



Food Contamination and Safety

Emiliano Johnston

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This book elucidates new techniques and the applications in the field of food contamination in a multidisciplinary approach. It elaborates on the different theories and concepts related to this area. Food contamination refers to the degradation of food because of harmful chemicals or bacteria that cause various diseases and infections. In order to ensure food quality, the finished product goes through a thorough quality check. In this text, effort has been made to present the explanation of various methods of food safety, easy and simple. It is designed specifically for students. The topics covered in this extensive textbook deal with the core subjects of food contamination and safety. It will serve as a valuable source of reference for those interested in this field.

Emiliano Johnston pursued his post-graduation in Food Safety from Manchester Metropolitan University, United Kingdom. He works with the food industry and his work focuses on foodborne illness, adverse effects of agrochemicals and processing contaminants. Johnston has authored and edited more than 57 articles, journal papers and book chapters in the field of food testing and food safety. His works have also been helpful to many fellow researchers in their respective fields.

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Preface

This book elucidates new techniques and the applications in the field of food contamination in a multidisciplinary approach. It elaborates on the different theories and concepts related to this area. Food contamination refers to the degradation of food because of harmful chemicals or bacteria that cause various diseases and infections. In order to ensure food quality, the finished product goes through a thorough quality check. In this text, effort has been made to present the explanation of various methods of food safety, easy and simple. It is designed specifically for students. The topics covered in this extensive textbook deal with the core subjects of food contamination and safety. It will serve as a valuable source of reference for those interested in this field.

To facilitate a deeper understanding of the contents of this book a short introduction of every chapter is written below:

Chapter 1- Contaminated food is food that has harmful chemicals and caused illness in consumers. Adulterated food is unsafe and is contaminated food. This chapter will provide an integrated understanding of adulterated food.

Chapter 2- Aflatoxins are chemicals that cause cancer; they are produced by certain molds that grow in the soil. The alternative natural toxins prions are aflatoxin B₁, mycotoxin, prions, scrapie and bovine spongiform encephalopathy. The section serves as a source to understand the major natural toxins prions and carcinogens in food.

Chapter 3- Foodborne illnesses are illnesses that are caused because of contaminated food. Symptoms of food illness are fever, vomiting and aches. Bacterias that cause infection are pathogenic bacteria, bacillus cereus, staphylococcal enteritis and vibrio vulnificus. The section on food illness offers an insightful focus, keeping in mind the subject matter.

Chapter 4- Diseases that are related to food contamination are cholera, gastroenteritis, shigellosis, botulism, salmonellosis, Gerstmann-Straussler-Scheinker syndrome and kuru. Cholera is an infection caused by the bacterium vibrio cholera; the symptoms are vomiting and diarrhea. The section serves as a source to understand the diseases related to food contamination.

Chapter 5- The zoonotic diseases that spread through food are salmonellosis, bubonic plague, avian influenza, caliciviridae and trichinosis. Salmonellosis is an infection caused by bacterias, the symptoms of which vary from fever to abdominal cramps. The topics discussed in the chapter are of great importance to broaden the existing knowledge on zoonotic diseases.

Chapter 6- Food safety is the handling and storing of food in ways that helps in preventing foodborne illnesses. The aspects elucidated are food processing, food preservation, food storage and calcium propanoate. The major categories of food safety are dealt with great details in the chapter.

I would like to share the credit of this book with my editorial team who worked tirelessly on this book. I owe the completion of this book to the never-ending support of my family, who supported me throughout the project.

Editor

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Understanding Food Contamination

Contaminated food is food that has harmful chemicals and caused illness in consumers. Adulterated food is unsafe and is contaminated food. This chapter will provide an integrated understanding of adulterated food.

Food Contaminant

Food contamination refers to the presence in food of harmful chemicals and microorganisms which can cause consumer illness. This article addresses the chemical contamination of foods, as opposed to microbiological contamination, which can be found under foodborne illness.

The impact of chemical contaminants on consumer health and well-being is often apparent only after many years of processing. Prolonged exposure at low levels (e.g., cancer). Chemical contaminants present in foods are often unaffected by thermal processing (unlike most microbiological agents). Chemical contaminants can be classified according to the source of contamination and the mechanism by which they enter the food product.

Agrochemicals

Agrochemicals are chemicals used in agricultural practices and animal husbandry with the intent to increase crops and reduce costs. Such agents include pesticides (e.g., insecticides, herbicides, rodenticides), plant growth regulators, veterinary drugs (e.g., nitrofurans, fluoroquinolones, malachite green, chloramphenicol), and bovine somatotropin (rBST).

Environmental Contaminants

Environmental contaminants are chemicals that are present in the environment in which the food is grown, harvested, transported, stored, packaged, processed, and consumed. The physical contact of the food with its environment results in its contamination. Possible sources of contamination include:

- Air: radionuclides (¹³⁷Caesium, ⁹⁰Strontium), polycyclic aromatic hydrocarbons (PAH)
- Water: arsenic, mercury
- Soil: cadmium, nitrates, perchlorates
- Polychlorinated biphenyls (PCB), dioxins, and polybrominated diphenyl ethers (PBDE) are ubiquitous chemicals
- Packaging materials: antimony, tin, lead, perfluorooctanoic acid (PFOA), semicarbazide,

benzophenone, isopropyl thioxanthone (ITX), bisphenol A

- Processing/cooking equipment: copper, or other metal chips, lubricants, cleaning, and sanitizing agents
- Naturally occurring toxins: mycotoxins, phytohaemagglutinin, pyrrolizidine alkaloids, grayanotoxin, mushroom toxins, scombrototoxin (histamine), ciguatera, shellfish toxins, tetrodotoxin, among many others.

Pesticides and Carcinogens

There are many cases of banned pesticides or carcinogens found in foods.

- Greenpeace exposed in 2006 in China that 25% of surveyed supermarkets agricultural products contained banned pesticides. Over 70% of tomatoes that tested were found to have the banned pesticide Lindane, and almost 40% of the samples had a mix of three or more types of pesticides. Fruits were also tested in this investigation. Tangerines, strawberries, and Kyofung grapes samples were found contaminated by banned pesticides, including the highly toxic Methamidophos. These fruits can also be found in Hong Kong market. Greenpeace says there exists no comprehensive monitoring on fruit produce in the Hong Kong as of 2006.
- In India, soft drinks were found contaminated with high levels of pesticides and insecticides, including lindane, DDT, malathion and chlorpyrifos.
- News of Formaldehyde, a carcinogen was found in Vietnamese national dish, Pho, broke in 2007 Vietnam food scare. Vegetables and fruits were also found to have banned pesticides. “Health agencies have known that Vietnamese soy sauce, the country’s second most popular sauce after fish sauce, has been chock full of cancer agents since at least 2001”, thundered the *Thanh Nien* daily. “Why didn’t anyone tell us?” The carcinogen in Asian sauces is 3-MCPD and its metabolite 1,3-DCP, which has been an ongoing problem before 2000 affecting multiple continents.
- 2005 Indonesia food scare, carcinogenic formaldehyde was added as a preservative to noodles, tofu, salted fish, and meatballs
- 2008 Chinese milk scandal

Hair in Food

There is a heavy stigma attached to the presence of hair in food in most societies. There is a risk that it may induce choking and vomiting, and also that it may be contaminated by toxic substances. Views differ as to the level of risk it poses to the inadvertent consumer.

In most countries, people working in the food industry are required to cover their hair because it will contaminate the food. When people are served food which contains hair in restaurants or cafés, it is usual for them to complain to the staff. Despite this, it is not a valid ground on which to sue the restaurant in the United States but in the United Kingdom it breaks the regulations of the UK Food Safety Act 1990, and people can sue over this.

There are a range of possible reasons for the objection to hair in food, ranging from cultural taboos to the simple fact that it is difficult to digest and unpleasant to eat. It may also be interpreted as a sign of more widespread problems with hygiene. The introduction of complete-capture hairnets is believed to have resulted in a decrease in incidents of contamination of this type.

Sometimes protein from human hair is used as a food ingredient, in bread and other such similar products. Such use of human hair in food is forbidden in Islam. Historically, in Judaism, finding hair in food was a sign of bad luck.

Processing Contaminants

Processing contaminants are generated during the processing of foods (e.g., heating, fermentation). They are absent in the raw materials, and are formed by chemical reactions between natural and/or added food constituents during processing. The presence of these contaminants in processed foods cannot be entirely avoided. Technological processes can be adjusted and/or optimized, however, in order to reduce the levels of formation of processing contaminants. Examples are: nitrosamines, polycyclic aromatic hydrocarbons (PAH), heterocyclic amines, histamine, acrylamide, furan, benzene, trans fat, 3-MCPD, semicarbazide, 4-hydroxynonenal (4-HNE), and ethyl carbamate. There is also the possibility of metal chips from the processing equipment contaminating food. These can be identified using metal detection equipment. In many conveyor lines, the line will be stopped, or when weighing the product with a Check weigher, the item can be rejected for being over- or underweight or because small pieces of metal are detected within it.

Emerging Food Contaminants

While many food contaminants have been known for decades, the formation and presence of certain chemicals in foods has been discovered relatively recently. These are the so-called emerging food contaminants like acrylamide, furan, benzene, perchlorate, perfluorooctanoic acid (PFOA), 3-monochloropropane-1,3-diol (3-MCPD), 4-hydroxynonenal, and (4-HNE).

Safety and Regulation

Acceptable Daily Intake (ADI) levels and tolerable concentrations of contaminants in individual foods are determined on the basis of the “No Observed Adverse Effect Level” (NOAEL) in animal experiments, by using a safety factor (usually 100). The maximum concentrations of contaminants allowed by legislation are often well below toxicological tolerance levels, because such levels can often be reasonably achieved by using good agricultural and manufacturing practices.

Regulatory officials, in order to combat the dangers associated with foodborne viruses, are pursuing various possible measures.

- The EFSA published a report in 2011 on “scientific opinion regarding an update of the present knowledge on the occurrence and control of foodborne viruses”.
- This year, an expert working group created by the European Committee for Standardization (CEN), is expected to publish a standard method for the detection of norovirus and hepatitis A virus in food.

- The CODEX Committee on Food Hygiene (CCFH) is also working on a guideline which is now ready for final adoption.
- European Commission Regulation (EC) No 2073/2005 of 15 November 2005 indicates that “foodstuffs should not contain micro-organisms or their toxins or metabolites in quantities that present an unacceptable risk for human health”, underlining that methods are required for foodborne virus detection.

Food Contaminant Testing

To maintain high quality of food and comply with health, safety and environmental regulatory standards it is best to rely on food contaminant testing through an independent third party such as laboratories, certification companies or similar. For manufacturers the testing for food contaminants can minimize the risk of noncompliance in relation to raw ingredients, semi-manufactured foods and final products. Also, food contaminant testing assures consumers safety and quality of purchased food products and can prevent foodborne diseases, and chemical, microbiological, or physical food hazards.

The establishment of ADIs for certain emerging food contaminants is currently an active area of research and regulatory debate.

Adulterated Food

Adulterated food is impure, unsafe, or unwholesome food. Incidents of food contamination have occurred because of poor harvesting or storage of grain, use of banned veterinary products, industrial discharges, human error and deliberate adulteration and fraud.

History of Incidents

Historians have recognized cases of food adulteration in Ancient Rome and the Middle Ages. Contemporary accounts of adulteration date from the 1850s to the present day. Now a days food are adulterated by chemicals such as plastic and so on This is a dangerous issue. Human beings are harmed by this adulterated food. Plastic is mixed up with certain food item such as chips, rice etc. Drinking hot drinks in plastic cups glass is dangerous as the heat melts the plastic layer and the plastic mixes with the drink.

Legislative History

In the United States, the Food and Drug Administration (FDA), regulates and enforces laws on food safety as well as Food Defense. The FDA provides some technical definitions of adulterated food in various United States laws.

- 1906 (21 U.S.C. 601 et seq.)
- 1938 Federal Food, Drug, and Cosmetic Act (21 U.S.C. 321 et seq.)
- 1957 Poultry Products Inspection Act (21 U.S.C. 451 et seq.)

- 2011 Food Safety and Modernization Act

Definition

“Adulteration” is a legal term meaning that a food product fails to meet federal or state standards. Adulteration is an addition of another substance to a food item in order to increase the quantity of the food item in raw form or prepared form, which may result in the loss of actual quality of food item. These substances may be other available food items or non-food items. Among meat and meat products some of the items used to adulterate are water or ice, carcasses, or carcasses of animals other than the animal meant to be consumed.

Federal Food, Drug, and Cosmetic Act

The Federal Food, Drug, and Cosmetic (FD&C) Act 2888) provides that food is “adulterated” if it meets any one of the following criteria:

- (1) it bears or contains any “poisonous or deleterious substance” which may render it injurious to health;
- (2) it bears or contains any added poisonous or added deleterious substance (other than a pesticide residue, food additive, color additive, or new animal drug, which are covered by separate provisions) that is unsafe;
- (3) its container is composed, in whole or in part, of any poisonous or deleterious substance which may render the contents injurious to health;
- or (4) it bears or contains a pesticide chemical residue that is unsafe. (Note: The United States Environmental Protection Agency (EPA) establishes tolerances for pesticide residues in foods, which are enforced by the FDA.)

Food also meets the definition of adulteration if:

- (5) it is, or it bears or contains, an unsafe food additive;
- (6) it is, or it bears or contains, an unsafe new animal drug;
- (7) it is, or it bears or contains, an unsafe colour additive;
- (8) it consists, in whole or in part, of “any filthy, putrid, or decomposed substance” or is otherwise unfit for food;
- or (9) it has been prepared, packed, or held under unsanitary conditions (insect, rodent, or bird infestation) whereby it may have become contaminated with filth or rendered injurious to health.

Further, food is considered adulterated if:

- (10) it has been irradiated and the irradiation processing was not done in conformity with a regulation permitting irradiation of the food in question (the FDA has approved irradiation of a number of foods, including refrigerated or frozen uncooked meat, fresh or frozen uncooked poultry, and seeds for sprouting [21 C.F.R. Part 179].);

- (11) it contains a dietary ingredient that presents a significant or unreasonable risk of illness or injury under the conditions of use recommended in labelling (for example, foods or dietary supplements containing aristolochic acids, which have been linked to kidney failure, have been banned.);
- (12) a valuable constituent has been omitted in whole or in part or replaced with another substance; damage or inferiority has been concealed in any manner; or a substance has been added to increase the product's bulk or weight, reduce its quality or strength, or make it appear of greater value than it is (this is "economic adulteration");
- or (13) it is offered for import into the United States and is a food that has previously been refused admission, unless the person reoffering the food establishes that it is in compliance with U.S. law [21 U.S.C. § 342].

Federal Meat Inspection Act and the Poultry Products Inspection Act

The Federal Meat Inspection Act and the Poultry Products Inspection Act of 1957 contain similar provisions for meat and poultry products. [21 U.S.C. § 453(g), 601(m)].

Poisonous or Deleterious Substances

Generally, if a food contains a poisonous or deleterious substance that may render it injurious to health, it is considered to be adulterated. For example, apple cider contaminated with *E. coli* O157:H7 and Brie cheese contaminated with *Listeria monocytogenes* are adulterated. There are two exceptions to this general rule. First, if the poisonous substance is inherent or naturally occurring and its quantity in the food does not ordinarily render it injurious to health, the food will not be considered adulterated. Thus, a food that contains a natural toxin at very low levels that would not ordinarily be harmful (for instance, small amounts of amygdalin in apricot kernels) is not adulterated.

Second, if the poisonous or deleterious substance is unavoidable and is within an established tolerance, regulatory limit, or action level, the food will not be deemed to be adulterated. Tolerances and regulatory limits are thresholds above which a food will be considered adulterated. They are binding on FDA, the food industry, and the courts. Action levels are limits at or above which FDA may regard food as adulterated. They are not binding on FDA. FDA has established numerous action levels (for example, one part per million methylmercury in fish), which are set forth in its booklet *Action Levels for Poisonous or Deleterious Substances in Human Food and Animal Feed*.

If a food contains a poisonous substance in excess of a tolerance, regulatory limit, or action level, mixing it with "clean" food to reduce the level of contamination is not allowed. The deliberate mixing of adulterated food with good food renders the finished product adulterated (FDA, *Compliance Policy Guide* [CPG § 555.200]).

Filth and Foreign Matter of Adulteration

Filth and extraneous material include any objectionable substances in foods, such as foreign matter (for example, glass, metal, plastic, wood, stones, sand, cigarette butts), undesirable parts of the raw plant material (such as stems, pits in pitted olives, pieces of shell in canned oysters), and filth