Wageningen Academic Publishers

Food safety conundrum: a Pakistan's scenario

S. Akhtar[1*], M.A. Randhawa[2], M. Riaz[1], A. Hameed[1], T. Ismail[1], A. Ismail[1] and Z. Ali[3]

[1]Bahauddin Zakariya University, Department of Food Science and Technology, 60000 Multan, Pakistan; [2]University of Agriculture Faisalabad, National Institute of Food Science and Technology, 38040 Faisalabad, Pakistan; [3] Karakoram International University, Department of Agriculture and Food Technology, 15100 Gilgit-Baltistan, Pakistan; saeedbzu@yahoo.com

Received: 11 April 2014 / Accepted: 18 August 2014

REVIEW ARTICLE

Abstract

The present review aims at highlighting the current status of food safety in Pakistan, focusing upon foodborne illness, aflatoxins, pesticides residues, heavy metal contamination and food adulteration. A computerised bibliographic search was carried out on PubMed, Medline, Google Scholar and Scopus to retrieve the most relevant abstracts and full-text articles. The results revealed higher morbidity and mortality associated with foodborne illness especially among children and infants. Retrospective studies demonstrated higher levels of aflatoxins, pesticides residues and heavy metals in a wide range of foods leading to increased disease burden especially kidney failure and resurgence of cancer in the country. Practicing adulteration of foods especially milk seems to be rapidly growing thereby posing a public health risk. Poverty remains to be the most instrumental determinant to exacerbate this issue of public health significance. Presently, there exists no precise and integrated system of monitoring and surveillance to mitigate health and economic losses associated with substandard food safety system in Pakistan. The country needs to bring about certain radical legislative changes to ensure that safe food reaches every one without bearing any kind of additional cost.

Keywords: food safety, foodborne illness, pesticide residues, heavy metals, aflatoxin, adulterants, Pakistan

1. Introduction

Food safety has now become a public health issue in developing countries and is regarded a fundamental element of international trade. Economic growth of the developing nations seems to be solely dependent upon food safety however; evidence suggests current food safety status of resource limited countries to be highly inacceptable and distressing. Poverty appears to be a primary indicator for engendering food safety issues in poorer societies where frequent natural calamities and disasters typically exacerbate the issue. Global intervention is essentially needed to scale up efforts for ensuring food safety at gross root level in developing countries (Akhtar *et al.*, 2012).

Pakistan is the sixth most populated country in the world with a population of 180.1 million which is projected to reach 210.13 million by 2020 (Nizami, 2010). According to Human Development Indices (2009), around 20% of the population has been living below the international poverty line of US$ 1.25 per day. Disease burden is enormous with unsatisfactory maternal and child health conditions despite the fact that Pakistan expends 2.5% of its gross domestic product on health (WHO, 2011). Safety status of Pakistani foods is highly hazardous as a wide range of food products especially street-vended foods have been found to be chemically and microbiologically contaminated (Akhtar, 2015; Akhtar *et al.*, 2013a; Farzana *et al.*, 2009).

Given the role of media, global campaigning and local interventions to create awareness on bacterial pathogenesis, the magnitude of foodborne illness, especially diarrhoea, gastroenteritis, and upper respiratory tract infections continue to grow among children in Pakistan. Several indigenous milk products were found to be heavily contaminated with foodborne pathogens such as *Staphylococcus aureus*, *Escherichia coli*, and *Klebsiella* spp., resulting in the hospitalisation of subjects after ingesting

these products (Akhtar *et al.*, 2012; Farzana *et al.*, 2009). Though, a considerable number of foodborne illness cases go unreported and unrecognised in Pakistan yet botulism, *Campylobacter* infection, shigellosis, *E. coli* infection, *S. aureus* infection, listeriosis and *Vibrio cholera* infection continue to trouble populations especially those living in poorer settings of Pakistan (Akhtar, 2015; Akhtar *et al.*, 2012).

Aflatoxins are the metabolites of fungal contamination in a variety of foods. These fungi hold the ability to thrive at low moisture levels and proliferate in stored foods, especially nuts, spices and storage grains. Pakistani foods have been shown to be highly implicated with aflatoxin contamination because of the warm and humid climate and the situation is worsened by malpractices during handling and storage of many edible commodities (Akhtar *et al.*, 2010; Mobeen *et al.*, 2011).

There is an ever-growing amount of literature available to demonstrate health risks and mortality associated with the ingestion of foods containing pesticides residues especially in countries of the developing world where no precise and integrated system of agriculture exists. Evidence is available to confirm Pakistani population to be gravely predisposed to the risk of ingesting foods contaminated with pesticide residues thus leading to high resurgence of various forms of cancer. Several reports have also confirmed high rate of mortality resulting from the consumption of contaminated foods (Akhtar, 2015). Likewise, presence of heavy metals and a number of adulterants in several foods, especially milk, is a major threat to human health. Several studies reported varying levels of different heavy metals in some Pakistani foods (Jalbani *et al.*, 2010; Kazi *et al.*, 2010; Zahir *et al.*, 2009). Milk has been gravely adulterated as considerable number of adulterants have been reported in the literature that are used to debase the quality of milk including hydrogen peroxide (Murthy *et al.*, 1981), carbonates, bicarbonates (Rideout *et al.*, 2008), urea (Baumgartner *et al.*, 2005), boric soda (See *et al.*, 2010) and formalin (Gwin *et al.*, 2009). These hazardous chemical compounds intoxicate the milk, leading to the onset of disease such as vomiting, diarrhoea, and abdominal pain, shallow respiration, bleeding from uterus, kidney damage and cancer.

The economic loss resulting from virtual absence of food safety system is huge and hampers Pakistani nation to step on the track of progress and prosperity. The state of food safety is very hostile to the health and economic wellbeing of the population. The country bears massive economic burden for being unable to resolve the critical issue of food safety. Apparently, no concerted efforts have yet been directed in terms of monitoring, surveillance, control, legislation, awareness and advocacy on food safety in Pakistan. Several indicators have been identified as rudimentary barriers to prevent and control this multipronged threat to human health including consumers' economic constraints to access safe food, considering food safety as a low priority plan, poor legislation and an imprecise health care system. This situation further heightens the likelihood of the incidence of foodborne illness and enhances disease burden. Food safety in different food chains like industries, hotels and restaurants cannot be successfully achieved without strict monitoring and surveillance. Indeed, not much has been done in the realm of food safety in Pakistan and the prevailing conditions warrant immediate interventions to modulate human health risks associated with inadequate food system. Seemingly, there exists an abysmal gap between the sensitivity of the issue and the government's understanding and priority to address this problem (Akhtar, 2015; Akhtar *et al.*, 2012).

2. Bacterial pathogenesis in Pakistan

Ingestion of improperly processed canned foods has been particularly associated with the onset of botulism. There are primarily 4 major species of *Clostridium* namely *Clostridium botulinum*, *Clostridium difficile*, *Clostridium perfringens* and *Clostridium tetani.* Proliferation of *C. botulinum* in foods is marked with the production of a potent neurotoxin which can rapidly result in severe neuroparalytic syndrome on ingestion of contaminated food (Skarin *et al.*, 2011). Pakistan lacks a precise system of diagnosis of botulism and therefore a considerable number of cases go undiagnosed and unreported.

Shigellosis is generally caused by 4 main serotypes, *Shigella sonnei*, *Shigella boydii*, *Shigella flexneri* and *Shigella dysenteria* and is represented as fever, abdominal cramps, and tenesmus resulting in hemolytic uremic syndrome. Several estimates have revealed high rate of child deaths (576,000 annually) associated with shigellosis in Northern Pakistan. The frequency of shigellosis in community settings of Pakistan is hard to reduce as long as proper sanitation and hygiene are improved (Soofi *et al.*, 2011).

Campylobacter jejuni has been recognised as potential milk borne pathogen (Serichantalergs *et al.*, 2007) and virtually no surveillance or monitoring system exists to control campylobacteriosis in Pakistan. These conditions have led to the occurrence of frequent episodes of *Campylobacter* infections (Gibreel and Taylor, 2006). In the same way, aggressive form of shiga toxin-producing enterohemorrhagic *E. coli* O104:H4 is known to cause hemolytic uremic syndrome and kidney failure (Sinha, 2011). The recent incidence of *E. coli* O104:H4 in Germany (Greinacher *et al.*, 2011) is an example of the severity of the risks associated with deadly strain of shiga toxin-producing *E. coli*. Gastroenteritis caused by *S. aureus* in Pakistan is a routine foodborne illness distressing thousands of people each year. Summer season promotes the prevalence of this infection on consumption of contaminated and poorly handled foods stored at elevated temperature.

Street-vended foods seem to substantially contribute to the mortality rate due to this type of food infection in Pakistan. Methicillin-resistant *S. aureus* is also considered to be the most dreadful bacterial strain that causes human infections (Nickerson *et al.*, 2006).

High prevalence of salmonellosis adds to the sufferings of the population especially the have-nots and all impoverished communities in Pakistan. The infection has been established as a major public health problem due to the frequency of typhoid fever incidences. The disease has shown to exert a direct impact on the socioeconomic status of the affected population and scales up the level of poverty (Hassan *et al.*, 2008; Razzaque *et al.*, 2009). Chickens have been associated with *Salmonella* which through poultry products, are subsequently transmitted to humans to cause disease (Flor *et al.*, 2011; Rajashekara *et al.*, 2000).

Listeriosis is mostly manifested as diarrhea, fever, nausea, and vomiting (Ooi and Lorber 2005). *Listeria monocytogenes* have the ability to thrive at refrigeration temperatures and at a wide range of pH, and this ability of the microorganism endangers the safety of food products kept over at low temperatures (Moretro and Langsrud, 2004; WHO, 1988).

Data on the prevalence and outbreaks of *V. cholera* are scant in Pakistan. Two consecutive *cholera* epidemics were reported in Karachi, Pakistan in 2006 that jeopardised the lives of thousands of people and resulted in high morbidity. Poor catering practices have been shown to contribute to 97% of all foodborne illnesses (Howes *et al.*, 1996). Moreover, malnutrition especially the deficiency of zinc provokes infections and has been associated with frequent diarrheal episodes among infants and children (Akhtar, 2013; Akhtar *et al.*, 2013b). Similarly, the pattern of displaying foods offered for sale is a compelling reason for contamination of such foods (Akhtar *et al.*, 2013a). Specifically in Pakistan, bus and train stations are the sale points where foods are kept at inappropriate temperatures resulting in increased infections and outbreaks (Bryan *et al.*, 1992; Teufel *et al.*, 1992).

3. Aflatoxin contamination in foods

Aflatoxins (a class of mycotoxins) are naturally occurring potent carcinogenic, mutagenic, and teratogenic metabolites of *Aspergillus flavus* (B_1 and B_2) and *Aspergillus parasiticus* (G_1 and G_2). Aflatoxin M_1 is the metabolite of aflatoxin B_1 in humans and animals and M_2 is the metabolite of aflatoxin B_2 in milk of cattle fed contaminated feed (Garrido *et al.*, 2003; George 1998). Aflatoxins are highly toxic and may cause immune suppression and cancer in humans (Egal *et al.*, 2005). Several reports have illustrated the presence of aflatoxin in Pakistani foods generally stored in a warm and humid climate that favours the proliferation of fungi. A plausible description of the levels of aflatoxins in a wide range of Pakistani foods has been recently provided by Mushtaq *et al.* (2012). This study concluded that the levels of aflatoxins were shown to be higher in the processed foods as compared to the permissible limits set by the European Union. Serious interventions in the form of national and international programmes to prevent and control aflatoxin contamination in processed foods need to be undertaken at government level to ensure optimal human health. High prevalence of cancer particularly liver cancer, among population groups have been reported as a result of consuming aflatoxin contaminated foods in Karachi (Qureshi *et al.*, 1990).

Distribution of aflatoxins in rice milling fractions was investigated more recently by Iqbal *et al.* (2012b) in Pakistan and the researchers revealed 14 to 36% of the samples, exceeding European Union (EU) maximum contents for total aflatoxins in rice (4 µg/kg). Similarly, cereals and beans were reported to contain high concentrations of aflatoxins of which a variety of the food commodities exhibited higher levels of aflatoxin as compared to the limits (4 µg/kg) set by the EU (Ahsan *et al.*, 2010; Shah *et al.*, 2010).

Milk and milk products have also been extensively examined for aflatoxin contamination in Pakistan and the reports indicate high aflatoxin M_1 levels in milk (Hussain and Anwar, 2008). A plethora of literature is available to elucidate the presence of aflatoxin in milk sold in Pakistan (Table 1). Asi *et al.* (2012) determined aflatoxin M_1 in 356 milk samples showing recoveries of aflatoxin M_1 ranging from 92 to 97% of the tested samples. The authors were of the view that contamination with aflatoxin M_1 in milk, exceeding EU maximum limits is terrifying and warrants feed samples to be evaluated periodically. Another similar study with milk and milk products confirmed 76.3% of 200 and 97% of 138 samples to be containing aflatoxin with an average of 0.252 µg/l in milk and 0.48 µg/kg in sweets, much higher than those of European Union permissible levels of 0.05 µg/l. The researchers stressed the need for regulatory mechanism to be ensured to control the toxins in milk and milk products (Sadia *et al.*, 2012). Similar results with 221 samples of milk and milk products were reported in another recent study by Iqbal *et al.* (2013) signifying strict monitoring and control on feed contamination with aflatoxins.

Similarly, nuts and dried fruits in Pakistan were reported to carry concentration of aflatoxin higher than that of 4 µg/kg set by EU regulations (Luttfullah and Hussain, 2011). More studies demonstrated pistachio, almond, cardamom and raisins to contain aflatoxin levels exceeding permissible limits (Iqbal *et al.*, 2012a, 2013). Chilies have also been found to carry aflatoxin up to levels of 8-fold higher than the EU permissible limits (Iqbal *et al.*, 2010; Paterson, 2007; Qazi and Fayyaz, 2006).

Table 1. Aflatoxin prevalence (µg/kg) trends in various foods and food products of Pakistan.

Aflatoxin type	Commodity	Range (µg/kg)	Maximum residual levels[a]	Reference
M_1	milk	0.01-0.70	0.05	Hussain and Anwar (2008)
M_1	sweets	0.01-1.5	-	Sadia *et al.* (2012)
M_1	raw milk	0.002-1.6	0.05	Sadia *et al.* (2012)
B_1	almond seed	0.00-140	5.0	Bilgrami and Ghaffar (1999)
B_1	chilies	0.00-96.3	5.0[b]	Iqbal *et al.* (2010)
B_1	maize	8-46	2.0	Ahsan *et al.* (2010)
Total aflatoxins	cereals	14-45	4.0	Iqbal *et al.* (2006)
Total aflatoxins	nuts	5.0-17.0	4.0	Iqbal *et al.* (2006)
Total aflatoxins	chilies	0.1-96.2	10.0[b]	Paterson (2007)

[a] EC (2006, 2010).
[b] Spices.

Lack of consumer awareness, poorly managed and inefficient production, improper processing and storage of foods throughout the supply chain, lacking decontamination techniques and absence of strict legislation to sustain the quality of edible commodities are the potential determinants for rapidly growing prevalence of aflatoxins in various foods. Implementing fundamental food safety principles, proper monitoring and surveillance, availability of inexpensive and easy-to-perform testing and analytical facilities for foods and educating the stakeholders on deadly consequences of ingesting aflatoxin contaminated foods are the additional measures to minimise associated health risks.

4. Pesticide and heavy metal contamination in Pakistani foods

Extensive use of pesticides for plant protection and crop production raises a profound concern in terms of food safety and human health in developing countries. The presence of residual pesticides in foods has been widely reported in the literature and pesticide contamination has now emerged as a serious public health issue. Evidently, benefit associated with pesticide usage is the increased crop yield, yet the deleterious impact of these chemicals on human health merits special attention (Taylor *et al.*, 2003). Several studies elucidate the environmental impact of pesticide use in agriculture with respect to their accumulation on fruits, vegetable and other food crops (Kumari, 2008; Kumari *et al.*, 2003).

Pakistan is the second largest consumer of pesticides in South Asia (Hussain *et al.*, 2002), and therefore is also a subject to the dreadful outcome of uncontrolled application of pesticides (Tariq *et al.*, 2007). Presence of high levels of pesticide residues in several crops would be attributed to farmers' unawareness on their toxic effects and recommendations made by private pesticide selling companies for using more pesticides (Tariq, 2005). The types of insecticides, being used in Pakistan tally 108 in addition to 30 fungicides and 39 weedicides (PPSGDP, 2002).

Abundant literature is available to clearly explicit the presence of varying levels of pesticide residues in a variety of foods and the health risks associated with the ingestion of these foods in Pakistan (Table 2; Akhtar, 2015). Indiscreet and injudicious application of pesticides especially on vegetables has been challenging thereby posing a serious threat to the feeble food safety system already in place in the country. The urge to promote vegetable production to meet the growing needs for escalating population, has drastically impacted the health and economic wellbeing of a considerable population fraction. One recent study suggested 100% of the carrot samples tested for S-metolachlorn contained up to 0.45 to 0.73 mg per kg of this chemical above the permissible limits of 0.40 mg per kg. The authors emphasised to rationalise the mechanism and use of pesticides for the production of safe food (Amjad *et al.*, 2013).

Monitoring and surveillance on pesticides application lack in Pakistan and on top of that, there are no appropriate frequent diagnostic facilities available for the detection of residual pesticides in various foodstuffs particularly in fruits and vegetables. The government impetus to enhance export of fruits and vegetables is likely to be negatively affected due to the presence of higher pesticide residues in fruits and vegetables. Therefore, the export of fruits and vegetables is also at risk because of the possible high level of pesticide residues in such food commodities (Tariq *et al.*, 2007). It is therefore imperative that the issue be examined in the light of environmental policies, laws and regulations to curtail health implications associated with pesticide exposure (Akhtar, 2015).

Table 2. Heavy metals prevalence (mg/kg) trends in various foods and food products of Pakistan.

Product	Pb	Cd	Cr	Zn	Cu	Fe	References
Fish muscles	7.58	–	–	75.42	–	64.49	Javed (2005)
	2.82-9.53	0.30-2.58	–	–	1.33-2.11	–	Qadir *et al.* (2011)
Spices	6.6-9.2	0.65-1.34	–	64.2-65.8		142.3-285	Sattar *et al.* (1989)
Dry fruits	1.02	0.24	–	–	–	–	Sattar *et al.* (1989)
Fruits	0.531-7.571	0.173-0.299	3.268-4.343	0.138-21.409	0.543-3.234	7.924-24.674	Zahir *et al.* (2009)
	0.95-1.32	0.18-0.22	4.04-4.44	2.1-2.76	–	2.86-3.70	Akhtar *et al.* (2010)
	–	0.08-0.09	0.23-0.24	0.04	0.09-0.10	–	Khan *et al.* (2013)
Vegetables	2.12-5.41	1.45-2.55	3.10-4.92	16.58-24.08	12.15-20.50	–	Ahmed *et al.* (2012)
Canned foods	0.11-2.04	0.15-1.16	–	0.19-22.8	0.04-8.88	3.07-126	Waheed *et al.* (2003)
MRLs3	0.1-1.01	0.05-0.11	0.52	–	–	–	

1 Codex Standard (1995).
2 NSPRC (2005).
3 MRLs = maximum residual levels.

Extensive research has been focused upon the risks associated with the consumption of foods contaminated with heavy metals (D'Mello, 2003). A number of studies have confirmed heavy metal contamination of the food items to be the most significant public health problem. Consistent ingestion of heavy metal contaminated foods leads to the chronic accumulation of heavy metals in kidney and liver (Jarup, 2003; WHO, 1992).

A multitude of foods have been reported to be highly contaminated with heavy metals in Pakistan including black tea. The per capita consumption of tea in Pakistan is one of the highest in the world while studies report the presence of a numbers of toxic metals in inferior quality of tea (Ahmad *et al.*, 2012). Several regional representative studies with a sufficient sample size provide baseline data to suggest that foods especially vegetables are not fit for human consumption. More recently, Abbasi *et al.* (2013) reported high concentrations of Zn, Cu and Cr in *Solanum nigrum*, and maximum concentrations of Mn and Pb were observed in *Convolvulus arvensis* and *Amaranthus viridis*, respectively in Pakistani Himalayas. In this study, authors supported that levels of toxic compounds were higher than the recommended values therefore the consumption of the vegetables in this area may be associated with carcinogenic health risks. Accumulation of heavy metals in green vegetables was extensively studied in Mardan and Swat District, in Pakistan. The upshots of these studies validated high concentration of Cd in 100% vegetable samples while waste water irrigated *Allium cepa* was shown to carry the maximum Mn concentration (28.05 mg per kg) concluding that consumption of these vegetable is potentially hazardous for the local residents (Table 3; Amin *et al.*, 2012; Khan *et al.*, 2013).

Besides, fruits and vegetables, several processed foods were found to contain heavy metals, such as fruit juices (Jalbani *et al.*, 2010), branded and non-branded biscuits (Jalbani *et al.*, 2007), cattle and goat milk (Javed *et al.*, 2009), and solid baby foods (Kazi *et al.*, 2010). The possible remediation approaches to lessen the likelihood of heavy metal contamination of foods and to prevent excessive build-up of these heavy metals in the human food chain include regular monitoring, development of awareness on lethal impact of these toxic substances, reporting, and cost effective analysis of water sources, soils and foods (Akhtar, 2015).

5. Food adulteration in Pakistan

Adulteration of foods has been widely covered in the literature and the menace is thought to be common in all developing countries because of poor/non-existent monitoring by authorities. The art of adulterating foods is primarily promoted in societies where legal control of food quality is weak. Unscrupulous and deceitful acts of adulteration not only weaken the national integrity but also destroy the health and economic infrastructure. A variety of foods have been consistently adulterated in Pakistan notably beverages, bakery products, oil, ghee, tea, spices sweets, bottled water and milk and milk products. Interestingly, 80% of all the milk sold as either processed or raw is adulterated with multiple adulterants such as hydrogen peroxide, carbonates, bicarbonates, antibiotics, caustic soda and formalin (Anonymous, 2009), not to mention water.

Food adulteration is not easy to control especially in the developing world. Recent development in reviving legislation and enactment of new food rules since 2007 does not seemingly work to eradicate this social evil in

Table 3. Pesticides residues prevalence (mg/kg) trends in various foods and food products of Pakistan.

Food commodity	Dieldrin	Endosulfan sulfate	Chlorpyrifos	Parathion	Malathion	Lambda-cyhalothrin	Cypermethrin	References
Vegetables	–	–	–	0.15-4.0	–	–	Traces-1.63	Masud and Hassan (1995)
Vegetables	–	0.177-2.43	–	–	–	–	–	Randhawa *et al.* (2007)
Vegetables	–	–	not detected-1.7	–	–	–	–	Baig *et al.* (2009)
Vegetables	–	–	0.05-0.96	–	–	–	–	Latif *et al.* (2011)
Fruits	–	–	–	1.1-4.0	–	–	–	Masud and Hassan (1995)
Fruits	0.005-0.196	0.0009-0.110	0.060-0.680	0.059-0.681	–	–	–	Latif *et al.* (2011)
Mother's milk	–	0.134-0.732	0.012-0.417	–	–	0.241-0.629	traces-0.327	Jabbar *et al.* (2000)
Rice	–	–	–	–	108-131	90-148	–	Ahmad *et al.* (2008)
Cattle meat	–	13.381	0.341	–	–	4.655	2.397	Muhammad *et al.* (2010)
MRLs[3]	0.05[1]	0.01-0.5[1]	0.01-2.0[1]	0.05-5.0[1]	0.1[2]	0.2-3.0[1]	0.01-2.0[1]	

[1] Codex Alimentarius (2014).
[2] JFCRF (2014).
[3] MRLs = maximum residual levels.

Pakistan. The Pakistani nation now seems to have largely established to co-exist with food adulteration. Basically, control over food adulteration does not merely require strict enforcement; it demands honesty and positive thinking on the part of traders, producers, and enforcers. It is important, in extreme cases, to impose harsh deterrent punishment to adulterators.

Numerous determinants have been documented in the literature that tangibly heighten the likelihood of failure to assure food safety in developing economies such as political commitment, intervention of international agencies, awareness and strict legislation. Undeniably, food safety management systems (HACCP, ISO 22000) have not been appropriately implemented and the food industries and allied entrepreneurs simply show off for being certified to promote their business. Virtually, the claims made by the food industry have never been verified by the respective authorities. Moreover, no precise mechanism of reporting food safety issues exists in Pakistan (Akhtar *et al.*, 2012).

6. Conclusions

Foodborne illness particularly diarrhoea has been a significant cause of child morbidity and mortality in Pakistan. Presence of aflatoxins, pesticide residues, heavy metal contaminants and highly injurious adulterants in foods beyond permissible limits, has also been widely reported in many parts of Pakistan. Ingestion of these contaminants is the potential cause of several chronic diseases, including many types of malignancies. Ensuring availability of safe food for the Pakistani population seems to be exceedingly complex in the prevailing scenario and may require revamping of social, economic, and cultural infrastructure. Unfortunately, the connotation of food safety has always been misunderstood and underestimated therefore the government and the policy makers lack tendency to resolve this issue of vital economic significance in Pakistan. Success of any policy framed to improve food safety situation cannot be seen until the impact is witnessed at gross root level. This approach demands bridging up an ever widening gap among stakeholders and devising aggressive, vibrant and implementable plans for sustainable food safety system to reduce child mortality, improve maternal health, and control infectious diseases to achieve millennium development goals by 2015.

Acknowledgements

The author greatly acknowledges the Higher Education Commission of Pakistan for its continued financial support to carry out various projects on food safety in Pakistan thus enabling the author to generate this review.

References

Abbasi, A.M., Iqbal, J., Khan, M.A. and Shah, M.H., 2013. Health risk assessment and multivariate apportionment of trace metals in wild leafy vegetables from Lesser Himalayas, Pakistan. Ecotoxicology and Environmental Safety 92: 237-244.

Ahmad, S., Khader, J.A., Gilani, S.S., Khan, S., Noor, S., Ullah, R., Hussain, I., Kanwal, F., Ullah, H. and Shah, Z., 2012. Determination of mineral and toxic heavy elements in different brands of black tea of Pakistan. African Journal of Pharmacy and Pharmacology 6: 1194-1196.

Ahmad, S., Zia-Ul-Haq, M., Imran, M., Iqbal, S., Iqbal, J. and Ahmad, M., 2008. Determination of residual contents of pesticides in rice (*Oryza sativa* L.) crop from different regions of Pakistan. Pakistan Journal of Botany 40: 1253-1257.

Ahsan, S., Bhatti, I.A., Asi, M.R., Bhatti, H.N. and Sheikh, M.A., 2010. Occurrence of aflatoxins in maize grains from central areas of Punjab, Pakistan. International Journal of Agriculture and Biology 12: 571-575.

Akhtar, S., 2013. Zinc status in South Asian populations – an update. Journal of Health, Population and Nutrition 31: 139-149.

Akhtar, S., 2015. Food safety challenges – a Pakistan's perspective. Critical Reviews in Food Science and Nutrition 55: 219-226.

Akhtar, S., Ismail, T., Sunethra, A. and Arlappa, N., 2013b. Micronutrient deficiencies in South Asia-current status and strategies. Trends in Food Science and Technology 31: 55-62.

Akhtar, S., Mahfur, R.S. and Hossain A., 2012. Microbiological food safety: a dilemma of developing societies. Critical Reviews in Microbiology 40: 348-359.

Akhtar, S., Riaz, M., Ahmad, A. and Nisar, A., 2010. Physico-chemical, microbiological and sensory stability of chemically preserved mango pulp. Pakistan Journal of Botany 42: 853-862.

Akhtar, S., Riaz, M., Ismail, T. and Farooq, U., 2013a. Microbiological safety of street vended fresh fruit juices, drinks and conventional blends in Multan-Pakistan. Pakistan Journal of Agricultural Sciences 50: 255-260.

Amin, N.U., Hussain, A., Alamzeb, S. and Begum, S., 2012. Accumulation of heavy metals in edible parts of vegetables irrigated with waste water and their daily intake to adults and children, District Mardan Pakistan. Food Chemistry 136: 1515-1523.

Amjad, M., Ahmad, T., Iqbal, Q., Nawaz, A. and Jahangir, M.M., 2013. Herbicide contamination in carrot grown in Punjab, Pakistan. Pakistan Journal of Agricultural Sciences 50: 7-10.

Anonymous, 2009. Milk adulteration. The Nation Newspaper, Lahore, Pakistan. Available at: http://nation.com.pk/editorials/11-Apr-2009/Milk-adulteration.

Asi, M.R., Iqbal, S.Z., Ariño, A. and Hussain, A., 2012. Effect of seasonal variations and lactation times on aflatoxin M_1 contamination in milk of different species from Punjab, Pakistan. Food Control 25: 34-38.

Baig, S.A., Akhtera, N.A., Ashfaq, M. and Asi, M.R., 2009. Determination of the organophosphorus pesticide in vegetables by high-performance liquid chromatography. American-Eurasian Journal of Agriculture and Environmental Science 6: 513-519.

Baumgartner, M., Flock, M., Winter, P., Lu, W. and Baumgartner, W., 2005. Evaluation of flow injection analysis for determination of urea in sheep's and cow's milk. Acta Veterinaria Hungarica 50: 263-271.

Bilgrami, Z. and Ghaffar, A., 1999. Detection of aflatoxin in almond seed. Pakistan Journal of Botany 31: 227-230.

Bryan, F.L., Teufel, P., Roohi, S., Qadar, F., Riaz, S. and Malik, Z.R., 1992. Hazards and critical control points of food preparation and storage in homes in a village and town in Pakistan. Journal of Food Protection 55: 714-721.

Codex Alimentarius, 2014. Codex pesticides residues in food online database. Available at: http://tinyurl.com/kd6mwja.

Codex Standard, 1995. Codex general standard for contaminants and toxins in food and feed. Codex Stan 193-1995: 1-44.

D'Mello, J.P.F., 2003. Food safety, contaminants and toxins. CABI Publishing, Wallingford, UK.

Egal, S., Hounsa, A., Gong, Y.Y., Turner, P.C., Wild, C.P. and Hall, A.J., 2005. Dietary exposure to aflatoxin from maize and groundnut in young children from Benin and Togo, West Africa. International Journal of Food Microbiology 104: 215-224.

European Commission (EC), 2006. Commission regulation (EC) no. 1881/2006. Official Journal of the European Communities L364: 5-24.

European Commission (EC), 2010. Commission regulation (EC) no. 165/2010. Official Journal of the European Communities L50: 8-12.

Farzana, K., Akhtar, S. and Jabeen, F., 2009. Prevalence and antibiotic resistance of some bacteria in two ethnic milk based products. Pakistan Journal of Botany 41: 935-943.

Flor, M.S., Maisam, A.A. and Oscar, G.G., 2011. *Salmonella* infections: an update on epidemiology, management and prevention. Travel Medicine and Infectious Disease 9: 263-277.

Garrido, N.S., Iha, M.H., Santos Ortolani, M.R. and Duarte Fávaro, R.M., 2003. Occurrence of aflatoxin M(1) and aflatoxin M(2) in milk commercialized in Ribeirão Preto-SP, Brazil. Food Additives and Contaminants 20: 70-73.

George, H., 1998. Magical mushrooms, mischievous molds. Princeton University Press, Princeton, NJ, USA.

Gibreel, A. and Taylor, D.E., 2006. Macrolide resistance in *Campylobacter jejuni* and *Campylobacter coli*. Journal of Antimicrobial Chemotherapy 58: 243-255.

Greinacher, A., Friesecke, S., Abel, P., Dressel, A., Stracke, S., Fiene, M., Ernst, F., Selleng, K., Weissenborn, K., Schmidt, B.M., Schiffer, M., Felix, S.B., Lerch, M.M., Kielstein, J.T. and Mayerle, J., 2011. Treatment of severe neurological deficits with IgG depletion through immunoadsorption in patients with Escherichia coli O104:H4-associated haemolytic uraemic syndrome: a prospective trial. The Lancet, 378: 1166-1173.

Gwin, M.C., Lienert, G., and Kennedy, J., 2009. Formaldehyde exposure and asthma in children. A systematic review. Environmental Health Perspectives 118: 313-317.

Hassan, M., Hussain, I., Shahzadi, B., Shaheen, M., Mahmood, M.S., Rafique, A. and Hassan, M., 2008. Occurrence of some zoonotic microorganisms in faecal matter of house rat (*Rattus rattus*) and house mouse (*Mus musculus*) trapped from various structures. Pakistan Veterinary Journal 28: 171-174.

Howes, M., McEwan, S., Griffiths, M. and Harris, L., 1996. Food handler certification by home study: measuring changes in knowledge and behaviour. Dairy, Food and Environment Sanitation 16: 737-744.

Human Development Indices, 2009. United Nations development programme: human development reports. Human Development Report, New York, NY, USA. Available at: http://hdr.undp.org/en/media/HDI_2008_EN_Tables.pdf.

Hussain, I. and Anwar, J., 2008. A study on contamination of aflatoxin M1 in raw milk in the Punjab province of Pakistan. Food Control 19: 393-395.

Hussain, S., Masud, T. and Ahad, K., 2002. Determination of pesticides residues in selected varieties of mango. Pakistan Journal of Nutrition 1: 41-42.

Iqbal, A., Khalil, I.A. and Shah, H., 2006. Aflatoxin contents of stored and artificially inoculated cereals and nuts. Food Chemistry 98: 699-703.

Iqbal, S.Z., Asi, M.R., Ariño, A., Akram, N. and Zuber, M., 2012b. Aflatoxin contamination in different fractions of rice from Pakistan and estimation of dietary intakes. Mycotoxin Research 28: 175-180.

Iqbal, S.Z., Asi, M.R. and Jinap, S., 2013. Variation of aflatoxin M_1 contamination in milk and milk products collected during winter and summer seasons. Food Control 34: 714-718.

Iqbal, S.Z., Asi, M.R., Zuber, M., Akram, N. and Batool, N., 2012a. Aflatoxins contamination in peanut and peanut products commercially available in retail markets of Punjab, Pakistan. Food Control 32: 83-86.

Iqbal, S.Z., Paterson, R.R., Bhatti, I.A., Asi, M.R., Sheikh, M.A. and Bhatti, H.N., 2010. Aflatoxin B_1 in chilies from the Punjab region-Pakistan. Mycotoxin Research 26: 205-209.

Jabbar, A., Masih, R. and Jehangir, W.A., 2000. Health hazards of pesticides in Pakistan (no. H026193). International Water Management Institute, Lahore, Pakistan.

Jalbani, N., Ahmed, F., Kazi, T.G., Rashid, U., Munshi, A.B. and Kandhro, A., 2010. Determination of essential elements (Cu, Fe and Zn) in juices of commercially available in Pakistan. Food and Chemical Toxicology 48: 2737-2740.

Jalbani, N., Kazi, T.G., Jamali, M.K., Arain, B.M., Afridi, H.I. and Baloch, A., 2007. Evaluation of aluminum contents in different bakery foods by electrothermal atomic absorption spectrometer. Journal of Food Composition and Analysis 20: 226-231.

Japan Food Chemical Research Foundation (JFCRF), 2014. MRLs of agricultural chemicals, feed additives and veterinary drugs in foods. JFCRF, Osaka, Japan. Available at: http://www.m5.ws001.squarestart.ne.jp/foundation/fooddtl.php?f_inq=100.

Jarup, L., 2003. Hazards of heavy metal contamination. British Medical Bulletin 68: 167-182.

Javed, I., Jan, I., Muhammad, F., Khan, M.Z., Aslam, B. and Sultan, J.I., 2009. Heavy metal residues in the milk of cattle and goats during winter season. Bulletin of Environmental Contamination and Toxicology 82: 616-620.

Javed, M., 2005. Heavy metal contamination of freshwater fish and bed sediments in the river Ravi stretch and related tributaries. Pakistan Journal of Biological Sciences 8: 1337-1341.

Kazi, T.G., Jalbani, N., Baig, J.A., Arain, M.B., Afridi, H.I., Jamali, M.K., Shah, Q.A. and Memon, N.A., 2010. Evaluation of toxic elements in baby foods commercially available in Pakistan. Food Chemistry 119: 1313-1317.

Khan, K., Lu, Y., Khan, H., Ishtiaq, M., Khan, S., Waqas, M., Wei, L. and Wang, T., 2013. Heavy metals in agricultural soils and crops and their health risks in Swat District, Northern Pakistan. Food and Chemical Toxicology 58: 449-458.

Kumari, B., 2008. Effects of household processing on reduction of pesticide residues in vegetables. ARPN Journal of Agricultural and Biological Sciences 3: 46-48.

Kumari, B., Kumar, R., Madan, V.K., Singh, R., Singh, J. and Kathpal, T.S., 2003. Magnitude of pesticidal contamination in winter vegetables from Hisar, Haryana. Environmental Monitoring and Assessment 87: 311-318.

Latif, Y., Sherazi, S.T.H. and Bhanger, M.I., 2011. Assessment of pesticide residues in some fruits using gas chromatography coupled with micro electron capture detector. Pakistan Journal of Analytical and Environmental Chemistry 12: 76-87.

Luttfullah, G. and Hussain, A., 2011. Studies on contamination level of aflatoxins in some dried fruits and nuts of Pakistan. Food Control 22: 426-429.

Masud, S.Z. and Hasan, N., 1995. Pesticide residues in foodstuffs in Pakistan: organochlorine, organophosphorus and pyrethroid insecticides in fruits and vegetables. In: Richardson, M. (ed.) Environmental toxicology assessment. Taylor & Francis, London, UK.

Mobeen, A.K., Aftab, A., Asif, A. and Zuzzer, A.S., 2011. Aflatoxins B_1 and B_2 contamination of peanut and peanut products and subsequent microwave detoxification. Journal of Pharmacy and Nutrition Sciences 1: 1-31.

Moretro, T. and Langsrud, S., 2004. Listeria monocytogenes, biofilm formation and persistence in food-processing environments. Biofilms 1: 107-121.

Muhammad, F., Akhtar, M., Rahman, Z.U., Farooq, H.U., Khaliq, T. and Anwar, M.I., 2010. Multi-residue determination of pesticides in the meat of cattle in Faisalabad-Pakistan. Egyptian Academic Journal of Biological Sciences 2: 19-28.

Murthy, M.R., Reid, T.J., Sicignano, A., Tanaka, N. and Rossmann, M.G. 1981. Structure of beef liver catalase. Journal of Molecular Biology 152: 465-499.

Mushtaq, M., Sultana, B., Anwar, F., Khan, M.Z. and Ashrafuzzaman, M., 2012. Occurrence of aflatoxins in selected processed foods from Pakistan. International Journal of Molecular Sciences 13: 8324-8337.

National Standards of the People's Republic of China (NSPRC), 2005. Maximum levels of contaminants in foods. Ministry of Hygiene and the Standardization Administration of China, Beijing, China P.R.

Nickerson, E.K., Wuthiekanun, V., Day, N.P., Chaowagul, W. and Peacock, S.J., 2006. Methicillin-resistant *Staphylococcus aureus* in rural Asia. The Lancet Infectious Diseases 6: 70-71.

Nizami, N.S., 2010. Population, labour force and employment. Ministry of Finance, Islamabad, Pakistan. Available at: http://www.finance.gov.pk/survey/chapter_10/16_Population.pdf.

Ooi, S.T. and Lorber, B., 2005. Gastroenteritis due to *Listeria monocytogenes*. Clinical Infectious Diseases 40: 1327-1332.

Paterson, R.R.M., 2007. Aflatoxins contamination in chilli samples from Pakistan. Food Control 18: 817-820.

Punjab Private Sector Groundwater Development Project (PPSGDP), 2002. Environmental assessment and water quality monitoring program. Technical Report 54, Irrigation and Power Department, Government of the Punjab, Punjab, Pakistan.

Qadir, A. and Malik, R.N., 2011. Heavy metals in eight edible fish species from two polluted tributaries (Aik and Palkhu) of the River Chenab, Pakistan. Biological Trace Element Research 143: 1524-1540.

Qazi, J.I., and Fayyaz, Z., 2006. Aflatoxin contaminated foods and health risk perspective for Pakistani population. Mycopathology 4: 27-34.

Qureshi, H., Zuberi, S.J., Jafarey, N.A. and Zaidi, S.H., 1990. Hepatocellular carcinoma in Karachi. Journal of Gastroenterology and Hepatology 5: 1-6.

Rajashekara, G., Haverly, E., Halvorson, D.A., Ferris, K.E., Lauer, D.C. and Nagaraja, K.V., 2000. Multidrug-resistant *Salmonella typhimurium* DT104 in poultry. Journal of Food Protection 63: 155-161.

Randhawa, M.A., Anjum, F.M., Asi, M.R., Butt, M.S., Ahmed, A. and Randhawa, M.S., 2007. Removal of endosulfan residues from vegetables by household practices. Journal of Scientific and Industrial Research 66: 849-852.

Razzaque, M.A., Bedair, M., Abbas, S. and Mutawa, T., 2009. Economic impact of calf mortality on dairy farms in Kuwait. Pakistan Veterinary Journal 29: 97-101.

Rideout, T.C., Liu, Q., Wood, P. and Fan, M.Z., 2008. Nutrient utilization and intestinal fermentation are differentially affected by the consumption of resistant starch varieties and conventional fibres in pigs. British Journal of Nutrition 99: 984-992.

Sadia, A., Jabbar, M.A., Deng, Y., Hussain, E.A., Riffat, S., Naveed, S. and Arif, M., 2012. A survey of aflatoxin M1 in milk and sweets of Punjab, Pakistan. Food Control 26: 235-240.

Sattar, A., Wahid, M. and Durrani, S.K., 1989. Concentration of selected heavy metals in spices, dry fruits and plant nuts. Plant Foods for Human Nutrition 39: 279-286.

See, A.S., Salleh, A.B., Bakar, F.A., Yusof, N.A., Abdulamir, A.S. and Heng, L.Y., 2010. Risk and health effect of boric acid. American Journal of Applied Sciences 7: 620-627.

Serichantalergs, O., Dalsgaard, A., Bodhidatta, L., Krasaesub, S., Pitarangsi, C., Srijan, A. and Mason, C.J., 2007. Emerging fluoroquinolone and macrolide resistance of *Campylobacter jejuni* and *Campylobacter coli* isolates and their serotypes in Thai children from 1991 to 2000. Epidemiology and Infection 135: 1299-1306.

Shah, H.U., Simpson, T.J., Alam, S., Khattak, K.F. and Perveen, S., 2010. Mould incidence and mycotoxin contamination in maize kernels from Swat Valley, North West Frontier Province of Pakistan. Food and Chemical Toxicology 48: 1111-1116.

Sinha, K., 2011. India on high alert against deadly *E. coli* strain that causes kidney failure. The Time of India, Gurgaon, India. Available at: http://tinyurl.com/3ktf2re.

Skarin, H., Hafstrom, T., Westerberg, J. and Segerman, B., 2011. Clostridium botulinum group III: a group with dual identity shaped by plasmids, phages and mobile elements. BMC Genomics 12: 185.

Soofi, S.B., Habib, M.A., Von Seidlein, L., Khan, M.J., Muhammad, S., Bhutto, N., Khan, M.I., Rasool, S., Zafar, A., Clemens, J. D., Nizami, Q. and Bhutta, Z.A., 2011. A comparison of disease caused by Shigella and *Campylobacter* species, 24 months community based surveillance in 4 slums of Karachi-Pakistan. Journal of Infection and Public Health 4: 12-21.

Tariq, M.I., 2005. Leaching and degradation of cotton pesticides on different soil series of cotton growing areas of Punjab, Pakistan in Lysimeters. PhD thesis, University of the Punjab, Lahore, Pakistan.

Tariq, M.I., Afzal, S., Hussain, I. and Sultana, N., 2007. Pesticides exposure in Pakistan: a review. Environment International 33: 1107-1122.

Taylor, M., Klaine, S. and Carvalho, F.P., 2003. Pesticide residues in coastal tropical ecosystems. distribution, fate and effects. Taylor and Francis, London, UK.

Teufel, P., Bryan, F.L., Qadar, F., Riaz, S., Roohi, S. and Malik, Z.U.R., 1992. Risks of salmonellosis and staphyloccocal food poisoning from a Pakistani milk-based confectioneries. Journal of Food Protection 55: 588-594.

Waheed, A., Jaffar, M. and Masud, K., 2003. Comparative study of selected essential and non-essential metals in various canned and raw foodstuffs consumed in Pakistan. Nutrition & Food Science 33: 261-267.

World Health Organization (WHO), 1988. Guidelines for the control of epidemics due to *Shigella dysenteriae* type 1. WHO, Geneva, Switzerland. Available at: http://tinyurl.com/mwnuwb4.

World Health Organization (WHO), 1992. Environmental health criteria, volume 134. WHO, Geneva, Switzerland.

World Health Organization (WHO), 2011. Country data. WHO, Geneva, Switzerland. Available at: http://www.who.int/countries/pak/en/.

Zahir, E., Naqvi, I.I. and Uddin, S.M., 2009. Market basket survey of selected metals in fruits from Karachi city (Pakistan). Journal of Basic and Applied Sciences 5: 19-52.