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CHEMICAL RESIDUES IN MEAT AND MEAT PRODUCTS: A REVIEW

Heena Jalal[1], Parveez Ahmad Para[2], Subha Ganguly[3]*, Moloya Gogai[4], Mohammad Mansoor Bhat[1], Praveen Kumar Praveen[5] and Syed Arshid Bukhari[1]

[1]Department of Livestock Products Technology, F.V.Sc. & A.H., SKUAST- Kashmir (J & K) – 190006, India.

[2]Assistant Professor, Department of Livestock Products Technology.

[3]Associate Professor & Head, Department of Veterinary Microbiology.

[4]Assistant Professor, Department of Foods & Nutrition, AAUJ, Assam, India.

[5]Assistant Professor, Department of Veterinary Public Health & Epidemiology, Arawali Veterinary College (Affiliated with Rajasthan University of Veterinary and Animal Science, Bikaner), N.H. – 52 Jaipur Road, V.P.O. Bajor, Dist. Sikar, Pin – 332001, Rajasthan, India.

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***Correspondence for Author**
Dr. Subha Ganguly
Associate Professor & Head, Department of Veterinary Microbiology (Affiliated with Rajasthan University of Veterinary and Animal Sciences, Bikaner), N.H. – 52 Jaipur Road, V.P.O. Bajor, Dist. Sikar, Pin – 332001, Rajasthan, India.

ABSTRACT

The consumers increased awareness of a growing chemicalization of animal origin foods presents a challenge to the meat and poultry industry. A great number of chemical compounds are used either directly or indirectly during the production, processing and storage of meat and meat products. The rate of urbanization and industrialization is increasing day by day in India and all over the world leading to increased environmental pollution in conjunction with it, the inappropriate use of veterinary drugs may induce the presence of residues in food products, which can pose a major threat to public health. In this paper, the potential sources of exposure to contaminants and conditions affecting their presence in meat and processed meat are briefly discussed.

KEYWORDS: Antibiotics, biogenic amines, drugs, nitrosamines, pesticides, residues.

INTRODUCTION

Meat and meat products are important for nutrition and the human diet, but are also one of the major routes of human intake of contaminants. Contaminating substances may enter the food chain at many different stages. Through various constituents like fertilizer ingredients and contaminants, irrigation water, contaminants and pesticides can enter food crops through plant roots. Contaminants in forages and other feeds can be transmitted to animal products. Veterinary drugs can leave residues in animal products. Environmental chemicals such as heavy metals (e.g., lead and mercury) from many sources have sometimes been found as food contaminants. Thus range of contaminants/toxicants found in food is varied but can be broadly subdivided into:

- Food processing by products;
- Food additives, processing aids and those chemicals that may migrate from packaging.
- Agricultural and veterinary chemicals used in primary production;
- Natural chemicals found in plants, fungi or bacteria associated with plants
- Environmental contaminants, including heavy metals and organic contaminants.

1. Food processing toxicants

During the processing of foods, products may be produced that, if present in large amounts, could potentially adversely affect health. For example, cooking certain meats at high temperatures creates chemicals that are not present in uncooked meats. A few of these chemicals may increase cancer risk, such as polycyclic aromatic hydrocarbons and heterocyclic amines. Another example is when nitrates and nitrites react with secondary amines to form nitrosamine. Nitrosamines are mutagens which have been linked to cancers. Nitrates and nitrites are used to preserve meats and contribute to prevention of growth of *Clostridium botulinum*, the bacterium responsible for producing the highly potent botulinum toxin.

a. Polycyclic aromatic hydrocarbons

Polycyclic aromatic hydrocarbons (PAH) are produced when any incomplete combustion occurs. Thus, they are found in cooking oil fumes, smoked foods and foods cooked at high temperature. Most PAHs are not carcinogenic, although a few are, for example benzo (a) pyrene (Simko, 2009a). They appear mainly in meats cooked during high temperature grilling. Microwaving does not produce PAHs and foods other than meats contain negligible amounts of PAHs. Foods low in fat, or cooked beneath the source of heat, contain many fewer PAHs, so the type of food cooked and the method of cooking are important determinants of PAHs. Breathing air containing PAHs can occur in the workplace of smokehouses. Eating grilled or charred meats, meats and processed or pickled foods increases an individual's exposure to PAHs. Drinking PAH contaminated water or cow's milk can increase an individual's exposure to PAHs. Nursing infants of mothers living near hazardous waste sites may be exposed to PAHs through their mother's milk (Simko, 2009b).

Table1: Potential sources of exposure to contaminants and conditions affecting their presence in meat and processed meat.

Group of compounds	Exposure source	Conditions affecting
Nitrosamines	Cured meats	Available residual nitrite in cured meats with presence of secondary amines and catalyzed by temperature
Biogenic amines	Fermented meats or non-hygienic meats	Hygiene and/or type of microbial flora: decarboxylation of certain amino acids
Heterocyclic amines	Cooked meats at high temperature	Type of cooking of meat, heating temperature and time
Polycyclic aromatic hydrocarbons	Smoked meats	Smoking, especially traditional smoking at high temperature for long time. Smoke flavorings if not adequately treated
Lipid oxidation	Cooked or processed meats	Chemical reactions during storage or processing catalyzed by oxygen, salt, hydrogen peroxide, radiations, lypoxigenase, temperature.
Protein oxidation	Cooked or processed meats	Chemical reactions during processing catalyzed by oxygen reactive species and temperature
Veterinary drugs	All meats	Intentional addition to feed or water given to animals
Growth promoters	All meats	Intentional addition to feed or water given to animals
Environmental contaminants	All meats	Contaminants already present in primary ingredients formulated in feeds given to animals

b. N-nitrosamines

Approximately 300 of these compounds have been tested and 90% of them have been found to be carcinogenic in a wide variety of experimental animals (Sen *et al.,* 1987). Dimethylnitrosamine (DMNA) (also called N-nitrosodimethylamine or NDMA) is a member of a group of chemicals known as nitrosamines which are recognized as cancer-causing substances. DMNA is a volatile liquid, which dissolves easily in water and in oil. It can be broken down by light or microorganisms but, in their absence, DMNA can persist in water for a very long time. Even in a sewage treatment plant, DMNA degrades only very slowly. Cured meats can contain nitrosamines because meats contain amines and sodium nitrite, a source of nitrosating agents added to cured meats as a preservative. Of all the cured meats, bacon has received the most attention. It almost always contains detectable levels of nitrosamines, principally nitrosopyrrolidine and, to a lesser extent, DMNA. The very high cooking temperatures used to fry bacon are conducive to nitrosamine formation. In the late 1970s, extensive attention was focused on the issue of nitrosamines in cured meats and the removal of sodium nitrite as a food additive was considered. However, the prospect of sodium nitrite removal presented a formidable dilemma for the regulatory agencies. Removal of sodium nitrite would prevent nitrosamine formation, but it might also increase the risk of botulism poisoning. Sodium nitrite and sodium chloride together are particularly effective against *Clostridium botulinum.* The solution to the dilemma was to limit the addition of sodium nitrite to 120 ppm, the lowest level found to be effective in controlling growth and toxin production by Clostridium botulinum.

Ascorbic acid also inhibits nitrosamine formation. The addition of 550 ppm of ascorbic acid is now required in the manufacture of cured meat in the United States. Actually, most cured meat manufacturers add erythorbic acid (a less expensive isomer of ascorbic acid) rather than ascorbic acid. Another antioxidant, alpha-tocopherol (vitamin E), is added to some cured meats to inhibit nitrosamine formation. As a result of these strategies, there are now significantly lower levels of nitrosamines in fried bacon and other cured meats than there were some years ago. Ascorbic acid, erythorbic acid, and alpha-tocopherol inhibit nitrosamine formation due to their oxidation and N reduction properties. It is difficult to evaluate the risk of cancer from daily exposure of 1microg from foods and beverages. The same difficulty applies to the risk assessment of the exposure to minute amounts of aflatoxin, PAHs, and heterocyclic amines in a variety of foods and beverages.

c. Heterocyclic amines

Heterocyclic amines (HCAs) are the carcinogenic chemicals formed from the cooking of muscle meats such as beef, pork, fowl, and fish (Sinha *et al.*, 1998). HCAs form when amino acids (the building blocks of proteins) and creatine (a chemical found in muscles) react at high cooking temperatures. Some 17 different HCAs have been found, resulting from the cooking of muscle meats that may pose human cancer risk. Research conducted by the National Cancer Institute (NCI) as well as by Japanese and European scientists indicates that HCAs are created within muscle meats during most types of high temperature cooking. Further evaluation is needed of the relationship between methods of cooking meat and the development of specific types of cancer. One study conducted by researchers from NCI's

Division of Cancer Epidemiology and Genetics found a link between individuals with stomach cancer and the consumption of cooked meats. Those who ate their beef medium-well or well-done had more than three times the risk of stomach cancer than those who ate their beef rare or medium-rare. They also found that people who ate beef four or more times a week had more than twice the risk of stomach cancer than those consuming beef less frequently. Additional studies have shown that an increased risk of developing colorectal, pancreatic and breast cancer is associated with high intakes of well-done, fried, or barbecued meats.

2. Biogenic Amines

Biogenic amines are produced through microbial decarboxylase activity against precursor amino acids. Consequently, tyramine is produced from tyrosine, tryptamine from tryptophan, histamine from histidine, phenyl ethylamine from phenylalanine, cadaverine from lysine, agmatine from arginine, and putrescine from ornithine. Polyamines spermine and sperdimine follow a different generation route, usually originated from putrescine. Low amounts of amines consumed in meats are generally degraded in humans by the enzyme monoamine oxidase (MAO) through oxidative deamination reactions. However, when significant amounts are consumed, some risk situations like hypertensive crisis may appear due to their vasoactive and psychoactive properties. The presence of these amines in meat may be an indication of its hygienic quality. Thus, the presence of cadaverine and/or putrescine may indicate the presence of contaminating meat flora. In other cases, the processing conditions are very important for the generation of biogenic amines, especially in fermented meats where the decarboxylase activity in any of the microorganisms of natural flora or microbial starters must be carefully controlled. For instance, certain lactic acid bacteria with decarboxylase activity can generate tyramine from tyrosine (Eerola *et al.* 1996). The estimated tolerance level for this amine is 100 – 800 mg/kg (Nout, 1994), but larger ingested amounts may result in higher blood pressure and the risk of hypertensive crisis (Shalaby 1996). Other amines like phenyl ethylamine may cause migraine and increases in blood pressure. Ways to control amine generation are based on the use of starter cultures unable to produce amines but competitive against amine producing microorganisms; the use of microorganisms having amine oxidase activity; the selection of raw materials of high quality; and good manufacturing practices (Vidal Carou *et al.* 2007).

3. Oxidation

a. Lipid - Derived Compounds

Lipid oxidation is a cause of major deterioration in meat and meat products. Triacylglycerols, phospholipids, lipoproteins, and cholesterol constitute the main lipid compounds in meat that are susceptible to oxidation. Phospholipids are very susceptible to oxidation due to their high content in polyunsaturated fatty acids. Oxidation may be induced by light, metal ions (i.e., iron, copper, cobalt, manganese, etc.), or enzymes like lipoxygenase. In the case of induction by lipoxygenase, this enzyme needs activation by preformed hydro peroxide (Honikel 2009). Lipid oxidation may also be induced by hydrogen peroxide generated by peroxide forming bacteria during meat fermentation. Lipid oxidation follows a free radical mechanism consisting of 3 steps: initiation, propagation, and termination. Hydro peroxides are the primary products of oxidation, but they are relatively unstable and odourless, while the secondary products of oxidation can contribute to off-flavours, color deterioration, and potential generation of toxic compounds (Kanner 1994). These compounds are aldehydes, ketones, alkanes, alkenes, alcohols, esters, acids, and hydrocarbons. The development of rancid taste is associated with lipid oxidation, mainly aldehydes that have low threshold values. Some products of lipid oxidation may be chronic toxicants, and high levels have been reported to contribute to aging, cancer, and cardiovascular diseases (Hotchkiss and Parker 1990). Cholesterol oxidation may occur through an autoxidative process or in conjunction with fatty acid oxidation (Hotchkiss and Parker 1990). Cholesterol oxides are considered to be prejudicial for health due to their role in arteriosclerotic plaque but can also be mutagenic, carcinogenic and cytotoxic (Guardiola *et al.* 1996). Cholesterol oxides may be formed when reheating chilled meat or during the chilling storage of meat. No cholesterol oxides were reported to be detected after the heating of pork sausages (Baggio and Bragagnolo 2006), but studies made on European sausages revealed the generation of up to 1.5 μ g/g of cholesterol oxides, even though the percentage of cholesterol oxidation was below 0.17. The major cholesterol oxide found in an Italian sausage was reported to be 7 - ketocholesterol, while 5, 6 α - 5, 6 - epoxy cholesterol was the major end product in other analyzed sausages (Demeyer *et al.* 2000). The reported values were below the toxic levels, as concluded with assays performed with laboratory animals (*in vivo* tests) (Bosinger *et al.* 1993).

b. Protein - Derived Compounds

Muscle proteins may be oxidized by reactive oxygen species, for instance, the hydrogen peroxide generated by certain bacteria during meat fermentation. Oxidative damage of proteins may result in degradation or polymerization of myofibrillar proteins and alter their functionality in properties such as gelation, emulsification, solubility, and water holding capacity (Ooizumi and Xiong 2004). The main modifications of amino acids by oxidation, especially proline, arginine, lysine, methionine, and cysteine residues, consist of the formation of carbonyl derivatives (Giulivi et al. 2003). The formation of carbonyl compounds can be used as a kind of measurement of protein damage by oxygen radicals under processing conditions. Other oxidative mechanisms consist of thiol oxidation and aromatic hydroxylation (Morzel *et al.* 2006). Sulphur amino acids of proteins are those more susceptible to oxidation by peroxide reagents, like hydrogen peroxide. Consequently, cystine is oxidized only partly to cysteic acid, while methionine is oxidized to methionine sulfoxide and methionine sulfone in small amounts (Slump and Schreuder 1973). Sulfinic and cysteic acids can also be produced by direct oxidation of cysteine (Finley *et al*. 1981). The oxidation of homocystine can generate homolanthionine sulfoxide as a main product (Lipton et al. 1977). Peptides such as reduced glutathione can also be oxidized by hydrogen peroxide. The oxidation rates increase with the pH and most of the cysteine in the glutathione is oxidized to the monoxide or dioxide forms.

4. Chemicals used in processing

Food additives and processing aids are used in the manufacture of a wide range of meat products. Food additives may be added to achieve a technological function, such as preservation or colouring, and are present in the final food, whereas processing aids fulfil a technological function during processing, but are not present in the final food. The use of food additives and processing aids is regulated in the Code by maximum permitted use\ levels or according to Good Manufacturing Practice (GMP). At the end of the production chain, packaging may also lead to the unintentional migration of chemicals from the packaging material into meat products. There is a paucity of data on the levels of migration of chemicals from packaging materials into foods in general. Where information on migration is available the levels are very low and of negligible risk to human health and safety. Migration of chemicals from packaging into meat and meat products is not considered to present a risk to human health and safety.

Table 2: The main veterinary drugs and substances with anabolic effect

Group A: Substances having anabolic effect	Representative substances
1 Stilbenes	Diethylstilbestrol
2 Anthithyroid agents	Thiouracils, mercaptobenzimidazoles
3 Steroids	
Androgens	Trenbolone acetate
Gestagens	Melengestrol acetate
Estrogens	17-β-estradiol
4 Resorcyilic acid lactones	Zeranol
5 β-agonists	Clenbuterol, mabuterol, salbutamol
6 Other substances	Nitrofurans
Group B: Veterinary drugs	
1 Antibacterial substances	Sulfonamides, tetracyclines, β-lactam, macrolides (tylosin), quinolones, aminoglycosides, carbadox and olaquindox
2 Other veterinary drugs	
Antihelmintics	Benzimidazoles, probenzimidazoles, piperazines, imidazothiazoles, avermectins, tetrahydropyrimidines, anilides
Anticoccidials	Nitroimidazoles, carbanilides, 4-hydroxyquinolones, pyridinols, ionophores
Carbamates and pyrethroids	Esters of carbamic acid, type 1 and 2 pyrethroids
Sedatives	Butyrophenones, promazines, β-blocker carazolol
Non-steroidal anti-inflammatory drugs	Salicylates, pyrazolones, nicotinic acids, phenamates, arylpropionic acids, pyrrolizines
Other pharmacologically active substances	Dexamethasone
Group B: Contaminants	
3 Environmental contaminants	
Organochlorine compounds	PCBs, compounds derived from aromatic, cyclodiene or terpenic hydrocarbons
Organophosphorous compounds	Malathion, phorate
Chemical elements	Heavy metals
Mycotoxins	Aflatoxins, deoxynivalenol, zearalenone
Dyes	
Others	

The illegal addition of any of these substances to farm animals may imply that their residues could remain in the animal – treated derived foods, constituting a risk. As a result, the presence of these substances in farm animals and foods of animal origin must be monitored (Croubels *et al*. 2004).

5. Veterinary Drugs and Growth Promoters Residues

Veterinary pharmaceutical drugs have been used for a long time in animal production as therapeutic agents to control infectious diseases or as prophylactic agents to prevent outbreaks of diseases and control parasitic infections (Dixon 2001). Meanwhile, growth - promoting agents like the anabolic agents are added to improve the feed conversion efficiency by increasing the lean - to - fat ratio, while antimicrobial agents are added to make more nutrients available to the animal and not to the gut bacteria. In recent years, there has been an increasing concern regarding the development of increased bacterial resistance to certain antibiotics due to the abuse of antibiotics consumption (Butaye *et al.* 2001). Most veterinary drugs have been banned in the European Union for use in farm animals because of fears about health effects (genotoxic, immunotoxic, carcinogenic, or endocrine) from their residues in animal tissues. These substances can only be administered to animals for therapeutic purposes under strict control of a responsible veterinarian (Van Peteghem and

Daeselaire 2004). Antibiotics were banned due to concerns about the development of antimicrobial resistance (Reig and Toldra 2009).

Table 3: Maximum permissible level of antibiotics in meat.

Antibiotics	Animal species	Level (mg/kg)
Penicillin	Cattle, calves	0.050
Tetracycline	Calves, sheep, goats, pig	0.25
Tylosine	Cattle, calves, pigs	0.20
Erythromycin	Pigs	0.10
Neomycin	Calves	0.25
Ox tetracycline	Cattle, calves, pigs	0.10
Chlortetracycline Chlortetracycline Chlortetracycline Chlortetracycline	Cattle Calves and pig muscle Calf liver and kidney Pig liver	0.10 1.00 4.00 2.0
Lincomycine	Pigs	0.10

The WHO has recommended that antibiotics which are also licensed in human medicine should not be used any more as growth promoters in livestock. Not only is there a risk to human health from direct toxicity and from allergic reactions in persons sensitized to the antibiotics involved but antibiotic residues may also interfere with any microbial examinations which may be necessary in assessing the fitness of the carcass. The age restrictions have been imposed for feeding of antibiotics in animals. It is given in Table 4. If use of antibiotics is necessary as in treatment of animals a withholding period must be allowed till residues can no longer be detected. The withdrawal time and tolerance level of antibiotics in different species of animals is furnished in Tables 5, 6 and 7.

Table 4: Age restriction on feeding antibiotics.

Species	Age
Swine	4-6 weeks
Poultry	8-10 weeks
Lamb	2 months
Fur bearing animals	2-3 months
Calves	3 months
Beef Cattle	18 months

Table 5: Withdrawal time and tolerance level of antibiotics in cattle.

Drugs	Pre-slaughter withdrawal time (days)		
	Oral	Injectables	Tolerance level (ppm)
Ampicillin	15	6	0.01
Bacitracin	0	-	0.05
Chlortetracycline	10	10	0.10
Dihydrostreptomycine	10	30	-
Erythromycin	-	14	0
Neomycin	-	-	0.10
Procaine penicillin	-	10	0.05
Ox tetracycline	7	22	0.10
Sulphamezathine	21	-	0.10

Table 6: Withdrawal time and tolerance level of antibiotics in sheep and goats

Drugs	Pre-slaughter withdrawal time (days)		
	Oral	Injectables	Tolerance level (ppm)
Dihydrostreptomycine	-	30	-
Erythromycin	-	3	-
Procaine penicillin G	-	9	0
Chlortetracycline	2	-	-
Sulphamezathine	10	10	-
Sulphaquinoxaline	10	-	-

Table 7: Withdrawal time and tolerance level of antibiotics in chickens.

Drugs	Pre-slaughter withdrawal time (days)	Tolerance level (ppm)
Bacitracin	0	0.05
Chlortetracycline	1	0
Erythromycin	2	0.125
Gentamycine	35	-
Streptomycin	4	0.10
Carbomycine	1	0
Monensine	5	0.05
Tylosine	5	0.20

Hormones are used for therapeutic and growth modifying purposes in animals. They are important because they may be associated with neoplasia. The beta agonists are used to produce less fatty meat from cattle as they have the activities of neurotransmitter and of hormones and as such have both physiological and metabolic activities. They are important in residue analysis because they have major metabolic effects by repartitioning energy from fat to lean meat production. There are about 20 beta-agonists *e.g.* cematerol, clenbuterol, salbutamol, mabuterol which are added to cattle feed to reduce the fat content of the carcass liked by the consumers. For this effect, the dose required is several times greater than therapeutic. At this concentration residues accumulate in the edible tissues of cattle like kidney or liver.

Table 8: Maximum residue levels for Hormones/ beta-agonist in food animals.

Carazolol ADI is 0- to 0.1 µg/kg b. wt.	**Clenbuterol** ADI is 0- to 0.004 µg/kg b. wt.
Pig Muscle 5 Liver 25 Kidney 25 Fat/ skin 5	Cattle Muscle 0.2 Liver 0.6 Kidney 0.6 Fat 0.2 Milk 0.05
Estradiols ADI is 0- to 0.05 µg/kg	**Melengestrol Acetate** ADI is 0- to 0.03 µg/kg
Cattle Muscle UN Liver UN Kidney UN Fat UN	Cattle Muscle 1 Liver 10 Kidney 2 Fat 18
Ractopomine ADI is 0- 1 µg/kg	**Progesterone** (ADI is 0-30 µg/kg) & Testosterone (ADI is 0- 2 µg/kg)
Cattle Muscle UN Cattle Muscle 10 Liver 40 Kidney 90 Fat 10	Cattle Muscle 1 Cattle Muscle UN Liver UN Kidney UN Fat UN
	Zeranol ADI is 0- to 0.5 µg/kg
Pig Muscle 10 Liver 40 Kidney 90 Fat 10	Cattle Muscle 2 Liver 10

6. Environmental Contaminants

There are a wide variety of environmental contaminants. The main concern is that they may be present in the feeds consumed by farm animals and thus contaminate the resulting meats.

a. Pesticides

Some well known contaminants are dioxins, organophosphorous, and organochlorine pesticides. These contaminants are quite extensive worldwide, making their control very difficult. The term "persistent organic pollutants" (POPs) was defined by the United Nations Environment Programme as those persistent chemical substances that can accumulate in foods and cause adverse effects to consumers. Most of the organochlorine pesticides were banned during the 1970s and 1980s, but they are persistent and stable and may remain in the environment for many years, constituting a risk of long - term exposure (Moats, 1994). These substances tend to be accumulated in the fatty tissue of living organisms. Current maximum residue limits in the

EU for the organochloride pesticides that can be present in animal products are within 0.02 and 1 mg/kg of fat, while in the United States they are established between 0.1 and 7 mg/kg fat (Iamiceli *et al.* 2009). The contaminants described above, as well as polychlorinated biphenyls (PCBs) (a family of 209 compounds that were used in lubricating oils and heat exchange fluids) can be present in feeds used for farm animals. The reasons for such contamination are varied: use of contaminated ingredients, lack of control of the ingredients, inadequate processing etc. (Croubels *et al.* 2004). Environmental contaminants are rather difficult to control, even though they can exert potential toxicity in the product (Heggum 2004). The use of pesticides have no doubt helped immensely in the success of India's green revolution, but these are also the agents polluting water, air and land and posing serious threat to public health, by entering in to food chain. However, since 1993, after imposing ban on some of these pesticides in India, their levels have declined and residues were below the recommended ADI.

Agnihotri (1999) has suggested some recommendations as given below which need attention to overcome the worsening situation.

1. Adoption of Integrated Crop Management System (ICMS)
2. Encouragement of organic farming.
3. Application of more biodegradable pesticides
4. Strict ban on use of organo-chlorine pesticides

5. Treatment of pasture/food crops much grazing or harvest.
6. Adoption of genetically modified insect pest resistant seed for commercial cultivation.
7. Agrochemical companies should provide pesticide guide (environment data sheet, dose rate efficacy of individual pesticide etc.) to the farmers.

b. Heavy Metals

Heavy metals such as lead, iron, cadmium, mercury, chromium, copper and nickel, together with the metalloid, arsenic in their many compounds in nature all enter man's food chain from the soil or from water in the first instance (Bock, 2007). Since man has always been exposed to certain low levels of many of the chemical contaminants known today, a population would have to be subject to exposure at well above average levels to detect an increased incidence of a health effect. The levels of heavy metal residues which have been found in food in recent times have only been detected by sophisticated developments in analytical methodology. Whereas ten, or even five years ago, the detectability and sensitivity of an analytical method was expressed in terms of milligrams, or micrograms, today, the nanogram and picogram are invoked with increasing frequency (Saegerman *et al.*, 2006).

Table 9: Current status of organochlorine pesticide in India.

Pesticide	Status
Aldrin	Banned
Benzenehexachloride	Banned (w.e.f. 1.4.1997)
Chlordane	Banned
Chlorobenzilate	Permitted for mite control
DDT	Restricted use (banned in agriculture)
Dicofol	Used for mite control on tea plantations
Dieldrin	Restricted use (for locust control in
Endosulfan	deserts)
Endrin	Used for agricultural pest control
Heptachlor	Banned
Gamma-HCH	Banned
	Restricted. Not permitted for indoor use.
Pentachlorophenol	Used for field application on crops.
(PCP)	Banned
Pentachloronitrobenzene	Banned
Toxaphene	Banned
Tetradifon	Banned

c. Mycotoxins

Problems from molds and mycotoxins have considerable worldwide significance in terms of public health, agriculture, and economics. Examples of molds affecting health include.

Aflatoxin

metabolic products of the molds *Aspergillus flavus* and *A. parasiticus*, may occur in food as a result of mold growth in a number of susceptible commodities including peanuts and corn. Other domestic nuts and grains are susceptible but less prone to contamination with aflatoxins. Because aflatoxins are known carcinogens to laboratory animals and presumably man, the presence of aflatoxins in foods should be restricted to the minimum levels practically attainable using modern processing techniques.

Ochratoxin A is a naturally-occurring nephrotoxic fungal metabolite produced by certain species of the genera Aspergillus and Penicillium. It is mainly a contaminant of cereals (corn, barley, wheat, and oats) and has been found in edible animal tissues as well as in human blood sera and milk. Studies indicate that this toxin is carcinogenic in mice and rats. It is not completely destroyed during the processing and cooking of food, therefore the implication for risk to human health and safety must be considered.

CONCLUSION

There are extensive regulatory and non-regulatory measures in place to ensure that chemicals used or present in meat and meat products present a very low public health and safety risk. The regulations and control measures currently in place along the meat primary production chain have resulted in minimal public health and safety concerns regarding the use or presence of chemicals in meat and meat products. The extensive monitoring of chemical residues in meat over many years has demonstrated a high level of compliance with the regulations. Continuation of the current management practices, particularly monitoring programs for chemicals along the primary production chain, will ensure that the meat industry continues to maintain a high standard of public health and safety. Thus, by observing proper scientific guidelines and precautions we can minimize the harmful effects of antibiotic residues.

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