Animal Husbandry Practice to Contaminants and Residues of Chemical in Animal Origin Foods and Health Hazard

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Abstract The consumers increased awareness of a growing chemicalization of animal origin foods (milk, meat, eggs and their products) presents a challenge to the dairy, meat and poultry industry. A great number of chemical compounds are used either directly or indirectly during the production, processing and storage of it. 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 and this matter is of greatest concern worldwide, as all these factors are causing contamination of food leading to adverse effects of pollutant residues on human health. The stable to table approach to food safety is a holistic approach embracing all elements, which may have an impact on the safety of food, at every level of the food chain from animal feed manufacturers to consumers. The potential for human exposure to hazardous chemical pollutants through consumption of animal origin foods is an issue wrought with scientific and emotional complexities. Animal origin foods are particularly susceptible to contamination with veterinary drugs, pesticides, heavy metals, aflatoxins, Polychlorinated Biphenyls (PCBs), Polychlorinated dibenzodioxins and furans (PCDD/Fs), nitrate/nitrite/nitrosamines and detergents/disinfectants to a lesser or greater extents for several reasons. However, the major sources of exposure to hazardous chemical pollutants and environmental chemicals may contaminate animal feed and constitute a hazard not only to animal health but also to human.

Keywords Animal husbandry; Contaminants; Animal origin foods; Animal health

Introduction

The contaminant that adversely alters the physical, chemical and/or biological properties of the environment is known as pollutant. The chemical pollutant residue is a potentially harmful chemical substance, of anthropogenic or natural origin, present in food following deliberate treatment or accidental contamination during the production, transformation or preservation of foodstuffs (Saegerman et al., 2006).

The veterinary drugs and active compounds associated with animal origin foods are chemotherapeutics (antibiotics and sulphonamides), endoparaciticides (fasciolicides and anthelmintics), ectoparaciticides, hormones, and teat and skin disinfectants (Schuler, 2005 and Eeckhout et al., 1998). Antimicrobial residues in these foods should be taken into account for health aspects, like possible impact on the emergence of antimicrobial resistance for antimicrobials administered in human therapy, disorders of the intestinal flora and possible occurrence of allergic symptoms. In dairy industry, antimicrobial residues cause economical losses. In fermented milk products, the effect of antimicrobials is seen in a slow or inhibited acid formation and in a decrease of aroma formation. The concentration of antimicrobials required to inhibit different starter strains are strain dependent (Khan et al., 2003). Maximum

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residue limits (MRL) levels, maximum concentration of pesticide residue recommended by Codex Alimentarius Commission to be legally permitted in or on food commodities and animal food (Roy, 2003), are generally lower than the level, which inhibit lactic acid bacteria, bifidobacteria and propionic acid bacteria. However, very low levels of antibiotics can cause defects in cheese, like off flavours, uneven texture, uneven eye development and tendency for butyric acid fermentation (Khan et al., 2003).

During the past 4~5 decades, the variety and usage of pesticides have increased in India and worldwide. Since, it was recognized that pesticides are needed to produce an economical and high quality food production (Riva and Andon, 1991); pesticides are used in agricultural which are expected to result in residues in or on food and feed. These residues through food chain enter the human body. The principal route of exposure is the consumption of food particularly leafy and root vegetables, fatty meat, fish and poultry. Monitoring studies done in India have revealed wide spread contamination of fruits, vegetables, milk, meat and their products with pesticide residues (Pandit et al., 2002 and Bedi et al., 2005). That’s why the use of OCPs like dichlorodiphenyl trichloroethane (DDT) and hexachlorocyclohexane (HCH) has either been banned or restricted in agriculture in India but are still being used in public health programmes for the control of vector borne diseases such as malaria, filaria and kala azar etc (Merai and Boghra, 2004).

Following list of hazardous chemical contaminants and residues in animal origin foods (Saegerman et al. 2006).

1. Veterinary drugs and pharmacologically active compounds
2. Pesticides / residues
3. Heavy metals, other trace elements and radio nuclides
4. Mycotoxins
5. Polychlorinated Biphenyls (PCBs), Polychlorinated dibenzodioxins and furans (PCDD/Fs)
6. Nitrate, nitrite and nitrosamines
7. Detergents and disinfectants.

**Veterinary Drugs and Pharmacologically Active Compounds**

In every case the diseased animal is treated directly, either orally, parenterally or by cutaneous application, by spraying, dusting or pour-on (spot-on) application of the veterinary remedy. All the antimicrobial drugs administered to cows can enter the milk to some degree (Roy, 2003 and Klassen, 2001). This leads to an immediate contamination of the prospective food compartments of the treated organism within just a few minutes. The transfer of residues into milk, if any, originates from absorbed parts of the dose passing the blood-milk-barrier in the mammary gland (Nigam and Siddiqui, 2001). A drug administered to a milk producing animal has a withdrawal period, during which the drug residue should fall below a predetermined level. A residue can be the drug itself or its metabolites. The dominating residues in most countries are β-lactam antibiotics and sulfa drugs, but others e.g. tetracyclines, aminoglycosides, chloramphenicol also occur. A lot of hormones like, steroid anabolics and β-agonists which are being used illegally for growth promotion of animal (Schuler, 2005). The testing of residue is significance for ethical, public health, dairy technological and environmental reasons. Though the level of antibiotic residues in milk remains very low and the human health risks associated with these residues are small, as compared to other contaminants (Eeckhout et al., 1998).

<table>
<thead>
<tr>
<th>Anti-infectious agent</th>
<th>MRLs (ppm)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Codex EC</td>
</tr>
<tr>
<td>Benzylpenicillin</td>
<td>4</td>
</tr>
<tr>
<td>Ampicillin, Amoxycillin</td>
<td>4</td>
</tr>
<tr>
<td>Cloxacillin</td>
<td>30</td>
</tr>
<tr>
<td>Ceftriaxone</td>
<td>100</td>
</tr>
<tr>
<td>Cefquinome</td>
<td>20</td>
</tr>
<tr>
<td>Tetracylines</td>
<td>100</td>
</tr>
<tr>
<td>Oxytetracylines</td>
<td>100</td>
</tr>
<tr>
<td>Tylosin</td>
<td>50</td>
</tr>
<tr>
<td>Erythromycin</td>
<td>40</td>
</tr>
<tr>
<td>Dihydrostreptomycin</td>
<td>200</td>
</tr>
<tr>
<td>Gentamycin</td>
<td>100</td>
</tr>
<tr>
<td>Neomycin (+ Framycetin)</td>
<td>500</td>
</tr>
<tr>
<td>Marbofloxacin</td>
<td>75</td>
</tr>
<tr>
<td>Sulfadimidine</td>
<td>25</td>
</tr>
<tr>
<td>Trimethoprim</td>
<td>50</td>
</tr>
</tbody>
</table>

Table 1 The MRLs for residues of antimicrobials and chemotherapeutics in milk as per Codex and/or EU
Maximum Residue Limits

The MRLs for residues of antimicrobials and chemotherapeutics in milk provided by Codex and/or EU are listed in Table 1 (Merai and Boghra, 2004).

Pesticides Residues

Synthetic organic insecticides are most widely used and consist of three main classes, viz. organochlorines pesticides (OCPs), organophosphates pesticides (OPs) and carbamates. Organochlorine pesticides have been used in agriculture and livestock for quite a long time to control a variety of crop pests and animal ectoparasites. They have also been employed to combat vectors of malaria and some other deadly diseases of human being. Of late, some of the compounds belonging to OCPs like aldrin, dieldrin, heptachlor, DDT, HCH, etc. which are also important constituents of the toxic group known as persistent organic pollutants (POPs), have been banned or restricted in Table 2.

Table 2 Current status of organochlorine pesticide in India

<table>
<thead>
<tr>
<th>Pesticide</th>
<th>Status</th>
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</thead>
<tbody>
<tr>
<td>Aldrin</td>
<td>Banned</td>
</tr>
<tr>
<td>Benzenehexachloride</td>
<td>Banned (w.e.f. 1.4.1997)</td>
</tr>
<tr>
<td>Chlordane</td>
<td>Banned</td>
</tr>
<tr>
<td>Chlorobenzilate</td>
<td>Permitted for mite control</td>
</tr>
<tr>
<td>DDT</td>
<td>Restricted use (banned in agriculture)</td>
</tr>
<tr>
<td>Dicofol</td>
<td>Used for mite control on tea plantations</td>
</tr>
<tr>
<td>Dieldrin</td>
<td>Restricted use (for locust control in deserts)</td>
</tr>
<tr>
<td>Endosulfan</td>
<td>Used for agricultural pest control</td>
</tr>
<tr>
<td>Endrin</td>
<td>Banned</td>
</tr>
<tr>
<td>Heptachlor</td>
<td>Banned</td>
</tr>
<tr>
<td>γ-HCH</td>
<td>Restricted. Not permitted for indoor use. Used for field application on crops.</td>
</tr>
<tr>
<td>Pentachlorophenol (PCP)</td>
<td>Banned</td>
</tr>
<tr>
<td>Pentachloronitrobenzene</td>
<td>Banned</td>
</tr>
<tr>
<td>Toxaphene</td>
<td>Banned</td>
</tr>
<tr>
<td>Tetrachlorfon</td>
<td>Banned</td>
</tr>
</tbody>
</table>

It was observed that organophosphates and carbamates due to their easy metabolism do not create problems. These compounds get degraded or destroyed during feed processing or in rumen of the animals (Merai and Boghra, 2004). However, OCPs owing to their lipophilic nature can get deposited and concentrate in body fat (Pandit et al., 2002). The residues being insoluble in water can remain in the environment for longer time as well as enter the food. The OCPs owing to their high persistence nature due to chemical stability and lipophilic character accumulate in different environmental compartments and in food chain thus causing elevated contamination in human body. These residues bio concentrate in lipid rich tissues according to equilibrium pattern of internal transport and lipid tissue content and decline at a very slow rate even after sources of contamination are eliminated (Agnihotri, 1999; Anonymous, 1999).

The contamination of animal origin foods with pesticide residues is never as a result of a direct treatment of these food products. The normal route is the indirect pathway through animal’s body, yielding secretory residues of such pesticides, which can pass the blood-milk barrier. Pesticides/residues also enter milk and milk products through air, soil, plants or animal feeds, water, parasitic control of animals and control of insects in the products manufacturing areas, as well several miscellaneous factors (Pandit et al., 2002). The possibilities of contamination of milk and milk products with DDT and HCH are mainly through feed and fodder and some times due to spraying of animal dwellings to keep the animals free from insect pests. DDT deposits on walls gradually volatilize and vapours are absorbed in to the animal body through inhalation and direct absorption through skin. The organochlorine pesticides are the most persistent,
bio-accumulative, lipophilic and therefore accumulate in plant and animal tissues. These properties cause them to rapidly absorb in the fatty tissues for long period even in an unchanged form. These pesticide deposits are metabolized at the time of lactation or stress and secreted into milk (Khan et al., 2003).

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 into 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 organochlorine 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.

**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). Not surprisingly, the ease with which consumer concern can be aroused and both food manufacturers and regulatory authorities criticized increases with each succeeding report in a world striving unrealistically towards absolute purity. Much of this criticism may be ill-informed but regulatory authorities responsible for public health could be failing in their duty if they did not consider the implications for public health of both the contaminants themselves and levels at which these occur in food and the environment (Tarek, 2004 and López Alonso et al., 2000).

Heavy metal contamination may originate through ingestion by the animals (feed, fodder, drinking water, pharmaceutical medicines etc.), during transportation, processing and storage of milk and milk products, food additives and from environment (motor emission etc.). The principal routes of metal contamination of milk and milk products are the secretory route (after uptake by the cow) and the post secretory route (only limited importance and usually restricted to isolated incidents). The post secretory route is caused by unsuitable surfaces or equipment coming in contact with milk, especially when the pH is lowered through fermentation processes Swarup (2005). In modern dairy plant, where stainless steel, aluminium or plastic polymers are exclusively used for storage and manufacturing processes, practically no secondary contamination will occur, providing good manufacturing practice including cleaning with acids or alkali is carefully performed. The principal route of exposure of the dairy animal to the metals is naturally occurring concentrations in the forage. Other sources are accidental access to limed fields. Mineral supplements with high content of trace metals and licking of painted surfaces containing metallic pigments. The movement of metals in the ecosystem, combining natural pathways and man made influences is shown in figure 1 (Bock, 2007 and Merai and Boghra, 2004).
Polychlorinated Biphenyls (PCBs)

Schuler (2005) reported that commercial PCBs are mixtures of chlorinated, biphenyl with varying percentage of chlorine by weight. The properties of enhanced chemical stability, low solubility in water, low flammability and excellent insulating properties provided many commercial advantages for the use of PCB as heat transfer fluids, flame retardants, lubricating and hydraulic oils, additives in plastics and in myriads of other applications. Chemically, there are 209 chlorinated biphenyls ranging in degree of chlorination from the 3 monochlorinated congeners to the fully chlorinated decachlorbiphenyl congener. They are extremely stable and undergo biomagnifications; i.e. their bioaccumulation increases at every tropic level.

Originating from environment sources such as soil, water and air, the PCBs are distributed mainly by atmospheric transport either in the gaseous phase or condensed as aerosols. PCBs were introduced in 1929 and were first detected in the milk of cow in 1970. PCB free milk is not likely to be found due to the worldwide spread of PCBs and the continuous replenishment of the depot in soil and oceans from the atmosphere. The presence of PCBs in milk has been traced to cattle feed and other sources such as silos coated with sealant or paint, oils and grease containing PCBs, sewage sludge application to agricultural pasture. Food packaging materials that contain PCBs in printing inks also may contaminate the food products they hold (Schuler, 2005). The average concentrations of PCBs # 153 in milk fat are in the order of 5 µg/kg or less as is shown by survey of European milk fat. Human milk has also been reported to contain PCBs (50–300 ng/kg).

Polychlorinated Dibenzodioxins and Furans (PCDD/Fs) Compounds

During the last two decades there has been growing interest in a group of substances called dioxins. Dibenzofurans are also mentioned in connection to toxicity (Schuler, 2005). They are a mixture of 210 different chlorinated congeners and exhibit high priority pollutants in environment, food and public health care.

These chlorinated hydrocarbons enter the milk presumably through the contamination the grass with smoke particles, food packaging paper and plastics. Both of the compounds are lipophilic, chemically stable and of low volatility. The 2, 3, 7, 8, TCI (Tetrachlorodibenzo-p-dioxin) has received the more attention as it has the greatest toxic potency all the chlorinated dioxins and furans (Schuler, 2005). This dissipation into the global environment is through emissions and aerosols. Once in the global environment, they are largely immobilized due to their strong absorption to particles and insolubility in water.

Recycling of animal fats into animal feed is a major source of concentrated dioxin-like chemicals. Cow fat is routinely fed to pigs and chickens and pig and chicken fat to cows, thus increasing the concentration of these contaminants in these animals. Choosing meat carefully, such as from grass-fed animals, avoids this problem (Schuler, 2005).


These guidelines are intended to help competent authorities and stakeholders, especially farmers, to fully assume their responsibilities at the first stage of the food chain to optimise the food safety control of products of animal origin offered to consumers. The recommendations in these guidelines serve as a tool to help competent authorities at the farm level, particularly Veterinary Services, to fulfill their responsibilities.

The guidelines presented here cover eight areas of
primary production in which preventive actions can usefully be implemented; they are, as follows:

a) Buildings and other facilities: surroundings and environmental control
b) Health conditions for introduction of animals into the farm
c) Animal feeding
d) Animal watering
e) Veterinary drugs
f) Farm management
g) Preparation of animals for slaughter
h) Common measures for record keeping and traceability.

As far as animal products and products of animal origin are concerned, this inevitably means controlling the health status of the animals from which these food products are derived. Animal health status must be assessed with regard to any infectious (bacterial and viral) or parasitic agents, and especially zoonotic agents, that they could be carrying at the primary production stage. The possibility of the animals having ingested and possibly accumulated chemical (drug residues, pesticides, heavy metals, etc.) or physical contaminants (radioactive elements, foreign bodies, etc.) during their lifetime must also be addressed.

Any such biological, chemical and physical agents present in the body of the live animal may contaminate animal products (milk, meat, fish, eggs, etc.) at levels that are unacceptable in terms of public health. Controlling the safety of food of animal origin at the primary production stage therefore involves all the measures (implemented at the farm or production unit level) necessary to ensure that these contaminants do not end up in animal products, or, if they do, that their levels do not exceed the maximum permissible levels, notably the maximum residue limits and microbiological criteria set by the CAC.

The tools for controlling food safety, namely the codes of hygienic practice and the hazard analysis and critical control point system, have proved their effectiveness at the secondary production and distribution stages. It is clearly appropriate to try to apply them wherever possible at the primary production stage of animal products, in other words at the farm or production unit level, whenever an appreciable improvement in the level of the control of food safety may result.

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