Potential food contaminants and associated health risks

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ABSTRACT

The potential toxicants in food are derived from natural or industrial sources. Compounds like lectins and glycoalkaloids that are toxic to man are naturally present in some vegetables like potatoes or legumes. A wide variety of marine toxins mostly produced by dinoflagellates occurring secondarily in moluscs and mussels are usually ingested by human beings causing poisoning. On the other hand, toxic compounds find their way into food during manufacture, storage, or transportation. These include largely the industrial contaminants, persistent organic pollutants (POP), pesticides, heavy metals, and toxins of fungal and bacterial origin. Further, toxic compounds like higher alcohols may be produced as byproducts during processing. Migration of compounds from packaging materials into packaged food like contamination with lead from solder in certain metal cans is well known. Additives (emulsifiers, preservatives, and antioxidants) could also influence the quality of foods. Solvent residues may find their way into food as a result of their use in extraction processes like the use of trichloroethylene and methylene chloride in decaffeination of coffee. In addition, poor hygiene, storage, and preparation may also lead to food contamination by various microbes and ova or cysts of nematodes. The problem of food contamination can be overcome to a great extent by regular surveillance and monitoring programmes and strict implementation of food and adulteration act. In the present review some of these aspects of food contamination have been discussed in detail.

INTRODUCTION

There is a growing awareness that chemical and biological contaminants in foodstuffs may play an etiological role in various human diseases. The potential toxicants of concern to consumers are intentional additives (adulterants) or unintentional contaminants. Adulteration involves deliberate addition of undesirable, cheap agent for disguising inferior commodities and earning undue profits while contamination refers to accidental incorporation of toxicants during production, processing, packaging, or storage. A number of food contamination episodes resulting in great morbidity and mortality have occurred in the past. Epidemics of ergotism have occurred due to ingestion of bread contaminated with the fungus Claviceps purpurea over the centuries. Inadvertent use of wheat seeds treated with hexachlorobenzene resulted in porphyria cutanea tertia in Turkey in 1956. Epping Jaundice, an outbreak of toxic hepatitis in England was due to accidental contamination of a sac of flour with methylene diamine during transport to a bakery. In Japan, in 1968 contamination of rice oil with polychlorinated biphenyls (PCB) and polychlorinated dibenzofurans (PCDF) led to an illness called Yusho disease. A similar epidemic referred to as Yucheng followed in Taiwan in 1979. Another toxic oil syndrome characterised by multisystem disorder affected a large number of people in Spain in 1981 after consuming rape seed oil contaminated with 2% aniline. Heavy metals like lead, arsenic, mercury, and cadmium have also been involved in various episodes of food contamination in the past. An episode known as Devonshire colic is reported due to ingestion of lead contaminated cider. Aquatic food contamination with methyl mercury resulted in infamous Minimata disease in Japan during 1950's. A similar episode took place in Iraq in 1971 due to consumption of homemade bread baked from wheat contaminated with methylmercury. Itai-itai disease with typical symptoms of extreme bone pain and
ostomalacia in Japan resulted from contamination of local water supply with waste water run off from zinc-lead-cadmium mine\[10\]. Ingestion of contaminated bengal gram flour with Lathyrus sativus crippled thousands of people in the past\[11,12\]. In Calcutta in 1988, an epidemic of polynuertis especially of hands and feet was caused due to contamination of rape seed oil with inresyl phosphate. Several episodes of epidemic dropsy have occurred since 1937 in the country due to adulteration and or contamination of mustard oil with argemone oil\[13–15\].

Thus surveillance and monitoring of food contamiants becomes mandatory for each country so that timely preventive and control measures can be initiated. One of the important federal agencies in USA which protects the public from hazards of unrecognized toxins is the Food and Drug Administration (FDA), the other three being Consumer Product Safety and Health Commission (CPSC), Environmental Protection Agency (EPA), and Occupational Safety and Health Administration (OSHA). Though in India, the Prevention of Food Adulteration Act (1954) lays down regulations to be followed for sampling procedures and methods of analysis of food, however, the routine sampling of food is mostly done by export laboratories only. Chemical analysis is usually carried out for the disputed foods by state laboratories and hence there is no routine sampling and testing of raw materials or cooked food to maintain prescribed limits of contaminants. A similar situation exists in other developing countries as well.

In this review an attempt is made to discuss some common contaminants and their health effects. Toxicovigilance of such toxicants may help in prevention and implementation of legal measures.

**POLYCHLORINATED BIPHENYLS AND DIOXINS**

Industrial toxicants, polychlorinated biphenyls (PCB), polybrominated biphenyls (PBB) and dioxofurans may be present together as contamiants. Due to their accumulation in the environment, animal and human tissues, the potential for chronic or delayed toxicity is significant. More than twenty years back an incident of mass poisoning in central Taiwan referred to as Yucheng (oil disease) took place due to consumption of rice bran oil contaminated with PCB and their degraded byproducts\[14\]. Similarly in some parts of Japan Yusho disease was caused due to consumption of contaminated rice oil with polychlorodibenzo-p-dioxins (PCDD) and its related compounds like polychlorodibenzoofurans (PCDF). Characteristic toxic manifestations in the affected population included chloracne, hyperpigmentation, subcutaneous facial edema, cheese like discharge from eyes, swelling of eye lids, transient visual disturbances, hyperemia of conjunctiva, and hearing difficulty. Increased incidence of liver cancer and adverse reproductive effects have been reported in the exposed populations. Serum levels of conger specific PCB/PCDF were found to be good indicators of previous exposure in women\[16\]. Blood PCB levels were high in patients with typical eye and skin symptoms\[17\]. Children born to mothers who had consumed the contaminated oil are reported to have higher prevalence of middle ear diseases than their matched controls\[18\]. Food animals have been found to contain PCB, PBB, and dioxins\[19\]. Consumption of fatty fish like salmon and herring from Baltic sea has been found to be an important source of human exposure to PCBs, PCDDs, and PCDFs\[20\]. Aquatic food products from industrialized countries have been found to contain markedly high levels of PCB and chlordane\[21\]. Dietary intake of fish contaminated with persistent organochlorine compounds has been associated with low birth weight babies and endocrine abnormalities\[22,23\]. Great increase of blood levels of PCDD/PCDF in the population consuming fish and shell fish from contaminated areas has been observed\[24\].

Dioxins are among the most toxic anthropogenic chemicals in the environment, contaminating the soil thus entering the food chain. Pathways of entry into foods are atmospheric transport of emissions and subsequent deposition on plants, soil, and water. These products are not generally taken up and translocated by the plants, resulting in negligible residues in foods and feeds derived from seeds. However, the main sources are animal diet contaminated with soil that has accumulated dioxin residues from the environment\[25\]. It is estimated that 98% of human exposure is through foods particularly meat, fish, and dairy products. A survey has shown that about 25% or more of marine products are contaminated by trace amounts of dioxins and related compounds\[26\]. Dioxins are practically insoluble in water and get concentrated in lipids of biological systems and groups at risk for highest exposure are nursing infants and people on high fish/meat diet. An association between exposure via mother’s milk to dioxins and developmental dental defects has been found\[27\].
Dioxins are reported to be plausible myelomagens.\textsuperscript{(28)}

PESTICIDES

Contamination of food with pesticides and residues is of special concern because of their inherently high toxicity. Organochlorine pesticides because of their persistence in environment, susceptibility to biomagnification, toxicity to higher animals and ecological catastrophe, have been banned in advanced nations. However, DDT and several others are still used for vector control in many developing countries in Asia and South Pacific region, with the result human populations are still exposed to these compounds mainly through bovine milk and milk produce. After a ban for ten years in Hong Kong, a survey of milk in local markets in 1993 - 1995 showed residues of both DDT and HCH.\textsuperscript{(29)} Data from India indicate DDT and HCH to be the major residues in food. Though their concentration has declined in farm products like food grains and vegetables, milk and milk products are still the major sources. Dietary intake of these residues in Indians is reported to be 100 fold greater than that seen in the population of developed countries. In addition concentration of more than 1 \textmu g/g of aldrin, dieldrin, and heptachlor have also been found in vegetables and in untreated water. In Malaysia and Thailand meat was found to be contaminated with aldrin, dieldrin, and DDT, however, in Australia and New Zealand chlordane and PCB were more prevalent organochlorines in food stuffs. The greatest concern has been for infants and children who are exposed through human and dairy milk. Malnutrition also increases the risk of toxicity. The estimated daily intake of DDT by infants in India has been found to be at least 100 fold greater than the acceptable daily intake of FAO/WHO.\textsuperscript{(21)} DDT has been listed as a possible carcinogen in humans. Toxaphene has been found to be a major organochlorine in fish.\textsuperscript{(30)} Chronic exposure to these pesticides may be associated with birth defects, endocrine disorders (estrogenic effects), and neurological deficits.\textsuperscript{(31,32)}

Organophosphates (OP) are widely used for home and garden pest control. Though they degrade relatively rapidly in the environment, a few like demeton and demeton methyl are transllocated from soil to plant tissues which could ultimately lead to contamination of the products. Exposure to residues of OP in lettuce and cauliflower plants has led to anticholinesterase poisoning in farm workers. Prothiofos and cyanophos residues are reported to migrate from insecticides impregnated paper bags to fruits.\textsuperscript{(34)} Pregnant women believed to have consumed trichlorfon contaminated fish during pregnancy are reported to have developed a cluster of congenital anomalies in Hungary.\textsuperscript{(31)} Myeloid leukemia has been reported after chronic exposure to isothenfos contaminated drinking well water.\textsuperscript{(36)} Consumption of food contaminated with OP is reported to cause mass food borne poisoning outbreaks especially in developing countries and rural areas.\textsuperscript{(37,38)}

NITRITES AND HETEROCYCLIC AMINES

Nitrites are ubiquitous and potentially hazardous inorganic ions. They are used for meat curing, coloring and preservation. In certain green vegetables nitrates and nitrites may be formed by microbial reduction after preparation and storage. Acute effect of nitrites and nitrates is toxic methemoglobinemia.\textsuperscript{(39-40)} Outbreaks of methemoglobinemia have been reported due to nitrite contamination of drinking water from corrosion inhibitor.\textsuperscript{(41)} Nitrites may further react with a number of nitrogenous compounds like amines and indoles to form nitrosocompounds. Nitrosamines may also be formed by nitrosation of secondary amines.\textsuperscript{(42)} Volatile N-nitrosamines like N-nitrosodimethylamine (NDMA) has been detected in 52% of Spanish beers.\textsuperscript{(43)} Relatively high content of various N-nitrosamines in different diets is suspected as one of the etiological factors for oesophageal cancer. Heterocyclic amines which are formed during cooking of fast food meat products can also contribute to mutagenic and carcinogenic effects.\textsuperscript{(44)} 3,4-Cholsteroids formed during the production of flavour enhancers though not acutely toxic in animals could however be harmful chronically, as small amounts are absorbed by intestinal tract and accumulated in adipose tissue.\textsuperscript{(45)}

POLYCYCLIC AROMATIC HYDROCARBONS AND PHTHALATES

Polycyclic aromatic hydrocarbons (PAH) and other related chemicals are reported to be mutagenic and carcinogenic.\textsuperscript{(46)} Direct human exposure is from diverse sources like tobacco smoke, automobile engine exhausts, high boiling petroleum distillates, carbon black, coal, pitch rubber, etc. However, food contamination occurs by polluted air, water, and during cooking. Common foods contaminated with PAH are edible oils (soybean,
coconut, cotton seed, and sunflower), fats, margarine, mayonnaise, and marine products. Smoked and grilled foods and over heated oil fried products also have PAH. Wax paper packaging has led to contamination of bread, biscuits, and breakfast cereals.\(^{12}\)

Packaging in polymer based materials can lead to changes in product flavor due to aroma sorption and transfer of undesirable flavors from packaging to food. Certain packaging materials have the potential to contribute plasticizers like phthalate and di-2-ethyl hexyl adipate (DEHA) into the food items especially wrapped meat, poultry, fish, cheese, and ready to eat foods. Low levels of diethyl hexyl phthalate esters have been found with the use of phthalate ester cap or lid seals in a variety of glass packaged foods. The di-2-ethyl hexyl, dibutyl, and butyl benzyl phthalate esters have been found to migrate from aluminum foil paper laminates into butter and margarine, etc. In most cases plasticizers found in food have been detected in associated packages also.\(^{83}\). Certain foods or liquids acquire estrogenic activity after leaching of bisphenol-A from lacquer coating in food cans.\(^{90}\)

**MONOSODIUM GLUTAMATE**

Monosodium glutamate (MSG) marketed as a flavoring agent causes burning, facial pressure, headache, flushing, chest pain, nausea, and vomiting. Life threatening bronchospasm and angioedema is rarely seen. There is a significant variation in individual responses, however, the intensity and duration of symptoms are also dose-related. In young children sudden attacks or a seizure-like syndrome is reported. There is rapid absorption in the fasting state with typical burning symptoms rapidly spreading over the back, neck, shoulders, abdomen, and occasionally thighs.\(^{90}\)

**OIL CONTAMINATION**

Contamination of oil has caused poisoning episodes in the past. High concentrations of benzo-\((a)\)-pyrene was reported in Brazilian corn oils.\(^{94}\). Toxic oil syndrome in Spain caused an epidemic due to contamination of rape seed oil with aniline resulting in multisystem disorder.\(^{1,22}\). The syndrome was characterized by pneumonia, eosinophilia, pulmonary hypertension, scleroderma like features, and neuromuscular weakness. Contamination of mustard oil with argemone seeds has caused several outbreaks of epidemic dropsy in India and other parts of the world. The manifestations of the poisoning include vomiting, diarrhea, nausea, abdominal pain, edema of feet and legs, erythema, breathlessness, lethargy, and low grade fever. The cardiovascular manifestations include tachycardia, precordial pain, ECG changes and congestive heart failure. Among the various ocular manifestations are itching and burning of eyes with superficial retinal hemorrhages, disc edema, and glaucoma.\(^{13-15}\). Several outbreaks have been reported after consumption of tricresyl phosphate (TOCP) contaminated foodstuffs and oil.\(^{52}\). Major toxicity of TOCP is a delayed neuropathy of the dying back or peripheral axonopathy variety. It is known to induce delayed neurotoxicity.\(^{54}\).

**HEAVY METALS**

Heavy metals are widespread in nature and their presence has been found from traces to macro levels. Increased environmental load with respect to metallic pollutants is a serious concern. Significant contamination of seeds, plants, and plant products with heavy metals through soil, fertilizers, and water may cause chronic toxicity. Industrial effluents are released into sea, rivers, or even to irrigation channels and fields which facilitates the entry of metallic constituents of effluents into the foodchain. The Minimata disease was caused by contamination of water due to discharge of effluents containing mercury into Minimata bay. The disease was characterised by chronic brain damage, tunnel vision, deafness, and severe congenital defects.\(^{51}\). Children exposed in-utero developed cerebral palsy, chorea, ataxia, tremors, seizures, and profound mental retardation.\(^{56}\). Similarly in Iraq an outbreak of organomercurial poisoning took place due to consumption of home-made bread baked from wheat treated with methylmercury used as seed dressing to prevent wheat bunt and other crop diseases. The symptoms included speech disturbances, abnormal behaviour, loss of visual and auditory acuity, and ataxia. Severe disabilities and deaths were reported in this episode.\(^{56}\). Elemental mercury originating from natural and anthropogenic sources is in the inorganic form predominantly as metallic vapour, which is microbiologically transformed into lipophilic organic compound methylmercury in aquatic environments. The lipophilic states make mercury more prone to biomagnification in aquatic foodchains. Consequently, populations with a traditionally high
dietary intake of food originating from either fresh-water or marine environments have highest exposure to methylmercury. Ingestion of contaminated pork with organic mercury is reported to result in severe toxicity. \(^{47}\) Populations like polar Eskimos in North West Greenland have a high dietary access to methylmercury due to intake of foods originating from either fresh water or marine environments \(^{58,59}\). Studies in humans chronically exposed to food contaminated with methylmercury showed increased sister chromatid exchange rates, chromosomal aberration, and aneuploidy in the lymphocytes \(^{60,61}\). Contamination of rice with cadmium led to Itai-itai disease in Japan manifested by extreme bone pain and osteomalacia \(^{62,63}\). Cadmium has also been documented to cause hypertension and nephrotoxicity \(^{64,65}\). It is reported to induce immunosuppression in experimental studies \(^{66-67}\). Markedly high blood mercury levels have been reported after consumption of sea bass containing remarkable mercury levels \(^{68}\). In certain fish eaters high mercury levels are reported in urine and hair \(^{69}\). Wild mushrooms growing in vicinity of mercury and copper smelter areas have shown extremely high concentrations of mercury, copper, lead, and cadmium \(^{70,71}\). Children living in vicinity of mercury contaminated industrial sites are the most sensitive group mainly exposed by soil ingestion which makes up nearly 80% of ADI \(^{72}\). Lead and cadmium are reported to get transferred from contaminated soil to crop plants or food of plant origin \(^{73}\). Maternal exposure to mercury can lead to impaired intellectual and motor development in breast fed infants.

With rapid increase in the consumption of canned food products throughout the world, the possibility of food contamination with different metals is expected. The metals involved could be arsenic, aluminium, copper, iron, lead, tin, and zinc. Metals used in food packaging material or food processing equipment may contribute to contamination \(^{74}\). Leaching of metals like iron, chromium, and nickel from stainless steel utensils into food is reported \(^{75}\). Acute poisoning is less common however food contaminated with arsenic oxide is reported \(^{76}\). Arsenic salts are also used as rodent baits, insecticidal fruit sprays, and herbicides, so food or fruits may get accidentally contaminated. Severe arsenic poisoning has been reported due to contamination of wells in Minnesota \(^{77}\). In West Bengal in India and Bangladesh drinking water is also contaminated with arsenic \(^{78}\). A large number of population is suffering from peripheral neuropathy, hyperkeratosis, and skin cancer. Remarkable arsenic concentrations have been found in sea food especially shell fish. Remarkable elevations of urinary monomethyl and dimethyl arsenic acid are reported after mussel ingestion \(^{79,80}\). Excessive intake of manganese due to food contamination coupled with low intake of magnesium from drinking water has led to motor neuron disease in Japan \(^{81}\). Aluminium salts are sometimes used as food additives and aluminium may also leach from aluminium utensils and cans \(^{82}\). Processed cheese and wheat flour may contain aluminium containing additives \(^{83}\). The metal leaching tends to increase with increasing acid concentration of soft drinks in the cans. However, possible intake through ingestion is negligible \(^{84}\). Leaching of aluminium from aluminium-lead alloy utensils is reported to be enhanced by water containing high concentration of fluoride ions at a low pH than from high quality utensils of aluminium-manganese alloy \(^{85}\). Inadvertent addition of a massive amount of aluminium sulfate during water treatment resulted in very high aluminium concentrations as compared to maximum admissible limits and led to symptoms like nausea, vomiting, diarrhea, mouth ulcers, skin rashes, and arthritic pains \(^{86}\). A number of commercial teas have been found to contain aluminium. However its absorption from tea may be quite low \(^{87,88}\). Some parenteral and dialysing solutions containing aluminium salts and in uremic patients on dialysis metabolic bone disease can occur \(^{89}\).

Lead contamination could occur from ceramic glazed pottery. A correlation between the use of lead glazed ceramicware for cooking or food preparations and elevated lead levels has been found. More leaching ( > 0.5 mmol/L) occurs into acidic foods cooked or stored in lead ceramicware than neutral foods. Sequential extractions of acidic foods yield variable but declining levels of lead \(^{90}\). Leaching from old ceramic dinnerware with 4% acetic acid or 0.5% citric acid has been reported after microwave heating. Use of such dishes for microwaving of common foods could result in ingestion of dangerously large amounts of lead. Further, dishes with uranium and copper containing glazes could also lead to unsafe concentration of lead in microwave leachates \(^{91}\). Automobile radiators used as condensers for illegally distilled whisky add lead to the final products. Baking processes of bread may contribute to contamination due to lead and benzo-(a)-pyrene \(^{92}\). Lead is also present in lead arsenate, a pesticide used for spraying apples. Anemia and lead colic have been reported after prolonged use. The children show weight loss, weakness, and
neurobehavioural deficits. Vague gastrointestinal and CNS effects are manifested in adults. Barium salts have been investigated as one of the alternatives to lead in frit formulations for glazes. The potential hazard associated with the leaching of barium from glazed ceramicware is reported to vary with the level of use.

Food contamination with lead and its salts could occur in occupationally exposed people working with unrecognized sectors through transfer of metallic particles on clothes and hands. Drinking water may be contaminated by lead pipes. Experimental evidence suggests that lead induces immunotoxicity. Metal contamination may also occur from the food processing equipments and corrosion of packing materials. Nickel is used in hydrogenation of vegetable oils, however the health effects are not known.

**Fungal Toxins**

Fungal toxins are one of the major food contaminants. Three groups of fungi that easily grow on food stuffs include *Aspergillus*, *Fusarium*, and *Penicillium*. These fungi elaborate several hundred toxic metabolites. A variety of consumable articles like cereals, pulses, oil seeds, vegetables, dry fruits, spices, dried fish, milk and its products, and meat get contaminated by fungi. The common mycotoxins include aflatoxins, ochratoxins, citrinin, zearalenone, deoxynivalenol, fumonisins, trichothecenes, patulin, tenuazonic acid, and penicillic acid, etc. However, aflatoxins being toxic are potent carcinogenic, mutagenic, and teratogenic compounds.

In India, the problem is of greater magnitude due to congenial climatic conditions, socio-economic backwardness, and traditional and unscientific agronomic and storage practices. The genetic make up of the aflatoxin strains and the environmental factors determine the degree of aflatoxic poisoning to a great extent. The main environmental factors include moisture, temperature, length of storage, level of carbon dioxide, and oxygen. Besides these abiotic factors, the biotic factors like insect vectors, birds, rodents, crop varieties, and fungal interactions affect the contamination. Reports indicate insect and bird damaged samples of crops have high levels of aflatoxins as compared to the healthy samples. Of the various aflatoxins, aflatoxin B1 is the most toxic with proven carcinogenicity. It constitutes an important risk factor for hepatocellular carcinoma in exposed populations.

It exerts its effects after conversion to the reactive compound aflatoxin B1-epoxide by the action of cytochrome P-450-dependent enzymes in the body. Aflatoxin B1 and G1 have been found in sorghum seeds during storage under controlled conditions. In Philippines, toxic levels have been found in corn and peanuts. Black pepper may be heavily contaminated with aflatoxin B1. An outbreak of acute hepatic encephalopathy due to severe aflatoxicosis has been reported from Malaysia due to ingestion of contaminated noodles. On the basis of reports of natural occurrence and level of aflatoxins from different parts of India maize, groundnut, cotton seed, rice, and millet can be categorized as high risk crops. Further, rice bran, a valuable product utilized for various purposes in food and feed industry, is also reported to be a good substrate for natural occurrence of *Aspergillus flavus*. Through infected animal feed milk may get contaminated. Oil seeds also provide good substrate for growth of toxigenic fungi and toxin elaboration. A ten year Indian study showed remarkable contamination of groundnut and deoiled groundnut cake, maize, and mixed feeds.

Patulin, a metabolite of *Aspergillus and Penicillium* having carcinogenic, teratogenic and mutagenic properties is detected in some fruits. Kojic acid, a common metabolite of *Aspergillus flavus* is reported to be a convulsant.

Ergot alkaloids of various species of *Claviceps* infect millet and produce peripheral, vascular, neurohumoral, and CNS effects (ergotism). Streigmatocystin, a potent toxin from heavily fungal infected wheat can contaminate processed foods. Ochratoxin A (OA) is the most toxic of ochratoxins produced by a number of *Aspergillus and Penicillium* species and is carcinogenic, teratogenic, mutagenic, and immunosuppressive. It grows in cereals, legumes and green coffee beans. Though porcine nephrotoxicity is established, acute human nephrotoxicity seems to be rare. It has been found in coffee beans besides being present predominantly in cereals. OA has also been found in brew. Levels of 0.1 – 12 µg/kg of OA have been found in the breast milk of donor mothers in Italy.

Fusarium mycotoxins (fumonisins, nivalenol, deoxynivalenol, and zearalenone) may contaminate cereals and animal feeds and cause health risks in domestic animals and humans. Contamination of commercially available corn based food stuffs for human consumption is reported from Taiwan. Zearalenone and its derivatives are reported to show estrogenic effects in animals. Nivalenol has been reported in high
concentrations (4700 µg/kg) in Swedish cereal. Certain toxins survive the brewing process in the manufacture of beers. These mycotoxins could originate from malted grain or from adjuncts. Although increased incidence and concentrations of aflatoxins and zearalenone have been found in local beers brewed in Africa, no aflatoxins have been found in European beers. In naturally contaminated corn used for ethyl alcohol fermentation and wet milling operations fumonisins B1 and B2 are stable to conditions for fermentations and tend to concentrate in distillers dried grain generally used for animal feed. Trichothecenes may cause severe hemorrhage in intestines, nose and throat, leukopenia, dermatitis, cough, and rhinitis.

Ingestion of moldy sugarcane has resulted in acute encephalopathy, delayed dystonia, and bilateral lenticonular lucencies. Such cases have been reported from China and the most likely etiologic agent is 3-nitropropionic acid produced by Arthrinium species of fungus.

MICROORGANISMS

Common microorganisms that contaminate food include Salmonella, Staphylococcus aureus, Bacillus cereus, Clostridium perfringens, and Campylobacter jejuni. Botulism caused by Clostridium botulinum is manifested as acute descending paralysis due to blocking of neuromuscular transmission. The growth and toxin production of Clostridium botulinum in food is enhanced by high moisture, low salt, low acid, reduced oxygen, and increased temperature conditions. Milk products, potato salads, custards, ham, creamy pastry, and cheese provide good medium for growth of Staphylococi and enterotoxins released can cause vomiting, diarrhea, and dehydration. Bacillus cereus, which grows on inadequately refrigerated starchy foods and cereals causes both diarrhea and emesis. Clostridium perfringens present in previously cooked, inadequately refrigerated poultry and meat products causes diarrhea and clostridial myonecrosis. Milk and cream are the source of Campylobacter associated with food borne disease. Human infection due to Salmonella is frequent and widespread and the types of foods most often associated with the poisoning are meat, milk, and eggs. Usual symptoms include headache, chills, abdominal pain, nausea, vomiting, diarrhea, and fever. Systemic anaphylaxis has been reported after ingestion of storage mite contaminated food. Mite contaminated wheat flour can lead to anaphylaxis and an increased frequency of sensitivity to aspirin and other nonsteroidal anti-inflammatory drugs (NSAID).

The problem of food contamination can be overcome to a great extent by the use of good quality raw materials and maintenance of absolute hygienic conditions, undertaking regular surveillance, and monitoring programmes. There is an absolute need for formulating maximum permissible standards for each country taking into account food habits, social, cultural, and economic status. Further, widespread contamination of cereals, pulses, poultry, dairy products with pesticide residues warrants caution and efforts to ensure any further rise. This can be achieved by ensuring absolute ban or restricted use and disposal of organochlorine pesticides. In addition proper disposal of effluents from industries dealing with persistent organochlorines and heavy metals should be ensured and lastly there should be a strict implementation of food and adulteration act.

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潛在的食品污染剂和与之相关的健康危险

关键词 食品污染；有机磷化合物；油类；芳香烃类；重金属；微生物学；真菌

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