Chemical Residues in Meat

A large number of drugs used to control or prevent infections or to promote growth are considered essential by some authorities in modern animal production systems. Additional chemicals may be added to food to ensure maximum utilization and to delay deterioration. However there is growing consumer resistance to the presence of unwanted residues in food. The principal consumer concerns are drug resistance, toxicity and potential allergy. Drug resistance has been postulated as a problem both from the effect that trace residues may have in stimulating resistance in or transferring resistance from non-pathogenic bacteria in the meat *to,* pathogenic bacteria within the consumer's digestive system. Drugs are intended to be toxic to various forms of parasite and as such may have inherent toxic, mutagenic, teratogenic or carcinogenic effects. Penicillin ranks highly among the known allergens and can invoke an allergic reaction in consumers eating food containing sufficient residual drug. **A *residue* is defined** in (EC Directive 96/23/EC) **as 'a residue of substances having a pharmacological action, of their metabolites and of other substances transmitted to animal products and which are likely to be harmful to human health'**. Almost all chemicals administered knowingly or unknowingly to animals result in some trace residue remaining in the carcass. Increasingly, laboratory technology is able to detect these minute traces. It is therefore important to differentiate between safe and unsafe residual concentrations rather than to insist on zero residues.

Residues can occur for a variety of reasons.

1- Clearance rates for drugs can vary. Conditions that prolong the process can lead to tissue residues at slaughter. For example, even when drugs are used according to recognized doses and routes of administration and when preslaughter

withholding times are observed, other parameters, e.g. disease conditions, age of animal and husbandry practices can result in violative tissue residues.

2- Drugs are also sometimes administered to food-producing animals at a dose rate in excess of the recommended level by unauthorized routes or at more frequent intervals than specified. These therapies can alter the *withholding time required to* ensure that all tissues are clear of residues (Mercer *et al.*, 1977).

3- Veterinary surgeons can administer drugs, approved for use in one country but not in another, to deal with local disease problems

4- The pharmacokinetics (movement of drugs in the body) of specific preparations has a major effect on persistence in the animal tissue and is dependent on several factors.

a- Formulations can give slow or rapid release. Current trends favour the use of slow-release formulations, both to prolong therapeutically-active concentrations of therapeutic drugs in tissues and to minimise the stress involved in repeated handling of animals.

b- The chemical composition of some drugs prevents rapid metabolism and, in some animals in which the metabolic processes are reduced as result of disease, persistence can occur.

c- The route of administration, e.g. by injection, orally or other means, also affects the rate of excretion. An injection into poorly vascularised tissue can result in slower absorption than expected from studies on normal tissues.

d- The recommended withholding time for the residue to fall into the acceptable range should be based on the tissue with the slowest decay rate.

5- The therapeutic products that cause concern fall into a number of categories. The major ones are *antimicrobials*, which are a diffuse group containing several classes of compounds used to treat or prevent bacterial infection. The *pesticides* are also a diffuse group including anthelmintics used for their activities against roundworms, tapeworms, and fluke, ectoparasiticides used to kill external parasites such as mange, sheep scab mites or lice, and antiprotozoals which are most commonly used for the control and treatment of coccidiosis and babesiosis. *Hormones* are used for therapeutic purposes in various fertility treatments or for growth promotion and are administered as injection or implant. One general category includes *tranquillisers* and β-agonists.

The safe use of veterinary medicines

The following advice to farmers has been issued by the Veterinary Medicines Directorate of the UK Ministry of Agriculture, Fisheries and Food:

1- Source of medicines

• The supply of veterinary medicines is controlled by law.

• Buy medicines only from your veterinary surgeon, a registered distributor or a pharmacist.

• Medicines from unauthorized sources may not be safe or effective.

• Only purchase or use licensed products. Under the new regulations you are committing an offence if you use an unlicensed product unless it has been prescribed by your veterinary surgeon.

2- Administration of medicines

• Certain medicines may only be administered under the supervision of a veterinary surgeon or according to a veterinary prescription.

• Read instructions for the current use and administration of the medicine and ensure that you understand the directions.

• If in doubt, ask your veterinary surgeon for advice on how to administer medicines.

• Check dosage levels.

• Check route and site for administration.

• Unless it has been prescribed by your veterinary surgeon, use a medicine only in the species of animal for which it is approved. Check the label or leaflet.

• carry out the treatment program.

3- Withdrawal times

• Check and observe the withdrawal period laid down for that particular medicine. Under the new regulation you have a legal obligation to observe the withdrawal period. Check the label for details.

• Do not sell for slaughter, or slaughter, animals before the end of the withdrawal period. Under the new Regulations you will be committing an offence if you do.

4- Record keeping

• Record keeping should help to ensure that withdrawal periods for animal medicines are observed.

• You have a legal obligation to keep records of the administration of medicines, including in-feed medication.

REMEMBER Farmers who already follow sound management practices have nothing to fear from the new controls.

Acceptable daily intake (ADI)

The term *acceptable daily intake* was first used by the joint FAO/WHO Expert Committee on Food Additives (JECFA) in 1958. The most recent definition is **'an estimate of the amount of a food additive, expressed on a body weight basis that can be ingested daily over a lifetime without appreciable health risk'** (FAO/WHO, 1987). Calculation of the ADI depends on the toxicological effects as determined by ac ute and chronic animal studies involving genotoxicity, carcinogenicity, mutagenicity, teratogenicity neurotoxicity and effects on the immune and reproductive systems. These result in a defined maximum quantity which may be consumed daily by even the most sensitive group in the population without any untoward effects.

Maximum residue levels (MRLs)

No chemical is safe under all conditions of use. **The *maximum residue level* (MRL) is a concept developed to estimate the maximum acceptable human intake over a lifetime.** It is adjusted to accept dietary intakes which are at the extremes of expected consumption of tissues containing the highest residue concentrations. It is generally accepted that the MRL of an analytic of any foodstuff is determined by three factors:

1- A minimum dose which produces detectable effects in experimental animals or which, in a therapeutic preparation used in human medicine produces a recognizable effect

2- A safety factor in the range 10:1000 and which is lower (1:10) if a preparation is already acceptable in human medicine or higher (1:1000) if there is any evidence to indicate a special risk from experience with chemically similar compounds.

3- A series of factors to balance the proportions of the particular tissues in the normal diet.

An MRL can give no more than a conservative indication of levels that are considered unlikely to pose any toxicological hazard to humans.

Type of chemical residue in meat

ANTIMICROBIALS

In mammals the most numerous and most frequently used drugs in this group are the *antibiotics.* An *antibiotic* is a chemical substance, produced wholly or partly by a microorganism (usually a fungus or a bacterium), which has the capacity to inhibit the growth of or to kill bacteria. These drugs can be used therapeutically in short courses of treatment to control disease in animals or, at lower concentrations but over a longer time, to promote growth. The latter use occurs most frequently in young calves, pigs and poultry. In the adult ruminant, alterations in the ruminal flora may reduce efficiency of digestion, growth and weight gain. When used therapeutically, antibiotics can reduce the symptoms of disease and may result in unhealthy animals being accepted at ante-mortem inspection. *Antimicrobials* are a difficult group to detect chemically because they are diverse and show great variation in their chemical structure and molecular weights. They are also used in a wide range of formulations and are administered by many routes. However, not all antibiotic residues retain activity after metabolism in animal tissues and in a significant number of cases the drug continues to be metabolised by tissue

enzymes cold storage. It is essential that the inspection team remain constantly vigilant for the *potential abuse of antibiotics* throughout the inspection procedure. At ante-mortem and post-mortem the presence of disease conditions such as pleuropneumonia or arthritis in pigs and sheep or chronic mastitis in cows, may suggest that an antibiotic has been administered recently. Recent *injection sites* may appear as an area of discoloration or bruising, but frequently deep intramuscular injections can only be detected as a very slight swelling or lack of symmetry in the muscle. If there is any suspicion, the carcass must be retained until samples prove negative to laboratory investigation.

Tests for antimicrobial agents

The most frequently used tests for antimicrobial agents are based on the detection of residual antimicrobial activity. The basic microbiological method is the *four-plate test* (FPT). This test has the advantage of requiring simple apparatus and limited training for analysts, and of having rapid turnaround and broad spectrum detection.

Growth promoters (hormones and antibacterials)

1- Natural sex steroid hormones

2- Synthetic steroid androgens

3- Synthetic non-steroidal oestrogens

4- Synthetic steroidal progestens

5- Peptide hormones

6- β-Adrenoceptor agonists (beta-agonists)

7- Antibacterial

PESTICIDES

Pest control chemicals must be toxic to some living organisms to fulfil their role. Depending on the pest being controlled, they may be termed insecticides, fungicides, etc.

Insecticides

The *chlorinated hydrocarbons* are extremely durable, persistent and bioaccumulation compounds which find their way into the food chain usually through use in controlling environmental or animal pests.

Anthelmintics

Pesticides used to remove *internal parasites* such as liver fluke and nematodes are important in animal production systems.

Heavy metals

Excessive intakes of *heavy metals* in food have caused intoxications in man. These are most often caused by contaminated cereals or by accidental additions during processing. Occasionally, toxic concentrations occur in animal tissues and products. These can be associated with soils naturally high in the element or through environmental contamination from local industry and are cumulative in animal tissues. They may also occur from feeding grain treated with the toxic metal or from excess amounts remaining in the environment following previous use in paints, etc. These toxic chemicals are detected by *atomic absorption spectrometry.*

Arsenic

Although restrictions have been placed on the use of *arsenic* because of Its toxicity, this element was once widely used in farm practices and is persistent in the environment.

Lead

Lead can accumulate in the tissues of animals grazing close to smelting plants or in .animals ingesting paints or substances w ith high lead contents.

Mercury

Mercury preparations containing inorganic salts or organic mercurial compounds have been used widely in agricultural and horticultural dressings and in veterinary medicines.

Selenium

Selenium is an essential element for animals and man. Although it is widely distributed, areas of deficiency and of toxicity occur. The most common sign of

selenium deficiency is flaccid white muscle.

Cadmium

Cadmium has received much attention because of its reported toxicity to humans. This metal accumulates in body tissues and is said to cause kidney failure.

OTHER SUBSTANCES

Fluorine

Cases of *fluorosis* have been reported in cattle grazing pasture contaminated with industrial discharges.

Copper

Copper-supplemented feeds are prepared for pigs. The metal tends to be accumulated in the liver and kidney.

NATURAL TOXINS

Mycotoxins

Mycotoxins are products of toxigenic moulds (fungi) growing in food and foodstuffs. These agents have caused many problems in livestock, and the potential for residues in meat, poultry or dairy products is a cause for public concern.

Shellfish toxin

Shellfish tissues can contain at least three different groups of natural toxins which are grouped according to the clinical signs produced in the consumer: paralytic shellfish toxins, diarrhoetic shellfish toxin and anamnestic shellfish toxin. These result from the accumulation of toxins produced by algae in the environment which are eaten by the shellfish.