Dear Establishment Owner/Operator:

More than two years ago the Meat and Poultry Subcommittee of the National Advisory Committee on Microbiological Criteria for Foods (NACMCF) graciously accepted an assignment from FSIS Administrator Tom Billy to prepare some helpful technical assistance material that very small establishments could use in accomplishing the difficult, but critical, HACCP principle of conducting a hazard analysis. FSIS and most HACCP experts believe that a successful HACCP plan must be founded on a good hazard analysis.

Recently this very busy subcommittee has completed a working DRAFT of this document. FSIS officials have participated in its development, carried out some review, and arrived at a belief that, even in its current DRAFT form, it is an excellent piece of work and may be of assistance to very small establishments facing the January, 2000 HACCP implementation date. FSIS believes that it is particularly valuable because it complements the less thorough consideration of the hazard analysis principle that is reflected in the Agency revised guidebook and generic models.

FSIS is therefore making this document available as part of its package of materials for very small establishments and to others who request it. The Agency will also post the document on its web site.

FSIS wants to remind users that this is an advisory document, that it offers excellent advice, but that regulated establishments remain responsible for complying with the requirements of 9CFR Part 417. This document remains a DRAFT and may be commented on, before, and during the NACMCF meeting September 21-24, 1999.

Written comments should be directed to:

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Sincerely,

Mary Cutshall

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FSIS:OPPDE:Mcutshall:db:8-26-99
(MSWORD August 26 Ltr#2 Dear Establishment Owner

FSIS MICROBIOLOGICAL HAZARD IDENTIFICATION GUIDE FOR MEAT AND POULTRY COMPONENTS OF PRODUCTS PRODUCED BY VERY SMALL PLANTS

Developed in Consultation with the Meat and Poultry Subcommittee of the
National Advisory Committee on Microbiological Criteria for Foods
August 26, 1999

Introduction

Background

The Meat and Poultry Subcommittee of the National Advisory Committee on Microbiological Criteria for Foods (NACMCF) was asked by the NACMCF Steering Committee to produce a microbiological hazard identification guide for very small plant operators (plants with less than 10 employees or with annual sales of less than $2.5 million). The purpose of this document is to aid very small plant operators in identifying microbial hazards associated with meat and poultry components in their products. Under section 9 Code of Federal Regulations (CFR) Part 417, all very small plant operators are required to implement Hazard Analysis and Critical Control Point (HACCP) systems by January 2000.

The first step in performing the hazard analysis portion of a HACCP plan is to identify the biological (as referred to in 9 CFR 417), physical, and chemical hazards that may be encountered in the production of a food product. This step is the hazard identification portion of a hazard analysis. This guide is designed to be a simple, easy-to-understand aid to identifying biological (specifically microbiological) hazards in meat and poultry for very small plant operators. It does not provide guidance on biological hazards presented by other components used to assemble combination products, nor does it address hazards that may be introduced by processing procedures. Finally, this guide is designed to assist establishments subject to the regulatory requirements of 9 CFR 417 in complying with those requirements; these regulatory requirements may slightly differ from the various explanations of HACCP developed by NACMCF, the most recent version of which was published in 1997.

How to Use This Guide

The guide consists of tables that identify the microbiological hazards in various process categories of products (Tables i through ix), followed by a justification for the identification of those hazards reasonably likely to be occur in the absence of controls. In addition, the microbiological hazards identified in this guide are specific to meat and poultry and not to ingredients other than meat or poultry (e.g., plant, fish, or synthetic material) which may be used in the manufacturing of more complex processed meat and poultry products. Although these other ingredients may contain microbiological hazards that may need to be addressed in a HACCP plan, other HACCP resources should be consulted for guidance. A brief summary of each pathogen has also been provided as Appendix 1. Appendix 2 lists additional resources for very small plant operators wishing to learn more about HACCP.

Microbiological Hazards in Meat and Poultry

Bacteria: Potential biological hazards in meat and poultry include bacteria, toxins, viruses, protozoa, and parasites. Of the microbiological hazards, the most important are bacteria. Bacteria cause a large proportion (approximately 90%) of all foodborne illnesses. Bacteria that cause human illness, including disease, are termed pathogenic. The pathogens that are most likely to be found in commonly slaughtered livestock (cattle, sheep, and swine) and poultry (chicken and turkey) include *Salmonella*, *Campylobacter*, and *Listeria monocytogenes*. *Listeria monocytogenes* also is widespread in the environment and is often present in soil, water, and silage. Although *Escherichia coli* also is found in livestock and poultry, most forms of *Escherichia coli* are not pathogenic. *Escherichia coli* O157:H7 is pathogenic. The ultimate source for all of these pathogens is apparently healthy animals that may shed these bacteria in their feces. While dressing the carcasses during the slaughter process, these bacteria may be transferred from the hide and offal to the carcass causing contamination. All of these pathogens have been implicated in widely publicized foodborne disease outbreaks associated with the consumption of meat and poultry products. Proper cooking, fermentation, cooling, and storage of food can destroy and/or prevent growth of these bacteria.

Toxins: Toxins of most concern are produced by *Clostridium botulinum*, *Clostridium perfringens*, *Bacillus cereus*, and *Staphylococcus aureus*. All are the result of the growth of bacteria and the production of toxins in foods that have been mishandled. These bacteria are common in the environment and are often found on carcasses. Proper cooking, fermentation, cooling, and storage of food can prevent growth of these bacteria and, more importantly, the production of their toxins. However, cooking will not destroy several of these toxins once they are formed in food.

Parasites: Parasites (parasitic worms) of public health importance are the beef and pork tapeworms (*Taenia saginata* and *Taenia solium*, respectively) and the roundworm that causes trichinosis (*Trichinella spiralis*). Federal and state inspection program personnel can observe the immature stages (cysts) of tapeworms in carcasses of animals with severe infection and when detected by government inspection personnel or by employees of the very small plant, such product cannot be further processed for human consumption. When the cysts are less severe or evident, infected meat may enter the human food chain. Humans consuming undercooked meat infected with these tapeworms become ill generally after the mature stages of the tapeworms invade the intestinal tract.

Trichinella spiralis is an intestinal worm that produces larvae that migrate to and encyst in muscles of a number of animals, particularly swine. Humans consuming infected pork which is undercooked get ill from the cysts which then live in the muscles of the human hosts.

Tapeworms and roundworms generally are readily destroyed at cooking temperature and time combinations less rigorous than the combinations necessary to destroy pathogenic bacteria.

Viruses and Protozoa: Viruses can cause diseases such as hepatitis and polio and protozoa can cause diseases such as toxoplasmosis and cryptosporidiosis in humans. Neither organism involves livestock or poultry. The presence of viruses in food and water is generally associated with a contaminated food worker, usually in the retail or food service arena. Contaminated food and water serve as sources of transport for the viruses. However, viruses do not reproduce in food or water. Monitoring for disease-causing protozoa is a complicated and time-consuming process, and is not considered a potential hazard for the very small plant operator at the slaughter or processing plant level.

Control of Bacteria in Food

Prevention of Contamination: It is important to avoid the contamination of meat and poultry whenever possible. This includes inadvertent contamination from the live animal, processing procedures and equipment, employees, and the environment. Contamination can be minimized or avoided altogether by following appropriate sanitation procedures, good manufacturing practices, and procedures for employee hygiene. The term "cross-contamination" generally refers to the transfer of organisms from a contaminated source to a previously uncontaminated surface. A particular concern is the cross-contamination of ready-to-eat foods with not-ready-to-eat (raw or partially cooked) meat or poultry, or with drippings from not-ready-to-eat meat or poultry. It is particularly important to ensure complete separation of not-ready-to-eat and ready-to-eat products.

Restriction of Growth: Recognizing that bacteria will be present on meat and poultry, it is important to keep the overall number of bacteria very low in order that concern about pathogens can be minimized. Temperature, acidity, salt and drying, and combinations of these can be used to restrict growth of pathogens.

Temperature -- The growth of most bacteria can be slowed (controlled) by maintaining the product at refrigeration temperatures (less than 41^{o}F), or by freezing. Some bacteria survive freezing, so freezing cannot be considered a method to eliminate bacteria. Holding products at higher temperatures (greater than 130^{o}F) also restricts the growth of the bacteria.

Acidity -- Fermentation restricts the growth of bacteria of public health concern by increasing the acidity (lowering the pH) of the product. Generally a pH of less than 5 will severely restrict or completely stop the growth of harmful bacteria. Some bacteria can survive in acidic conditions, so fermentation alone cannot be relied upon to completely eliminate all harmful bacteria.

Salt and Drying -- Some products contain high levels of salt. Salt and low moisture content in a product can be effective in controlling growth of some harmful bacteria, but some organisms (e.g., *Staphylococcus aureus*) survive in high salt environments.

Destruction of Bacteria: Most pathogenic bacteria, including *Salmonella*, *Escherichia coli* O157:H7, *Listeria monocytogenes*, and *Campylobacter*, can be fairly easily

destroyed using a rather mild cooking process--maintaining a minimum temperature within the range of 130 ^{o}F to 165 ^{o}F for a specific amount of time. However, cooking at this temperature range and for the specified dwell time will not destroy the heat resistant forms (spores) of certain bacteria, nor will some types of toxins be destroyed if they have already been formed in the product. Thermal processing (canning) at a minimum retort temperature of greater than 240 ^{o}F for a specific amount of time is necessary to destroy most spores and toxins.

Sanitation: Some bacteria, such as *Listeria* (including *Listeria monocytogenes*), can be found in the processing environment. Although most forms of *Listeria* are not pathogenic, *Listeria monocytogenes* is a pathogen. This emphasizes the need for adequate sanitation, not only of the equipment, but also the floors. Employee hygiene, air flow, and traffic flow of people and equipment between areas used for not-ready-to-eat processing and ready-to-eat processing is very important and should be strictly controlled.

Table i – Microbiological Hazards in Beef, Lamb, Pork, and Poultry: Slaughter – All Species

Process Category	**General Product Examples**	**Species**	**Biological Hazards Reasonably Likely to be Present and Cause Foodborne Illness denoted by "+"** (an empty box signifies that no biological hazard is reasonably likely to occur; however, an unusually high level of contamination or improper handling and storage may cause one or more of the pathogens to become a hazard)						
			Salmonella	***Escherichia coli* O157:H7**	***Campylobacter***	***Listeria monocytogenes***	***Staphylococcus aureus***	***Clostridium perfringens***	***Clostridium botulinum***
(i) Slaughter – All Species	Carcasses, Carcass Parts, and Variety Meats	Beef	+	+					
		Lamb	+						
		Pork	+						
		Poultry	+		+				

Justification:

(i) Slaughter – All Species

The occurrence of pathogens such as *Salmonella* in beef, lamb, pork, and poultry carcasses varies greatly. The overall contamination of meat and poultry carcasses with these pathogens depends not only on the prevalence and numbers of the pathogens on the hair, feathers, skin, and in the intestinal tract of the animal, but is also significantly affected by the degree of cross-contamination occurring from these sources during slaughter and processing. Very small plant operators must adhere to pathogen reduction performance standards for *Salmonella*, as specified in 9 CFR 310.25 for livestock and in 9 CFR 381.94 for poultry.

Cattle and sheep may carry *Escherichia coli* O157:H7 in the intestinal tract at the time of slaughter. However, beef (but not lamb) has been implicated in a number of foodborne illness associated with this pathogen. Contamination with *Escherichia coli* O157:H7 can be reduced, but not eliminated, through the use of strict hygienic practices during slaughter (dehiding and evisceration) and pathogen reduction intervention treatments (organic acid rinses, hot water rinses, and steam pasteurization).

Raw poultry is the major source of *Campylobacter*. Cross-contamination during preparation of raw chicken and the consumption of inadequately cooked poultry appear to be significant sources of this human illness.

Table ii – Microbiological Hazards in Beef, Lamb, Pork, and Poultry: Raw Product -- Ground

Process Category	**General Product Examples**	**Species**	**Biological Hazards Reasonably Likely to be Present and Cause Foodborne Illness denoted by "+"** (an empty box signifies that no biological hazard is reasonably likely to occur; however, an unusually high level of contamination or improper handling and storage may cause one or more of the pathogens to become a hazard)						
			Salmonella	***Escherichia coli* O157:H7**	***Campylobacter***	***Listeria monocytogenes***	***Staphylococcus aureus***	***Clostridium perfringens***	***Clostridium botulinum***
(ii) Raw Product – Ground	Ground product	Beef	+	+					
		Lamb	+						
		Pork	+						
		Poultry	+		+				

Justification:

(ii) Raw Product -- Ground

The bacteria on ground raw meat and poultry are primarily influenced by the bacteria on the carcasses, parts, and trimmings. Processing, such as grinding, distributes the bacteria originally on the surface of the meat or poultry throughout the ground product. Grinding also tends to increase the temperature of the meat or poultry allowing bacteria to grow more rapidly. Other practices sometimes used in making ground products, such as the common practice of using leftover trim and scraps, may result in a product substantially higher in levels of bacteria than the original fresh carcass or part.

Very small plant operators must adhere to pathogen reduction performance standards for *Salmonella*, as specified in 9 CFR 310.25 for ground beef and fresh pork sausage and in 9 CFR 381.94 for ground chicken and ground turkey. *Escherichia coli* O157:H7 is of specific concern in ground beef.

Table iii – Microbiological Hazards in Beef, Lamb, Pork, and Poultry: Raw Product – Not Ground

Process Category	**General Product Examples**	**Species**	**Biological Hazards Reasonably Likely to be Present and Cause Foodborne Illness denoted by "+"** (an empty box signifies that no biological hazard is reasonably likely to occur; however, an unusually high level of contamination or improper handling and storage may cause one or more of the pathogens to become a hazard)						
			Salmonella	***Escherichia coli* O157:H7**	***Campylobacter***	***Listeria monocytogenes***	***Staphylococcus aureus***	***Clostridium perfringens***	***Clostridium botulinum***
(iii) Raw Product – Not Ground	Steaks, Roasts, Chops	Beef	+	+					
		Lamb	+						
		Pork	+						
		Poultry	+		+				

Justification:

(iii) Raw Product – Not Ground

Raw cuts of meat or poultry generally have the same level of contamination as the carcass; therefore, the microbial concerns are similar to those described in category (i) for Slaughter – All Species. In addition, cuts of meat or poultry can become contaminated by equipment that has not been properly cleaned and sanitized.

Table iv – Microbiological Hazards in Beef, Lamb, Pork, and Poultry: Thermally-Processed – Commercially Sterile

Process Category	**General Product Examples**	**Species**	**Biological Hazards Reasonably Likely to be Present and Cause Foodborne Illness denoted by "+"** (an empty box signifies that no biological hazard is reasonably likely to occur; however, an unusually high level of contamination or improper handling and storage may cause one or more of the pathogens to become a hazard)						
			Salmonella	***Escherichia coli* O157:H7**	***Campylobacter***	***Listeria monocytogenes***	***Staphylococcus aureus***	***Clostridium perfringens***	***Clostridium botulinum***
(iv) Thermally-Processed – Commercially Sterile	Canned Beef	Beef							+
		Lamb							+
		Pork							+
		Poultry							+

Justification:

(iv) Thermally-Processed -- Commercially Sterile

The pathogen of concern in this product category is *Clostridium botulinum*, the cause of botulism in humans. It may be present in raw foods at very low levels. In proper heat processing, the heat resistant spores of *Clostridium botulinum* cannot survive and grow into the vegetative form that produces toxin in product. In this category, it is essential that the heat process be adequate to destroy *Clostridium botulinum* spores. Very small plant operators that adhere strictly to all the regulatory requirements contained in 9 CFR Subparts G (Canning and Canned Products -- Meat) and X (Canning and Canned Products – Poultry) are not required to conduct a hazard analysis for biological hazards because the regulations are designed to specifically address the control of this biological hazard.

Table v – Microbiological Hazards in Beef, Lamb, Pork, and Poultry: Not Heat Treated – Shelf Stable

Process Category	**General Product Examples**	**Species**	**Biological Hazards Reasonably Likely to be Present and Cause Foodborne Illness denoted by "+"** (an empty box signifies that no biological hazard is reasonably likely to occur; however, an unusually high level of contamination or improper handling and storage may cause one or more of the pathogens to become a hazard)						
			Salmonella	***Escherichia coli* O157:H7**	***Campylobacter***	***Listeria monocytogenes***	***Staphylococcus aureus***	***Clostridium perfringens***	***Clostridium botulinum***
(v) Not Heat Treated – Shelf Stable	Country Cured Product, unrefrigerated	Beef				+	+		
		Lamb				+	+		
		Pork				+	+		
		Poultry				+	+		

Justification:

(v) Not Heat Treated — Shelf Stable

These products, which generally are made from pork, may become contaminated with *Staphylococcus aureus* from the raw materials or from human contact. Adequate attention to drying, good manufacturing practices, and personnel hygiene are necessary to minimize this hazard. Generally, it takes high numbers and growth of *Staphylococcus aureus* (particularly coagulase-positive *Staphylococcus aureus*) to cause a hazard.

Listeria monocytogenes may survive the high salt concentration of these products unless the proper extended drying time is achieved. *Salmonella* generally does not grow well in the high salt concentration.

Table vi – Microbiological Hazards in Beef, Lamb, Pork, and Poultry: Heat Treated – Shelf Stable

Process Category	**General Product Examples**	**Species**	**Biological Hazards Reasonably Likely to be Present and Cause Foodborne Illness denoted by "+"** (an empty box signifies that no biological hazard is reasonably likely to occur; however, an unusually high level of contamination or improper handling and storage may cause one or more of the pathogens to become a hazard)						
			Salmonella	***Escherichia coli* O157:H7**	***Campylobacter***	***Listeria monocytogenes***	***Staphylococcus aureus***	***Clostridium perfringens***	***Clostridium botulinum***
(vi) Heat Treated – Shelf Stable	Lard	Beef							
		Lamb							
		Pork							
		Poultry							

Justification:

(vi) Heat Treated – Shelf Stable

For lard, the manufacturing of this product involves exceptionally high heat during rendering to produce lard, and lard has an exceptionally low moisture content that severely limits growth of most bacteria. Other types of products in this category (e.g., jerky that is heated prior to drying) may have pathogens of concern similar to those in category (viii) for Heat Treated But Not Fully Cooked and Not Shelf Stable.

Table vii – Microbiological Hazards in Beef, Lamb, Pork, and Poultry: Fully Cooked – Not Shelf Stable

Process Category	**General Product Examples**	**Species**	**Biological Hazards Reasonably Likely to be Present and Cause Foodborne Illness denoted by "+"** (an empty box signifies that no biological hazard is reasonably likely to occur; however, an unusually high level of contamination or improper handling and storage may cause one or more of the pathogens to become a hazard)						
			Salmonella	***Escherichia coli* O157:H7**	***Campylobacter***	***Listeria monocytogenes***	***Staphylococcus aureus***	***Clostridium perfringens***	***Clostridium botulinum***
(vii) Fully Cooked – Not Shelf Stable	Bologna, Deli Meats, Patties, Hot Dogs	Beef	+	+		+		+	+
		Lamb	+			+		+	+
		Pork	+			+		+	+
		Poultry	+		+	+		+	+

Justification:

(vii) Fully Cooked – Not Shelf Stable

Bacteria (i.e., *Salmonella*, *Escherichia coli* O157:H7, and *Campylobacter*) may be present in the raw meat or poultry. These bacteria are killed by proper cooking. Regulatory requirements contained in 9 CFR 318.17 for cooked roast beef and in 9 CFR 381.150 for cooked poultry require the very small plant operator to address a lethality performance standard for *Salmonella*. Generally, *Escherichia coli* O157:H7 and *Campylobacter* are easily controlled when the lethality procedure is at least sufficient to destroy *Salmonella*. *Salmonella* generally is present in higher numbers than are most other pathogens.

Spore-forming bacteria (*Clostridium perfringens* and *Clostridium botulinum*) can survive cooking when in the heat-resistant spore form, and these organisms need to be considered as the products are chilled. Growth (sometimes referred to as "outgrowth") of these bacteria are slowed by proper cooling. Regulatory requirements contained in 9 CFR 318.17 for cooked roast beef, in 9 CFR 318.23 for cooked uncured patties, and in 9 CFR 381.150 for cooked poultry require the very small plant operator to address a stabilization (cooling) performance standard for both *Clostridium perfringens* and *Clostridium botulinum*.

Recontamination with bacteria (e.g., *Listeria monocytogenes* and *Salmonella*) must be considered as cooked products are exposed to the environment, food contact surfaces, or raw product prior to final packaging.

Table viii – Microbiological Hazards in Beef, Lamb, Pork, and Poultry: Heat-Treated But Not Fully-Cooked And Not Shelf Stable

Process Category	**General Product Examples**	**Species**	**Biological Hazards Reasonably Likely to be Present and Cause Foodborne Illness denoted by "+"** (an empty box signifies that no biological hazard is reasonably likely to occur; however, an unusually high level of contamination or improper handling and storage may cause one or more of the pathogens to become a hazard)						
			Salmonella	***Escherichia coli* O157:H7**	***Campylobacter***	***Listeria monocytogenes***	***Staphylococcus aureus***	***Clostridium perfringens***	***Clostridium botulinum***
(viii) Heat-Treated But Not Fully-Cooked And Not Shelf Stable	Partially-Cooked Patties	Beef	+	+					
		Lamb	+						
		Pork	+						
		Poultry	+		+				

Justification:

(viii) Heat Treated But Not Fully Cooked And Not Shelf Stable

The pathogens of concern for partially-cooked products are generally the same as described in category (i) for Slaughter – All Species. It is important for the very small plant operator to ensure that the levels of bacteria and the types of bacteria on the meat or poultry are minimized. The ultimate food safety control for these products rests with the person who will do the final cooking and preparation steps.

Table ix – Microbiological Hazards in Beef, Lamb, Pork, and Poultry: Product With Secondary Inhibitors – Not Shelf Stable

Process Category	**General Product Examples**	**Species**	**Biological Hazards Reasonably Likely to be Present and Cause Foodborne Illness denoted by "+"** (an empty box signifies that no biological hazard is reasonably likely to occur; however, an unusually high level of contamination or improper handling and storage may cause one or more of the pathogens to become a hazard)						
			Salmonella	***Escherichia coli* O157:H7**	***Campylobacter***	***Listeria monocytogenes***	***Staphylococcus aureus***	***Clostridium perfringens***	***Clostridium botulinum***
(ix) Product With Secondary Inhibitors — Not Shelf Stable	Fermented Sausage, Acidulated Sausage, Country Ham	Beef	+	+			+		
		Lamb	+				+		
		Pork*	+				+		
		Poultry	+		+		+		

Justification:

(ix) Products With Secondary Inhibitors – Not Shelf Stable

The raw materials (meat and poultry) used to make these products may contain certain harmful bacteria--see category (i) for Slaughter – All Species; category (ii) for Raw Product – Ground; and category (iii) for Raw Product – Not Ground. The presence of *Staphylococcus aureus* is of concern in products that are fermented. *Staphylococcus aureus* can multiply to high numbers during fermentation if the product is not rapidly fermented (e.g., the starter culture is not active) and cause a toxin to be produced that can cause illness to consumers.

* Pork muscle tissue may carry *Trichinella spiralis*, better known as trichinae. Specific regulatory requirements that outline procedures to control Trichinella are found in 9 CFR 318.10. *Trichinella spiralis* is an additional biological hazard that must be addressed in the manufacturing of processed pork product, especially if the product is intended to be eaten without thorough cooking by the consumer.

Appendix 1

The appendix describes common characteristics of the meat and poultry bacterial pathogens referenced in this guide. Each table presents the disease, symptoms, and onset of the disease caused by the particular bacterium; the source of the bacterium transmission to humans; and common characteristics of the bacterium. Further discussions on biological hazards can be found in: Scott, V. N., 1999. Chapter 5: Biological Hazards and Controls, in *HACCP, A Systematic Approach to Food Safety*, third edition, K. E. Stevenson and D. T. Bernard (eds.), The National Food Processors Association, Washington, DC, in press - from which these tables were reproduced.

Campylobacter

Disease, Symptoms and Onset	Causes diarrhea 2-7 days after eating contaminated food. May cause nerve damage 1-6 weeks after infection.
Main Disease Factor	Invasion of the cells lining the intestine.
Source	Fecal contamination of raw poultry and meat.
Transmission	Cross contamination from raw meat or poultry drippings or consumption of undercooked food.
Characteristics	• Sensitive to heat and drying. • Grows in reduced oxygen environments. • Grows at human body temperature. • Does not grow in acid food. • Survives but does not grow during refrigeration and freezing.

Clostridium botulinum

Disease, Symptoms and Onset	Botulism is the name of the disease caused by *C. botulinum* toxin. A severe disease resulting from ingestion of toxin in food. Blurred or double vision, dry mouth, difficulty swallowing, paralysis of respiratory muscles. Vomiting and diarrhea may be present. Symptoms develop 12-36 hours after eating contaminated food (sometimes days). Unless adequately treated there is a high death rate. Recovery may be slow (months, rarely years).
Main Disease Factor	Production of toxin.
Source	Soil and the intestinal tract of animals.
Transmission	Consumption of toxin that has been formed in food by *Clostridium botulinum*. Heat stable forms of the bacteria (spores) may be present in food and in the absence of air can produce toxin.
Characteristics	• Spores are extremely heat resistant. Toxin is destroyed by high heat (boiling for 5 min). • Bacteria grow best without oxygen. • Bacteria can grow in most low-acid foods under low oxygen conditions. • Inclusion of sodium nitrite in processed foods slows the occurrence of toxin production. • High acid (pH 4.6) prevents the occurrence of toxin production.

Clostridium perfringens

Disease, Symptoms and Onset	Causes diarrhea and abdominal pain 6-24 hours after eating contaminated food.
Main Disease Factor	Production of toxins.
Source	Soil. Intestinal tract of healthy persons and animals.
Transmission	Usually inadequately heated or reheated meats, pot pies, stews, or gravies. Inadequate cooling of cooked food allows bacteria to multiply.
Characteristics	• Has a heat resistant form known as a spore. • Spores survive normal cooking procedures, including boiling. • Grows well without oxygen. • Bacteria grow best at 110-120°F. • Slow cooling and non-refrigerated storage of cooked meat and poultry permit growth of bacteria to high numbers. Can grow in foods placed on steam tables if food is not maintained at or above 130°F.

Escherichia coli O157:H7

Disease, Symptoms and Onset	Causes diarrhea (may be bloody) and occasionally fever. Incubation period is generally 2-3 days after ingestion of food (range 1-5 days). May result in kidney failure and death, especially in children.
Main Disease Factor	Production of a potent toxin in the intestinal tract of infected people.
Source	Fecal contamination of beef.
Transmission	Consumption of raw or undercooked hamburger, contaminated produce, such as sprouts, unpasteurized milk, and juices.
Characteristics	• Killed by mild heat. • Grows with or without air. Optimum temperature for growth is human body temperature. • Grows in moist, low-acid foods.

Listeria monocytogenes

Disease, Symptoms and Onset	Causes meningitis (sudden fever, intense headache, nausea, vomiting, delirium and coma). This is a particular problem in the elderly, infants, and pregnant women. One third of those who are hospitalized will die. In a healthy person, infection with *Listeria monocytogenes* may cause symptoms such as a flu-like illness and diarrhea.
Main Disease Factor	Bacterial invasion of the blood stream.
Source	Post-heat-processing contamination from the plant environment including plant personnel, equipment, floors, walls, drains, condensation from coolers, etc.
Transmission	Consumption of contaminated processed ready-to-eat meats. Also vegetables, unpasteurized dairy products.
Characteristics	• Killed by pasteurization temperatures. • Grows with or without air – however, prefers reduced oxygen conditions. • Able to grow at refrigeration temperatures and high salt concentration. • Acid conditions will slow growth but may allow survival. • Extremely hardy in comparison to most bacteria. Withstands repeated freezing and thawing. Survives for prolonged periods in dry conditions.

Salmonella

Disease, Symptoms and Onset	Causes acute diarrhea, vomiting, abdominal pain, and fever. Occasionally, may cause blood stream infections and death. Symptoms occur 6 to 72 hours after eating contaminated food.
Main Disease Factor	Invasion of the lining of the intestine.
Source	Fecal contamination of meat and poultry.
Transmission	Primarily from consumption of raw or undercooked eggs, milk, meat and poultry.
Characteristics	• Killed by mild heat. • Grows with or without air. Grows best at human body temperature. Grows very poorly at refrigeration temperatures and does not grow above 130°F. • Does not grow well or at all in acidic foods. • Survives well in frozen or dry foods. Bacteria in dry foods are more resistant to heat.

Staphylococcus aureus

Disease, Symptoms and Onset	Causes vomiting, nausea, abdominal cramps, and diarrhea 1-6 hours after eating food contaminated with toxin produced by this organism.
Main Disease Factor	Production of a heat resistant toxin in food.
Source	May be present on raw meat and poultry but contamination of food is primarily from humans.
Transmission	Bacteria multiply in food products to high levels and produce a heat-stable toxin.
Characteristics	• Bacteria killed by mild heat. Toxins are very heat stable, and will withstand thermal processing for prolonged periods. • Bacteria grow with or without air at body temperatures. • Toxin not usually produced in acid food. • Bacteria resistant to high salt (up to 15%).

Appendix 2

HACCP Resources

The Subcommittee for Meat and Poultry members have provided a list of HACCP resources for very small plant operators wishing to learn about HACCP. Subcommittee members did not review these sites for the quality of their content and their quality varies considerably. Their inclusion in this guide is simply to provide a resource and does not constitute an endorsement by the NACMCF. In addition, this is not an exhaustive list and many fine resources may have been omitted. It is suggested that the very small plant operator review these and all HACCP materials with a microbiologist trained in HACCP concepts.

- International Meat and Poultry HACCP Alliance
  http://ifse.tamu.edu/alliance

- HACCP Implementation Manual
  http://foodnet.fic.ca/safety/v3chap5.html

- FDA/CFSAN Managing Food Safety: A HACCP Principles Guide for Operators of Food Establishments
  www.cfsan.fda.gov

- USDA HACCP Publications
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