

*Review Article*

## **Food safety research in India: a review**

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### **Abstract**

With growing international trade, food safety has emerged as an important global issue. The present research was an attempt to study the food safety research in India in the past ten years during 1995-2005. Many studies were focused on detection of pathogenic microorganisms, adulterants and contaminants in food. However, there is a striking paucity of reliable data on important issues like evaluation of risks through adulterants, additives and contaminants. Consequently, the protection of diets from these hazards must be considered one of the essential public health functions of any country, which emphasizes the need for total diet studies.

**Keywords:** food-borne diseases, pathogenic organisms, adulterants, contaminants

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### **Introduction**

Food safety has emerged as an important global issue with international trade and public health implications. In response to the increasing number of food borne illnesses, governments all over the world are intensifying their efforts to improve food safety. The World Health Assembly adopted a resolution (WHA 53.15) in which, the World Health Organization (WHO) was asked “to give greater emphasis on food safety...with the goal of developing suitable, integrated food safety systems for the reduction in health risk along the entire food chain, from primary producer to the consumers”.

Food borne illnesses are a widespread public health problem globally. Developing countries bear the brunt of the problem due to the presence of a wide range of food-borne diseases [1]. In India an estimated 4,00,000 children below five years age die each year due to diarrhoea. Several millions more suffer from multiple episodes of diarrhoea and still others fall ill on account of hepatitis A, enteric fever, etc. caused by poor hygiene and unsafe drinking water [2].

However, in the context of widespread poverty and malnutrition in developing countries, programs directed towards the promotion of adequate access to food that satisfy calorie needs and minimize hunger and malnutrition have precedence over programs designed to ensure wholesomeness and quality of food. In short the emphasis so far has been more on food adequacy rather than on food quality.

Food safety programs have become increasingly necessary due to technological advances in food and agricultural sectors and also due to social changes introducing new food habits. In the past, food was consumed by those who produced it or by their immediate neighbours. Increased world production, urbanization, industrialization and migration have however introduced new food safety problems into our food supply [3].

In India too, ensuring food safety has been recognized as an important component in protecting the health of the people. Among the developing countries, India and Sri Lanka were the earliest to enact modern food laws. Based on the experiences of the west, a most comprehensive definition of food adulteration has been given for PFA (Prevention of Food Adulteration) Act 1955 of India. Historically, the regulatory process of food laws was to discourage fraudulent practices of food adulteration which changed with the advent of globalization in July 1991 in India. This in turn brought changes in the domestic economy thereby leading to absorption of labour, increasing incomes and overall prosperity. The impact of higher incomes in turn had an impact on dietary patterns, which was evident by greater demand for processed food.

The domestic food processing industry in India which has been reeling under uncertainties for years, is now facing fierce competition from the developed and some of the developing countries. This could be due to the wide variations in the usage of food additives and consequent technologies. With the government's economic policy and the influx of imported food items containing ingredients not permitted under the PFA Act in India, the regulatory authorities are flooded with requests to liberalize food laws and permit the use of a greater variety of food additives. In addition, traders are more readily going in for importing ready-to-eat foodstuffs containing various additives. Here again the Indian food laws may vary from the laws of the exporting country. However, being a signatory to the World Trade Organization (WTO), India cannot stop the entry of foreign products and thereafter has to incorporate the standards suggested by Codex Alimentarius Commission unless scientific basis is provided to do so [4]. In order to ensure that the food sectors match up to the best global standards, the Government of India enacted an integrated food law called the Food Safety and Standards Act in August 2006 and in addition a Food Safety Authority is being established shortly. This autonomous authority will set standards and license the manufacture of food products which are healthy and safe [5].

In view of the vastness of the country, differences in cultural and geographical features, diversity in food habits, hygiene practices and centuries-old traditions on one hand and changes brought in by globalization on the other, it is indeed a daunting task to obtain information on each of these issues. While there have been a few nationwide surveys to understand the profile of food intake and nutritional status of the people, only limited studies have been carried out to understand the food eating habits, wholesomeness of food consumed, hygiene and knowledge of the people on food safety. Although a few research studies addressing a few food safety issues have been done at the college level, most of these have not been published. The present study was an attempt to review the scenario of food safety research in India in the past ten years during 1995-2005.

## **Methodology**

The status of food safety research in India was reviewed by assessing data published in journals, websites and published data from universities in the form of doctoral theses and dissertations at the post-graduate level. For this, literature for the years 1995-2005 was reviewed. The inclusion criteria for reviewing the literature on food safety was to address all issues that had a direct or indirect bearing on food safety issues such as food-borne diseases, pathogenic organisms, food contaminants and adulterants, Hazard Analysis and Critical Control Point (HACCP), risk assessment, hygiene and sanitation, food standards, knowledge, attitudes, beliefs and practices (KABP), street food, food additives and food safety education. The databases such as Google search, Google scholar, PubMed, ScienceDirect were used to search for food safety research in India by using keywords such as food-borne diseases/outbreaks, pathogenic organisms + food, diarrhoeal death + food poisoning, risk assessment of food, street food, etc. The studies that were included for this review were those with a representative sample size and carried out by scholars studying in well-reputed universities, doctoral theses, original research articles in peer reviewed journals, annual reports of research organizations and institutions. Qualitative reviews were reviewed in similar topics and the results were tabulated and compared to get a better understanding of the research carried out in these issues.

Health and nutrition are both dependant on the wholesomeness of food and its freedom from microbial and chemical contamination, as well as on its adequacy with respect to quantity and nutritive value. In this paper an attempt was made to collect data on the status of food safety research in India. The findings of the selected studies have been discussed under the following topics:

- ✚ Health Risk: probability of an adverse event of diarrhea.
- ✚ Hazard Identification: pathogens, adulterants, contaminants and their health effects.
- ✚ Industrial food safety: existing laws, standards, sanitation and hygiene practices, specific hazards.
- ✚ Hazard Exposure Assessment: how much people eat, what food they consume and where they consume.
- ✚ Consumer Behaviour: hand washing, hygiene.

## Health Risk

Studies revealed that food-borne diseases are a serious health hazard and important cause of morbidity and mortality in developing countries. Most cases go unreported and scientific investigations are rarely feasible [6]. Recent studies carried out during 1995- 2005 showed that the incidence of food-borne disease outbreaks were due to microorganisms like *Salmonella* [7], *Campylobacter jejuni* [8] or Norwalk Virus [9], toxins like *Y. enterocolitica* [10], consumption of rancid biscuits characterized by vomiting, abdominal pain and diarrhea among the affected children [11], consumption of rice and soup contaminated with lead and copper [12], consumption of mouldy sorghum and maize containing fumonisin mycotoxins characterized by abdomen, borborygmi and diarrhoea [13]. A more recent outbreak in 1998 was that of epidemic dropsy which occurred in Delhi, India, 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% of them [14]. Though most food-borne diseases are sporadic and often not reported in India, a nation-wide study carried out recently, reported an alarming 13.2% prevalence at household level [15].

At present, the reporting and surveillance of food-borne diseases in developing countries is grossly neglected. The exact extent of the problem of food-borne diseases in developing countries including India has not been fully understood. Although most of the studies showed the incidence of food-borne diseases, they either lacked data on the organisms involved or the food implicated. This may be due to the time lapse in reporting disease outbreaks as the food-borne diseases appear to be non-epidemic in nature and are most often not recognized either by the public or by the health authorities. The actual scenario of food-borne diseases can emerge only with proper emphasis on surveillance and with the establishment of a national food-borne disease surveillance system.

## Hazard Identification

Some studies focused on various pathogenic organisms that were detected in a variety of foodstuffs revealed the presence of *Staphylococcus spp.*, *Coliform*, *Salmonella spp* and *Vibrio cholerae* in seafood such as shrimp [16, 17, 18], *E. coli*, *Enterobacter spp*, *Shigella spp* in milk and milk products [19, 20, 21, 22], faecal *coliforms* and *E. coli* in vegetables [23], water, juice,  $1.5 \times 3.0 \times 10^4$ /g bacterial count in ready-to-eat snacks which increased on storage for one week to  $84.4 \times 10^4$ /g [24], *S. aureus*, *E. coli*, *Enterobacter spp*, *S. typhi* in salad vegetables, fruit and sprouts [25], *Bacillus cereus* in cooked food [26], *Salmonella typhi* in dehydrated food [27], high *coliform* counts in coriander leaves [28], *Salmonella spp*, *coliform* in mango pulp [29], *Staphylococcus aureus*, *Bacillus* and *E. coli* in spice mixtures [30], presence of microorganisms in commercial and home-made chocolates stored at room temperature [31], *E. coli*, *Staphylococcus*, *Streptococci* in non-branded ice cream [32] and *E. coli*, *Vibrio cholerae*, *Salmonella* in non-vegetarian food like meat, eggs and fish [33, 34, 35]. Other studies showing some emerging food and water borne pathogens detected in food were *Listeria monocytogenes*, *Campylobacter jejuni*, *Yersinia enterocolytica*, *Salmonella*, *E. coli*, *Vibrio cholera* [36].

However when samples of milk, spices and condiments were collected from the respondents households, adulterants such as water in milk, chalk powder in turmeric, artificial colour in chilli

powder, pulses were found to be present [37]. A study showed that in India among the eight permitted colours, only six of the colours were being used to colour food and being consumed by most individuals. The intakes of coloured food showed that children had high intakes of solid (2-465g) and liquid food (25-840 ml) per day [38]. Some studies showed that milk was adulterated with specific adulterants like gentamycin at levels ranging from 40-80 µg/ml while in some of the milk samples, sugar, starch and carbohydrate were detected and were found to have adverse effects on the natural microbial flora of milk for curd preparation. Other forms of adulteration showed that about 44% of oils were adulterated with 5-20% of cotton seed /palmolein oil, castor oil and also with 17-1260 ppb of aflatoxins. Diet surveys showed the intake of aflatoxin to be as high as 0-493- 56.7 µg/d [39].

The analysis of food items in selected hostels showed the per gram bacterial counts were  $2.3 \times 10^4$  to  $2.6 \times 10^{12}$  C.F.U. for *S. aureus*, 30 to  $2.91 \times 10^3$  C.F.U. for *coliform* and  $5.6 \times 10^3$  to  $2.85 \times 10^3$  C.F.U. for yeast and moulds. The palms of food handlers showed a range of  $1.03 \times 10^3$  C.F.U. of total microbial counts per sq.cm. It was observed that the overhead tank of one particular hostel had high count of *coliform* which was beyond the permissible limits. In recent years, consumer health concerns and awareness in food have become of paramount importance. Food safety and hygiene in the hospitality industry has become an international requirement and vital for all those involved in food handling and preparation [40].

Many human illnesses are food-related. Nutritional status and economic well-being are affected by food carrying pathogenic organisms and their toxins and by poisonous chemicals. It is estimated that approximately 3 million children below the age of five die of diarrhoea every year. About 70% of these deaths are said to be of food-borne origin [41]. Many food products are highly perishable. They are easily contaminated when produced in an unhealthy and unclean environment. In fact, food is a very good indicator of environmental pollution and is quite often used to monitor the state of the environment. Microbiological contamination and spoilage of food needs to be prevented through good handling practices [42].

Street food is ready-to-eat food and beverages prepared and sold by vendors and hawkers in public places especially in streets and other similar public places such as schools, hospitals, railway stations, bus terminals, shopping centers, etc. at reasonable prices. In India during recent years, there has been an increasing trend towards the sale and consumption of street food at the road side. This phenomenon is more seen in the urban areas of the country. Street food-vendors are common in urban and semi-urban areas, but they also operate in rural areas, particularly if there is a market or community fair.

Studies on urban street food in India are few. In Maharashtra, urban street food vendors are provided licenses on terms and conditions similar to regular eating establishments. The Corporation of Chennai has prescribed certain guidelines for urban street food vendors and collects an annual license fee from them. However, in most other Indian cities, no control is exercised over street food vendors by government authorities [43].

Microbiological examination of various food items served by the street vendors in various parts of India indicated the presence of microorganisms in most of the food sold as well as the use of non-permitted coal tar food colours in sweetmeats and of *Lathyrus sativus*, a harmful legume

banned under the Prevention of Food Adulteration Act, in certain snack food. Most of the street food recipes are very simple, involving limited utensils and material for the preparation. Hence, poor hygiene and sanitation practices are one of the major bottlenecks in street food vending. Inadequate water availability, location near garbage, exposure to atmospheric pollutants and poor personal hygiene practices of personal involved, all precipitate to higher incidents of health problems.

A number of studies have been carried out to study the microbiological profile of various street food items. In the south Indian state of Karnataka, food like sweets, deep fried savouries, milk lollies and other food showed the presence of *E. coli*, *S. aureus*, *coliforms* and *Enterococci* [44, 45], while in Calcutta another study on urban street food showed similar organisms (*E. coli* and *S. aureus*) and also pointed out that the critical control points of contamination of both food and water samples are poor during handling and prolonged storage conditions [46]. In various parts of Tamil Nadu studies on the quality of street food showed that four commonly sold street food items such as fried fish, sugarcane juice, *gulab jamoon* (Indian traditional sweet preparation made of cereal flour and dipped in sugar syrup) and *athirasai* (Indian traditional sweet preparation made of rice flour and sugar) contained *vibrio* and *E. Coli* [47]; in another study in Chennai (capital city), *coliforms* in the range of 5-2000 MPN/g and *Staphylococcus* in the range of 100-60,000 cells/g was found in some of the street food [48], while in a study in Madurai, the aerobic microbial count in breakfast food *idli*, *dosa* (fermented cereal/legume preparations) and *chapathi* was  $5.3 \times 10^2$  cfu/g, in rice preparations, tomato rice, vegetable *pulav* (cooked rice preparation with vegetables), fried rice and curd rice about  $11 \times 10^3$  cfu/g, snack food *bhel puris*, *pani puris*, (savory snacks, typically served at the side of the road from stalls or carts. Most of these preparations had originated in the western Indian state of Gujarat, but they are now eaten across the country) *masala vada* (deep fried patties made from soaked and ground legumes) and fried mushrooms had  $0.7 \times 10^2$  cfu/g of *E. coli* and sweets (*jilebi*, *laddu*, *athiarsam* – *sweet preparations made from cereal flours and sugar*) had a fungal count of  $0.81 \times 10^2$  cfu/g while beverages (synthetic drinks, apple juice, banana milk shake and water melon) had highest total aerobic plate counts of bacteria showing that the food was not safe for consumption [49, 50]. In another study the microbiology of commonly available street food in Coimbatore showed that the microbial counts were above 1,00,000 cfu/g while the HACCP analysis of a deep fried savoury indicated a high *coliform* count only during the handling procedures [51]. A study in Hyderabad showed that many vendors were selling snack preparations which either contained synthetic colours that were not permitted to be used in food by the government or were prepared using unhygienic practices [52, 53], while other studies in the same place showed that *E. coli* was highest in pineapple juice ( $34.35 \times 10^4$ ) indicating fecal contamination in the water used to make the juice, whereas sugarcane juice contained yeast and mould count ( $48.98 \times 10^4$ ) [54], and high plate count ( $0.8 \times 10^4$  to  $1.7 \times 10^7$ ), total *coliform* organisms ( $0.2 \times 10^4$  to  $7.5 \times 10^4$ ) and fungal contamination ( $0.9 \times 10^2$  to  $0.1 \times 10^3$ ) were detected in urban street food in the city of Hyderabad [55]. Some other studies found non-permitted sweeteners and non-permitted colours in samples of ice cream sold on streets, whereas oil samples revealed the presence of castor and mineral oil; HACCP analysis of samples of sugarcane juice showed that the ice used to prepare the juice had high microbial load followed by water and equipment used in the process of juice preparation [56]. A study in Kerala revealed that the water used to prepare the street food was contaminated with fecal *coliforms* and *Bacillus aureus* [57]. One doctoral research work

indicated *Shigella*, *Salmonella* and *E. coli* in sugarcane juice and ice samples respectively, *Vibrio* and *E. coli* in *gulab jamoon* (sweet preparation) [58].

Although people enjoy food from these vendors, in many cases the food is of poor quality and it represents a serious health risk. In part, this is because the street vendors have little or no access to safe water supplies or sanitation facilities and they commonly cook and handle food with dirty hands. Raw foodstuffs, too, cannot be kept in safe storage places and are easily contaminated by vermin and insects. Moreover, the street vendors often keep cooked food at ambient (environmental) temperatures for prolonged periods of time and may heat the food only slightly before serving. All these factors may make the food from street vendors dangerous [59].

Food as a basic need for all people, must be wholesome and safe. Food adulteration is a major public hazard which affects the quality of life of people [60]. The nature of food adulteration and contamination may vary from place to place or there could be newer adulterants, as a result of changing environmental factors, like non-seasonal rains or improved production/cultivation practices. The use of saccharin and non-permitted colours in confectionery is an old problem. Colours are now being added to food like peas, potatoes, aniseed (*Pimpinella anisum*) and asafetida. Use of newer adulterants like ultramarine blue in dry ginger, urea in puffed rice and aluminium in *supari* (*Areca catechu*) was detected [61]. A survey on veterinary drug use and residues in milk was carried out in Hyderabad which showed that 73% of the individual milk samples contained oxytetracycline residues in the range of 0.2-6.7 µgm/ml [62].

A study on the parasitic contamination of stored water used for cooking and drinking indicated the presence of pathogenic parasites which include protozoans (cysts of *Giardia lamblia*, *Entamoeba histolytica*, etc.) and nematode eggs [63]. More recent studies showed the use of non-permitted colours like Orange II, Rhodamine and Auramine in street food like *jilebi* and *coconut burfi* (*coconut based fudge*) [64]. Another study in which 700 food items were analyzed from urban areas and 300 from rural areas showed that 93% and 95% respectively were detected to contain permitted colours viz. tartrazine, sunset yellow, ponceau 4R, carmoisine, erythrosine and brilliant blue while 7% of the food from urban and 5% from rural contained non-permitted colours [65]. The use of certain dyes has been banned, as they are well known for their toxicity in experimental animals.

In recent years food adulteration has progressed from a simple means of fraud to a highly sophisticated and lucrative business [66]. A study on newer adulterants stated that calcium oxide treated ginger was being coated with ultramarine blue [67]. Adulteration of milk has been rampant since the past several years. In some places studies showed that cow/buffalo milk was found to be adulterated with 2% cotton seed oil which was detected by a rapid method [68].

Some studies carried out in the past three decades showed the contamination of certain food stuffs such as coffee contaminated with ochratoxin at levels below 5 µg/kg which is the current limit proposed by European Union and also reiterated that effective control measures through HACCP may help in reducing mould contamination and improve the quality of coffee [69]. A few studies indicated contaminants like *Vibrio cholerae* to be present in fish [70], neutralizer and organochloride pesticides, DDT and HCH residues, polychlorinated biphenyls in milk and

milk products [71, 72, 73, 74], insecticidal residues in vegetables [75]. Other studies focused on mould contamination indicated that 21% of groundnut samples were contaminated with aflatoxin B1 above the permissible Indian regulatory limit of 30 µg/kg [76], the presence of 0.1 -1 µg/l of aflatoxin M1 in milk samples which is against the maximum limit of 0.5 µg/l [77], 400 µg/kg aflatoxin in red chillies and lesser levels of the same in pepper, coriander, etc. [78], aflatoxin contamination in walnuts [79].

With the liberalization of trade in India, there is a growing list of food additives and processing aids which require approval from the regulatory authorities for their use in different foodstuffs. There is an urgent need for the scientific community in India to evaluate whether these additives are indeed technological necessities and whether they pose a hazard to the Indian consumer. In India several independent studies carried out in various parts of the country have focused on adulteration of different food with added colours. The findings of most of these studies showed that a variety of food such as milk products, including ice cream, *khoya* (a dairy product which is made by and reducing the milk to a semi-solid stage), cottage cheese, non-milk products (sweets, savouries), legumes, miscellaneous (confectionery, soft drinks, spices, condiments, tea, flattened rice, fish, fresh vegetables and cut fruit) and spices (turmeric, chilli powder) were usually adulterated with non-permitted colours such as metanil yellow, auramine, rhodamine B, congo red, malachite green and orange II [80, 81].

A market survey carried out in 236 outlets in urban areas showed that a variety of food from categories like breakfast accompaniments, beverages, sweetmeats, bakery food, savouries and confectionery contained added colours. However certain food such as spices, condiments, rusk, vegetables, savouries and a variety of cooked food preparations such as soups, noodles, gravy curries, starters, *manchuria* (starters made from chicken, or vegetables with cornflour and sauces), *biryani* (rice preparation made vegetables or chicken or lamb), ground legume flour used in preparation of savouries like *sev*, *chegodi*, *boondi*, *finger fries*, *bajjis*, all of which do not form a part of the PFA permitted list of specified food items, were found to contain added colours [82].

Several cases of adulteration of food with colours have been recorded. Mustard seeds were adulterated with non-permitted colour (not specified) but had conformed to the standards [83]. Metanil yellow, a non-permitted colour was a common adulterant in food like *laddu*, *toor dal* and turmeric, which could be due to its easy availability and reasonable cost [84]. Spices like chilli powder were found to contain non-permitted colours like sudan dyes [85]. Analysis of samples of sweets and confectionery collected during festivals showed the wide usage of non-permitted colours like rhodamine to the extent of 10-95ppm, orange II (135-560ppm) and auramine (15-400 ppm) [86]. The use of permitted colours also evoked concern as they were used in excess of the statutory limit (100ppm) to an extent of 15157 mg/kg in sweetmeats and 9450µg/ml in beverages [87] or they were used in food in which they were not permitted [88, 89, 90, 91].

Interestingly, a study in 1998 carried out to investigate awareness pertaining to use of edible food colours among selected housewives in the north-western part of India showed that a majority purchased expensive and packaged food colours considering these were safe; although more than three fourth of the housewives were aware about the hazards due to non-permitted

synthetic food colours, none of them were aware of the limits at which the synthetic colours are added indicating that there is a need for consumer education programs to impart knowledge on the purchase and use of safe edible food colours [92].

### **Industrial Food Safety**

Hazard Analysis Critical Control Point (HACCP) System is a process system which identifies, evaluates and control hazards that are significant to food safety, while the traditional Quality Control System relies mostly on end product testing or quality analysis. In 1998, the Bureau of Indian Standards laid down the Food Hygiene-HACCP-System and guidelines for its application as ISO 15000 [93].

HACCP studies were carried out to examine the International Trade Requirements of Agricultural Produce by a Quality Evaluation Approach. Other such studies were aimed to identify, evaluate and control hazards during the processing of various food products. The findings of these studies reveal that the HACCP system is now being promoted as a basis for regulatory food control and as a standard for international trade [94, 95]. Another study showed that by the application of HACCP to selected recipes, the selected food was completely devoid of organisms like *Bacillus cereus* and *Staphylococcus aureus* [96]. A similar study revealed that a number of microorganisms were detected from the hand swabs of harvesters for *coliforms* in the range of  $1.7 \times 10^4$  to  $2.2 \times 10^7$ . Lack of food safety awareness among the workers resulted in high microbial loads [97]. In a few studies, the Critical Control Points (CCPs) for deterioration of the quality of food was identified as *coliform* contamination from the hands of the food handlers and this was reduced drastically when the food handlers used soap to wash their hands [98, 99].

Most of the studies showed that food handlers were directly involved in some stages of food processing. These studies emphasized the need to educate food handlers on GMP/GHP and also that application of HACCP in the Indian context is possible and would yield the desired results of improving the safety of food. Another study was undertaken to apply the HACCP concept in *khoa* manufacturing in two districts in the southern state of Andhra Pradesh in India. The types of preparation of *khoa* in both the areas were studied and Critical Control Points identified. The identified critical control points were handling of food by many food handlers, longer duration of storage and use of cleaning utensils [100, 101].

India being a signatory to the World Trade Organisation automatically becomes a party to the related agreements on Sanitary and Phytosanitary Measures and Technical Barriers to Trade. Both these agreements lay great emphasis to the decisions of the Codex Alimentarius Commission. The Codex has adopted General Principles of Food Hygiene as an International Code of Practice which also includes guidelines for the Application of the Hazard Analysis Critical Control Point (HACCP) System.

Thus adopting the HACCP system approach becomes particularly relevant wherein it helps to identify and control such critical processes at each step from harvest, processing, manufacture, storage and distribution of food products until the point of consumption. By adopting such an approach it will go a long way in improving the export of many foodstuffs [102].

A number of studies were carried out to study the quality of water, hygiene and sanitation on institutional/industrial canteens, school canteens, and sanitary conditions in *dhabas* (in India, highways are dotted with local restaurants/eateries popularly known as *dhaba*, which generally serve local cuisine, and also serve as truck stops), effect of hand washing agents on bacterial contamination, microbial studies of hostel food services. The overall hygiene in selected industrial canteens was unsatisfactory while in most of the hotels and restaurants, washing facilities were inadequate. *E. coli* contamination was high (96.5% isolation) in food served in school canteens [103]. None of the food handlers had any training in food hygiene and only in 35% of the canteens drinking water was either filtered or boiled. In *dhabas*, the total bacterial count was high in food, serving utensils, hands and nails of the food handlers and the cloth used to clean the dishes. Some of the microorganisms identified were *E. coli*, *Enterobacter*, *S. aureus*, *B. cereus*, but were within their permissible limits. The effect of hand washing agents on bacterial contamination was evaluated among mothers of selected households in Andhra Pradesh. Among the mothers, 30% from the High Income Group (HIG) families used soap to wash their hands while 10% from the Low Income Groups (LIG) did the same and 40% from LIG used ash to wash their hands before feeding their children. Plain water was used to wash hands by 50% of the HIG mothers and 15% of the LIG mothers. However 20% of mothers from HIG and 35% from LIG were not in the habit of washing their hands before feeding their children. The total bacterial counts from their hand washings were  $55 \pm 32.52$  for HIG mothers and  $61.6 \pm 70.6$  for LIG mothers, while the counts for both HIG and LIG mothers who washed their hands with only water were  $529 \pm 189.23$  and  $655 \pm 351.0$  respectively. The bacterial counts were higher for mothers from both the groups who did not wash their hands at all which was  $972.25 \pm 109.07$  and  $1224.6 \pm 251.06$  respectively [104].

Recent studies carried out in various parts of Hyderabad to assess food safety in institutional catering, industrial canteens, and hospital catering and selected commercial and non-commercial food service institutions indicated that about 20% of the personnel who had undergone training in institutions showed good scores when evaluated for their awareness on food safety. This was evident from their post-cooking storage practices, food handlers' hygiene and garbage disposal [105]. A similar study carried out in industrial canteens showed a majority of the food handlers to be in the habit of washing hands, wearing uniforms and aprons while cooking and there were no incidence of food-borne disease outbreaks, indicating that the food handlers who undergo training maintain good standards of hygiene [106]. The knowledge, attitudes and practices of selected kitchen personnel from a selected group of hospitals showed that although most of them were aware of the food safety practices and hygiene, this was not evident from their practices [107]. Other studies revealed that the sanitation and hygiene practices followed by commercial institutions were satisfactory, whereas in non-commercial institutions the personal hygiene of food handlers was not satisfactory [108]. A study on improvisation of existing physical facilities, sanitation hygiene and work schedule of a private canteen in Coimbatore indicated that educating and training the personnel brought about a greater awareness among the personnel which in turn improved the canteen [109].

### **Hazard/ Exposure Assessment**

There seem to be a limited number of studies in the area of risk assessment. Among these studies four were focused on the exposure of individuals to various adulterants and additives. One other

study aimed to assess the safety and quality of food in respect of certain specifications, analyticals and metal pollutants. The aflatoxin intake through consumption of maize was assessed in a rural population in southern India. The average aflatoxin intake in nine out of twelve households ranged from 0.33 to 1.5µg/day. When assessed on a body weight basis, aflatoxin intakes in the younger age groups were observed to be higher. The average intakes in pre-school and school age children were observed to be 22-47 nanograms/kilogram body weight/day. The aflatoxin intakes were calculated based on the levels of aflatoxin in maize before cooking which was significantly ( $p < 0.001$ ) higher by 36% showing that on cooking aflatoxin levels decrease [110].

The Acceptable Daily Intake (ADI) for colours like tartrazine, sunset yellow, erythrosine was exceeded among pre-school and school children either due to high intake of coloured food or due to ingestion of food with high concentrations of these colours. A significant difference ( $p \leq 0.005$ ) was observed in the intake of sunset yellow during both the seasons. The mean intake was higher during winter i.e. 9.6 mg which was by way of consumption of soups and fast food like manchuria. Significant differences were observed in the intake of tartrazine, sunset yellow and carmoisine during the seasons of winter and summer among the 6-18 years, 19-44 years and above 45 years individuals. The difference in intake of these colours was higher during summer which was due to the high consumption of beverages containing these colours [111].

During festivals the intake of tartrazine and sunset yellow was observed to be higher due to the extensive use of these colours in sweetmeats, savouries and beverages that are most commonly available during festivals and such intakes resulted in the ADI exceeding among few children (10 years) by intake of sweetmeats viz. *burfis* (fudge) and confectionery like sugar toys [112].

As consumers are demanding protection for whole food supply chains, from primary producers to the end consumers, health authorities are also getting more proactive towards legalizing the in-house hygiene and food safety monitoring system. It has now become the prime responsibility of industry practitioners who need to be up to the mark when it comes to maintaining safety and hygiene in the workplace.

The main challenges to food safety in South East Asian countries are increased international trade in food which has led to a significantly increased availability of a very large number of food items, globalization in hygiene management, allocation of resources for hygiene management by board and other regulatory measures. Similarly, the main cause for food illness in Asia are microbial contamination, overuse of pesticides, use of authorized pesticides, contaminated water, lack of knowledge and inconsistent standards in food production hygiene and the last but not the least the very important one is the attitude of the people towards food safety standards [113].

The studies conducted showed that most of the food handlers lacked training in food hygiene which was evident by the microbial count from their hand washings. Since food handlers in bigger eating establishments cater to a larger number of people, they are epidemiologically more important than domestic food handlers in spreading of food-borne diseases [114].

## **Consumer Behaviour**

There are limited studies carried out on the Knowledge, Attitudes, Beliefs and Practices (KABP) of people on food safety issues. A study in 1999 which was carried out to assess the attitudes and practices regarding diarrhea in a rural community revealed that a majority of the mothers were not aware of the precautionary measures to be taken to prevent diarrhea. A striking observation during the study showed that the prevalence of diarrhea was high (23%) among pre-school children in spite of access to safe drinking water, availability of toilet facilities in most of the households and existence of a strong health infrastructure [115]. Another study carried out to assess the knowledge of consumers regarding the nature and extent of adulteration of Indian food showed that most of the respondents gave correct responses to statements on adulteration of spices and condiments, the most commonly adulterated food item and to whom they could approach for making complaints about adulterated food and the definition of food adulteration.

A recent study on the KABP on food safety in India showed that about 54.2% of the respondents did not know or associate diarrhoea as a symptom of food-borne disease, while about 50 to 70% did not know or associate abdominal pain, nausea and vomiting as symptoms of food-borne disease. When asked on storage of food, 75% reported to leave the cooked food at room temperature and only 29.4% of them consume the stored food after thorough heating. Only 6% of the respondents were inclined to complain about food adulteration and others were either ignorant or did not bother about it; 72% in the same study did not take any action after an episode of food-borne disease outbreak in the village; about 50% of the respondents did not recognize food spoilage by smell. The findings of this study showed that there is a need to increase awareness pertaining to storage of food, recognition of food spoilage, symptoms of food-borne disease and action to be taken after detecting food adulteration/poisoning [116].

Consumer attitudes have been shown to influence and predict behaviour. Diverse attitudes are usually based on a variety of factors including demographics and socio-economic status. Consumers' attitudes towards food safety are themes of interest to food producers and retailers, public authorities and health educators. This interest has been reflected in discussions about how food safety should be defined and how consumers perceive food safety and choose food. The correlation between food safety and consumer acceptance has been especially prevalent in North America and Europe [117, 118].

## **Conclusions**

The present review on food safety research in India indicates that there is a striking paucity of reliable data on important issues like HACCP, risk assessment and KABP. In India there have been hardly any studies to evaluate the risks posed by adulterants, additives and contaminants to the health of consumers. Consequently, the protection of our diets from these hazards must be considered one of the essential public health functions of any country, which emphasizes the need for total diet studies. The World Health Organization (WHO), the lead United Nations agency for health, supports total diet studies as the one of the most cost-effective means for assuring that people are not exposed to unsafe levels of toxic chemicals through food. The WHO's Global Environment Monitoring System/Food Contamination Monitoring and Assessment Program (GEMS/Food) has encouraged all countries, and in particular developing

countries, to undertake total diet studies as a matter of public health significance, while recognizing the importance of total diet studies to standards development and trade and environmental management. In India it is envisaged that in the future there would be a more serious focus on risk assessment, early warning/rapid alert situations as the exporters of agro-products and processed food have been facing the stringent food safety standards in the developed country markets

### **Acknowledgements**

The authors would like to thank the National Institute of Nutrition (NIN), Hyderabad, India and Lady Irwin College, New Delhi, India for providing library services. The investigators are also thankful to Dr B. Sesikeran, Director of NIN, for his constant encouragement. Grateful thanks are due to the heads of departments in the Home Science colleges in Andhra Pradesh, Chennai, Kerala, Madurai and Coimbatore.

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