3) THE ROLE AND IMPORTANCE OF HACCP

INTRODUCTION

Hazard Analysis Critical Control Point System (HACCP) is defined as a systematic approach to assure food safety by U.S. National Advisory Committee on Microbiological Criteria for Foods (NACMSF). The system was developed as an alternative to traditional control systems such as finished product analysis and process controls. It was reported a decrease in some food borne diseases was observed between the years of 1996-1998 due to widely implementation of the system (Giese, 1998). HACCP is a preventive system and assures food safety as close to 100%. The success of HACCP depends largely on prerequisite programs including GMP, SOPs and SSOPs.

PRINCIPLES OF HACCP SYSTEM

HACCP is based on seven basic principles (Pennington, 2000):

1. Conduct a hazard analysis
2. Determine critical control points
3. Establish critical limits
4. Establish monitoring limits
5. Establish corrective actions
6. Establish verification procedures
7. Establish effective record keeping procedures

FOOD SAFETY HAZARDS

Hazard is described as any biological, chemical or physical property agent that may cause a consumer health risk (Rhodehamel, 1992).

Biological Hazards

Biological hazards can be divided into three categories: microorganisms, parasites and prions. It has been reported that microorganisms are the principal sources of food borne diseases (Eilers, 1990).

Parasites.

Cysticerci, *Tenia* spp., trematodes, nematodes, cestodes, *Trichinella* spp., *Echinococcus* spp., *Cryptococcus* spp. and *Anisakis* spp. are commonly isolated parasites from foods. Raw meat and fish are the most risky foods for parasite infections. Conventional cooking destroys them. They may also loss their viability during freezing depending on the time and temperature (Untermann, 1998).

Prions

Prions are considered as causative agent of “Bovine Spongiform Encephalitis” (BSE). They are resistant to heat treatments and mainly isolated from offal (Untermann, 1998).

Microorganisms

No food product unless it is sterilised free from microorganisms. Microorganisms of concern in food safety include viruses, some species of bacteria, moulds and protozoa. Of the microorganisms certain species of bacteria and moulds are able to produce toxic metabolites. Their toxigenic effects can range from mild to severe gastrointestinal disorders or chronic syndromes such as carcinogenicity, teratogenicity, mutagenity and immunosuppression (Moss, 1987).
**Viruses**

Hepatitis A, poliovirus, rotavirus, astrovirus and Norwalk viruses are transmitted to man by foods and drinking water. Contamination occurs through faecal oral route (Fries, 1994).

**Moulds**

Moulds represent health hazards because of their toxic metabolites called mycotoxins. Mycotoxins may be produced in some plants in the field or during drying and storage under improper conditions.

**Algae**

Some types of algae such as Cyanobacteria (blue green algae) and Pyrrophyta (dinoflagellates) produce toxic compounds for human being. Poisoning occur after consumption of some seafood fed with these toxic algae (Falconer, 1993).

**Bacteria**

Food borne diseases caused by performed toxins are referred to food poisoning (intoxications), whereas the disorders caused by bacterial growth or endotoxin production in the body after ingestion were called food infections (Table 1).

<table>
<thead>
<tr>
<th>Table 1 Food borne diseases(*)</th>
<th>Bacteria</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Intoxication/infection</strong></td>
<td><strong>Salmonella</strong> spp., <strong>Shigella</strong> spp., <strong>Campylobacter</strong> spp., <strong>Yersinia enterocolitica</strong>, <strong>Listeria monocytogenes</strong>, pathogenic <strong>E. coli</strong>, <strong>Aeronomas</strong> spp., <strong>Vibrio cholerae</strong>, <strong>Bacillus cereus</strong> (diarrhoagenic type), <strong>Clostridium perfringens</strong></td>
</tr>
<tr>
<td><strong>Infections</strong></td>
<td><strong>Clostridium botulinum</strong>, <strong>B. cereus</strong> (emetic type), <strong>Staphylococcus aureus</strong></td>
</tr>
</tbody>
</table>

(*)Eley, 1992; Frazier and Westhoff, 1988; Granum et al.1995

Symptoms of the food borne diseases vary with the type of organisms and are more severe in immuno-compromised persons, children and elderly. Infective doses of bacteria range between 10 to 10^8 cells/g depending on bacterial strain, type of foods consumed together with implicated one and health status of consumer (Granum et al. 1995).

**Bacillus cereus:** Some strains of B. cereus produce diarrhoagenic and emetic toxins. Emetic toxin is secreted into foods and stable to heat treatments above 120°C (Moss, 1987). Spices, cereals, dried foods, meat and meat products, fried or boiled rice, ice cream, cooked rice dishes, soups, green vegetables, sauces (Kramer and Gilbert, 1989) are the implicated food commodities in B. cereus contamination. However, commonly associated foods with emetic and diarrhoagenic syndromes are cooked rice and proteinaceous foods respectively (Notermans and Batt, 1998).

**Campylobacter spp.:** Campylobacter jejuni and C. coli are the major species of Campylobacters causing food poisonings and considered as the common causes of gastrointestinal diseases. Most commonly associated foods with C. jejuni contaminations are poultry and poultry products (Bryan and Doyle, 1995).

**Clostridium spp.:** Clostridium botulinum and C. perfringens are the well-known toxin producing species of the genus. The C. botulinum represents health hazard rather than its frequency incidence than its deadly antigenic types of botulin toxins (A, B, C1, C2, D, E, F and G) and may be classified based on the type of toxin produced. (Dodd and Austin, 1997). The botulism caused by C. botulinum strains is divided into four
categories: food borne, infant, wound and those classified as undetermined. Symptoms of food borne botulism involving nausea, vomiting, weakness, headache, dryness in the throat, double vision and difficulty in swallowing and speaking exists usually 12-72 hours (Hatheway, 1990). Ingestion of \textit{C. botulinum} spores mainly by honey is the cause of infant botulism. The main causes of botulism outbreaks are improperly canned or preserved foods (Delmas et al. 1994).

\textit{Clostridium perfringens} is one of the causes of gastroenteritis outbreaks. At least 13 different toxins were produced by \textit{Clostridium perfringens} strains. \textit{C. perfringens} Type A is one of the most common causes of food borne diseases associated with diarrhoeal and cramping symptoms in the USA (McClane, 1992). Beta-toxin produced by \textit{Clostridium perfringens} type C is responsible for a deadly food poisoning known as necrotic enteritis (Granum, 1990). Uncured meat and meat products, sauces, salads, particularly inadequately cooled ones were implicated in \textit{C. perfringens} gastroenteritis (Labbe and Huang, 1995).

Pathogenic \textit{Escherichia coli}: Pathogenic \textit{E. coli} strains are classified into specific groups: enteropathogenic \textit{E. coli} (EPEC), enterotoxigenic \textit{E. coli} (ETEC), enteroinvasive \textit{E. coli} (EIEC), diffuse-adhering \textit{E. coli} (DAEC), enteroaggregative \textit{E. coli} (EaggEC), enterohemorrhagic \textit{E. coli}. serotype O157:H7 (Doyle et al. 1997). Pathogenic \textit{E. coli} strains were associated with diarrhoeal diseases, wound infections, meningitis, septicaemia, arterioscleroses, haemolytic uremic syndrome and immunological diseases (Olsvik et al. 1991). The main reservoir for \textit{E. coli} O157:H7 serotypes were reported to be bovine or other foods cross contaminated by beef products or bovine manure (Piérard et al. 1997). Foods involved in pathogenic \textit{E. coli} outbreaks mainly include cheese, water, turkey, mayonnaise, crabmeat, scallops, meat, hamburgers, and beef sandwiches (Olsvik et al. 1991).

\textit{Salmonella} spp.: \textit{Salmonella} are considered as one of the most important and common food borne diseases in several countries worldwide. Gastroenteritis, dysentery, enteritis and typhoid are the symptoms of \textit{Salmonella} infections. Meats, poultry and their products are commonly associated foods with \textit{Salmonella} infections (Bryan and Doyle, 1995).

\textit{Shigella} spp.: \textit{Shigella dysenteriae}, \textit{S. flexneri}, \textit{S. boydii} and \textit{S. sonnei} are the pathogenic strains of genus \textit{Shigella} and regarded as the principal causes bacillary dysentery (Vargas et al. 1999). Contaminated raw vegetables and fruits, soiled hands, seafood, milk and puddings are the main sources of \textit{Shigella} spp. (Farber, 1989).

\textit{Staphylococcus aureus}: Medical expenses and loss of productivity due to food poisoning caused by \textit{S. aureus} were estimated to cost $1.5 billion each year in the United States (Su and Lee Wong, 1997). Enterotoxins are secreted into the foods and resistant to almost all food processing procedures (Moss, 1987). Vomiting, nausea, abdominal cramps, prostration and some diarrhoea usually occur after 2-4 hours following ingestion of contaminated food. Foods frequently involved in \textit{S. aureus} poisoning include meat, poultry, eggs, dairy products, and seafood (Reed, 1993). Man is the main reservoir of post-process contaminations of foods (Reed, 1993).

\textit{Listeria monocytogenes}: \textit{Listeria monocytogenes} is the causative bacteria of listeriosis and has been linked mainly with flu-like illness, abortion and stillbirth in pregnant woman. \textit{L. monocytogenes} also causes septicemia and meningitis in immunocompromised persons. Healthy individuals are not affected in the presence of low numbers.
of *L. monocytogenes*. Foods commonly implicated with *L. monocytogenes* contaminations are raw milk, fresh vegetables (Schothorst, 1999).

**Other Bacteria**

Symptoms of *Vibrio cholerae* infections involve loss of water at high levels that may cause to collapse and death. Human can also transmit the bacteria the others as well as foods. The reservoir of *V. parahaemolyticus* is water, seafood and fish and foods contaminated with water (Schothorst, 1999). There exist some reports indicating intoxications developing with watery diarrhoea due to the consumption of foods contaminated with *Yersinia enterocolitica* (Walker, 1987). Pigs are the main reservoir of *Y. enterocolitica* (Frazier and Westhoff, 1988). Motile groups of *Aeromonas* genus were shown to be responsible for food borne illnesses from mild diarrhoea to ‘cholera-like’ and a ‘dysentery-like’ nature gastroenteritis (Stelma, 1988). Water was considered as one the sources of *Aeromonas* spp. (Stern et al. 1987).

**CONTROL OF MICROBIAL HAZARDS IN FOODS**

The main control measures in order to control microbial hazards in foods are given below:

- Prevention of contaminations
- Limitation of microbial growth
- Elimination/destruction of microorganisms

Control methods for microbial hazards are tabulated in Table 2.

Table 2 Control of microbial hazards (*)

<table>
<thead>
<tr>
<th>Heat treatment</th>
<th></th>
<th>Chemical preservatives</th>
<th>Prevention of contaminations</th>
<th>Modified atmosphere</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pasteurisation</td>
<td></td>
<td>pH</td>
<td>Personnel hygiene</td>
<td>Radiation</td>
</tr>
<tr>
<td>Sterilisation</td>
<td></td>
<td>Water activity</td>
<td>Packaging</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Raw material control</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Process sanitation</td>
<td></td>
</tr>
</tbody>
</table>

(*) Troller, 1993

**CHEMICAL HAZARDS**

Foods may contain several types of chemicals that are hazardous for men. Limits have been established for some types of chemicals whereas others are not allowed to be found in foods (Rhodehamel, 1992). Chemical hazards for foods have been presented in Table 3.

Table 3 Chemical hazards (**,*)

<table>
<thead>
<tr>
<th>1. Chemicals naturally occurred in foods</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Mycotoxins</td>
<td></td>
</tr>
<tr>
<td>Mushrooms</td>
<td></td>
</tr>
<tr>
<td>Shellfish toxins</td>
<td></td>
</tr>
</tbody>
</table>
PSP ("paralytic shellfish poisoning") toksinleri
DSP ("Diarthaic shellfish poisoning") toksinleri
NSP ("Neurotoxic shellfish poisoning") toksinleri
ASP ("Amnesic shellfish poisoning") toksinleri
Scrambotoxin
Tetratoksin
Ciguatoxin
Plant toxins
Allergens

2. Chemicals used in the field
   Pesticides
   Antibiotics and growth hormones
   Fertilisers

3. Environmental contaminants
   Toxic minerals
   Polychlorinated biphenyls (PCBs)

4. Food additives

5. Chemicals occurred during processing
   Pyocyclic Aromatic Hydrocarbons (PAH)
   N-Nitrosamins

6. Contaminants from food packaging materials

5. Detergent, disinfection residues, chemicals intentionally added

(*) Rhodehamel, 1992; Shibamoto et al. 1993

Mycotoxins
Mycotoxins are secondary metabolites of moulds. Aflatoxins (B1, B2, G2, G2), fumonisins, moniliformin, ochratoxin A, patulin, sterigmatocystine, trichothecenes, zearealenone, alternariols, altetroxins, deoxinivalenol and T-2 toxin are the most commonly isolated mycotoxins. Limit values for some mycotoxins are given in Table 4.

Table 4 Established limits for some common types of mycotoxins (*)

<table>
<thead>
<tr>
<th>Mycotoxins</th>
<th>Established limits (ppb)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aflatoxins in foods</td>
<td>0-50</td>
</tr>
<tr>
<td>Aflatoxin in milk (M1)</td>
<td>0-0,5</td>
</tr>
<tr>
<td>Ochratoxin A</td>
<td>1-300</td>
</tr>
<tr>
<td>Patulin in apple juice</td>
<td>20-50</td>
</tr>
<tr>
<td>T-2 toxin</td>
<td>100</td>
</tr>
</tbody>
</table>

(*) Moss, 1996

Studies on mycotoxins have been concentrated on aflatoxins, which are considered as potential carcinogens. Fumonisins have received great attention in recent years; epidemiological studies indicated a correlation between eusophagus cancer and consumption of foods contaminated with fumonisins. Ochratoxin A is commonly isolated from coffee grains and barley. Patulin is a common problem in apple juice all over the world.

Shellfish Toxins

Allergens
Some chemicals in foods and additives can cause allergic reactions in susceptible individuals, and are considered as components of HACCP system.

Other Chemicals
Pesticides do not represent health risk in case they are used under proper conditions. Maximum residue limits have been established for permitted pesticides and regulated by Environmental Protection Agency (EPA) (Rhodehamel, 1992).

- Increase in the use of nitrate containing fertilisers has caused the accumulation of nitrates in some plants (Anon. 1997).
- Antibiotics are mainly used for the treatment of infections in animals. However, they are sometimes used as growth stimulating agents also. They increase the chance for evolution of antibiotic resistant pathogens in human (Anon. 1997).
- Maximum tolerable limits have been established for toxic elements including mercury, lead, arsenic and cadmium. Toxic elements as well as polychlorinated biphenyls (PCBs) contaminate foods as the result of environmental pollution (Jones, 1989).
- Some chemicals such as polycyclic aromatic hydrocarbons (PAH) occur in foods during processing at high temperatures (>300°C). Their concentrations increase with direct exposure to flame. They can also contaminate plants through accumulation of these compounds found in air (Shibamoto and Bjeldanes, 1993).
- Detergent, disinfection residues and migration from food packaging materials are also considered among chemical hazards in foods. Control methods for chemical hazards are given in Table 5.

Table 5 Control methods for chemical hazards (*)

<table>
<thead>
<tr>
<th>Control before receipt</th>
<th>Control before use</th>
<th>Control storage and handling conditions</th>
<th>Control all the chemicals in facility</th>
</tr>
</thead>
<tbody>
<tr>
<td>Raw material specifications</td>
<td>Check the purpose for the use of chemical</td>
<td>Review uses</td>
<td>Record of uses</td>
</tr>
<tr>
<td>Supplier guarantees</td>
<td>Control purity, formulation and labelling</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Random checks</td>
<td>Check the quantities to be used</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(*) Rhodehamel, 1992

**PHYSICAL HAZARDS**
Foreign objects such as glass, wood, stones, metal, bone, plastic are the main physical hazards. They can cause injuries to man. Their presence in foods also indicates that foodstuffs were not processed under hygienic conditions.

**CRITICAL CONTROL POINTS**

Critical control points (CCPs) are any point or procedure in a specific food where loss of control may result in an acceptable health risk.

**Representative CCPs (Sperber, 1992)**

**Growing:**
- The use of antibiotics
- Application of pesticides
- Location of growing field

**Ingredient receiving:**
- Temperature control

**Processing**
- Mixing of ingredients
- Thermal processing

**Distribution**
- Time-temperature control

**CRITICAL LIMITS**

Critical limits are minimum or maximum established values to control hazards at each CCPs. Exceeding critical limits indicates that the product may represent is a health hazard. Most frequently used critical limits are given below (Moberg, 1992):

- Time
- Temperature
- Humidity
- Moisture content
- pH
- Preservatives
- Salt concentration
- Available chlorine
- Viscosity

**MONITORING CRITICAL CONTROL POINT LIMITS AND CORRECTIVE ACTIONS**

Monitoring and record keeping are essential to HACCP system’s success. Monitoring parameters can be qualitative and quantitative. Temperature checks, testing (microbiological, chemical etc.), sensory and visual examinations are examples of
monitoring procedures. To establish an effective monitoring procedures the questions of what, why, how, where, who and when must be answered (Hudak-Roos and Garret, 1992).

Corrective actions cover procedures that should be applied when a deviation occurred. Examples of corrective actions include continued cooking until 70°C; addition of acid to reach target pH; addition of preservative to achieve proper concentration etc.

RECORD KEEPING AND VERIFICATION

Record keeping provides evidence of food safety, documentation for audits. In addition it is a tool for personnel training and solving problems (Stevenson and Hum, 1992).

Verification is the sum of activities other than monitoring that determines the validity and compliance with HACCP program (Prince, 1992).

REFERENCES


