HACCP in the meat and poultry industry

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An international consensus now exists for the principles of HACCP and how they should be implemented. The relative roles of industry and regulatory agencies has been described. A generic flow diagram is outlined and briefly discussed. A questionnaire for use in HACCP verification is provided. A rationale is suggested for determining when HACCP should be mandatory. The transition from theory to practice and regulatory involvement raises a variety of issues, some of which are discussed.

Keywords: HACCP; poultry industry

INTRODUCTION

An international consensus has been reached on the basic principles of HACCP and how they should be implemented. A consensus has also been reached on the definition of hazard. This is important because the term 'hazard' defines the scope of HACCP. The current Codex definition of hazard is 'the potential to cause harm. Hazards can be biological, chemical or physical' (Codex, 1993c). This definition clearly places the focus of HACCP on food safety.

Universal acceptance of HACCP is very important to the meat and poultry industry because an enormous quantity of these products move in international commerce. Reliance upon microbiological criteria at the port of entry cannot assure that foods are safe. Realization of this fact led the International Commission on the Microbiological Safety of Foods (ICMSF) to further develop and promote the use of HACCP (ICMSF, 1988). After much debate and evaluation, HACCP has now matured to the point where it can be promoted by industry and regulatory agencies alike. Both groups are becoming convinced that this approach is more effective for assuring the safety of domestic and imported foods than relying upon traditional end-product testing to detect unsafe food.

HACCP combines prevention with detection at the steps in the food chain where food safety problems are most likely to occur. In the event that control is lost at a critical control point (CCP) it will be detected so that appropriate corrective actions can be taken to prevent unsafe food from reaching consumers (Tompkin, 1992). Widespread adoption of HACCP by the meat and poultry industry should enhance consumer confidence in its products and reduce barriers to international trade.

The meat and poultry industry can derive several benefits through the application of HACCP. Foremost among these is that HACCP is the most cost-effective management tool for producing the safest foods possible with existing technology. A complete, properly developed HACCP plan can minimize or prevent the occurrence of food safety problems; thereby maintaining consumer confidence and protecting the business.

The process of developing and maintaining a HACCP plan is also educational. Appropriate plant personnel must participate in the development and maintenance of the HACCP plan because they know the limitations of the facility, equipment, people and other factors. In the process, they should become more knowledgeable as they develop the plan with appropriate experts. Through detailed analysis, steps in the process are identified which can impact upon product safety. Through this analysis, plant personnel become familiar with the real food safety issues and learn to

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Food Control 1994 Volume 5 Number 3 153
focus their efforts to minimize or prevent their occurrence. There are numerous demands for the time and attention of plant management and employees (e.g. profit, filling orders, product quality, increasing the rate of production). HACCP places into proper perspective the factors that are of the highest priority and that must be controlled. As active participants, plant personnel are more likely to assume ownership of the plan and see that it is correctly implemented.

When developing a HACCP plan, a generic HACCP plan can be used for guidance. The plant must customize the plan to its own specific conditions, however, because each HACCP plan must address the unique features of the plant's process, equipment, layout, people and other factors.

The use of HACCP for the meat and poultry industry must begin at the farm because certain safety concerns cannot be eliminated during the slaughtering process. For example, chemical residues and certain microbial pathogens (e.g. salmonellae, Campylobacter jejuni, Escherichia coli 0157:H7) cannot be controlled without enlisting the help of producers. Eliminating these human pathogens from farm animals is a long-term objective. In the short term, companies with integrated operations may have more opportunity for controlling certain hazards than those who purchase livestock on the open market for slaughtering.

APPLICATION OF THE PRINCIPLES OF HACCP

The principles of HACCP have been described by Codex (1993c) and in this issue of Food Control by Käferstein (1994). Additional information is available from ICMSF (1988), NACMCF (1992), ILSI Europe (1993) and others. ICMSF (1988) provides information on the importance of plant layout, equipment design, cleaning and disinfecting, and employee health that is not available in the other documents. Codes of hygienic practice have been developed for the production of fresh meat and poultry (Codex, 1976, 1993a, 1993b) and for processed meat and poultry products (Codex, 1986). An assessment of the microbiological hazards associated with beef slaughtering and a generic HACCP plan were recently developed by the US National Advisory Committee on Microbiological Criteria for Foods (NACMCF, 1993).

Codex (1993a) has described HACCP as a scientific approach to food safety and wholesomeness throughout the production, processing and distribution of fresh meat. Codex has endorsed the inclusion of HACCP into the codes of practice and, also, the development of specific HACCP systems tailored to the individual product, processing and distribution conditions of each abattoir or establishment. The purpose of the Codex codes of practice has been to specify the conditions required at each step in the process from production through distribution that will assure that meat will be safe and wholesome. Codex has defined 'safe and wholesome' to mean that the meat has passed inspection and:

(a) will not cause foodborne infection or intoxication when properly handled and prepared with respect to the intended use;
(b) does not contain residues in excess of established Codex limits;
(c) is free of obvious contamination;
(d) is free of defects that are generally recognized as objectionable to consumers;
(e) has been produced under adequate hygiene control;
(f) has not been treated with illegal substances as specified in relevant national legislation.

This definition is somewhat broader than the Codex definition of hazard. It is clear, however, that the objective of HACCP and the Codex codes of practice for fresh meat and poultry do share a common goal, safe foods for consumers.

The application of HACCP in the meat and poultry industry will be described in a very limited, generic sense. Figure 1 outlines a generic HACCP plan which begins at the farm and ends with the shipping of a vacuum-packaged cured sliced meat or poultry product from the plant. The flow diagram is adapted from Simonsen et al. (1987) and ICMSF (1988). Although spore-forming pathogens (Clostridium botulinum, C. perfringens, Bacillus cereus) and certain parasites must be controlled, the hazards of primary concern to humans in fresh meat have been microbial infectious agents. Information on the effect which the steps from the farm through slaughtering have on salmonellae, E. coli 0157:H7, Campylobacter jejuni and Yersinia enterocolitica in meat and poultry has been described (Simonsen et al., 1987; Kapperud, 1991; NACMCF, 1994a, 1994b). Salmonellae, Y. enterocolitica and Trichinella spiralis; salmonellae and C. jejuni; and salmonellae and E. coli 0157:H7 are the pathogens of greatest importance to human health in raw pork, poultry and beef, respectively.

As the association of Y. enterocolitica with raw pork became recognized, particularly in Scandinavia, attention has been given to reducing the risk of contamination. Figure 2 is a flow diagram which shows the major sites of contamination of pork from production through processing (Kapperud, 1991). Investigations are leading to recommendations to modify certain slaughtering and inspection procedures (Kapperud, 1991). Some of these modifications also may reduce contamination of pork with salmonellae.

The hazards associated with meat and poultry products may differ in various regions of the world. These differences should result in HACCP plans which reflect the existing hazards. For example, the existence of pathogenic bioserotypes of Y. enterocolitica in raw pork is of greater concern in cooler climates (e.g. Scandinavia) than in countries where these specific bioserotypes are of lower risk. In another example, the
Figure 1  Flow diagram from farming to shipping sliced lunchmeat from a plant. Sites of contamination and control of human pathogens. ●, Major contamination; ○, possible contamination; CCP1, effective CCP; CCP2, not absolute
restrictions applied to control *T. spiralis* in pork products in Europe and North America do not apply in Australia where *T. spiralis* does not exist.

The primary goal of farmers is to achieve efficient feed conversion and sufficient disease control to maintain a favourable health status and maximize the growth rate of the animals. Human pathogens (e.g., salmonellae, *C. jejuni*) can be introduced into the animal population from a variety of sources. The potential for higher carrier rates of these pathogens can increase due to stress and crowding as the animals are collected in pens and transported to the slaughtering plant. Other factors (e.g., age of animals) also can affect the carrier rates of human enteric pathogens. Chemicals (e.g., pesticides, antibiotics) used by farmers must be properly applied to avoid unacceptable residue levels in meat. The risk of chemical residues is best controlled through continuing education of farmers and an appropriate level of testing to verify compliance.

Two fundamental concepts must be considered during the slaughtering process. First and foremost is the use of procedures which will minimize the degree of contamination on carcasses during the slaughtering process. This may involve training workers in the proper use of knives and equipment, providing adequate work space and time to perform each function correctly, providing a plant layout that favours microbial control, and selecting equipment which is readily cleanable and which minimizes contamination. Research may be necessary to reduce contamination below current levels. For example, more improved, cost-effective technology is needed to hygienically remove feathers from poultry and hair from hogs. The second concept has been gaining increasing acceptance in recent years by industry and regulatory officials. That is to include procedures (e.g., spraying with organic acids) which can remove and/or destroy pathogens which inadvertently contaminate the carcass during slaughtering (Dickson and Anderson, 1992). When properly designed and implemented these decontamination procedures can enhance the safety of fresh meat beyond that which can be accomplished by relying solely upon preventing contamination. Additional research to develop more effective methods for decontamination should be encouraged by Codex and national regulatory agencies.

After eviscerating and chilling, the carcasses often are cut into various sections of meat. In the example of Figure 1, deboned meat is selected for processing into a cooked meat or poultry product. The species of meat (i.e., beef, pork, chicken) must agree with the ingredient statement on the package because some indi-
viduals are sensitive to certain types of meat. For this reason species control is a CCP. A curing solution is prepared and injected into the meat to achieve the desired level of ingredients. The quantity of nitrite added is a CCP because excessive quantities can be toxic to consumers. The level of nitrite can be controlled through the use of a preblended nitrite-curing salt. Other measures also can be effective. Both the type of meat and the nitrite content can be effectively controlled (CCP1).

In this example, the meat is tumbled under vacuum in a chamber and then filled into a can, casing, mould or other container for cooking. The meat is heated sufficiently to destroy non-spore-forming pathogens and then chilled at a rate that will prevent the outgrowth of surviving spores. After chilling, the product is removed from the container, sliced, vacuum-packaged and placed into shipping cartons for storing and distributing. The packages and cartons are labelled with appropriate statements (e.g. 'keep refrigerated') to inform distributors, retailers and food handlers of the necessity for keeping the product cold. The condition of holding, slicing and packaging the ham after cooking is critical to minimize the risk of contamination with pathogens such as salmonellae and Listeria monocytogenes. Experience indicates that post-process contamination with salmonellae can be prevented (CCP1) (Tompkin and Borchert, 1992) whereas contamination with Listeria monocytogenes can be minimized (CCP2) (Tompkin et al. 1992). The latter psychrotrophic pathogen is more difficult to control in the cooked product environment. HACCP has been recommended to control L. monocytogenes and assure the safety of processed meat and poultry products (WHO, 1988; NACMCF, 1991; ICMSF, 1994).

Figure 1 contains four CCPs which can provide effective control (CCP1). One involves formulating the product correctly to control the species of meat and the quantity of nitrite. Another is for cooking because it effectively destroys non-spore-forming pathogens. The remaining two are for chilling. When properly controlled the chilling of carcasses is effective for preventing the multiplication of pathogens. The other involves chilling the cooked meat or poultry product. In this case, the rate of chilling can be controlled to prevent the outgrowth and multiplication of spore-forming pathogens which survive cooking.

Physical hazards (e.g. metal, bone, plastic, wood, glass) must be controlled by applying preventive measures which minimize their introduction into the product via the raw materials and during the processing steps prior to cooking. Possible product contamination with metal can be monitored by passing the packaged product through a metal detector.

AREAS WHERE FURTHER INFORMATION OR STANDARDIZATION MAY BE NEEDED

Principle 4 of the current Codex document on HACCP (Codex, 1993c) should be modified to incorporate an important aspect of HACCP. As currently stated, the emphasis of Principle 4 is on monitoring (i.e. checking) whether CCPs are under control. Instead, the results of monitoring should be used to make adjustments in processes to 'prevent loss of control', not 'regain control'. If control has been lost, then a deviation will have occurred and specific corrective action will be necessary (Principle 5). It is in Principle 4 that detection and prevention are combined to prevent loss of control and deviations from occurring.

It is necessary that educational materials begin to be based upon one common understanding of the HACCP principles and definitions; otherwise, continued confusion will be detrimental to the acceptance of HACCP. With recent agreement on the principles of HACCP standardized teaching materials, such as the WHO document on training (WHO, 1993), can provide a uniform basis for educational programs on an international level.

The question of education raises the issue of certification. Is it necessary or desirable to certify individuals or processing facilities for having met certain basic requirements? Should educational courses on HACCP be certified if they meet certain standards? Should the graduates of such courses be certified? Should food establishments be required to employ or have available for consultation a person who is certified in HACCP? These issues must be resolved at a national rather than an international level.

Verification (Principle 6) is an important aspect of HACCP. In fact, the major role of regulatory agencies in facilities with HACCP plans should be to verify whether HACCP plans are complete, accurate and being correctly followed (NACMCF, 1994a, 1994b). Periodic verification also is a responsibility of the HACCP team. Some companies have representatives who visit facilities for periodic reviews. With so many groups involved in verification activities a standardized checklist could be helpful. Table 1 contains a general questionnaire which can be used to facilitate these reviews. The questionnaire also can be helpful to the HACCP team as it develops its HACCP plan(s) or as it prepared for verification activities by outside inspectors.

POTENTIAL PROBLEMS IN THE USE OF HACCP

A number of issues must be resolved during the transition from traditional inspection to inspection of meat and poultry facilities which have HACCP plans (Tompkin, 1990). One significant factor affecting the acceptance of HACCP by industry and government inspectors is job security. As HACCP plans become implemented there is less emphasis on end-product inspection and testing. The responsibility for assuring product safety, and other product attributes, should shift to production personnel who actually monitor and
control the process. The role of traditional inspectors should shift toward verification activities. This can result in fewer inspectors being required in plants that have effective HACCP plans. This could result in significant changes in the meat and poultry industry which, in many countries, traditionally has received more intensive regulatory inspection than other food industries.

A second significant issue in the meat and poultry industry concerns expectations. As the potential value of HACCP becomes more widely recognized, there is a tendency to oversell the benefits of HACCP, particularly to consumers and legislators. This stems from failure to acknowledge the existence and distinction between CCP1 and CCP2 (ICMSF, 1988). A CCP1 is a CCP that will assure control of a hazard. A CCP2 is a CCP that will minimize but cannot assure the control of a hazard. Thus, certain hazards can be minimized but not prevented.

The new draft revised code of hygienic practice for fresh meat (Codex, 1993a) clearly states throughout the document that some level of contamination will occur during the slaughtering process but conditions should be such that the contamination is held to a minimum. Thus, the Codex document fully recognizes the existence of CCP2 at many steps in the process of converting live animals into fresh meat. The adoption of HACCP will not eliminate all hazards because current technology is inadequate to reach this desirable goal. The absence of an effective kill step (e.g. pasteurization, cooking) during slaughtering means that raw meat and poultry may harbour some level of pathogens. The adoption of HACCP can lead to a reduction, but not the elimination of enteric pathogens (i.e. salmonellae, C. jejuni, Y. enterococlitica, E. coli 0157:H7), spor-forming pathogens (e.g. C. botulinum, C. perfringens, B. cereus) and certain parasites. Thus, proper handling and preparation of meat and poultry products by the food preparer is essential for food safety.

Recognition that carcasses may harbour microbial pathogens has led some to believe that rapid tests are needed to detect pathogens on carcasses. Such tests could qualify as monitoring procedures if the results become available before the carcasses are shipped from the plant. This presumably would permit the processor to subject carcasses which test positive to some additional process to eliminate the pathogens or, perhaps, divert the meat to a processor who would use the meat in a cooked product. This approach, however, overlooks the weakness that no feasible sampling plan can guarantee the absence of a pathogen. Also, in the event that an enteric pathogen is found, then how many carcasses must be diverted? Which carcasses are unacceptable – those that were tested, all carcasses from the same farm or all the carcasses processed that hour, shift or day? The long-term solution to enteric pathogens lies not in testing carcasses but in controlling the pathogens at the farm plus improved technology during slaughtering.

Other problems must be resolved as HACCP becomes more widely adopted. As HACCP becomes incorporated into the regulatory inspection process there will be disagreements over whether certain hazards of potential significance are likely to occur in a process and whether certain steps in the process are CCPs. These debates will be influenced by existing knowledge and the conservative nature of the parties involved.

Decisions over the risk of a hazard and whether a processing step is a CCP are best made by an 'expert in hazard analysis'. These experts are individuals with the knowledge and experience to correctly: (a) identify potential hazards; (b) assign levels of severity and risk;
appropriate corrective actions when a deviation occurs; (e) recommend research related to the HACCP plan if important information is not known; and (f) predict the success of the HACCP plan (NACMCF, 1992). Unfortunately, at this time there is an insufficient number of experts in hazard analysis available to assist in the development and assessment of HACCP plans.

Wider use of HACCP will result from supplier-buyer relationships. Some buyers of meat and poultry products now require the use of HACCP plans by suppliers; perhaps, even requesting that suppliers submit a copy of their HACCP plan. Such a request is unacceptable for two reasons. First, HACCP plans are unique to each operating facility and are of value only when reviewed for accuracy and completeness during a visit to the plant. Second, HACCP plans contain important proprietary information concerning the plant's operating procedure. Careless or unethical sharing of the HACCP plan with other potential suppliers could occur. HACCP plans should be available for buyer review only at the plant.

The generic HACCP plan as described above and in Figure I shows eviscerating as a CCP. In reality there are many steps involved between when the hide, hair or feathers are removed and when the carcass is chilled. Thus, decisions should be made whether any of these steps are CCPs. The Codex HACCP decision tree which was developed to help decide whether the steps in a process (e.g. slaughtering) are CCPs can lead to debatable results. The first question the decision tree asks is whether preventative measures exist. The response should be, yes, measures do exist to minimize contamination (Q1 = yes). The second question is pivotal with the answer depending upon one's view of an 'acceptable level'. It is possible to specifically design and control certain steps in the slaughtering process to minimize carcass contamination with enteric pathogens. The acceptable level should be the minimum level that can be consistently achieved for a facility when the process is under control. The acceptable level in one facility may differ from another facility. Failure to control a specific step could result in a higher level of carcass contamination. In agreement with the Codex code of hygienic practice for fresh meat (Codex 1993a) the conditions should be such that the level of contamination is held to a minimum. Thus, it must be concluded that certain steps in the slaughtering process can be CCPs (Q2 = yes). This conclusion should be the one favoured by most proponents of HACCP, including those who are redrafting the code of hygienic practice for fresh meats.

If, on the other hand, an unrealistic position is taken that no contamination is acceptable, then the answer to question 2 becomes no (Q2 = no). Under a zero tolerance, any contamination at a step would be in excess of the acceptable level (Q3 = yes). Since a subsequent step (i.e. cooking) can eliminate the hazard of enteric pathogens (Q4 = yes), this could lead to the conclusion that under a zero tolerance for carcass contamination none of the steps in the slaughtering process are CCPs.

The answer to question 2 of the decision tree also can lead to another conclusion depending on one's view of 'specifically designed'. Many of the steps in the slaughtering process can be controlled to minimize contamination even though they may not be 'specifically designed' to do so. Since these steps are not 'specifically designed' to eliminate or reduce contamination with enteric pathogens, the answer to question 2 is no (Q2 = no). The response to question 3 is yes (Q3 = yes). The decision tree would suggest that the contamination which may occur at these steps is of little, or no, concern because a subsequent step (i.e. cooking) will eliminate the hazard of excessive levels of enteric pathogens on carcass meat. Thus, the steps in slaughtering which are not 'specifically designed' to eliminate or reduce contamination with enteric pathogens are not CCPs. Perhaps this was the intended result of those who designed the decision tree. On the other hand, since these steps are not CCPs they may receive less attention and, thus, less effort to control the level of contamination.

Two variations of question 4 of the Codex decision tree have been proposed which place even greater emphasis on the role (i.e. responsibility) of the consumer for eliminating the hazards associated with contamination that may occur during slaughtering. One asks, 'will subsequent processing including correct consumer use, guarantee removal of the hazard or reduction to a level regarded as safe?' (Mayes, 1992). The other asks 'will subsequent processing stages including expected consumer use, guarantee removal of the hazard or reduction to an acceptable level?' (ILSI Europe, 1993). This is unfortunate because control should be exercised wherever possible during various steps in the slaughtering process to minimize contamination, even though cooking by the consumer will kill enteric pathogens. The potential for cross contamination from raw meat and poultry to ready to eat foods in the kitchen must be considered. The higher the level of contamination during slaughtering, the greater the risk of subsequent cross contamination. Furthermore, the burden of food safety should not be shifted disproportionately from the producer and processor to the consumer.

It is evident that 'acceptable level' and 'specifically designed' in question 2 of the decision tree are key phrases influencing the decision whether a step in the slaughtering process is a CCP. It is the intention of HACCP to focus on the steps which are CCPs because they are of greatest concern to food safety. If it is concluded that certain steps in slaughtering are not CCPs, even though contamination can be minimized, then HACCP will not achieve its potential of improved food safety. The use of the Codex decision tree is optional and is intended to facilitate the identification of CCPs. If used, the decision tree should be used with caution and not taken literally as has been done in this
A thorough understanding of the goals and principles of HACCP should be the overriding guide when deciding whether a step in a process is a CCP.

ROLE OF GOVERNMENT AGENCIES

The role of government agencies has been described by the NACMCF (1994a). An early draft of this report was provided to the WHO Consultation on HACCP Training (WHO, 1993). For a variety of reasons the NACMCF did not fully address the specific issue of whether HACCP should be voluntary or mandatory. This issue, however, could be approached through the same logic used by Codex, and others, for deciding whether microbiological criteria should be established for a food. Codex states that, ‘the purpose of microbiological criteria for foods is to protect the health of the consumer by providing safe, sound and wholesome products and to meet the requirements of fair practices in trade’ (Codex, 1989). Codex also states that, ‘a microbiological criterion should be established and applied only where there is a definite need for it and where it can be shown to be effective and practical’. Furthermore, to fulfil the purpose of microbiological criteria, Codex recommended that consideration be given to:

- the evidence of hazard to health;
- the microbiology of the raw material;
- the effect of processing on the microbiology of the food;
- the likelihood and consequences of microbial contamination and/or growth during subsequent handling and storage;
- the category of consumer at risk;
- the cost/benefit ratio associated with the application of the criterion.

The purpose of HACCP is to protect the health of the consumer by providing safe products. Similar to microbiological criteria, HACCP should be mandatory only where there is a definite need for it and where it can be shown to be effective and practical. HACCP is used to control chemical, physical and biological hazards in food. Thus, to fulfil the purpose of HACCP, consideration should be given to:

- the evidence of hazard to health;
- the expected hazards associated with the raw materials;
- the effect of processing on expected hazards;
- the likelihood and consequences of food safety hazards during subsequent handling and storage;
- the category of consumer at risk;
- the cost/benefit ratio associated with the application of HACCP.

In most instances if a specific process has been found to be linked with repeated instances of foodborne illness, national authorities have responded by imposing appropriate regulations. The regulations are usually targeted for a specific step or steps (e.g. cooking, chilling, labelling, separating raw meat from cooked products) in the process where control must be applied to prevent foodborne illness. Thus, certain aspects of HACCP are already in place through national regulations. Updating regulations in response to newly recognized problems will continue to be necessary to assure food safety.

The scope of HACCP and HACCP plans is limited to food safety. One of the most contentious issues of HACCP is the availability of records to regulatory agencies. Record-keeping is an essential aspect of HACCP. Industry is responsible for producing safe food products. Regulatory agencies are responsible for verifying that industry is producing safe meat and poultry products. To fulfil their responsibilities of verification, regulatory agencies which are responsible for meat or poultry inspection must have access to those records which pertain to the HACCP plan. This would include, for example, the HACCP plan and records which pertain to CCPs, deviations, corrective actions, revalidations and the training and education of individuals who are involved in implementing the HACCP plan.

Another significant issue is whether regulatory agencies should preapprove HACCP plans. In general, it is unrealistic to expect regulatory agencies to preapprove HACCP plans. Such a requirement would be administratively and economically burdensome. If preapproval is deemed necessary, this practice should be limited to selected processes which involve hazards of high risk and severity. A policy of regulatory preapproval ignores the fact that HACCP plans are documents which are unique to each specific plant and must be verified on site for accuracy and completeness. Also, it is normal that changes (e.g. method of processing, location, equipment, establishment layout, reorganization of management structure and responsibilities) will occur. Thus, HACCP plans must be dynamic and reflect the changes as they occur.

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