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Dietary Carcinogens

In this issue of *Science*, Bruce Ames reviews the increasing body of evidence that large numbers of potent carcinogens arise from natural processes. Mutagens are present in substantial quantities in fruits and vegetables. Carcinogens are formed in cooking as a result of reactions involving proteins or fats. Dietary practices may be an important determinant of current cancer risks.

Ames describes the role of plant materials as follows: Plants in nature synthesize toxic chemicals in large amounts, apparently as a primary defense against the hordes of bacterial, fungal, and insect and other animal predators. Plants in the human diet are no exception. The variety of toxic chemicals is so great that organic chemists have been characterizing them for over 100 years, and new plant chemicals are still being discovered. Recent widespread use of short-term tests for detecting mutagens and the increased testing of plant substances for carcinogenicity in animals have contributed to the identification of many natural mutagens, teratogens, and carcinogens in the human diet.

Safrole and related compounds are present in many edible plants. Safrole is a carcinogen in rodents and some of its metabolites are mutagens. Oil of sassafras, once used to flavor some root beer, is about 75 percent safrole. Black pepper contains about 10 percent by weight of a closely related compound, piperine. Extracts of black pepper at a dose equivalent to 4 milligrams of dried pepper per day cause tumors in mice at many sites. Many hydrazines are carcinogens and mutagens, and large amounts of them are found in edible mushrooms. One carcinogenic hydrazine is present in the false morel at a concentration of 50 milligrams per 100 grams. It causes lung tumors in mice at a level of 20 micrograms per mouse per day.

Carcinogens and mutagens are present in mold-contaminated foods such as corn, nuts, peanut butter, bread, cheese, and fruit. Some of these contaminants, such as aflatoxin, are among the most potent known carcinogens and mutagens. Nitrosamines and nitroso compounds are suspect as causative agents of stomach and esophageal cancer in humans. In the digestive system these nitrogen compounds are formed from nitrate and nitrite. Beets, celery, lettuce, spinach, radishes, and rhubarb all contain about 200 milligrams of nitrate per 100-gram portion.

Rancid fats are possible causative agents of colon and breast cancer in humans. These forms account for a substantial fraction of all the cancer deaths in the United States. Unsaturated fats are easily oxidized on standing and in cooking to form mutagens, promoters, and carcinogens. Among the numerous products of such oxidations are fatty acid hydroperoxides and cholesterol epoxide. Thus the colon and digestive tract are exposed to many fat-derived carcinogens. Human breast fluid can contain high levels of cholesterol epoxide.

Burnt and browned materials formed by heating proteins during cooking are highly mutagenic. Chemicals isolated from such products have been found to be carcinogenic when fed to rodents. In addition, the browning reaction products from caramelization of sugars or the reaction of amino acids and sugars during cooking contain a large variety of DNA-damaging agents.

The view that dietary practices might be a causative factor in cancer is not new. Epidemiologists have noted marked differences in cancer rates between population groups. Effects from changes in diet following migration have also been observed. Results of current studies are beginning to delineate more sharply specific causative agents. When more definitive information is available, it should be possible for prudent people to choose fruits and vegetables that present minimal hazards. In the meantime, there is persuasive evidence that charred meats and rancid fats should not be part of the diet.—PHILIP H. ABELSON