The role of Hazard Analysis Critical Control Point in food safety

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ABSTRACT

Food-borne diseases of multiple aetiologies are a widespread and growing public health problem, both in developed and developing countries. Microbial health hazards are responsible for over 90% of the incidents of global food-borne illenesses. It is estimated that about one-third of people in the developing nations are affected by food-borne pathogens every year. Hazard analysis and critical control point (HACCP) is an internationally agreed approach to food safety management system. It was initially developed for use by food processors to prevent or control hazards, but the application of HACCP system has been evolving and expanding to form a basis for official food control and for establishing food safety standards for the international food trade as well. HACCP is a proactive approach to food safety management and it is flexible, where necessary control measures can be adapted to changes in operations. HACCP helps to target resources to the most critical part of the food operations, and it is applicable to the entire food chain, from the raw material to the end product. In addition, the application of HACCP system can aid inspection by food control regulatory authorities, and promote international trade by increasing buyer confidence in food safety. HACCP overcomes many of the limitations of the traditional approaches to food safety control. HACCP system is comprised of seven principles, and its application is not a stand-alone system, but it should be seen as an element of food safety management. It complements basic good hygienic practices in food safety assurance by targeting product-specific hazards, and devising control measures necessary for managing risks relevant to the product and conditions of operations. HACCP can be a powerful tool for the management of food safety only if it is correctly understood and applied, and if there is adequate commitment by the management for providing necessary resources and expertise. It is recommended that training of personnel in food industry, government, and academia in HACCP principles and applications, and increasing awareness of consumers are pertinent elements for effective implementation of HACCP programme.

This paper is dedicated to the memory of late Dr.A.P.S.Abdul Kalam, the then President of India, who was a very learned, simple, gentle, kind hearted person, and distinguished scientist, and is remembered as Missile Man of India.

***Key words**: Food borne diseases, Food chain, Food safety, HACCP, Public health, Surveillance*

INTRODUCTION

Food is a very essential element for the survival of human beings. Everybody expect that the food they eat is clean, wholesome and safe for consumption. Unfortunately, the ingestion of contaminated food due to microbes can result food poisoning (Pal and Mahendra, 2015). Food-borne disease is at best unpleasant and at worst, it can be fatal. Consequences of food borne illness include adverse effects on trade and tourism, loss of earnings and productivity, unemployment, and litigation. Food spoilage is wasteful and costly, and can adversely affect the economy and erode consumer confidence (Whitehead and Orriss, 1995).

Food safety has been a concern of mankind since the dawn of history. Food safety is an assurance that food will not cause any harm to the consumer when it is prepared and /or eaten (Pal and Mahendra, 2015). Food-borne diseases caused by multiple etiologic agents are a growing public health concern, both in developing as well as in developed nations of the world, as international trade in food continues to expand (Pal and Mahendra, 2015). It is estimated that in developing countries, food-borne diseases cause an estimated 2.2 million deaths each year (Pal *et al*., 2015). According to the World Health Organization, food-borne disease (together with water) is a significant contributor to mortality from diarrheal disease resulting 1.8 million deaths worldwide in 2005 (WHO, 2007). Food-borne diseases causes are responsible for 76 million illnesses, 325,000 hospitalizations, and 5000 deaths in USA each year (CDC, 2005). In England and Wales, from 1996 to 2000, an estimated 1,724,315 cases of indigenous food-borne disease per year resulted in 21,997 hospitalizations, and 687 deaths (Adak *et al.,* 2005). About 75 million people in India suffer from food-borne illnesses every year (Pal *et al*., 2015). In developing nations, food-borne disease often goes unreported and strong surveillance and reporting systems are unavailable. However, the high prevalence of diarrheal diseases suggests major underlying food safety problems (WHO, 2007). The major goal of food industries is to provide safe, clean, wholesome, and acceptable food to the consumer, and also to control the microbes, which can produce spoilage and food poisoning (Pal and Mahendra, 2015). Hence, it is emphasized that all food establishments should implement HACCP programme from food safety point of view.

Over the last decade, the occurrence of international food

safety issues has resulted in a decline in public trust in food safety regulation. The increasing number of food-borne disease incidents and food related scares has prompted a great deal of activity by public health authorities and other concerned parties in order to develop new methods to ensure food safety. Today, governments and other parties involved in food control are under constant pressure to find more efficient and effective mechanisms to carry out their mandates for food control. Many food-borne diseases are preventable through a number of control efforts along the entire food chain from production to consumption (Pal and Mahendra, 2012). This has led to international recognition of the importance of the hazard analysis and critical control point (HACCP) system as a means to control food related hazard (Al-Kandari and Jukes, 2011). HACCP is a prevention based food safety system that identifies and monitors specific food safety hazards (Pal and Mahendra, 2015). It is recognized that application of HACCP system to food production and preparation has the potential of enhancing food safety, and preventing many cases of food-borne diseases (WHO, 1999). Thus this review is prepared with the objectives of describing the role of HACCP in food safety, the principles of HACCP, and its application in food safety.

THE ROLE OF HACCP IN FOOD SAFETY

All countries need adequate food control programmes to ensure that national food supplies are safe, of good quality, and available in adequate amounts at affordable prices to ensure an acceptable nutritional, and health status for all population groups. Food control includes all activities to ensure the quality, safety and honest presentation of the food, from primary production, through processing and storage, to marketing and consumption. The term has been used to describe a total national effort involving an integrated approach between governments and all segments, and sectors of the food industry. Food control is linked to improvement of the health of the population, the potential for a country's economic development, and the reduction of spoilage and food losses **(**Whitehead and Orriss, 1995). Sincere attempts should be made to prevent the contamination of food by microbes in the food chain that starts from production to consumption (Pal and Mahendra, 2015).

The concept of HACCP was developed in the late 1960s as a quality assurance to enhance food safety. Until the introduction of HACCP system, the food safety assurance system was a reactive one, i.e. based on the implementation of directives referred to as "codes of practice", which were developed based on experience, combined with end-product testing. Such codes had to be fairly general in order to be applicable in diverse situations of food production and food processing. Therefore, they could not and did not consider hazards, which where specific to a food product, i.e. its ingredients and/or the specific conditions of operation. As with globalization and changes in society, the nature and origin of raw material were becoming more and more diverse, the technology used in food production and processing more complex, and the traditional approach became increasingly inadequate for preventing and controlling hazards in foods.

Also, with increased industrialization, mass production and distribution of food, the risk of large-scale food-borne disease outbreaks as has been experienced in recent years became greater. Many food-borne pathogens proved to be particularly virulent, in particular with the vulnerable group of the population, such as children, elderly persons, pregnant women, and immunocompromised individuals; and led to severe or chronic health problems, if not death. It had become clear that end-product testing, until that time used as the main quality control method, proved to be inadequate for providing assurance, since a large number of samples would need to be tested to have a certain degree of assurance of safety; in practice, adequate end-product testing to obtain reliable information was economically not feasible, and often the results would be received after the product had been marketed and/or eaten (Motarjemi, 2014). HACCP is a scientific, rational, and systematic approach for identification, assessment, and control of biological, chemical, and physical hazards during production, processing, manufacturing, preparation, and use of food to ensure that the food is safe when consumed (Motarjemi *et al*.,1996; Scoti and Stevenson, 2006; Pal and Mahendra,2015). HACCP system was initially developed for use by food processors to prevent or control hazards, but the application of HACCP system has been evolving and expanding to form a basis for official food control and for establishing food safety standards for the international food trade as well. It is designed to control significant food safety hazards, i.e., those hazards that are likely to cause an adverse health effect when products are consumed (Whitehead and Orriss, 1995).

HACCP is systematic approach to identification, assessment, and control of hazard during production, processing, manufacturing, and preparation of food (Pal and Mahendra, 2015).This system became internationally prompted as one of the most effective and efficient ways to enhance food safety (FAO, 1994). Countries were becoming more and more committed to move from prescriptive food hygiene rules to HACCP based approach, and therefore, guidance on the role of governments and industries became necessary. Recognizing this, the Codex Alimentarius and its parent organizations FAO and WHO have produced useful guidelines, training and information materials on the application of HACCP in food control (WHO,1995; FAO,1998).

Today, there is worldwide interest in implementation of HACCP system by the food industry and food control regulatory agencies as a means to control food safety through eliminating or reducing food-borne hazards. It has been indicated that application of HACCP systems leads to more efficient prevention of food-borne diseases (Motarjemi *et al*., 1996; WHO, 1997; Scoti and Stevenson, 2006; Pal, 2015). Many countries have integrated or are in the process of integrating the HACCP system into their regulatory mechanisms, as a way of reducing the incidence of food-borne disease as well as ensuring a safe food supply for the population; promote and facilitate trade in food products and to promote tourism (WHO, 1995; WHO, 1997).

HACCP approach is enshrined into legislation in many countries, and it is widely recognized that the principles of HACCP are flexible, and can be applied at any stage of the food chain anywhere in the world. HACCP can be applied by all food businesses, large and small, and also to improving food safety control in developing countries and even to food safety control in the home (Wallace, 2014).

The general benefits of HACCP system are summarized by Motarjemi (2014) as follows:

1. Is a proactive approach to food safety management; this means it allows conceivable and reasonably expected hazards to be identified, even when failures have not previously been experienced. It is particularly useful for new operations.
2. Is flexible, i.e. necessary control measures can be adapted to changes in operations, such as change in equipment design, in processing procedures and technological development.
3. Helps to target resources to the most critical part of the food operations.
4. Is applicable to the entire food chain, from the raw material to the end product, i.e. growing, harvesting, processing or manufacturing, transport and distribution, preparation and consumption.
5. Overcomes many of the limitations of the traditional approaches to food safety control, generally based on:
   a. snap-shot inspection, which is a rather ineffective approach in foreseeing potential problems;
   b. end-product testing, which would entail high costs for analysis and which would lead to identifying problems without understanding their cause.

In addition, the application of HACCP system can aid inspection by food control regulatory authorities and promote international trade by increasing buyer confidence in food safety (Whitehead and Orriss, 1995).

PRINCIPLES AND APPLICATION OF HACCP SYSTEM

As stipulated in the Codex guidelines, HACCP system is comprised of seven principles. These are presented and described as follows:

Principle 1: Conduct a Hazard Analysis

The Codex defines a hazard as a biological, chemical or physical agent in, or condition of, food with the potential to cause an adverse health effect. The hazard analysis identifies, which hazards need to be controlled to prevent the contamination of food.

Principle 2: Identify Critical Control Points

According to the Codex, a critical control point (CCP) is a point, step, or procedure in a food process at which control should be applied so that a food safety hazard can be prevented, eliminated, or reduced to an acceptable level.

Principle 3: Establish Critical Limits for each Critical Control Point

A critical limit represents the boundaries that are used to ensure that a process step produces safe products. Critical limits are set for factors such as temperature, exposure time, physical product dimensions, water quality, moisture level, etc.

Principle 4: Establish requirements for monitoring critical control points

Monitoring activities are necessary to ensure that the process is under control at each critical control point. Therefore, it is important to specify fully how, when, and by whom monitoring is to be performed.

Principle 5: Establish Corrective Action

The Codex defines corrective action as "any action to be taken when the results of monitoring at CCP indicate a loss of control". Loss of control is considered as a deviation from a critical limit for a CCP. All deviations must be controlled by taking action(s) to control the non-compliant product and to correct the cause of non-compliance.

Principle 6: Establish Verification Procedures

The Codex guidelines define verification as the application of methods, procedures, tests and other evaluations, in addition to monitoring to determine compliance with HACCP plan. Verification and auditing methods, procedures and tests, can be used to determine, if HACCP system is functioning correctly.

Principle 7: Establish Documentation and Record Keeping

A record shows the process history, the monitoring, the deviations and the corrective actions (including disposition of product) that occurred at the identified CCP. It is imperative that the manufacturer maintain complete, current, properly filed and accurate records.

The basic requirements and clarifications of the seven HACCP principles are summarized in Table 1 (Wallace, 2014).

TABLE 1: ***HACCP Principles and their clarifications***

HACCP Principle	Clarification
Principle 1: Conduct a hazard analysis	This requires the team to look at each process step one at a time, consider which hazards might occur, evaluate their significance, and establish how best to control them.
Principle 2: Determine CCPs tree	At this stage, the points that are critical to product safety are identified. This can be done through judgment and experience or using a structured tool - the Codex decision.
Principle 3: Establish critical limit (s)	Critical limits are the safety limits that form the boundary between safe and potentially unsafe food. These need to be established to manage all CCPs.
Principle 4: Establish a system to monitor control of CCP	The monitoring system needs to demonstrate that CCP is under control on a day-to-day basis and must be capable of detecting loss of control.
Principle 5: Establish the corrective action to be taken when monitoring indicates that a particular CCP is not under control	If CCP is not working, action needs to be taken to protect the consumer and to put right the cause of the deviation.
Principle 6: Establish procedures for verification to confirm that HACCP system is working effectively	This requires checking that the system is capable of controlling relevant hazards, is working in practice, and is up-to-date on an ongoing basis.
Principle 7: Establish documentation concerning all procedures and records and appropriate to these principles and their application	Documentation will include the process flow diagrams and tables created during HACCP study (HACCP plans development records) as well as monitoring records.

The successful application of HACCP requires the full commitment and involvement of management and the workforce. It also requires a team approach. The application of HACCP system is compatible with the implementation of quality management systems, such as the International Organization for Standardization's ISO 9000 series, and is the system of choice in the management of food safety within such systems (Whitehead and Orriss, 1995).

Good hygienic practices include the environmental hygiene, hygienic production of food sources, handling, storage and transport, cleaning, maintenance and personnel hygiene at primary production, the locations of

establishments and equipment, hygiene facilities of water supply, waste disposal, cleaning, personal, adequate means of natural or mechanical ventilation and lighting, and adequate facilities for the storage of food, ingredients, and non-food chemicals (Pal,2008; Pal and Mahendra, 2015)

According to FAO recommendations, preparatory steps for the introduction of HACCP system include:

i. Assemble HACCP team

Prior to selecting the members of HACCP team, it is extremely important to ensure the full commitment of management at all levels. Preferably, the development of HACCP system should be carried out by more than one person, even in a small or very small enterprise. Analysing the entire food production process requires a variety of different kinds of knowledge and experience. The team could include personnel from production, cleaning, quality assurance, the laboratory, engineering and inspection.

It is essential that the team members are trained on the Codex General Principles of Food Hygiene and the fundamentals of HACCP system to ensure that the team will work together with a common focus and use the same approach and terminology.

ii. Describe the product

In the next step, HACCP team describes the product and its method of production and distribution, as well as intended use and consumers.

iii. Develop and verify a process flow diagram

The best way to draw the company's process flow diagram is by walking through the plant and making sure that all the steps in the process are included in the flow diagram.

iv. Decide whether products can be grouped using process categories

One way to reduce paperwork that is a part of HACCP system is to control all products in the same process category using a single HACCP plan. This is especially advantageous for very small establishments which may produce many different products. If given products differ only in properties that would not affect safety, e.g. the amount or kind of seasoning used, they are clearly in the same process category and may be covered by the same HACCP plan.

After the preparatory steps for the development of HACCP system have been completed, the next steps involve applying the seven principles of HACCP and developing HACCP plan. The following flow diagram shows the sequence of application of these seven principles of HACCP to the food industry. HACCP programme can be adapted to other industries as well.

It is pertinent to mention that sanitation is an essential prerequisite for the successful implementation and maintenance of a HACCP system. A good sanitation programme has been found to minimize many of the potential hazards in a food operation (Pal and Mahendra, 2015).

CONCLUSION

HACCP system became internationally prompted as one of the most effective and efficient ways to enhance food safety. Today, many countries have integrated or are in the process of integrating HACCP system into their regulatory mechanisms, as a way of reducing the incidence of food-borne disease as well as ensuring a safe food supply for the population; promote and facilitate trade in food products, and to promote tourism. The efficacy of any HACCP system rely on management and employees having appropriate knowledge of HACCP, therefore, ongoing training is imperative for all levels of employees and managers. It is emphasized that HACCP can be applied by all food businesses, large and small, and also to improving food safety control in developing countries, and even to food safety control in the home.

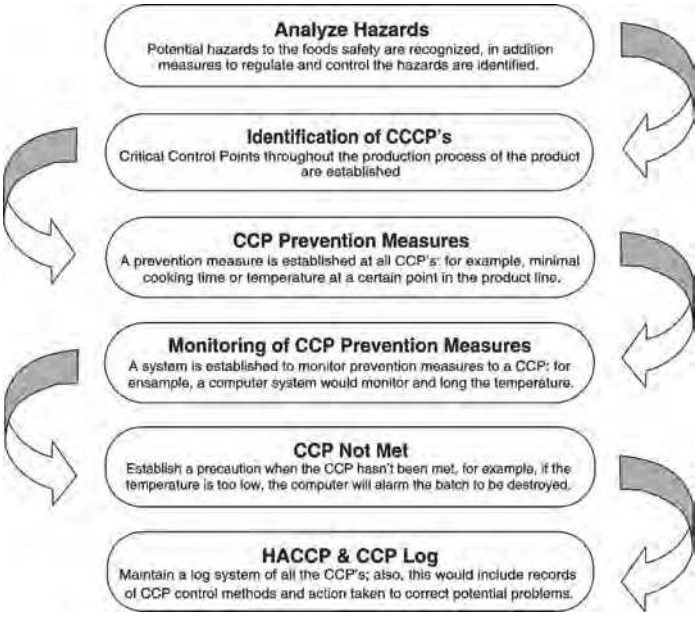

Fig. 2 : *Sequence of application of the seven principles of HACCP*
Source: AMIF (1994)

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