REVIEW OF LITERATURE

CHAPTER II

REVIEW OF LITERATURE

Access to good quality food has been man's main endeavor from the earliest days of human existence. At the 1996 World Food Summit, government leaders called attention to the right to food, which, according to FAO, is "the right of everyone to have access to safe and nutritious food (FAO n.d), as recognized in the 1948 Universal Declaration of Human Rights (U.N. n.d.). This right is not limited to the freedom from hunger, but also includes the obligation from all states "to promote full enjoyment of the right of access to adequate nutrition for each individual". Therefore, food quality (including nutritional quality and protection for consumers against fraudulent practices such as the use of false or deceptive labeling) and food safety are concepts that are rooted in the most basic rights of humanity and are so recognized by the world community (Molins R, 2007).

Safety of food is an inherent component of food quality. Food quality can be considered as a complex characteristic of food that determines its value or acceptability to the consumers.

This chapter will focus on the available literature under the following heads:

2.1 Food borne diseases and its detrimental effect on masses
2.2 Causes of Food borne diseases
2.3 Eating out on rise... A risk??
2.4 Risk of street foods
2.5 Risk of food served in small and medium restaurants
2.6 Food safety education
2.7 Role of government and non governmental organization towards supply of safe food
2.8 Outbreaks associated with raw produce
2.9 Role of disinfectants in reducing the microbial load of raw produce

2.1 FOOD BORNE DISEASES AND ITS DETRIMENTAL EFFECT ON MASSES

Food borne disease (FBD) has emerged as an important and growing public health and economic problem in many countries during the last two decades. Frequent outbreaks caused by new pathogens, the use of antibiotics in animal husbandry and the transfer of antibiotic resistance to human, as well as the ongoing concerns about Bovine Spongiform Encephalitis (BSE) are just few examples (WHO 2005).

Food borne illness are defined as diseases, usually either infectious or toxic in nature, caused by agents that enter the body through the ingestion of food. Every person is at risk of food borne illness.

As defined by the Center for Disease Control and Prevention, a food borne disease outbreak is "occurrence of two or more cases of a similar illness resulting from the ingestion of a common food."

2.1.1 Magnitude of food borne illness: Global scenario

Each year, 9.4 million suffer from food borne diseases throughout the world (Sanlier and Turkmen 2010). It is estimated that each year FBDs causes approximately 76 million illnesses, 3,25,000 hospitalizations and 5000 deaths in the USA and 2,366,000 cases, 21,138 hospitalizations, 718 deaths in England and Wales (Mead et al 1999). In another stidy, 60,854 hospitalizations and over 1800 deaths were estimated to be caused by food borne diseases (Bryan 2002). Globally, in the year 2000 alone 2.1 million people died from diarrheal diseases (WHO, 2002). A great proportion of these cases can be attributed to contamination of food and drinking water. Additionally, diarrhea is a major cause of malnutrition in infants and young children. In 1994, an outbreak of salmonellosis due to contaminated ice cream occurred in USA, affecting an estimated 224,000 persons. In 1988, an outbreak of hepatitis A, resulting from the consumption of contaminated cams, affected some 300,000 individuals in China (WHO, 2002).

In the year 1998, an epidemic dropsy occurred in Delhi city, due to consumption of contaminated mustard oil characterized by pitting edema, skin

erythema, limb tenderness, diarrhea and hepatomegaly with a few others developing open angle glaucoma and cardiac failure in about 14 per cent of them (Beniwal and Khetarpaul, 1999).

According to the Turkish statistics Institute in 2000-2002, 26,772 people were hospitalized with food poisoning and 509 deaths (Egan 2007).

CDC's Emerging Infections Program Food borne Diseases Active Surveillance Network (FoodNet) collects data on about 10 food borne diseases in nine U.S. sites to quantify and monitor food borne illnesses (CDC 2000). During 2001, a total of 13,705 laboratory diagnosed cases of 10 food borne diseases under surveillance were identified: 5,198 of *Salmonella* infection, 4740 of *Campylobacter*, 2201 of *Shigella*, 544 of *Crytosporidium*, 565 of *E coli*, 145 of *Yersinia*, 94 of *Listeria*, 80 of *Vibrio*, 32 of *Cyclospora* and 76 of Hemolytic Uremic Syndrome (HUS). Among the 4,520 (87%) *Salmonella* infection isolates serotyped, the five most common serotypes accounted for 65% of the infections that included: 1,132 (25%) of serotype typhimurium, 689 (15%) of enteritidis, 553 (12%) of Newport, 321 (7%) Heidelberg, and 227 (5%) of Javiana. The summary statistics of food borne diseases outbreak by etiology for the year 2005 and 2006 have been depicted in table 2.1.1.1 and 2.1.1.2.

Table 2.1.1.1: Summary statistics for Food borne Disease Outbreaks, 2005

Number of food borne disease Outbreaks by etiology

Etiology	No. of Outbreaks	No. Cases
Bacterial	**188**	**4,348**
Chemical	**40**	**151**
Parasitic	**6**	**739**
Viral	**170**	**5018**
Multiple	**6**	**525**
Total confirmed etiology	**410**	**10,781**
Unknown etilogy	**572**	**9,3998**
Total	**982**	**20,179**

Source: CDC 2005[a]

Table 2.1.1.2: Summary statistics for Food borne Diseases Outbreaks, 2006

Number of food borne disease Outbreaks by etiology		
Confirmed Etiology	**No. Outbreaks**	**No. Cases**
Bacterial	223	5,336
Chemical	53	221
Parasitic	9	129
Viral	337	11,122
Suspect Etiology		
Bacterial	75	1,440
Chemical	11	39
Parasitic	3	18
Viral	165	2,841
Multiple Etiology		
Confirmed	1	96
Suspect	20	254
Confirmed and Suspected	1	32
All Etiology Status		
Total Confirmed Etiology	623	16,904
Total Suspect Etiology	275	4,592
Unknown Etiology	349	4,163
Grand Total	1247	25,659

Source: CDC 2006[a]

2.1.2 Magnitude of food borne illness: Indian scenario

With the global incidence of food borne diseases increasing day by day, India is no exception. In India more than 3,00,000 cases of enteric fever were associated with significant morbidity and mortality (Agrawal 1962). Drug resistant *Salmonella typhi* has been reported in India since 1960 and outbreaks by these strains occur at intervals in various parts of India (Sridhar et al 1983). There was an epidemic in Mumbai military garrison by drug resistant *S. typhi* during Nov-Dec 2000 (Misra et al 2005).

As many as 148 fresh cases of food poisoning were reported in Dahod from various villages while a woman admitted to Dahod civil hospital died of food poisoning. (Source: Times of India; Date: 26/05/10)

In a suspected case of food poisoning and water contamination, about 50 BSc nursing students of the MGM Nursing School, which is attached to the

MGM Hospital, Hyderabad, were admitted into the hospital after they showed symptoms of vomiting, high fever and diarrhoea. (Source: Deccan Chronicle (Hyderabad) Date: 22/04/2010)

A 14-year-old girl lost her life and about 100 people were taken ill due to food poisoning after they ate sweet bundi at Lakadbari village of Vasda taluka, about 70 km from Surat, in Navsari district on Saturday. (Source: Times of India (Ahmedabad); Date: 19/04/2010)

Six children and an adult died of food poisoning at remote Gudrimaha village of Daringbadi block in Kandhamal district, Berhampur. (Source: Hindu (New Delhi); Date: 21/09/2009)

Noon meal caused food poisoning to 27 students and a teacher at the Government LP School, Ambalamukku, Thiruvananthapuram. After the students complained of itching in mouth and uneasiness, all were admitted to the Government Hospital, Peroorkada. As per indications, yam in the curry 'aviyal' caused the poisoning. (Source: Express News Service; Date: 26 Jun 2010)

2.1.3 Pathogens and Foodborne diseases

The Centres for Disease Control and Prevention (CDC) estimates that there are 250 food borne pathogens. Many pathogens, including *Salmonella, Escherichia coli 0157:H7, Campylobacter and Yersinia enteroclotica,* have reservoirs in healthy animals, food from which they spread to an increasing variety of foods. New pathogens have emerged, and some have spread worldwide. Some known pathogens such as *Listeria monocytogenes and Campylobacter jejuni* have recently shown to be of food borne origin causing millions of cases of sporadic illness, chronic complications, as well as large and challenging outbreaks over many states and nations (Tauxe R, 1997).

Serious health problems are arising in the world due to the consumption of foods contaminated with pathogens.

Salmonella: Salmonella is a genus consisting of many species of gram negative bacteria, most of which are motile, and are present in animal reservoirs and in the environment.

The top 4 Salmonella isolates that cause gastrointestinal illness are *Salmonella typhimurium, Salmonella enteritidis, Salmonella heidelberg* and *Salmonella newport.* Other prominent members of the *salmonella* species that are implicated in gastrointestinal illness are *Salmonella javiana, Salmonella poona* and *Salmonella montevedio.*

Raw meats, poultry, eggs, milk and dairy products, fish, shrimp, frog legs, yeast, coconut, sauces and salad dressing, cake mixes, cream-filled desserts and toppings, dried gelatin, peanut butter, cocoa, and chocolate are commonly associated with *salmonella* food poisoning.

People of all age groups are susceptible to these bacteria; however immune compromised, elderly and young children are at a higher risk. Patient's who are HIV positive and who have fully developed AIDS suffer from Salmonella infections more frequently. Each year, approximately 40,000 cases of *Salmonellosis* are reported in the United States. As many milder cases are not diagnosed or reported, the actual number may be 30 or more times greater (CDC 2008 a).

A large outbreak of *Salmonella enteritidis* was reported in North East London. This outbreak was due to the consumption of kebab by 94% of the consumers who later developed symptoms of *Salmonellosis* (FoodHACCP.com Information, 2005).

***Shigella*:** *Shigella* can cause sudden and severe diarrhea (gastroenteritis) in humans. *Shigella* thrives in the human intestine and is commonly spread both through food and by person-to-person contact. *Shigella* was discovered over 100 years ago. Shigellosis is a disease caused by *shigella* and is known as "bacillary dysentery".

50,000 persons in the US are hospitalized yearly because of *Shigella* food poisoning and it is found that about 700 persons die from shigellosis (Baer et al 1999). Upto 3% of persons who are infected with *Shigella* may later

develop a syndrome that includes joint pain and swelling, irritation of the eyes and sometimes painful urination as well.

Escherichia coli: *Escherichia coli* is an important organism in the microbiology of foods. Besides being involved in gastroenteritis, the organisms in this species are considered to be indicators of possible fecal contamination and can cause spoilage of some foods. There are more than 160 serotypes of *E.coli.*

One of the most pathogenic serotype of *E.coli* which is emerging is *E.coli 0157:H7.* It is estimated that nearly 73,000 infections by *E.coli 0157:H7* occur in the United states each year, and 61 of these cases were fatal (FSRIO, 2003).

E. coli 0157:H7 can cause bloody diarrhea (hemorrhagic colitis). Some patients, mainly young children, may develop hemolytic uremic syndrome (HUS) which leads to kidney damage and failure, with long term chronic consequences and even death. Deaths can also occur among the elderly (WHO, 1997).

In 1996, an outbreak of *Ecoli 0157:H7* in Japan affected over 6,300 school children and resulted in 2 deaths. This is the largest outbreaks ever recorded for this pathogen (WHO, 2002).

Listeria monocytogenes (LM): *Listeria monocytogenes* is considered emerging because the role of food in its transmission has only been recently recognized. In pregnant women, infections with *LM* can cause abortion and weakened immune system and it can lead to septicemia (blood poisoning) and meningitis. The disease is most often associated with the consumption of foods such as soft cheese and processed meat products that are kept refrigerated for a long time because *listeria monocytogenes* can grow at low temperatures. Listeria may also be transmitted through food, soil and water (FoodHACCP.com Information, 2005). Outbreaks of lisreriosis have been reported from many countries, including Australia, Switzerland, France and the United States. Two recent outbreaks of listeria monocytogenes in France

in 2000 and in the USA in 1999 were caused by contaminated pork and hot dog respectively (WHO, 2002).

According to CDC, about 2500 people in the United States, develop listeriosis each year. About 20% of people with listeriosis die from the infection.

Oktem et al (2006) isolated *Listeria monocytogenes* from 13.75% , 4% and 2% of 80 prepared ground beef, 100 white cheese and 100 parsley samples, respectively, indicating that these foodstuffs have risk of *Listeria monocytogenes*.

E coli O157 H7 and listeriosis are important food borne diseases which have emerged over the last decades. Although their incidence is relatively low, their severe and sometimes fatal health consequences, particularly among infants, children and elderly, make them amongst the most serious food borne infections.

Staphylococcus aureus: *S aureus* is the cause of a wide range of different kinds of major and minor pyogenic infections, and also occurs harmlessly as a commensal parasite in the anterior nares and on moist areas of the skin.

Food samples collected from cafeterias and restaurants yielded strains of enterogenic staphylococci (Soriano et al, 2002). Toxigenic *Staphylococcus aureus* contamination in ready-to-eat (RTE) food is a leading cause of foodborne illness in Korea (Su Kyung Oh et al, 2007).

Effective cleaning and sanitizing of food preparation sites is important because pathogens readily spread to food contact surfaces with the contaminated raw products. Use of wiping and cleaning cloths resulted in a considerable reduction of micro-organisms from surfaces and greater difficulty in removing *S aureus* from the surfaces has been experienced as against Salmonella. Depending on the cloth type, *S aureus* were reduced on surfaces from initial numbers of approximately 10^5 CFU/100cm^2 to numbers less than 4 CFU/100cm^2 (below the detection limit) to 100 CFU/100cm^2 (Kusumaningum et al, 2003).

Campylobacter: *Campylobacter* is a bacterial pathogen that causes severe abdominal pain, fever, nausea and diarrhea (CDC 2005[b]).Campylobacteriosis is a widespread infection. It is caused by certain species of campylobacter bacteria and in some countries, the reported number of cases surpasses the incidence of Salmonellosis (WHO 2002). In two per cent of the cases the infection may lead to chronic health problems, including reactive arthritis and neurological disorders.

Vibrio Cholerae: Cholera is a major public health problem in developing countries, also causing enormous economic losses. The disease is caused by the bacterium *Vibrio Cholerae*. In addition to water, contaminated foods can be the vehicle of infection. Different foods, including rice, vegetables, millet gruesl and various types of sea food have been implicated in outbreaks of cholera. Symptoms, including abdominal pain, vomiting and profuse watery diarrhea may lead to severe dehydration and possibly death, unless fluid and salt are replaced (WHO 2002).

Noroviruses: Noroviruses are a group of related, single-stranded RNA, non-enveloped viruses that cause acute gastroenteritis in humans. The most common symptoms of acute gastroenteritis are diarrhea, vomiting, and stomach pain. Norovirus is the official genus name for the group of viruses previously described as "Norwalk-like viruses" (NLV). Noroviruses spread from person to person, through contaminated food or water, and by touching contaminated surfaces. In the United States, CDC estimates that more than 21 million cases of acute gastroenteritis each year are due to norovirus infection, and more than 50% of all foodborne disease outbreaks can be attributed to noroviruses.

2.1.4 Cost of Food borne diseases

The economic and social cost of FBDs is probably very high in most countries of the hemisphere. Every year, FBDs can have important indirect, as well as direct, effects on the economies of the countries of the Americas, which can overload already strained public health systems, generate enormous medical costs and lead to lost productivity (Molins 2007). The estimated cost of 5.4

million annual cases of FBDs in Australia is 1.2 million Australian dollars (Abelson 2006). Also, some 120 thousand cases of FBDs in New Zealand in 2000 were estimated to have cost US$88 million (Scott et al. 2000). In the United States, the cost of 6.5-33 million cases of FBDs, caused by the six bacteria most commonly involved was estimated at between US$9.3-12.9 billion (Buzby et al 1996).

These figures include medical and hospitalization costs, loss of productivity (absenteeism, poor on-job performance), as well as a complicated quantification of the economic cost of the loss of each life. FBDs can produce short- and long-term after effects (leading to early death and causing chronic diseases such Guillain-Barre syndrome, in 2-3% of the cases, arthritis, autoimmune diseases, etc.) which increase the total cost of such diseases (Buzby et al 1996; Lindsay 1997). A new study by a former U.S. Food and Drug Administration (FDA) economist estimates the total economic impact of foodborne illness across the nation to be a combined $152 billion annually.

In the USA, diseases caused by the major pathogens alone are estimated to cost up to US $35 billion annually (1997) in medical costs and lost productivity. The re-emergence of cholera in Peru in 1991 resulted in loss of US $500 million in fish and fishery product exports that year (WHO 2002). As per the CDC data, it was estimated that foodborne illness costs related to produce alone are almost $39 billion per year in the U.S.

2.2 WHY FOOD BORNE DISEASES.....??

Food borne illness of microbial origin is the most serious food safety problem in the United States. The Centers for Disease Control and Prevention reports that 79% of outbreaks between 1987 and 1992 were bacterial; improper holding temperature and poor personal hygiene of food handlers contributed most to disease incidence. Some microbes have demonstrated resistance to standard methods of preparation and storage of foods (Collins 1997). Food handlers play an important role in ensuring food safety throughout the chain of production, processing, storage and preparation (Hedberg et al 1994; Goh 1997; WHO 1998). Approxmately 10 to 20% of food borne disease outbreaks are due to contamination by the food handler.

Several researchers have given numerous factors responsible for FBDs outbreaks. These include, Poor personal hygiene of food handler (Cogen et al 2002; Collins 2001), Inadequate knowledge and practices of food handlers, Cross contamination (Clayton et al 2002) and Improper storage or reheating of food (Egan 2007).

Poor personal hygiene of food handler:

Food handlers harbor disease producing organisms on the skin, in the nose and throat and in the gastrointestinal tract. This makes personal hygiene very important in preventing bacteria from reaching the food (Roday 1999). Lacking personal hygiene amongst food handlers is one of the most commonly reported practices contributing to food-borne illness and poor hand and surface hygiene is also a significant contributory factor (Cogan et al 2002; Collins, 2001; Olsen et al 2000; Guzewich and Ross 1999). Olsen et al found

that annually from 1993 to 1997, poor personal hygiene of food workers was a contributing factor in 27% to 38% of food borne illness outbreaks. Contamination of surfaces in food premises has been shown to be associated with poor hygiene standards (Powell & Attwell,1997; Sagoo et al 2003). Dangerous organisms present in or on the food handler's body can multiply to an infective dose, given the right conditions, and come in contact with food or surfaces used to prepare food (Jacob 1998).

Unhygienic practices like coughing, sneezing in food preparation area, wearing dirty clothes and caps, spitting and chewing pan, tobacco, etc., all may introduce a variety of micro-organisms in food (Kudu and Mishra 2003).

Food workers can spread food borne illness in the food service environment through hand contact with pathogens from their gastrointestinal tracts or objects or food contaminated with pathogens and subsequent passage of pathogens to food (Paulson 2000). Thus, worker's hand contact with foods represents a potentially important mechanism by which pathogens may enter the food supply. Of these 81 food borne illness outbreaks attributed to food contaminated by food workers, 89% of these outbreaks involved the transmission of pathogens to food by workers' hands (Guzewich and Ross 1999).

According to the data provided by the American society for Microbiology (1996), people do not wash their hands as often as they think to do. In telephone surveys, 94% of respondents claimed that they always wash up after using the rest room; however researchers report that almost 1/3rd of people do not wash their hands after using the bathroom. Of more than 7000 people who participated in the nationwide study, 81% said that they wash their hands before handling or eating food. However, most say they do not wash up after petting an animal (48%), coughing or sneezing (33%), or handling money (22%).

A study carried out on the food handlers of the delicatessen sections of a prominent South African retail group showed that the Total Viable Counts (TVC) and coliforms were present on hands of 98% and 40 % of the food handlers respectively. *Enterobacteriaceae* and *S.aureus* were respectively

present on the hands of 44 % and 88% of food handlers (Lues and Tonder, 2007).

Ingestion of infective eggs and cysts of fecal orally transmissible parasites has been linked with the level of environmental and personal hygiene. The possibility of contamination of food with eggs and cysts by infected food vendors has also been recorded (Idowu and Rowland 2006). Parasites such as *Entemoeba histolytica, Giardia duodenale, Trichuris trichiura, Ascaris lumbricoides* and *Enterobius vermicularis. Ameobiasis* is known to cause about 450 million infections per annum in developing world with an incidence of about 50 million and 100,000 deaths (Ravdin 1988). Ninety seven percent of the food vendors of Abeokuta town in Ogun state were infected with one or more faecal- orally transmissible parasites.

A study by Mohan et al (2006) showed that 12.9 per cent of food handlers of health and educational institutions were found to be suffering from intestinal parasitic infestation, out of which 42.81% were contributed by Entamoeba histolytica. Evaluation of health stats of food handlers employed in food service establishments of Bijapur city showed that 62.65% of them were suffering from anemia, orodental disease, gastroenteritis, febrile illness and parasitic infestation (Udgiri and Masali 2007).

Inadequate knowledge and practices of food handlers:

Data on risk factors for food borne diseases indicate that the majority of outbreaks results from faulty food handling practices (Clayton et al 2002). Several observational studies have indicated that food workers frequently engage in unsafe food preparation practices (Clayton and Griffith. 2004; Howes et al 1996; Manning and Snider 1993).

According to WHO the most important cause of the spread of food borne disease is the poor knowledge on food safety and unhygienic methods adopted by the food handler. Jay et al (1999) reported that 70% of the food handlers were unaware of the correct temperatures for storing perishables, while 25% failed to identify that washing hands before and during food preparation is necessary.

Askarin et al (2004) reported that the food service staff in hospitals of Iran had little knowledge regarding the pathogens that cause Food Borne Illnesses and the correct temperature for the storage of hot or cold ready – to –eat foods. It was noted in another study that the street food vendors of Nairobi, Kenya were not aware of hygiene and sanitary practices and lacked training (Muinde and Kuria, 2005). Subratty et al, 2004 reported that the street food vendors in rural areas in Mauritius had poor knowledge and practice of handling and preparing foods. The food safety knowledge and practices of 54 street food vendors in Philippines University campus was studied and the findings revealed a gap between food safety knowledge and practices of street food vendors (Azana et al 2000).

Cross contamination and improper storage or reheating of food:

Food borne diseases have been associated with improper storage or reheating of food and cross contamination (Egan 2007). The purpose of holding potentially hazardous foods at proper temperatures is to minimize the growth of any pathogenic bacteria that may be present in the food. The number of bacteria that a person ingests with their food has a direct impact on a possible illness. A small number of disease causing bacteria may cause a mild illness or possibly no illness at all. However, a large number of the same bacteria may cause a very severe illness. Holding potentially hazardous foods at improper temperatures may allow pathogenic bacteria to reproduce rapidly and progressively to great numbers, thus putting someone who eats that food at great risk for food borne illness. Bas, Ersun and Kivanc, 2006 found that 47.8% of food handlers of Turkey had not taken a basic food safety training. They also lacked knowledge regarding basic food hygiene such as critical temperatures of hot and cold food, cross contamination, refrigeration temperature, etc. Similar finding were also reported by other investigators (Walker, Pritchard and Forsythe, 2003). Such inadequacies in knowledge of the handlers regarding temperatures of hot and cold foods can be critical factor in causation of food borne illnesses.

Another common cause of food borne illness is cross contamination. Cross contamination may occur when a sick employee handles food, raw food

contaminates a ready-to-eat food, food contact surfaces that are not cleaned and sanitized properly come in contact with a ready-to-eat food, or equipment is used for multiple foods without cleaning and sanitizing between preparing foods.

Various studies have demonstrated that the main sources of cross contamination during processing come from food contact surfaces, equipment and employees (Gill et al., 2001; McEnvoy et al., 2004; Tsalo et al., 2007; Aarnisalo et al., 2006; Bagge-Ravn et al., 2003; Cools et al., 2005; Fuster-Valls et al., 2008).

The cutting board is one of the top five sites most contaminated with heterotrophic bacteria in the kitchen and may facilitate transmission of foodborne pathogens by cross-contamination (DeVere & Purchase, 2007) due to the fact that it is a moist environment and is frequently touched (Rusin, Orosz-Coughlin & Gerba, 1998).

In the same way, slicers have been found to be critical surfaces that may retain bacteria and pathogens such as *Listeria monocytogenes* and to be sources of cross contamination (Grassi et al., 2008; Sheen & Hwang, 2008; Vorst et al 2006). Finally, hands too are considered as a critical source of cross contamination according to other studies that have found contamination with *Campylobacter* and *Staphylococcus aureus* microorganisms coming from hands (Bidawid et al 2000; Gorman et al 2002; Aarnisalo et al., 2006). Hands can contaminate food through residential flora of the skin e.g. micrococci, staphylococci, propionic bacteria and corynebacteria; and the transient flora such as faecal pathogens like *Escherichia coli* and *Salmonella* (Aarnisalo et al., 2006) or viruses such as the Hepatitis A virus (Bidawid et al 2000) when they have contact with the environment.

Handling money and ready to eat food with same gloved hands or without hygiene intervention between these activities can introduce the risk of cross contamination to foods provided in food service establishments. With low infectious doses capable of causing illness noted for a number of different infectious intestinal diseases, failure to adequately sanitize hands, or use food handling tools (tongs, spoons, utensils or bakery/serving papers) between handling money and serving food, could put patrons at risk (Michaels 2002).

Paper currency provides a large surface area as a breeding ground for pathogens (Podhajny 2004). In most parts of the developed world, there is a popular belief that the simultaneous handling of food and money contributes to the incidence of food-related public health incidents (FSA 2000). Over the last two decades, the observed data indicated that simultaneous handling indeed was a cause of sporadic food borne-illness and survival of pathogens on currency notes in Turkey (Goktas & Oktay 1992), United States (News 1998, Jiang & Doyle 1999, Pope et al 2002), Australia (FSA 2000), India (Singh et al 2002), Egypt (El-Dars & Hassan 2005), China (Xu et al 2005), and Myanmar (Khin Nwe et al 1989).

Kuria et al (2009) studied the profile of bacteria and fungi on money coins and found them to be contaminated with *Escherichia coli, Klebsiella, Serratia, Enterobacter, Salmonella, Acinetobacter, Enterococci, Staphylococcus* and *Bacillus cereus.*

2.3 EATING OUT ON RISE..... A RISK??

Vast changes in the Indian social and cultural practices have been brought about by rapid modernization and influenced by the media. Increase in buying power and long hours spent away from home, commuting to work place make eating out a necessary part of life. Thus, eating out besides a social event, can also be a matter of convenience such as the catering facilities available at hospitals, schools, colleges, industries and also while travelling by rail, ship, road and air. Crowded fast food joints, the frequency with which new pubs are cropping up, are some of the indicators of the fact that eating out in big way is here to stay (Roday 1999). In recent years, there has been an increasing trend towards the sale and consumption of outside foods. This trend is more obvious in the urban areas, where due to the increasing population, changing lifestyle, breakdown of joint family system and increasing number of working women compel people to depend on "ready-to-eat" foods (Udgiri and Masali 2007). Many reported food borne illness outbreaks originate in food service establishments (Olsen et al 2000; Jones at al 2004), and sporadic food borne illnesses have been associated with having eaten outside the home (Friedman et al 2004; Kassenborg et al 2004; Kimura et 2004; Sobel et al 2000).

An American Meat Institute (1996) study details lifestyle changes affecting food behavior, including an increasing number of women in the workforce, limited commitment to food preparation, and a greater number of single heads of households. Consumers appear to be more interested in convenience and saving time than in proper food handling and preparation.

Food service establishments (FSE) such as restaurants, hotels, bars, and cafeterias are considered an important source of food borne outbreaks as studied in various European countries (Effler et al, 2001; Olsen et al., 2000; Hughes et al., 2007).

2.4 STREET FOODS

Street foods are consumed by an estimated two and a half billion people worldwide. Because of its low cost and convenience, street food is an indispensable part of urban and rural diets in the developing world. But there are also risks. Food stalls often lack the necessary storage, refrigeration and cooking facilities to prevent contamination with pathogenic bacteria. Limited access to running water and waste disposal increases the potential for passing the problem on to many customers (FAO, 2001). The Food and Agricultural Organization of the United Nations (FAO/ WHO 1996) defined street foods as ready-to-eat foods and beverages prepared and sold by vendors and hawkers in streets and other similar public places (Simopoulos 2000). For practical purposes, street foods could be classified according to the processing/preparation they require, as foods without preparation, street-cooked foods and ready-to-eat foods (WHO 1984). FAO studies show that, from Bogota to Bombay, selling snacks and whole meals on the streets is an important way to obtain income, especially among poor women. In Calcutta, the 130,000 street food vendors make an estimated profit of nearly US$100 million per year. In Latin America and the Caribbean studies showed that average monthly sales per vendor were within a range of US$150 to US$500. In Bangkok, it is estimated that 120,000 vendors purchase between US$16 and US$41 of raw material per day each, stimulating the local economy (FAO, 1997).

The street food industry plays an important role in the food supply chain, conveniently serving "people on the run" (Muñoz de Chavez *et al.* 2000). Street foods, which are inexpensive and readily available, form an integral part of the diet of people because they are consumed with regularity and consistency across all income groups (Simopoulos 2000).

In developing countries, drinks, meals and snacks sold by street food vendors are widely consumed by millions of people (FAO, 1988). These street foods provide an affordable source of nutrients to many sectors of population (Ohiokpehai, 2003). Urban street foods vending provides employment and incomes for many people (Barro et al., 2002a; Canet and N'Diaye, 1996). Street foods are well appreciated by consumers, because of their taste, low price and availability at right time (Barro et al., 2002b; Canet and N'Diaye, 1996). However, street foods are frequently associated with diarrhoeal diseases due to poor handling practice of the vendors (Akinyele, 1998; Barro et al., 2002a; 2002b; Bryan et al., 1988; King et al., 2000; Mosupye and Van Holy, 1999; Tjoa et al., 1977; Umoh and Odoba, 1999; WHO, 2002). They are mostly uninformed of good hygiene practices (GHP) and causes of diarrhoeal diseases (Barro et al., 2002a; Mensah et al., 2002), such practice can increase the risk of street food contamination (Bhaskar et al., 2004; Bryan et al., 1988; Barro et al., 2002b). Therefore, the conditions of street food preparation and vending raise many concerns for consumers health (Bryan et al., 1988; Mosupye and van Holy, 1999).

2.4.1 Risk associated with street foods

In contrast to the potential benefits of street foods, it is also recognized that street food vendors are often poor and uneducated and lack appreciation for safe food handling. Consequently, street foods are perceived to be a major public health risk. Street foods may pose significant public health problems due to the following factors (WHO, 1996).

- ✓ Lack of basic infrastructure and services such as potable water supplies
- ✓ Difficulty in controlling the large numbers of street food vending operations because of their diversity, mobility and temporary nature.

- ✓ Insufficient resources for inspection and laboratory analysis.
- ✓ General lack of factual knowledge about the microbiological status or premise epidemiological significance of many street vended foods.
- ✓ Poor knowledge of the street vendors in basic food safety measures.
- ✓ Inadequate public awareness of hazards posed by certain street foods.

Risk associated with the microbial quality of street foods

In most cases, running water is not available at vending sites, hands and dish washing are usually done in one or more buckets, and sometimes without soap. Waste waters and garbages are discarded nearby, providing nutrients for insects and rodents. Some of the foods are not efficiently protected against flies which may carry food borne pathogens. Safe food storage temperatures are rarely applied to street foods (Bryan et al., 1988). In addition, there are potential health risk associated with initial contamination of foods by pathogenic bacteria as well as subsequent contamination by vendors during preparation and through post-cooking handing and cross contamination (Bryan et al., 1988).

The major concern with street foods is their microbiological safety, mainly because vending is done in places that may have poor sanitation. Street foods in some African countries have been tested for various microorganisms of public health concern, including feacal coliforms, *Escherichia coli*, *Staphylococcus aureus*, *Salmonella* spp and *Bacillus cereus*. *E. coli* and *S. aureus* were recovered in a significant proportion of the food, water, hand and surface swabs tested in Harare. Mensah et al. (2002) reported that of 511 street food items examined in Accra, 69.7% contained mesophilic bacteria, 5.5% contained *Bacillus cereus*, 31.9% contained *S. aureus* and 33.7% contained Enterobacteriaceae. *Shigella sonnei* was isolated from macaroni, *Salmonella arizonae* from meat-based soup and enteroaggregative *E. coli* from macaroni, tomato stew and rice (Mensah et al 2002). In a separate study, it was observed that over 26% of street food samples analyzed in Nigeria contained *B. cereus*, while 16% contained *S. aureus* (Umoh and Odoba 1999). Chakravorty and Canet (1996) studied the street foods of Calcutta city and found that street foods were contaminated with *Salmonella*,

Shigella, E Coli and *S aureus. Bhelpuri* (an Indian Chaat) sold by street food vendors of Vadodara city were found to be highly contaminated with pathogenic microorganisms (Sheth al 2005).

These observations indicate that although street foods are a major source of nutritious food, they are also a possible source of food poisoning microorganisms.

Personal hygiene of the street food vendors

Purchasing ready-to-eat foods and ingredients from street/market vendors poses a considerable risk to public health, especially due to the observed poor hygienic practices (Ehiri et al 2001). Defective personal hygiene can facilitate the transmission of these pathogens bacteria found in environment and on peoples' hands via food to humans (Bhaskar et al., 2004; Mensah et al., 2002). Burt et al. (2003) and Black et al. (1989) showed that hands are important in the contamination and the dissemination of fecal-oral transmitted bacteria. The risk increases when vendors during vending use bare hands to serve. In general, spoons and bare hands were used to serve rice, pork, salads, *Benga* and other foods. Several authors have shown that serving stage is a critical point in the street food industries (Barro et al., 2002a; Bryan et al., 1988; Bryan, 1988; El-Sherbeeny et al., 1985). Enteropathogens can survive on the hands for three hours or longer. Bacteria in food can survive and multiply if held for prolonged periods at ambient temperature.

In a study by Sheth, Sukul and Patel (2007) it was reported that, majority of the staff working in University Boy's hostel of Vadodara city, India, were having dirty nails and moustache indicating poor personal hygiene of the staff. Barro et al (2006) studied the microbial quality of dish washing waters, utensils, hands and pieces of money from street food processing sites in Ouagadougou. Microbial analysis revealed that the above samples showed presence of large number of food borne pathogens such as *Salmonella, Shigella, coliforms* and *Staphylococcus aureus.* Pieces of money are in permanent movement, passing in all environments that constitute a reservoir and source of various bacteria as pathogenic *Escherichia coli*, which can survive 11 days on the inert surfaces (Pomperayer and Gaylarde, 2000). Money handling constitutes another risk factor of street foods contamination.

In most cases where studies of street food vending have been done, the vendors do not have adequate washing facilities, and some vendors started their duties without taking a proper bath. Some of the vendors sleep at the vending sites in order to protect their wares (FAO/WHO 2005).

Environmental hygiene of the street vending site

Street food vendors may be located outdoors or under a roof which is easily accessible from the street. The site where street foods are prepared and sold affects their safety significantly because the food gets exposed to numerous potential contaminants. These locations do not meet all food safety requirements, for example; large amounts of garbage accumulate and provide harborage for insects and animals (Bryan et al 1997). Inadequate refuse disposal facilities lead to the accumulation of refuse at food vending sites. This leads to an increased pest population and results in an increased risk of food contamination. The street vending site of West Indies lacked the basic facility of drainage system, made use of open bins for garbage disposal and also had presence of stray animals (Olliviera and Badre 2006).

In many instances, the vending sites are not included within the city or town plans, and therefore amenities such as refuse collection are not available. Poor sanitary conditions in the area where foods are vended also contribute to poor food storage and transport conditions. Most of the vendors have no fixed stalls where they can store their raw materials on site. They usually store their goods at home overnight and transport them the following day, often improperly covered, to their operating sites. Thus, the food becomes prone to contamination during transportation (FAO/WHO 2005).

2.5 SMALL AND MEDIUM RESTAURANTS

Another category of food service establishment is the small and medium restaurants that cater food to a major population of the society. A restaurant is a retail establishment that serves prepared food to customers. Food served in such establishments is cheaper and easily affordable. Restaurants served >70 billion meals in the United States in 2005. Of all the money spent on food in the United States, 47% is spent in restaurants, and the food service industry employs >9% of the nation's workforce (National Restaurant

Association. National industry fact sheet 2005). Four in 10 Americans eat in restaurants on any given day, and 1 in 6 eats 15 meals per week in restaurants (German et al 2002).

Small restaurants cater mostly to people belonging to low and lower-middle socio-economic class. Customers eating at a restaurant have a right to expect that the food they eat will not harm them. However, customers have no way to control what goes on in restaurant kitchens. They depend on restaurants to follow safe standards of food handling, and on local inspection agencies to enforce those standards. But restaurants can be an important setting for the spread of food borne illnesses. Unlike the street foods, restaurants do have infrastructure facilities such as water supply, electricity, but a limited working area.

Outbreak Data

Food borne disease outbreak surveillance data include some information on the association of restaurants with reported outbreaks. From 1998 to 2004, an average of 1290 foodborne disease outbreaks each year (involving an average of 25,600 ill people each year) were reported to the Centers for Disease Control and Prevention (CDC) (CDC 2006[a]). Of the 9040 foodborne disease outbreaks that were reported to the CDC from 1998 to 2004 (CDC 2006), 4675 (52%) were associated with restaurants or delicatessens (including cafeterias and hotels; figure 2.5.1). Of these, 622 (13%) had a bacterial etiology, 535 (11%) were viral, and 3377 (72%) had an unknown etiology (table 2.5.1). Furthermore, when stratifying the 9040 reported outbreaks by etiology, restaurants were associated with substantial proportions of outbreaks associated with all etiologies, including bacterial (39%), chemical (47%), parasitic (24%), viral (48%), and unknown etiology (56%) outbreaks. CDC outbreak reports categorize restaurants and delicatessens together, precluding the determination of the precise proportion of outbreaks that are specifically associated with restaurants.

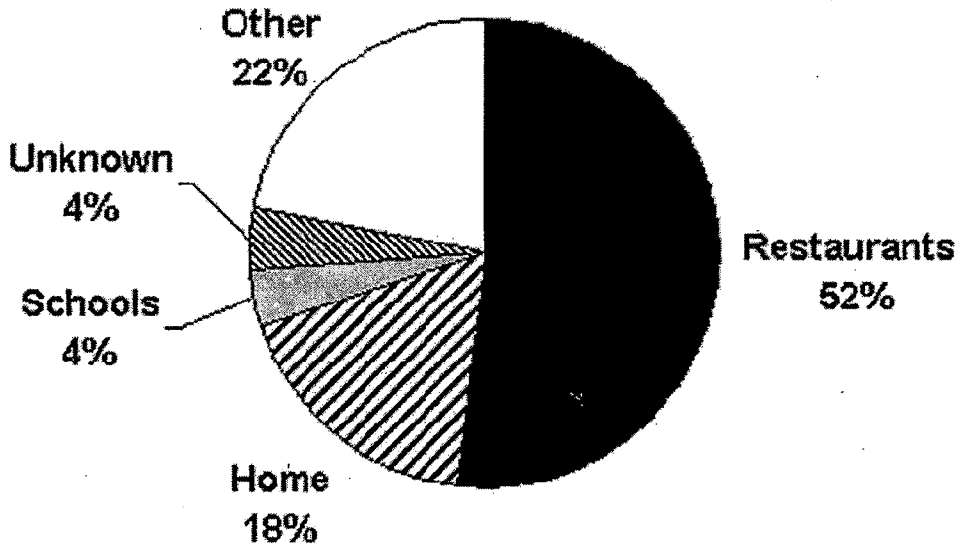

Figure 2.5.1: Sources of food borne disease outbreaks reported to the CDC during the period 1998-2004. "Restaurants" include dellicatessens, cafeterias and hotels. Data are from CDC 2006[d].

Table 2.5.1: Etiology of restaurant-associated outbreaks reported to the Centers for Disease Control and Prevention during the period 1998–2004.

Etiology	No. (%) of outbreaks
Norovirus	496 (11)
Salmonella species	349 (7)
Scombroid	119 (3)
Escherichia coli	57 (1)
Clostridium perfringens	54 (1)
Shigella species	50 (1)
Hepatitis A	36 (1)
Staphylococcus species	35 (1)
Other	122 (3)

A large study of persons with infection due to *Salmonella* serogroups B and D (which includes infection due to *Salmonella* serotype Enteritidis) revealed an association with the consumption of eggs in a restaurant (Mermin et al 2004). In a case-control study involving persons infected with *Salmonella* serotype Typhimurium, eating fried eggs that were prepared outside of the home was associated with illness (mOR, 4.2; 95% CI, 1.4–12.9) (Glynn et al 2004). In analyses comparing persons infected with multidrug-resistant strains of

Salmonella serotype Typhimurium with healthy control subjects, eating scrambled eggs prepared outside of the home was a risk factor, with a population-attributable risk of 13%.

In a large case-control study involving persons infected with *Campylobacter* species, infection was associated with eating chicken, turkey, or nonpoultry meat prepared at a restaurant (Rodrigues et al 2001). In a study of infection due to domestically acquired, fluoroquinolone-resistant *Campylobacter* species, eating chicken or turkey cooked at a commercial establishment was implicated as an important source of infection (Sobel et al 2000).

A study of a newly-introduced phage type of *Salmonella* serotype Enteritidis in Utah revealed that sporadic infections were significantly associated with eating in restaurants, particularly restaurants that used 12000 eggs per week or that used pooled eggs (Sobel et al 2000).

2.6 FOOD SAFETY EDUCATION AND ROLE OF STAKEHOLDERS TOWARDS SUPPLY OF SAFE FOOD

In order to establish a system of safe supply of ready to eat foods to customers either through street food vendors or restaurants of small and medium type, a systematic approach needs to be employed. This process includes involvement of various governmental and non-governmental bodies, which can put in their expertise to achieve this goal. Governments through the relevant institutions and agencies are responsible for safeguarding the health of the people (Molins R 2007). Government has the primary responsibility for identifying and assessing health risks associated with the food supply, and developing national strategies to manage the risks. Canada is of the view of that collaboration of all stakeholders in the food continuum (feed manufacturers, primary producers, food manufacturers/operators, government authorities, consumers) is essential to ensure a comprehensive and integrated approach to the availability of a safe and nutritious food supply (FAO/WHO 2004).

It is essential that the food safety and quality system include proper channels for information and communication between the system and stakeholders in

the agrifood chain, with a view to facilitating inter sectoral dialogue and continually improving the safety and quality of food products through education, training and the understanding and adoption of good practices (FAO 2003).

An effective food safety infrastructure along with an adequate educational program can be adopted to safeguard the health of the public at risk from food borne diseases (WHO, 1993). This calls for adopting strategies that would involve both the government as well as non governmental organizations for a sustainable impact of any educational program.

For any system to survive and sustain it is necessary that all the bodies join hands and work towards achievement of specified goals. Formation of the 'Canadian Partnership' for consumer food safety education is a testimony towards such joint efforts.

Canadian Partnership for Consumer Food Safety Education (FAO/WHO 2004)

Communication between industry, health, environmental and consumer organizations, and federal and provincial government agencies concerned with food safety, resulted in the formation of the Canadian Partnership for Consumer Food Safety Education with the mandate to "Contribute to the reduction of microbial food borne illness in Canada by increasing awareness of safe food handling practices through the coordination and delivery of food safety education programs focused on the consumer. This non-profit organization is a national association of more than 50 public and private organizations committed to educating Canadians about the ease and importance of food safety in the home.

The development of Calcutta Model and its success can be attributed to the fact that there was mutual trust and dependence among all stakeholders (Chakravarty I 2006).

Education of consumers and training of food handlers in safe food preparation is one of the most critical interventions in the prevention of food borne

illnesses (WHO, 2002). A food handler must not only know "what" to do, but also "how" and "why" it is being done (Linton, 1995).

In particular, as pointed above, WHO believes that health education in food safety has to be developed in line with the results obtained through the application of HACCP during the preparation and storage of foods in food service establishments. The most important component of imparting education is to train the unskilled workers – the food handlers.

Thus, the instrument of "Food Safety Education" (FSE) should sharpen considerably the consciousness of low level food handlers to achieve high quality food catering service. Angelillo *et al* (2000) reported that there were inadequacies in knowledge and emphasized the need for educational program to control FBDs and prevent outbreaks in food service industry.

Experience has shown that well designed and implemented educational program is feasible and cost effective means of improving health status. This statement can hold true only when training is imparted in an effective manner. Varieties of channels along with reinforcement are necessary to make the communication process effective, interesting, entertaining and complete. A study by Sheth and Sukul (2007) showed food safety education interventions that made use of variety of training materials, increased the knowledge scores of food handlers from 38.4 percent to 50.2 per cent.

In another food safety education training imparted to Louisiana consumers and food handlers through mass media efforts, including news articles, radio and television and circular letters; and through the "Safe Food Handler" training program conducted at fairs, festivals, schools, day care, nursing homes and other food service establishments resulted in knowledge gains on various aspects of food safety (Impact Reports, 2003).

According to CDC (2006[a]), food safety education has shown a significant impact in the reduction of FBDs from 1996-2001. Rates of infections declined for 6 of the major food borne illness as follows:

Yersinia enterocolitica	49%
Listeria monocytogenes	35%
Campylobacter	27%
Escherichia coli 0157:H7	21%
Salmonella	15%

Efforts to promote FOODSAFETY EDUCATION by government of various countries

Food and Drug Administration (FDA) and Food Safety and Inspection Service (FSIS) have worked to a great extent in the area of food safety education (CDC, 2004).

- ✓ FDA and FSIS develop and distribute materials for consumers and various organizations on issues of food safety, such as the importance of cooking foods to safe limit, food borne lionesses associated with raw and undercooked eggs and raw sea food and food safety for seniors.
- ✓ In Spring 2000 FSIS, USDA launched a new national food safety education campaign to promote the use of food thermometers. The campaign theme is: **"It's Safe to Bite When the Temperature is Right!"**
- ✓ In 2003, FSIS introduced a new educational campaign designed to reach millions of consumers with food safety messages. The campaign's centerpiece is the **Food Safety Mobile**, which travels the country delivering food safety education and developing partnerships at the local level.
- ✓ Each year FDA and FSIS develop a kit of consumer education materials for **National Food Safety Education Month**[SM] (September), in support of the four key food safety practices. These kits reach some 42,000 health educators, including FDA and USDA field staff, State and local health department personnel, school food service directors, and school nurses and are used in a variety of local educational activities.
- ✓ In cooperation with Radio Unica, FDA distributed information in Spanish and English on the four key food safety behaviors, as well as

the risks associated with undercooked eggs and raw seafood, at 12 health fairs held in major Hispanic population centers across the U.S.

- ✓ In cooperation with the California Department of Health Services, FDA developed and implemented a program to educate the Latino community on the dangers of eating raw molluscan shellfish because they may be contaminated with the bacteria *Vibrio vulnificus,* which can cause serious illness or death.

Various school based educational programmes have also been started to impart food safety education to the children.

- ✓ The ***K-3 Presenter's Kit,*** a compendium of games, songs and coloring materials utilizing the **Fight BAC!®** character has been widely distributed to elementary schools and has proven effective with pre-schoolers as well.
- ✓ ***Your Game Plan for Food Safety,*** for grades 4-6, includes an award-winning video and food safety-related experiments to teach basic microbiological concepts illustrating the importance of the four key behaviors. Developed in partnership with the National Science Teachers Association (NSTA), some 17,000 copies are now in use by teachers.
- ✓ ***Science and Our Food Supply,*** a supplementary food safety curriculum for middle and high school students developed by FDA and NSTA and is in wide use with more than 23,000 copies distributed in response to teacher requests. In addition, FDA and NSTA host an annual train-the-trainer program, bringing 25 middle school and 25 high school science teachers to Washington each year for a week of food safety/food science training, in return for which the teachers hold workshops in their local areas on *Science and Our Food Supply.* To date, more than 4000 teachers have participated in the local workshops.

2.8 OUTBREAKS ASSOCIATED WITH RAW PRODUCE

Food borne outbreaks from contaminated fresh produce have been increasingly recognized in many parts of the world. This reflects a convergence of increasing consumption of fresh produce, changes in production and distribution, and a growing awareness of the problem on the part of public health officials. Biological hazards are the most common cause of food borne disease linked to fresh fruits and vegetables (CDC 2006[c]; CDC 2008[b]; Sivapalasingam 2004). Increased consumer demand in recent years for fresh "natural" and "organically" cultivated produce has increased the risk for food handling errors and food borne illnesses associated with fresh produce (Hurst and Schuler 1994). The frequency of documented outbreaks of human illness associated with consumption of raw fruits and vegetables, as well as unpasteurized juices, has increased in the United States in recent years (DeRoever 1998).

It has been estimated that the number of produce associated outbreaks per year in the US doubled between the periods 1973-1987 and 1988-1992 (Olsen et al 2000). Given sufficient time at an appropriate temperature, some pathogens can grow to populations exceeding 10^7 CFU/g of raw produce (USDA 2001). Surveillance of vegetables has indicated that they can be contaminated with various bacterial pathogens including *Salmonella, Shigella, E coli O157H7, Listeria monocytogenes* and *Campylobacter* (NACMCF 1999; Beuchat 1996). Salmonellosis has been linked to tomatoes, seed sprouts, cantaloupe, watermelon, apple juice, and orange juice. Escherichia coli O157:H7 infection has been associated with lettuce, alfalfa sprouts, and apple juice, and enterotoxigenic E. coli has been linked to carrots. Associations of shigellosis with lettuce, scallions, and parsley, cholera with strawberries, hepatitis A virus with lettuce, raspberries, and frozen strawberries, and Norwalk/ Norwalk- like virus with melon, salad, and celery have also been documented. Most recently, Cryptosporidium infection linked to apple cider and Cyclospora infection linked to raspberries, lettuce, and basil have broadened awareness that produce- associated illnesses are not confined to bacteria and viruses as causative agents (Burnett and Beuchat 2001). The epidemiology of food borne diseases has undoubtedly contributed to an

increased frequency of outbreaks of infections linked to raw produce. In Australia, fresh produce accounted for 4% of all food borne outbreaks reported from 2001 to 2005 (Kirk et al 2008). Tambekar and Mundhaba (2006) studied the bacteriological quality of salad vegetables sold in Amravati city. Amongst the salad vegetables studied, coriander was found to be predominantly contaminated with *Escherichia coli* and *Salmonella* sp. Beuchat (1998) reported the presence of *Aeromonas, Bacillus Cereus, Campylobacter, Escherichia coli, Salmonella, Shigella* and *Staphylococcus sp.* on salad vegetables such as spinach, cucumber, coriander, tomato, carrot and raddish.

Several produce related outbreaks have been multi-national in scope (Table 2.8.1).

Table 2.8.1: Selected recent multinational foodborne outbreaks due to contaminated produce items (Lewis et al 2007; CDC 2006[c]; CDC 2008[c]; Pezzoli et al 2007; Emberland et al 2007)

Year	Pathogen	No. of cases	No. of countries	Affected regions Implicated food	Implicated food
2008	Salmonella Saintpaul	1442	2	North America	Fresh peppers, tomatoes
2007	Salmonella Senftenberg	51	5	Europe, North America	Fresh basil
2007	Shigella sonnei	175	2	Australia, Europe	Raw baby corn
2007	Salmonella Weltevreden	45	3	Europe	Alfalfa sprouts
2006	Escherichia coli O157:H7	206	2	North America	Fresh spinach
2006	Salmonella Thompson	20+	3	Europe	Ruccola (arugula)

Changes in dietary habits, methods of produce production and processing, sources of produce, and the emergence of pathogens previously not recognized for their association with raw produce have enhanced the potential for outbreaks associated with raw fruits and vegetables (Beuchat and Ryu 1997; Hedberg et al 1994). Some factors that contribute to the epidemiology of food borne disease associated with fresh produce and other foods include changes in diet, increased consumption of food in commercial food service establishments, increased handling, and the development of large and complex international networks of distribution (Hedberg et al 1994). Produce

can become contaminated with microbial pathogens by a wide variety of mechanisms. (Figure 2.8.1)

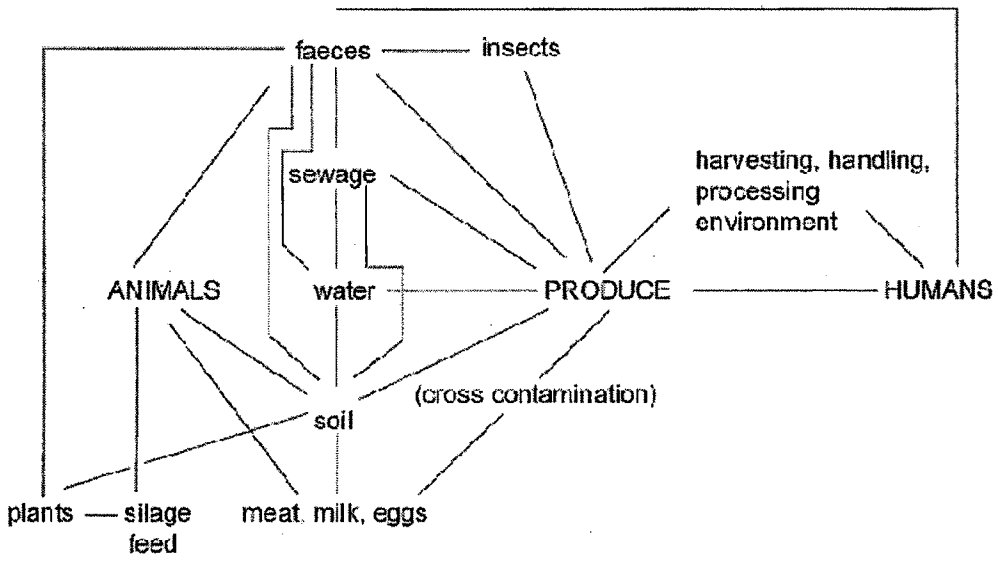

Figure 2.8.1: Mechanisms by which produce can become contaminated with pathogenic microorganisms (adapted from Beuchat 1996).

The microbial ecosystem on the surface of raw fruits and vegetables is diverse and complex. The presence and numbers of microorganisms differ, depending on the type of produce, agronomic practices, geographical area of production, and weather conditions before harvest (Lund 1992; Nguyen and Carlin 1994; Brackett 1999).

Ready to eat or ready to use vegetables are subjected to minimal or no processing prior to consumption. They can be used as ingredients in cooked dishes, but many are consumed raw without any treatment that would normally destroy the pathogenic microorganisms (Richard et al 2002). Coriander leaves are used in many culinary Indian dishes, for garnishing of cooked foods, or used in the preparation of chutney that under go no thermal treatment. Coriander leaves used in green chutney has been responsible for the outbreak of several food borne diseases (Roday 1999). In Mexico City 20% coriander samples were found to be contaminated with *E coli O157:H7* (Zepeda et al 1995).

Street foods in India make use of coriander leaves for the purpose of garnishing the foods such as *pav bhaji*, curried vegetables, *bhel, pani puri,*

etc. The leaves in raw form are used as garnishing and undergo very little cooking. Many a times the leaves are not subjected to washing prior to their use. Such a practice may pose health hazard and is likely source for food borne diseases.

2.9 ROLE OF DISINFECTANTS / SANITIZERS IN REDUCING THE MICROBIAL LOAD OF RAW PRODUCE

In order to ensure complete removal of pathogens from fruits and vegetables it is necessary that they are treated with waters having adequate amount of disinfectant. Washing of raw produce with tap water cannot be relied upon to remove pathogenic bacteria completely (Bracket 1992; Nguyen and Carlin 1994) or they result in very low reductions of 0.1 to 1 $\log_{10}$ units (Beuchat 1998). Various sanitizers such as chlorine, $KMnO_4$, chlorine dioxide, bromine, iodine, tri sodium phosphate, quaternary ammonium compounds, organic acids, hydrogen peroxide, etc have been known to disinfect fruits and vegetables.

Chlorine has been used for many years to treat drinking-water and wastewater as well as to sanitize food processing equipment and surfaces in processing environments. It is also used as a disinfectant in wash, spray and flume waters in the raw fruit and vegetable industry. Chlorination is generally accomplished by using elemental chlorine or one of the hypochlorites. Liquid chlorine and hypochlorites are moderately effective disinfectants for surfaces that may come in contact with fruits and vegetables during harvesting and handling, for processing equipment, and for whole and cut fruits and vegetables. To disinfect produce, chlorine is commonly used at concentrations of 50- 200 ppm with a contact time of 1-2 minutes.

The effectiveness of chlorine in killing salmonellae on alfalfa seeds has been studied. Treatment of seeds inoculated with *Salmonella* Stanley (102-103 CFU/g) in 100 ppm chlorine solution for 10 minutes has been reported to cause a significant reduction of the pathogen; treatment in 290 ppm chlorine solution resulted in a significant reduction compared to treatment with 100 ppm chlorine (Jaquette *et al.*, 1996).

Samples of lettuce (n = 144) analyzed from 16 universities for the enumeration of pathogens, that were given wash treatments with sodium

hypochlorite or $KMnO_4$ solutions reduced the microbial counts by more than two log units, and total coliforms by at least one log (Soriano et al 2000). The effectiveness of washing lettuce for 2 min in sodium hypochlorite at 70 ppm or $KMnO_4$ at 25 ppm brought from six college establishments was studied and reductions in populations of aerobic bacteria and total coliforms from 7 log to 2 logs CFU/g of mesophilic bacteria was reported (Mathews 2006).

Washing lettuce for 2 min in sodium hypochlorite at 70 ppm or $KMnO_4$ at 25 ppm reduced populations of aerobic bacteria and total coliforms by nearly 2 logs (Mathews 2006). The maximum observed log_{10} reduction of *Listeria monocytogenes* at $4^{o}C$ and $22^{o}C$ was 1.3 and 1.7 for lettuce and 0.9 and 1.2 for cabbage respectively (Zhang and Farber 1996). Washing of cantaloupes in chlorinated (1000 ppm) water within 24 h after inoculation reduced the population of attached *Salmonella Stanley* on the cantaloupe surface and the possibility of transfer during fresh cut produce (Ukuku and Gerald 2001).

Adams et al (1989) observed that treatment of salad greens with 100 ppm free chlorine reduced aerobic plate counts by 92% to 98%. Increasing concentrations of hypochlorite resulted in limited improvement of disinfection.

In view of the literature cited above the study was undertaken with the following scope of investigation.