Chapter 4 Preparation Module

Overview

The purpose of the preparation module is to determine the number and extent of human exposures to *E. coli* O157 from prepared ground beef products. This module models beef from slaughter through grinding and distribution, to preparation.

Inputs to the preparation module come from the slaughter module. Output for each product type of the slaughter module will consist of the proportion of contaminated pieces of beef, the number of bacteria per contaminated piece, and the size of pieces of beef used for grinding.

The output from the preparation module will consist of the number of contaminated servings and distribution of bacteria within contaminated servings.

Module structure

A simplified flowchart of the preparation module is presented as Appendix A. Parallel arrows leading from boxes indicate branching. The part of the diagram after the arrows represents one branch. All branches are identical in terms of needed variables although they differ in the values of the variables.

The preparation module is a multi-path model that simulates grinding, distribution, and preparation of all ground beef products on each iteration. This approach allows the entire model to calculate total illnesses in the population as well as allow for rapid evaluation of possible mitigation strategies. As the model branches it provides greater resolution and the number of pathways and the number of variables across the pathways increase. Thus there will be many more variables for cooking than for grinding. It is expected that many of the variables will not have specific values. Rather the same values will be used across all paths. When additional evidence for specific pathways becomes available, this can be used to refine the model without constructing a new model. This multi-path approach requires two types of variables: Product Fraction variables and Concentration variables.

Product Fraction variables determine the amount of product that goes into each pathway. For instance the proportion of hamburger that is prepared in the home is a Product Fraction variable. All Product Fraction variables reflect uncertainty only. In other words there is a certain proportion of hamburger that gets used in the home but we do not know exactly what that proportion is.

Concentration variables determine the amount of bacteria present in the product. Concentration variables generally reflect both uncertainty and variability. For instance we know that the time hamburger is stored in the home varies from minutes to days. This represents the variability of storage practices. Additionally, we are uncertain as to the proportions of hamburger that are stored for the various times.

Variable descriptions and evidence

The variables needed to simulate the Preparation Module are presented below. Descriptions of the variables and evidence available for estimating the distributions of these variables are provided. Some of the variables appear to have an abundance of evidence from which to construct distributions. Other variables have little or no evidence at this time. Although it is for these variables that information is most needed, additional evidence for all variables will strengthen the risk assessment. Specific distributions for the variables are not given. The distributions will be constructed after all available evidence is collected.

Nevertheless, responses to this document and further literature searches may provide no additional evidence for some variables. In these cases we will attempt to construct reasonable upper and lower bounds for the variables and use distributions that reflect the large uncertainty in those variables.

Product Fraction Variables

Location of grinder – Beef is generally ground at the processing plant, at an off site processor, or at a retail facility. Beef can also be ground at other sites. These other sites may or may not be included in the model depending on the amount of product that follows other branches.

Evidence:

USDA:APHIS:VS, *Escherichia coli* O157:H7 issues and ramifications, Centers for Epidemiology and Animal Health, Fort Collins, CO, March 1994.

Type of grinder – Grinders vary in capacity and type. This variable may be sufficiently correlated with location of grinder that modeling separate pathways is not necessary.

Evidence:

None

Product fabrication – Secondary processing, or fabrication, of products that contain ground beef (e.g., frozen patties) may occur at the processing plant, at an off-site fabrication plant, or at a retail facility. Comminuted beef derived from advanced meat recovery, mechanical separation, or low temperature rendering may be combined with ground beef during fabrication.

Evidence:

None

Distribution of product – Ground beef is used in a variety of locations. We intend to model ground beef distribution to the following locations:

a) Homes
b) Institutions that provide mass feeding services such as hospitals, nursing homes, and military dining facilities.
c) Institutions that provide cook to order meals such as most restaurants.
d) Picnics

Evidence:

Cattle-Fax (1991)

Type of ground beef product – Ground beef is used in a variety of ways. These uses influence cooking times and temperatures as well as holding times and temperatures. We intend to model ground beef usage in the following types of products:

a) Hamburgers – Ground beef prepared, cooked, and served as hamburger patties.
b) Ground beef based dishes – Products which contain 50% or more ground beef such as meatballs or meatloaf.
c) Ground beef used as ingredient – Products which contain less than 50% ground beef such as meat sauce.

Evidence:

USDA:ARS, The 1995 continuing survey of food intakes by individuals and the 1995 diet and health knowledge survey, Riverdale, MD, 1997

Type of cooking – Products can be broiled, baked, boiled, grilled, fried, or microwaved. Every path will allow for every type of cooking practice. Where certain practices do not occur the product fraction will drop to 0. This allows the branches to develop in parallel without including nonsensical scenarios.

Evidence:

None

Concentration variables

Common variables

Growth response of E. coli O157 in raw product – Given the temperature of the product how quickly does *E. coli* grow? Using an equation or set of equations we

will calculate the product temperature from the ambient temperature and then the growth of *E. coli*.

Evidence:

Buchanan, RL; Klawitter, LA; The effect of incubation temperature, initial pH, and sodium chloride on the growth kinetics of *Escherichia coli* O157:H7. Food Microbiology, 9:185-96, 1992

Palumbo SA; Call JE; Schultz FJ; Williams AC; Minimum and maximum temperatures for growth and verotoxin production by hemorrhagic strains of *Escherichia coli*, Journal of Food Protection, 58:352-6, 1995

Palumbo SA; Pickard A; Call JE; Population changes and verotoxin production of enterohemorrhagic *Escherichia coli* strains inoculated in milk and ground beef held at low temperatures, Journal of Food Protection, 60:746-50, 1997

Rajkowski KT; Marmer BS; Growth of *Escherichia coli* O157:H7 at fluctuating incubation temperatures, Journal of Food Protection, 58:1307-13, 1995

Response of E. coli O157 to cooking – Survival of *E. coli* will be modeled. Information is available that shows heat resistance of *E. coli* depending on original growth conditions.

Evidence:

Ahmed, NM; Conner, DE; Huffman, DL; Heat-resistance *of Escherichia coli* O157:H7 in meat and poultry as affected by product composition. Journal of Food Science, 60:606-10, 1995

Clavero MRS; Beuchat LR; Doyle MP; Thermal inactivation of *Escherichia coli* O157:H7 isolated from ground beef and bovine feces, and suitability of media for enumeration, Journal of Food Protection, 61:285-9, 1998

Heddleson RA; Doores S; Factors affecting microwave heating of foods and microwave induced destruction of foodborne pathogens – a review, Journal of Food Protection, 57:1025-37, 1994

Jackson, TC; Hardin, MD; Acuff, GR; Heat Resistance of *Escherichia coli* O157:H7 in a nutrient medium and in ground beef patties as influenced by storage and holding temperatures. Journal of Food Protection, 59:230-7

Juneja VK; Snyder OP Jr.; Marmer BS; Thermal destruction of *Escherichia coli* O157:H7 in beef and chicken: determination of D- and z-values. Int J Food Microbiol, 84:231-7, 1997 Apr 15

Juneja VK; Klein PG; Marmer BS; Viability of *Escherichia coli* O157:H7 in pepperoni during the manufacture of sticks and the subsequent storage of slices at 21, 4 and -20 degrees C under air, vacuum and CO2. Int J Food Microbiol, 84:47-54, 1997 Jun 17

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Juneja VK; Klein PG; Marmer BS; Heat shock and thermotolerance of *Escherichia coli* O157:H7 in a model beef gravy system and ground beef. J Appl Microbiol, 84:677-84, 1998 Apr

Kenney PB; Prasal RK; Campbell RE; Kastner CL; Fung DYC; Microbiological quality of beef carcasses and vacuum-packaged subprimals: process intervention during slaughter and intervention, Journal of Food Protection, 58:633-38, 1995

Line JE, Fain AR Jr; Moran AB; Martin LM; Lechowich RV; Carosella JM; Brown WL; Lethality of heat to *Escherichia coli* O157:H7: d-value and z-value determinations in ground beef, Journal of Food Protection, 54:762-6, 1991

Semanchek JJ, Golden DA; Influence of growth temperature on inactivation and injury of *Escherichia coli* O157:H7 by heat, acid, and freezing, Journal of Food Protection, 61:395-401, 1998

Williams NC; Ingham SC; Changes in heat resistance of *Escherichia coli* O157:H7 following heat shock, Journal of Food Protection, 60:1128-31, 1997

Growth response of E. coli O157 in cooked product – Growth of *E. coli* in cooked products will only be modeled for surviving organisms. Recontamination of product or cross contamination from other sources will not be modeled.

Evidence:

Buchanan, RL; Klawitter, LA; The effect of incubation temperature, initial pH, and sodium chloride on the growth kinetics of *Escherichia coli* O157:H7. Food Microbiology, 9:185-96, 1992

Murano EA; Pierson MD; Effect of heat shock and incubation atmosphere on injury and recovery of *Escherichia coli* O157:H7, Journal of Food Protection, 56:568-72, 1993

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Pre-grind transportation and storage variables

Time in transportation – Transportation is dependent on the distance the product travels and whether the product goes within plant, off-site, or to a retail facility.

Evidence:

None

Temperature during transportation – Will be modeled as ambient temperature of the transport vehicle. Product temperature will be calculated through cooling curves.

Evidence:

None

Grinding variables

FSIS has conducted a microbiological survey of ground beef, and continues to monitor ground beef for *Escherichia coli* O157:H7. These sources of information may be used to construct input variables regarding the prevalence of *E. coli* O157:H7 in ground beef products.

Evidence:

USDA, Food Safety and Inspection Service, Nationwide Federal Plant Raw Ground Beef Microbiological Survey (August 1993-March 1994). July, 1995. USDA, Room 0157-South Building Washington, DC 20250.

Time for grinding – In addition to other factors, this variable will be dependent on lotting practices (i.e., the quantity of ground beef produced between performance of complete cleaning and sanitization procedures for all equipment used in handling or processing a raw ground beef product (FSIS Directive 10,010.1)).

Evidence:

None

Grinding temperature – This will be dependent on room temperature, original product temperatures, as well as the mechanics of the grinder.

Evidence:

None

Lotting practices – This set of variables will take into account the amount of beef that gets ground at one time as well the number of sources for a single grind.

Evidence:

None

Cleaning practices – The frequency of cleaning as well as the thoroughness contribute to the retention of *E. coli* within the grinder between operations.

Evidence:

Farrell BL; Ronner AB; Wong AC; Attachment of *Escherichia coli* O157:H7 in ground beef to meat grinders and survival after sanitation with chlorine and peroxyacetic acid. J Food Prot, 119:817-22, 1998 Jul

Roels TH; Frazak PA; Kazmierczak JJ; Mackenzie WR; Proctor ME; Kurzynski TA; Davis JP; Incomplete sanitation of a meat grinder and ingestion of raw ground beef: contributing factors to a large outbreak of Salmonella typhimurium infection. Epidemiol Infect, 119:127-34, 1997 Oct

Post-grind transportation and storage variables

Time in transportation – The total time in transportation until the product reaches the end user.

Evidence:

Will use USDA FSIS ground beef recall information to determine distribution for time of product in transportation and storage. The time that elapses between test results and recall of the product and the percent of product returned will allow construction of a distribution that represents time in transportation and storage before preparation.

Temperature during transportation – The temperatures the product is exposed to during the entire transportation phase.

Evidence:

None

Distribution and storage of ground beef variables

Storage time – Time ground beef is in storage after it has reached the end user.

Evidence:

Will use USDA FSIS ground beef recall information to determine distribution for time of product in transportation and storage.

Storage temperature – Temperature to which product is exposed after it reaches end user.

Evidence:

None

Product preparation variables – Product preparation consists of the time the product leaves end user storage until it is cooked.

Evidence:

Fein SB; Lin CTJ; Levy AS; Foodborne illness: perceptions, experience, and preventive behaviors in the United States, Journal of Food Protection, 58:1405-11, 1995

Time – Time it takes to produce final product for consumption. This will refer to total time the product is unrefrigerated during preparation.

Evidence:

None

Temperature – Temperature at which preparation takes place.

Evidence:

None

Cooking variables – Cooking will be modeled as either exposure to a combination of time and temperature or as a log reduction of the number of *E. coli* present based on standard cooking practices. The variables below assume a time and temperature approach.

Time – Time at which product is exposed to cooking temperature.

Evidence:

None

Temperature – Cooking temperature for product. Internal temperature for cooking will be used if available.

Evidence:

None

Post cooking storage variables – Product may not be immediately consumed, but may be subjected to additional storage after it has been cooked. Surviving *E. coli* would then have an opportunity to increase in numbers. Post cooking contamination or cross contamination will not be modeled.

Time – Time that product is kept after cooking but before consumption.

Evidence:

None

Temperature – Temperature at which post cooking storage takes place.

Evidence:

None

References

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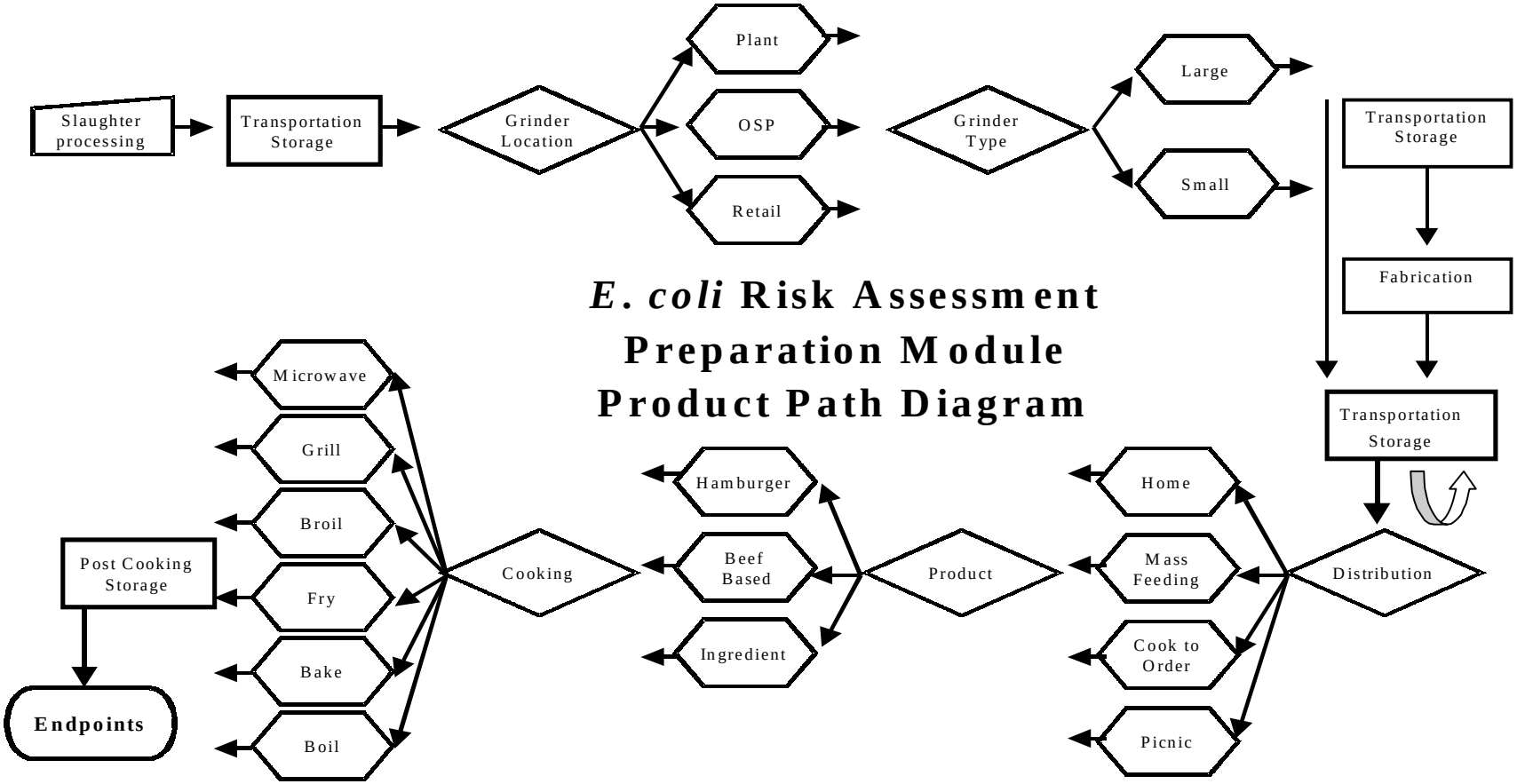
Slaughter processing
Transportation Storage
Grinder Location
Plant
OSP
Retail
Grinder Type
Large
Small
Transportation Storage
Fabrication
Transportation Storage
Distribution
Home
Mass Feeding
Cook to Order
Picnic
Product
Hamburger
Beef Based
Ingredient
Cooking
Microwave
Grill
Broil
Fry
Bake
Boil
Post Cooking Storage
Endpoints
E. coli Risk Assessment
Preparation Module
Product Path Diagram