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Identification, Effects, and Control of Food Contamination

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At a TIME when boosting food production is a national and international priority, there is compelling evidence that there is an urgent need to identify food contaminants, to evaluate their hazards, and to take such steps as may be needed to protect consumers against contaminated foods. This report is concerned with the various forms of contamination that can cause severe and sometimes fatal illness in animal and man—namely, biological, chemical, and radioactive environmental exposures—and with the great waste of food and economic losses caused by insect infestation and bacterial and other forms of contamination.

The purposes of this report are to illustrate the important types of contamination, to assess the magnitude and nature of risk, and to examine practical preventive and control approaches in dealing with the many pollutants and contaminants that may affect the health and well-being of man.

Characteristics of Food Contamination

Food contaminants come from the immediate environment in which a food is grown, harvested, stored, or prepared.^{1,2,3} Unless food is adequately protected, it is subject to environmental contamination at every stage from production to consumption.

Two of the more prevalent forms of biological contamination are filth and microbiologic agents.^{4,5,6,7,8,9} either of which can inflict illness in both man and lower animals. At least 30 diseases are considered transmissible to man through milk, meat, poultry, eggs, and other animal products. Animal products may also be the source of parasitisms. Fish and shellfish grown in polluted waters may carry pathogenic bacteria, viruses, or parasites to man. We also must recognize the importance of vermin contamination. Insects infest and damage growing crops to such extent that the crops become unacceptable for food use. Rodents and insects destroy, infest, or contaminate great quantities of food.

Amid this vast array of exposures, naturally occurring substances^{10,11,12,13,14,15,16,17} having extremely high toxicity have been identified in certain food components. Research on mycotoxins led to the discovery of many toxicogenic fungi as well as many toxic fungal metabolites.¹⁸ The fungi can be toxic only to the plant itself, and control is necessary to prevent loss of the crop. In some cases, however, the fungi produce highly toxic chemicals that present a hazard to the consumer. A specific example would be aflatoxin-related compounds

in the milk of animals after the use of feeds containing the toxin of this particular fungus.

With increasing industrialization, large numbers of new chemical compounds have been contributed to the environment.^{19,20} The question repeatedly being asked is, "What adverse impacts do uses of chemicals exercise on man's health today?" Usually the firmest basis for answering this question is to begin from estimates of death linked to chemical causes. Chemical pollution^{10,11,12,13,14,15,16,17} may be accidental and sometimes have grave consequences but is more often caused by contamination with unsafe residues via a variety of routes of exposure. New pesticides^{10,11,12,13,14} have been synthesized and widely used; use of antibiotics²¹ and other new veterinary drugs and feed additives has become common; industrial wastes containing many pollutants and agricultural effluents from animals have been allowed to burden the environment. All of these sources have increased the opportunity for environmental contamination and the exposure of foods to contamination with toxic chemicals.

Recent findings by the Food and Drug Administration involved 2 such environmental pollutants, polychlorinated biphenyls (PCB)^{1,2,3,10,11,12,13,14,15,16,17,18,19,20,21,22,23,24,25} and polybrominated biphenyls (PBB). The latter compound, a highly toxic flame retardant, was reported to have been mistaken for magnesium oxide, a feed supplement, resulting in contamination of several thousand cattle, swine, sheep, chickens, and eggs and cheese produced from animals carrying the chemical residues. Though current knowledge of biological activity of PBB is not complete, available evidence dictates immediate action to preclude environmental exposure. It is known that, like PCB, PBB residues accumulate in fat, including human fat, and that they can be distributed through man's food chain, just like PCB has been dispersed into the environment. Certain toxicologic properties of PCB^{1,2,3,10,11,12,13,14,15,16,17} are being discovered only now, more than 40 years after the introduction of PCB into commerce and some 5 years after their identification as widespread environmental pollutants.

Recently there has been increasing concern over metallic contaminants^{12,13,14,15,16,17,18,19,20,21,22,23,24,25} because of their toxic effects and their importance as environmental hazards. Heavy metals such as lead, arsenic, mercury, copper, antimony, zinc, selenium, and cadmium occur naturally in water and some soils, but usually in trace amounts that present no hazard to human health. Streams may become contaminated with dangerous loads of heavy metals from mine wastes or industrial pollution. Even when the heavy metal content does not make the water unsafe to drink, fish or other organisms

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may concentrate it to hazardous concentrations. Residues of antibiotics, sulfonamides, nitrofurans, and other veterinary drugs may appear in meat, milk, or other animal foods unless the use is discontinued long enough before the animal is slaughtered for meat or the animal products are marketed.

Radiologic contamination has most commonly been the result of fallout of radioactive materials after nuclear blasts. More recently, however, such contamination has occurred from radionuclides in wastes released from nuclear energy installations. It has been demonstrated that some radionuclides have been concentrated in animal or marine foods, including edible seaweed.

Effects of Food Contamination

The problem is to assess risks to health from various environmental contaminants. Both the way the threat affects health and the way health workers assign its importance are far from direct. The magnitude and nature of risk varies case by case. Generally, the effects all fall into 2 categories—health hazards and economic implications. A particular threat in sufficient amounts may have acute effects almost immediately or be more subtle and be suspected by its delayed response and have accumulative effects on man or other animals. Good examples of an acute contamination are paralytic shellfish poisoning and arsenic poisoning. Other episodes of illness with a high percentage of fatalities due to accidental contamination of foods include poisoning with endrin or parathion. For infective microorganisms^{3,10,35,40} like salmonella the effects may be mild, but in the case of infants or the aged, they may be quite severe and often fatal. In the cases of diseases such as infectious hepatitis and brucellosis, a prolonged and debilitating illness is followed by slow convalescence. Food contamination from parasites⁹ such as that due to trichinella in pork often causes a delayed, painful condition in man.

Serious delayed neurologic damage was caused by methylmercury¹⁸ in fish and shellfish in one area of Japan. In other areas the contaminant caused a number of deaths, serious injuries, and congenitally affected babies. In these cases, the direct cause was contaminated fish containing 5 to 20 ppm of methylmercury. Another reported incident in Japan was the pollution of the environment with cadmium, resulting in the removal of calcium from affected bones, causing easy breakage and deformity (Itai Itai disease).⁴¹

In the case of antibiotic residues^{41,42} in food products from treated animals, the potential hazard to man's health may cause pathogenic bacteria to develop strains of organisms that are resistant to antibiotics used for therapeutic treatment in man or they may sensitize the person so he cannot be treated with antibiotics.

Some food contaminants are known to be carcinogenic to lower animals and are suspected of causing cancer in man. A good example is aflatoxins produced by *Aspergillus flavus* growing on peanuts, Brazil nuts, corn, and certain other foods. Aflatoxins are powerful carcinogens in trout, turkey poult, ducklings, and other animals.^{5,8,43} The nitrosamines,⁴¹ which can be

formed in foods treated with nitrates and nitrites,⁷ have been shown to cause cancer in many animal tissues.

Certain pesticides,^{25,31} including aldrin, dpt, dieldrin, and heptachlor have induced tumors in laboratory animals. Conclusive evidence that they cause cancer in human beings at lower levels of exposure is still lacking. Some of these pesticides are found to concentrate in oysters and mussels grown in polluted water; however, there is yet no definite proof that these substances have caused health hazards to the consumer. Some chemicals are capable of causing genetic damage, which would not manifest itself until future generations. High energy radiation also has the potential of causing this particular health effect. Other chemicals may adversely affect reproduction.^{26,41} For example, mercury and cadmium have been shown to cause fetal deaths.

The toxic effects resulting from PCB and PBB residues have not been well established. Cases have been reported in Japan attributed to the ingestion of rice bran contaminated with PCB residues. The acute lethal dose of some of the PCB is relatively low. Toxicologic studies⁶ of PCB are complicated by the fact that the PCB consist of mixtures of many isomers with potentially different toxicities. Studies have been further complicated by the fact that commercial batches were discovered to contain highly toxic contaminants which may be toxicologically significant at concentrations too low for detection by existing techniques. Thus the case of the PCB has demonstrated again that routine toxicologic testing of pure compounds is inadequate to detect all the potential toxic effects that may be significant in our environment.

Low-level, long-term exposure to chemical contaminants can cause detrimental health effects. Exposure to mercury, lead, or certain other heavy metals has caused accumulative damage to vital systems and body organs and has adversely affected reproduction.

The economic losses due to food contamination are enormous. Even when there is no hazard to human health, growing crops may be rendered unfit for use by damage from insects or contamination with biological agents that cause the food to become so repulsive in taste, appearance, or odor that it is unfit for use. Common examples include milk with odors or flavors from certain plants the cow eats. Decaying sludge in estuaries sometimes releases hydrogen sulfide, imparting an unpleasant appearance, odor, and taste to clams or oysters.

Remember the old saying about how a horse and rider were lost because somebody neglected to tend to a small matter like a missing horseshoe nail? Some scientists and agriculturists are worried that the same sort of ballooning consequences may stem from what many people probably consider to be a minor irrelevancy. Slowly but steadily, the nation's honeybees are being exterminated; not on purpose, of course, but as the honeybees forage for pollen and nectar they increasingly are gathering poison, including pesticides that farmers apply to protect their crops from destructive insects. Some crops already are threatened by a lack of bees. Among these crops are almonds, apples,

cherries, plums, broccoli, cucumbers, cabbage, melons—indeed, virtually all fruits and berries as well as many vegetables and even some livestock—forage crops such as alfalfa. Thus, at a time when boosting food production is becoming a global priority, the fate of honeybees takes on some of the significance of the proverbial horse-shoe nail.

In slaughter plants, millions of pounds of meat and poultry and their parts must be condemned each year because of diseased conditions¹ or residues of pesticides, veterinary drugs, or environmental contaminants in excess of legal tolerances.

During transportation, foods may become spoiled, infected with insects, or contaminated by rodents. Many of these foods are sources of high-quality protein and the losses add to the nation's and world's deficiency of protein. One must not overlook the financial costs for medical care, hospitalization, and loss of wages when persons are made ill by contaminated foods. In addition, potential growing areas are being abandoned for food and forage because of pollution. Added to these are the losses of international trade, incurred whenever a food is denied entry in world trade.

Prevention and Control of Food Contamination

As new technical advances are made to meet our increased food production needs, practical prevention and control approaches must be applied in unison to maintain consumer confidence in the wholesomeness of the food they purchase and to retain the credibility of the agriculture businessman who produces it. Simultaneous actions are needed to provide for the general safety of all involved, to protect consumers against harm from contaminated foods, and to protect the environment against long-term degradation. The American system depends heavily on the producer and processor for prevention and control of food contamination. The chemical and drug producer has an inherent responsibility to the farmer and rancher to meet product compositional and quality requirements and to provide informative-use labeling, including misuse warnings. In using drugs, the veterinarian has a responsibility to help the food producer avoid costly problems. Instructions on withdrawal times necessary to meet requirements with respect to residues in animal products should be provided and followed, as given on labeling and packaging inserts. The attention of health authorities and educators should be drawn to meet the needs of practitioners, students, and producers. There appear to be some major areas and concepts where public education is needed to avoid contamination of foods and feed. Because of the scientific and technical nature of the problems associated with food contamination, scientists must engage actively in the process of interpretation. In the past, some have avoided this responsibility because of the hazards of public controversy.

In contamination problems, we are confronted in each case with weighing the risk involved. The risk/benefit ratio must be balanced and carefully considered by the producer, control official, and consumer.

Almost any analysis of past decisions in the area

of food contamination reveals decision making in a heavy climate of crisis. This applies to the collection of data as well as to making decisions on the basis of the information generated. There is a widely recognized need for environmental forecasts that will detail plans for prevention or containment of adverse impacts. The total plan should develop priorities for research aimed at illuminating effects on animal and human health as well as the environment—as far in advance of major decisions and technologic developments as possible.

Immediate prevention and control approaches relate directly to municipal, state, and national food control laws and to enforcement organizations. The competence of the enforcement organizations must be adequate to deal with complex problems in the processing, storage, and marketing of foods, and to protect consumers against widespread contamination. The importance of maintaining enforcement organizations, laboratories with trained staffs, and education of food handlers and consumers cannot be underestimated and is an integral part of the problem of prevention and control. A food-contamination monitoring system based on national monitoring data should be kept current. Such a system would detect trends in food contamination, assess probable effects on human health and food supplies, and inform and advise on how to best prevent or prepare to handle developing problems that can erode food resources.

The large and growing number of chemical substances and environmental pollution problems introduced into man's environment emphasize the necessity to focus efforts on increasing knowledge of environmental effects on human and animal health, thereby providing information that will contribute to an early warning system. I am convinced a number of problems in the area of food contamination control can and will be solved through education.

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Mumps Suspected in a Dog

In November, 1974, a 6-year-old Labrador Retriever-type bitch was examined because it had a body temperature of 40 C (104 F), greatly enlarged and painful submaxillary lymph nodes, and edema of the jaw. The dog had been depressed and anorectic for 24 hours. The owner asked if the dog had mumps because a 16-month-old child in the family had been diagnosed as having mumps the previous day. Blood samples collected 2 days after initial examination and 7 weeks later were submitted to a public health laboratory for evaluation. Presence of antibody titers indicated that the dog had responded to a mumps virus challenge and that when the first sample was taken the disease was well established. The signs were similar and occurred at the same time as those in the child.—R. E. Smith in *Vet Rec*, 96, (March 29, 1975): 296.

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