

Hazard Analysis Critical Control Point (HACCP) Systems for Retail Food and Restaurant Operations

FRANK L. BRYAN

Food Safety Consultation and Training, 8233 Pleasant Hill Road, Lithonia, Georgia 30058

(Received for publication January 29, 1990)

ABSTRACT

There are many hazardous operations that are associated with the preparation of foods in food markets and foodservice establishments. These hazards have been repeatedly documented as major contributing factors during investigation of outbreaks of foodborne disease. Risks vary depending on (a) the food source, (b) methods used to prepare foods, (c) conditions during storage and display, and (d) the interval between heating and consumption. Although many different foods are prepared in these operations, they can be classified into categories of foodservice systems and certain critical control points apply to each system. For example, cooking is a critical control point of Cook/Serve Systems; hot holding, as well as cooking, is a critical control point for Cook/Hot Hold Systems; chilling is a critical control point for Cook/Chill and Cook/Freeze Systems; and obtaining foods from safe sources and/or reheating, if applicable, are critical control points for Assemble/Serve Systems. The HACCP system provides several magnitudes of food safety assurance over that offered by traditional inspections for food market and foodservice operations.

There are microbiological hazards and risks associated with preparation and storage of foods in retail markets and foodservice establishments. **Foodservice operations are frequently identified as places where mishandling of foods has led to outbreaks of foodborne diseases.** Deli operations in food markets are similar to those in foodservice establishments, so there should be the same concern. Sometimes operations in food markets are even of higher risk because holding of prepared foods may be prolonged.

Certain prepared foods are implicated repeatedly as vehicles of foodborne diseases (3). These include in decreasing order of risk: roast beef, turkey, chicken, ham, other pork products, Mexican-style foods (beans, ground/shredded meat), Chinese foods (usually rice), potato salad, rice, chicken salad, cream-filled pastry, meat tacos/enchiladas, shrimp, macaroni salad, pizza, turkey salad, tuna salad, ground meat, barbecue meat, and egg salad. Many of these foods are commonly prepared in food markets and foodservice establishments. Hence, particular care and precautions need to be taken whenever these foods are prepared and held for sale.

Data collected during investigation of outbreaks of foodborne diseases arising from foods prepared in food-

service establishments between 1973-1982 in the United States of America show that certain practices/operations frequently contributed to the causation of these outbreaks (4). The ten most important contributory factors are:

1. Improper cooling (56%)
Leaving cooked foods at room temperature
Storing foods in large containers in refrigerators
2. Lapse of 12 or more hours between preparation and eating (31%)
3. Colonized/infected persons handling foods (24%)
4. Inadequate reheating (20%)
5. **Improper hot holding (16%)**
6. Contaminated raw foods/ingredients (9%)
7. Foods from unsafe sources (6%)
8. **Improper cleaning of equipment and utensils (6%)**
9. Cross contamination from raw to cooked foods (5%)
10. Inadequate cooking (4%)

Risks of foodborne illnesses are high wherever these practices (contributory factors), which relate to contamination, survival, and/or growth of microorganisms, are followed. Hence, particular care must be taken whenever these operations are performed so that such failures will not occur (Note that the percentages exceed 100% because multiple factors contribute to the causation of outbreaks.) Control/preventive measures deal with (a) preventing or at least minimizing contamination of foods, (b) killing microbial contaminants or denaturing toxins, and (c) inhibiting growth of pathogenic microorganisms in foods. These measures can be accomplished with a high degree of assurance that they achieve their intended purpose through application of the hazard analysis critical control point (HACCP) system to food service/marketing operations. This system consists of (a) determining hazards and assessing their severity and risks, (b) identifying critical control points, (c) developing criteria for control and applying preventive/control measures, (d) monitoring critical control points, and (e) taking immediate action to correct the situation whenever the criteria are not met.

HAZARD ANALYSES AND ASSESSMENT OF RISKS

Recipe review

Recipe data are usually either listed or shown in a

flow diagram. By either of these procedures, hazards are assessed. Raw foods of animal origin (raw meat, raw poultry, raw seafoods, and shell eggs), for example, often harbor foodborne pathogens (such as *Salmonella*) and common spoilage microorganisms. Raw vegetables have large numbers of bacteria on their surfaces; these include spores that survive heating and microbes that cause spoilage. Spices and herbs frequently contain bacterial spores that survive heating.

Hazards and their severity and probability of occurrence (risk) are assessed according to epidemiologic data and information about handling of implicated food. Foods that have been commonly identified as vehicles should be considered as potential high-risk items and their preparation steps and storage carefully scrutinized. The flow diagram is particularly useful because all who review it will be aware of the ingredients and processes that the product undergoes. Hazards and critical control points can be depicted at appropriate operations by symbols.

Process/preparation review

The possibilities of contamination, survival of contaminants, and growth of microorganisms are analyzed in a process review. Sources of contamination are people who handle foods and utensils and equipment that the foods contact as well as the raw foods. Human beings usually carry foodborne pathogens on their skin, in skin lesions and burns, in their noses, in their intestinal tracts, and in their mouths. Pathogens from these sources can be transferred to foods as they are handled. Poorly-cleaned utensil and equipment surfaces harbor and promote the spread of microorganisms.

Insufficient heating allows heat-sensitive microorganisms to survive; spores will survive time/temperature exposures of typical cooking. Bacteria increase with time as they are (a) left at room temperature, (b) held at insufficiently-hot temperatures on steam tables and in warm-holding cabinets, or (c) held in large containers of food while kept in refrigerators.

Flow diagrams of the process show interrelationships of each operation to hazards and attempts to control the hazards. They indicate whether a product is being prepared safely and aid in assessing risks of preparation procedures and final products. It provides guidance of ways to lower the risks. (For more information, see references 7-9.)

Observing, measuring, and testing operations

Process reviews can be supplemented by watching operations, measuring temperatures of foods during preparation and storage, and taking samples of products at various steps of preparation and during storage (see reference 1). Modes of contamination can be seen while operations are watched. As a result of observations and other information on the subject, investigators can form hypotheses about whether microorganisms are likely to survive processes or multiply during storage and display. These hypotheses must be tested by either making measurements or taking and testing samples.

Temperature and time measurements show whether pathogens would survive or die during cooking and re-

heating and whether they would multiply during storage and display. Such measurements give considerable information on which to base estimates of hazards and assessment of severity and risks and guide priority setting for control.

Results of analyses of samples can confirm expected outcomes. The data can show that pathogens or indicator organisms (a) are present after handling; (b) have died during heating; and/or (c) multiplied during holding at room temperature, during improper hot holding, or during cooling in large containers. In questionable situations, inoculated-pack studies can be conducted. This is done by inoculating products with microorganisms of concern and then holding them under conditions that simulate operational conditions and situations of expected abuse by purchasers.

Hazards observed are usually the same operations that have been shown to contribute to the causation of outbreaks of foodborne diseases (4). For example, some recently observed hazards are summarized in the following listing:

Observations of hazardous practices during preparation and display of raw seafoods/poultry/meats:

- * Setting up and taking down raw and cooked items for display with either bare hands or the same pair of gloves
- * Reusing the same kale, lemon leaves, lettuce, or other vegetable garnish or decorative plastic dividers or color enhancers indiscriminately for raw and cooked foods
- * Displaying cooked foods in the same case as raw seafood/poultry/meat:
 - as to be in physical contact with one another
 - so that drippage from raw items can flow through ice or along garnish and reach the cooked items below
 - without separation by baffles or in separate cases
- * Infrequent hand washing by persons who handle these foods
- * Refrigerators and cases not kept at temperatures between 30 and 34°F (-1 and +1°C)

Observations of hazardous practice during salad preparation and display:

- * Handling salad ingredients with bare hands during preparation
- * Soaking vegetables in a sink previously used for thawing or washing raw poultry
- * Ingredients not prechilled
- * Slicing, chopping, and grating equipment and utensils not properly cleaned
- * Foods on display, particularly near top surfaces not at temperatures of 45°F (7.1°C) or below
- * Refrigerator temperatures higher than 40°F (4.4°C)
- * Infrequent hand washing

Observations of hazardous practices during cooked-food preparation (including soups/chowders/gumbos/stews):

- * Cooked foods left in kitchen areas for long periods (sometimes for several hours) after cooking (A certain period of time may be required for room-temperature tempering of some thick or pastry-covered foods, but seldom should this period exceed half an hour)

- * Inadequate cooking of poultry, pork, and other foods that are likely to be contaminated with vegetative-forms of foodborne pathogens
- * Temperatures of batches of meat, poultry, items containing ground meat, and stuffed items not monitored at the completion of cooking
- * Insufficient thawing of foods before cooking which may contribute to inadequate cooking
- * Leftovers reheated to insufficiently high temperatures
- * Kitchen personnel handling or otherwise touching cooked foods with their bare hands
- * Kitchen personnel handling raw foods or egg shells either with their hands or gloves and then handling cooked foods
- * Table surfaces or cutting boards used for raw meat, raw poultry, raw seafoods and then (without washing and disinfecting) used for either cooked foods or foods that will not be heated subsequently
- * Clothes and sponges used to wipe raw-foods areas or equipment used for raw foods and then used to wipe areas or equipment to be used for cooked foods
- * Improper cleaning and disinfection of utensils and equipment (wash, rinse, and disinfect procedure not used)
- * **Improper hot holding (see below)**
- * Improper cooling (see below)

Observations of hazardous practices during hot holding:

- * Foods held warm, but not hot, for 8 h or longer
- * Foods not held at temperatures of 130°F [54.4°C]; (140°F [60°C] to satisfy requirements in many codes) or higher, sometimes in the temperature range of 70 to 120°F (21.1 to 48.9°C) within which bacterial growth can be very rapid
- * Hot-holding units not used as designed; for example:
 - foods on display in baking pans or baskets which are tilted up by objects under the back end of the pans or baskets
 - foods in bowls while displayed in steam tables
 - packaged foods on edges of heating elements and on the side framing of the units
 - items stacked on top of other items
- * Hot-holding units not operated as intended, for example:
 - thermostats turned lower than recommended or necessary to hold foods at temperatures of 130°F (140°F to satisfy requirements in many codes) or higher
 - fans in units not turned on
 - glass walls removed from units
 - steam-table water not in contact with bottom of pans

Observations of hazardous practices during cooling:

- * Storing foods while they are being cooled in large containers, such as:
 - 5-gallon (22.7 L) plastic buckets
 - stock pots
 - soup-kettle inserts
 - pans (plastic or metal) that have heights greater than 4 inches (10 cm)
- * Tightly covered containers of hot foods during initial cooling

- * Containers of foods being "cooled" while stacked on top of others
- * Refrigerator temperatures higher than 40°F (4.4°C)
 - * Inadequate number of racks in refrigerators to adequately store shallow pans of foods
- * Shelf-spacing in refrigerators too great to facilitate the storage of the needed number of shallow pans

If these hazardous practices go uncontrolled, foodborne illness can result and shelf-life of products will be shortened with resulting spoilage. Additionally, and sometimes even more severe, abuse can occur in the hands of the persons who purchase or otherwise use the foods.

Field observations should be done with the total process in mind. Short inspections, as usually done by health officials, provide little useful information about hazards and risks because only part of an operation is being done at the time of inspection and items of minor importance are sometimes stressed.

CRITICAL CONTROL POINTS

After hazards are analyzed and their severity and risks assessed for each preparation step for a food, critical control points can be determined. A critical control point is an operation at or by which a preventive or control measure can be exercised that will eliminate, prevent, or minimize the hazard(s). The critical control point is unique to the HACCP system in that preventive and control measures are focused on identified problems rather than to do everything known about sanitation with the hope that something will work to prevent a problem. Hence, maximal effect can be obtained for minimal cost, and yet a higher degree of assurance of food safety can be obtained. Good manufacturing (processing and preparation) practices are advisable and may be applied as company or store policy, but only a few of them qualify as critical control points which will be effective in preventing foodborne illness and spoilage.

There are a few basic foodservice systems. These include Assemble/Serve, Cook/Serve, **Cook/Hold Hot**, Cook/Chill, and Cook/Freeze. The nature of these systems dictates certain critical control points. Assemble/Serve Systems may not have any operation within the place where the foods are prepared and served that will offer any form of control. Hence, critical control points must be based upon the source of such foods. For example, shellfish must be harvested from certified/approved waters which are free of sewage pollution. Canned foods should be processed in plants (a) that heat the filled cans in retorts which are capable of providing time/temperature exposures that ensure destruction of *Clostridium botulinum* and (b) that implement a hazard analysis critical control point system. Milk and dairy products should be pasteurized in plants that (a) implement a hazard analysis critical control point system, (b) that monitor the pasteurization process, and (c) that verify control by testing finished products to ensure effectiveness of pasteurization and absence of post-pasteurization contamination.

Cooking is the critical control point of the Cook/Serve

System. This system is safe when foods are thoroughly cooked and eaten immediately after cooking. Vegetative forms of pathogenic microorganisms which may have been present in the raw products would be killed and time does not permit spores to germinate or post-heating bacterial pathogens to multiply.

Hot holding and cooking are critical control points for the Cook/Hold Hot or Conventional Foodservice System. Failures to hold foods hot (above temperatures at which bacteria multiply) have frequently contributed to outbreaks of foodborne disease in foodservice establishments and are a great potential for causing outbreaks in fast-food restaurants, cafeterias, and food-market delis where cooked foods are held hot, or sometimes only warm, for long durations.

Cooling is an essential critical control point for Cook/Chill and Cook/Freeze Systems. Improper cooling is the most frequent procedure that contributes to outbreaks of foodborne diseases associated with foods that are cooked and then chilled and stored cold.

These are useful guidelines for identifying critical control points, but the development of the HACCP system for foods prepared and held in foodservice establishments and markets is more complex. In many establishments, multiple foodservice systems are in operation, and scores or even a hundred or more different foods are prepared. Foods, however, can be classified into categories that undergo similar operations and, hence, have identical critical control points.

Selection of critical control points should be limited to operations where control action will prevent, control, or at least minimize hazards (6). The hazards to be controlled should be considered as being of high or at least moderate severity and risks. The critical control point must be capable of being monitored either before start-up or during operations, so that appropriate action can be taken to eliminate or prevent hazards as defects are found.

CRITERIA

Criteria for controlling hazards must be specified. These can come from recommendations following investigation of foodborne outbreaks, research data, and/or requirements specified in food-related ordinances and codes. Whatever their source, however, they must be applicable for the foods under investigation and work under the operational setting within the establishment implementing the HACCP program. Control measures must be established whereby these criteria are applied.

MONITORING

For the HACCP system to function properly, critical control points (critical operations) must be monitored. Monitoring is done by persons involved with the operation. It may take the form of making observations, taking measurements, or collecting and, in rare situations, testing samples. In certain food processing operations, monitoring and logging are integral to an operation. For example, a recording thermometer and the operation may also be hooked up with a device that diverts product flow or continues to

hold the product until a prescribed temperature is attained. Such systems are not yet available for very many food preparation activities, but, nevertheless, the HACCP system is still applicable. Monitoring must be done to determine whether the established (safe) criteria are effective for prevention and control. Such monitoring will have to be done for a batch rather than for each item. Other examples of monitoring critical control points of specific food preparation activities are given in references (2,5).

Prudence calls for operators to record monitored data whenever it is practicable and for supervisors to review the logs and to verify by other means that monitoring is being done effectively. These documents can be vital to define responsibility during legal proceedings.

ACTION

Whenever the results of monitoring indicate that criteria are not met, immediate action must be taken to rectify the situation. This may take the form of reheating foods that are being held hot or those that are touched by bare hands, chilling foods by a more efficient way to increase the rate of cooling, returning foods to ovens or other cooking devices until time and/or temperature criteria are attained, or discarding foods. Assessment of hazards and risks dictates appropriate action.

VERIFICATION

HACCP systems should be verified. No matter who develops a HACCP system, an outside party should verify that (a) known hazards have been identified, (b) correct critical control points have been selected, (c) effective criteria for control have been specified, (d) control measures are in place, and (e) the monitoring procedures are the most effective that are available. Furthermore, the effectiveness of monitoring needs to be evaluated periodically and determination made as to whether appropriate action is taken to correct problems as they are detected.

Supervisors must be actively involved to ensure that monitoring is done and, hence, to review logs to ensure that they have been filled out appropriately and to verify that monitoring has, indeed, been done and done effectively. Additional verification may be done by health department staff and other regulatory-agency personnel.

HOW THE SYSTEM WORKS

An example is given to show how the system works in foodservice and market operations. Critical control points for potato salad preparation, for example, are cooking eggs, formulating, mixing, cooling, and cold storage (Fig. 1). Heating eggs in boiling water for sufficiently long can inactivate salmonellae in the albumen and yolk. Hence, this step can eliminate these bacteria from the eggs. The formulation step can give absolute control if enough highly-acid ingredients (e.g., vinegar, mayonnaise, pickle juice, and/or salad dressing) are added and thoroughly blended. Bacteria that cause foodborne illnesses cannot multiply in highly-acid foods. For assurance of control, the pH of the

salad can be measured and adjusted to give a product with a pH of 4.5 or less. When this is not practicable, the pH of the formulation can be tested and adjusted and afterwards the recipe carefully followed with thorough mixing and given sufficient time for acidification. Hence, thorough mixing becomes a critical control point, but measurement of this attribute cannot be done with a high degree of assurance. For further assurance that contamination is minimized, the mixing should be done either with hands covered by disposable gloves or with clean utensils so that hands do not contact the salad. Rapid cooling is an abso-

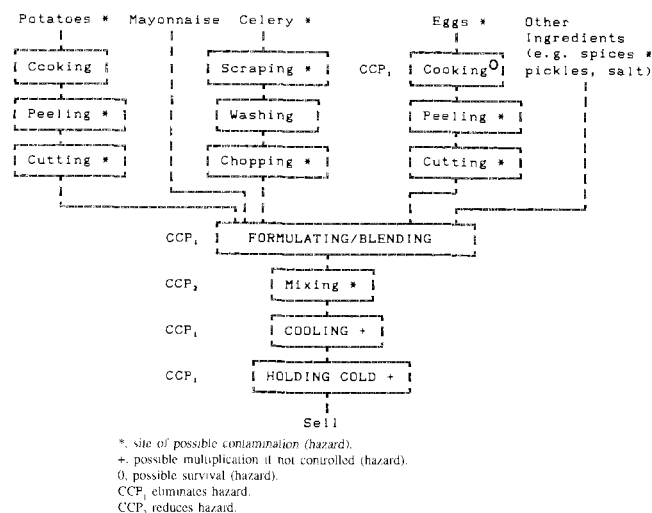


Figure 1. Flow diagram for preparation of potato salad in market deli¹.

lute critical control point in that its accomplishment prevents the growth and associated toxin production by bacteria. Cold storage continues this assurance of control if there is a time limit that ensures that the food is used before any pathogenic psychrotrophic microorganism has a chance to increase to large numbers. Example procedures for monitoring critical control points are given in Table 1. Complete layouts for HACCP systems are given by Bryan for a variety of foods that are commonly prepared in retail and restaurant operations (5).

HACCP COMPARED TO OTHER FOOD SAFETY MEASURES

Traditional approaches employed for food safety have significant limitations. Training courses for food workers, for example, are usually of short duration (i.e., a few hours or days). Subsequent use of information presented and action taken depends on the degree of understanding and motivation. Often, a trained person returns to work where peers and even supervisors who have not had the benefit of the training do not readily accept the new ideas or skills that the trainee has acquired so there is little change.

It is usually not practical to collect and test enough samples to have a high degree of assurance that contaminants are found if present. Microbiological analyses take a few days and results are usually unknown until after foods are sold or consumed. Furthermore, microbiological testing is expensive.

TABLE 1. Critical control points and example monitoring procedures for potato salad.

Critical control point	Monitoring
Cooking eggs	Measure time of boiling and whether egg contents are solidified
Formulation	Measure quantity of acid ingredients used in salad (i.e., follow recipes carefully; measure pH)
Mixing	Observe whether salad ingredients are thoroughly mixed
Cooling	Measure height of salad and depth of pan (e.g., shallow depths 3 inches (<7.5 cm) in pans no higher than 4 inches (10 cm) Observe that pans are not stacked on top of one another or stored in any other manner that impedes cooling Observe that pans are on racks that facilitate air circulation Measure temperature of cooling unit
Cold storing	Measure temperature of cooling unit Measure time of storage (e.g., stock rotation and expiration date)

Inspections are usually of short duration and only a portion of a process is sporadically evaluated. Certain items in regulations are not specific and judgments must be made by inspectors; these may be quite divergent when made by different inspectors and particularly when made by persons in different agencies.

The HACCP system provides a high degree of assurance of food safety - many magnitudes over that offered by the traditional approaches - for food market and food-service operations. Intensified efforts need to be made to implement the HACCP system in foodservice and food market operations.

REFERENCES

- Bryan, F. L. 1981. Hazard analysis of foodservice operations. *Food Technol.* 35(2):78-87.
- Bryan, F. L. 1982. Microbiological hazards of feeding systems. pp. 64-80. In "Microbiological Safety of Foods in Feeding Systems." ABMPS Rep. No. 125. National Research Council, National Academy Press, Washington, DC.
- Bryan, F. L. 1988. Risks associated with vehicles of foodborne pathogens and toxins. *J. Food Prot.* 51:498-508.
- Bryan, F. L. 1988. Risks of practices, procedures and processes that lead to outbreaks of foodborne diseases. *J. Food Prot.* 51:663-673.
- Bryan, F. L. 1989. HACCP hazard analysis critical control point manual. Food Marketing Institute, Washington, DC.
- Bryan, F. L. 1990 Hazard analysis critical control point (HACCP) concept. *Dairy, Food, Environ. Sanit.* 10:416-418.
- International Commission on Microbiological Specifications for Foods. (J. H. Silliker, A. C. Baird-Parker, F. L. Bryan, J. C. Olson, Jr., B. Simonsen, M. van Schothorst, ad hoc committee)/WHO (A. Koulikovskii

- and Z. Matyas, conveners). 1982. Report of the WHO/ICMSF meeting in hazard analysis: critical control point system in food hygiene. VPH/82.37. World Health Organization, Geneva.
8. International Commission on Microbiological Specifications for Foods. (B. Simonsen, F. L. Bryan, J. H. B. Christian, T. A. Roberts, J. H. Silliker, and R. B. Tompkin, ad hoc committee). 1986. Prevention and control of food-borne salmonellosis through application of the hazard analysis critical control point system. WHO/CDS/VPH/86.65. World Health Organization, Geneva.
9. International Commission on Microbiological Specifications for Foods. 1988. Microorganisms in foods 4. Application of the Hazard Analysis Critical Control Point (HACCP) System to Ensure Microbiological Safety and Quality. Blackwell Scientific Publications, Ltd., Oxford.