food&waterwatch

Fact Sheet

Food Irradiation and Vitamin Loss

In 2007, Indian mangoes made their first trip in 18 years to the United States. While the U.S. government hailed the fact that irradiation had been used to kill any pests that might have been living in or on the fruit before its overseas ride, consumers should question how exposing mangoes to high levels of ionizing radiation affects the nutritional quality of the fruit. During storage, for example, irradiated mangoes can lose more than half of their vitamin C.[1]

Irradiation has three main purposes: to eradicate pests such as fruit flies on harvested crops, to extend the shelf life of food, and, with a higher radiation dosage, to kill disease-causing microorganisms such as *E. coli* and *Salmonella*.

What Food is Irradiated?

In addition to Indian mangoes, irradiated lemons from South Africa can now be shipped to the United States. Starting on July 23, 2007, Thailand was allowed to export irradiated mangoes, mangosteens, pineapples, rambutans, litchis, and longans to the United States.[2] Additionally, the Mexican company Phytosan plans to build two facilities to irradiate tropical fruits for export to the United States, although its plans have been met with significant local opposition.[3] Some spices and seasonings also are irradiated, but many brands available in grocery stores are not.

Within the United States, some meat is irradiated, but it has not been commercially successful due to public distrust. Since 2004, when schools were first offered irradiated meat through The U.S. Department of Agriculture's National School Lunch Program, not a single school system has purchased irradiated ground beef from USDA. Hawaii hosts one facility that irradiates papayas and other tropical fruits. However, plans for a second facility on Oahu have been delayed by local opposition and a legal challenge.

Irradiated Indian mangoes at a Department of Agriculture press conference.

How Does Food Irradiation Destroy Vitamins?

When food is irradiated, ionizing radiation reacts with water in the food, causing the release of electrons and the formation of highly reactive free radicals. The free radicals interact with vitamins in ways that can alter and degrade their structure and/or activity.[4] The extent to which vitamin loss occurs can vary based on a number of factors, including the type of food, temperature of irradiation, and availability of oxygen. Nonetheless, vitamin loss almost always increases with increasing doses of radiation.

The destruction of vitamins continues beyond the time of irradiation. Therefore, when irradiated food is stored, it will experience greater vitamin loss than food that has not been irradiated. Cooking further accelerates vitamin destruction in irradiated food more than in non-irradiated food.[5]

The very fact that irradiation is used to extend the shelf life of food compounds the issue of vitamin loss. For example, an irradiated mango can sit in a crate for a longer time without rotting, but it will continue losing vitamins for the period after which a non-irradiated mango would

Food	Legal Dose of Radiation	Vitamins Lost
Mango[6]	1.0 kGy	Vitamin C
Mandarin orange[7]	1.0 kGy	Vitamin C
Grapefruit[8]	1.0 kGy	Vitamin C
Apple[9]	1.0 kGy	Vitamin C
Potato[10]	1.0 kGy	Vitamin C
Oats[11]	1.0 kGy	Thiamin
Wheat flour[12]	1.0 kGy	Thiamin
Pork[13]	1.0 kGy	Thiamin
Chicken[14]	3.0 kGy	Thiamin & Vitamin E
Turkey[15]	3.0 kGy	Thiamin
Beef[16]	4.5 kGy	Thiamin
Lamb[17]	4.5 kGy	Thiamin

Radiation Doses from Food Irradiation Compared to Chest X-Rays

A kiloGray (kGy) is the unit of measuring radiation unique to the process of food irradiation. In the United States, fruits and vegetables are irradiated with up to one kGy, which equals the radiation output of approximately 33 million chest x-rays. Fresh meat and poultry are irradiated with up to 4.5 kGy, which equal the radiation output of approximately 150 million chest x-rays.

have been discarded. Therefore, a direct comparison between the vitamin content of irradiated versus non-irradiated food stored for an equal length of time actually understates the extent of the problem.

What Vitamins Are Affected by Food Irradiation?

Vitamin C, vitamin B1, and, vitamin E are reduced in foods exposed to commercial levels of irradiation (1 kGy – 4.5 kGy). Studies at higher levels of irradiation also have demonstrated the destruction of vitamins A and K in food.[18]

Vitamin C

Fruits and vegetables, such as oranges and potatoes, are important sources of vitamin C, which is important for healthy gums, teeth, bones, and muscles. It helps to heal wounds, fight infection, and may also reduce the risk of heart disease, cancer, and cataracts.

At the low doses of 0.3 to 0.75 kGy, food irradiation has been found to destroy up to 11 percent of vitamin C in fruit before storage, and up to 79 percent of vitamin C after three weeks of storage.[19] Additionally, at the limit of its shelf life (270 days) irradiated mango pulp contains 57 percent less vitamin C than non-irradiated mango pulp at the limit of its shelf life (60 days).[20]

Vitamin B1 (Thiamine)

Whole grains, beans, and meat are important sources of thiamine, which helps convert carbohydrates into energy. It is essential for heart, muscle, and nervous system function. Wheat flour irradiated at the low dose of 0.25 kGy lost up to 20 percent of thiamine initially and 62 percent after three months of storage.[25] Beef irradiated at 3.0 kGy, which is below the legal limit, experienced a 19 percent loss of thiamine.[26]

Food	Vitamin Lost	% Loss from irradiation before storage[a]	% lower vitamin content than non-irradiated food after 15 days of storage[b]	% lower vitamin content than non-irradiated food after 16-35 days of storage[d]
Mango[21]	Vitamin C	11%	33%	N/A
Mango pulp[22]	Vitamin C	8%	10%	8%
Mandarin orange[23]	Vitamin C	4-17%	6%	11-60%
Grapefruit[24] (late harvest)	Vitamin C	0%	N/A	11%

Food	Vitamin Lost	% loss from irradiation before storage[a]	% lower vitamin content than non-irradiated food after three months of storage[b]	% lower vitamin content than non-irradiated food after three months of storage and then being cooked[d]	% lower than non-irradiated food after eight months of storage (uncooked)[f]
Wheat flour[27]	Thiamine	20%	62%	55%	42%
Oats[28]	Thiamine	37%	57%	66%	N/A
Oats[29]	Vitamin E	17%	40%	34%	59%
Hazelnuts[30]	Vitamin E	17%	38%	58%	N/A

Vitamin E

Oils, corn, nuts, seeds, and green vegetables are important sources of vitamin E, an antioxidant that protects body tissues and cells. It also may improve the immune system and help fight heart disease, cancer, Alzheimer's disease, and cataracts. Hazelnuts irradiated at 1.0 kGy lost 17 percent of vitamin E upon irradiation, and 58 percent of vitamin E after three months of storage and 30 minutes of baking.[31]

What You Can Do:

Before biting into an irradiated mango from India or Thailand, consumers should be aware that these fruits are likely less nutritious than their counterparts that have not been exposed to radiation.

- Be on the lookout for the irradiation symbol on the label, and avoid such foods.
- For the highest vitamin content, buy locally produced foods, which likely are fresher than food from hundreds or thousands of miles away. Ask your senators and representative in Congress to support accurate labels on irradiated food, and not allow the Food and Drug Administration to weaken labeling rules by allowing some irradiated food to be labeled as "pasteurized" and other irradiated food to be sold unlabeled.

The radura is the symbol for irradiated foods.

Food	Vitamin Lost	% Loss from irradiation raw[a]	% less than non-irradiated food after cooking[b]
Pork[32]	Thiamine	5-9%	8-14%
Beef[33]	Thiamine	19%	N/A
Chicken[34]	Vitamin E	30-55%	N/A

Endnotes

[1] Lacroix, Monique. "Effect of irradiation on the biochemical and organoleptic changes during the ripening of papaya and mango fruits." Radiat. Phys.Chem., 35(1-3): 296-300, 1990.

[2] Karp, David. "Thailand will be allowed to ship once-forbidden fruit." San Jose Mercury News, July 4, 2007.

[3] Morales, Rosa María. "Camelenses exigen informe de Phytosan." Pulso (San Luis Potosí, Mexico), June 24, 2007.

[4] Murano, Peter. *Food Irradiation: A Sourcebook.* Ed. Dr. Elsa Murano, Iowa State University: Blackwell Pub Professional, 1995.

[5] Diehl, J.H. "Combined effects of irradiation, storage, and cooking on the vitamin E and B1 levels of foods." Food Irradiation, 10: 2-7, April 14, 1967.

[6] Youssef, Bothaina M. et al. "Combined effect of steaming and gamma irradiation on the quality of mango pulp stored at refrigerated temperature." Food Research International, 35: 1-13, 2002; Mitchell, G.E. et al. "Effect of low dose irradiation on composition of tropical fruits and vegetables." Journal of Food Composition and Analysis, 5: 291-311, 1992; Lacroix, Monique. "Effect of irradiation on the biochemical and organoleptic changes during the ripening of papaya and mango fruits." Radiat. Phys.Chem., 35(1-3): 296-300, 1990; Beyers, Marguerite and Thomas, Austin C. "γ Irradiation of subtropical fruits. 4. Changes in certain nutrients present in mangoes, papayas, and litchis during canning, freezing, and γ irradiation." J. Agric. Food Chem., 27(1): 48-51, 1979.

[7] Ladaniya, M.S. et al. "Response of 'Nagpur' mandarin, 'Mosambi' sweet orange, and 'Kagzi' acid lime to gamma irradiation." Radiation Physics and Chemistry, 67: 665-675, 2003; Mitchell, G.E. et al. "Effect of low dose irradiation on composition of tropical fruits and vegetables." Journal of Food Composition and Analysis, 5: 291-311, 1992.

[8] Patil, Bhimanagouda S., et al. "Irradiation and storage influence on bioactive components and quality of early and late season 'Rio Red' grapefruit (Citrus paradisi Macf.)." Postharvest Biology and Technology, 34: 53-64, 2004.

[9] Lee, C.Y. and Salunkhe, D.K. "Effects of gamma radiation on freeze-dehydrated apples (Pyrus malus)." Nature, 210(5039): 971-972, May 28, 1966.

[10] Wang, Jun and Du Yaoshun. "The effect of γ-ray irradiation on the drying characteristics and final quality of dried potato slices." International Journal of Food Science and Technology, 40: 75-82, 2005.

[11] Diehl, J.F. "Combined effects of irradiation, storage and cooking on the vitamin E and B1 levels of food." Presented at the 33rd Annual Meeting of the American Institute of Nutrition, Atlantic City, NJ, Apr. 14, 1969.

[12] Ibid.

[13] Fox, Jay B. Jr. et al. "Thiamin, riboflavin and α-tocopherol retention in processed and stored irradiated pork." Journal of Food Science, 62(5): 1022-1025, 1997; Fox, Jay B., Jr. et al. "Gamma irradiation effects on thiamin and riboflavin in beef, lamb, pork, and turkey." Journal of Food Science, 60(3): 596-598, 1995; Fox, J.B. Jr. et al. "Effect of gamma irradiation on the B vitamins of pork chops and chicken breasts." International Journal of Radiation Biology, 55(4): 689-703, 1989; Jenkins, R.K. et al. "Effect of low-dose irradiation and post-irradiation cooking on the thiamin content of fresh pork." Journal of Food Science, 54(6): 1461-1465, 1989.

[14] Lakritz, L. and Thayer, D.W. "Effect of ionizing radiation on unesterified tocopherols in fresh chicken breast muscle." Meat Science, 32: 257-265, 1992; Hanis, T. et al. "Poultry meat irradiation—effect of temperature on chemical changes and inactivation of microorganisms." Journal of Food Protection, 52: 26-29, 1989, cited in Kilcast, David. "Effect of irradiation on vitamins." Food Chemistry, 49: 157-164, 1994.

[15] Fox, Jay B., Jr. et al. "Gamma irradiation effects on thiamin and riboflavin in beef, lamb, pork, and turkey." Journal of Food Science, 60(3): 596-598, 1995.

[16] Fox, Jay B., Jr. et al. "Gamma irradiation effects on thiamin and riboflavin in beef, lamb, pork, and turkey." Journal of Food Science, 60(3): 596-598, 1995; Wilson, G.M. "The treatment of meats with ionizing radiations. II. —Observations on the destruction of thiamine." J. Sci. Food Agric. 10: 295-300, May 1959.

[17] Fox, Jay B., Jr. et al. "Gamma irradiation effects on thiamin and riboflavin in beef, lamb, pork, and turkey." Journal of Food Science, 60(3): 596-598, 1995.

[18] Stevenson, M.H. "Nutritional and other implications of irradiating meat." Proceedings of the Nutrition Society, 53: 317-325, 1994; Metta, V.C., et al. "Vitamin K deficiency in rats induced by feeding of irradiated beef." Journal of Nutrition, 69: 18-21, 1959.

[19] Mitchell, G.E. et al. "Effect of low dose irradiation on composition of tropical fruits and vegetables." Journal of Food Composition and Analysis, 5: 291-311, 1992.

[20] Youssef, Bothaina M. et al. "Combined effect of steaming and gamma irradiation on the quality of mango pulp stored at refrigerated temperature." Food Research International, 35: 1-13, 2002.

[21] Mitchell, G.E. et al. "Effect of low dose irradiation on composition of tropical fruits and vegetables." Journal of Food Composition and Analysis, 5: 291-311, 1992; Lacroix, Monique. "Effect of irradiation on the biochemical and organoleptic changes during the ripening of papaya and mango fruits." Radiat. Phys.Chem., 35(1-3): 296-300, 1990; Beyers, Marguerite and Thomas, Austin C. "γ Irradiation of subtropical fruits. 4. Changes in certain nutrients present in mangoes, papayas, and litchis during canning, freezing, and γ irradiation." J. Agric. Food Chem., 27(1): 48-51, 1979.

[22] Youssef, Bothaina M. et al. "Combined effect of steaming and gamma irradiation on the quality of mango pulp stored at refrigerated temperature." Food Research International, 35: 1-13, 2002.

[23] Ladaniya, M.S. et al. "Response of 'Nagpur' mandarin, 'Mosambi' sweet orange, and 'Kagzi' acid lime to gamma irradiation." Radiation Physics and Chemistry, 67: 665-675, 2003; Mitchell, G.E. et al. "Effect of low dose irradiation on composition of tropical fruits and vegetables." Journal of Food Composition and Analysis, 5: 291-311, 1992.

[24] Patil, Bhimanagouda S., et al. "Irradiation and storage influence on bioactive components and quality of early and late season 'Rio Red' grapefruit (Citrus paradisi Macf.)." Postharvest Biology and Technology, 34: 53-64, 2004.

[25] Diehl, J.F. "Combined effects of irradiation, storage and cooking on the vitamin E and B1 levels of food." Presented at the 33rd Annual Meeting of the American Institute of Nutrition, Atlantic City, NJ, Apr. 14, 1969.

[26] Wilson, G.M. "The treatment of meats with ionizing radiations. II. —Observations on the destruction of thiamine." J. Sci. Food Agric. 10: 295-300, May 1959.

[27] Diehl, J.F. "Combined effects of irradiation, storage and cooking on the vitamin E and B1 levels of food." Presented at the 33rd Annual Meeting of the American Institute of Nutrition, Atlantic City, NJ, Apr. 14, 1969.

[28] Ibid.

[29] Ibid.

[30] Ibid.

[31] Ibid.

[32] Fox, J.B. Jr. et al. "Effect of gamma irradiation on the B vitamins of pork chops and chicken breasts." International Journal of Radiation Biology, 55(4): 689-703, 1989; Jenkins, R.K. et al. "Effect of low-dose irradiation and post-irradiation cooking on the thiamin content of fresh pork." Journal of Food Science, 54(6): 1461-1465, 1989.

[33] Wilson, G.M. "The treatment of meats with ionizing radiations. II. —Observations on the destruction of thiamine." J. Sci. Food Agric. 10: 295-300, May 1959.

[34] Lakritz, L. and Thayer, D.W. "Effect of ionizing radiation on unesterified tocopherols in fresh chicken breast muscle." Meat Science, 32: 257-265, 1992.

For more information:
web: www.foodandwaterwatch.org
email: foodandwater@fwwatch.org
phone: (202) 797-6550