Minimizing risks posed by mycotoxins utilizing the HACCP concept

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Unavoidable, naturally occurring toxicants pose a unique challenge to food safety. According to FAO, at least 25 percent of the world's food crops are contaminated with mycotoxins, at a time when the production of agricultural commodities is barely sustaining the increasing population (Boutrif and Canet, 1998). The global volume of such agricultural products as maize, groundnuts, copra, palm nuts and oilseed cake, which are high-risk commodities, is about 100 million tonnes – 20 million tonnes of which come from the developing countries (FAO, 1996). The destruction of contaminated products or their diversion to non-human uses is not always practical and could seriously compromise the world food supply. Efforts to limit mycotoxins in human foods and animal feedstuffs are based on two major concerns: the adverse effects of mycotoxin-contaminated crops or feeds on human or animal health and productivity; and potential residues of mycotoxin or toxic metabolites in edible animal food products.

Hazard Analysis and Critical Control Point (HACCP) is a system of food safety control based on the systematic identification and assessment of hazards in foods and the definition of means to control them. It is a preventive, rather than a reactive, tool that places the protection of the food supply from microbial, chemical and physical hazards into the hands of food management systems. The HACCP system is designed to minimize the risk of food safety hazards by identifying the hazards, establishing controls and monitoring these controls (FAO, 1995; Gamboa, 1998). When the HACCP concept is applied to the management of likely adverse health effects resulting from exposure to mycotoxins, an adequate, wholesome and safe food supply can be maintained. In order to design and develop effective HACCP-based integrated mycotoxin management programmes, a given country has to consider such factors as the climate, farming systems, pre- and post-harvest technologies, public health significance of the contaminant, producer and processor compliance, availability of analytical resources and, last but not least, the economy (FAO, 1979).

Prevention through pre-harvest management is the best method for controlling mycotoxin contamination; however, should contamination occur, the hazards associated with the toxins must be managed through post-harvest procedures, if the product is to be used for food and feed purposes. In an ideal integrated management system, mycotoxin hazards would be minimized in every phase of production, harvesting, processing and distribution (Lopez-Garcia and Park, 1998; FAO, 1979).

HACCP PROGRAMME FOR MYCOTOXIN CONTAMINATION

In the terminology of HACCP systems, "hazard" refers to conditions or contaminants in foods that can cause illness or injury. It does not refer to certain other undesirable conditions or contaminants such as insects, hair, filth and spoilage, which would be considered in the context of a broader quality assurance system. The HACCP concept is built on seven principles and actions:

- conduct hazard analysis and identify preventive measures;
- identify critical control points (CCPs);
- establish critical limits;
- monitor each CCP;
- establish corrective action in the event of a deviation from a critical limit;
- establish record keeping;
- establish verification procedures.

The development and application of HACCP programmes are complex matters, and not all countries have the required technical expertise and experience to establish effective integrated mycotoxin management systems that are based on the HACCP approach. Given the importance of HACCP in food safety programmes, FAO has given high priority to the provision of training to professionals in developing countries on the HACCP approach and its application (FAO, 1995).

Integrated mycotoxin management systems based on the HACCP approach must, of course, consider hazards at all stages of production, handling and processing. Furthermore, a prerequisite for the development of HACCP programmes is observance of good agricultural practice (GAP) and good manufacturing practice (GMP) (Sperber *et al*., 1998). In the field, mycotoxin contamination is primarily the result of environmental conditions such as ambient temperature, precipitation, relative humidity, moisture of the product and its susceptibility, and the mould inocula that occur naturally throughout the world (*Aspergillus*, *Penicillium*, *Fusarium*, etc.). It has now been universally acknowledged that mycotoxin formation may also occur at various stages of processing. Based on findings in the literature regarding mycotoxins, control can be effected during pre-harvest, harvest and post-harvest phases which, for the purposes of this article, will include storage and all forms of processing. It is important that these points in the food handling systems are identified, understood and well managed. In integrated mycotoxin management incorporating the HACCP concept, each identified and appropriately managed phase will help prevent the risk of exposure to the toxins.

The prevention and control of mycotoxin contamination to reduce qualitative and quantitative losses in food and agricultural products were integrated into many of FAO's Prevention of Food Losses projects. Of about 200 projects within this programme, over 50 included components for mycotoxin control (Boutrif and Canet, 1998).

Pre-harvest procedures

Significant levels of mycotoxins can occur in food crops in the field. Drought, insect infestation, primary inoculum and delayed harvesting are important external factors that contribute to this. Some of these factors are environmental and humans have minimal control over them. However, good crop husbandry practices, such as crop rotation, irrigation, timed planting and harvesting, and the use of pesticides are preventive actions that reduce mycotoxin contamination of field crops. Numerous studies have shown that insect infestation can serve as a vector for mould infection in commodities that are susceptible to mycotoxin formation. Reduction of insect infestation is, therefore, critical for pre-harvest mycotoxin control. The main objective is to prevent mycotoxin formation at this phase of food production.

Harvesting procedures

Harvesting may inflict mechanical damage on commodities. When damage is kept to a minimum during this phase, subsequent contamination is significantly reduced. Field crops should be harvested in a timely manner to reduce the moisture or water activity (Aw) levels to a point where mycotoxin formation will not occur.

Post-harvest procedures

Prevention through pre-harvest management is the best method for controlling mycotoxin contamination; however, should the contamination occur or persist after this phase, the hazards associated with the toxins must be managed through post-harvest procedures if the product is to be used for food and feed purposes. In the post-harvest phase, storage and processing are the major areas where contamination can be prevented. Processing can involve the removal of parts of the commodity, and this may make it more susceptible to mould infestation. The toxin may also be eliminated through the physical separation or chemical inactivation that occurs during specific processing procedures. In this regard, the activity will prevent exposure of consumers to the hazard.

Storage

Storage, whether on the farm, at the manufacturing premises or in the grocery store, is the most critical post-harvest phase in food handling. An inappropriate storage facility, improper packaging and / or the state of the food product can cause mycotoxin contamination during storage. An accumulation of moisture and heat and / or physical damage to the product enhance fungal invasion, leading to the occurrence of mycotoxins. Stored products should not be exposed to environmental conditions, such as moisture, that promote mould growth. Neither should storage pests be allowed to be present in large enough numbers to cause significant physical damage to the product. Appropriate packaging is often a successful way of excluding insect pests and, where deficits in packaging are likely, general hygiene and the use of pesticides could help minimize contamination. When operating limits are violated, operators of storage facilities need to adjust the processes followed. Under such a scheme mycotoxin contamination is detected before it becomes unmanageable, and the situation is rectified.

Processing

After the pre-harvest and harvesting phases, a commodity may undergo various changes during processing. This is another stage at which mycotoxins could be intentionally eliminated or their formation unintentionally enhanced. The nature of the processing procedure may increase the likelihood of clean commodities becoming colonized by moulds and the subsequent production of toxins. Processors must always be aware of this possibility. Decreasing contamination at this phase ensures that the product reaching the consumer will have minimal likelihood of suffering the hazards associated with mycotoxin contamination of food. Among control procedures that could be employed during the processing phase are clean-up and separation, and thermal and chemical inactivation.

Once a contaminated product has been identified at a processing facility, clean-up and separation are the first alternatives of control. For example, electronic sorting and hand-picking to remove damaged, immature or mould-infested kernels, grains or nuts can remove a significant proportion of the aflatoxins in shelled peanuts. These procedures are usually non-invasive and will not significantly alter the product. The separation of grain into fractions by milling, followed by the elimination of the toxic portions is another decontamination strategy. Complete separation of all contaminated particles may not, however, be achieved since the toxin can diffuse into the interior of the kernel. Other procedures must, therefore, be used to manage contamination in the final product.

Thermal inactivation is a good alternative for products that are usually heat-processed. Fumonisin and ochratoxin levels have been shown to be lower in thermally processed maize and wheat products. On the other hand, aflatoxins and deoxynivalenol are resistant to thermal inactivation and are not destroyed completely by boiling water, autoclaving or a variety of food and feed processing procedures. Thermal inactivation for use at a CCP during processing should be evaluated for the conditions of the particular process and the subsequent fraction(s) containing mycotoxin residues identified.

Other potential control processes

Exploring the application of other processes to control mycotoxins could widen the opportunities for risk management. Where physical separation and thermal inactivation are inappropriate, other techniques may be employed, as long as the end product is acceptable to the consumer. For instance, ammoniation has been successfully employed to reduce aflatoxin contamination in maize, peanuts, cottonseed and meals. Extensive evaluation of this procedure has demonstrated the efficacy and safety of ammoniation in decontaminating animal feeds (Park *et al.*, 1988) and it has been successfully used for many years in the United States, France, Senegal, the Sudan, Brazil, Mexico and South Africa. By including hydrogen peroxide and sodium bicarbonate in the nixtamalization procedure (a traditional alkaline heat treatment of maize used in the manufacture of tortillas), its efficacy against fumonisin and aflatoxin toxicity is increased.

In such industries as oil refining, the use of adsorbent materials is part of normal processing operations. A variety of adsorbent materials, i.e. activated carbon and clays, have been shown to bind aflatoxins in aqueous solutions, and certain aluminosilicates have been reported to bind aflatoxins in peanut oil and animal feeds. Phyllosilicate clay has been shown to prevent acute aflatoxicosis in farm animals and decrease the levels of aflatoxin M1 residues in milk. Activated charcoal has also proved to be effective in reducing patulin in naturally contaminated fruit juices. However, since some adsorbent materials may pose a greater risk than benefit, care must be taken when choosing these products.

ASSOCIATED PROGRAMMES IN MYCOTOXIN CONTROL

Effective integrated mycotoxin management programmes not only cover prevention of mycotoxin formation in agricultural products or their detoxification / decontamination, but also involve: routine surveillance; regulatory measures to control the flow of mycotoxin-contaminated material in national and international trade; and information, education and communication activities.

FAO has been widely involved in reviewing national food control systems in its developing member countries, in many instances focusing on problems of mycotoxin control. Such reviews involve the identification of weaknesses in the food control infrastructure – i.e. the food control administration, inspection and analytical capacity, regulatory issues, etc. After the review process, FAO is frequently involved in the implementation of technical assistance projects to address existing problems.

FAO has played an important role in the dissemination of technical literature to its member countries in support of their efforts in the area of mycotoxin control. Several publications and training aids on various aspects of mycotoxin control have been prepared and distributed. The publications cover a variety of topics, such as methods of sampling and analysis; a training syllabus for use in short-term courses on aflatoxin analysis; a compilation of mycotoxin regulations; and directories of mycotoxin prevention and control institutions in selected regions. The latter are examples of FAO's efforts to facilitate regional networking so as to optimize the use of scarce financial, human and technical resources in the implementation and upgrading of mycotoxin management programmes. Such networking is also promoted through FAO's regional mycotoxin projects and programmes.

Establishment of regulatory limits

Hazard analysis and CCP systems must be built on existing or simultaneously established food safety programmes in each country. Implementation of HACCP cannot be expected to succeed in the absence of regulatory activities. Regulatory limits or standards provide a benchmark against which the effectiveness of food safety programmes can be tested. Regulatory limits are law, violation of which has legal consequences.

FAO has supported the compilation of information, at regional and global levels, on maximum tolerable levels for mycotoxins in food and feed. The last global compilation dates from 1995 and contains data from 90 countries on mycotoxin regulations, tolerance levels and methods of sampling and analysis. It has been published and widely distributed (FAO, 1997).

The importance of the development of internationally harmonized regulatory mycotoxin control measures that protect public health and promote fair trade at the international level cannot be overemphasized. It is of particular importance in view of the World Trade Organization (WTO) Agreements on Sanitary and Phytosanitary Measures (SPS) and Technical Barriers to Trade (TBT). These agreements call for greater harmonization and transparency in the establishment of food regulations that are meant to facilitate trade without compromising consumer protection. The SPS Agreement states that measures conforming to international Codex standards, guidelines or other recommendations are deemed to be appropriate, necessary and non-discriminatory. WTO's recognition of Codex standards, guidelines and other recommendations as benchmarks for food safety is undoubtedly related to the role of science in the Codex process. The Joint FAO / WHO Expert Committee on Food Additives (JECFA) plays an important role in the elaboration of Codex standards and guidelines related to mycotoxin contamination by providing evaluations based on sound scientific and risk assessment principles.

Considerations that enter into regulatory decisions for controlling mycotoxin levels in human foods and animal feeds include:

- control of human exposure to mycotoxins;
- the source of the mycotoxin contamination;
- toxicological characteristics of mycotoxin residues and their metabolites;
- the capability of current analytical methods to measure and confirm the identity of such residues;
- relationships between mycotoxin levels in feeds and their residues in animal products;
- the effects of particular control levels on the availability of the food or feed;
- the effects of the mycotoxins on human and animal health and productivity;
- the practicability and effectiveness of various possible regulatory enforcement strategies.

Consideration of all of these factors is required in the design and implementation of a mycotoxin control programme.

Implementation of surveillance and monitoring programmes

Surveillance and monitoring activities fall within HACCP principles 4 to 7. In the absence of regulation and surveillance, voluntary compliance with any system may not be wholly achieved. Announcing the seafood HACCP regulation in 1995, David Kessler, the US Food and Drug Administration Commissioner at the time, stated "Our safety inspections should focus on preventing problems rather than chasing the horses after they are out of the barn". Safety inspections are the responsibility of government regulatory agencies that ensure the adequacy of industry food safety programmes. Inspections to uncover violations are based on set limits and standards. In order to set up a monitoring and management programme, the following data and policy decisions must be acquired and made:

- identify the mycotoxin(s) and the products or commodities that are to be included in the programme;
- set up a system of inspection and sample collection;
- set up a sampling plan;
- establish a policy guide for end use of the products, for example:
  - proceed into market channels "as is";
  - use as designated animal feed, e.g. dairy, feed lot, finishing, starter;
  - divert to decontamination procedures or lower-risk uses.

Once a regulatory limit has been set, monitoring programmes play an important role in determining compliance. For mycotoxin contamination, it is important to consider adequate random sampling techniques that consider the existence of "hot spots" or highly contaminated portions of the product. A well-designed sampling plan and validated methodology will provide, within limitations, the concentrations of specific analyte for a specified lot of material. The greatest likelihood of obtaining a representative sample occurs when several small portions of a lot are taken and combined. For instance, when collecting the analytical sample for cottonseed or maize, ten randomly selected samples of about 0.5 to 1.5 kg each are required (FAO, 1993). It is important that the analyst is competent to conduct the method. The analytical result is of no value if the sample collected and prepared for analysis does not represent the lot and conceals or overexpresses violations of critical limits. Care must therefore be taken to assure that proper procedures are followed.

A good example of management through a monitoring programme is the aflatoxin control programme established by the State of Arizona in the United States. In 1978, almost 910 000 pounds of milk were discarded because of high aflatoxin M_1 levels. As a result of this huge commercial loss, the state instituted a programme to monitor aflatoxin levels in whole cottonseed and cottonseed products at processing points. All cottonseed produced in the state is tested for aflatoxin content. The maximum size of the lots tested is 100 tonnes, and the testing is conducted in state-certified laboratories. The end use of the product is dictated by the aflatoxin levels that are found. Cottonseed lots testing over 20 µg of aflatoxin per kilogram are usually treated with ammonia to reduce these levels, and then re-tested (Park and Pohland, 1986). The use of this programme has kept Arizona's milk supply safe from aflatoxin. The same concept can also be applied to other commodities.

The establishment of monitoring and surveillance programmes for mycotoxins requires suitably equipped laboratories, well-trained staff for both analytical and inspection activities, reliable analysis and sampling methods, and application of analytical quality assurance programmes. Specific FAO projects in a number of countries have addressed these issues in providing technical assistance in the area of surveillance of mycotoxin contamination. Although aflatoxin was the first priority in most of the projects, they all also gave some attention to the surveillance of other mycotoxins. Existing systems for monitoring food contaminants, including various mycotoxins, have been studied and strengthened in Asian countries such as Bhutan, China, India, Indonesia, Nepal, Pakistan, the Philippines, Sri Lanka, Thailand and Vanuatu; Latin American countries such as Chile, Cuba, Guatemala and Uruguay; and in African countries such as Malawi, Rwanda, the United Republic of Tanzania and several West African States (Boutrif and Canet, 1998).

Analytical quality assurance studies were carried out at regional level in Latin America and Asia. Results highlighted the need for continuing such exercises and increasing the number of participating laboratories.

As a means of building sustainable national capacity, training has been a major component of FAO's assistance to developing countries in improving mycotoxin control. A long-term, international training programme was carried out during the 1980s in collaboration with the United Nations Environment Programme (UNEP) and what was then the Union of Socialist Soviet Republics (USSR). Other activities included local and regional courses for laboratory staff and practical demonstrations on field detection, identification and analysis of various mycotoxins. In Asia, a training network was implemented to provide training in methods of analysis and sampling of various mycotoxins, including guidance on policy issues. Regional workshops on mycotoxin analysis were held in Senegal, Botswana and various Latin American countries.

CONCLUSIONS

Much has been accomplished at national, regional and international levels regarding mycotoxin prevention and

Possible stages in application of the HACCP principle to agricultural commodities, food products and animal feedstuffs

Stage	Commodity	Hazard	Corrective action
Pre-harvest	Cereal grains, oilseeds, nuts, fruits	Mould infestation with subsequent mycotoxin formation	Utilize crop resistant varieties Enforce effective insect control programmes Maintain adequate irrigation schedules Perform good tillage, crop rotation, weed control practices, etc.
Harvesting	Cereal grains, oilseeds, nuts, fruits	Increase in mycotoxin formation	Harvest at appropriate time Maintain at lower temperature, if possible Remove extraneous material Dry rapidly to below 10% moisture
Post-harvest and storage	Cereal grains, oilseeds, nuts, fruits	Increase and/or occurrence of mycotoxin	Protect stored product from moisture, insects, environmental factors, etc. Store product on dry clean surface
Post-harvest, processing and manufacturing	Cereal grains, oilseeds, nuts, fruits	Mycotoxin carryover or contamination	Test all ingredients added Monitor processing/manufacturing operation to maintain high-quality product Follow good manufacturing practices
Animal feeding	Dairy, meat and poultry products	Transfer of mycotoxin to dairy products, meat and poultry products	Monitor mycotoxin levels in feed ingredients Test products for mycotoxin residues

control, but much still remains to be done. It is now widely recognized that food safety programmes should be based on the strict observance of good agricultural, processing and handling practices, including the application of HACCP concepts; governments should therefore upgrade their mycotoxin management programmes to include the HACCP principles. HACCP-based mycotoxin management programmes must involve control and surveillance at all stages of production and post-production, as there are several factors at pre-harvest, harvest and post-harvest stages that are implicated in mycotoxin contamination of crops. FAO has been active in providing assistance to its member countries in various aspects of mycotoxin management including mycotoxin prevention and control, routine surveillance and regulatory matters. Minimizing the risks posed by mycotoxins through applying good agricultural, processing and handling practices and utilizing the HACCP concept continues to be priority for FAO. ◆

REFERENCES

Boutrif, E. & Canet, C. 1998. Mycotoxin prevention and control: FAO programmes. *Revue Méd. Vét.*, 149: 6, 681-694.

FAO. 1979. *Recommended practices for the prevention of mycotoxins in food, feed and their products*. FAO Food and Nutrition Paper No.10. Rome.

FAO. 1993. *Sampling plans for aflatoxin analysis in peanuts and corn. A technical consultation.* FAO Food and Nutrition Paper No. 55. Rome.

FAO. 1995. *The use of hazard analysis critical control point (HACCP) principles in food control.* FAO Food and Nutrition Paper No. 58. Rome.

FAO. 1996. *Basic facts on the world cereal situation.* Food Outlook, 5/6. Rome.

FAO. 1997. *Worldwide regulations for mycotoxins 1995 – A compendium*. FAO Food and Nutrition Paper No. 64. Rome.

Gamboa, D.E. 1998. HACCP implementation by the meat and poultry industry: a survey. *Dairy Food Environ. Sanit.*, 18: 288.

Lopez-Garcia, R. & Park, D.L. 1998. Management of mycotoxin hazards through post-harvest procedures. *In* D. Bhatnagar. & K.K. Sinha, eds. *Mycotoxins in agriculture and food safety*, Chapter 9. New York, Marcel Dekker.

Park, D.L. & Pohland, A.E. 1986. A rationale for the control of aflatoxin in animal feeds. *In* P.S. Steyn & M. Vleggar, eds. New York, Elsevier. 473 pp.

Park, D.L., Lee, L.S., Price, R.L., & Pohland, A.E. 1988. Review of decontamination of aflatoxin by ammoniation: current status and regulation. *J. AOAC,* 71: 685.

Sperber, W.H., Stevenson, K.E., Bernard, D.T., Deibel, K.E., Moberg, L.J., Hontz, L.R. & Scott, V.N. 1998. The role of prerequisite programmes in managing a HACCP system. *Dairy Food Environ. Sanit.*, 18: 418. ◆

Minimizing risks posed by mycotoxins utilizing the HACCP concept

Mycotoxin contamination of susceptible commodities occurs as a result of environmental conditions in the field and improper harvesting, storage and processing operations. Hazard Analysis Critical Control Point (HACCP) programmes have been useful in managing the risks associated with potential contamination of food products with pathogenic micro-organisms and chemical toxicants. Food safety programmes routinely use information about the factors leading to contamination to establish preventive and control procedures, thus providing the consumer with a safe, wholesome food supply. When an effective HACCP programme for mycotoxins is being established, key elements are identified that can be used or modified to reduce mycotoxin formation in field and storage environments. Such elements include limiting insect infestation and moisture levels in the commodities. Specific processing and decontamination procedures can play a role in reducing mycotoxin levels through the physical separation of damaged, immature and mould-infested kernels, grains or nuts, and the physical and chemical inactivation and/or removal of the toxin. The development and application of HACCP-based food safety programmes require expertise in a range of fields. FAO has been active in providing technical assistance to its member countries, helping to build national capacity to implement and maintain effective HACCP-based mycotoxin management programmes.

Minimiser les risques associés aux mycotoxines, à l'aide du concept HACCP

La contamination des produits sensibles par les mycotoxines est une conséquence de certaines conditions écologiques sur le terrain et d'opérations de récolte, d'entreposage et de transformation inappropriées. Les programmes du Système d'analyse des risques – points critiques pour leur maîtrise (HACCP) ont permis de limiter les risques associés à la contamination potentielle des produits alimentaires par des micro-organismes pathogènes et des produits chimiques toxiques. Les programmes visant à garantir l'innocuité des aliments utilisent régulièrement des informations sur les facteurs favorisant la contamination pour établir des procédures de prévention et de contrôle et garantir aux consommateurs l'accès à des aliments sains et salubres. Lors de la mise en place d'un programme HACCP efficace, des éléments clés sont identifiés pouvant être utilisés ou modifiés pour réduire la formation de mycotoxines dans les champs et dans les lieux d'entreposage. De tels éléments comprennent la limitation des infestations d'insectes et la teneur en humidité des produits alimentaires. Des procédures de transformation et de décontamination spécifiques peuvent contribuer à réduire les concentrations de mycotoxines, par la séparation physique des amandes, des semences ou des coques abîmées, non mûres et moisies, et par l'inactivation physique et chimique et/ou l'élimination de la toxine. L'élaboration et l'application de programmes destinés à assurer l'innocuité des aliments fondés sur le HACCP nécessite des compétences dans divers domaines. La FAO a fourni une assistance technique à ses pays membres en les aidant à renforcer leurs capacités nationales afin qu'ils soient mieux à même de mettre en œuvre et de maintenir des programmes efficaces de gestion des mycotoxines, basés sur le HACCP.

Reducción al mínimo de los riesgos que plantean las micotoxinas mediante la utilización del concepto de HACCP

La contaminación por micotoxinas de productos expuestos se produce como resultado de las condiciones ambientales en el campo o de operaciones inadecuadas de recolección, almacenamiento y elaboración. Los programas de análisis de peligros y puntos críticos de control (HACCP) han sido útiles para hacer frente a los riesgos asociados con la posible contaminación de productos alimenticios y sustancias químicas tóxicas. Los programas de inocuidad de los alimentos suelen utilizar información sobre los factores que propician la contaminación para establecer medidas preventivas y de control y ofrecer de ese modo al consumidor un suministro de alimentos inocuos y sanos. Al introducir un programa eficaz de HACCP para las micotoxinas, se determinan los principales elementos que pueden utilizarse o modificarse para reducir la formación de micotoxinas en el campo y en el lugar de almacenamiento, por ejemplo la limitación de la infestación por insectos y del nivel de humedad en los productos. Determinados procedimientos de elaboración y descontaminación pueden contribuir a reducir el nivel de las micotoxinas mediante la separación física de las almendras, granos o nueces dañados, inmaduros e infestados por mohos, y la inactivación física y química o la eliminación de la toxina. La elaboración y aplicación de programas de inocuidad de los alimentos basados en el sistema de HACCP exigen conocimientos técnicos en diversos ámbitos. La FAO se ha esforzado por proporcionar asistencia técnica a sus Estados Miembros con el fin de fortalecer la capacidad nacional para introducir y mantener programas eficaces de gestión de micotoxinas según el sistema de HACCP. ♦

CORRIGENDUM

In *Food, Nutrition and Agriculture* 22, 1998, the photo caption on p. 9 should read "A small garden in Dar-es-Salaam, United Republic of Tanzania".