PESTICIDE MANAGEMENT IN THE FIELD AND ITS RELEVANCE TO RESIDUES IN FEED GRAINS

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INTRODUCTION

Animal feeds are prepared from materials of plant and animal origin along with several supplements. Consequently, animal feeds may contain contaminants and toxins from various sources. Animal feeds can be contaminated with industrial pollutants, heavy metals, radionuclides, microorganisms and toxins from microorganisms, toxic substances from plants, especially fodder plants, and residues of pesticides accumulated by the plants during their growth from chemicals persistent in the environment (soil) or from chemicals used to manage pests during crop production in the field and during storage of harvested commodities. In addition, feed stuffs may also contain veterinary drugs (Kan and Meijer 2007). The contaminants and toxins in animal feeds will negatively affect the quality and safety of the feed. Furthermore, contaminants and toxins in feed tend to accumulate in animal tissues and products and could subsequently impact human health.

Dioxins and polychlorinated biphenyls (PCBs) are industrial pollutants that could contaminate feeds made from vegetative parts of plants. In 1999, dioxin-contaminated animal fat was accidentally added to animal feeds intended for Belgian, French, and Netherlands farms. High levels of dioxins were later found in meat products and eggs from farms in these countries (D'Mello 2004). The Chernobyl accident in 1986 led to contamination of pastures with cesium-134 and cesium-137 radionuclides. Milk and sheep carcasses were contaminated and the movement and slaughter of sheep was therefore restricted (MAFF 1994).

Several species of bacteria are associated with animal feeds and these include *Escherichia coli*, *Salmonella* spp., *Listeria monocyotegenes*, and *Campylobacter* spp. *Salmonella enterica* has been reported in cattle feeds from the United States, Europe, and South Africa, and the contamination rates ranged from 5 to 19% (Krytenburg *et al.* 1998).

Several species of fungi are associated with animal feeds and the fungal species include *Aspergillus*, *Fusarium*, *Penicillium*, and *Alternaria* (D'Mello *et al.* 1993, Dhand *et al.* 1998), and mycotoxins produced by the fungi can affect animal health and reproductive performance (D'Mello and Macdonald 1998). Fumonosins B1 and B2 were present in more than 50% of the maize samples collected from Philippines, Thailand, and Indonesia, and these toxins co-occurred with aflatoxins in 48% of the samples (Placinta *et al.* 1999). Fumonosins have also been implicated as causal agents of esophageal cancer in humans. Association of some fungi with perennial tall fescue and perennial ryegrass results in production of alkaloids. The ergopeptine alkaloid, ergovaline is present in tall fescue infected with *Neotyphodium coenophialum* and indole isoprenoid lolitrem alkaloid is present in *N. lolli*-infected ryegrass. These alkaloids affect growth, reproductive performance, and milk production, or cause neurological problems in cattle (D'Mello 2000). Phomopsins are present in lupins infected with *Phomopsis leptostromiformis* and this toxin in sheep can cause liver damage (D'Mello and Macdonald 1998).

Many plant toxins have been reported from various plants, especially legumes, and these toxins are distributed throughout the leaves and/or the seeds. Some of these toxins are heat stable and can withstand temperatures used during feed manufacturing while other toxins are susceptible to heat. Examples of these toxins include lectins from Jack bean, Lima bean; trypsin inhibitors from soybean; antigenic proteins from soybean; quinolizidine alkaloids from lupin and glucosinates from rapeseed (D'Mello 1995). These toxins generally exert antinutritional effects.

Some undeclared animal drugs may occur in animal feeds in the feed mills due to cross-contamination, and adequate systems for flushing and sequencing should be practiced to prevent "drug carry-over" on feed-contact surfaces. Kan and Meijer (2007) have reviewed risks associated with the presence of toxic substances in animal feed and provided a comprehensive review of carry-over of toxic substances from feed to the animal and to human food products originating from the animals.

Pesticides residue have been reported from animal feeds, although in the United States the number of pesticides reported from feeds and the percentage of samples with detectable residues is extremely low. In this paper, I present information on how pesticides are regulated and used in the United States, provide sources of information on pesticide use, and discuss agencies involved in pesticide residue surveillance programs. I have excerpted examples from literature to show types of pesticides and levels of residues found in feeds grains and feed stuffs in the United States and describe several pesticide management methods to minimize residues in animal feed.

DEFINITIONS OF PESTICIDE, PEST, AND INTEGRATED PEST MANAGEMENT

My presentation is about pesticide management and its relevance to pesticide residues that may occur in animal feed. Therefore, a basic understanding of pesticides is necessary. In some text books and in conversations with people I find that there is confusion about what the terms "pesticide" and "pest" mean. The definitions I provide here are federal (US Environmental Protection Agency [US-EPA] interpretations of these two terms. A pesticide is any substance or mixture of substances intended for preventing or mitigating any pest. A pesticide need not always kill a pest, it could affect a pest's behavior, it could make a pest sterile, or it could repel a pest. This definition is all encompassing because a chemical or substance can manage pests by different mechanisms rather than directly killing exposed pests. Pesticides used to manage weeds are called herbicides; those used to manage insects are called insecticides (fumigants (toxic to pests in gaseous form) are also pesticides, despite erroneous allusion to them being separate from pesticides in some texts); and those used to manage fungi are called fungicides; and those used to manage rodents are called rodenticides. Pesticides also include plant growth regulators, defoliants, or desiccants. Fertilizers are <u>not</u> pesticides. Pesticides are used to manage and not control pests, because the latter term refers to elimination of pests, and history has indicated that controlling or eliminating pests has serious environmental consequences and it is extremely rare to control pests. Therefore, the word "management" is appropriate because research has shown that in order to prevent economic losses pests have to be kept below damaging levels, which are determined empirically. The word integrated pest management (IPM) refers to the use of multiple tactics (chemical and non-chemical) to maintain pests below damaging levels with favorable social and environmental consequences. IPM is an ecological approach that involves sampling and monitoring of pests and an assessment of cost/benefit analyses of pest management tactics employed (Hagstrum and Subramanyam 2006).

PESTICIDE REGULATORY AGENCIES IN THE US

The first act in the United States that regulated pesticides was the Federal Insecticide Act of 1910, and the act was administered by the United States Department of Agriculture (USDA). This act was passed in response to concerns from the USDA and farm groups that fraudulent and substandard pesticides were being sold to end users. This act set the standards for manufacture of pesticides, especially Paris green, lead arsenate, insecticides, and fungicides. The act allowed for inspection of pesticide manufacturing facilities and seizure of adulterated or mislabeled pesticides, and prosecution of violators. After World War II, with the advent of newer pesticides, this act was replaced by the Federal Insecticide, Fungicide, and Rodenticide Act of 1947. This act included chemicals that were herbicides (to manage weeds) and rodenticides (to manage rodents). This act has been amended several times over the years. The act primarily required registration of all pesticides used or sold in the United States, it established a regulatory standard for registration which included a battery of tests to prove safety, and it required changes in labeling, packaging, formulation, and disposal. This act did not provide USDA an adequate means of removing hazardous products from the market place. The 1962 publication of *Silent Spring* by Rachel Carson, in which she alluded to the bioaccumulation of pesticide residues (especially DDT) in the environment and animal species, primarily birds, led to major changes in how pesticides were regulated with a major emphasis on protecting the environment and public health. In 1970 the Environmental Protection Agency (EPA) was created and the authority to regulate pesticides was transferred from USDA to EPA. In 1972, FIFRA was changed under a new act, The Federal Environmental Pesticide Control Act (FEPCA). This act resulted in classifying pesticides as general use (based on its low toxicity) and restricted use (based on its high toxicity), and required certification and training of people using restricted use pesticides. FEPCA also mandated pesticide registrants to show that the pesticide being registered would not cause unreasonable adverse effects on the environment. In 1992 the Worker Protection Standards for Agricultural Pesticides were revised from the 1974 amendments, by setting reentry intervals and personal protection standards for people working in pesticide treated areas. Pesticides in the United States are registered after careful consideration of their safety and environmental impacts. For example, it takes about 7 to 10 years from discovery of a pesticide molecule until its registration and the costs can be $50 million or more to bring a pesticide to the marketplace.

In order to ensure that fresh, canned or frozen shipments in interstate commerce are pure and wholesome, the United States Congress in 1906 passed the Federal Food and Drugs Act or the Pure Food Law to protect consumers from adulterated processed food. This law did not consider pesticide residues as adulteration, and was administered by USDA. The Federal Food, Drug, and Cosmetic Act (FFDCA) passed in 1938 authorized the Food and Drug Administration to set upper limits (tolerances) for chemicals in food to protect consumers. Tolerances were established for pesticides under this act. In 1954, Congress passed the Miller Amendment that set tolerances for all pesticides and considered a raw agricultural commodity adulterated if a pesticide residue was above the set tolerance limit. The Food Additives Amendment of 1958 covered tolerances for all additives in or on processed food and set limits for pesticides in processed food. Pesticides residues in or on processed food exceeding established tolerances were considered adulterated. Currently, EPA, FDA, and USDA are jointly involved in enforcing FFDCA. The EPA establishes tolerances for all pesticides on raw agricultural commodities and processed food during the registration process. Enforcement of tolerances on processed food, including fruits, vegetables, and seafood, is the responsibility of FDA and enforcement of tolerances on meat, poultry, aquacultural food, and egg products is the responsibility of USDA.

Section 408 of the FFDCA authorizes EPA to establish a tolerance for a pesticide in or on raw agricultural commodity (domestic or imported), and exempt a pesticide from a tolerance requirement if it is found to be generally recognized as safe (GRAS). In cases where a pesticide is used on an experimental basis, EPA may grant a temporary tolerance for a pesticide. EPA is also authorized under FIFRA to grant exemption from registration of a non-registered pesticide (Section 18) if such a pesticide is needed to manage an emerging pest where alternative registered pesticides are ineffective. FIFRA and FFDCA do not have a procedure for establishing emergency tolerances for a pesticide exempted from registration for such emergency uses.

Pesticide residues on raw commodities may end up in processed commodity during processing. Under Section 409 of FFDCA, EPA is authorized to establish tolerances for such residues in processed food or feed. A pesticide exceeding this established tolerance in processed food or feed is considered adulterated under Section 402 (a) (2) of FFDCA, which states that the processed food or feed is adulterated if it has added poisonous and deleterious substances above the established tolerances.

In the past, we have applied pesticides that to this day persistent in the environment, such as the chlorinated hydrocarbons. Crops grown in lands that contain the persistent chemicals may accumulate these in plant parts used in processed food or feed. These residues are therefore unavoidable and have to be regulated. Section 406 of FFDCA has set action levels for these unavoidable pesticide residues.

In 1996 the United States Congress passed the Food Quality protection Act (FQPA), a landmark legislation, which established a single safety standard under FFDCA for setting tolerances. The FQPA significantly amended both FIFRA and FFDCA. The FQPA also established a different framework by which safety of pesticides are determined. It authorized EPA to consider aggregate exposures from occupational and non-occupational sources and cumulative exposures (for a group of closely related pesticides) when establishing safety standards and tolerances. It also required a special finding to protect infants and children. The aggregate and cumulative risk assessments had to be assessed based on realistic use of pesticides in the field, presence of realistic residues in or on foods, and on the consumption patterns of the public. The FQPA established a schedule for review of pesticide tolerances within a prescribed time period (10-15 years) under the Tolerance Reassessment Program. Furthermore, the FQPA required tolerances to be established for pesticides receiving emergency exemption from registration (Section 18 of FIFRA). One of immediate impacts of the FQPA was that nearly 50% of the products registered prior to the passing of the FQPA were dropped by pesticide registrants who were reluctant to provide additional data required for continued registration of their products. This act required regulatory agencies (USDA and FDA) to monitor pesticide residues in or on raw and processed foods and feeds, both domestic and imported, to assess dietary risks from pesticide exposure based on realistic data.

PESTICIDE CERTIFICATION OF APPLICATORS

The state and provincial governments enforce EPA pesticide laws and regulations. Pesticides that are registered by EPA should also receive state registrations if that particular pesticide is to be used on a particular site (crop, grain, etc.). In addition, pesticide registrants should pay an annual maintenance fee to keep a particular pesticide registration active in a state. In the United States, almost every state has a state department of agriculture. A list of general and restricted pesticides can be obtained by contacting the state department of agriculture. In Kansas, this department is called Kansas Department of Agriculture, which has a special unit that deals with registration and all issues relevant to enforcement of pesticide laws. This unit develops state pesticide laws and regulations. Information about pesticide laws and regulations for a given state may be available through the World Wide Web. The state department of agriculture contracts with the state agricultural university (e.g., Kansas State University) to host pesticide applicator training programs to certify and license pesticide applicators, especially those using restricted use pesticides, which are toxic and where adequate training is required to protect applicators from pesticide poisoning. In order to get certified, applicators must first contact the state department of agriculture take a preliminary exam, which has questions about basic and principles related to pesticides. There are several categories of certification. For instance, agricultural plant pest control is a category as is agricultural animal pest control. Other categories include fumigation of soil and agricultural products, chemigation, forest pest control, ornamental pest control, seed treatment, aquatic pest control, right-of-way pest control, general pest control, wood destroying pest control, regulatory pest control, aerial pesticide application and so on. Books and printed material about each of these categories are shared with the individuals taking the exam, and once one receives a passing grade they are given a pesticide applicator license number. In order to get recertified, the applicators must attend a "Pesticide Applicator Training (PAT) Program" developed and hosted by the state universities for a particular category where new information and training in specific categories is delivered. The state departments approve and ensure that the material covered by the university PAT program meets the EPA mandated training requirements. Some states require recertification every year, others require recertification every 2-3 years. Training is given on how pesticides should be used based on the label language, because all pesticide labels contain an important statement: "It is a violation to use the product inconsistent with its labeling." This does not, however, mean that the training requirements are similar among the states. The type of training required varies slightly from state to state, and has a bearing on that particular state's pesticide laws and regulations, which may go beyond EPA's laws and regulations. The states cannot preempt existing EPA laws and regulations but can include additional restrictions on where and how pesticides are to be used to protect the environment and public health.

In most states, the state universities have the expertise and connections to host PAT programs. In some states, any private or public entity can host these programs and applicators can receive continuing education credits towards certification, if such programs are approved by the state department of agriculture. In some cases, the state department of agriculture may accept a PAT program of an adjacent state, because applicators may live in one state but make applications in an adjacent state.

Besides pesticide applicators, pesticide dealers also have to be licensed to sell pesticides.

PESTICIDE USE RECOMMENDATIONS

It is not unusual to see several pesticides registered for use on a crop or site for a particular pest. When one reads a pesticide label, they may see that the pesticide label has a list of pest species against which the pesticide is effective. For a novice, at the outset, it is difficult to know which data support the claims of efficacy of a pesticide against a pest. Some of this information may be with pesticide registrants, and could be construed as being proprietary. Generally, pesticide registrants are willing to share such information with interested clients. The most unbiased and valuable sources of information on pesticide efficacy are university researchers and extension personnel. Every state university has extension personnel in various departments, especially in the College of Agriculture, that evaluate effectiveness of registered pesticides against pests on various crops or sites.

Extension personnel provide a valuable service as they work closely with producers or anyone requiring university information or assistance. Extension personnel in conjunction with university researchers conduct field trials with various pesticides and pesticide alternatives against different pests (insects, diseases, weeds, etc.), and summarize these findings annually and share such information with end users. Every extension expert in a given discipline is well versed with types of pests that affect a crop or animal species and methods for managing the pests. These experts not only generate new knowledge every year, they also keep abreast of current literature on pest management relative to their field of expertise. They share new information on an emerging pest or conduct trials with a new un-registered pesticide. Many pesticide registrants support pesticide efficacy trials by university researchers and extension personnel, because of the unique role they play in recommending pest management information to producers and others. In addition to recommendations from extension personnel, crop consultants in the United States play a vital technology transfer role.

PEST MANAGEMENT PRACTICES OF PRODUCERS/END USERS

Ultimately whether or not a pesticide is used by the producers is based on the geographic location, whether or not the pest problem is at a level that warrants treatment (economic threshold determined by a sampling program), and the stage of the crop. There are some routine treatments that the producers follow, such as seed treatments or treatments of pesticides to manage weeds prior to planting. In order to prevent the presence of pesticide residues from occurring in harvested useable plant parts, pesticides have to be applied at a certain interval prior to harvest. Depending on the pesticide this interval may range from a week to two months. Following strict pre-harvest intervals for pesticides should result in pesticide residues occurring at levels well below the established tolerances, because data to set pre-harvest intervals are based on how quickly pesticide residues dissipate under different environmental conditions. Once grains are harvested, to prevent insect infestations, commodities are treated prior to storage, and these treatments protect grains for a year to two years. Some countries allow treatment of grain in storage while other countries do not allow such a treatment. In the latter case, frequent fumigation with phosphine is practiced and fumigants do not leave toxic residues on treated commodities.

From time to time, university extension personnel and researchers conduct surveys of pesticides used on various crops and pest management perceptions and practices of producers. These surveys are designed to understand pesticide use patterns of producers, and enable university personnel to develop best management practices (BMPs) for crops, identify research and educational needs relative to pests and their management, and facilitate development of educational programs for adoption of IPM practices by producers.

PESTICIDE USE AND RESIDUE SURVEILLANCE PROGRAMS

There are several federal agencies that collect agricultural census data, especially on types and quantities of pesticides used, and on the levels of pesticide residues found in domestic and imported raw and processed agricultural commodities and foods. The agencies involved include USDA and FDA, and all of their data are available on the internet. The USDA's Food Safety Inspection Service (FSIS) has a National Residue Program, which started in 1967, and this agency collects data on residues of pharmaceutical drugs, pesticide residues, antibiotics, and environmental contaminants that may occur in USDA-inspected meat, poultry, and egg products. This program was developed to ensure that the meat, poultry, and egg products do not contain any illegal chemical residues. The National Agricultural Statistics Service (NASS; www.nass.usda.gov), with its local offices in the state department of agriculture (for example, Kansas Agricultural Statistics Service) collect data on crop acreage planted, harvested, and importance of crop production and animal husbandry to the particular state. These data are summarized and reported by state, and are valuable sources of information for researchers and extension personnel. The data are reported on an annual basis. In addition, NASS conducts surveys on fertilizers and pesticides used on specific crops, every five years. The pesticide use surveys report on the types and quantities of pesticides used on crops and/or on stored grain in the marketing system, as a percentage of the harvested acreage or percentage of grain stocks stored. These surveys do not show data on residues resulting from pesticide applications.

The USDA's Pesticide Data Program (PDP) has been collecting pesticide residue data on domestic and imported foods, especially those consumed by infants and children, since 1991. This program provides a more realistic data for pesticide dietary risk assessments. To date, residue data have been collected and reported on 35 fresh commodities, 26 processed commodities, 8 types of grains, 3 types of dairy products, and 4 meat, poultry, and egg products, and on drinking water collected from several states. Statistically valid sampling schemes are used for collection of samples, and multiple residue methods are used to detect pesticides and their degradation products. Data reported include number of samples collected of a commodity, percentage of samples with a specific pesticide/metabolite residue, level of residue (in ppb or ppm), EPA tolerance for the pesticide/metabolite, and international tolerance level (Maximum Residue Levels, MRLs). For example, in 2006, 660 samples of corn grain were collected from the marketing channels in the United States. These samples were checked for 104 pesticide/metabolite residues. Residues of only 14 pesticides were detected, and only 0.2 to 37.9% of the total samples had any measurable levels of residues, and the levels of residues found were several magnitudes lower than the established tolerances. A perusal of data reported for various commodities reveals a similar trend. Punzi et al. (2005) provided a critical review of the PDP and report that it serves a useful purpose in dietary risk assessment of pesticides.

The FDA initiated a residue monitoring program since 1987, where domestic and imported foods/feeds in interstate commerce are sampled for detection of residues for realistic assessment of dietary exposure risks. The FDA's Center for Veterinary Medicine (CVM) samples and analyzes domestic and imported feeds for pesticide residues. Multiple residue testing methods are followed to analyze residues. This monitoring program has resulted in cooperative efforts with various countries to assure the quality of exported and imported food products and in implementing food safety standards that are essential for international trade. For example, in 1999, 463 domestic feed samples consisting of whole/ground grains, plant by-products, mixed feed rations, animal by-products, supplements, and hay/hay products were analyzed for pesticide residues. Only 40.8% of the samples had measurable residues and only 1.5% of these samples had residues that exceed tolerances. In 2006, 335 domestic and imported feed samples were analyzed, and 21.2% of the samples had residues and 0.6% of the samples had residues that exceeded tolerance levels. It is rare to find residues exceeding tolerance levels, and in a majority of cases, such a result is due to applying pesticides at a rate higher than the recommended rate.

In the United States, we have an excellent infrastructure to track residues found in foods or feeds to actual pesticide use in the field by examining data collected by the various sources mentioned above. In developing and under developed countries, such a system would help in assuring quality of food and feeds and in improving the global competitiveness and international trade of foods and feeds produced domestically.

PESTICIDE MANAGEMENT TACTICS

A thorough understanding of how pesticides are used has a bearing on the types and levels of residues found in finished or ready-to-eat products. The levels of residues found are well below tolerances because of sampling and blending issues. Nevertheless, residue data from the various federal agencies suggests that not all of the foods and feeds tested had residues of all pesticides, and the levels of residues found were below established tolerances. The use of IPM tactics for pest management and using pesticides only when needed perhaps can explain the reasons for low levels of pesticides found in domestic foods and feeds. In addition, research and educational efforts on several pesticide management tactics also contribute to low levels of pesticide residues in foods and feeds. Pesticide management tactics can be defined as tactics that optimize the use of pesticides without compromising efficacy while protecting the environment. The selection, calibration, and use of proper pesticide application equipment is essential for applying pesticides correctly in the field. For information on selection of equipment and calibration, visit http://entweb.clemson.edu/pesticid/saftyed/Aplequip.htm. The use of guidance and precision application techniques will result in optimal use of pesticides in the field. Remote sensing, global positioning system, and geographic information system technologies have been explored for optimal placement of pesticides to manage weeds and pests. Understanding the frequency of pesticides applications and why they are used by producers is essential for developing best management practices for pest management. In order to change the behavior of producers takes several years, and cannot be accomplished without carefully planned demonstration projects in producer-managed trials along with educational efforts to promote and implement IPM and best management practices. Huter *et al.* (1999) provide an example of a successful nutrient and pesticide management project in Idaho.

In summary, pesticide residues can occur in animal feeds from use of pesticides in the field or in storage. The level of residue of a particular pesticide found in animal feeds is influenced by the percentage of a crop that is treated, persistence of the pesticide in the plant, and effect of processing on the residue. Pesticide residue data in the United States are collected by USDA and FDA and these data suggest that the commodities intended for animal feed and finished animal feeds in the United States contain detectable levels of pesticides. However, only a small percentage of the samples tested contained residues of a few pesticides and the levels of residues found were well below the established tolerance levels. In the United States, an infrastructure exists to track types and quantities of pesticides used in the field and correlate this information with levels of residues found in foods and feeds. The structure presented for United States can be emulated by other countries to assure and ensure food and feed safety.

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Overseas pesticide residue data demonstrates that food crop, namely fruits, vegetables and cereals, is the major dietary source of pesticide residues for the general population.Â 2.7 The lack of relevant subsidiary legislation on pesticide residues in food in Hong Kong poses regulatory and enforcement problems. In other words, there is currently no provision which empowers CFS to take legal action against the food trade if the pesticide residue level in a particular food sample, collected during our routine food surveillance programme, is found to exceed standards recommended by Codex.

The occurrence of pesticide residues was studied in samples of feed-stuffs produced in Sweden or imported to Sweden during the years 1972--1976.Â Chlorinated hydrocarbons were found in several samples. DDT and its transformation products were detected in 66 samples (29.5%), lindane in 44 (19.5%), PCBs in 25 (11.2%), alpha-BHC in 22 (9.8%), beta-BHC in 11 (4.9%) and dieldrin in 9 (4.0%).Â Considering the apparently low level of contamination of Swedish grain with chloropesticides, PCBs and phenoxy acids and the dilution on compounding feed-stuffs of animal origin and oil-feeds, only very low pesticide residue levels can be expected in Swedish finished animal feeds. PMID: 225727. â€¢ Controls in the area of pesticide residues in food need to be strengthened through the extension of the range of analysis and enhanced laboratory capacity. â€¢ Further adjustments are needed in order to ensure full alignment with the European food safety framework. 3. Description. 3.1 Background and justification: Acquis relevance: Council Directive 91/414/EEC, Directive 1999/45/EC, Council Directive 67/548/EEC. Plant protection products can have non-beneficial effects on the environment by leaving pesticide residues in the agricultural products of plant origin which may cause risks and hazard Unsafe food contaminated with pesticide residues poses serious risk to the health of consumers particularly in the developing countries where pesticides are inadvertently sprayed in high doses. Organic farming and other approaches are effective in dealing with pesticide contamination but would take significant time in being adopted worldwide. Therefore, simple as well as effective solution in the transient phase is offered by domestic processing techniques such as washing, cooking, milling, parboiling, storage, etc. It is concluded that a combination of processing techniques renders food grain...

The subject of pesticide residues in food has been in the public eye for many years, as the regular media coverage of the subject shows. At the same time a European survey has shown that the residues of pesticides in fruit and vegetables is seen by consumers in Germany as the major risk factor in the field of foodstuffs. This makes knowl-edge-based communication concerning the actual risks posed by foods substantially more difficult.Â â€¢ What expectations do consumers have regarding information on pesticides and pesticide residues in foods? How and where do consumers find out about the properties and occur-rence of pesticides and pesticide residues in foods? How and by whom would consumers like to be informed about pesticide residues in foods? Pesticide residues may be present in the substrate from which insects feed, so this aspect must also be taken into account. Some edible insects such as grasshoppers and dumplings are fed completely or partly with fresh vegetables. Pesticide residues present in such vegetables within the maximum residue limits established for consumers could damage the health of bred insects. As with vertebrates, bioaccumulation potential is partly due to the chemical properties of a given pesticide. However, there is no information on the potential capacity of edible insects to bioaccumulate pesticide residues ... bioavailability Extent to which a pesticide residue can be taken up into an organism from its food and environment, and the rate at which this occurs. (Duffus, 1993). biodegradation Conversion or breakdown of the chemical structure of a pesticide catalysed by enzymes in uitro or in uiuo, resulting in loss of biological activity.Â See also pollutant. control sample (field) Sample from a field test plot to which. no. pesticide was applied (a zero rate sample) or which received chemical treatments identical to the test plots except for the test chemical.Â Residues in soils and feeds, and maximum residue limits (MRLs) for feedstuffs are expressed on a dry weight basis. dustable powder (DP) Free flowing powder suitable for dusting. (GIFAP, 1995).