formed in Irradiated Food Containing Fat [I]

When food containing fat is treated by ionizing radiation, a group of 2-alkylcyclobutanones is formed... To date, there is no evidence that the cyclobutanones occur in unirradiated food... *In vitro* experiments using rat and human colon cells indicate that 2-dodecylcyclobutanone (2-DCB)...is clearly cytotoxic and genotoxic... [M]ore experiments than these preliminary ones are required.

- Delincee, H. and Pool-Zobel, B. "Genotoxic properties of 2-dodecylcyclobutanone, a compound formed on irradiation of food containing fat." *Radiation Physics and Chemistry*, 52:39-42, 1998. (Co-sponsored by the International Consultative Group on Food Irradiation.)

Unique, Toxic Chemicals Formed in Irradiated Food Containing Fat [II]

In this study, *in vivo* experiments were conducted on rats, which received two different doses of 2-DCB by way of pharyngeal probe... Slight but significant DNA damage was observed in the experimental group that received the higher concentration of 2-DCB (14.9 mg/kg body weight). Further studies are needed to clarify the relevance of these results to an evaluation of risk from the consumption of irradiated foods.

- Delincée, H. et al. "Genotoxicity of 2-dodecylcyclobutanone." Food Irradiation: Fifth German Conference, Report BFE-R-99-01, Federal Nutrition Research Institute, Karlsruhe, Germany, 1998.

Unique, Toxic Chemicals Formed in Irradiated Food Containing Fat [III]

To date, there is no evidence that 2-alkylcyclobutanones [2-ACB's] occur in unirradiated food, and therefore, it is advisable to determine the toxicological potential... [Human colon tumor cells were incubated with 2-tetradecylcyclobutanone, one particular ACB.] After prolonged incubation times, (1-2 days) at higher concentrations (>50iM), cytotoxicity did appear.

- Delincée, H. et al. "Genotoxicity of 2-alkylcyclobutanones, markers for an irradiation treatment in fat-containing food – Part I: Cyto- and genotoxic potential of 2- tetradecylcyclobutanone." *Radiation Physics and Chemistry*, 63:431-435, 2002.

Unique, Toxic Chemicals Formed in Irradiated Food Containing Fat [IV]

[U]sing an experimental colon carcinogenesis model in rats, 2-ACB's [2-alkylcyclobutanones], when tested at a high concentration, potentiate the effect of an inducing carcinogen on the long term. This was revealed by the increase of colonic neoplastic lesions and the development of a higher number of colon tumours with larger size... This suggests that, in this experiment, 2-ACB's, although they do not induce carcinogenesis, *per se*, rather promote the colonic carcinogenesis process. Finally, it was shown that small fractions of 2-ACB's had been stored in rat adipose tissues and excreted in faeces of the treated rats. This indicates that most of the 2-ACB's is metabolically transformed or stored in other organs...[I]n our opinion further investigations...will help to elucidate a possible risk associated with the consumption of irradiated fat-containing foods.

- Marchioni, E. et al. "Toxicological study to assess the risk associated with consumption of irradiated fat-containing food." (Summary) International Consultative Group on Food Irradiation, Dec. 2001.

Radioactivity in Organs and Excrement of Rats

Considerable amounts of radioactivity were present in the liver, kidney, stomach, gastrointestinal tract, and blood serum of rats [fed irradiated sucrose solutions]... Radioactivity was present in urine and feces samples.

- De, A.K. et al. "Biochemical effects of irradiated sucrose solutions in the rat." *Radiation Research*, 37:202-215, 1969.

Fatal Internal Bleeding in Rats [I]

A significant number of rats consuming irradiated beef died from internal hemorrhage within 46 days, the first death of a male rat coming on the 11th day of feeding. This rat became sluggish on the 8th day of the regimen and started refusing food. He continued [to be] morbid during the next two days, did not eat any food, lost weight and appeared anemic. He was found dead on the 11th day. Post-mortem examination showed hemothorax, the blood had not clotted; there was bleeding also in the epididymis.

- Metta, V.C. et al. "Vitamin K deficiency in rats induced by feeding of irradiated beef." *Journal of Nutrition*, 69:18-21, 1959. (Co-sponsored by the Surgeon General of the U.S. Army)

Fatal Internal Bleeding in Rats [II]

Hemorrhagic death had occurred in all males fed irradiated diets by day 34... There is evidence to suggest that inefficient absorption of vitamins, i.e. vitamin K, from the intestinal tract may contribute to a deficiency state.

- Mellette, S.J. and Leone, L.A. "Influence of age, sex, strain of rat and fat soluble vitamins on hemorrhagic syndromes in rats fed irradiated beef." *Federation Proceedings*, 19:1045-1048, 1960. (Co-sponsored by the Surgeon General of the U.S. Army)

Fatal Vitamin E Deficiency in Rats

A considerable number of the second litter of the experimental group [of rats that ate irradiated beef] died... Symptoms observed were marked edema of the face, ruffled hair coat, general incoordination, spastic hopping gait, and sometimes complete loss of movement with dragging of the hind quarters. Those pups most severely affected often became completely prostrated a short time before death... In no case were these symptoms

noted in the control group... The probability [is that the pups] were suffering from the characteristic muscular dystrophy syndrome (commonly referred to as nutritional muscular dystrophy) known to result from a marginal vitamin E intake.

- Poling, C.E. et al. "Growth, reproduction, survival and histopathology of rats fed beef irradiated with electrons." *Food Res*, 20:193-214, 1955.

Prenatal Deaths in Mice [I]

Freshly irradiated diets produced elevated levels of early deaths in [mice fetuses]... The increase in early deaths would suggest that the diet when irradiated has some mutagenic potential.

- Anderson, D. et al. "Irradiated laboratory animal diets: Dominant lethal studies in the mouse." *Mutation Research*, 80:333-345, 1981.

Prenatal Deaths in Mice [II]

Feeding of mice for two months before mating with 50 percent of the standard complete diet irradiated with [gamma rays] provokes a significant increase of embryonal deaths,... probably to be interpreted as a dominant lethal mutation associated with gross chromosomal aberrations, such as breaks repeatedly found to be induced by irradiated materials.

- Moutschen-Dahmen, M. et al. "Pre-implantation death of mouse eggs caused by irradiated food." *Inter Journ Rad Biol*, 18:201-216, 1970.

Chromosomal Aberrations in Monkeys

The increased incidence of cells with numerical aberrations in animals which received a diet containing freshly irradiated wheat...must be considered significant.... Also, the disappearance of these cells, following the replacement of freshly irradiated wheat with unirradiated wheat, clearly indicates that the appearance of the abnormal cells was due to the ingestion of freshly irradiated wheat.

- Vijayalaxmi. "Cytogenetic studies in monkeys fed irradiated wheat." *Toxicology* 9:181-184, 1978.

Chromosomal Aberrations and Blood Disorder in Rats; Mutations in Mice

[A]n increase of chromosomal aberrations which was significant at the 5 percent level [was observed]... [Later experiments] demonstrated beyond a doubt that this effect is real, and running experiments also indicate an increase of intrauterine foetal death, possibly dominant lethal mutations in the mouse... [A] 15-20 percent decrease of the absolute lymphocyte numbers in the peripheral blood of the rat [was observed]... [T]he lymphopenia produced by irradiated food increased with increasing age of the rats.

- Lofroth, G. et al. "Biological effects of irradiated food. II: Chemical and biological studies of compounds distilled from irradiated food." *Arkiv. Zool.* 18:529-547, 1966.

Chromosomal Aberrations in Mice

Feeding of freshly irradiated wheat resulted in significantly increased incidence of polyploidy cells in bone marrow, aneuploid cells in testis, reduction in number of spermatogonia...as well as a higher mutagenic index... [S]ome toxic substance(s) may be formed during irradiation.

- Vijayalaxmi. "Genetic effects of feeding irradiated wheat to mice." *Canadian Journal of Genetics and Cytology*, 18:231-238, 1976.

Chromosomal Aberrations in Rats

Feeding irradiated wheat to rats was associated with an increase in the number of polyploid cells in the bone-marrow... Irrespective of the protein content in the diet, animals which received irradiated wheat had polyploid cells in their bone-marrow.

- Vijayalaxmi and G. Sadasivan. "Chromosomal aberrations in rats fed irradiated wheat." *Inter Journ Rad Biol*, 27:135-142, 1975.

Chromosomal Aberrations in Hamsters

The proportion of [bone marrow] cells with polyploidy increased between 4 to 5 times the control level... When feeding of the irradiated diet stopped, the proportion of polyploid cells returned to the control level.

- Renner, H.W. "Chromosome studies on bone marrow cells of chinese hamsters fed a radiosterilized diet." *Toxicology*, 8:213-222, 1977.

Genetic Damage in Rats

Well-fed rats, when switched over to a diet of irradiated wheat, showed a higher mutagenic index than those given unirradiated wheat.

- Vijayalaxmi and K.V. Rao. "Dominant lethal mutations in rats fed on irradiated wheat." *Inter Journ Rad Biol*, 29:93-98, 1976.

Immune Dysfunction in Rats

Rats given diets containing freshly irradiated wheat showed significantly lower mean antibody titres to four different antigens, decreased numbers of antibody-forming cells in the spleen and rosette-forming lymphocytes... [T]he consumption of irradiated wheat is associated with changes in the immune status of the animal.

- Vijayalaxmi. "Immune response in rats given irradiated wheat." *British Journal of Nutrition*, 40:535-541, 1978.

Immune Dysfunction in Hamsters

The irradiated fish diet has apparently caused an even greater immunological response than unirradiated fish... [T]he possibility of a mutagen remaining undetected must be considered.

- Renner, H.W. et al. "An investigation of the genetic toxicology of irradiated foodstuffs using short-term test systems. III – *In vivo* tests in small rodents and in *Drosophila melanogaster*." *Food Chemistry and Toxicology*, 20:867-878, 1982.

Reproductive Dysfunction, Cancer, Stunted Growth in Mammals

A careful analysis by FDA of all [Army] data present (including 31 looseleaf notebooks of animal feeding test results) showed significant adverse effects produced in animals fed irradiated food... What were these adverse effects?... A decrease of 20.7 percent in surviving weaned rats... A 32.3 percent decrease in surviving progeny of dogs... Dogs weighing 11.3 percent less than animals on the control diets... Carcinomas of the pituitary gland, a particularly disturbing finding since this is an extremely rare type of malignant tumor.

- Spiher, A.T. "Food irradiation: An FDA report." *FDA Papers*, Oct. 1968.

Reproductive Dysfunction in Rats [I]

Very high losses of litter in the [first] and [second] generations [80 and 85 percent, respectively] in spite of a high fertility rate and normal size of litter in all dietary groups caused at first great difficulty. The suspicion that the animals had obtained too little vitamin E was certified correct.

- Reichelt, D. et al. "Long-term animal feeding study for testing the wholesomeness of an irradiated diet with a high content of free radicals." Federal Research Institute for Food Preservation, Institute for Radiation Technology, Karlsruhe, Germany, 1972.

Reproductive Dysfunction in Rats [II]

An impairment in the fertility of the male and an increased mortality in litters, which [researchers] believed was due to vitamin E destruction.

- DaCosta, E. and Levenson, S.M. "Effect of diet exposed to capacitron irradiation on the growth and fertility of the albino rat." U.S. Army Medical Nutrition Laboratory, Fitzsimons Army Hospital, Denver. Report No. 89, 1951. Cited in Kraybill, H.F. and Huber, T.E. "The wholesomeness of irradiated food and its military implications." Paper to be presented at 63rd Annual Convention, Association of Military Surgeons, United States of America, Hotel Statler, Washington, D.C., Nov. 12-14, 1956.

Reproductive Dysfunction in Mice [I]

Cytogenic examinations of the developing spermatogonia in 30 mice of each group revealed that cytogenetic abnormalities were significantly more frequent in the group fed irradiated flour than in the control group... [T]he incidence of litters [with non-viable offspring] was significantly higher in the group fed irradiated flour... [O]n the average the losses [of young mice] were about 35% higher in the test group than in the controls. The life span of mice fed irradiated flour was slightly shorter than in the control mice.

- Bugyaki, L., A.R. Deschreider, J. Moutschen, M. Moutschen-Dahmen, A. Thijs, and A. Lafontaine. "Do irradiated foodstuffs have a radiomimetic effect? II. Trials with mice fed wheat meal irradiated at 5 Mrad." *Atompraxis* 14:112-118, 1968.

Reproductive Dysfunction in Mice [II]

The mice raised on the irradiated diet exhibited some impairment in lactational performance.

- Luckey, T.D. et al. "Nutritional adequacy of a semi-synthetic diet sterilized by steam or cathode rays." *Food Research*, 20(2):180, 1955. Cited in Kraybill, H.F. "Problems in food processing by ionizing radiations with special reference to wholesomeness studies on irradiated foods." Paper to be presented at Fifth Annual Conference sponsored by Pennsylvania Public Health Association, Pennsylvania Health Council, Medical Society of Pennsylvania, Pennsylvania Department of Health, held at Pennsylvania State University, University Park, Pennsylvania, August 21, 1956.

Reproductive Dysfunction in Fruit Flies

The production of *Drosophila* offspring in cultures containing gamma irradiated chicken meat was much lower... The production...was not increased by changing the basal medium or by adding a vitamin supplement.

- Raltech Scientific Services Inc., Madison, Wisconsin. "Final Report: Evaluation of the mutagenicity of irradiated sterilized chicken by the sex-linked recessive lethal test in *Drosophila melanogaster*." Contract DAMD 17-76-C-6047, submitted to U.S. Army Medical Research and Development Command, Fort Detrick, Frederick, Maryland. June 15, 1979.

Mutations in Fruit Flies [I]

An increase in the rate of mutation has been found in *Drosophila melanogaster* reared on a basic medium that was irradiated with a sterilizing dose (150,000 rads) of cobalt-60 gamma rays... Visible changes were two to six times more frequent in the irradiated series than in the controls,...[such as] half-thorax, vestigial wings and incurved wings.

- Swaminathan, M.S. et al. "Mutations: Incidence in *Drosophila melanogaster* reared on irradiated medium." *Science*, 141:637-638, 1963.

Mutations in Fruit Flies [II]

[S]everal experimental variables in culture medium may be associated with increased mutation frequencies in *Drosophila*; namely irradiated whole food... The increased mutation frequencies associated with flies cultured on aged food implies that the [toxic products] are long lived.

- Rinehart, R.R. and Ratty, F.J. "Mutation in *Drosophila melanogaster* cultured on irradiated whole food or food components." *Intern Journ Rad Biol*, 12(4):347-354, 1967.

Mutations in Fruit Flies [III]

There was an approximate twofold increase in sex-linked recessive lethality [in *Drosophila melanogaster* cultured in irradiated medium]. This increase can be attributed largely to an increase in gonial mutants.

- Rinehart, R.R. and Ratty, F.J. "Mutation in *Drosophila melanogaster* cultured on irradiated food." *Genetics*, 52(6):1119-1126, 1965.

Mutations in Fruit Flies [IV]

[A] small but constant increase in sex-linked and autosomal recessive lethal frequencies [was observed in *Drosophila melanogaster* cultured in irradiated medium]... A linear relationship of dose and effect was obtained with regard to dominant lethals.

- Kesavan, P.C. and Swaminathan, M.S. "Mutagenic effects of irradiated culture media in *Drosophila melanogaster*." *Indian Journal of Genetics*, 29:173-183, 1969. Cited in Kesavan, P.C. and Swaminathan, M.S. "Cytotoxic and mutagenic effects of irradiated substrates and food material." *Radiation Botany*, 11:253-281, 1971.

Stunted Growth of Rats

In general, the irradiated foods produced a depressed growth rate... The effect of the radiation variable is significant... Higher intake coupled with the lower growth rates of rats on the rations containing irradiated carrots resulted in a lower [food] efficiency.

- Tinsley, I.J. et al. "The growth, reproduction, longevity, and histopathology of rats fed gamma-irradiated carrots." *Toxicology and Applied Pharmacology*, 16:306-317, 1970.

Mutations in Salmonella

Groups of Swiss albino mice (SPF) fed with normal and gamma-irradiated food at doses of 0.75, 1.5, and 3.0 Mrad, were injected intraperitoneally with *Salmonella typhimurium* TA 1530 for the host mediated assay test of mutagenesis. The results indicate that there is a significant increase in mutation frequency induced by the 3 Mrad sterilized food.

- Johnston-Arthur T., M. Brena-Valle, K. Turanitz, R. Hruba, and G. Stehlik. "Mutagenicity of irradiated food in the host mediated assay system." *Studia Biophysica*, (Berlin), 50:137-141, 1975.



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