

NCSU Web Based On-Farm Food Safety Course

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The effective prevention and control of infectious and foodborne diseases in poultry flocks and humans is critically important to ensure the economic vitality of the world's poultry industry. The cost of both animal and human disease is enormous as evidenced by the Foot and Mouth Disease outbreak in the United Kingdom in 2001 and the continued existence of global foodborne diseases. Combating these diseases with effective preventative approaches and strategies has never been more important than today. The focus of this presentation will be to introduce a new internet-based food safety course aimed at the production sector of the integrated U.S. poultry industry.

The necessity for developing on-farm food safety educational programs in the United States arose in response to the ever-increasing need for the U.S. food industry to produce safe and healthy foods. Among the desirable qualities that should be inherent in all foods is freedom from chemical and physical contaminants and infectious organisms. To illustrate the magnitude of the problem, the U.S. Centers for Disease Control and Prevention have estimated an annual incidence of 76 million cases of foodborne disease in the U.S. resulting in 325,000 hospitalizations and 5,000 deaths. These occurrences translate into an estimated \$6 billion dollar annual lost in worker productivity and medical costs, not counting the price of human suffering and costs associated with litigating cases that may ensue. Stated another way, about 1 in 4 consumers in the U.S. will suffer a foodborne illness this year. Of the outbreaks that do occur, 10% are linked to the consumption of contaminated poultry products and eggs leading to an estimated 500 deaths and 7.5 million cases. Although it may impossible to assure complete freedom from these hazards using good manufacturing practices (GMP) or best management/production practices (BMP), the production of foods with the lowest possible level of contamination is a desirable goal.

Today's consumers choose among a wide variety of ultra-fresh food products shipped from across the nation and often from around the world. These products are typically minimally processed with few to no added preservatives. Thus, new approaches are needed to ensure food safety. One approach, the Hazard Analysis Critical Control Point (HACCP) program, was first introduced in 1971 by its founders, the Pillsbury Company, the National Aeronautics and Space Administration (NASA), and the U.S. Army Natick Laboratories, as a systematic plan for producing foods with a high degree of assurance of safety for use in the space program.

Since its introduction in 1971, the HACCP concept has undergone several changes according to specific needs. In 1980, the National Academy of Sciences suggested that food industries in the United States adopt HACCP principles to produce safer foods while regulatory agencies were recommended to help develop food safety programs suitable for particular processing operations. In the early 1980's, the National Research Council (NRC) was asked by the Food Safety Inspection Service (FSIS) of the United States Department of Agriculture (USDA) to evaluate the scientific basis of meat and poultry inspection programs. The 1985 NRC report recommended the establishment of a risk assessment-based meat and poultry inspection program to address public health concerns as opposed to the existing mandatory bird-by-bird organoleptic-based inspection program. Moreover, in 1988 the National Advisory Committee on Microbiological Criteria for Foods (NACMCF) and in 1990 the National Advisory Committee on Meat and Poultry Inspection (NACMPI) were established to provide advice and recommendations to the Secretary of Agriculture on microbiological criteria and inspection programs, respectively, pertaining to the safety and wholesomeness of meat and poultry.

Each of these committees, reports, and recommendations eventually led to the issuance of a final rule by the FSIS on July 25, 1996 termed the Pathogen Reduction and Hazard Analysis Critical Control Point System. Under this final rule that was phased in between 1997 and 2000, each meat and poultry processing plant was required to develop a written HACCP plan to systematically address all significant hazards associated with its products. Regulatory performance standards were also introduced to reduce *Salmonella* in raw meat and poultry. In addition to the establishment of written plant Sanitation Standard Operating Procedures (SSOPs), microbial testing for generic *Escherichia coli* was also required to monitor process control and verify the effectiveness of reducing fecal contamination during slaughter operations. Since its phased-in implementation into large, small, and very small poultry processing plants starting in 1999, there has been a reduction in the incidence of *Salmonella* contamination on broiler carcasses (from 20% before HACCP to 9.9 % on June 30, 2000). However, as noted in Table 1, there has been a rise in the incidence of *Salmonella*-contaminated broiler carcasses for large plants (since 2002) and small plants (since 2003).

Table 1. Incidence of *Salmonella* positive broiler carcasses by year and plant size (USDA Baseline *Salmonella* Performance Standard: 20%; based on USDA “A” sets data).

Year	Large (%)	Small (%)	Very Small (%)	All Plants (%)
1998	10.8	7.1	----	10.8
1999	9.3	15.6	----	11.4
2000	7.5	13.0	18.0	9.1
2001	9.7	13.0	37.2	11.9
2002	10.9	13.2	8.4	11.5
2003	12.2	14.5	16.7	12.8
98-03	9.9	13.7	24.3	11.2

Failure to meet the *Salmonella* Performance standard requires immediate corrective measures by the plant and can lead to enforcement action including withdrawal of inspection and plant closure on the third consecutive failure. Although the percentage of plants in compliance appears high, the statistics show a significant number of plants are failing this standard (Table 2). Similar to the trends noted in Table 1, there was a 2% and 5.2% increase in large and small plant failures between 2002 and 2003, respectively. Although most plants are currently in compliance with the *Salmonella* Performance Standard, the upward trends reported in Tables 1 and 2 and stated goal of the USDA/FSIS to further reduce the incidence of salmonellosis by lowering the 20% *Salmonella*-positive broiler carcass standard demands further attention by the industry. Moreover, consideration is also being given to developing a second performance standard for *Campylobacter*, another foodborne pathogen that presents considerable control challenge for poultry and red meat processors. Although these moves are likely to be viewed by regulators and consumers as necessary for further reducing the risk of foodborne illness, their impact on the poultry and red meat industry has and will continue to be very significant. To assure compliance with HACCP regulations, processors have spent millions of dollars on implementing corrective actions, adding new equipment and disinfectant/sanitizer treatments, hiring and training personnel, and on escalating water and wastewater treatment costs.

Table 2. Percentage of broiler processing plants failing the *Salmonella* Performance Standard by year and plant size (based on USDA “A” sets data).

Year	Large (%)	Small (%)	Very Small (%)	All Plants (%)
1998	9.1	----	----	9.1
1999	9.0	15.0	----	10.6
2000	3.6	20.8	----	8.4
2001	6.0	10.2	75.0	8.8
2002	9.7	13.0	37.5	11.8
2003	11.7	18.2	----	13.4
98-03	7.9	15.3	50.0	10.3

How can poultry processors continue to ensure compliance with HACCP regulations given the likelihood that more stringent regulations may be on the way? One approach is to share the burden with poultry and red meat producers. The current challenge facing most poultry processors is that they bear much of the burden for HACCP regulation compliance and secondly, there are no magic bullet remedies for eliminating all biological and chemical hazards from raw products. Because of the widespread nature and complex ecology of different bacterial pathogens, it appears that attaining significant control will require comprehensive, multifaceted interventions from the farm to the consumer. Although many pathogen control strategies have been identified and approved for the processing plant environment, approaches to control infections in poultry flocks prior to slaughter are just beginning to be evaluated, and

considerable progress will undoubtedly be made in this area in the future. Nevertheless, it is clear that the primary origin of these foodborne pathogens on processed carcasses is from the farm. Hence, antemortem foodborne pathogen control can have a significant impact on reducing contamination of fresh poultry products as intervention strategies are identified, tested, and eventually implemented.

In response to these reported food safety trends, the NCSU Poultry Coordinating Committee comprised of Extension campus and field faculty took on this challenge by developing an internet based on-farm food safety course. Besides having the opportunity to train traditional university students, the course was designed using a module format of specific topics that can be modified and used as separate stand alone training packages for flock supervisors, growers, feedmill and hatchery personnel, and Cooperative Extension agents. Although the course has included a number of components that simulate the basic principles of the HACCP food safety program, the course was structured around on-farm food safety best management practices. However, one of the course modules, feed milling, has been specifically developed around the seven basic principles of HACCP. The course index with corresponding authors encompasses 11 separate modules or chapters as listed below (Table 3).

Table 3. Course index with authors, department affiliation, and email addresses.

Course Index	Authors	Department	Email Address
Introduction	Dr. Brian Sheldon	Poultry Science	brian_sheldon@ncsu.edu
HACCP Approach to Food Safety	Dr. Pat Curtis	Poultry Science	curtipa@acesag.auburn.edu
Breeder, Hatchery to Farm	Dr. Mike Wineland	Poultry Science	mike_wineland@ncsu.edu
Feed Manufacturing	Drs. Peter Ferket & Brian Sheldon	Poultry Science	brian_sheldon@ncsu.edu peter_ferket@ncsu.edu
Biosecurity	Dr. Donna Carver	Poultry Science	donna_carver@ncsu.edu
Disinfection	Dr. Mike Wineland	Poultry Science	mike_wineland@ncsu.edu
Poultry Integrated Pest Management	Mike Stringham	Entomology	mike_stringham@ncsu.edu
Preventive Health	Dr. Donna Carver	Poultry Science	donna_carver@ncsu.edu
Vaccination	Dr. Donna Carver	Poultry Science	donna_carver@ncsu.edu
Water Quality	Kathy Bunton	Area Specialized Poultry Agent	kathy_bunton@ncsu.edu
Loading and Transport	Dr. Jesse Grimes	Poultry Science	jgrimes@poultry.poulsci.ncsu.edu

The course home page as depicted below (Figure 1) is comprised of a course contents page that contains a condensed listing of the 11 course chapters plus an expanded version listing the specific topics covered under each module as illustrated for the feed mill module (Figure 3). The home page also contains a “Quizzes” page link that takes the student to a page containing a specific quiz designed for each module. Students are required to take a quiz as they complete their study of each module. Upon completion and on-line submission of the quiz, the students can immediately assess their

performance on the quiz by clicking the appropriate icon. Additionally, students can view how their test score on a particular quiz compares to the whole class (class statistics) and they are also able to view a summary of their performance for all quizzes taken. To facilitate the learning process, students have access to a “key word” search engine for locating specific topics covered in the course plus a glossary of terms and definitions used in the course. By clicking on the course “Content Compiler”, notes for each specific module can be printed out by the student for further study or reference. Throughout the course students are also directed to additional reading materials via internet links. Additionally, students are exposed to relevant photos and videos to further enhance the learning process.

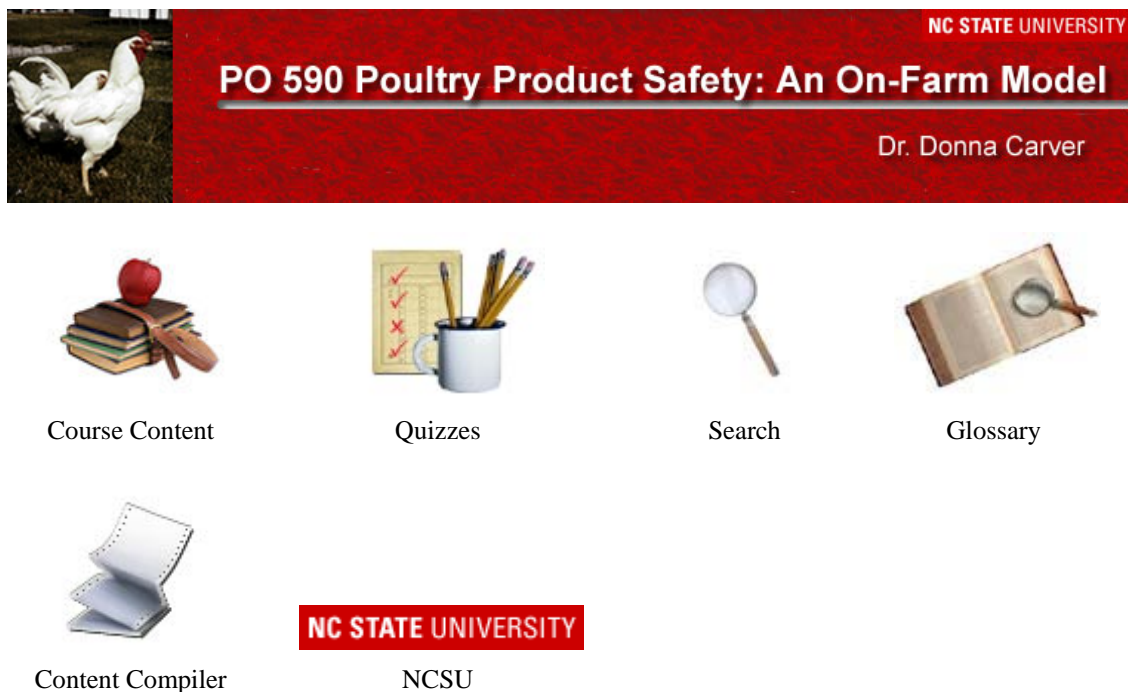


Figure 1. Home page of the internet-based on-farm food safety course.

How to Navigate this Course

As students navigate through the course modules it is helpful for them to understand where they are in terms of the Chain of Infection and the Vertical Integration flowchart. For this reason, when they begin a new module they will find schematics indicating their location in both the Chain of Infection schematic (Figure 2) and the Vertical Integration flowchart (Figure 3).

Table 3. Course table of contents including for illustration purposes, the expanded listing of topics covered under the feed mill module.

Table of Contents

- ▶ 1. Introduction
- ▶ 2. Breeder and Hatchery
- ▶ 3. Biosecurity
- ▶ 4. Disinfection
- ▶ 5. Poultry Integrated Pest Management
- ▶ 6. Preventative Health
- ▶ 7. Vaccination
- ▶ 8. Water Quality
- ▶ 9. Loading and Transport
- ▶ 10. Hazard Analysis and Critical Control Point System
- ▼ 11. Feed Mill
 - 11.1. Feed Mill HACCP Plan
 - ▼ 11.2. Feed Mill Product Flow Diagram
 - 11.2.1. Facilities
 - 11.2.2. Ingredient Receiving
 - ▼ 11.2.3. Ingredient Storage
 - 11.2.3.1. Receiving and Storage Slideshow - Index
 - ▼ 11.2.4. Grinding
 - 11.2.4.1. Grinding Slideshow - Index
 - ▼ 11.2.5. Batching
 - 11.2.5.1. Batching and Mixing Slideshow - Index
 - 11.2.6. Mash Distribution
 - ▼ 11.2.7. Pelleting and Fat Application
 - 11.2.7.1. Conditioning and Pelleting Slideshow - Index
 - 11.2.8. Finished Feed
 - ▼ 11.2.9. Load Out
 - 11.2.9.1. Feed Storage and Loadout Slideshow - Index
 - 11.2.10. Farm Delivery

The Chain of Infection

The basic principle underlying identification of critical control points (CCPs) to control food safety biological and chemical hazards is understanding how disease transmission occurs. This can be illustrated using a schematic developed by J. P. Vaillancourt, a former faculty member in the NCSU College of Veterinarian Medicine. This schematic depicts infection as a chain of events that are dependent on each other to cause infection (Figure 2). An infection can occur only when all links of the chain are intact. Breaking one link of the chain will result in breaking the infection cycle. The infectious agent must be present in sufficient numbers and it must be able to gain access to susceptible birds. Sufficient numbers can be achieved either by introducing large numbers of organisms, or by organisms persisting in an area in close proximity to the birds. In order to persist in an area, transmissible organisms need a reservoir. This can be other birds, mammals (rodents), insects, or any organic matter (used litter spread or

stored on farm). Susceptible birds are those that have no or insufficient immunity to the infectious agent. Transmission can occur via direct (bird to bird) contact, indirect contact (fomites, the environment, etc.) or by vectors (flies, beetles, humans, etc.)

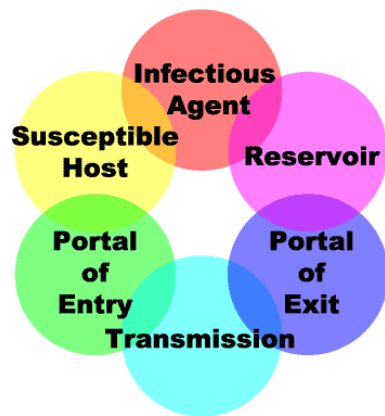


Figure 2. The Chain of Infection.

Vertical Integration Flowchart

The integration of the modern poultry industry combines the different segments of production that were previously separate (Figure 3). This streamlined system allows for greater industry control of production in order to meet marketing needs. Specifically, it provides for potential coordination and cooperation among segments to produce quality product while maximizing profit. This system holds great promise for reducing food-borne pathogens on poultry products. The various segments of the continuum in an integrated operation include feed mill, breeders, hatchery, growout and livehaul to processing.

A major incentive for integrated companies to produce a quality product is that the product is packaged bearing the company name. Unlike other segments of the livestock industry, poultry products can easily be traced to the source of contamination. Few, if any poultry products are further processed at the retail outlet. All processing occurs at the processing plant and product is packaged so that there is little opportunity for cross-contamination at the retail level.

While integrated poultry companies control all segments of production, the segments are often managed as separate entities using least cost production systems. This creates an environment whereby implementation of pathogen-reducing strategies in a segment far removed from processing may not be considered due to the extra cost that would net positive results for a different segment of the integrated system. For example, vaccinating breeders for *Salmonella* species may well reduce *Salmonella* shedding in progeny, but the cost of vaccinating breeders would be incurred by the breeder segment and the payoff would be realized by the growout or processing segment. Failure to utilize good management practices in an earlier segment of the integrated continuum may negate any later attempts to reduce food-borne pathogens on the finished product.

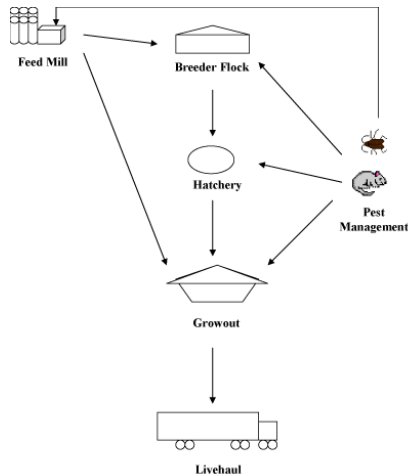


Figure 2. Vertical Integration of the Poultry Industry.

Since basic HACCP principles provide the foundation for several of the course modules, it is important to have a general understanding of the 7 steps of HACCP. Hazard Analysis and Critical Control Points (HACCP) is a process control system that was originally designed to identify and prevent microbial, chemical, and physical hazards in food production. It includes steps designed to prevent problems before they occur and to correct deviations as soon as they are detected. Such preventive control systems with documentation and verification are widely recognized by scientific authorities and international organizations as the most effective approach available for producing safe food.

The seven steps of HACCP are: (1) conducting a hazard analysis, (2) identifying critical control points (CCPs), (3) establishing critical limits for the CCPs, (4) establish monitoring procedures at the CCPs, (5) developing corrective actions when CCPs are outside their limits, (6) keeping appropriate records, and (7) verifying and validating the efficacy of the procedures and overall plan. In discussing each of these 7 principles, some examples that cover both production and processing sector of the business are provided.

Step 1: Conduct a hazard analysis. Processing plants/farms/hatcheries/feed mills etc. identify all food safety biological, chemical, or physical hazards and determine the preventive measures that can be applied to control the identified hazards. At the production level, generally only biological (i.e., foodborne pathogens - *Salmonella* species and *Campylobacter jejuni*) or chemical hazards (i.e., agricultural chemicals - pesticides, animal drugs, fertilizers; farm chemicals - cleaners, sanitizers, lubricants; naturally-occurring toxicants - aflatoxins; environmental contaminants - PCBs, lead, mercury) are of concern. To identify these hazards you will need to understand the chemical and microbiological characteristics of your product (i.e., poultry product, chick or poul, egg, feed or feed ingredient) as well as how various processes (i.e., production-related processes) affect those characteristics. Each step in the process flow should be

evaluated as to the risk of introducing a hazard and whether preventive measures are available to control the hazard.

Principle 2: Identify critical control points. A critical control point (CCP) is a point, step, or procedure in a food production process at which control can be applied and, as a result, a food safety hazard can be prevented, eliminated, or reduced to an acceptable level. One good tool for identifying CCPs is the CCP Decision Tree that consists of answering four questions. Depending on how the questions are answered, the correct CCPs will be identified that eliminate hazards from occurring or decrease their likely occurrence to acceptable levels (i.e., the conditioning/pelletizing process in the feed mill).

Principle 3: Establish critical limits for preventive measures associated with each identified critical control point. A critical limit is the maximum or minimum value to which a biological or chemical hazard must be controlled at a critical control point to prevent, eliminate, or reduce to an acceptable level the occurrence of the identified food safety hazard. Critical limits are expressed as numbers or specific parameters based on visual observation such as time/temperature, humidity, pH, chlorine concentration, etc. Furthermore, some hazards may require multiple critical limits to assure adequate control (i.e., time/temperature, conveyor speed, and humidity of feed going through a pelleting operation).

Principle 4: Establish critical control point monitoring requirements. Monitoring is a planned sequence of observations or measurements to assess whether a CCP is under control and to produce an accurate record for future use in verification. It is useful to detect trends toward loss of control so that action can be taken to bring a process back into control before a critical limit is exceeded. Monitoring can be continuous (i.e., use of automatic recording instruments such as temperature or pH monitors) or non-continuous (i.e., visual examinations, measurements of pH and product temperature, etc.). For the feed mill example, the temperature and flow rate of the conditioner/pelletizer would be continuously monitored.

Principle 5: Establish corrective actions. These are actions to be taken when monitoring indicates a deviation from an established critical limit. Corrective actions are intended to ensure that no product is injurious to health or otherwise adulterated as a result of a deviation (hazard) entering commerce. Corrective action(s) should be established for each CCP. For the feed mill example, a corrective action might include the redirection and reprocessing of a batch of feed that does not reach the appropriate conditioning/pelletizing temperatures.

Principle 6: Establish record keeping procedures. The processing HACCP regulation requires that all plants maintain certain documents, including its hazard analysis and written HACCP plan, and records documenting the monitoring of critical control points, critical limits, verification activities, and the handling of process deviations. These records serve as written documentation of the company's compliance with the HACCP plan. For the feed mill example, a record of the conditioner/pelletizer temperature and flow rate for each batch of feed would be recorded.

Principle 7: Establish procedures for verifying and validating that the HACCP system is working as intended. Verification ensures the HACCP plan is adequate and working as intended. Verification procedures may include such activities as review of HACCP plans, CCP records, critical limits, auditing monitoring procedures, calibrating equipment, and microbial sampling and analysis. Besides verification, the processor/producer must validate that the CCPs and associated critical limits actually prevent, eliminate, or reduce to a regulated and/or commercially feasible and appropriate level, identified microbiological and chemical hazards. It is the process of validation where a company assembles data (i.e., scientific literature, product testing results, experimental research results, scientifically-based regulatory requirements, etc.) showing that the HACCP plan it will use, will work to control the process and prevent food safety hazards.

To further illustrate how these seven HACCP steps might be applied to the production sector, I will provide some additional examples during my presentation on how these basic steps of HACCP and other best management food safety tools can be applied to feed milling and other poultry production operations.

In developing this course it was the intent of the Poultry Coordinating Committee to provide traditional and nontraditional Poultry Science students, Extension agents, and poultry producers with educational programming materials that address a significant problem impacting the poultry industry, that being the assurance of a safe food supply. We have elected to develop an internet-based course because it provides the greatest flexibility for our own students, students located at other universities, and for the non-traditional student not located near campus. For additional information about this course and how you can enroll, contact either Dr. Donna Carver (donna_carver@ncsu.edu), Dr. Brian Sheldon (brian_sheldon@ncsu.edu), or Dr. Mike Wineland (mike_wineland@ncsu.edu).