SECOND PRINTING

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Food Safety

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Dedication

I would like to dedicate this book to my parents, who instilled in me the love of learning and the idea that, as a woman, I needed a career, and to my husband David and my sons Christopher and Nicholas Jones.

Preface

We are bombarded daily with seemingly conflicting information about the safety of our food and the food supply. Newspapers, talk shows, books, news magazines, and even fashion magazines discuss food safety. Interpreting the information is frequently very difficult, even for professionals. Often it is difficult to determine the true picture when aspersions are cast on a substance used in the food supply, as the information may be in a research journal held by only one or two libraries in a state. In some cases, the information may be only partially presented, providing a distorted view of the situation. In other cases, the information about a substance may be accurately presented but neither the consumer nor the scientist is able to extrapolate from the reactions to large doses fed under experimental conditions to what will happen when extremely small amounts are consumed under normal dietary conditions.

It is my hope that this book will prove useful to students and professionals alike, especially those just entering or contemplating entering upon a career in food or nutrition. While the information in each chapter may or may not be news to experienced researchers in the field of its particular subject matter, all 15 chapters taken as a whole should provide a perspective on food safety issues not usually available in a single volume. For each issue, the risks and benefits to consumers are considered, as well as environmental, agricultural, and economic concerns. Widely available, inexpensive food is among the benefits considered important for the whole of society.

I hope that food scientists and other food professionals, dietitians and professional nutritionists, food editors and other journalists, home economists, and students will all find this a ready reference for their food safety questions.

I would like to thank all of the staff at Eagan Press for their tireless work in helping to get the manuscript into book form and also Elwood Caldwell for his suggestions on the content of the chapters and his editorial expertise.

Julie Miller Jones

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An Overview of Food Safety

CHAPTER 1

For many things in life, what we want is not necessarily the same as what actually is. Food clearly fits this truism. On an emotional level, we think of food as that which sustains life. This endows food with an almost spiritual quality. On a factual level, we are bewildered to learn that food is comprised of an array of chemicals put there by Mother Nature herself. This undermines our notion that food is an uncomplicated, pure source of essential nutrients. Despite being told that only a small percentage of dietary chemicals possess nutritional significance, we want desperately to cling to the myth that natural foods and combinations of them are inherently pure and salutary.

We don't mind learning that some of the constituents of food enhance nutritive value; in fact, we pay little attention to these discoveries because it is only what we expect. On the other hand, we feel betrayed when we learn that some constituents or combinations of natural foods contain things that decrease nutritional value or, worse yet, are toxic (Daniel, 1991; Kada, 1983; Rosin, 1982). This violates a basic sense of order that we feel ought to occur, and as a result we either remain uninformed or disbelieve the reports.

Since it fits much better with the way we believe things ought to be, we shift our attention from natural toxicity to toxicity from chemicals added to food either intentionally or unintentionally during production and processing. We also choose not to acknowledge that cooking, storing, and processing create new components and different interactions, which may either create toxic factors or render them completely innocuous.

Complexity is increased still more because of the interactions among body fluids and components of the diet. Such interactions may prove either beneficial or harmful. For example, human saliva has the inherent capacity to inactivate a wide spectrum of cancer-causing agents (carcinogens) that enter the body through food. This is true even though the inactivation capacity may be overpowered by excessive use of known carcinogens such as tobacco (Rosin and Stich, 1983). On the other hand, this very same fluid, saliva, is a rich source of nitrate, which can be

reduced to nitrite. Under certain conditions, nitrites react with proteins in the stomach to become carcinogenic nitrosamines. Such possible interactions make foods and food safety a complicated business—rarely a realization we want to face.

IS THERE A FOOD SAFETY CRISIS?

In Western industrialized countries, concerns about safe food have replaced those about adequate food. Many feel that such concerns are a product of our convenience society. However, as early as just after the Civil War, Dr. W. O. Atwater, a scientist in the U.S. Department of Agriculture (USDA) and director of the first nationwide program of human nutrition research, warned in *Harper's Weekly* that city people were in constant danger of buying unwholesome meat—dealers were unscrupulous and consumers uneducated. It was common knowledge to New Yorkers at that time that their milk was diluted with water. Not uncommonly, coffee was adulterated with charcoal, cocoa with sawdust, olive oil with coconut oil, and butter with margarine. Milk was preserved with formaldehyde, meat with sulfurous acid, and butter with borax (Foster, 1982). Upton Sinclair's book *The Jungle* warned of unwholesome meat and unsanitary conditions.

Thus, concerns about safe food are definitely not new in the United States. As in Atwater's day, we seem daily to be faced with reports of a food or food constituent whose safety has come under scrutiny. In the face of these frequent allegations, it is hard not to succumb to the belief that a food safety crisis exists.

Conflicting Views

Articles in the popular press claim that we are overfed and that our food has been overprocessed, oversalted, oversaturated, and oversugared, in the end leaving us undernourished. As if such charges weren't bad enough, many articles claim that our food is devitalized; colored; filled with chemicals, drugs, and synthetic ingredients; polluted by agricultural and environmental chemicals; and grown on impoverished land puffed up by the use of chemical fertilizers and other aids. Moreover, the chemicals used in the growing or processing of food are frequently alleged to cause adverse effects, even cancer, in humans or laboratory animals.

Articles with opposing views, frequently in the medical and scientific press rather than the popular press, state that these claims are either totally untrue or blown out of proportion. In fact, most bona fide nutritionists and academic, corporate, and government food scientists, including those from the Food and Drug Administration (FDA), claim

that the United States has the safest, least expensive, and most varied food supply in the world (Foster, 1982). Unfortunately safety suffers from having a pretty boring newsbite and tends to be discussed only in stories that shock and scare.

The success of delivering an enormous variety of food for diversified lifestyles has created some of the problem. Consumers are now faced with the complex task of selecting the right balance from a vast array of food choices. It is my strong contention that malnourishment that exists in the United States results in the majority of cases from poor personal food choices rather than from a deficient food supply or even inadequate access to food.

DEFINITIONS

In any discussion of food safety, some agreed-upon definitions of *safety, hazard*, and *toxicity* are crucial, since these are basic concepts.

Box 1.1

A Passage from Upton Sinclair's 1906 novel, *The Jungle*

With one member trimming beef in a cannery, and another working in a sausage factory, the family had a first-hand knowledge of the great majority of Packingtown swindles. For it was the custom, as they found, whenever meat was so spoiled that it could not be used for anything else, either to can it or else to chop it up into sausage. With what had been told them by Jonas, who had worked in the pickle rooms, they could now study the whole of the spoiled-meat industry on the inside. . . . Jonas had told them how the meat that was taken out of pickle would often be found sour, and how they would rub it up with soda to take away the smell, and sell it to be eaten on free-lunch counters; also of all the miracles of chemistry which they performed, giving to any sort of meat, fresh or salted, whole or chopped, any color and any flavor and any odor they chose. . . . Also, after the hams had been smoked, there would be found some that had gone to the bad. Formerly these had been sold as "Number Three Grade," but later on some ingenious person had hit upon a new device, and now they would extract the bone, about which the bad part generally lay, and insert in the hole a white-hot iron. After this invention there was no longer Number One, Two, and Three Grade—there was only Number One Grade.

(From Chapter 14)

Absolute safety is the assurance that damage or injury from use of a substance is impossible. Any ethical scientist must concede that some risk exists with any food, any chemical or, indeed, any human endeavor. Thus, absolute safety is unattainable. This is extremely frustrating to the average consumer, who would like to see a good eating "Seal of Approval" guaranteeing 100% safety before consuming any food.

Foods safe under normal conditions will never qualify for a seal of approval if they are consumed in excessive quantities or used in an unusual manner. Relative food safety can then be defined as the practical certainty that injury or damage will not result from a food or ingredient used in a reasonable and customary manner and quantity (Hall, 1988; Hall, 1991).

Relative Safety

The two following examples illustrate the difference between absolute safety and relative safety. Most would agree that peanut butter is safe to eat, yet peanut butter causes an average of seven asphyxiations in young children each year. All would agree that water is not only safe but essential. However, even pure water is "poisonous" if it is

Figure 1.1. Consumers may be confused by conflicting reports in the media.

not used in a reasonable and customary manner and quantity. A Massachusetts woman died from drinking too much water. In this case, the woman's mother had recently died of cancer, and the young woman believed that drinking lots of water would purify her internal organs so that she would not die of cancer. She didn't! She died of renal shutdown caused by drinking many gallons of water in a short period of time (Minneapolis Tribune, 1977). Thus, any substance, no matter how beneficial or how low its toxicity, has some level or condition of use that may be injurious.

Furthermore, food safety refers not only to the food itself, but also to the person ingesting it. Foods considered safe for most people when used in a reasonable and customary manner and quantity can be extremely toxic, even lethal, to certain sensitive or allergic individuals. For example, properly cooked fish is considered both a safe and nutritious food. As a low-fat source of protein that is often rich in certain types of fatty acids (omega-3) believed to be beneficial, its consumption is frequently encouraged. However, for a person with a severe fish allergy, one bite of fish could prove fatal. Thus, the answer to the question of whether fish is safe to eat is a qualified yes. It depends upon who is ingesting it.

Toxicity vs. Hazard

An understanding of food safety is improved by defining two other basic concepts, toxicity and hazard. *Toxicity* is the capacity of a substance to produce harm or injury of any kind (chronic or acute) under any conditions. This might include the capacity to damage the developing fetus (teratogenicity), to alter the genetic code (mutagenicity), or to induce cancer (carcinogenicity). Furthermore, any deviation from normal is viewed as a possible negative effect, even though the change may seem to be positive, such as increased growth rates or enhanced nutrient absorption. The change is assumed to be negative until proven beneficial. *Hazard* is the relative probability that harm or injury will result when the substance is used in a proposed manner and quantity. Assessments of whether a food or ingredient is safe should not be based on its inherent toxicity but on whether or not a hazard is created.

Unfortunately, the public does not perceive the difference between hazard and toxicity. The press often scoops findings from journals or scientific meetings that describe the toxic effects resulting from ingestion of high levels of a food constituent. Upon reading or hearing of these press reports, many consumers assume that a constituent is hazardous at current consumption levels. This assumption occurs because of an inability to distinguish between toxicity and hazard.

Consumers are not alone. All too frequently, scientists themselves are unable to extrapolate from studies of high-dose toxicity to assess the actual human hazard from low-dose ingestion of the food or food constituent.

The inability to give an accurate assessment of hazard leaves a void that is filled in one of two ways: 1) self-appointed experts pontificate their assessment of the hazard with alacrity in books or on talk shows or 2) bewildered consumers, muddled by questions of safety, decide to believe the worst and stop eating the food anyway.

A recent example of the inability to differentiate between toxicity and hazard resulted from studies on methylene chloride, the chemical used to decaffeinate coffee. This chemical, also used to dry-clean clothes, was shown to be carcinogenic when inhaled by laboratory rats. Interestingly, it was not carcinogenic when rats ingested it. For the purpose of this example, let's assume that the effects of inhaling the compound are the same as those of ingesting it, which they are not. The amount of methylene chloride residue that remains in the decaffeinated coffee would necessitate drinking 50,000 cups of decaf coffee per day to reach the dose level that caused cancer in rats. Coffee itself contains over 350 compounds that have been identified. Many of these natural compounds at 50,000 times their customary dose have toxicities much greater than the toxicity of methylene chloride. Even if all the naturally occurring chemicals didn't exert adverse effects, excessive water consumption would clearly cause renal shutdown long before the hazardous dose of residue was reached. The FDA calculated the increased cancer risk from drinking two and a half cups of decaffeinated coffee per day to be, at most, one in a million—which is pretty close to zero!

Now, admittedly, two alternative, ostensibly natural, processes are available for the decaffeination of coffee. One uses ethyl acetate, a compound produced naturally during the ripening of fruit, the other, carbon dioxide and water. Decaffeinated coffee processed by these

Box 1.2

Basic Concepts

Toxicity = Capacity to harm

Hazard = Likelihood of harm

Safety = No likelihood of harm when used normally

methods has the allure of being safer because it doesn't employ any chemicals that are carcinogenic. However, the degree to which it is safer is miniscule, and the difference in the cost of the methods is not.

FOOD AND SCIENCE IN THE INFORMATION AGE

The decaffeinated coffee story is just one example of scientific advances creating more data than can be rationally managed or fully understood. Analytical chemists can now measure levels that toxicologists are unable to evaluate for biological significance. The zealous attempt to make food safer through microscopic scrutiny of food constituents has made researchers and consumers aware of small risks that were unknown in the past. Analytical chemistry has become so sophisticated that we may soon have enough data to ban the whole food supply!

Scientists and academicians believe that the only food safety crisis is that which exists in people's minds as a result of incomplete reporting of scientific information coupled with distortion of the facts by fearmongers, hucksters, and misdirected "consumer interest groups." Dr. Sanford Miller (1984), former director of the FDA's Bureau of Foods, said, "We live in neo-muckraking times, and since muckrakers need to have muck to rake, each report of a possible problem of food is treated as if it represented a major threat to individual life and to the survival of the civilization." In addition, financial support of many of these consumer interest groups is dependent on keeping their names before the public. They thus seek muckraking issues to garner donations and support.

The food industry itself is frequently guilty of delivering mixed messages. The scientific and technical affairs staff of one company may spend time trying to assure the consumer that a certain product, additive, or ingredient is safe. At the very same time, the marketing department of the same company may be advertising another product in their line as not having any artificial additives or preservatives. No wonder consumers are confused and unsure where to place their trust!

The word *crisis* implies a turning point or decisive stage in the progress of anything. This book looks at many food safety issues. With facts presented from all sides of these issues, a decision can be made about whether real crises exist or whether they have been created. If the crisis is real, we can make recommendations for managing it in such a way that will prevent a turn for the worse and enable a change for the better. If the crisis is created, a massive public education program will need to be launched.

WHAT ARE THE FOOD SAFETY ISSUES?

Specific food safety concerns differ markedly depending on the segment of the population involved. Consumers are most concerned about pesticides and additives. Since both of these are linked in the consumer's mind to cancer, they create great fear. A 1986 study by the Food Marketing Institute showed that 76% of consumers considered pesticides a serious hazard. Additives still concern consumers, although the percentage who are very concerned has decreased in the past few years (Bruhn, 1991; FMI, 1986, 1990; Lecos, 1984). Irradiation concerns a specific group of consumers. Many consumers stated that they would prefer irradiation if it had the capability to eliminate additives and pesticides (Bruhn et al, 1986).

The level of concern about any one of the issues is dependent on the level of attention it receives from the media. However, several issues have been noted for which both interest and concern have risen steadily in the past decade. One such issue is nutrition; another is fear of product tampering. Ironically, fear of product tampering is on the rise at the same time as increased use of self-serve barrels in grocery stores and co-ops—avenues for all kinds of contamination and tampering.

Microbiological Contamination, the Top Priority

It is also interesting, perhaps even alarming, that most consumers are not concerned about microbiological contamination, despite solid

Box 1.3

Food Safety Issues

Additives, colors, and flavors
Antibiotics and other feed additives
Fertilizers and other growing aids
Irradiation
Microbiological contamination
Naturally occurring food toxicants
Nutrition
Pesticides
Pollutants (e.g., PCBs)
Processing, packaging, and labeling
Tampering

(Expanded from Hall, 1988)

evidence that, of all the hazards, it is the one most likely to occur. Many homes have unsafe food storage and preparation practices. These may cause flulike and other illnesses that are never traced to improper handling of food. Consumers rarely consider their own food practices a hazard (Gravani and Williamson, 1991; Rucker et al, 1977).

Microbiological contamination of food is the FDA's top priority, as measured by both dollar outlay and staff activity. Although only 6% of the reported cases of foodborne disease in 1981 (Bryan, 1982) involved microbial contamination of processed food sold at grocery stores, it was still considered the most likely hazard to occur from manufactured food and therefore the top priority. (The other 94% of the cases were from incidents in a home or restaurant.)

Extraneous Matter, GMP, HACCP

Like the FDA, the food industry is most concerned about the microbiological safety of its products. In addition, many quality control checks are in place that help assure that foods are free of extraneous matter such as glass, machine filings, and insect parts. Interest in these two areas (microbiological and physical hazards) stems from experience that marks them as the hazards most likely to occur during manufacturing. In addition to being regulated by the FDA, large food companies in the United States adhere to a code of manufacturing practice known as Good Manufacturing Practice (GMP). This code helps to assure that products are manufactured under conditions of proper storage and sanitation. Many also employ an elaborate system known as HACCP (hazard analysis and critical control points) to make sure that there is no chance for contamination or error during processing.

Product Tampering

Industry has recently increased its activity in the area of product tampering. Since a fatal incident in 1984 involving malicious addition of poison to the analgesic Tylenol, over 100 incidents of food tampering have occurred. Even though the current risk of ingesting food from a package that has been tampered with is far less than the risk of being struck by lightning, the industry realizes that it must be proactive with this issue. As a result, tamper-resistant packaging, such as seals around bottle tops, and tamper-evident packaging are rapidly taking over.

Pesticide Residues

In the later part of the 1980s, the FDA raised pesticides to a higher level of concern. The elevation was not caused by an increase in adverse effects known to be caused by pesticides, but rather by reports that