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Food Safety Challenges — A Pakistan's Perspective

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Review Article

Food Safety Challenges – A Pakistan's Perspective

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Abstract

Biological, chemical and physical contamination of foods is a terrifying threat for the health and economic growth in developing societies. Rampantly available literature on foodborne illnesses especially diarrhea among children exclusively depicts the intensified disease burden associated with foodborne illness in the underdeveloped economies. Prevalence of many pathogens in several foods is a commonplace in Pakistan. Precise estimates for foodborne illnesses in Pakistan are hard to make because of the absence of any monitoring, surveillance and infection control. Poor processing and storage of milk, cereal grains and nuts are a major cause of

aflatoxin contamination and mold proliferation. Numerous studies manifest a multitude of foods to be contaminated with heavy metals. Escalating population growth limits the economic potential of the individual and the state through a tendency among the traders and manufactures to intentionally debase food commodities offered for sale to make profit at the cost of their quality and safety. Therefore, a growing trend of adulteration in foods during the recent past, particularly adulteration of milk, poses a pressing challenge for the government. This review is a concerted attempt to elucidate the prevailing food safety scenario in Pakistan. Information derived from local and related international studies will be presented to clearly depict a picture of food safety in Pakistan. It is proposed that an extensive food safety infrastructure leading to a safer supply of foods needs to be devised, designed and implemented.

Introduction

Growing world population and competiveness in trade have given rise to the issue of food safety and security especially in the poorer economies. Food safety issues undoubtedly pose a big challenge to these nations, as they work to sustain and improve their economic status. According to the World Health Organization, food borne illnesses predominantly affect the economy of underdeveloped nations by contributing to the burden of disease in the region. The situation is heightened owing to little or no surveillance and monitoring since most of the cases of foodborne illnesses remain unreported and unrecognized. Considering this issue as a priority, a majority of the nations have initiated stern efforts to control hazards associated with food borne illnesses specifically in the developing nations. Food safety issues in developing countries are widely recognized and are of interest to many international organizations. World Health Organization has placed food safety among its top 11 priorities and is making tremendous efforts

to address the issue in the developing countries**.** (Kaferstein and Abdussalam, 1998; WHO 2002).

Infants and small children in the developing countries are the most vulnerable groups, with a primary cause of morbidity and mortality in that group. Efforts directed towards reducing poverty and hunger in the regions will obviously not work in the absence of a strategic approach to improve food safety situation. Significant causes of diarrhoea and related complications, such as kidney failure, include Salmonella, Listeria, Campylobacter, or *E. coli.* Tuberculosis or brucellosis are transmitted through animals and affect a substantial segment of the rural population involved in agriculture and livestock management. Water contamination also results in many types of intestinal infections, afflicting millions of people.

Food borne illnesses are regarded as a potential threat and key challenge as it mounts up the burden of disease in developing societies. Estimates indicate around 1500 diarrheal episodes occurring globally, 75 % of which are attributed to biological contamination of food and result in 3 million deaths of children aged 5 or less. Moreover, biologically contaminated foods are considered as a clear determinant in the epidemiology of cholera and epidemic diarrhoea (Laurian and Nancy, 2000).

Aflatoxins, heavy metals, pesticide residues and numerous adulterants find their way in the food chain and damage the health of a large number of people in the developing world, owing to poor and unreliable monitoring, surveillance, and control. These contaminants are reported to increase the risk of cancer and other chronic diseases in humans. Likewise, excessive use of antibiotics to treat animals has the consequence of increasing resistance of microorganisms to these antibiotics. Heavy metals present in the environment or following use of

pesticides, are a major cause of cancer and neurochemical damage (Motarjemi *et al.,* 1993; Forstner, 1995; Laurian and Nancy, 2000).

This review is primarily an attempt to highlight the current food safety issues and its consequences on the health and economics of Pakistani population. The information provided in this review will enable the stakeholders to better comprehend the food safety issue at national and international levels. Scientific research in the domain of food safety in Pakistan is scant therefore, paucity of literature pertaining to safety status of many foods appears to be a virtual limitation to further elucidate the issue. The figures and statistics, derived from several international and local studies carried out to assess the extent of the presence of various food contaminants in several parts of the country in the last few decades have been presented as potential determinants for the appraisal of food safety situation in Pakistan.

Microbiological safety of foods

Cholera, campylobacteriosis, *E. coli* gastroenteritis, salmonellosis, shigellosis, typhoid, and brucellosis, have been demonstrated to be the major food borne illnesses caused by bacteria, viruses, and parasites comprising *E. coli, Shigella* spp., *Salmonella* spp., *Vibrio cholerae O1,* and *Campylobacter jejuni. Protozoa* such as *Giardia lamblia, Entamoeba histolytica,* and *Cryptosporidium* spp. enteric viruses such as *rotavirus, hepatitis A, E.* viruses, and *caliciviruses* have also been found to be implicated in majority of the cases to cause these illnesses in developing countries like Pakistan. Diarrhoea, however, is the most pervasive of these food borne illness and has emerged as a primary risk and a public health concern, especially among infant and children in Pakistan (Motarjemi *et al.,* 1993; Soofi *et al.,* 2011).

Mishandling of foods is an important factor for the occurrence of foodborne illness, as 97% of all foodborne illnesses were attributed to improper care in catering (Howes *et al.*, 1996). For example, street-vended fruit salads in Pakistan, locally called fruit *chats*, were found to be heavily contaminated with *Enterobacter* spp., *E. coli*, *Klebsiella* spp., *Salmonella* spp., *S.aureus* and *S. Epidermidis.* The pattern of display of these fruit *chats*, offered for sale without cover, was considered to be the major source of contamination. Similarly, *khoya* and *burfi*, two indigenous sweet dairy products were evaluated for bacterial contamination. A high prevalence of food borne pathogens such as *S. aureus*, *E. coli* and *Klebsiella* spp., constitute a major part of bacterial flora in *burfi* and *khoya* samples resulting in outbreaks, that lead to some people being hospitalized (Bryan *et al.*, 1992a; Farzana *et al.*, 2009; Farzana *et al.*, 2011).

Bus and train stations are the two most perilous areas in Pakistan where pulses (edible seeds of various crops as peas, beans, or lentils), ground meat dishes and chick peas are sold round the clock and studies have clearly demonstrated that such foods carry significantly higher levels of bacterial flora when kept at inappropriate temperature regimes. *Clostridium perfringens*, an anaerobic endospore forming Gram-positive bacteria, a major cause of histotoxic and gastrointestinal (GI) diseases, is often a contaminant of these foods (Labbe, 1989; Bryan *et al.*, 1992a; McClane, 2007).

Sweet dishes and home-prepared foods in small communities in Pakistan were commonly infected with *S. aureus*, *C. perfringens* and *Bacillus cereus* intoxication. Another study demonstrated higher percentage of the tested samples of ice cream to be highly contaminated with *Enterobacter (En). aerogenes* (34%), *S. aureus* (26%), *Proteus* spp., (16%), *Streptococcus(St.) faecalis* (12%), *Citrobacter* spp., (10%) and *B. cereus* (4%) confirming that

commercially prepared ice-cream was not fit for human consumption (Masud, 1989; Teufel *et al.*, 1992; Bryan *et al.*, 1992b).

Campylobacter infections are associated with abdominal pain and dysentery. Studies indicate higher prevalence of Campylobacters as potential threats in milk and meat samples in Pakistan. One study confirmed Campylobacters to be present in 48% of the total (1636) tested samples of milk and meats and 40.9% of vegetables in three major cities of Pakistan. Shigellosis is another potential health risk in Pakistan and has been rapidly emerging as a more severe illness than Campylobacter infections. *Shigella* Spp., has been shown to develop resistance and is generally thought to be a major cause of food borne illnesses. Shigellosis is mostly associated with poor sanitary conditions, unsafe drinking water and unavailability of normal health care facilities. Hence, this infection is regarded as the disease of poor in Pakistan. A wide array of vegetables are routinely consumed in Pakistan and serve as a rich source of vitamins, minerals, bioactive compounds and fibre. *Listeria monocytogenes* is commonly present in numerous raw and minimally processed vegetables, thus more care has to be exercised to benefit from their nutritional value (Beuchat, 1996; Hussain *et al.*, 2007; Soofi *et al.*, 2011).

Pesticides residues in foods

Consistent intentional use of pesticides and their ability to deleteriously impact other forms of life in addition to pest control raises significant concern with food safety and human health. The residues of these pesticides find their way into the food chain and water and ultimately pass into the human blood system. In spite of the potential hazards and risks associated with the use of these pesticides, their types and quantities have increased in the world specifically in underdeveloped countries. Unquestionably, the crop yield is improved

significantly through application of pesticides by reducing the loss induced by pests and insects. However, the loss of health and disease burden related to the ingestion of the residual pesticides multiples and comes out as a serious issue (Barcelo and Hennion, 1997; Taylor *et al.,* 2003).

<Insert table 1 here>

Soomro *et al.,* (2008) highlighted the indiscreet use of pesticides in agriculture and its impact on environmental pollution. The authors are of the opinion that despite the increased production cost associated with extensive use of pesticides, their use is still common. However, excessive use of pesticides has specifically resulted in relatively higher accumulation of residues in vegetables eventually consumed by human beings (Agnihotri, 1999: Kumari *et al.,* 2003). The most significant physico-chemical characteristics that determine the extent of pesticide residues accumulation in different foods are their volatility, solubility, water–octanol partition coefficient, hydrolytic rate constants, etc. (Holland *et al.,* 1994; Kaushik *et al.,* 2009).

Owing to the advancement of science and transition of print media to electronic media, a great deal of awareness has been witnessed among the consumer groups on the adverse health consequences of pesticides residues. Citizens worldwide are becoming aware of pesticide effects on human health and international trade (Sanborn *et al.,* 2004). Numerous studies have demonstrated substantial levels of pesticides residues in various food stuffs in Pakistan, and the ground water has been observed to be considerably polluted in many parts of Punjab and Sindh provinces of Pakistan. The growing application of pesticides has been a consequential cause of constantly contaminating the water thus posing a potential health risk for the consumers. Field workers and pickers in cotton growing areas are victims of indiscriminate use of pesticides and are prone to chronic health challenges. Surveillance and reliable monitoring, proper reporting

and documentation need to be in place to curtail the damaging impact of pesticides residues. Strict adherence to environmental policies, laws and regulations seems another logical approach to minimize health implications associated with pesticides exposure (Tariq *et al.,* 2007)

Commonly used open rural wells in Bahwalnagar, Muzafargarh, D.G Khan and Rajanpur districts of Punjab Pakistan, were found to be badly polluted with six pesticides. Bifenthrin (13.5%), λ-cyhalothrin (5.4%), carbofuran (59.4%), endosulfan (8%), methyl parathion (5.4%) and monocrotophos (35.1%) were detected in these water samples, indicating a possible health risk for local residents. Similarly, vegetables in Hyderabad region of Pakistan showed elevated levels of pesticide residues as 61 % of the total tested samples of eight vegetables (cauliflower, green chilli, eggplant, tomato, peas, bitter gourd, spinach and apple gourd) were found to be contaminated with pesticides residues exceeding maximum recommended limits (MRLs) (Anwar *et al.,* 2011; Tariq *et al.,* 2003).

Since fruits and vegetables constitute a major part of the diets of Pakistani population hence, contaminated with pesticides, dangerously impact the health and wellbeing of the consumers. In the capital city of Islamabad, where hygiene and sanitation are relatively sound and living standards are high, the concentration of dimethoate was estimated to be 0.032 mg /kg in apple, 0.110 mg/ kg in banana, 0.004 mg/ kg in brinjal, 1.80 mg /kg in cauliflower and 0.13 mg/ kg in *arvi*, while fenvalerate was assessed to be 0.010 mg/ kg in apple and chlorpyrifos 0.004 mg /kg in brinjal. However, these pesticides residues levels were within the maximum recommended limits (Parveen and Masud, 2001; Tahir *et al.,* 2001).

Heavy metals contamination in foods

A limited number of foods have been analysed for heavy metals in Pakistan, but hardly any comprehensive study has been conducted to assess their widespread prevalence in foods. Limited small studies mainly with selected fruits and vegetables in selected regions of Pakistan do not precisely scale up the presence of heavy metals.

Growing population and industrialization worldwide predominate as two aggravating elements, concomitantly transforming the human life style with an emergence of food safety and security issues especially in the developing countries. Agriculture is the main source of livelihood for the majority of the population in Pakistan. Heavy metals are badly contaminating the agricultural soils thus polluting the environment with cadmium (Cd), copper (Cu), lead (Pb), and zinc (Zn) (Forstner, 1995). Heavy metals emitted from industries and vehicles deposit on the surface of various fruits and vegetables (Hampton *et al.,* 1997; Jassir *et al.*, 2005) and become a part of the food products during processing and packaging (Tsoumbaris and Tsoukali-Papadopoulou, 1994). Ingestion of heavy metal contaminated foods results in decreasing immunological defence, disabilities associated with malnutrition, neurological disorders, intrauterine growth retardation, impaired psycho-social behaviour and a high prevalence of upper gastrointestinal cancer (Arora *et al.,* 2008).

A few representative studies uncovered high concentrations of Cu, Nickle (Ni), Pb and Zn in various vegetables cultivated in *Gilgit,* a relatively less polluted area of northern Pakistan. Spinach, coriander and peppermint, grown in Sindh province were reported to contain 0.90-1.20 mg/kg of arsenic resulting in a total ingestion of arsenic 9.7-12.2 µg/kg body weight/day in diet (Khan *et al.,* 2010; Arain *et al.,* 2009).

<Insert table 2 here>

Mango, is very popular in Pakistan, served fresh in the summer season and in the form of mango products all year long. Mangoes from three major mango growing districts (Multan, Rahim Yar Khan and Mir Pur Khas), were tested for heavy metal content in four popular mango varieties (*Dusahri, Chaunsa, Ratol* and *Langra*). Results indicated elevated concentrations of Chromium , Ni, Cd and Pb in mango varieties from all regions as compared to the permissible limits of 1.00mg/kg. Similarly, another study exhibited the concentrations of minor elements in eleven summer fruits grown in Pakistan in the order Cd<Pb<Zn<Cr<Ni< Iron (Fe) with the Fe being 14.25mg/kg and major elements were observed to be in the order calcium (Ca)< sodium (Na)<magnesium (Mg)< potassium (K) with K being 409.7mg/kg. Concentration of minor elements was higher than the permissible limits laid down by the World Health Organization (Zahoor *et al.,* 2003; Akhtar *et al.,* 2010).

Several other studies demonstrated varying levels of different heavy metals in some Pakistani foods. Fruit juices were found to contain Cu (22.7 µg/L), Fe (3.85 µg/L) and Zn (3.05 µg/L) (Jalbani *et al.,* 2010) while aluminium (Al) concentration in branded and non-branded biscuit samples from Hyderabad were found to range 7.4–84.3 and 34.5–70.2 mg/kg, respectively (Jalbani *et al.,* 2007). Similarly, Javed et al. (2009) detected higher concentrations of Cd, Cr, Ni and Pb residues (mg/L) in cattle and goat milk. Solid baby foods were analysed for Al, Cd, Ni and Pb and heavy metals concentrations were found to be above MRL's, indicating a significant risk following ingestion of such foods (Kazi *et al.,* 2010). Different fruits of Pakistan were also subjected to analysis for heavy metals detection and the results are presented in table 3 indicating metal content below

the safe limits set by WHO (Zahir *et al.,* 2009).

<Insert table 3 here>

Aflatoxins contamination in foods

Aflatoxins, naturally occurring potent carcinogenic, mutagenic, and teratogenic metabolites mainly produced by *Aspergillus flavus* (B_1 & B_2) and *A. parasiticus* (G_1 & G_2), M_1 (metabolite of aflatoxin B_1 in humans and animals) and M_2 (metabolite of aflatoxin B_2 in milk of cattle fed on contaminated food) are the most potential threats for the human health (George, 1998; Garrido *et al.,* 2003). Pakistani foods are more prone to aflatoxin contamination because of the warm and humid climate, and the situation is exacerbated by malpractices during handling and storage of edible commodities (Eaton *et al.,* 1993; Shapira *et al.,* 1996; Mobeen *et al.,* 2011). Aflatoxin contamination is reported to be associated with a high level of cancer prevalence particularly, liver cancer among population groups in Karachi, the biggest city of Pakistan. For example 10% and 17% aflatoxin contamination was reported in different parts of Karachi (Nizami and Zuberi, 1977; Qureshi *et al.,* 1990).

Pakistan ranks as the sixth largest exporter of chili peppers, contributing 1.5 % of GDP (Abrar *et al.,* 2009). Chillies are prone to aflatoxin contamination in Pakistan, and are viewed as a potential threat to health. A more concerted approach needs to be followed to eliminate these constraints for the development in Pakistan. Many studies reported levels of aflatoxin that were at least 8-fold higher than the EU permissible limits (Paterson, 2007; Iqbal *et al.,* 2010; Munir *et al.,* 1989; Javed and Zunerea, 2006). Concentrations detected in chili samples are high enough to pose a potential health risk to the consumers in Pakistan and therefore, more appropriate care and handling of the chillies is required at pre and post harvest stages.

A number of other food items in Pakistan were found to carry aflatoxins including cereals and beans. Percentage of the contaminated samples of broken rice, wheat, maize, barley and sorghum ranged 15 to 45 % with the highest concentration (15.5 µg/kg), in wheat samples, however majority of the samples showed higher limits than those limits (4 µg/kg), set by European Union (EU) regulations (Shah *et al.,* 2010). Similarly, aflatoxin B_1 content in maize kernels and maize, tested in North West Frontier Province of Pakistan and other rural localities ranged from undetected to 30.92 µg/kg. Aflatoxin contamination was observed in 70 % of rice samples in a separate study with concentrations up to a mean concentration of 4.9 ng/g (Siddiqui *et al.,* 2006; Ahsan *et al.,* 2010; Hussain et al., 2011).

<Insert Figure 1 here>

Nuts and dried fruits in Pakistan are cultivated and processed in the northern areas and have been shown to carry drastically higher aflatoxin levels. For example the percentage of the total samples detected; dried apricot (20%), dates (10%), dried figs (50%), dried mulberries (26%) and raisins (20%), while in apricot kernels (26%), almonds without shell (30%), walnuts with shell (40%), walnuts without shell (70%), peanut with shell (40%), peanuts without shell (50%), pistachios with shell (20%), pistachios without shell (50%) and pine nuts with shell (20%) were contaminated with aflatoxin and showed higher concentration comparing with the suggested limit of 4 µg/kg, set by EU regulations (Ahmad *et al.,* 1989; Luttfullah and Hussain, 2011).

Contamination of milk in Pakistan is among the most pressing food safety issue in the country. Numerous contaminants and adulterants have been frequently detected in milk and milk products, collected from every region of Pakistan. Aflatoxin M_1 in milk and milk products

require regular monitoring in Pakistan since 3% of the total tested samples of milk were found to exceed the US tolerance limit of 0.5 µg/L (Hussain and Anwar, 2008). Several other studies manifested elevated aflatoxin concentrations in milks e.g. 34.5%, 37.5%, 20%, and 16.7%, of the total 169 samples of buffaloes, cows, goats and sheep milks respectively were found to exhibit aflatoxin M_1. Buffalo milk had higher levels of aflatoxin contamination when compared with cow's milk (Hussain *et al.,* 2008; Hussain *et al.,* 2010). Cow' milk, yoghurt and butter samples analysed for aflatoxin M_1 depicted 40, 13, and 7.4 ng /L, indicating levels below EU permissible limits of 50 ng/ L (Maqbool *et al.,* 2009).

Health consequences of aflatoxins ingestion through foods has been widely debated in the literature under the domain of food safety. Developing countries however, are still lagging behind in this and are constantly prone to this challenge that may paralyse the health and economic infrastructure of the developing societies through huge disease burden and low productivity. Lack of aware ness among masses, public health interventions for efficient production, processing and storage, absence of decontamination techniques at commercial and home scale and lacking strict legislation are some of the obvious reasons for uncontrolled and rapidly growing prevalence of aflatoxins in various food commodities. Extreme care needs to be exercised at all levels to ensure implementation of fundamental food safety principals. Persistent monitoring and surveillance, viable and sustainable public health programs, and testing and analytical facilities of foods at gross root level need to be in place as measures to eradicate or minimize health risks. Food safety and security in Pakistan are two visible contributing factors, deterring the national economic growth through augmenting the disease burden among the rapidly growing population. Several attempts over the last few decades have been made by the

research community in Pakistan to estimate the extent of prevalence of these toxins in foods. The existing body of information derived through these studies may not be complete enough to completely reflect the severity of damage caused by aflatoxins ingestion in diets.

Adulterants in foods

Food adulteration is well recognized as a serious problem worldwide. Intentional deception by blending low cost and inferior quality ingredients that are injurious for human health, to make more profit at the cost of the quality of food intended for sale is quite prevalent in the developing countries. This problem is pervasive in the Indian subcontinent, with relatively more gravity where in an average family (even the affluent) is eating dangerous dyes, sawdust, soapstone, harmful chemicals and other harmful substances mixed with consumable goods.

Beverages, oil or ghee, bakery products, spices, tea, sweets bottled water and especially milk and milk products have been extensively adulterated in Pakistan. The data gathered by food department of city district government of Lahore- Pakistan, presented in table 4 clearly depict the extent of adulteration various foods suggesting serious remedial measures to safeguard the health and wellbeing of the vulnerable populations.

<Insert table 4 here>

Adulteration of milk is the most prevalent type of adulteration in Pakistan and 80 % of the total milk sold in tetra packs or in the loose form is adulterated. Hydrogen peroxide, carbonates, bicarbonates, antibiotics, caustic soda and formalin have been confirmed in the milk as adulterants (Anon, 2009; Tariq, 2001).

<Insert table 5 here>

Numerous studies have reported a variety of adulterants being added to milk for sale indicating the overall quality of the milk available to the consumers in Pakistan. Milk sold in Pakistan is of inferior quality with very less nutritive value in it and more toxic compounds (Loudon, 1986). Drugs frequently observed in milk available in Pakistan for consumption is a potential health risk (Afzal *et al.,* 2010). To top it off, hair removing powders and urea have been reported to be used to cosmetic milk appearance (Walker *et al.,* 2004). Another study conducted with 82 milk samples to evaluate the nutritional composition, the results showed none of the sample meeting the required compositional quality accepted as standard (Khan *et al.,* 1999). Jaffar et al. (2004) reported the presence of 12 different metals in nineteen different imported brands of milk in Karachi.

Conclusions

The current food safety situation in Pakistan is a pressing challenge and will continue to have serious implications to the nation's economic infrastructure if the corrective measures are not taken in a timely manner. Increases in the prevalence of food borne illnesses especially diarrhoea among children, is alarming, as Pakistan's future depends upon a healthier nation. Moreover, there is a dire need to scientifically tackle food safety issue in Pakistan. Evidence from the literature suggests that majority of Pakistani foods are drastically implicated with contaminants like heavy metals, pesticides residues and adulterants hence pose a dreadful threat to the human health and wellbeing. Food hygiene training as a means of improving food safety, strong consumer protection groups, awareness of food safety, and the right to acquire safe food, strict adherence to food laws, new legislation with changing food safety perspectives, and the recognition of this challenging problem by all stakeholders are some of the practical, systematic

and aggressive steps that can be taken to curtail the risk of microbiological and chemical foodborne diseases and to minimize the health consequences associated with the consumption of unsafe foods in Pakistan.

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Table 1 Imports of pesticides in Pakistan (1990-2010)[1]

Sr. No	Fiscal Year	Import of Insecticides	
		Quantity (Tonnes)	Value (Million Rs)
1.	1990-91	13,030	1,489
2.	1991-92	15,258	1,946
3.	1992-93	14,435	1,731
4.	1993-94	12,100	1,706
5.	1994-95	21,776	2,978
6.	1995-96	30,479	5,081
7.	1996-97	30,856	5,272
8.	1997-98	29,225	4,801
9.	1998-99	31,893	5,515
10.	1999-00	26,124	4,692
11.	2000-01	21,255	3,477
12.	2001-02	31,783	5,320
13.	2002-03	22,242	3,441
14.	2003-04	41,406	7,157
15.	2004-05	41,561	8,281
16.	2005-06	33,954	6,804
17.	2006-07	29,089	5,848
18.	2007-08	27,814	6,330
19.	2008-09	28,839	8,981
20.	2009-10	27,995	8,741

[1]Derived from FBS (2010)

Table 2 Nutrients and heavy metals in Pakistani soils irrigated with canal water[2]

Depth(cm)	Fe (ppm)	Mn (ppm)	Zn (ppm)	Cu (ppm)	Ni (ppm)	P (ppm)	P (ppm)	N (ppm)
0-15	11.32	10.78	14.2	1	0.84	0	10.2	0.07
15-3	6.04	7.92	8.68	1.36	0.5	0	7	0.056
30-60	4.2	3.96	6.04	0.56	0.1	0	4.2	0.028
60-90	3.54	3.96	4.2	0.34	0.12	0	3.8	0.007
90-120	6.24	0.22	3.96	6.74	0.1	0	3.8	0.006

[2]Derived from Butt *et al.,* 2005

Table 3 Concentration (μg/g dry wt) of heavy metals in different fruits of Pakistan[3]

Fruit Samples	Fe	Pb	Mn	Cu	Ni	Cd	Cr	Zn	Co
Apple	24.676 ±1.261	1.818± 0.205	0.019± 0.008	0.543± 0.035	0.971 ±0.183	0.173 ±0.069	3.93 ±0.270	21.496 ±1.733	0.407 ±0.053
Apricot	14.086 ±0.166	1.597 ±0.995	0.037 ±0.005	1.420± 0.09	1.119 ±0.220	0.246 ±0.038	3.975 ±0.462	1.543 ±0.542	1.049 ±0.203
Banana	16.508 ±2.177	3.152 ±0.665	0.037 ±0.002	1.606± 0.25	1.316 ±0.635	0.262 ±0.032	4.343 ±0.326	0.785 ±0.124	1.168 ±0.559
Chikoo	14.544 ±1.655	7.571± 2.417	0.064 ±0.005	3.145± 0.1	1.099 ±0.368	0.28 ±0.061	4.304 ±0.125	28.227 ±3.007	0.272 ±0.026
Date	16.517 ±2.950	2.291 ±0.699	0.045 ±0.003	0.644± 0.049	1.818 ±0.103	0.194 ±0.036	4.18 ±0.382	49.586 ±9.063	0.141 ±0.091
Jaman	9.12 ±3.251	2.928 ±0.886	0.021 ±0.001	2.772± 0.455	0.597 ±0.280	0.278 ±0.017	3.931 ±0.280	0.138 ±0.006	0.104 ±0.091
Lemon	16.366 ±6.843	1.961 ±0.164	0.612 ±0.065	2.947± 0.042	0.975 ±0.102	0.292 ±0.070	3.973 ±0.893	0.032 ±0.005	0.364 ±0.048
Mango	9.563 ±4.394	1.914 ±0.932	0.05 ±0.028	3.234± 0.279	5.033 ±1.723	0.275 ±0.025	4.095 ±0.194	0.668 ±0.066	0.871 ±0.201
Neem	9.962 ±1.178	1.554 ±0.027	0.013 ±0.002	1.829± 0.308	0.645 ±0.195	0.299 ±0.068	3.268 ±0.062	10.845 ±1.543	0.388 ±0.051
Tomato	7.924 ±0.680	0.531 ±0.092	0.049 ±0.008	3.122± 0.08	0.144 ±0.061	0.245± 0.034	2.864± 0.032	12.345 ±0.784	0.34 ±0.014

± Standard deviation of heavy metals in fruits

[3]Derived from Zahir *et al.*, 2009

Table 4 Percentage of Food Samples tested for adulterants in Lahore Pakistan[4]

Sr. No.	Food	Samples Tested	Unfit for Consumption	% age
1.	Milk	1734	1043	60.15
2.	Milk products	774	375	48.85
3.	Beverages	1587	757	47.7
4.	Cooking oil /Ghee	758	345	45.51
5.	Sweeteners	327	134	40.98
6.	Spices	1070	286	26.73
7.	Fruits and vegetable Products	333	88	26.43
8.	miscellaneous edibles	331	106	32.02
9.	Sweets/meat/bakery Products	1312	325	24.77
10.	Cereal products	396	33	8.33

[4] Derived from Jahangir, 2008

Table 5 Some of the chemicals used as adulterants in milk and their effects on the health of consumers

Sr.No	Milk Adulterant	Health implication	Reference
1.	Formalin	vomiting, diarrhea and abdominal pain shallow respiration, carcinogenicity	(Gwin *et al.*, 2009)
2.	Hydrogen peroxide	Inflammation of the intestine and bloody diarrhea	(Murthy *et al.*, 1981)
3.	Octylphenol and nonylphenolparts of detergents	Breast cancer, reduced sperm production.	(Ali *et al.*, 2005)
4.	Urea	Bleeding from uterus. Appearance of unwanted hair on women and children face	(Baumgartner *et al.*, 2005)
5.	starch	Diarrhea	(Rideout *et al.*, 2008)
6.	carbonates/bicarbonates	Disrupted hormones signals regulating reproduction	(Rideout *et al.*, 2008)
7.	Boric Acid	Nausea, vomiting, diarrhea, kidney damage	(See *et al.*, 2010)

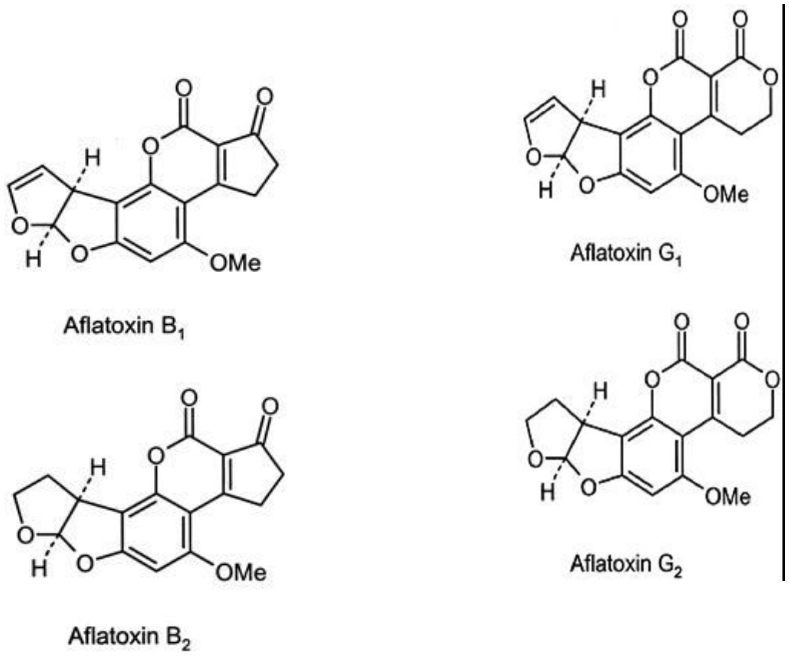

Figure 1: chemical structure of aflatoxins
Derived from Williams et al 2004

Figure 1 Aflatoxin B_1, B_2 and G_1, G_2,