REPORT OF THE CONFERENCE

Introduction

1. The Third Joint FAO/WHO/UNEP International Conference on Mycotoxins was held in Tunis, Tunisia, from 3 to 6 March 1999. The Conference was convened by the Directors-General of the Food and Agriculture Organization (FAO), the World Health Organization (WHO) and the Executive Director of the United Nations Environment Programme (UNEP), and was kindly hosted by the Government of the Republic of Tunisia. Delegates from 38 countries and representatives of 10 international organizations attended the Conference. The list of participants is attached as Annex 1 to this report.

2. Mycotoxin contamination of food, feed and agricultural crops continues to seriously affect the availability and safety of the food supply worldwide. Previous conferences (Nairobi, 1977; Bangkok, 1987) organized by FAO, WHO and UNEP, addressed issues of mycotoxin contamination, prevention and control. A series of recommendations aimed at minimizing the economic and health effects of mycotoxins as well as enhancing preventative measures were proposed. Numerous national and international programmes designed to minimize the risks posed by mycotoxins have been instituted.

3. The need to hold a third conference on mycotoxins jointly supported by FAO, WHO and UNEP has been highlighted by a number of developments such as identification of new or emerging mycotoxins, progress made in sampling and testing and results of monitoring programmes as well as advances in decontamination procedures. The issuing of mycotoxin regulations by a number of countries, and greater concern about the health effects of specific mycotoxins are the most important factors.

4. The objectives of the current Conference were: (i) to increase the awareness of policy makers about the health risks and potential economic impact of mycotoxin contamination of
food products and animal feeds, including their impact on international trade; (ii) to provide a forum for the exchange of current scientific and technical information related to mycotoxins, (iii) to promote the harmonization of mycotoxin regulations and control procedures; and, (iv) to provide recommendations on strategies and programmes for enhancing the assessment, prevention and control of mycotoxin contamination, thus ensuring the safety and wholesomeness of the food supply.

Agenda item 1: Opening session

5. In his opening statement, Mr. John Lupien welcomed the delegates on behalf of Mr. Jacques Diouf, Director General of FAO. He outlined the need for convening the Third Joint FAO/WHO/UNEP International Conference on Mycotoxins, approximately ten years after the last conference (Bangkok in 1987). He discussed the current food safety regulatory environment that precipitated the need for the third conference. Mr. Lupien explained the objectives of the Joint FAO/WHO Food Standards Programme, which are to protect public health and facilitate international trade of food. The Codex Committee on Food Additives and Contaminants has been responsible for developing maximum limits for mycotoxins in food. This has been done on the basis of risk assessments carried out by the Joint FAO/WHO Expert Committee on Food Additives (JECFA) based on information provided by member governments. Mr. Lupien highlighted FAO’s involvement in mycotoxin prevention and control activities. This includes both field and standard-setting work, and is geared towards the strengthening of food control systems in member countries, including the strengthening of mycotoxin management programmes. He also noted that according to the WTO agreements, food safety measures must be based on sound scientific risk assessment. It is very important for all countries to be aware of the processes involved in risk assessments related to mycotoxin contamination of food and feed. As a result of this Conference, governments should be better prepared to contribute more effectively to the work of the Codex Committee on Food Additives and Contaminants.

6. On behalf of Dr. Gro Brundtland, Director General of WHO, Dr. Gerald Moy addressed the delegates and noted that the risks posed by mycotoxins in food presented an enormous challenge to national governments and international agencies responsible for their control. He emphasized that deficiencies in our knowledge about them not only can lead to uncertainties in the risk assessment, but may also result in risk management decisions which are disruptive for international trade. While it is essential for national governments to adopt a consistent, science-based risk analysis approach to mycotoxins, Dr. Moy also stressed that it was equally essential that Member States support research for filling those data gaps that can undermine the evaluation process.

7. Dr. Moy stated that WHO remains committed to the elucidation of the possible risks posed by mycotoxins by strengthening the role of JECFA in hazard characterization. WHO continues to expand and improve its global food contamination monitoring programme for mycotoxins under the auspices of GEMS/Food Programme and in collaboration with member states. In light of the potential risks posed by mycotoxins, he noted that the conference offered a timely opportunity to take stock of progress and to review the latest knowledge about mycotoxins and their adverse effects on human health. Dr. Moy noted that JECFA has recommended that it would be prudent to continue efforts to prevent, reduce or eliminate the presence of mycotoxins in the food supply.
8. In his opening remarks, the representative of UNEP, Mr. Hiremagalur Gopalan welcomed the delegates on behalf of Dr. Klaus Topfer, the new Executive Director of UNEP. Mr. Gopalan stressed the need for integrated management for the prevention and control of mycotoxins to ensure food safety, food security and adequate nutrition, as well as the protection and promotion of public health and the environment. Mr. Gopalan expressed UNEP’s gratitude to the government of the Republic of Tunisia for agreeing to host the conference in the beautiful city of Tunis.

9. Mr. Mohamed Ben Ahmed, Secretary of State for Scientific Research and Technology, welcomed the participants on behalf of the Tunisian Government. He underlined the importance that the Government of Tunisia gives in its policies and programmes to the issues of food safety and public health. He recalled efforts made during the last few years in the field of mycotoxin prevention and control, and expressed his Government’s determination to pursue these efforts to ensure the quality and safety of the food supply. Mr. Ben Ahmed highlighted the need for an integrated approach in addressing the mycotoxin contamination problem involving all stakeholders in agriculture, food, health, environment and scientific research and technology. He wished all participants a fruitful meeting and an enjoyable stay in Tunisia.

10. Prof. Mongi Jemmali, President of the African Association of Microbiology and Food Hygiene, welcomed the participants and expressed his gratitude to FAO, WHO and UNEP for having chosen Tunisia for the venue of the Conference. He pointed out the multidisciplinary nature of mycotoxin work which integrates different scientific areas and research, that aim at the improvement of the quality of life; and explained the related points linked to food hygiene. He stressed the trade effects of mycotoxin contamination, and the importance of toxicological studies and risk assessments.

**Agenda item 2: Election of Officers**

11. Dr. Albert E. Pohland (USA) was elected Chairman of the Conference, and Dr. Mongi Jemmali (Tunisia) as Vice-Chairman. The Conference also elected Dr. Peter Scott (Canada) as Rapporteur.

**Agenda item 3: Adoption of the Agenda and Time Table**

12. The proposed agenda and time table were adopted with the following changes under agenda item 9 with regard to the subjects to be addressed by Round Table discussions: (i) health and environmental considerations of mycotoxin contamination; (ii) mycotoxin prevention and control; and (iii) sampling and analysis for mycotoxins.

**Agenda Item 4: Mycotoxin Contamination of Foods and Feeds**

13. Dr. Ramesh Bhat presented the document entitled “Mycotoxin contamination in food and feeds, an overview” (MYC-CONF/99/4a) prepared by himself and Dr. S. Vasanthi. He stated that mycotoxin contamination of foods and feeds has gained much global attention in
recent years owing to its adverse health and economic effects. Apart from aflatoxins, considerable attention has focused on fumonisins. The simultaneous occurrence of fumonisin and aflatoxin is being reported by various countries. Concern over the presence of ergot alkaloids and crop losses in sorghum has emerged recently due to ergot epiphytotics.

14. The Conference was informed of the considerable economic impact of mycotoxins on the food grain and livestock industry. Losses have been encountered particularly in the peanut industry due to aflatoxin contamination. Poultry and swine are highly affected by aflatoxin, fumonisin, deoxynivalenol and zearalenone. Export of agricultural commodities, particularly groundnuts and groundnut products, has been reduced considerably in recent times because of mycotoxin contamination. This has resulted in huge economic losses to the producing countries.

15. Mycotoxins are produced by fungi that invade crops in the field and contaminate agricultural commodities during post-harvest stages, like storage, when conditions favour their growth. Aflatoxin continues to receive major attention. However, in the last decade the interest in aflatoxin has been centered on the measurement of aflatoxin biomarkers, like aflatoxin-DNA adducts in human serum to accurately assess exposure. Newer mycotoxins such as fumonisins, mycotoxins affecting new commodities like ochratoxin A in coffee, and the appearance of mycotoxins in different foods and regions such as ergot alkaloids in Latin America and Australia sorghum, have gained importance. The focus of many surveillance programmes on mycotoxins has shifted from single mycotoxin surveys to multi-mycotoxin surveys, particularly in relation to cereal grains.

16. The Chairman pointed out that limits of detection of analytical methods must be reported when percentage incidence of mycotoxins in foodstuffs are presented. Studies of acute human mycotoxicoses should include confirmation by other laboratories that the toxin has occurred in the suspect food. It was noted that the Malaysian incident of aflatoxin poisoning was backed up by analyses in the United Kingdom. Dr. Visconti warned that one should be careful to get large samples of the suspect commodity. This was a concern in the reported mycotoxicosis from rain-damaged sorghum in India which contained fumonisin B₁. Normally, fungi growing on sorghum do not produce appreciable levels of fumonisin B₁. Small sample sizes may skew analytical results in cases of human mycotoxicosis. Economic losses due to the presence of mycotoxins in commodities are very difficult to quantify. In the opinion of the Chair, confidence in such estimates is low. Dr. Pohland stated that if economic losses could be better defined, this would justify applications for more research funds.

Agenda Item 5: Mycotoxins of Growing Interest

Fumonisins

17. The first document (MYC-CONF/99/5a) under this agenda item relates to fumonisins, and was presented on behalf of the Secretariat by Dr. Angelo Visconti. Dr. Visconti informed the Conference of the chemical nature, origin and occurrence of fumonisins in maize and maize-based products destined for human and animal consumption. He indicated that more than 10 fumonisin analogues have been isolated and structurally characterized from fungal cultures of F. moniliforme [= F. verticillioides (Sacc.) Nirenberg] or F. proliferatum. Only fumonisin B₁ (FB₁) and, to a lesser extent, fumonisins B₂ and B₃ are
commonly found as natural contaminants of foods and feeds.

18. Several methods are available for determining fumonisins in maize, the most widely used involving the liquid chromatographic analysis of fluorescent derivatives.

19. With respect to animal mycotoxicoses, FB₁ causes equine leukoencephalomalacia and porcine pulmonary oedema. FB₁ causes hypercholesterolemia and a number of immunological alterations in several animal species. It has been demonstrated to result in renal toxicity at low exposures in several animal species but is hepatotoxic in all animal species tested to date. The rat liver carcinogenicity of FB₁ has not been confirmed by the United States National Toxicology Programme in its report released in May 1999. Fumonisin B₁ was the first discovered specific inhibitor of de novo sphingolipid metabolism and is currently widely used to study the role of sphingolipids in cellular regulation.

20. The Conference was told that research was underway to produce genetically-modified maize plants with reduced fumonisin concentrations. Fumonisins are largely stable during food processing. Several possible detoxification processes, including chemical and physical treatments, have been tested for reducing fumonisin in contaminated maize. Available epidemiological evidence [correlation studies] has suggested a link between high dietary fumonisin exposure and human oesophageal cancer in some locations with high disease rates. Switzerland is the only country that has set a regulatory limit for fumonisins in maize-based foods (1 mg/kg FB₁ + FB₂), and recommended limits are available for feeds in the USA. Human exposure estimates vary considerably (from 0.02 to 355 µg/kg body weight/day) according to the level of contamination and extent of maize in the diet. Care must be taken in the establishment of safe limits for human dietary exposure to consider populations consuming high amounts of maize.

21. To a question on the toxicity of hydrolyzed fumonisin B₁, Dr. Riley replied that nixtamalized maize was somewhat less toxic than the original maize but lesions in animals was the same. Dr. Boutrif drew attention to special groups at risk from fumonisins, i.e., non-wheat eaters and maize eaters. Dr. Scott pointed out the possible occurrence of fumonisins in other commodities such as rice but this has not been confirmed outside the US. Discussion on the toxicology of fumonisins included the importance of exposure time based on the observation that fumonisin can both induce and inhibit apoptosis (Dr. Riley).

Ochratoxins

He indicated that the chlorinated isocoumarin compound, ochratoxin A (OTA), together with some related derivatives (ochratoxins B, C, α and β) are produced by Penicillium verrucosum and by several species of Aspergillus, most notably A. ochraceus. P. verrucosum is the principal source of OTA contamination of stored foods in temperate climates, while Aspergillus species predominate in warmer countries.

23. The major dietary sources of OTA are cereals, but contamination may be found in grape juice, red wine, coffee, cocoa, nuts, spices and dried fruits. Contamination may also carry over into pork and pig blood products.
24. The Conference was informed that OTA is potently nephrotoxic. It is a renal carcinogen in rodents, the potency varying markedly between species and sexes; it is also teratogenic and immunotoxic. There have been different approaches to the risk assessment of OTA in different jurisdictions, largely arising from whether or not the carcinogenicity of OTA is considered to arise through a thresholded or non-thresholded mechanism. Consequently the tolerable intakes have variously been estimated at 100 ng/kg b.wt/week (JECFA), 1.5 to 5.7 ng/kg b.wt/day (Kuiper-Goodman et al.) and 5 ng/kg b.wt/day (Nordic Council of Ministers; European Commission). Prof. Walker indicated that, in his opinion, very large safety factors had been used in the latter two risk assessments. These differences have been further complicated by different risk management procedures that have lead to different maximum contamination levels for commodities in different countries.

25. Prof. Walker concluded that prevention of contamination at the source is the most effective public health measure. There is also a need to harmonise the risk assessment and management procedures to a greater extent than currently exists if barriers to trade are to be avoided.

26. The delegate from Italy brought up the question of ochratoxin A in human milk, which in Italy is present at an incidence of 80%. Dr. Walker was not able to express an opinion on this source of exposure. Although the infant’s diet is not very varied, the levels of OTA are low and unlikely to exceed the provisional tolerable weekly intake; there appeared to be no need for additional safety factors for infants. There was another discussion on risk assessment for OTA. Blood levels were the best indicator of intake of the toxin by populations. Dr. Kuiper-Goodman pointed out that the fact that OTA caused metastases of tumours in male Fisher rats supported a relatively larger safety factor. Dr. Castegnaro thought that levels of OTA in wine were lower than Prof. Walker reported. Dr. Mantle felt that there was insufficient evidence to link OTA or DNA adducts with any human disease. Experimentally, Dr. Mantle has found no adducts in rats when the OTA was dosed in food, rather than by gavage, and recommended that experimental work on this topic be carefully considered. He has experiments underway to see whether OTA can be taken up from soil by growing plants such as coffee. These may suggest an answer to the source of OTA in coffee, and perhaps grapes.

**Trichothecenes**

27. Prof. Chester Mirocha presented a paper entitled “Mycotoxins of Growing Interest: Trichothecenes” (MYC-CONF/99/5c). Prof. Mirocha informed the Conference about the nature and origin of trichothecenes which are produced by species of the genus *Fusarium*. He indicated that there are many species of *Fusarium*, that can infect many different crops, especially cereals. There are over 60 different trichothecenes, but the most well known are deoxynivalenol (DON) and nivalenol (NIV). DON has been found in wheat, barley and maize and occurs worldwide; NIV is more restricted in occurrence being found more in Asia and parts of Europe.

28. The Conference was informed that in humans, DON causes vomiting, headache, fever and nausea. In animals, DON and NIV cause vomiting and feed refusal but also affect the immune system. In the USA, the recommended advisory level is 1 ppm for flour intended for
human consumption and 1 to 10 ppm for animal feed depending on the species. DON frequently occurs with another mycotoxin called zearalenone which is produced by the same fungus that produces DON. These mycotoxins are produced on cereal grains infected by Fusarium in the field. These plant diseases are difficult to control.

29. The question of what levels of DON cause vomiting in humans was not answered. Dr. Bhat said he had no new information on toxicity of DON in humans beyond the studies published in Lancet in 1989. In view of the data presented by Dr. Mirocha on variability of DON levels in individual kernels of Fusarium damaged wheat, more studies on sampling for DON may be needed. Dr. Bhat also mentioned three other human diseases possibly associated with Fusarium, e.g., Kashin-Beck disease, Mseleni joint disease and endemic Familial Arthritis of Malnad.

Zearalenone

30. Dr. Rudolf Krska presented a paper entitled “Mycotoxins of Growing Interest: Zearalenone” (MYC-CONF/99/5d). He noted that zearalenone (ZEA) is a fungal metabolite, mainly produced by F. graminearum and F. culmorum, which are known to colonize maize, barley, wheat, oats and sorghum. Of several ZEA derivatives that can be produced by Fusarium spp., only trans-alpha-zearalenol has been found to occur naturally in cereal grains. These compounds have low acute toxicity but marked oestrogenic and anabolic properties in rats, mice and swine.

31. ZEA and its related compounds can cause hyperoestrogenism and severe reproductive and infertility problems in animals, especially in swine. Therefore, high levels of ZEA contamination that occurs occasionally during years with Fusarium epidemics, can seriously reduce the quality of cereals and grain products. Due to its frequent occurrence and the recent discussion on the health impact of endocrine disrupting substances, ZEA has received increasing attention.

32. It was pointed out that the impact of ZEA on public health is, however, difficult to evaluate. Nine countries have set maximum tolerable levels for ZEA in food so far. For the analysis of ZEA the time consuming liquid/liquid clean-up has been replaced by immuno-affinity columns and solid phase extraction techniques.

33. Dr. Krska's presentation on ZEA led to discussion of other natural oestrogens, such as those in soybeans, and whether these were beneficial or potentially harmful. Dr. Mirocha stated that sheep, like swine, were sensitive to ZEA and that ZEA was an unusual mycotoxin in that it was metabolized to compounds which were more active (zearalenols).

Agenda Item 6: Mycotoxin Prevention and Decontamination

34. The discussions on this agenda item were based on four documents (MYC-CONF/99/6a, 6b, 6c et 6d) which present studies on different commodities with approaches and strategies for reducing risks posed by different mycotoxins. This includes measures on the prevention of mycotoxin formation, establishment of regulatory limits and monitoring programmes, and the use of processing and decontamination operations to remove, destroy or inactivate the toxins.
Integrated Mycotoxin Management Systems

35. Profs. Douglas L. Park and Timothy D. Phillips opened this agenda item for discussion with presentations on pre-harvest, harvest and post-harvest control operations (MYC-CONF/99/6a).

The Conference was informed that naturally occurring toxicants are common in food and their occurrence was unpredictable. They pose a unique challenge to food safety. The destruction of contaminated products or diversion to non-human uses is not always practical, and could seriously compromise the food supply. Procedures for the prevention of mycotoxin formation in the field as well as during storage have been developed. However, in spite of these efforts, contamination still occurs. Therefore, the hazards associated with the toxin must also be managed through post-harvest procedures if the safety of food and feed is to be assured.

36. The Conference was informed of the importance of risk management and of approaches to the management of the risks associated with mycotoxin contamination. An integrated mycotoxin management system would entail strategies for the prevention of mycotoxin formation, establishment of regulatory limits and monitoring programmes, and the use of processing and decontamination operations to remove, destroy or inactivate the toxins while at the same time ensuring an adequate, safe and wholesome food supply.

Case Study One: Corn

37. Dr. Ronald Riley presented paper entitled “Corn: a case study” (MYC-CONF/99/6b). The Conference was informed that mycotoxin detoxification refers to post-harvest treatments to eliminate or reduce the toxic effects. Failure to prevent mycotoxin formation in the field or in storage inevitably will lead to an increased health risk and economic loss. However, successful monitoring should prevent mycotoxins from becoming a significant source of increased health risk. An integrated multi-faceted approach is the preferred strategy for controlling mycotoxin contamination. The pre-harvest or post-harvest strategy that should be emphasized will be dependent on the climatic conditions of that particular year. Understanding the environmental factors that promote infection, growth, and toxin production is the first step towards an effective plan to minimize mycotoxins in foods and feeds.

38. The Conference was further informed that Fusarium verticillioides is one of the most common pathogens of corn. Because F. verticillioides can be a seed-borne, symptomless endophyte in corn, its elimination will be difficult. Tillage practices, crop rotation, weed control, late season rainfall, wind, and pest vectors can all affect the amount and source of fungal inoculum that maintains the disease cycle in corn. There are many new and exciting pre-harvest prevention strategies being explored that involve production of genetically engineered resistant corn. Biocontrol using non-toxigenic biocompetitive agents are being researched. Post-harvest prevention of mycotoxin production is primarily dependent on good management practices before harvest and after harvest. Detoxification using physical, chemical, or microbiological techniques can destroy, modify, or absorb the mycotoxin and therefore reduce or eliminate the toxic effects.

Case Study Two: Coffee
39. This item was presented by Dr. Mick Frank based on a untitled “HACCP and its Mycotoxin Control Potential: An Evaluation of Ochratoxin A in Coffee Production” (MYC-CONF/99/6c). The Conference was informed of the developments concerning ochratoxin A (OTA) contamination of coffee, and the potential use of HACCP principles to reduce this contamination. Coffee is produced in over 50 nations, most of which are developing, and constitutes an important source of income for farmers as well as hard currency for the producer nations. A revision in the scientific view of the significance of OTA to human health has led coffee consuming nations to consider legislation to prevent the importation of coffee containing more than minute amounts of this toxin. The results of two years of field and laboratory study aimed at providing the information required to develop a HACCP model to prevent accumulation of OTA in coffee were presented.

40. Poor quality coffee beans used by the local people can contain up to 1 ppm of OTA, Dr. Frank reported. His studies so far have shown that Aspergillus niger was not an important producer of OTA. Only 1 out of 80 isolated strains was a producer compared to 40/50 positive Aspergillus ochraceus strains. The application of HACCP principles is new to agriculture and HACCP for coffee has not yet been tried in the field. A small farmer might have difficulty implementing HACCP.

Case Study Three: Pistachios

41. This item was presented by Dr. Monica Olsen based on a document entitled “Prevention of Aflatoxins in Pistachios” (MYC-CONF/99/6d). The Conference was informed that pistachio is a semi-dry stone fruit with a single kernel enclosed in a thin, hard shell, which is surrounded by the hull. The shell partially splits to varying extents at least a month before maturity and harvest. Normally, the hull does not rupture when the shell splits in the immature pistachio fruit. However, in a small percentage of the pistachios, the shell and the still adhering hull split together. This hull rupture, often referred to as “early splitting”, is a very important event for infection with the aflatoxin producing fungi Aspergillus flavus/parasiticus. This exposes the kernel to airborne fungal spores or insects, like the navel orange worm, which carries fungal spores. An “early split” is characterised by a distinct, dark and smooth-edged split on the hull. The oldest “early splits” have rough and shrivelled hulls and contain the highest levels of aflatoxin. Infection with A. flavus/parasiticus before harvest may lead to further build up of aflatoxin after harvest if drying is slow or if storage and transportation is under high humidity.

42. Prevention of aflatoxin in pistachios can be achieved in one or two ways: by preventing the infection in the first place or by modifying the environment to inhibit mould growth and mycotoxin production. In the orchard, important preventive measures are those that reduce the amount of “early splits” and the sources of the aflatoxin producing fungi as far as possible, and those that minimise insect damage. Prevention at harvest and during processing is favoured by avoiding contact with soil, and dehulling and drying the pistachios to a moisture content corresponding to a Water Activity of less than 0.70 as soon as possible after harvest. Prevention from aflatoxin being built up during storage and transportation depends on keeping a low moisture content, low temperature in the environment and maintaining hygienic conditions. When preventive cannot be achieved, corrective action, such as sorting, needs to be carried out to ensure that contaminated material does not enter the food chain.

43. The Chairman asked if a competing fungal species inoculated into the soil could
prevent growth of *Aspergillus flavus* in pistachios. Dr. Olsen replied that this approach, which has been tried for peanuts, has not been used for pistachios. In reply to Dr. Bhat's question on whether *A. parasiticus* is transported by insects into pistachios, Dr. Olsen stated that *A. flavus* is more common. There was discussion on conditions for transportation of pistachios to the dehulling center as to whether polypropylene bags should be used and the requirement of relative humidity below 70%. Transportation time after picking should be kept short.

**Other related activities:**

44. The conference was informed by the Delegate of GTZ\(^1\) of a 3-year study of 450 maize stores in Benin and Nigeria. This study aims at developing a strategy to reduce human exposure to aflatoxin in West Africa. It was found that on average, 30% of the stores at any given time were found to contain maize with aflatoxin B\(_1\) levels above 20 ppb. In one agro-ecological zone, 50% of the maize was positive after 6 months in storage, with an average of 220 ppb. The farmers' management practices that significantly increased or decreased the risk of toxin development were assessed by zone, providing insight on system modifications that might be developed into extension messages. Cost/efficacy analysis of farm management options for aflatoxin reduction will begin in 1999 in a project funded by the German Bundesministerium für Zusammenarbeit. To produce a situation in which on-the-shelf farm management solutions might be adopted, action is required in the realm of social and political discourse. A Rotary International (RI) Health, Hunger, and Humanity Project has been designed with IITA, FAO, governmental organizations, and Rotary Clubs from 5 countries to increase trader and consumer awareness of the deleterious nature of poor grain quality in West Africa. Information campaigns and grain quality monitoring in urban market centers of Bénin, Togo, Ghana, and Burkina Faso will be undertaken. Animal husbandry will be the target of another set of RI campaign messages about how to render safe low quality feeds in order to provide a legitimate alternative market for poor quality grain. The other important factor in food quality management is government policy. Most governments in West Africa have a mycotoxin monitoring capability and regulatory aflatoxin limits as statutes of law. The problem is lack of priority and insufficient funding. Countries with a low tax base and a large social burden must have economic prioritization of the state-run programmes. A medical interface study, funded by BMZ, to begin in 1999, will attempt to assess the immune-suppressive effect of mycotoxins in small children. Finally, in the event that aflatoxin control becomes a priority policy issue in Africa, research into host plant resistance will be needed. A biological control solution is being looked for with collaboration between the USDA and IITA. It is expected that within five years the various components of this multi-partner endeavour will begin to show effects in West Africa, resulting in a sustainable change towards mycotoxin management and elimination.

**Agenda Item 7: Risk Analysis in Regulating Mycotoxins**

45. The basis of these discussions were two documents, MYC-CONF/99/7a and MYC-

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CONF/99/7b, that presented the processes of evaluating risks posed by food contaminants, in particular mycotoxins, which would be useful in policy-making decisions. These decisions can affect public health and trade at an international level. The process of risk evaluation with respect to Codex Alimentarius and JECFA was presented.

Overview

46. Dr. Tine Kuiper-Goodman presented document, MYC-CONF/99/7a, which provides basic concepts of the analysis of risks posed by mycotoxins. The Conference was informed that procedures used to determine risks posed by mycotoxins can be used to set up mycotoxin management programmes. With lower levels of many mycotoxins (aflatoxins, ochratoxins, fumonisins and zearalenone) possible chronic toxicity is usually of greater concern than acute toxicity since some of these substances are potent carcinogens, and exposure to them is widespread. While complete elimination of mycotoxins from foods is an impossible goal, it is important to ensure that their levels in food do not pose a health concern. A variety of interrelated approaches have been developed in recent years to assess the hazards, monitor and assess exposure, and determine the associated risks. This process needs to be transparent in stating the hazards and the need for risk management and intervention. Risk assessments provide the scientific background and understanding for sound policy decisions that protect the public at an affordable cost, and allow for public/international discussion, scrutiny and harmonisation. Because of differences in the significance of biological effects and available data, there is at present no single approach that can be used for all problems regarding mycotoxins, rather a case by case approach is needed.

47. The Conference was informed by Dr. Pfohl-Leszkowicz of the approach used in France for the risk assessment of food contamination by mycotoxins and of proposed recommendations for the revision of current guideline levels. This approach takes into account the mode of action of aflatoxins (AF) and ochratoxin A (OTA) at the molecular level (on macromolecules); subcellular level (on mitochondria), cellular level (protein synthesis inhibition) and the organ specificity (pathologies). The toxicokinetics of the two substances are similar, both are recycled via biliary excretion and bound to proteins. Moreover, OTA is reabsorbed at renal tubular level. These phenomena increase the difficulty to elaborate a mathematical model for the clearance of these molecules.

48. For aflatoxins, the acute risks to farm animals are dependent on dietary exposure and on time of exposure. All aflatoxins induce hepatocarcinoma in several animal species and in humans. Hepatitis B increases considerably the risk. The French calculated NOAEL is of 0.61 µg/kg Body Weight per day for AFB\(_1\) and 0.7 µg/kg Body Weight per day for AFM\(_1\). The evaluation of food contamination in relation to food consumption indicated a mean exposure of about 1.6 ng/kg per day in France (4.5 ng/kg for the most exposed children). These values are over the NOAELs and 90% of intake is due to cereals. For AFM\(_1\), the adult intake was 0.098 ng/kg BW per day and 0.52 for the group of children most exposed. For AFB\(_1\), which is a carcinogenic and genotoxic mycotoxin, the Conseil Supérieur d’Hygiène Publique de France (CSHPF) recommended the As Low As Reasonably Achievable (ALARA) principle be followed. The proposed Tolerable Limit (TL) is 2 ppb for wheat and corn, and the value was also applied to rice and nuts. For the cereals consumed by young children, the value of 1 ppb must be maintained.

OTA has little toxic effect on cattle, but can be excreted in milk. However, it is nephrotoxic to all other animal species, swine being the most susceptible. In addition, OTA is hepatotoxic,
immunotoxic, teratogenic and carcinogenic for rodents, and is implicated in Balkan Endemic Nephropathy. The usual mutagenicity tests are negative. Nevertheless, it is thought that, after biotransformation, OTA induces DNA damage. Since no data on OTA in milk, beer, wine or coffee were available in France at the time of the evaluation, these products were not taken into account in the evaluation. Thus, the main sources of contamination considered were wheat and corn. Also in France, the intake from consumption of pig products represents 5% of the total intake. Dr. Pfohl-Leszkowicz informed that the CSHPF is considering reducing the TL for OTA from the present 5 ppb to 4 ppb since 87% of the tested samples had less than 1 ppb of OTA, and the maximum level found was 2.9 ppb. Data from other countries indicate that poultry can be contaminated by OTA and suggest that a survey be made to cover these products.

49. Dr. Boutrif asked if wine and beer had been considered as sources of OTA intake by humans. They were not. The representative of the International Tree nut Council was concerned that a lower limit of 2 ppb for AF B1 in wheat (the main source of exposure in France) was proposed, while the limit for tree nuts was still 4 ppb, when the intake of nuts was so much less. Dr. Kuiper-Goodman commented that the use of rodent data for risk characterization for AF was not particularly useful since human data are available.

Risk Analysis of Mycotoxins by the Joint FAO/WHO Expert Committee on Food Additives (JECFA).

50. Document MYC-CONF/99/7b was presented by Prof. Ronald Walker. The Joint FAO/WHO Expert Committee on Food Additives (JECFA) provides scientific advice to the Codex Alimentarius Commission, primarily through two of its general subject committees, the Codex Committee on Residues of Veterinary Drugs in Foods (CCRVDF) and the Codex Committee on Food Additives and Contaminants (CCFAC). The JECFA has been meeting regularly since 1956 to evaluate food additives, contaminants, naturally occurring toxicants, and residues of all veterinary drugs in food.

51. To date, JECFA has evaluated three groups of mycotoxins, specifically, AFs, OTA, and patulin. Several additional mycotoxins are all on CCFAC priority list, including fumonisins, trichothecenes, and zearalenone for evaluation and OTA for re-evaluation. A traditional approach was used in these assessments in that no-observed-effect-levels (NOELs) and lowest-observed-effect-levels (LOELs) were identified, to which safety factors were applied.

52. In 1987, JECFA considered that, while good animal data were available, the association between AF exposure and primary liver cancer was difficult to evaluate because of the large number of uncertainties in these studies, including inadequate data on the dietary intake of AFs, the contribution of hepatitis B virus to the etiology of cancer, and cultural and dietary status and habits. At that time available scientific information did not permit a determination of the extent to which exposure to aflatoxins contributed to the increased incidence of primary liver cancer in the populations that were studied.

53. In 1997, the Committee considered that the weight of scientific evidence, which introduced epidemiological data, studies in laboratory animals and in vivo and in vitro studies of metabolism, supported the conclusion that AFs should be treated as carcinogenic food contaminants, the intake of which should be reduced to ALARA levels. The Committee used carcinogenic potency including limitations on data on AFs and observations relating to the
interaction between hepatitis B infection and AFs. The fraction of the incidence of liver cancer in a population attributable to intake of AFs was derived by combining estimates of AF potency (risk per unit dose) and estimates of AF intake (dose per person). Mean dietary intakes of AFs for various regions were estimated using the "Global Environment Monitoring System-Food Contamination Monitoring and Assessment Programme (GEMS/ Food)" diets.

54. After reviewing and analyzing food diets the data, the Committee came to the following conclusions: (1) AFs are considered to be human liver carcinogens, (2) the potency of the AFs in individuals who are hepatitis B surface antigen positive is substantially higher than in those who are negative, (3) vaccination against hepatitis B would reduce the potency of the AFs, (4) analysis of the application of hypothetical guideline levels for AFs contamination in food (10 µg/kg or 20 µg/kg) to model populations indicates that: (a) populations in which there is a low prevalence of hepatitis B positive individuals are unlikely to exhibit detectable differences in population risks; and (b) populations in which both the prevalence of hepatitis B positive individuals is higher and the intake of AF-containing foods is high would benefit from reduction in AF intake. Reductions in the intake of AF can be achieved through avoidance measures such as improved farming and proper storage practices and/or through enforcement of standards for levels of contamination in food or feed within countries and across borders.

55. The Delegate of Denmark questioned conclusion (4) because it is based on surveys in European countries where much lower limits are in force. Consequently lots with a content of aflatoxins between 10 and 20 µg/kg are rejected and any detectable difference in population risks cannot be expected when using a standard of 10 or 20 µg/kg. Further, the average intake of 1 ng/kg b. wt/day can be easily exceeded in Europe. Prof. Walker replied that the concern he had over a single exposure from, say, one contaminated fig was not justified in a risk evaluation based on continual exposure. There was discussion on whether the AF exposure estimates used in the evaluation were over- or under-estimated. Prof. Walker pointed out that only recent surveillance data was used in the 1997 evaluation, that limits that had come into force would tend to lower intake of AF, and that 20 years ago (when the cancer could have been initiated) levels of AFs could well have been higher.

Agenda Item 8: Mycotoxin Control - Regulations and Enforcement

56. This agenda item was presented in two phases, firstly, an account of mycotoxin regulations world-wide as well as factors affecting the establishment of regulatory limits (MYC-CONF/99/8a), and, secondly, procedures for minimizing risks posed by mycotoxin contamination (MYC-CONF/99/8b).

World-wide Regulations for Mycotoxins

57. The document MYC-CONF/99/8a was presented by Dr. Hans P. Van Egmond. The Conference was informed of the principles and methods used in the establishment of regulations for mycotoxins world-wide. Since the discovery of the aflatoxins in the 1960s, regulations have been established in many countries to protect the consumer from the harmful effects of mycotoxins that may contaminate foodstuffs. Various factors play a role in the decision-making process of setting limits for mycotoxins. These include scientific factors such as the availability of toxicological data, survey data, knowledge about the distribution of mycotoxins in commodities, and analytical methodology. Economical and political factors such
as commercial interests and sufficiency of food supply have their impact as well. Policies regarding genotoxic carcinogens are an important consideration for some mycotoxins.

58. It was pointed out that international surveys on existing mycotoxin legislation in foodstuffs and animal feedingstuffs have been carried out several times in the 1980s and 1990s and details about tolerances, legal bases, responsible authorities and official protocols of analysis and sampling have been published. Recently a comprehensive update on worldwide regulations was published as FAO Food and Nutrition Paper 64. From this update it appears that 77 countries have specific regulations for mycotoxins, 13 countries are known to have no specific regulations, and no data are available for about 50 countries, many of them in Africa. Over the years, a large number of tolerance levels for mycotoxins has remained. It is not likely that worldwide harmonised limits for mycotoxins will soon be achieved.

59. Dr. Boutrif reported considerable demand for the FAO 1995 publication on mycotoxin regulations and a further update is a possibility in the future; this would be placed on the Internet. There was discussion on whether regulation should be for AFB₁ only or for the sum of the four AF. Mr. Van Egmond thought regulations for AFB₁ was sufficient, but the Chairman mentioned that isolated occurrence of AFG₁ does occur. Dr. Van Egmond suggested that monitoring agencies in those countries that apply tolerances for the sum of the AF should review their analytical data to see how frequently the availability of data of the sum of the AFs (above that on AFB₁) has been indispensable to adequately protect the consumer. He thought this frequency would be low, whereas determination for the sum of the AFs involves extra analytical work and quality assurance. The analogous approach for one or more of the fumonisins will have to be carefully thought out when these mycotoxins are regulated. Regulations for AFM₁ in milk have to be related to regulations for AFB₁ in the feed. There do not appear to be special regulations for ammoniated feed. The European Union has funded a project on the toxicology of ammoniated feed and of milk derived from this feed. Data will be used for developing legislation. The question of whether special groups, such as non-wheat eaters and infants, are covered by regulations protecting the whole population was discussed at length. Dr. Visconti thought labelling was a possibility. Dr. Riley pointed out that risk assessment of mycotoxins should use human data and work should be done quickly before affected populations (e.g. in Guatemala) change.

Minimizing Risks Posed by Mycotoxins Utilizing the HACCP Concept

60. This item was introduced by Drs. Boutrif and Park (document MYC-CONF/99/8b). The Conference was informed about the use of Hazard Analysis Critical Control Point (HACCP) principles in minimizing risks posed by mycotoxins. Mycotoxin contamination in susceptible commodities occurs as a result of environmental conditions in the field, improper harvesting, storage, and processing operations. HACCP programmes have been useful in managing risks associated with potential contamination of food products with pathogenic microorganisms and chemical toxicants. Food safety programmes routinely utilize information about the factors leading to the contamination to establish preventative and control procedures thus providing the consumer with a safe, wholesome food supply.

61. It was pointed out how, in the establishment of an effective HACCP programme for mycotoxins, key elements are identified which can be used or modified to reduce mycotoxin formation in the field and storage environments, such as 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 physical and chemical inactivation and/or removal of the toxin. Development and application of HACCP-based food safety programmes requires expertise in a range of fields. The Conference was informed on ways FAO has been active in providing technical assistance to its Member States, to build national capacity to implement and maintain effective HACCP-based mycotoxin management programmes.

62. The representative of the International Treenut Council questioned the lack of interest by researchers and regulatory authorities in the European Union in Brazil nuts and pistachios, and pointed out the need for more research on how Aspergillus flavus enters these nuts. There was considerable discussion on HACCP. FAO has commissioned a HACCP manual. There are differences between HACCP and Quality Control; Good Agricultural Practice and Good Manufacturing Practice overlap HACCP and are pre-requisites to HACCP. It was also brought out by Dr. Piñeiro that not all regular control points are “critical” control points. For the moment, the Danish government is implementing HACCP programmes in all Danish food companies. The experience is that HACCP primarily will ensure and improve food quality in a controlled environment, and that it is necessary to keep HACCP programmes simple, practical and understandable for those who are going to use them.

**Agenda Item 9: Mycotoxin Control Activities - Sampling and Analysis**

63. The document (MYCO-CONF/99/9) presented by Dr. J. Gilbert provides guidance for maintaining quality assurance in the determination of mycotoxin contamination levels in foods and feeds.  
The Conference was informed on issues and errors associated with sample collection, preparation of the test portion, and analysis for the determination of mycotoxins. To ensure that representative samples of foods and feeds are taken for analysis, it is important to follow stipulations set out in sampling plans – many of these plans are now incorporated into regulations for controlling mycotoxin contamination. Validated analytical methods are those for which performance characteristics have been established by inter-laboratory collaborative trial, and these are now widely accepted as being essential for monitoring and regulatory purposes. In addition to employing validated methods, internal quality control procedures need to be implemented in chemical laboratories – this normally implies accreditation to EN45000, participation in proficiency testing and the proper use of control and reference materials.

64. Proficiency testing and sampling featured in the discussion of Dr. Gilbert’s presentation. The Food Analysis Performance Scheme (FAPAS) laboratory proficiency programme is a non-profit scheme but users are nonetheless charged for services. A way of making it available to developing countries is needed. The importance of sampling is realised but requirements for regulatory purposes, quality assurance programmes, and monitoring for the purpose of obtaining mycotoxin exposure information may be different. A sampling manual is still needed and perhaps FAO could look into this. Research is required on whether it is preferable to do one analysis on a large sample of a contaminated commodity or several analyses on smaller sub-samples. The very large variation in the levels of aflatoxins observed in small sub-samples of figs and cottonseed illustrates the problem. The question of attaching analytical values to non-detectable levels in monitoring programs must also be considered. Dr. Gilbert recommended analysis of total diets rather than individual foods for obtaining mycotoxin exposure data.
**Round Table Discussions**

65. The Conference divided in three groups for Round Table discussions on each of the following themes, and designated the officers for each group:

- Group 1: Health and Environmental Considerations on Mycotoxins;
  Chair: Dr. David Miller; Rapporteur: Prof. Ronald Walker
- Group 2: Prevention and Control of Mycotoxins;
  Chair: Dr. Hans Van Egmond; Rapporteur: Dr. Douglas Park
- Group 3: Sampling and Analysis of Mycotoxins.
  Chair: Dr. Ramesh Bhat; Rapporteur: Dr. John Gilbert

66. The Groups were requested to carry out the following tasks: (i) review and discuss the main conclusions included in the relevant conference documents; (ii) further discuss relevant issues/points raised at the plenary sessions of the relevant documents; and (iii) formulate specific conclusions and recommendations for inclusion in the draft Conference report. The outcome of the Round Table discussions formed the basis of the Conference recommendations which are given below.
CONFERENCE CONCLUSIONS AND RECOMMENDATIONS

67. Regarding the health and environmental considerations of mycotoxins, the Conference concluded that mycotoxins can pose significant risk for human and animal health. National regulations establishing limits for mycotoxins have been intended to reduce human exposure, but these limits have varied widely and resulted in international trade problems.

68. In attempting to address the problem of non-tariff barriers to trade, the signatory countries of the Agreement on the Application of Sanitary and Phytosanitary Measures (SPS Agreement) of the World Trade Organisation commmitted themselves to base their health and safety requirements for food on sound scientific risk assessment. In addition to other principles, such as consistency and transparency, countries are also required to take into account the risk assessment methodologies developed by international organisations. In general, there is inadequate information on the impact of mycotoxins on human health to complete the risk assessment paradigm. Therefore, only a few mycotoxins have been evaluated by the JECFA, and progress in adoption of maximum limits by the Codex Alimentarius Commission has been slow.

69. It was concluded that the effects of mycotoxins on human health were the principal concern, although control measures need to take account of the social and economic consequences. In this context, the following recommendations have been made to improve understanding of the health effects of mycotoxins and to acquire sufficient appropriate information to conduct risk assessments as required by the SPS Agreement.

69.1 Regulation and surveillance should be targeted at the major sources of exposure in order to be cost effective. It may be inappropriate to employ limited resources for commodities which make a non-significant contribution to intake.

69.2 Considering the importance of mycotoxins as a threat to human health and as a potential impediment to the availability of, and trade in, food and feedstuffs, the evaluation of mycotoxins by the JECFA should be allocated a high priority. In view of the urgency of this matter, FAO and WHO should consider convening a meeting of the JECFA devoted specifically to risk assessment of mycotoxins as soon as the requisite data bases can be compiled.

69.3 Member States are urged to supply FAO and WHO with all available data on levels of exposure and related effects determined experimentally, clinically, or epidemiologically. Where gaps are identified, measures should be taken to generate the required information. Priority should be given to those mycotoxins where there are human data on the effects and levels of exposure.

69.4 Risk assessment of mycotoxins should be conducted in a transparent manner and according to sound scientific principles with any gaps in knowledge and consequent assumptions made clear.

69.5 As previously indicated by the JECFA, where good quality human data are available these should take precedence over animal data in assessing the risk to human health. As a corollary, there is a need to improve procedures for obtaining human data related
to exposure and health consequences. In cases of acute outbreaks of mycotoxicoses, methods need to be developed to monitor these in real time. In view of the transient nature of such events, there is a need for speedy response to such disasters. Procedures should be established to ensure adequate exchange of information between the responsible national authorities and the responsible international agencies.

69.6 When evaluating data used for regulations, surveys or the establishment of toxicological properties, consideration must also be given to the validity and reliability of sampling procedures.

69.7 Research should be conducted to evaluate the modification of the toxic potential of mycotoxins due to the presence of natural constituents in complex food and feed matrices, including co-contamination with other mycotoxins.

69.8 In order to provide a more secure basis for assessing risk, WHO and its Member States are encouraged to acquire human mortality and morbidity data in populations known to be highly exposed.

69.9 Children represent a special “at risk” group because of the likelihood of higher exposure on a body weight basis. In most cases, it is not known whether children might be more susceptible to the same dose as adults. There is a need, therefore, to generate, where possible, more data to determine potency in children.

69.10 Population groups are often exposed to several mycotoxins concurrently with the possibility of interactions. For agriculturally important mycotoxins, and where there are plausible mechanistic reasons to suspect such an interaction (e.g. between a carcinogenic mycotoxin and another which is a promoter or immunosuppressant), such potential interactions should be considered.

69.11 Some agriculturally important mycotoxins have properties (e.g. immunotoxicity, increased gastrointestinal permeability) that may increase the susceptibility of a person to secondary sequelae such as infections with pathogenic bacteria. This may give rise to symptoms not recognised as a classical mycotoxicosis but should be investigated.

69.12 Methods for assessing dietary exposure should be harmonized, and should be appropriate for the purpose. The need for sound intake estimates should be emphasised since this is a means by which potency of mycotoxins in relation to chronic effects can be estimated. They are also indispensable in assessing the distribution of risks as a function of dose and identifying groups at risk.

69.13 In relation to human health, occupational exposure may represent an additional route of exposure, e.g. in agriculture, milling etc. and the associated risks should be explored.

69.14 In assessing human exposure, more emphasis should be placed on total diet and duplicate studies rather than individual foods. Where validated biomarkers are available, these should be used for assessing human exposure.

70. **Regarding mycotoxin prevention and control**
General recommendations

70.1 Harmonization of regulatory limits for mycotoxins worldwide should be promoted to reduce problems in international trade. An explanation of the risk assessment supporting specific regulations should be provided.

70.2 Enacted regulations and those under development should be the result of cooperation between interested parties from the industry, the ranks of the consumers, the scientific community and official government circles.

70.3 To minimize intake of mycotoxins, measures should be taken to ensure that lots which do not meet regulatory limits are not mixed with other lots but used for other purposes.

70.4 Regulatory standards can provide a benchmark against which the effectiveness of food safety programmes can be measured to provide a guarantee of successful implementation of HACCP systems.

70.5 In order to facilitate exposure assessment in the establishment of regulations, there is a need to obtain reliable survey data from laboratories utilizing a quality assurance programme. National governments and international and regional bodies, as appropriate, should develop and fund such studies.

70.6 Integrated mycotoxin control programmes should incorporate HACCP principles in the control of risks associated with mycotoxin contamination of foods and feeds.

70.7 HACCP principles can be used to highlight the roles that fungal econology, crop physiology, and agricultural practices play in mycotoxin contamination prevention and control.

70.8 There is a need for sensitization of all stakeholders in the production chain, particularly farmers, of the importance of measures to reduce or avoid mycotoxin contamination.

70.9 Due to limited information on mycotoxin contamination in developing countries such as those in Sub-Saharan Africa, collaborative and partnership research between scientists and laboratories in developing and developed countries should be encouraged to assess the extend of mycotoxin contamination in these countries.

70.10 Research should be conducted on new varieties on those agricultural commodities susceptible to mycotoxin contamination with a view to enhance their resistance to fungal infection, insect damage and toxin formation.

70.11 Before recommending the introduction of crops or genotypes into new environments, consideration should be given to the potential for increased fungal infection in such regions.

70.12 In drying procedures, the time period when the water activity is most favorable to mould growth should be minimized.

70.13 Training programmes for the development of practical control and management
strategies, essential to ensure consumer’s safety should be conducted, in particular in developing countries.

70.14 Training programmes should be developed and conducted on HACCP principles, applications and programmes.

70.15 Training programmes for those involved in agricultural and food processing activities addressing good agricultural, processing and handling practices should be conducted in order to set up strong mycotoxin management programmes.

70.16 More research should be conducted in the development of decontamination processes for fumonisins, ochratoxins, trichothecenes, zearalenone and other mycotoxins.

Specific recommendations

71. **Aflatoxins**

71.1 Research should be conducted (i) on the development of cultivars and procedures for preventing fungal contamination and formation of aflatoxins in pistachios in the field; and (ii) to determine the importance and critical effects that water used in processing may have on the aflatoxin levels in pistachios.

71.2 Training programmes should be conducted on the prevention of aflatoxin contamination in pistachios.

71.3 Research should be conducted to study the etiology of contamination of minor commodities such as Brazil nuts by aflatoxins and to develop industrial processes for reducing aflatoxins levels in these commodities.

72. **Fumonisins**

72.1 Research should be conducted (i) on the genetic variability of corn germ plasm to determine the effects on fumonisin production; and (ii) to develop biomarkers and indicators of contamination by fumonisins.

72.2 Safe limits for human dietary exposure to fumonisins should be established for those population groups that consume large amounts of corn products.

72.3 Accurate and extensive surveys of corn-based human food and animal feed, including processed products, should be conducted using methods verified for their efficiency of extraction of fumonisin analogs.

73. **Ochratoxins**

73.1 Research should be conducted to (i) determine the significance and presence of ochratoxin in human milk; and (ii) to identify and establish factors that affect pre-harvest contamination by ochratoxins.
74. **Regarding sampling and analysis of mycotoxins**

**Sampling**

74.1 Additional sampling plans should be developed to cover a wide range of commodities and for a wider range of mycotoxins. These sampling plans should be realistic, based on sound science and on a careful balance between consumer and producer risks.

74.2 The reasons for undertaking and applying specific sampling plans should be made explicit as should the intended aim of the sampling plan.

74.3 A manual should be developed which sets out in some detail the recommended manner of taking samples and also shows how samples should be prepared for homogenisation and for subsequent sub sampling.

74.4 Research should be undertaken to examine the relationship between the analysis of multiple small samples from a consignment and the analysis of a single sample taken from a homogenised large composite sample.

**Analytical methods**

74.5 Analytical methods should be developed which are simple, robust and of a low cost for use by developing countries. FAO, WHO, UNEP, IAEA, IUPAC and others concerned agencies should consider assisting in the transfer of appropriate technology. For example, they could make antibodies available that might be used to prepare ELISA kits or affinity columns locally rather than necessitating purchase of expensive commercial materials.

74.6 Research should be conducted on the development and validation of rapid testing methods.

74.7 More analytical methods for mycotoxins should be validated for a wider range of food and feed matrices than has been achieved to date. Recognising the cost and length of time involved in full collaborative trial validation, the AOAC International ‘Peer Verified Methods’ process should be encouraged and more widely employed. Methods so generated should be widely disseminated.

**Reference materials and analytical standards**

74.8 The development of reference materials should be encouraged for a wider range of mycotoxins and a wider range of foods and feeds than is presently the case. It should be recognised that certified materials with a high degree of confidence in the true values may not always be required and that lower cost, more stable materials may be more appropriate and relevant.

74.9 There still remains a need to provide analytical standards, particularly for the less common mycotoxins, and these should be made available centrally by FAO, IAEA and WHO to appropriate official and other control and monitoring laboratories.
74.10 FAO, IAEA, WHO and UNEP should develop a mechanism for the transfer of small quantities of mycotoxin reference standards among countries to overcome recently introduced export restrictions.

74.11 There is a need to establish and confirm physicochemical constants for a number of analytical standards that can be used for confirming quantification of analytical calibrant solutions.

74.12 FAO, IAEA, WHO and UNEP should encourage the development of analytical methods which do not employ environmentally damaging chemicals or those that might present health risks to laboratory personnel.

74.13 In order to encourage wider participation in proficiency testing, FAO, IAEA, WHO and UNEP should consider regional training in establishment of local proficiency testing schemes which would include preparation of test materials, homogeneity testing and the production of test reports based on the International Harmonised Protocol for proficiency testing.

75. **Regarding other related matters**

75.1 FAO, IAEA, WHO and UNEP should consider setting up a portable, self sufficient ‘turn key’ mycotoxin laboratory that could be transported anywhere in the world and could be rapidly operational. Such a laboratory could be used as a model for what would be required for a self-contained laboratory in a developing country.

75.2 FAO, IAEA, WHO, UNEP and other concerned organizations should encourage the authors of reports and publications containing analytical data on mycotoxins to include information on sampling and quality assurance undertaken so that judgements can be made on the quality of the reported data.