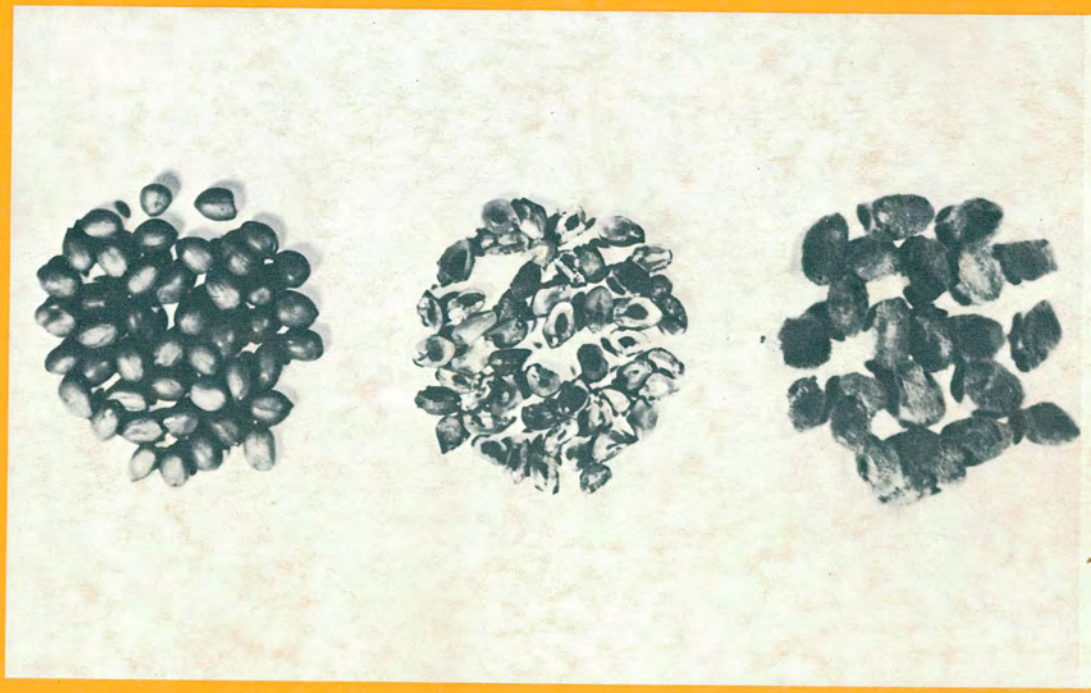
FAO FOOD AND NUTRITION PAPER 2

mycotoxins



FOOD AND AGRICULTURE ORGANIZATION
OF THE UNITED NATIONS ROME

FAO FOOD AND NUTRITION PAPER 2

report
of the

joint fao/who/unep conference

on

mycotoxins

held in nairobi,
19-27 september 1977

under the sponsorship of
the food and agriculture organization of the united nations
the world health organization
and
the united nations environment programme

FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS
Rome 1977

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REPORT

of the

Joint FAO/WHO/UNEP Conference on Mycotoxins

Nairobi, 19-27 September 1977

INTRODUCTION

1. A Joint FAO/WHO/UNEP Conference on Mycotoxins was held in Nairobi, Kenya, from 19-27 September 1977. The Conference was convened by the Directors-General of FAO and WHO and the Executive Director of UNEP and was kindly hosted by the Government of the Republic of Kenya. Delegates from forty countries attended sessions of the Conference; representatives of ten international organizations participated as observers. A List of Participants is attached as Annex I to this Report.

Opening Session

2. The representative of FAO (Mr. R.K. Malik) called the meeting to order and extended a general welcome on behalf of the Directors-General of the Food and Agriculture Organization of the United Nations and the World Health Organization and of the Executive Director of the United Nations Environment Programme. He expressed the appreciation of the sponsoring United Nations agencies to the Government of the Republic of Kenya for hosting the Conference, and to His Excellency, The Honourable J.C.N. Osogo, Minister of Health, for coming to the meeting to open the Conference.

3. His Excellency, The Hon. J.C.N. Osogo, Minister of Health, opened the Conference and welcomed the delegates on behalf of the Government of the Republic of Kenya. He stressed the importance of the Conference, which was the first of its kind to be held at intergovernmental level in order to seek application of the scientific and practical knowledge which has accumulated in this field especially over the past two decades. The hazards to human and animal health were well known, and the economic effects of mycotoxins were felt in virtually every country. Concerted action by national governments and international (UN) agencies was therefore urgent in order to achieve a measure of control over the problems due to mycotoxins. For such action, the concrete and practical recommendations of this Conference were needed. The full text of the Minister's address is attached as Annex II to this Report.

4. Mr. Malik (FAO) thanked Minister Osogo for his words of encouragement to the Conference and invited nominations for Chairman of the Conference. The delegate of India nominated Dr. W. Koinange, leader of the delegation of the Republic of Kenya, as Chairman; the nomination was seconded by the delegate of the United States of America. Dr. Koinange was elected Chairman. The Chairman took note that this was a Joint FAO/WHO/UNEP Conference and requested a statement from each of the representatives of the agencies. He invited the Deputy Executive Director of the United Nations Environment Programme, Mr. P. Thacher, to make his opening statement.

5. Welcoming the delegates on behalf of the United Nations Environment Programme, Mr. Thacher called the Conference a central event of two of UNEP's most important programmes: preserving natural resources and protecting human health. Food is an essential resource, perhaps the most basic of all human needs. But it is also, along with water and air, a main vehicle through which biological and chemical pollutants reach our bodies.

6. Mr. Thacher recalled that the need for assessing and protecting human foodstuffs was emphasized in a number of the recommendations of the 1972 United Nations Conference on the Human Environment which also underlined the need for FAO and WHO to undertake internationally coordinated programmes of research on and monitoring of food and animal feed contamination and that increased support be given to the Codex

Alimentarius Commission to develop international standards for pollutants in food and a code of ethics for international food trade with special regard to the needs of developing countries. In pursuit of those recommendations, UNEP from its very inception had worked in close cooperation with FAO and WHO. Mr. Thacher mentioned the training programmes for the control of food contamination in eastern Africa as an example of cooperation with FAO relevant to this Conference on Mycotoxins which, he felt, was adding a new element to the food control programme. The documentation indicated the magnitude and seriousness of the problem posed by mycotoxins both in developing and in developed countries. It showed clearly that the problem was global not only because it arises in so many different areas, but particularly because it affects major commodities that are traded internationally.

7. Ultimately the aim would be to establish an effective system of internationally agreed monitoring and control that would protect the consumer from exposure to some of the most toxic substances known and that would safeguard the producer from unexpected, and sometimes unjustified, deprivation of the fruits of his labour and his investments. He was not talking about a dream, Mr. Thacher said, but about concrete possibilities that could be turned into realities within the next few years. This would achieve for a major group of pollutants the protection of both human health and human food, two commodities that the three organizations involved in this Conference were pledged to preserve and enhance and toward which they trust that this Conference would make a major and lasting contribution.

8. Dr. C.A. Linsell (IARC/WHO) conveyed to the delegates the greetings and best wishes of Dr. Mahler, the Director-General of WHO, and of Dr. Higginson, the Director of the International Agency for Research in Cancer. The threat of mycotoxins to health was well recognized by WHO. A Health Criteria Document on aflatoxins was being finalized for the guidance of member states, with input from UNEP and FAO.

9. The presence of mycotoxins in food was neither accidental nor deliberate, Dr. Linsell suggested. These environmental pollutants were naturally occurring toxins creating problems of social and economic significance. The IARC was especially concerned because the aflatoxins had been demonstrated to be potent carcinogens in animals. This group of mycotoxins had been found worldwide, but was particularly common in countries where certain cancers were more frequent. Dr. Linsell emphasized that the relationship between level of ingested toxin and disease incidence was so far only an association of facts, and that other factors were also involved. More research and evaluation was needed. He referred to cigarette-smoking for which a causal relationship to lung cancer could not be claimed until it was found that the risk of lung cancer was diminished when exposure to cigarettes ceased. Intervention to decrease exposure of populations particularly to aflatoxins might possibly bring a fuller understanding of the relationship of toxin ingestion to liver cancer development. This task was in the hands of scientists concerned with the food chain from agriculture to consumption, not those of physicians. Dr. Linsell concluded his statement by expressing the hope that this Conference would point the way toward avoiding ingestion of these toxic entities and particularly the aflatoxins.

10. Mr. R.K. Malik extended to the delegates greetings and encouragement from Mr. E. Saouma, Director-General of the Food and Agriculture Organization of the United Nations, the agency responsible for the organization of the Conference. Mr. Malik stated the reasons why this Conference was needed, and at this time. These were first because much research and many scientific meetings had revealed most of the problems due to mycotoxins and second, because some governments, having recognized the hazards, had acted to protect their population, human as well as animal, through the setting of quantitative limits in foods or feedstuffs presented for importation.

11. The world has become too interdependent to entertain a notion that any country or its produce are immune to the ill effects of mycotoxins. Climate and other conditions would, however, favour mycotoxin development in certain countries and regions, in certain crops, and correspondingly greater efforts would need to be made where the danger of contamination and of adverse influences on economics and health loom relatively larger.

12. Mr. Malik explained to the delegates that FAO was concerned with food in all its aspects, from production by agriculture, livestock, fisheries and forestry to the further processing and marketing of the produce even to consumption. It was important to increase availability of food supplies especially in developing countries, to meet the colossal problems of hunger and malnutrition, appropriate protection of crops and prevention of food losses after harvesting. Mycotoxins had a role in reducing availability and certainly the quality of food supplies in many parts of the world.

13. Mr. Malik briefly acquainted the delegates with various programmes jointly operated by FAO and WHO, some of them also with the support and collaboration of UNEP. He mentioned the Joint FAO/WHO Food Standards Programme, the executive arm of which is the Codex Alimentarius Commission consisting of 114 Member Governments of the two Organizations, and explained that the efforts of this Commission are directed toward the development of international standards for foods for the protection of consumers, both with respect to health and well-being and prevention of fraud, and through harmonization of regulations to facilitate international trade in foods. Attention was also drawn to certain training programmes, an international food contamination monitoring programme, and a specific regional project for the control of contaminants in food based in Kenya. The present Conference on Mycotoxins was one of the series of such endeavours to monitor, assess and control problems of food contamination with a view to protecting human and animal health and well-being and better management and conservation of natural resources for food and agriculture.

14. The UN agencies would expect several things from a conference of this nature. Any efforts to lighten the work of the small farmer in keeping his crops and foods as free from mycotoxins as possible would be most welcome. Measures against mycotoxins and prevention and control of the hazards would have to be interdisciplinary and include better protection of crops, improved agricultural and animal husbandry practices, use of appropriate post-harvest technologies, better processing, storage, marketing and distribution systems and effective food quality control and feed control measures which would ensure protection of the consumer and facilitate growth of trade and industry. Mr. Malik concluded with the request that the Conference should provide a well-planned future course of action in this important area. FAO, UNEP and WHO would want to give careful consideration to the recommendations made in order to prepare for worthwhile concerted efforts in this field.

15. The CHAIRMAN thanked agencies for their statements and commented that the need for the Conference was apparent and that the assembled delegates were asked to come up with worthwhile, practical recommendations that would lead to a thorough attack on the problems due to mycotoxins within a country and in world trade. He noted the many past and current efforts of the agencies, and particularly the statements that follow-up activities recommended by the Conference would be given special consideration. He referred to the considerable and good background documentation provided as an indication of the amount of work ahead for the Conference.

16. The CHAIRMAN tabled the provisional agenda and the suggestion made to move Item 11, 'Other Matters', ahead of Item 10, 'Recommendations'. In addition, as the consultant chiefly concerned with 'Detoxification' was unable to stay beyond Tuesday, it was proposed that agenda Item 6 be moved ahead of Item 5, 'Prevention'. The agenda was adopted as modified. The Secretariat commented on the availability of the documents for the Conference. The timetable for the Conference was discussed and agreed. Mr. F.H. Shah of PAKISTAN and Prof. G. Nilsson of SWEDEN were elected

to be the two Vice-Chairmen of the Conference, having been nominated and seconded by the delegations of CANADA and The PHILIPPINES and KENYA and BELGIUM respectively. The Chairman appointed Mr. F.G. Peers (U.K.) to serve as overall Rapporteur. In addition, due to the multidisciplinary nature of the work before the Conference the following were appointed Rapporteurs:

SENEGAL (Mr. Fall) for agenda Item 5, 'Detoxification';
INDIA (Mr. Agrawal) for agenda Item 6, 'Prevention';
The NETHERLANDS (Mr. Rozenboom) for agenda Item 7, 'Surveillance/Control';
NIGERIA (Mr. Opadokun) for agenda Item 8, 'Extension';
Federal Republic of GERMANY (Mr. Leistner) for agenda Item 9, 'Research/ Training'.

PROBLEMS OF MYCOTOXINS (Agenda Item 4)

17. The Conference had before it four documents, namely MYC-3, MYC-4a, MYC-4b, and MYC-4c. The Secretariat, referring to the documents, mentioned that these were not discussion papers and were in fact prepared to provide background information on the different aspects of problems of mycotoxins. It was felt that this information would be useful in the consideration and discussion of the various other items on the agenda of the Conference. However, any general comments on the information contained in the document would be welcome.

Environmental Aspects

18. Dr. Alozie (UNEP) introduced the item 'General Perspective' and dealt with the environmental aspects of mycotoxin problems and the role of the United Nations Environment Programme in this and related fields (document MYC-3). He stated that UNEP's Fifth Governing Council had passed a decision that the Executive Director should continue to "give high priority to the protection of human and environmental health and to cooperate closely with UN agencies (in paying special attention to the problems) in both developed and developing countries of contaminants, both chemical and biological, of food, and to epidemiology and control of chronic diseases of all kinds...as far as they relate to environmental factors". Thus UNEP would continue to cooperate with specialized UN agencies, especially FAO, in assisting developing countries to strengthen capabilities for evaluating chemicals in their foods. Goals approved by the Fifth Governing Council call for UNEP to provide by 1982 concrete advice for governments on how to deal with priority pollutants.

19. Dr. Alozie stated that, according to document MYC-3, mycotoxins are environmental pollutants of biological origin. He further indicated that UNEP has a catalytic role in ensuring that specialized agencies like FAO and WHO can give priority attention to problems of environmental contaminants. FAO and WHO have the expertise and experience to deal with mycotoxin problems, as will be evident inter alia from the good documentation that had been prepared for the information of delegates and observers. UNEP had profound interest in food contamination problems. The ongoing programme in cooperation with FAO and WHO included a project in eastern Africa on the control of environmental contaminants in food. A joint FAO/IARC/UNEP/WHO follow-up action on the control of aflatoxins and their effects on human health (liver cancer) was envisaged to start in the near future. Support from this Conference would be expected to add considerable impetus for earliest initiation of the project.

20. Proper assessment of the impact of mycotoxins as pollutants was a major tool for management of environmental resources. Equally, training and educational programmes on preventive measures deserved strong efforts, as did also the establishment of sound agricultural extension services geared to introducing technology appropriate for the different levels from the small farm to the commercial establishment. A look into the methods of assessing human exposure to aflatoxin may be useful as well. Dr. Alozie

concluded that the recommendations and decisions of the Conference would draw support from UNEP especially in those areas that complement its recently defined goals in areas of pollution and human health.

Global Perspective

21. Mr. Rodricks (consultant) introduced document MYC-4a entitled 'Global Perspective on Mycotoxins'. Part I was a succinct statement of what the problem is and why it is important. Part II presented the most comprehensive collection of data available concerning the occurrence of mycotoxins in foods and feeds. Toxic chemicals produced by moulds (mycotoxins) number in the hundreds. The document considered only those few mycotoxins for which substantial knowledge of their roles as food and feed contaminants was available. Thus, the document laid stress on the aflatoxins, zearalenone, citrinin, ochratoxin, the trichothecene group, patulin and penicillic acid. The document indicated for each of these the producing moulds, natural occurrence in agricultural commodities, conditions for mould growth and toxin production, sites of contamination, adverse effects on livestock and poultry under both field and experimental conditions, and health effects in humans. Regulatory and economic aspects were also mentioned.

22. The conclusion was inescapable, according to Mr. Rodricks, that in all respects present knowledge of the aflatoxins exceeded by far the knowledge of any of the other mycotoxins. Therefore, rather than collect additional information on the aflatoxins, a stage had been reached where action could be taken to reduce this hazard while the search for information might shift to a stress on one or more of the other mycotoxins. The Conference might consider which other mycotoxins deserved research priority.

23. Document MYC-4a made quite clear that mycotoxins do indeed occur in foods and feeds, in some cases at frequencies and levels none would have thought possible a mere decade ago. Part II reflected the published information and that obtained from surveys conducted as part of the FAO/WHO/UNEP project of which this Conference was the culmination. Seven major cereal grains, 5 important oilseeds, 6 tree nuts, vegetable oils, pulses, root crops, other vegetable products and animal products including milk, cheese, meat and fish were covered in the document. The data were presented on a country-by-country basis. Other useful information presented was on the importance of the commodities in the diets of humans and animals, on climatic conditions that might bear on observed contamination, on agricultural practices that might have contributed to a problem, and on site of contamination where known. Such information could give initial guidance to countries interested in pursuing mycotoxin control programmes.

24. The document suggested that, on a global basis at least, the problem of mycotoxin contamination of maize outweighs that of any other commodity. Further, the incidence data must generally be interpreted with caution, because necessary background information was often incomplete or unavailable. Some commodities appeared to have been examined less thoroughly than their importance deserves, e.g. rice. Rational policy making could not proceed when the problem to be treated was of poorly known dimensions. Finally, there were no data from many regions of the world. The absence of such data should not be interpreted to mean that no mycotoxin problem exists. Based on experience, one should in fact assume that a problem does exist until proven otherwise. Because of the global nature of the problem, the sharing of incidence data was essential to a solution. It was hoped that additional data would be forthcoming to complement that contained in the 'Global Perspective' document.

Health and Toxicological Aspects

25. Dr. Fishbein (consultant) introduced document MYC-4b entitled 'Health and Toxicological Aspects of Mycotoxins'. A broad spectrum of diseases, both acute and chronic,

resulted from the consumption of mycotoxins. Humans and livestock in both industrialized and developing countries have been affected. The diagnosis of mycotoxicoses in man and animals was exceedingly difficult. Advances in chemical analysis had made possible the measurement of exposure of humans to specific mycotoxins, thus facilitating epidemiological investigation. Of the mycotoxins, aflatoxins had been most studied. Their occurrence in important food and feeding stuffs at high levels had led to concern for the health of people and of animals raised for food.

26. A cause-and-effect relationship between aflatoxin consumption and development of liver cancer had been unequivocally demonstrated in at least eight animal species including subhuman primates. For man, available epidemiological data primarily from regions of sub-Sahara Africa and southeast Asia supported the positive association of aflatoxin ingestion and liver cancer, a chronic disease which can become manifest after many years. Daily dietary aflatoxin exposures estimated as varying from 3.5 to 222.4 nanograms per kilogram body weight per day had been positively correlated with crude incidence rates of primary liver cell cancer ranging from 1.2 to 13.0 cases per 100 000 people per year in regions of Kenya, Mozambique, Swaziland and Thailand which differed in altitude (humidity) and in aflatoxin levels in foods commonly consumed. Other countries with significant daily consumption of aflatoxins might well have similar potential risks. Dr. Fishbein stressed that inasmuch as the hazard was dose-related, any reduction in aflatoxin exposure would reduce the risk. Although on scientific evidence the existence of a no-effect level for carcinogens was questioned, for practical purposes there might be one.

27. Hepatitis B virus might be involved in the etiology of aflatoxin-associated liver cancer in areas of the four countries studied. However, the association, if any, between hepatitis infection and aflatoxin ingestion had yet to be documented adequately. Potential also existed for acute effects in humans. Acute diseases of the liver affecting children in Thailand and India had been linked to aflatoxin ingestion, although the evidence was inconclusive. Of special importance was the observation that aflatoxins will pass the placenta of the mother and might thus expose the foetus to a relatively high dose at an immature stage of development. Because there had been so few studies of aflatoxin content of mother's milk, the hazard to infants from this source was presently unknown.

28. Mycotoxins other than aflatoxins might pose hazards for human and/or animal health and productivity. Evidence suggested such a possibility for ochratoxins, zearalenone and other Fusarium toxins, including members of the group of trichothecenes. Although it was not possible at present to define the hazard to humans from these mycotoxins, it should be noted that in the prevention of fungal contamination, all potentially hazardous mycotoxins should be avoided.

Trade and Economic Aspects

29. Mr. Jemmali (consultant) introduced the document entitled 'Trade and Economic Aspects of Mycotoxins' (MYC-4c). The document did not pretend to enumerate precisely and definitively the trade and economic repercussions of contamination of food by mycotoxins from causes usually incompletely known. The lack of quantitative data often allowed the problem to be simply dismissed. The trade and economic impact occurred at many stages between the producer and the consumer, often via the importer. In simple terms such impact could be expressed in terms of losses and costs due to mycotoxin contamination. The problem was real, affected numerous essential agricultural products in differing degrees, was not limited to developing countries in tropical or subtropical regions, but was also faced by the industrialized countries, although often with different consequences. Aflatoxins produced the most deleterious effects in tropical and subtropical countries, while other mycotoxins such as zearalenone and ochratoxins were more significant in countries of the temperate zone.

30. Mr. Jemmali referred to the nature of the losses and costs occasioned by mycotoxins. The consumption of contaminated foods could cause a progressive lowering of human productivity and health status - some aspects of these losses were covered in the paper MYC-4b summarized by Dr. Fishbein. Unfortunately, the regions most affected were those where malnutrition was also prevalent and the population could be more susceptible to the effects of fungal toxins as, very often, the gap between demand and production did not allow outright rejection of contaminated foods.

31. Losses of livestock could be quite spectacular with death of animals. But other losses could be greater in the aggregate, though less obvious: lower meat or milk productivity, poorer work performance, increased susceptibility to infections, difficulties with reproduction, etc. All countries had some problems of mycotoxins and animal mycotoxicoses. Outright loss of food and feed was large but not quantifiable at present. Mr. Jemmali referred to a limited survey carried out by FAO which arrived at estimates of global losses due to mould of 4.2% for peanuts, 3% for maize, 12% for other oilseeds, 5% for rice and 3% for soya, valued at US$16 billion. According to some estimates 1 000 million tons of world agricultural products might be threatened by mould and mycotoxins. Loss in value of rejected products was considerable and comprised cost of detoxification measures. Thus ammonia treatment of groundnut cake or cottonseed cake increased the price by at least 8-10%. Loss of export markets could occur. Many importing countries had set maximum levels of mycotoxins in food/feed in order to reduce hazards to their populations. For producer countries the effect could be disastrous. In France, the importation of groundnut cake had gradually been overtaken by that of soya. Contaminated pistachio nuts coming from Iran or Turkey and valued at US$5 million were refused entry into the USA in 1975. Lower availability of acceptable produce could cause fluctuation in world prices of affected commodities.

32. A reference was invited to the member countries of the African Groundnut Council which export about 370 000 tons of shelled groundnuts, or 40% of world groundnut exports. In-shell groundnut exports from these countries ranged between 10 and 20% of world exports, groundnut oil above 50% and meal about 25%. To indicate relative importances, the export of groundnut products represented one-fifth of the national product of Senegal, and one-third of Sudan's and two-thirds of The Gambia's agricultural exports were susceptible to mycotoxin contamination. In Senegal and The Gambia more than 60% of the population was involved in the cultivation of groundnuts. Mr. Jemmali referred to the costs of extension and control efforts which could be considerable and included cost of samples and of sampling and analysis during production, storage, processing, marketing and distribution. He concluded that only a partial view could presently be gained of the economic and trade aspects of mycotoxins. But it was apparent that exporting and importing countries and trade partners should cooperate in order to lower risks of mycotoxin occurrence and exposure. This cooperation was especially urgent on methods of sampling and analysis so that measures taken by importers might not be considered arbitrary by exporting countries.

Discussion

33. A number of delegates expressed their appreciation for the excellent documentation providing very useful background information on different facets of the mycotoxin problems and the manner in which this highly complex subject was introduced in the Conference.

34. The delegation of the Federal Republic of GERMANY questioned why the apparent priority among mycotoxins at this Conference should run counter to that agreed at last year's conference in Maryland, USA. That conference, according to the delegate, had recommended that *Fusarium* toxins should receive highest priority followed by *Penicillium* and *Aspergillus* toxins. According to the documentation presented and introduced by the previous speakers, it now appeared that aflatoxins should receive the highest priority.

35. As the question of priority was very important for any follow-up action after the Conference, a number of delegations participated including those of EGYPT, KENYA and the observer from the International Institute of Tropical Agriculture (IITA).

36. It was explained by Mr. Rodricks (consultant) that the emphasis in Maryland had been on research, it being considered that enough was known about aflatoxins to move on to their control and that research attention could be directed to other mycotoxins.

37. The delegations of SWEDEN and U.S.A. described their current research and control activities and stated that preventive action to control aflatoxins contamination was a definite priority. This contamination was now known to be both a field and storage problem. The delegation of SENEGAL described the history of groundnut production and effects of drought and agricultural practices in the Sahel region. A separate group had been formed to seek a multidisciplinary solution to the serious aflatoxin problem in this region. The delegation of UPPER VOLTA stated that, with weaning foods providing vegetable protein, one must also be concerned about aflatoxin contamination. Therefore, analysis and control were necessary to limit exposure of infants as much as possible. He referred to the need to set standards and to agree internationally on tolerance levels in different commodities and products.

38. The delegation of INDIA referred to the recent outbreak of acute hepatitis after consumption of mouldy maize in two western states of his country and how preventive action for control of aflatoxin contamination was being given priority. In addition, he sought advice on how to detect cancer in such exposed population in view of the long delay assumed to arise before manifestation of malignancy. The representative of WHO suggested that emphasis on aflatoxins was warranted since they were among the most carcinogenic substances known. Follow-up of the affected population in India was needed and should include monitoring of health status and diet by a dedicated team of nurses and doctors.

39. A question was raised as to whether a single global priority among the mycotoxins would be possible. The Conference agreed that priorities might differ from country to country and even on an "ecological zone" basis. However, according to the present state of knowledge, it would appear that the control of aflatoxins should receive the highest priority as these mycotoxins affected a very large population in most developing parts of the world - a population which, in many cases, was poor and undernourished. Priorities for research in different areas could be different; for example, development of trichothecene toxins demands conditions which are more likely to be found in temperate zones.

40. The delegation of NIGER asked whether disposal of contaminated produce as fertilizer might result in phytotoxicity of the soil. Information was not available at the Conference, but attention was drawn to experiments in Sweden with composting in which ammonia generated and temperatures rising to about 70°C were shown to decrease aflatoxin contamination to zero in a short time.

41. The representatives from NIGER, UPPER VOLTA, and SENEGAL sought to clarify whether exporters or importers must bear the burden of losses caused by contamination of groundnut cake detected only at the point of importation. It was suggested that the risk of sending contaminated shipments was the exporter's and that it was a matter of contract and agreement between trading partners which analysis and sampling procedures were acceptable. Insurance may, in some cases, cover contamination occurring during shipment.

42. The representative of FAO indicated that the matter of international trade depended upon the agreement between exporter and importer and had wide implications and was beyond the purview of this particular Conference. As regards harmonization of methods of sampling and analysis at international level, this was proceeding

inter alia through the Codex Alimentarius Commission. Effective food control systems were often not available in developing countries. On the other hand, importing countries had such systems so that sub-standard materials could not be sold and limits were enforced by the governments to protect their populations. In the long run therefore, exporting countries must improve their food control systems, and surveillance and monitoring programmes to reduce contamination.

PRACTICAL TECHNICAL AND ECONOMIC ASPECTS OF DETOXIFICATION (Agenda Item 5)

43. Mr. Jemmali (consultant) presented the highlights of document MYC-6 to the Conference and differentiated between physical segregation of contaminated produce and detoxification by chemical or other means which destroyed the toxin. He stressed that detoxification was to be resorted to as a last measure when prevention and control had otherwise failed. He also stated that practically all the available data on the subject related to aflatoxin detoxification. Methods explored in this field include: (a) solvent extraction techniques which have so far fallen short of expectations; and (b) chemical detoxification processes which have given encouraging results in gaseous ammonia treatment of groundnut cake and cottonseed cake; aqueous ammonia treatment of whole maize kernels; and hydrogen peroxide treatment of groundnut protein isolate production. The last process was in operation in India. In the USA gaseous ammonia had been used for detoxification of cottonseed cake (meal); the detoxified product had found experimental use as animal feed, and efforts were continuing to demonstrate the safety of processes developed for detoxification of maize and cottonseed meal. Oilseed cake possibly presented the largest and most immediate problem, and the gaseous ammonia process was the only one adequately tested to date. By this process the aflatoxin molecule was destroyed and the nutritive value of the oilseed cake retained apart from a minor, replaceable amino-acid loss. The detoxified product had been shown to cause no acute or chronic toxicity in feeding trials. Thus the gaseous ammonia process was the only one immediately available currently promising to meet safety requirements and was considered to be economically viable. The combined use of segregation and detoxification was mentioned as an attractive possibility yet to be applied widely.

44. The delegations of KENYA, Federal Republic of GERMANY, EGYPT, U.K., SENEGAL, NIGERIA, NIGER, AFRICAN GROUNDNUT COUNCIL and ICIPE participated in the discussion which was opened by the U.S.A. delegate, who agreed that solvent extraction had not been successful, at least in regard to economics. He confirmed the efficacy of gaseous ammonia for detoxification of aflatoxin contaminated cottonseed cake, and that the detoxified product was used experimentally for animal feeding in the USA.

45. Replying to queries on the safety of the gaseous ammonia detoxified groundnut cake product, Mr. Jemmali stated that the reaction products of this process had been identified, and that treated oilseed cake had been tested in feeding trials and was found to be innocuous. The product had been cleared in France for animal feed use.

46. The delegation of U.S.A. further informed the Conference about the development of a process using aqueous ammonia at ambient temperature to detoxify maize. The process had been able to reduce aflatoxin contamination of 1 000 ppb to below 5 ppb. The process was still in the experimental stage and studies were under way to determine the safety of the detoxified product for animal feed use. Results so far were encouraging. Replying to a question whether maize detoxified by this process could have been sent abroad for human food, the delegate of the U.S.A. stressed that aqueous ammonia detoxified maize was intended to be restricted to channeling contaminated material into animal feed use and not for human food. The discolouration occurring was in any event likely to add an esthetic barrier to human acceptance.

47. In reply to a query whether ammoniation of whole groundnut kernels was feasible, it was explained that certain technical problems and adverse effects on quality make it unlikely that this type of process would be available in the near future.

48. The delegation of INDIA, supported by the delegation of UPPER VOLTA, stressed the need for village level technology of detoxification and referred to the work on detoxification of unrefined groundnut oil by exposure to bright sunlight. It was suggested that such simple methods of detoxification should be more fully evaluated in relation to the toxicity of the photolytic products and any adverse effects on rancidity and shelf life. Information was provided that much of this work had been done in India. No solution had yet been found in the search for a detoxification method for oilseed cake at a rural or village level, and more research should be undertaken to help the primary producer concerned to detoxify his subsistence produce. The Conference further agreed that the possibility of composting as a means of detoxifying aflatoxin contaminated material for animal feeds should warrant investigation.

49. The representative of IITA drew attention to the possibility of mycotoxin contamination of cassava and other edible root crops. Further study was recommended.

50. In regard to segregation, a number of delegations made reference to handpicking through which 90-95% of contaminated kernels could be removed at large scale and household levels. The delegation of UPPER VOLTA referred to a technique with which it was possible to segregate sound kernels from contaminated ones through breaking of the shell by means of a hydraulic press. At the household level handpicking or sorting was often an effective and commonly practiced means of segregation of contaminated produce.

51. The delegation of SWEDEN questioned the possible protective effects of fish protein in the diet. Various statements were made underlining the inadequacy of available data on nutritional levels and diets in acute/chronic toxicity animal studies. Too little work had been done so far on possible factors countering the toxic effects of aflatoxins.

52. The Conference agreed that decontamination and detoxification were important means to have at disposal when preventive and control measures had not been completely successful. Certain technologies were available and application of these should now be sought where appropriate. There was a need for further applied research on village level and medium level technology of detoxification. In all cases, the safety of the product for use by man or animals had to be ensured.

PREVENTION OF CONTAMINATION BY MYCOTOXINS (Agenda Item 6)

53. The Vice-Chairman, Mr. F.H. Shah, deputizing for the Chairman, invited Mr. N.S. Agrawal (INDIA) to introduce document MYC-5 on the 'Prevention of Contamination of Foods and Feeds by Mycotoxins'.

54. Mr. Agrawal commented on the nature and extent of incidence of fungal contamination of foods, the need for prevention to conserve food supplies, health hazards to man and animals and the factors contributing to contamination by mycotoxins such as moisture, ambient temperature, relative humidity, insect infestation, etc. Various measures were available for prevention of mycotoxins, such as development of resistant varieties of seeds, harvesting under optimum conditions, protection during drying, storage and transportation, and use of fumigation or irradiation to prevent fungal growth. He stressed the importance of surveillance and control of mycotoxins and mentioned that one of the recommendations in the document dealt with incentives to farmers supplying mycotoxin-free produce. Lack of awareness, shortage of trained personnel, inadequate resources, ecological conditions and absence of technical facilities were mentioned as important constraints to the implementation of successful prevention and control measures.

55. The delegation of the U.S.A. informed that, in view of the high energy costs of artificial drying, research was being carried out in the USA by trickling small

amounts of aqueous ammonia through stored maize in order to prevent fungal growth and the formation of aflatoxin. He added that efforts were being made to develop varieties resistant to both fungal and insect attack.

56. The delegation of the Federal Republic of GERMANY stressed the importance of measuring the water activity of the produce rather than its moisture content which was not as directly related to the growth of fungi. He referred to the development of a suitable instrument for this purpose to be used in the field, the cost of which was approximately DM150. To overcome difficulties expressed by the delegation of UPPER VOLTA, it was stated that special versions for in-field use even by illiterate farmers could be produced at a lower price.

57. The delegation of EGYPT proposed the use of certain organic acids or their salts to prevent fungal growth during short stress periods.

58. The delegation of FRANCE mentioned that some results of development of resistant varieties were encouraging but that this was a medium-term approach and it was too optimistic to expect 100 percent resistant varieties. The most promising area appeared to be the selection of suitable varieties and this medium-term exercise is presently carried out by a number of agricultural research institutes around the world.

59. The representative of IITA stated that farmers needed to be made aware of suitable time for planting and harvesting and causes of infection when existing varieties were used, since the development of resistant varieties had not been successful as yet.

60. The delegation of PAKISTAN stressed the importance of educating farmers and mentioned that in his country field assistants, who were graduates in agriculture, were utilized under an integrated rural programme to inform the farmers in the villages on good agricultural practices.

61. The delegation of INDIA stated that efforts should be made to practice techniques known to be useful but felt that detoxification processes developed so far were highly sophisticated and required crops to be brought to a central place. He stressed the need to use proper storage structures in rural areas and mentioned that the Government of India subsidized 25 percent of the cost and that banks freely advanced loans to assist farmers in building relatively inexpensive galvanized iron storage structures which permit fumigation. Three-ml. ampules of ethylene dibromide were being supplied to fumigate one quintal of grain. Farmers who were initially reluctant now use such structures, having seen the advantages. He also dwelled on the need to educate the farmers and housewives on good storage practices utilizing extension officers and mass communication media. He added that farmers offering standard good quality grain were given a premium over the normal price.

62. The delegation of SWAZILAND observed that some traditional methods of groundnut or maize storage had in fact been found to be quite suitable in Swaziland. For example, storage in baskets or bins was adequate whereas pit methods of storage were conducive to development of aflatoxin and should be abandoned.

63. The delegation of NIGERIA informed the Conference about the various steps taken in the country since 1972, principally the application of known preventive measures, to reduce aflatoxin contamination of groundnuts. He mentioned that the "pyramid" method of storage of groundnuts had been practiced especially in the northern part of Nigeria where the weather was dry for seven months of the year. During rainy periods, tarpaulins covered the produce, but this also may not be a sufficient means to prevent mycotoxin development. The method was not altogether satisfactory for long-term storage as it was difficult to control insect infestation and absorption of moisture during the rainy season.

64. The representative of the AFRICAN GROUNDNUT COUNCIL suggested that for the prevention of mycotoxin formation attention should be paid to making resistant varieties available, to proper harvesting, drying and storage practices; to ensuring safe moisture levels during storage and transport including avoidance of re-wetting, to keeping the storage period to a minimum; to providing leak-proof storage bins that permit fumigation and to preventing the mixing of clean and contaminated pods. The need for training of officers to convey technical information on these matters to the farmers was also mentioned.

65. The delegates were informed that regulation of pesticides in the USA was in the hands of the Environmental Protection Agency, and that this agency had been withdrawing important insecticides and fungicides from use by farmers because of new information indicating they may be hazardous to health and the environment. The delegation of KENYA drew the attention of the Conference to the fact that some insecticides were not now used in the USA, whereas developing countries had no alternative but to continue using them to safeguard food supplies. Need for protection of food often transcends environmental concern in many countries. However, it was more important that the appropriate UN organizations should assist the developing countries in improving their capability to detect and monitor pesticide residues to permit control of any pesticides which it is decided to limit or withdraw from use.

66. The representative of WHO suggested that the problem had to be viewed from three angles: small farmers who produce grains solely for their own consumption, farmers who produce also for marketing some surplus, and commercial farmers producing for sale and export.

67. The Secretariat drew the attention of the delegates to the Conference Room Document on 'Low Cost Technology for Crop Drying' contributed by UNICEF, Nairobi. It showed some possibility of working at a village level in this direction.

68. Delegations from NIGER and CANADA also participated in the discussions and informed the Conference on some of the practices used in their countries.

Draft Guidelines

69. The CHAIRMAN asked Mr. Coomes of the U.K. delegation to present to the Conference and to discuss document AGS:MISC/77/7 entitled 'Recommended Practices for the Prevention of Mycotoxins in Food, Feed and their Products'. This draft of a guideline had been prepared for FAO/UNEP by the Central Food Technological Research Institute of India in collaboration with experts from France, Brazil and the USA.

70. Mr. Coomes suggested that discussion of the document and its subject matter might proceed under the headings of:

(i) breeding and selection of seed;
(ii) field practices;
(iii) harvesting practices and crop drying;
(iv) storage of the dried crops;
(v) transportation;
(vi) processing including decontamination.

He also suggested that the guidelines should be expanded to cover:

(vii) household use of raw materials and products;
(viii) marketing and distribution, including incentives.

He referred to some of the recommendations contained in the document and elaborated on others such as item (vi). In regard to item (vii), he emphasized the need to identify:

- high risk crops and commodities
- high risk regions
- high risk populations and age groups.

If this was done the problem could be tackled through education and promotion of improved feeding habits, and through providing nutritionally adequate and acceptable alternatives. To study the effectiveness of action along these lines, a continuing programme of surveillance of both the diets and the health status of the population would be required, perhaps over long periods of time, with all the attendant difficulties associated with such action. As regards item (viii), Mr. Coomes felt that guidelines should be developed at national and international level with the ultimate aim to provide mycotoxin-free product or crop.

71. Discussion followed on practices recommended for preventing in-field infection by fungi. On the development of resistant varieties a question was raised whether yield or other important characteristics would be affected. In reply it was stated that breeders would seek to strike a balance of all necessary properties when developing new strains.

72. The question of the advisability from the nutritional point of view of polishing rice before storage, as recommended in the document, and the potential for mycotoxin contamination of parboiled rice, were discussed at length.

73. Many delegates stressed the importance of prevention and highlighted the work being done in their countries in this field. It was realized that all recommendations in the draft guideline could not be universally applicable but that they provided sufficient information for the national authorities to take appropriate action within the infrastructure and practices existing in the country.

74. The delegation of INDIA stated that the problems of mycotoxins had, in fact, not been so well recognized until recent times. To the extent that an awareness of these problems was created it would be possible for the extension workers to carry the message to the farmers. The delegations of NIGER and SENEGAL, followed by KENYA and NIGERIA, again referred to two different types of marketing, that by farmers producing a limited number of commodities, mainly for their own consumption, and at the national level. National marketing systems were comparatively better organized in many cases for particular crops like groundnuts, and marketing boards had set up a system of grading and quality control. While the problems of storage at the farm level had been touched upon earlier, it needed to be pointed out that even in the case of national marketing boards, because of lack of resources, the produce often had been stored under conditions which were not ideal and which led to high risk of contamination.

75. The delegation of INDIA suggested that recommendations on storage should be split into two levels, namely, village level storage and large scale storage.

76. The delegation of FRANCE mentioned the importance of keeping the produce from parts of infected fields separate from the rest and also of the need for any later harvest to be collected and delivered separately and not to be mixed with the earlier one.

77. Referring to the problems of utilization of food, the representative of WHO supported Mr. Coomes' suggestion that the national authorities may like to deal with the problem under three different areas, namely, high risk crops, high risk regions and high risk populations/age groups. This would ensure that the national efforts were directed toward the right spot in a concentrated manner and would ensure optimum utilization of resources.

78. The Conference revised recommendations contained in paragraphs 1.3, 2.3 and 3.5 of the document AGS:MISC/77/7 which are referred to in Appendixes A to E to the Recommendations. The Conference further agreed that the guidelines should include an additional section on "marketing, distribution and incentives" based on the information provided by the delegations of PAKISTAN, INDIA, NIGERIA, KENYA, NIGER and SENEGAL. This section would deal with the importance of improved marketing systems based on grading, quality control and linking price with quality. Adequate incentives for better quality and uncontaminated produce would go a long way in preventing many problems of contamination.

SURVEILLANCE AND CONTROL MEASURES (Agenda Item 7)

79. Prof. G. Nilsson (SWEDEN), the Vice-Chairman presiding over this session, invited Mr. Rodricks (consultant) to introduce document MYC-7, 'Surveillance and Control Measures to Reduce Contamination by Mycotoxins'.

80. Mr. Rodricks in introducing the document stated that surveys and surveillance were essential parts of food control. The goal was to reduce mycotoxin contamination in foods and feeds moving in national and international commerce. Data obtained as a result of surveys could help to establish practical limits for mycotoxins in foods. As contaminated foods had to be prevented from reaching the consumer, the need for diverting them to use as animal feeds or to other industrial use had to be looked into. He emphasized the need for providing incentives for action and for taking a gradual approach to the establishment of mycotoxin surveillance programmes. The problems of sampling for aflatoxin content were so difficult that further study was necessary. He said that surveys should be started on high-risk commodities. Regulatory action, properly planned, should lead to minimal loss of availability of foods and feeds. Producer cooperation and quality control were essential elements of a mycotoxin control programme.

81. The delegation of PERU felt that the problem of mycotoxin control was one aspect of the total picture of food quality, nutrition and health. Without surveys it was not possible to find the extent of the problem and the risk to human and animal health. Peru had not yet established a regulatory programme or supporting laboratory facilities and this was an area where more needed to be done.

82. The delegation of the U.S.A. informed the Conference of the surveys carried out by the U.S. Department of Agriculture and also stated that an agreed sampling plan for groundnuts had been developed. This required a rather large lot sample which had economic implications. A sampling procedure for maize was under development.

83. The delegation of SENEGAL expressed general agreement with the main approach contained in document MYC-7. His country was anxious to ensure that its exports met any specifications importers may set. Some surveys concerning exports had been carried out. It was also important that surveys of locally consumed foods were carried out for which advice by experts was often needed.

84. The delegation of NIGERIA stated that while the need for surveillance of mycotoxins was recognized, the problems were to set the priority in the different countries at different stages of development and to determine what resources could be allotted to this activity. Reference was made to the work of the Nigerian Stored Products Institute and the work completed under the Food and Drug Law. The delegation of NIGERIA, supported by the delegations of KENYA and SENEGAL, requested UNEP, FAO and WHO to assist developing countries in regard to strengthening surveillance and control activities.

85. The need for internationally agreed methods of sampling and analysis was stressed. The delegation of KENYA agreed that a suitable sampling scheme was im-

portant and pointed to the high costs of such programmes. The delegation of KENYA further emphasized the importance of having an appropriate food law as a basis for surveillance and informed the Conference about the progress made in Kenya during the past few years. No country was starting from scratch in this regard and some further strengthening from international agencies like FAO could go a long way in improving matters. The catalytic role of an agency like UNEP was mentioned. The need to educate the public and to enlist its cooperation was also stressed.

86. The delegation of UPPER VOLTA proposed that sub-regional committees of the Codex Alimentarius Commission be formed in Africa to consider problems specific to a few neighbouring countries. The FAO representative stated that the existing Codex Coordinating Committee for Africa could consider the proposal but expressed doubts whether it could be of practical benefit.

87. On request from the Chairman, Mr. Ramanathan (in the absence of team leader Mr. W. Lampkin) explained the main activities of the FAO/UNEP project for control of food contaminants including aflatoxin in eastern Africa, based in Kenya. He mentioned that in Kenya, regulations had been drawn up under the Food, Drugs and Chemical Substances Act, setting out limits of metal contaminants and pesticide residues in various foods, and that these would be enforced soon. The project had assisted the Government in strengthening its capacity for chemical and microbiological analysis of food. Local staff had been trained in the analysis of pesticides and aflatoxins and in methods of microbiological analysis. Further training and seminars would be held for inspection staff after the regulations were finalized.

88. The Secretariat indicated that FAO had been giving to member countries various types of technical assistance for food control and for food contamination monitoring and surveillance programmes. The funds for these projects had been provided by various sources within the UN system and by several bilateral donors. Training in methods of inspection and analysis had been given a high priority under this programme. Support received from various industrialized countries in this regard was mentioned.

89. The representative of the AFRICAN GROUNDNUT COUNCIL emphasized the need for proper training and laboratory facilities. Agreed sampling procedures and plans for surveillance programmes, especially for commodities moving in international trade, were critically important.

Guidelines

90. Mr. Rodricks (consultant) was invited to present important aspects of the document 'Mycotoxins Surveillance - A Guideline', FAO Food Control Series No. 4. He mentioned that aspects of all the topics covered in the Guideline had been placed for discussion in document MYC-7. He invited special attention to the problem of aflatoxin limits and the sections dealing with eliciting producer cooperation and initiating programmes on mycotoxins other than aflatoxins. The flow charts for quality control schemes (Appendix 3 of the Guideline) should be considered merely as suggestions.

91. The delegation of MEXICO referred to recent experience gained in the country in the development of food contaminant monitoring and control programmes. The question of priorities was one of the most difficult decisions and the programme had to match with the resources available - laboratories, trained personnel and finance. Sampling was one of the most important areas needing attention and due consideration had to be given to the diet of the population, potential risk of contamination of food crops, import and export requirements, etc.

92. It was further suggested that the words "surveillance", "control" and inspection in the Guideline should be well defined in every language since the Spanish version

of Conference documents contained misleading words. He also emphasized the importance of ensuring that a sampling plan was appropriate for a given objective. The Secretariat undertook to see to correct translation when the Spanish version of the Guideline would be printed. In this connection the Conference was also informed by the Secretariat about the 'Guidelines on Establishing National Food Contamination Monitoring Programmes' under preparation.

93. The delegation of the Federal Republic of GERMANY (Prof. Leistner) mentioned that standards were a necessity for mounting sound survey or control programmes. He stated that reference standards of aflatoxins M_1 and M_2 were available from his Centre and could be supplied to developing countries on request.

94. The delegation of ITALY made information available on a study of Fusarium toxins. He stated his willingness to collaborate with countries experiencing problems with crops contaminated with this group of fungi and in particular offered to assist with analysis of zearalenone.

95. Referring to the question of limits, the delegation of UPPER VOLTA and the representative of the AFRICAN GROUNDNUT COUNCIL inquired what levels of aflatoxin would be carcinogenic in man. Studies on animals could not be used to indicate with certainty the degree of carcinogenicity in man. The opinion was therefore expressed that, in the absence of adequate data in regard to aflatoxin methods of sampling and analysis, and toxicity for man, it was inappropriate to set stringent limits for control.

96. The Conference agreed that surveillance and control activities were important measures to reduce contamination by mycotoxins of food and feed and deserved a high priority for action at the national level with the support of UN agencies, where necessary. The general approach to the problem as presented in the Conference documentation was considered acceptable.

INFRASTRUCTURES AND PROGRAMMING REQUIREMENTS FOR NATIONAL ACTION (Agenda Item 8)

97. Prof. G. Nilsson, deputizing for the Chairman, invited Mr. Sreenivasamurthy (consultant) to introduce document MYC-8 entitled 'Extension at National Levels to Solve the Problems of Contamination by Mycotoxins'.

98. Mr. Sreenivasamurthy referred to the various means described in the document for extension of information to those needing it. These means should be utilized by agricultural extension services, home demonstration agents, community workers, farm organizations, industry and trade organizations, school teachers, training institutes, health services and others, with attention to use of mass media. He outlined the importance of extension of information to all levels from the farmer to the consumer, including middlemen and processors.

99. The delegation of INDIA stressed the importance of the training of agricultural extension workers who, in India, were mostly home science students working at the village level, and also of the laboratory workers in the few centres in India analysing food and feed for mycotoxins. These centres were badly in need of strengthening. Lack of resources was the main obstacle to carrying out the necessary training programme and he requested the help of the various UN agencies in this respect. The delegate emphasized the need for cooperation between developed and developing countries to work out action programmes to find simple and economic methods of decontamination which could be applied in the developing countries. Additionally, the middlemen and traders should be educated in the proper methods of handling, storage and transportation. The delegation emphasized that the blending of contaminated and uncontaminated products should be strongly discouraged and consumers should also be taught to avoid such practices. Enough was already known about the problems and what was needed now were action programmes rather than further surveys.

100. The delegation of NIGERIA stated that, like other developing countries, Nigeria had some training centres and personnel, but there was a need to strengthen these institutions. Reference was made to a scheme for establishing a training institute for food control in Nigeria with the support of FAO and how, due to various unavoidable reasons, no progress had been made in that regard until now. The delegation placed a very high priority on the establishment of regional training centres for the prevention and control of food contamination in general. The delegation felt that very often UN agencies like UNDP placed more emphasis on production of food rather than on ensuring its quality and wholesomeness. Production must go hand-in-hand with quality if the objectives of feeding populations to raise their standard of nutrition were to be fully met.

101. Several delegations including those of PAKISTAN, INDIA, UPPER VOLTA, NIGER, SENEGAL and KENYA supported the Nigerian proposal and stressed the importance of creating or strengthening such regional training centres with the support of UN agencies. Emphasis was also laid on the exchange of information between countries with similar problems and it was stressed that periodic meetings would go a long way toward sharing experiences and developing regional or sub-regional programmes.

102. The delegate of UPPER VOLTA also considered that the training of nutritionists for extension work was vitally important. He emphasized that the training of personnel from developing countries in regional centres would be of greater value than training in developed countries where the facilities and general conditions are quite different.

103. The delegation of the Socialist Peoples' LIBYAN Arab Jamahiriya informed the Conference about a regional training project to be funded by his Government with the cooperation of FAO. This would be concerned with the overall problems of food and nutrition. The project would provide inter alia training in food control, and some of the information generated during this Conference would be utilized in such training courses.

104. The representative of FAO stressed the importance of food control systems as development measures rather than as mere policing activities.

105. The Chairman requested representatives of industrialized countries to give a brief account of the means of extension of information in their own countries so that the Conference could benefit from their experience.

106. The delegation of the U.K. stated that in his country the Ministry of Agriculture operated an extensive agricultural service which provided farmers with up-to-date information obtained in the various research centres. On request they also advised farmers on how to solve specific problems.

107. The delegation of the U.S.A. stated that in his country there were 30 to 40 county extension agents in each state. Whenever a farmer had a problem he requested help from the agent, who would visit the farm and provide advice. The county agents also helped in distributing information brochures, pamphlets and bulletins to farmers. The delegation added that extension of information to the affected industry was very important. A close relationship was maintained between the research institutes and the industry, and they worked together with the ultimate goal of providing safe products to the consumer.

108. The delegations of FRANCE and The NETHERLANDS mentioned that they had systems more or less similar to those of the UK and the USA. Extension work was an important means to keep the farmers informed of the developments in various fields of agricultural production and protection of crops. Equal efforts would need to be made to keep the wife of the farmer informed. The delegation of FRANCE also referred to the role

of consumers unions in the education of the general public. Mention was also made of the services working in the field of nutrition.

109. The delegation of SWAZILAND stated that the local Ministry of Agriculture with the help of various UN agencies provided farmers with similar valuable services.

110. The delegation of SWEDEN cautioned that extending information to the public should be done very carefully. Consumers were easily frightened, especially when dealing with matters concerning health. In Sweden, information was transmitted only to producers concerned with the problem. They were made aware of the problem and advised on what action to take in the light of decisions taken by control authorities.

111. The delegation of PERU emphasized the importance of educating the public so as to change attitudes and habits with regard to production, processing and consumption. He remarked that such a task should be undertaken carefully with due regard for local customs.

112. The representative of WHO warned that publicly associating any one item of commerce with a mycotoxin, even when it might not be a problem with the particular item, could unnecessarily turn people away from the product.

113. The representative of UNEP, Mr. El-Tayeb, stated that UNEP was awaiting the recommendation of the Conference to study possibilities for follow-up action. For UNEP, mycotoxins were a food and health problem in the first place, and an integrated approach to solution was required.

PRIORITIES FOR RESEARCH AND TRAINING AS MAJOR TOOLS IN PROGRAMMES FOR REDUCING MYCOTOXIN CONTAMINATION (Agenda Item 9)

114. The CHAIRMAN invited Mr. Sreenivasamurthy (consultant) to introduce document MYC-9 entitled 'Priorities for Research and Training in the Field of Mycotoxins'.

115. Mr. Sreenivasamurthy commented that considerable multidisciplinary research was still needed to fully define the extent of the problem with a view to future effective prevention and control. The document indicated eight major areas requiring further research, viz. surveys, sampling, prevention, decontamination, detoxification, animal health, human health, and analytical methods. Surveys should determine which mycotoxins were important in a particular country, which crops were affected and where the contamination occurred. A statistical design was essential for the surveys, and collecting the data for this on aflatoxin in commodities other than groundnuts and on other mycotoxins deserved research attention. Further studies were called for on how to avoid contamination by different mycotoxins of various crops pre- and post-harvest and by use of better drying practices. The roles of insects and fungicides had not yet been clarified. Improved methods of segregating contaminated portions of a lot would be useful, practical application of proposed solvent extraction processes for detoxification of oilseed cakes might be sought, and research efforts were desirable into detoxification procedures for mycotoxins other than aflatoxins.

116. A need had been identified for investigation of adverse effects of contamination of feeds by mycotoxins other than aflatoxins on animal health, productivity and the wholesomeness of animal products used as food, particularly with respect to metabolism and residues of various mycotoxins. These affected human health and assessments were needed of possible relationships between mycotoxin ingestion and various diseases.

117. The document pointed also to the needs of rapid and accurate methods for mycotoxins other than aflatoxins as well as for research on use of available simple, rapid methods for the detection of aflatoxins at the farm level and on the development of such methods for other mycotoxins.

18. Finally, the document described training needs in areas of inspection, sampling and analysis, survey design, extension activities by home demonstration, public health and community workers and diagnosis of mycotoxicoses by veterinarians. Such training was prerequisite for success of the necessary multifaceted attack upon mycotoxin problems.

19. The delegation of the U.S.A. opened the discussion by advising the Conference of the priority areas for mycotoxin research recently adopted by the U.S. Department of Agriculture, viz.:

a) Isolation and identification of toxigenic fungi known to be associated with important agricultural commodities;

b) Development of rapid, accurate, and precise methods for the detection and quantitation of mycotoxins during the production, marketing and processing of agricultural commodities;

c) Investigation by field surveys of the incidence of, and the factors contributing to, mycotoxin contamination of susceptible crops, and the development of methods to prevent mould growth;

d) Improvement of harvesting, drying and storage techniques to minimize mould growth;

e) Breeding of insect and fungal resistant varieties of cereal grains, groundnuts and tree nuts;

f) Investigation of the role played by insects and the effectiveness of pesticides to control growth of toxigenic fungi;

g) Development of a testing and control programme during marketing to meet the requirements of regulatory bodies for consumer protection;

h) Development of commercially feasible and economically viable physical and chemical processing methods to reduce mycotoxin contamination to acceptable levels without adversely affecting the nutritional and organoleptic properties of the final products;

i) Identification of fungal metabolites and of possible reaction products from decontamination procedures and assessment of their potential hazard to human and animal health;

j) Promotion of education among management and workers in the food industry as to mutual responsibility in coping with mycotoxin problems;

k) Culturing of fungi from feedstuffs and the environment and appropriate toxicological study whenever strong evidence of diminished productivity in animals or poultry is found.

The delegation of the U.S.A. stressed that these research activities of the U.S. Department of Agriculture were not listed in order of priority.

0. The delegation of the Federal Republic of GERMANY stated that during the preceding days of the Conference, about forty proposals for research activities had been made which were additional to those contained in document MYC-9. Developing countries in particular were more concerned about research applicable at the village, farmer and household level. A recent conference held in Maryland, USA, had focussed attention on basic research needed on the various mycotoxins and the present Conference should perhaps concentrate on applied research needs.

121. The representative of the AFRICAN GROUNDNUT COUNCIL stated that the problem of mycotoxins, the naturally occurring food and feed contaminants, would be with us for some time. In efforts to contain this problem, lines of action should be clearly defined. These could be of short-term and/or of long-term duration or nature. He considered that short-term actions would include:

(a) Strengthening the extension services in the concerned countries;

(b) Segregation and decontamination;

(c) Chemical detoxification;

(d) Improvement of storage facilities;

(e) Establishment and strengthening of laboratories for monitoring mycotoxins;

(f) Training;

(g) Sampling techniques;

whereas long-term actions would include:

(a) Introduction of varieties of different crops resistant to mycotoxin infection;

(b) Relation between mycotoxin ingested and ailments in man;

(c) Passage of mycotoxins to man through animal products.

122. From extensive discussions involving the delegations of ITALY, INDIA, KENYA, The NETHERLANDS, NIGER, NIGERIA, QATAR, SENEGAL, SWEDEN, SWAZILAND, TANZANIA, THAILAND, U.K. and UPPER VOLTA, the consensus of opinion was that the priorities could include:

(a) Surveys of mycotoxins in crops of different countries to determine the extent of the problem;

(b) Prevention of mycotoxin formation at the farm level;

(c) Assessment of human health problems due to mycotoxins;

(d) Development of analytical procedures useful at the farm level and study of their application;

(e) Detoxification procedures for crops at the farm level;

(f) Elucidation of acute and chronic effects in animals of mycotoxins other than aflatoxins;

(g) Training in all the above areas; this should receive the highest priority.

123. The general feeling of the Conference was that better international coordination was necessary on mycotoxins research and exchange of information. Also, closer cooperation between physicians and research workers particularly in the field was essential in evaluating potential human health problems. A suggestion was made that a multidisciplinary international investigation team of experts should be formed by FAO/WHO/IARC to be available for immediate follow-up of acute mycotoxicosis episodes to assist national authorities in developing countries.

124. The delegations of QATAR and NIGERIA stated that successful intervention programmes were dependent on availability of good methods of detection, sampling and quantitation. For some mycotoxins and crops, development of these was far from complete. The setting of tolerance limits also depended upon the methods. Therefore, development of suitable methodologies for sampling and analysis should have high priority, perhaps the highest.

125. The representative of UNEP, Mr. El-Tayeb, drew attention to exposure of local populations through contaminated traditional medicines and remedies. These deserved attention, as did also potential exposure to contamination in local fermented foods and beverages.

126. The Conference emphasized that regional training centres in developing countries could have a great impact on reducing exposure of the consumer (human and animal) to mycotoxins.

OTHER MATTERS (Agenda Item 10)

127. Mr. P. Thacher, Deputy Executive Director of UNEP, addressed the delegates to advise them of UNEP's present outlook on practical follow-up to the recommendations of the Conference. The full text of Mr. Thacher's address is attached as Annex III to this Report.

128. The Conference noted with interest the observations of the delegations of CHAD and the U.S.A. who raised the issue of sources of mycotoxin exposure other than foods and feeds, e.g. tobacco, and dusts encountered in dealing with any material that may have supported mould growth and toxin production.

RECOMMENDATIONS (Agenda Item 11)

129. The following recommendations indicate the actions considered necessary at national and international levels to reduce the current problems posed by mycotoxins. It should not be taken for granted that action to prevent or control the deleterious effects of mycotoxins will be among the first priorities of national governments. Inasmuch as action at all levels will be carried out largely by national organizations, the recommendations of this Conference accordingly aim to influence national governmental attitudes toward recognition of the problems due to mycotoxins and seek to secure the active commitment of governments to practicable solutions. It is expected that preventive and control measures can be linked to the national plans for development and will appear to be consistent with national goals.

General Recommendations

130. Programme Assistance: "The Joint FAO/WHO/UNEP Conference on Mycotoxins, viewing with great concern the effects of mycotoxin contamination of human food and animal feedstuffs, urges United Nations organizations — particularly the specialized agencies FAO and WHO with the collaboration and support of UNEP and UNDP — National Governments, other international organizations and interested bodies, to do all in their power to assist in programmes designed to reduce or eliminate the problem of mycotoxin contamination. Such action should lead to:

(i) an increase in availability and quantity of human foods and animal feedstuffs;

(ii) an increase in the quality and nutritional value of human foods and animal feedstuffs;

(iii) a lessening of the incidence of human and animal diseases, such as cancer and diseases of unknown etiology;

(iv) an increase in animal production and wholesomeness of products such as milk, meat and eggs;

(v) an increase in the marketability of food commodities and products."

131. Strengthening Institutions: "The Joint FAO/WHO/UNEP Conference on Mycotoxins urges United Nations organizations to establish or strengthen appropriate institutes in developing countries and encourage and support periodic discussions and seminars amongst scientific and regulatory personnel at international and particularly at regional levels for sharing knowledge and experiences on progress in the field of mycotoxin prevention and control."

132. Priorities: "The Joint FAO/WHO/UNEP Conference on Mycotoxins urges (a) specialized agencies like FAO and WHO, with the collaboration and support of UNEP, UNDP and other UN agencies, (b) National Governments, (c) international organizations, and (d) other interested bodies, to initiate and provide continuing support for the

under-mentioned programme areas as a first priority:

(i) reinforcement of existing, and establishment of new, facilities and organizations by provision of facilities and/or training of laboratory personnel and extension (food control, agricultural and domestic science) staff;

(ii) development of feasible and practical means of storage of the staple food commodities at both the local (village) level and at the large warehouse level to prevent fungal infection and insect damage;

(iii) development of feasible, economical and safe means of decontamination of mycotoxin-contaminated food commodities and products;

(iv) research into outstanding problems of mycotoxin toxicity, incidence, prevention and elimination;

(v) development and application of reliable and internationally accepted methods of sampling and analysis."

Specific Recommendations

133. The Joint FAO/WHO/UNEP Conference on Mycotoxins urges United Nations organizations, National Governments, and other interested bodies to implement its recommendations that:

Prevention of Mycotoxin Development

Recommendation 1: Field practices should follow the recommendations contained in the 'Guideline of Recommended Practices for the Prevention of Mycotoxins in Food, Feed and their Products', as modified (see Appendix A).

Recommendation 2: Since insects, mites and nematodes promote the invasion and growth of toxigenic fungi in crops, appropriate plant protection measures should be taken, keeping in view both the beneficial and any possible adverse effects of the use of insecticides and fungicides approved in particular countries.

Recommendation 3: Harvesting and crop drying practices should follow the recommendations contained in the 'Guideline of Recommended Practices for the Prevention of Mycotoxins in Food, Feed and their Products', as modified (see Appendix B).

Recommendation 4: Storage practices on the farm, in the markets, and in warehouses should follow the recommendations contained in the 'Guideline of Recommended Practices for the Prevention of Mycotoxins in Food, Feed and their Products', as modified (see Appendix C). In addition the Conference urges the development of practical storage facilities, at both the site of production (village) and large warehouse level, that will reduce loss of food and feedstuffs through mould growth and insect damage.

Recommendation 5: Transportation practices, locally, nationally and internationally, should follow the recommendations contained in the 'Guideline of Recommended Practices for the Prevention of Mycotoxins in Food, Feed and their Products', as modified (see Appendix D).

Recommendation 6: Post-harvest processing, including decontamination, of susceptible or affected crops should follow the recommendations contained in the 'Guideline of Recommended Practices for the Prevention of Mycotoxins in Food, Feed and their Products', as modified (see Appendix E).

Monitoring and Control of Mycotoxin Contamination

Recommendation 7: To permit assessment in each country of the problem and the priorities, and to facilitate further action, programmes of surveillance should be established to determine the incidence and sites of mycotoxin contamination in the food chain from production, through harvesting, storage and processing to consumption. Such surveillance will require:

(i) the design of suitable sampling procedures to provide representative samples; it is desirable that such sampling procedures should receive international acceptance;

(ii) the provision of suitably equipped laboratories in appropriate areas;

(iii) the provision of satisfactorily trained staff for both the laboratories and for sampling in the field;

(iv) the development of suitable detection methods and the improvement of existing analytical procedures where required. Initial pilot studies may be required to establish commodities and, upon occasion, population groups, at special risk.

Recommendation 8: It is recognized that any effective action on the control of environmental contaminants such as mycotoxins in food and animal feed must be based on a sound system of national food and feed control. UN and other agencies engaged in programmes of international technical assistance in this area should take this factor into consideration in determining the content and duration of individual projects.

Recommendation 9: Consideration should be given to provide technical assistance to countries which adopt recommended practices dealing with prevention and control of mycotoxins to study the effects thereof on human/animal health and international trade.

Recommendation 10: Detailed studies of local, national and international marketing and distribution should be undertaken in order to:

(i) develop investigational and control programmes to provide consumer protection;

(ii) evaluate the toxicological and economic aspects of the utilization of contaminated products other than directly in human food;

(iii) ascertain mechanisms by which producers and processors may be encouraged to eliminate mycotoxins from the food chain.

Recommendation 11: To facilitate international trade in commodities susceptible to contamination by aflatoxins and other mycotoxins, international harmonization and agreement should be secured through organizations like the Joint FAO/WHO Codex Alimentarius Commission on the design of sampling procedures and the analytical methodologies required.

Recommendation 12: Attention should be paid to the availability of mycotoxin reference standards to facilitate work in developing countries on prevention and control as well as in surveys to define the problems. It is recognized that the preparation of standards is difficult and costly, and that assistance of UN agencies would be needed to ensure availability for many developing countries.

Recommendation 13: Although prevention is the preferred approach to the problem of mycotoxin contamination of human foods and animal feedstuffs, the development of appropriate decontamination procedures represents, at the present time, a mechanism by which contaminated produce may be utilized. Decontamination clearly applies to both local food and feed consumption and to large-scale utilization. Suitable available procedures - whether physical (such as segregation or sunlight), enzymatic, solvent extraction (such as methoxymethane) or those involving chemical change (such as ammoniation or hydrogen peroxide) - should be applied where feasible, to appropriate commodities, uses and scales of operation. Such procedures should meet the Criteria stated in Appendix F.

Training, Information and Research

Recommendation 14: Suitable training and education programmes, at all levels, directed toward the prevention and elimination of fungal growth in, and mycotoxins contamination of, crops and its control should be supported and encouraged by every available means. Such measures should include:

(i) the establishment and supply of laboratory facilities for control and surveillance purposes especially in developing countries in appropriate areas throughout the world;

(ii) reinforcement of existing national research and diagnostic facilities where necessary, with particular emphasis on producer countries;

(iii) the training of personnel in the laboratory procedures required for monitoring of food contamination;

(iv) the training of personnel in agricultural and other extension services to ensure appropriate preventive and control action at all stages in the food chain which have potential for mycotoxin contamination;

(v) the training of domestic science personnel and appropriate public health officers who will be responsible for ensuring a domestic understanding of the problems associated with mycotoxins;

(vi) the training of medical and veterinary personnel in the clinical and post-mortem diagnosis of mycotoxicoses.

Recommendation 15: As part of an effective mycotoxin control programme, agricultural extension agents and field inspection staff should receive training in all aspects of the mycotoxin problem, including preventive measures. Such training should include:

(i) well-established principles of good agricultural practice;

(ii) appropriate methods of handling, drying and storage;

(iii) information on mycotoxins in relation to farm animal feeding practices;

(iv) information on mycotoxins in relation to human and animal health;

(v) information on local attitudes and traditional preventive practices.

For such programmes to be most effective, they should be organized in developing countries on regional or sub-regional bases as appropriate and a close liaison maintained between extension services and those agencies undertaking surveys and research.

Recommendation 16: Efforts should be made to collect, reproduce and disseminate widely in the developing countries information on adaptive research, including practices, processes and methods which have been successful in one or more countries and may be considered for application in other countries.

Recommendation 17: Further research is required to assist in defining the problem and in reducing the incidence of mycotoxins in foods and feedstuffs. The following areas of concern have been identified in the field of research on mycotoxins:

(i) means of preventing the occurrence of mycotoxins by plant breeding to produce resistant varieties, proper crop husbandry, drying and storage practices;

(ii) surveys to establish nature and incidence of mycotoxins, and high-risk commodities, regions and populations;

(iii) reduction of mycotoxins in, or their elimination from, contaminated commodities;

(iv) sampling procedures and analytical methods for the detection of mycotoxins and/or their metabolites in appropriate crops, animal tissues and animal products, including methods useful at the farm level;

(v) any adverse effects of mycotoxins upon human health, including effects of consumption of products from animals fed mycotoxin contaminated feedstuffs;

(vi) any adverse effects of mycotoxins upon animal health, with particular reference to productivity and residues;

(vii) environmental requirements for mycotoxin production by fungi;

(viii) exploration of the social and economic implications of the mycotoxin problem.

For the detailed proposals see Appendix G.

Appendix A
refers to
Recommendation 1

FIELD PRACTICES

1. Reduce insect and fungal damage by adoption of appropriate cultural practices - such as use of resistant varieties, crop rotation, proper and uniform irrigation - and of judicious use of approved pesticides/chemicals.

2. Sow at the recommended spacing for the specific crop involved.

3. Destroy weeds, grasses, debris, crop residues, alternate host plants, etc. which serve as reservoirs of fungal inoculum.

4. Ensure where possible that the sowing and harvesting times for crops coincide with periods in which mould infections are unlikely, or effectively minimal.

5. Reduce mechanical damage to crops to a minimum, particularly during cultivation, harvesting and subsequent processing.

6. Harvest crops when possible at full maturity (and completely).

7. Use if appropriate approved fungicides to reinforce other measures to prevent moulding of crops.

* * *

Appendix B
refers to
Recommendation 3

CROP DRYING

1. Do not delay the initiation of drying after harvesting of the crops, particularly if harvested at high moisture levels. (At the farm level, harvesting in dry weather and sun drying by spreading on a paved floor with intermittent stirring is usually the most feasible system. At collection centres which are easily accessible by road and which are not too far from the fields, use of large-scale driers - artificial heating - may be practical.)

2. Dry as rapidly as possible. Prolonged sun-drying of a crop, in conditions of high humidity, will lead to infection of the crop with moulds.

3. Avoid the occurrence of re-wetting of the crop during or after the drying process (e.g. by inadequate protection from rain during sun-drying, or use of plastic sheeting covers on which water vapour condenses at night).

4. Dry to the safe moisture level before placing the crop in storage. Safe moisture levels for a number of crops are indicated in Tables 2 and 3 of the draft guideline AGS:MISC/77/7.

* * *

Appendix C
refers to
Recommendation 4

STORAGE

1. Ensure that storage structures are dry and do not permit the entry of water either by leakage or by seepage of ground water. Build stacks of bagged grain on dunnage or pallets to avoid upward movement of ground water (unless it is quite certain that the floor incorporates a membrane impermeable to water vapour).

2. Keep temperature and relative humidity as constant as possible. Moisture migration and condensation resulting from thermal gradients within stored grain masses can lead to an accumulation of moisture in certain areas where mould growth will then occur.

3. Ensure that crops to be stored are whenever possible of a high quality, i.e. they should ideally be free from moulds, insects and "off" odours and they should have been dried to the safe moisture level for the particular crop (see Tables 2 and 3 of draft guideline AGS:MISC/77/7).

4. Use protective insecticide treatments for storage structures and stored bulk grain to control insect infestation. Insects which crawl on the grain deposit fungi and also help raise the moisture levels in pockets of grain where fungal growth then invariably occurs.

5. Use low-temperature storage whenever possible, as mycotoxin contamination is correlated directly with temperature. An exception to this general rule would be the production of some mycotoxins by Fusarium spp. at low temperatures; storage under nitrogen may be effective.

6. Farm storage:

a) If produce is already infected in the field, fumigate and dry it before storage (proper drying of groundnuts is usually indicated if the pods make a crackling sound when crushed between the teeth);

b) Winnow and sieve out the immature, discoloured and broken kernels;

c) Store the produce in structures or containers which are moisture proof and amenable to fumigation treatment;

d) Inspect the produce periodically and fumigate with suitable fumigants to control insect infestation.

7. Large-scale storage:

a) Do not store any produce which has a higher moisture level than that considered safe, i.e. as given in Tables 2 and 3 of the draft guideline AGS:MISC/77/7;

b) Ensure that the flooring of the warehouse is moisture and rodent proof. Use proper dunnage such as polyethylene sheet or wooden pallets under the stacks. Ensure that the warehouse can be well ventilated and made air-tight to allow fumigation as and when required.

c) Use suitable fumigants;

d) Resort to aeration (if air moisture permits) to reduce moisture level in the stored produce;

e) Prevent cross infestation of different lots of produce in the warehouse by suitable prophylactic insecticide treatment;

f) Prevent access by rodents and birds through appropriate control measures.

* * *

Appendix D
refers to
Recommendation 5

TRANSPORTATION PRACTICES

1. Evaluate the extent and conditions under which mycotoxins develop in commodities during transport. Act to correct undesirable conditions.

2. Ensure good practices such as periodical disinfestation of empty transport containers or vehicles by application of suitable (approved) pesticides or by fumigation.

3. Ensure that food shipments have safe moisture levels (Tables 2 and 3 of the draft guideline AGS:MISC/77/7) before warehousing; moisture may be absorbed during shipment. Methods such as the use of tarpaulins, ballooning, or air-tight containers may be considered appropriate.

4. Use packaging materials which do not allow easy entry of insects, or use packaging material or containers made insect- and rodent-repellent by chemical treatment.

* * *

Appendix E
refers to
Recommendation 6

POST HARVEST PROCESSING INCLUDING DECONTAMINATION

1. Protect crops during processing from any condition encouraging growth of fungi.

2. Expedite dehydration processes, especially those needed after re-hydration has taken place.

3. Segregate by physical means that portion of a crop which is damaged.

4. Ensure inactivation of mycotoxins by methods that will not result in the introduction of new toxic substances into the food or feed chain.

* * *

Appendix F
refers to
Recommendation 13

CRITERIA FOR DECONTAMINATION PROCESSES

A decontamination process must be technically and economically viable, and must meet the following criteria:

(i) destroys, inactivates or removes the mycotoxins;

(ii) does not produce or leave toxic or carcinogenic/mutagenic residues in the final products or in food products obtained from animals fed decontaminated feed;

(iii) retains the nutritive value and acceptability of the product;

(iv) does not significantly alter important technological properties;

and ideally

(v) destroys fungal spores and mycelia which could, under favourable conditions, proliferate and form new toxins.

* * *

Appendix G
refers to
Recommendation 17

RESEARCH REQUIRED

1. Surveys

(a) Definitive studies should be undertaken on foods known or likely to be contaminated by fungi or mycotoxins, including the identification of:

— high-risk commodities;
— high-risk regions;
— high-risk populations and age groups.

The medical and extension personnel involved in those studies should also be urged to study the relationship between nutritional status and the adverse effects of mycotoxin exposure.

(b) The design of suitable sampling plans for different commodities is required to ensure the provision of representative samples.

(c) The development and assessment of a spectrum of short-term mutagenic bioassays of certain mycotoxins be undertaken to determine their usefulness as predictors as well as to augment long-term carcinogenic bioassays in mammals. These mutagenic bioassays may serve as a pre-screen or early warning for a potential carcinogenic mycotoxin which may have to be confirmed by long-term bioassay.

2. Human Health

(d) Populations accidentally exposed to aflatoxins should be the subject of epidemiological studies to increase further knowledge of the role of this group of mycotoxins in human disease. International organizations should be prepared to send, upon request, scientific advisory groups to aid in the design of the studies.

(e) Dietary intervention studies seeking to clarify the possible direct relationship between ingestion of aflatoxins and human health should be conducted as an extension of the various epidemiological investigations already extant. The role of aflatoxins in the production of hepatocarcinoma is especially important, but other more acute effects should also receive attention.

(f) Preliminary trials indicate that aflatoxins depress the immune response of animals. Definitive studies involving mammals should be conducted in an attempt to determine whether man is potentially susceptible to this adverse effect.

(g) Further methods should be developed for the measurement and confirmation of mycotoxins in human tissues, body fluids and excreta, in cases in which significant human exposure has been demonstrated.

(h) Further studies are required to elucidate the possible connections between:

— aflatoxins and Indian childhood cirrhosis and aflatoxin and primary liver cancer
— aflatoxins and some cases of Reye's syndrome
— ochratoxin A and Balkan nephropathy
— aflatoxins, primary liver cancer and hepatitis B virus
— zearalenone and estrogen-related diseases.

(i) Investigation of the possibilities of non-alimentary human exposure to mycotoxins, e.g. in workers handling pure mycotoxins or contaminated materials.

3. Animal Health and Products

(j) Investigation of the adverse effects of feeds contaminated with mycotoxins on animal health and productivity.

(k) Investigation of the risks and hazards of aflatoxin and other mycotoxin residues in animal products such as milk, meat, cheese and eggs.

(l) Studies of possible therapeutic measures and antidotes to counter the adverse effects of mycotoxins in animals.

4. Prevention of Occurrence of Mycotoxins

(m) Efforts should be directed toward the breeding of fungal and insect resistant strains of crops in which yields and other factors, e.g. chemical composition, are not significantly altered from those of presently available strains. Testing should include evaluation of the stability of characteristics under conditions of cultivation in producing countries.

(n) The role of insects, mites and nematodes in promoting the invasion and growth of toxigenic fungi in crops should be thoroughly investigated in the field, together with the beneficial and any possible adverse effects of the use of pesticides approved in particular countries.

(o) Studies should be made to define crop practices which will result in minimum formation of mycotoxins in susceptible crops.

(p) The development of simple, inexpensive and energy-conserving methods for the drying of crops at the small farm or village level is required. Such methods must be compatible with the social structure and traditions of the communities in which they are used.

(q) Crop storage facilities should be developed suitable for construction and use in villages, and efforts should be made to establish the best way to introduce these facilities into the community.

(r) Crop storage facilities should be developed which can be quickly assembled to accommodate unforeseen or unusually large crop supplies.

5. Decontamination

(s) Development and evaluation should be continued of gaseous, chemical, solvent, enzymatic and mechanical methods of decontamination/detoxification of mycotoxin-contaminated commodities both at the industrial level and the farm level.

(t) Evaluation is required of methods such as ensilage, composting and burying or disposing of foodstuffs and crops containing toxigenic fungi, in order to prevent spread of spores and mycelia.

6. Analytical Methodology

(u) Further simple, inexpensive and transportable equipment/procedures should be developed for the rapid, accurate detection, measurement and confirmation of mycotoxins in crops under field conditions.

(v) Reliable, inexpensive devices for measurement of water activity and/or moisture content should be developed for use at the village level in order to maximize effectiveness of drying and good storage.

7. Toxigenic Fungi

(w) The parameters necessary for mycotoxin production by toxigenic fungi should be defined with a view to providing means of control, through e.g. limiting water activity, anaerobic storage, fungicides, or agricultural practices.

8. Economics

(x) Detailed studies of local, national, and international marketing should be undertaken in order to evaluate the economic aspects of the utilization of contaminated products (whether decontaminated or not) other than directly in human food.

(y) Mechanisms should be sought by which producers and processors may be encouraged to eliminate mycotoxins from the human food chain.

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Annex 1
Annexe 1
Anexo 1

Joint FAO/UNEP/WHO Conference on Mycotoxins
Nairobi, Kenya, 19 - 27 September 1977

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Text of the OPENING SPEECH by the
Honourable J.C.N. OSOGO, EGH, M.P.,
Minister for Health, Republic of Kenya

ANNEX II

Joint FAO/WHO/UNEP
Conference on Mycotoxins

Ladies and Gentlemen,

On behalf of the Government and the people of Kenya, I welcome you all to our country for the Mycotoxins Conference and wish you a very pleasant stay.

When the Director-General of the Food and Agriculture Organization of the United Nations on his own behalf, and on behalf of the Executive Director of UNEP and the Director-General of the World Health Organization inquired whether Kenya would be willing to host this Conference, my Government was very pleased to be able to give a positive response. This is the first time an international conference has been held on this subject of vital concern in the fight to eradicate threats to the quality and quantity of human food and animal feed, and we are naturally proud to have been chosen to host this important event. It is also a pleasure for us to be able to welcome such a distinguished gathering of delegates and observers from so many countries; your presence here today clearly demonstrates the world interest in attempting to explore and solve the problems related to mycotoxins.

Man's search for world peace and food security is surely an underlying factor in this quest. By joining together and pooling our knowledge and skills in this cooperative effort, may we not, in some small part, contribute to the achievement of this goal? Let us bear this in mind as we begin the work of the Conference.

We are particularly happy to be your hosts, as the mycotoxin problem appears to be another specific deterrent to international trade in the produce of developing countries, since exports containing mycotoxins are sometimes found and this results in destruction of specific shipments and often loss of entire markets and valuable foreign earnings. Also, it seems appropriate that this Conference should be sited in one of the areas of the world where mycotoxins can present a real hazard to the quality and quantity of human food and animal feed. There appear to be endless threats to our foods, some of which are readily identifiable such as droughts or floods, insect pests, rodents and birds; while others, such as mycotoxins, are less visible and are therefore in some ways more difficult to define and subsequently to control.

Although the mycotoxin problem as we know it has only been recognized during the past two decades, it is also true that the first incidences of food poisonings of humans and animals resulting from contamination of grains with toxigenic fungi were recorded hundreds of years ago.

In Europe, the parasitic fungus ergot frequently contaminated cereal grains, particularly rye and millet. The resulting disease, commonly called St. Anthony's Fire, often took on epidemic proportions and caused acute suffering and death in large numbers of humans and animals.

Sporadically, since that time, outbreaks of ergot poisoning have occurred. The last reported incidence was in France in 1951. There were also occasional reports of other food poisonings of farm animals which were assumed to be due to the consumption of mouldy feeds. However, it was not until the early 1960's in England, when many thousands of turkey poults died after eating groundnut meal contaminated with the mould Aspergillus flavus, that the real significance of the mycotoxin problem was fully appreciated. At that time, many research institutes and laboratories were involved in the initial search for, and identification of, the toxic and indeed highly carcinogenic contaminant of the groundnut meal, namely aflatoxin.

Gradually a realization has evolved that the problem of moulds and mycotoxins is not only of the mould Aspergillus flavus producing aflatoxin but of many other moulds elaborating a range of more or less toxic metabolites which have been found in numerous food commodities, ranging from cereal grains to oilseeds and oilseed products, tree nuts, animal products such as milk, cheese, liver and many others.

Recently, an increasing amount of effort has been put into the study of the implications of the acute and chronic toxicities of mycotoxins to human and animal health. Large doses of mycotoxins which cause acute disease symptoms and death, although rare, can readily be detected and only seldom do they present problems.

There have been reports of diseases and deaths of farm animals which have resulted from the ingestion of mouldy feeds. Subsequent investigation has shown the food to contain specific mycotoxins which have then been identified. A direct correlation between a mycotoxin and a disease syndrome in man and/or animals (i.e. a mycotoxicosis) can then be drawn. In this way the following mycotoxins have been classified: ergot alkaloids which are responsible for ergotism in man and animals; aflatoxins responsible for hepatitis and liver cirrhosis in man and animals; zearalenone, which produces vulvo-vaginitis and abortion in swine; and ochratoxin, the ingestion of which leads to kidney disease in swine. In all other cases of suspected mycotoxicoses, identification of the mycotoxin involved is either tentative or entirely unknown, and a great deal of research remains to be done.

There are some cases of human diseases which can be related to exposure to high levels of mycotoxins. A recent case was the ingestion of mouldy maize, contaminated with aflatoxin, by the population of various villages in the States of Gujarat and Rajastan in India, which resulted in an epidemic of fatal hepatitis. Over 400 people were affected and there was a mortality rate of 20%. The chronic ingestion of low levels of aflatoxin in contaminated foods has been studied in epidemiological surveys in Africa and southeast Asia. One such study conducted in Kenya 100 km from Nairobi, showed, as in other studies, a positive correlation between the level of intake of aflatoxin in contaminated foods and the incidence rate of primary liver cancer in the indigenous population.

Clearly the advancement of knowledge on the existence of fungal toxins, the crops in which they are found and the real and potential health hazard to humans and animals is considerable. This information has led us to believe that all countries and the international agencies should take concerted action in

order to achieve a measure of control over the mycotoxin problem, especially with regard to human health, and animal production, crops and indeed our daily food. Obviously where a mycotoxin problem exists it will affect not only all of these areas but also the economic position of producers, traders and consumers of the country concerned.

I would take this opportunity to commend the three United Nations organizations sponsoring this important Conference for their initiative in combating the problem by all the varied means at their disposal.

The deliberations of this Conference should give insight into the whole spectrum of problems of contamination by mycotoxins. I am informed that several Conference papers give background information on the environmental aspects; the health and toxicological aspects; and economic aspects of mycotoxins. The presentation which gives a general overview of the mycotoxin problem and a global review by commodities which includes reports on mycotoxin problems in many countries should prove interesting. I expect that there will be a lively and constructive discussion on the subjects of mycotoxin prevention; detoxification; surveillance and control; extension measures and the priorities for research and training particularly in the developing countries. I understand that the discussion papers on these topics present the critical questions on which your deliberations and decisions are needed.

I wish you success in your endeavours to formulate recommendations for action at all levels and I am sure that the deliberations of this Conference will thoroughly review all the ramifications of the problems of mycotoxins, and result in concrete and practical recommendations to governments and to UN organizations to enable renewed and concerted efforts to better identify and control mycotoxins for the good of all. In this hope it now gives me much pleasure in declaring this Conference open.

Text of Address made on 23 September 1977 by
Mr. P.S. Thacher, Deputy Executive Director of UNEP

ANNEX III

Joint FAO/WHO/UNEP
Conference on Mycotoxins

Thank you very much Mr. Chairman. I am happy to have this opportunity and I hope not to delay your work. I have been in touch with the Executive Director of UNEP and have informed him of the basis of the conversations I have had with you, Mr. Chairman, and others in the last few days on the good progress that has been made under your chairmanship.

I have come here with Mr. Michel Dina-Lobé, Regional Representative of UNEP for Africa who was, like me, Programme Director at the Stockholm Conference (UN Conference on the Human Environment) five years ago. We have been involved with UNEP's effort ever since then.

On behalf of the Executive Director, I want particularly to encourage you to do exactly what the Chairman just said; to prepare specific recommendations leading to practical action. Since I will not be here next week when you decide on your recommendations, I would like now to encourage you to be as specific as you can on the steps that can be taken by the international community, and specially by organizations such as FAO, WHO and others, to meet the problems you have identified. From UNEP's point of view, we wish to serve both importing countries and exporting countries; to work closely with WHO and both the rich and the poor to assess the risks to human health; and with FAO and others to assess the risks to animals, particularly from contaminants like mycotoxins which are frequently transmitted through food chains. UNEP wishes to assess the risks in more precise terms so that governments can have a solid basis on which to make decisions within their own values as to the level of risk they wish to accept.

We believe that by helping to improve assessments of the risks we will reduce the risks, and can reduce interferences to international trade and consequent economic hardship. We are very anxious to assist the exporting developing countries. This is a subject which we have worked at for more than five years, namely to reduce the threat to the exporting states caused by conflicting ways of setting protection standards, due to different procedures or methods of analysis to measure levels of contamination.

If you can agree on practical steps which can reduce risks of damage and of interruption in international trade, we will welcome them.

One of the organizations with which we work most closely is UNDP. The question has been raised here as to why UNDP is not present. I would like to explain this by pointing out that the Resident Representative of UNDP is also our representative. UNDP is very much a member of the team on which you can call for assistance. I was not given a formal license to speak for UNDP, but if you can agree on recommendations you can count on us to transmit them to UNDP and I am confident they will receive very positive attention there, as well as by other sister agencies. I can also say with complete confidence that if any

country or group of countries wish to use national Indicative Planning Figures (IPF) for this purpose, they will certainly find encouragement in the leadership of the UNDP. This also applies to regional or sub-regional IPF which may be available, and if there are groups of states which wish to join together and request assistance from UNDP I believe you should be encouraged to do so. You may be sure UNEP will back these requests.

From UNEP's point of view, prevention is more important than detoxification. Therefore, if you can identify practical steps that can be taken which will prevent or reduce levels of contamination, then I urge you to consider recommendations for their application through training, either at the farm level - perhaps by means of agricultural extension services - or elsewhere, e.g. as in the transport and storage of commodities after they leave the farm. The purpose of such training should be to prevent and reduce damage from contamination. Certainly, if there are regional or sub-regional groups which would like to draw up such recommendations and which seek assistance in this area, they should do so collectively. We believe that it is our function to help such groups which come together on specific requests for training programmes and preventive methods. Our own resources may be limited, but we accept the responsibility to enlist other sources of assistance both at the international level, such as UNDP, and the International Development System, and also from bilateral sources of assistance.

With regard to East Africa, we have modest training capabilities here in Kenya which we would like to strengthen if there is a need. I personally feel somewhat deficient with regard to West Africa, particularly in our services to French-speaking states. I know the Executive Director would want to give every support he can to improve our services with our cooperating agencies, especially FAO and WHO, and I urge those of you who would like to elaborate this further to discuss your ideas with my colleagues, especially Dr. Alozie and Mr. Dina-Lobé.

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ANNEX IV

Joint FAO/WHO/UNEP Conference on Mycotoxins

Kenyatta Conference Centre, Nairobi, Kenya

Nairobi, 19 - 27 September 1977

MYC-1

AGENDA

1. Opening of the Conference
2. Election of Chairman and two Vice-Chairmen
3. Adoption of the Agenda; appointment of Rapporteurs
4. Problems of mycotoxins
   - (a) Global perspective
   - (b) Health and toxicological aspects
   - (c) Trade and economic aspects
5. Detoxification, practical technical and economic aspects
6. Prevention of contamination by mycotoxins
7. Surveillance and control measures
8. Infrastructure and programming requirements for national action
9. Priorities for research and training as major tools in programmes for reducing mycotoxins contamination
10. Other matters
11. Recommendations of the Conference
12. Adoption of Report

ANNEX V

FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS - Rome

WORLD HEALTH ORGANIZATION Geneva

UNITED NATIONS ENVIRONMENT PROGRAMME - Nairobi

Agenda Item 5

MYC - 5

JOINT FAO/WHO/UNEP CONFERENCE ON MYCOTOXINS

Nairobi, Kenya 19-27 September 1977

PREVENTION OF CONTAMINATION OF FOODS AND FEEDS BY MYCOTOXINS

S U M M A R Y

This document examines the extent of fungal contamination and mycotoxin production and the factors influencing these under conditions prevalent in many developing countries. Possible measures towards prevention and control of mycotoxin problems are discussed in the light also of contraints encountered at regional, national and international levels.

W/G5675

PREVENTION OF CONTAMINATION OF FOODS AND FEEDS BY MYCOTOXINS

1. INTRODUCTION

1.1 Mycotoxins cause safety and trade problems for food and feed supplies. These problems can be countered by prevention of development of toxin or by measures to decrease toxin content after its formation. Prudence dictates that both approaches be used on the problem of mycotoxins development and its prevention and control. Most work of investigation and application has been done on one particular group of mycotoxins, the aflatoxins, and this situation is reflected in this document.

1.2 Ensuring the safety of food supplied to the consumer is a challenging problem in many countries, since several environmental factors either directly or indirectly can cause contamination of food and feed materials with toxic compounds. Among these the mycotoxins, which can be defined as toxic compounds produced by fungi, are of great importance. For many years, it has been appreciated that fungi are capable of changing the texture, colour, flavour and quality of many foods. Often those changes are induced by man, as in fermentation processes, in order to give a desirable flavour to foods. However, in other cases, when the moulds are unwanted or have not been suitably controlled, the contamination results in unpleasant odours and flavours and general decomposition of the foods. These qualities are not aesthetically pleasing to man or animal and therefore the foods become undesirable. It has only relatively recently been recognized that there is also a correlation between various types of fungal growth and possible toxic effects resulting from ingestion of the contaminated food.

1.3 For many centuries, poisoning due to the consumption of rye infected with the parasitic fungus ergot (Claviceps purpurea) has been recognized. The toxins, the ergot alkaloids, produced by this fungus, were identified over 100 years ago and caused death and an enormous degree of suffering to many people and animals.

1.4 Alimentary toxic aleukia (ATA) was first reported in Eastern Siberia in 1913. A severe epidemic occurred between 1941 and 1947 when the incidence of cases exceeded 10% of the population in the worst affected areas, and many deaths were recorded. The disease resulted from the consumption of overwintered grain (particularly wheat and millet) which had been infected with various fungi of the Fusarium spp.

1.5 However, it was not until 1961 that mycotoxins, and in particular aflatoxin, were recognized as presenting real and urgent problems in the sectors of human and animal health. The initial observation was of an outbreak of turkey disease in the U.K., when turkeys which had been fed on imported groundnut meal died in their thousands. Subsequent research indicated that the meal had been infected with a fungus, A. flavus, which was responsible for the production of aflatoxin, the toxic constituent of the meal.

1.6 The subsequent discovery that aflatoxin was a potent carcinogen, and that exposure of an animal for a short period to the toxin was sufficient to cause the development of a tumour, caused concern throughout the world. Epidemiological studies were undertaken in areas where there was a high incidence of primary liver cancer (e.g. Mozambique, Thailand and Uganda). Considerable indirect evidence was obtained suggesting that aflatoxin may play a part in the etiology of primary liver cancer in human populations of Africa and southeast Asia where mould damage to foods and feeds is frequent.

1.7 The realization that the mould metabolite aflatoxin was responsible for disease outbreaks and deaths of animals and was potentially dangerous to man, caused an immediate impetus of scientific research to uncover other moulds which produced toxic mould metabolites and to find ways to prevent or to control the contamination of foods and feeds by mycotoxins.

2. THE EXTENT OF FUNGAL CONTAMINATION

2.1 As fungal spores are airborne they are inevitably deposited on the su of any food material raw or processed that remains exposed to the air. Similarly, since chief habitat of these fungi is the soil, any agricultural crop, particularly sub-soil c cannot escape fungal contamination. If the contaminating organism is parasitic, the pla may die even before the grains are formed. In other cases, infections may occur at the inflorescence stage in which case the quality and quantity of the seeds produced is seri affected. There have also been reported other incidences of pre-harvest contamination o crops, e.g. of pistachio nuts. However, the main problem is encountered at the stages o drying and storage, when materials invariably become contaminated with saprophytic fungi often conditions prevail that are favourable for rapid fungal growth.

2.2 It should be emphasized however that the presence of the mould does nc necessarily indicate that the toxin will be present as, for example, many but not all str of A. flavus are toxin producers. Of 1,400 strains of the mould isolated from different sources, only 58% produced aflatoxin. Conversely the absence of visible indications of m growth does not necessarily mean that the toxin too will be absent. In some cases, cerea grains that appear sound and fit for human consumption may contain significant levels of mycotoxin.

2.3 It seems inevitable that there will be contamination of most foods and feeds with certain saprophytic fungi, whose dangers can only be avoided by finding suitab means for prevention and control of contamination.

3. NEED FOR PREVENTION OF FUNGAL CONTAMINATION

3.1 There are many reasons why fungal contamination of crops should be prevented; some of the more important are outlined below.

3.1.1 Fungal attack leads to loss of viability of the seeds.

3.1.2 A reduction is produced in the quality and acceptability of all types of crops, (e.g. cereal grains, oilseeds, pulses, tree nuts, vegetable oils), to the buyer and consumer.

3.1.3 Fungi are the most common cause of post-harvest deterioration of field crops.

3.1.4 Economic losses occur when there is extensive mould damage to the crop, as, in the worst case, the whole crop has to be destroyed or at best can only be sold as a lower grade.

3.2 If the fungus infecting a crop is of a toxin-producing strain, then the crop will be potentially hazardous to man and animals. The toxic mould metabolite may be dangerous in any of the following ways:

3.2.1 Animals fed on mould-contaminated crops die if there is a large quantity of toxic metabolites in the crop and if it is fed over a prolonged period.

3.2.2 Animals fed on crops contaminated to a lesser degree are affected in many ways; e.g. swine, cross-bred steers and calves, fed on diets containing aflatoxin show significant differences in weight gains, feed efficiency and organ weights when compared with animals given diets free from aflatoxin.

3.2.3 Dairy cows fed on diets containing aflatoxin B_1 excrete significant amounts of the toxic aflatoxin metabolite, aflatoxin M_1, into the milk.

3.2.4 Aflatoxin and other toxic mould metabolites are known to have contaminated certain cheeses, dried fish, fermented shrimps and fish sauces.

3.2.5 Although aflatoxin has not been reported in market samples of organ and muscle tissues of beef and swine, nor in the meat and eggs of chickens, it has been shown to be carried over into these tissues in experimental studies and is therefore potentially hazardous to the consumer.

3.2.6 Economic losses resulting from toxin-contaminated foods and feeds are difficult to estimate. Losses occur in many ways - livestock losses from deaths; lower growth rates and feed efficiency; from human illness and reduced productivity; in the reduced value of rejected commodities and in the costs of detection, control and detoxification of the contaminated products.

4. MYCOTOXINS: A GLOBAL PROBLEM

4.1 In the years immediately after the discovery of aflatoxin, it was hoped that the mycotoxin problem was confined to certain regions. However, it soon became clear that toxigenic strains of fungi were very widely distributed in nature and a large variety of food materials were vulnerable to their attack, followed by growth and toxin formation. Agricultural crops at various stages of growth, harvest and storage provide good substrates for fungal growth. Changes in traditional agronomic practices with a view to better yields and to facilitate easy operations, have in some instances enhanced opportunities for fungal growth. Adoption of mechanical harvesting is an example under this category. The combine harvester needs a slightly higher moisture level in the grain. If the harvest is not then dried to low moisture level prior to storage, fungal growth is almost inevitable.

4.2 In most of the developing countries, the weather conditions are such that there can be agricultural production throughout the year, but they are also ideal for promoting the growth of the flora and fauna (e.g. insect pests, micro-organisms, rodents and birds) which cause tremendous food spoilage. As a result, fungal growth and toxin formation in stored commodities are much more frequent. It is also in this region that the existing gap between production and demand forces the people and animals to desist from rejecting any material that can be used as food, even when it is infected with fungi and is aesthetically and organoleptically unacceptable. Often crops which have been rejected for export market are sold on the home markets. Any type of processing to make the food safe will enhance its cost and therefore make it unavailable to the people who need it. It should also be realized that as most of the people in the developing regions are under-nourished they may be more susceptible to the toxic effects of mycotoxins. When the mycotoxin problem is viewed against this background, it becomes clear that the bulk of the population in many developing countries is exposed to the toxic effects of mycotoxins.

4.3 However, the mycotoxin problem is certainly not confined to the tropical and sub-tropical developing countries. It is frequently encountered in more developed regions. Here, rejection of contaminated material is geared not so much to avoid creating food shortages but more to avoid the pollution of food which would increase the health risks of the community.

4.4 Foods fermented with fungi are extensively eaten in the Far East. It is therefore necessary to carefully examine the fermented foods for the presence of any toxigenic fungi. Similarly with blue cheeses, which are produced in various countries, care must be taken to ensure that non-toxigenic strains of fungi are used in their preparation.

4.5 Groundnut protein isolate is a valuable product which is used in the preparation of high protein foods, e.g. ice cream mixes, biscuits, etc. When the protein (which constitutes approximately 50% of the meal) is separated from the carbohydrate, oil and fibre, it takes the bulk (81%) of the aflatoxin with it - the remainder passes into the oil. Therefore, this process results in a concentration of aflatoxin in the protein isolate.

4.6 It is therefore clear that mycotoxin contamination of foods and feeds is a world problem and its prevention and control should be a responsibility of all the countries of the world.

5. FACTORS INFLUENCING FUNGAL GROWTH AND MYCOTOXIN DEVELOPMENT

5.1 Before considering various possibilities for action for prevention of contamination, it would be useful to review, very briefly, the critical factors which might in one way or another influence the growth of fungi or mycotoxin development. The following are listed on the basis of the state of knowledge at present available. Other avenues may open as further research is carried out.

5.2 Seed Variety

It has been observed for a number of years that there might be certain resistant varieties of seeds which, although they support fungal growth, do not support the production of aflatoxin. Such a resistant property of the seeds would seem to rest with their chemical characteristics and the possession of certain as yet unknown inhibitory factors. By a process of screening and selection, particularly in varieties such as groundnuts maize and sorghum, seeds may be obtained which offer a potential for such resistance.

5.3 Ambient Conditions in the Producing Areas

Ambient conditions can be defined as those conditions of moisture, temperature and relative humidity (and their seasonal variations) which are found within the producing areas.

5.3.1 Moisture and Relative Humidity

5.3.1.1 Since the moisture level of a commodity is dependent on relative humidity of the atmosphere at a particular temperature, the critical moisture level below which fungal growth is restricted or completely avoided has a direct bearing on the relative humidity (RH) of the atmosphere. The moisture equilibrium of a commodity at a given RH is again dependent on its chemical composition. Hence, the relative humidity deciding the critical moisture for fungal growth is different for different commodities. Since the composition of the commodity also has a significant influence on the equilibrium moisture level, the critical moisture level must be known for each commodity prior to storage.

5.3.1.2 The moisture level itself may either be naturally built-in moisture or it may be acquired during storage at a high ambient humidity. The type of fungus that will grow on a commodity is also dependent on the physiological activity of the substrate. If it is active, growth of saprophytic fungi, such as aspergilli and penicillia, is rather restricted; if the substrate is physiologically inactive, as is the case with old or heat-treated commodities, the strains belonging to the two genera will establish themselves on the commodity, grow and may produce toxic metabolites. The lower limits of moisture content for the growth of A. flavus and production of aflatoxin on natural substrates are as follows: 18% in wheat, corn and sorghum grains; 16.5% in unpolished rice and 17.5% in polished rice; 17-18% in soybeans and 9-10% in groundnuts, Brazil nuts, copra and other nuts. These limits do not represent safe storage conditions for the commodities listed, which would be obtained only if the limits were rather lower.

5.3.1.3 Certain measures can be taken to limit the formation of mycotoxins by the producing fungi. For example, laboratory studies show that a moisture content in equilibrium with a relative humidity of 85+ percent is the lower limit for the growth of A. flavus and production of aflatoxin or natural substrates. The optimum temperature reported for the production of aflatoxin by A. flavus is 25°C on sterilized groundnuts. The mould P. viridicatum, which produces ochratoxin, requires a higher level of moisture in grain for growth than does A. flavus. The trichothecene-producing Fusarium fungi prefer lower temperatures for toxin production than do those Fusarium species which produce zearalenone.

5.3.1.4 Interaction with competing fungi reduces zearalenone production by F. roseum and in a similar way production of aflatoxin by A. flavus may be affected by the presence of other fungi.

5.3.1.5 An example of the importance of moisture and relative humidity conditions for the production of uncontaminated crops is outlined below: in many regions, groundnut cultivation is organized as a rain-fed or lightly irrigated crop which is harvested in the dry season. Under these conditions, the seeds maintain low moisture levels and are thus resistant to fungal damage. With the growing demand for more and more edible oils and oilseed cakes, more land facilities with improved irrigation have been brought under groundnut cultivation. In this way, groundnuts are cultivated and harvested even in the rainy season. Groundnuts at harvest normally have a moisture content of 35-40%. At this stage, the groundnut is a physiologically active tissue and no saprophytic fungi can proliferate on such a medium. In the normal case, i.e. when the nuts are harvested in the dry season, they lose moisture to a level of 20% fairly rapidly. At this stage, the tissue is less physiologically active and hence becomes highly vulnerable to fungal attack. However, in dry weather conditions, the nuts will lose moisture readily to levels as low as 8-9%. If this drying occurs within a period of 3-4 days, there is little chance of fungal growth and mycotoxin formation. When the groundnuts are harvested in humid weather or in the rainy season, the drying period has to be prolonged to an extent that makes contamination with moulds inevitable.

5.3.2 Temperature

5.3.2.1 Since toxigenic strains of fungi are widely distributed in nature, toxin formation can be expected over a wide range of temperature (10-40°C) and pH (4-7). In the regions where the ambient temperature is less than 15°C, there are fewer problems of fungal growth and hence of mycotoxin contamination. A. flavus produces aflatoxin over a temperature range from about 12-40°C with an optimum production at 25-32°C; the limits depend on the substrate and the specific experimental conditions. Under laboratory conditions, at 25-30°C,

aflatoxin has developed within 48 hours on moistened groundnuts, rough rice and cottonseed, whereas a minimum period of 4-5 days on wheat has been reported. Other toxin-producing moulds require different conditions of temperature and moisture content of the substrate for maximum toxin production.

5.4 Insect Attack

Insect attack can lead to fungal development and mycotoxin contamination of a crop in two ways. Firstly, the damaged crop is more susceptible to infection by airborne fungi and secondly the insects themselves act as fungal spore carriers, taking the spores into the interior of the damaged crop. Insect infestation can occur at any stage from pre-harvest to storage of the crop. Almond nuts are a good example of a crop which often becomes contaminated as a result of insect attack. The navel orange worm (Paramyelois transitella) damages the nut and allows the A. flavus spores to enter and aflatoxin production to occur. At a moisture content of about 13% and temperatures of about 21°C, insects are very active. Insect activity can increase the moisture content of grain, hence increasing the possibility of contamination.

5.5 Although the majority examples used above, which illustrate the key factors influencing fungal growth and mycotoxin production, are of A. flavus infection leading to the production of aflatoxin, the majority of these key factors are equally applicable to other moulds and mould metabolites. For example:

(a) It has been reported that green coffee beans which had been improperly handled and stored for an abnormally long period of time became wet and mouldy. Various Aspergillus spp. were found to be infecting the beans and the toxic mould metabolite Ochratoxin A was present;

(b) Maize when planted late due to wet weather conditions in the spring and thus harvested late in the autumn is often contaminated to a high degree with the mycotoxin zearalenone. The Fusarium species which produce zearalenone generally require moisture levels of 22-25% with a fairly low ambient temperature for maximum toxin production.

Therefore, the methods employed for the prevention of fungal growth and mycotoxin production can be used for the majority of fungi and their mould metabolites.

6. MEASURES FOR PREVENTION OF MYCOTOXIN CONTAMINATION

The measures available for the prevention of mycotoxin contamination are of two types:

6.1 Prevention measures dependent upon the key factors influencing fungal growth and mycotoxin production

6.1.1 Use of Resistant Varieties of Seeds

Certain resistant varieties have been recognized among groundnuts, maize and sorghum to have potential for inhibiting aflatoxin production though not necessarily fungal growth. The findings have not been brought to a definitive stage and further research

is in progress in some places. Future studies should also concentrate on a search for seeds which are resistant to the production of all the more common mycotoxins. However, in all such studies it is equally necessary to ascertain that the nutritive value of the crop is maintained and that the crop shows a similar resistance to the production of other toxins. Work in this overall area of resistant varieties though potentially most interesting, has not yet reached a stage when it can be recommended for adoption on a large scale. Considerable further effort is required in this direction before such an option, if available, can be used practically.

6.1.2 Time and Ambient Conditions for Harvest of the Crop

Time and ambient conditions are of great importance in producing a resultant crop that is free from mould infection. Crops which are harvested under conditions of high humidity and moisture will be more susceptible to fungal attack than those harvested in dry conditions. Although pre-harvest contamination is relatively rare, it does occur. For example pistacchio nuts which are allowed to ripen on the tree, or almonds, which are damaged by insect attack, will be invaded by saprophytic fungi, thus allowing the possibility of mycotoxin production. On the other hand, the nuts that are harvested with the husks still intact are protected from infection. Other crops that are subject to in-field contamination are cottonseed and maize.

6.1.3 Protection Before and During Drying and Storage

Protective measures taken before and during storage which prevent moisture migration can help considerably in preventing mould growth and the resultant production of mycotoxins. These measures are, first of all, thorough cleaning before drying and storage to remove foreign matter and contaminants which generally carry a higher load of mould spores than does the crop itself; and, secondly, aeration to cool and prevent moisture re-distribution in the crop. In very moist climates, aeration with ambient air maybe unsafe. In this case refrigerated air is used to aerate the freshly harvested crop which is awaiting drying.

6.1.4 Methods of Drying

Drying after harvest is obligatory if contamination with post-harvest fungi is to be avoided. Delay in drying to safe moisture levels increases risks of mould growth and mycotoxin formation. Groundnuts in Africa and Asia are particularly vulnerable since they are lifted at high seed moisture levels and are usually contaminated with A. flavus due to contact with the soil. If the pod is damaged in any way, this permits entry of the mould into the seed and increases the possibility of aflatoxin contamination during any prolongation of the drying process.

Drying is usually carried out, by traditionally developed methods. For example, groundnuts in many parts of Asia and Africa after removal from the soil are dried in a number of different ways. Three of these are outlined below:-

(a) The pods are stacked on a bamboo frame with the pods facing the periphery or the inside;

(b) The plants are spread on a raised platform which has a perforated base;

(c) In some regions the pods are allowed to lie in the fields with the haulms for a few days; the pods are separated and further dried either by spreading on a floor or on raised, perforated bamboo platforms;

In the case of maize, drying is usually done in cobs and in cribs. Harvested Turkish filberts are sun dried on the ground or on sheets of material.

The following factors in the drying of crops need to be observed if contamination with mycotoxins is to be avoided:

(a) There should be no delay between harvesting of the crops, particularly at high moisture levels, and the initiation of drying;

(b) The drying process should be as rapid as possible. Prolonged sun drying of a crop, in conditions of high humidity, will lead to infection of the crop with moulds;

(c) The crops should not be re-wetted during the drying process. However, this may occur in two ways: (i) inadequate protection from rain during a sun-drying process; or (ii) plastic sheeting used to cover crops at night causes condensation of water vapour from the crop onto the cooler plastic sheet - this water can wet the crop again, leading to a prolongation of the drying process and hence mould growth;

(d) The crops should be dried to safe moisture levels before being placed in storage. These safe levels have been defined as follows: cereal grains should be dried to a moisture content of 13% or less for prolonged storage; peanuts to 8% and cottonseed to 10%; soybean to 10% and sorghum below 11%.

In recent years, artificial methods of drying have also been gradually introduced in various parts of the world. Usually the costs involved in artificial drying make it prohibitive for the individual farmer, so that driers are often organized as cooperatives or as a public service. However, even in this case, the distance of the driers from the various farmlands and bad approach roads pose serious problems.

6.1.5 Storage

Storage is of particular importance since bulk storage of food grains has become a necessity in many parts of the world. Good warehousing facilities are essential if grains and other food crops are to be adequately stored.

Mould growth and insect attack are the major causes of deterioration of quality of stored seeds. Major stress during storage has been on preventing insect infestation and prevention of moulds has not received equal attention. Insects can be controlled by use of fumigation, radiation and good sanitary practices, while mould growth is best prevented by limiting the moisture level of the stored seed by drying and by use of fungicides.

The recommendations to help provide the optimum conditions for storage to prevent fungal contamination will include the following:

(a) Storage structures should be dry and should not permit the entry of water either by leakage or by seepage of ground water. Stacks of bagged grain should be built on dunnage or pallets to avoid upward movement of ground water, unless it is quite certain that the floor incorporates a membrane impermeable to water vapour;

(b) The store should be kept at as constant a temperature and relative humidity as possible. Moisture migration and condensation resulting from thermal gradients within stored grain masses, can lead to an accumulation of moisture in certain areas where mould growth will then occur;

(c) The crops to be stored should whenever possible be of a high quality; they should ideally be free from moulds, insects and "off" odours and they should have been dried to the safe level of moisture content for the particular crop;

(d) Protective insecticidal treatments should be used for storage structures and stored bulk grain to control insect infestation of the grain. Insects which crawl on the grain deposit fungi and also help raise the moisture levels in pockets of grain, where fungal growth invariably occurs;

(e) Low temperature storage should be employed whenever possible as freedom from contamination is correlated directly with temperature. An exception to this general rule would be the Fusarium spp. which preferentially produce zearalenone in large quantities at low temperatures.

6.1.6 Transportation

Transportation of the crop can occur either before or after storage or both. In each case the crop will be susceptible to contamination if it is not maintained under suitable conditions during transportation. The transportation of Brazil nuts is a good example of contamination occurring during transportation. The nuts are collected from the equatorial forests. They are then transported to the processing plants, in bulk, by boat. The journey can last up to two months in high moisture and relative humidity conditions, under which fungal development and toxin production are likely to occur. The conditions of storage referred to earlier apply also in the case of transportation and should not be neglected.

6.1.7 Fumigation and Radiation

The practical use of fungicides to control fungal infestation in grain must overcome the same hurdle that exists for insect treatments, namely the problem of harmful chemical residues. There appears to be no fungal treatment that has been successfully employed for large-scale application despite extensive research in this area.

Irradiation of grain and related products is another treatment that has been studied primarily as an insect control procedure. Radiation levels which are used for the control of insects in grains (e.g. the FAO/IAEA/WHO Expert Committee Report recommends a dose of 15-100 krad for the control of insect infestation in stored wheat) are not high enough to kill storage fungi. Furthermore, radiation used to destroy storage fungi invariably kills the grain before the mould. This alone would not be a deterrent to irradiation, but at the high dose levels necessary to kill fungi, off flavours and odours may be produced.

6.1.8 Reference is also invited to "Recommended Practices for Prevention of Mycotoxin Development in Foods, Feeds and Their Products", available to delegates to the Conference (in English).

6.2 Measures available for the prevention of mycotoxin contaminations which concern the use of the crop and its system of marketing

6.2.1 The Choice of the Crop

One obvious option to avoid exposure of groups of populations to aflatoxin-contaminated foods is to change the agricultural production and resort to crops which are less prone to such contamination. This has been done in some cases but may be impracticable in every case.

The choice of crop to be grown will be dependent on the following:

(a) The traditional food habits and nutritional requirements of the community;

(b) The suitability of climatic and soil conditions for the production of an alternative crop;

(c) The experience of the farmer and facilities available for the plantation, harvesting, drying and storage of the crop in terms of the local economy.

Given however, that the above requirements can be met, the choice of crop to be grown should take account of the mycotoxin hazard. Hence hypothetically speaking, it would be preferable to produce a crop which is less susceptible to mould attack and mycotoxin production than to grow one which is highly susceptible to such invasion.

6.2.2 Trade Practices

Trade in agricultural produce in most countries is carried out by weight. Drying brings down the weight of the crop by the extent of the moisture loss; hence the farmer will receive a relatively lower price for dried than undried crops. Although slightly higher prices are often paid for the dried commodity, this may not compensate the farmer sufficiently to ensure that he will adequately dry his crop.

At the same time the farmer, if he can afford it, will usually wait for a favourable market price before selling his crop. This practice of storage at the level of the farmer tends to provide suitable conditions for the growth of fungi and subsequent mycotoxin contamination.

There is a growing demand by importing countries for hand-picked selected (HPS) groundnuts. In order to improve the balance of trade and build foreign currency reserves, many developing countries export HPS groundnuts. The remaining sub-standard seeds invariably enter local trade channels, thus increasing the chance of ingestion of contaminated groundnuts by the local community. Oil from such groundnuts invariably carries very high aflatoxin levels. In certain parts of the world for example, unrefined oil is still consumed quite extensively in preference to refined oil from which the aflatoxin has been removed by refining and filtration. In this way, a large number of the population is exposed to aflatoxin and because of its high cost and bland taste and aroma, refined oil has not replaced unrefined oil in commerce.

Increase in urbanization has brought many sociological changes and resultant changes in food consumption patterns. Frequent droughts, poor yields, famine and floods have forced several governments to build up buffer stocks of food grains to meet such emergencies. Since good storage practices are very exacting, even slight deviations from the codes of practices may create favourable conditions, either directly or indirectly, for fungal growth in cereal.

Some or all of the trade practices outlined above would need to be examined within the national context in order to determine areas where mycotoxin contamination could be either prevented or controlled and the consumption of such contaminated foods discouraged and reduced.

6.2.3 Incentives and Control

There should be incentives for the farmer to produce and market a toxin-free crop, for the purchaser to buy it and for the consumer to eat it. The farmer should be able to get a premium price for producing low toxin or toxin-free foods sufficient to compensate him for the extra costs and care involved in the process. Appropriate grading and marketing systems can play an important role in this direction. By general education, if the consumer demands safe foods, the farmer, the middleman and the processor will be forced to take all the necessary precautions in order to produce such foods. This is well illustrated by the export inspection systems of a number of countries in certain commodities. Many importing countries demand commodities which are free from or have a very low level of aflatoxin. Lots of certain crops, such as Brazil nuts and pistachio nuts and even groundnuts and their cakes from exporting countries have been embargoed at the port of entry into the importing country because their aflatoxin content was in excess of the permitted limit. Subsequently organization of aflatoxin surveillance programmes for exports in exporting countries have led to a dramatic reduction in the number of rejected lots. However, this type of incentive and control programme results only in improvement of export products; the rejected remainder is marketed internally and is a potential hazard for the local population.

6.2.4 Surveillance and Control

Several surveillance programmes have been conducted in various countries to determine the extent of the mycotoxin problem. It has been recognized that although aflatoxin presents the greatest hazard, the occurrence of other mycotoxins on foods such as ergot on rye, patulin on apples and in apple juice, zearalenone in beer and other fermented maize and sorghum products, etc. are also hazardous and occur fairly frequently. Regular surveillance programmes are necessary to monitor food materials for all types of mycotoxin contamination. Conference Document MYC-7 discusses in detail the need for, and the problems of, organizing such national programmes.

6.2.5 Detoxification

Economically it is not possible or even advisable to destroy all foods and feeds that are contaminated with mycotoxins. Thus both physical methods for separation of mycotoxin-contaminated materials and chemical methods of detoxification would be called for to salvage such produce. Conference Document MYC-6 deals with this subject in detail.

7. POSSIBLE CONSTRAINTS IN THE SUCCESSFUL IMPLEMENTATION OF PREVENTION AND CONTROL MEASURES

7.1 It is obvious that the prevention and control of mycotoxins, to be effective, would call for a concerted effort of an interdisciplinary nature as no individual measure can deliver the goods. Such an effort can be built on the state of knowledge existing on the subject and the availability of trained manpower to work in different aspects of prevention and control.

7.2 As in most other similar cases, the basic constraints inherent in the successful implementation of the series of activities for the prevention and control of mycotoxins are:

a) Lack of awareness;

b) Shortage of trained personnel;

c) Lack of resources;

d) A need for appropriate technology;

e) Inadequacy of infrastructure for action;

f) Ecology.

7.3 Lack of awareness

Half the battle for the cause is already won when people become more widely aware of the economic and health hazards of mycotoxins. In launching an action programme in this area a major hurdle is going to be the education of people at the grass root level dealing with production, processing and marketing of crops. Conference Document MCY-8 deals in detail with educational and extension measures and how these might be carried out at national level.

7.4 Shortage of trained personnel

Under the best of conditions there is bound to be a shortage of trained personnel to embark on a large scale multidisciplinary programme for the prevention and control of mycotoxins in various food and animal feed products. Concerted efforts would be required to augment the cadre of trainers who would be involved in further training of extension workers in different fields of activities. Again Conference Document MYC-8 deals with some of the problems in this area.

7.5 Lack of resources

Many of the resources which are necessary to contain the mycotoxin problem impose constraints on the options which are available for the control of the problem.

7.5.1 Source of Energy to Dry Crops

In most countries crops are sun-dried and are turned by hand to keep them aerated and to prevent pockets of moisture forming. However, crops that are harvested in the rainy season or in a country where there is little sun, must be dried using an artificial heat source. This is a serious constraint.

7.5.2 Capital Investment for Storage and Drying, etc.

The drying and adequate storing of crops to prevent possibilities of mould growth and fungal contamination require considerable capital investment. Driers have to be purchased, often in hard currency, and maintained by technically competent people. Similarly, warehouses and storage facilities, if they are to provide adequate protection of the crop, have to be well designed and maintained; both processes require a large amount of capital investment which is often not available in the developing countries. An Indian example of the costs, where the labour is comparatively cheaper, involved in maintenance and annual fumigation of a 5,000 ton warehouse is given:

1)	Cost of labour for fumigation	Rs 6,300.00
2)	Cost of insecticides, fungicides, etc.	Rs 3,700.00
3)	Cost of cover for the grain	Rs 1,000.00
		Rs 11,000.00
		Rs 2.2 per ton

(9Rs = 1$)

7.5.3 Technical Facilities

Laboratories and technical apparatus are necessary for the detection of mycotoxin contamination; these constraints can lead to a set-back in control programmes.

7.6 A need for appropriate technology

Application of any techniques on a mass scale should imply that the technology is appropriate for the purpose. The two operations which offer serious constraint from the point of view of technology are drying and storage of crops under tropical and sub-tropical conditions. In the case of drying, electricity or any carbon fuel can be used, but the economics of using such sources of energy and the conventional driers which may be available in some of the industrialised countries can offer serious constraints. In many cases it may be more practical to utilise solar energy which would call for the designing of relatively cheap and simple equipment. The scale of operations at farmers level in most of the developing countries is too small to permit use of sophisticated techniques and equipment.

7.7 Inadequacy of infrastructure for action

No measures in the prevention of mycotoxins can succeed at a national scale without the presence of a suitable infrastructure for carrying out these programmes. This is often one of the great bottle necks as Governments are more inclined to invest resources in production rather than in some of the prevention measures.

7.8 Ecology

Mycotoxins being environmental contaminants, the biggest constraint in their control is the ecology itself. It is not possible to change the weather and rainfall. Hence the need to adjust, accommodate and improvise and this calls for additional human and material resources.

7.8.1 Just as ecology affects our action, in a similar manner human action affects ecology. The two are interdependent. In this latter context, one cannot permit the use of fumigants, fungicides and insecticides indiscriminately to protect crops against various types of contamination without seriously effecting the local ecology.

8. The Conference may like to consider the problem in its overall context and make recommendations on the actions that might be taken by national or international bodies and research institutes.

ANNEX VI

FOOD AND AGRICULTURE ORGANIZATION
OF THE UNITED NATIONS - Rome

WORLD HEALTH ORGANIZATION
Geneva

UNITED NATIONS ENVIRONMENT
PROGRAMME - Nairobi

Agenda Item 6

MYC - 6

JOINT FAO/WHO/UNEP CONFERENCE ON MYCOTOXINS
Nairobi. Kenya, 19-27 September 1977

DETOXIFICATION OF FOOD AND ANIMAL FEED CONTAMINATED BY MYCOTOXINS

SUMMARY

Decontamination and chemical detoxification are needed because preventive measures will not be fully able to combat contamination by mycotoxins. Criteria for detoxification methods are given. Few chemical methods have been tried on industrial scale, and of these ammoniation shows greatest promise of short-term application to oilseed cakes. Technical, economic and public health aspects of ammonia treatment are discussed. Certain other detoxification techniques for oilseed cakes, oilseed protein isolates, crude vegetable oils and grains are considered briefly.

W/G5490

DETOXIFICATION OF FOOD AND ANIMAL FEED CONTAMINATED BY MYCOTOXINS

1. PREVENTION OF CONTAMINATION

1.1 Preventive measures at the agricultural level constitute without doubt the best approach to minimise the contamination of food and animal feed by fungi and their toxins. Although it may be possible to select mould resistant species through research it appears that the progress made in this field so far is very limited.

1.2 Appropriate preventive techniques exist and should be applied in harvesting, drying, storage and distribution of foods. Whether the application of such preventive measures are in fact applied is, however, dependent upon:

1.2.1 The level of awareness of the problem, with specific reference to:

a) Economic Factors

Many producing countries have minimized and often even ignored the problem of aflatoxins. But in the long run economic implications have stimulated their awareness of the problem to the point of earnest consideration. Senegal may provide an example. A rough estimate based on the 1975 groundnut harvest has shown that, had the EEC legislation of aflatoxin limits, been applied to the Senegalese produce a loss of about 15 billions CFA would have been incurred, which represents about one-fifth of the country's national budget (Dr. N'Diaye, round table, IUPAC 3rd Symposium on Mycotoxins, Paris, September 1976). The Senegalese Government has today a programme for the control of aflatoxins in groundnuts meant for export

b) Public Health Hazards

It is a pity that the public health aspect is often being given second priority, although already in 1966 the Protein Advisory Group (UN) which met in Geneva called attention to health hazards to humans and animals and recommended a safety level of 30 µg aflatoxin per kg for protein-rich food to be consumed daily by an infant. PAG wished to impose a lower level of aflatoxin in the foods and food mixtures concerned in order to provide a wider margin of safety, but believed that there was an even more urgent need to provide extra protein in some parts of the world so as to prevent malnutrition and starvation. These considerations outweighed the desirability of introducing measures for reducing a hypothetical health hazard by limitations which were difficult to enforce under current agricultural practices and techniques of food processing. Since then there have been a number of other expert consultations and meetings, including most recently one to finalize a WHO "Criteria Document" on Mycotoxins (1977), and all have continued to draw attention to the public health hazards involved. In this connection, if in the process of encouraging exports relatively more contaminated food is retained within the country, the risk to the health of humans and/or animals would be further aggraveted.

1.2.2 The performance of any system devised to introduce effective preventive measures in the field, at harvest, in drying and storage, etc. If the system is not appropriate or inefficient, the best measures will remain only on paper.

2. DECONTAMINATION METHODS ARE NEEDED

2.1 In the present state of the art of control of mycotoxins, reliance chiefly on preventive measures must be viewed as a long-term goal. However good the existing preventive measures are they can not be expected to succeed in all circumstances. There will, therefore, always be a need for measures which can be adopted once it is discovered that the produce is contaminated. Broadly speaking such measures might involve diversion of food from human consumption to animal feed, or careful blending of contaminated food with good quality produce to reduce the overall level of the toxin to the limit which is accepted legally or otherwise

considered sufficiently safe. A fuller discussion of these steps is to be found in another paper (MYC-7) and the "Guidelines" on surveillance. When such steps are not feasible, recourse has to be had to decontamination of the product.

3. DECONTAMINATION METHODS — GENERAL COMMENTS

3.1 Various decontamination techniques have been described in the literature, but very few have been utilised so far. Decontamination methods can be classified under three categories:

a) Separation of the contaminated parts of the produce.

b) Extraction of mycotoxins (i.e. solvents).

c) Inactivation of mycotoxins by physical (heat, cooking, roasting), chemical or biological means.

The term "decontamination" is often reserved for the physical removal of contaminated units, kernels or nuts. Those techniques which depend on the removal of the toxin from within the unit or on its destruction have been called "detoxification". It is obvious that each one of these techniques has certain advantages as well as limitations. Physical separation methods, where practical, are simple but often time and labour consuming when performed manually. While they may be applicable to small lots of produce made up of comparatively larger pieces, e.g. groundnuts, they are mostly impractical for bulk produce or for smaller size grains. Electronic sorting has been used to handle bulk groundnuts in USA. However, there is evidence to show that sound appearing kernels of groundnuts, without any outward visible sign of fungal attack, can carry aflatoxin. Moreover, physical methods of mechanical separation have no applicability in the case of oilseed cakes. Therefore "detoxification" techniques of one type or another become necessary.

3.2 Separation of contaminated portions of lots is covered in greater detail in the paper on prevention (MYC-5) and in a special publication on prevention practices available in English entitled " Recommended Practices for Prevention of Mycotoxin Development in Food, Feed and their Products".

4. CRITERIA FOR DETOXIFICATION METHODS

4.1 To have a potential for industrial application, a detoxification process must be technically and economically viable and must meet the following criteria:

a) destroys or inactivates the mycotoxin,

b) does not produce or leave toxic or carcinogenic residues in the final product,

c) destroys fungal spores and mycelia which could, under favourable conditions, proliferate and form new toxins,

d) preserves the nutritive value and acceptability of the product,

e) does not significantly alter important technological properties.

4.2 A protocol (prepared in France) is annexed to this paper to illustrate the application of criteria to materials contaminated by aflatoxins.

5. SPECIFIC DETOXIFICATION METHODS

5.1 Consideration needs to be given only to those decontamination processes which have been tried out on an industrial scale, in particular those used for the treatment of oilseed cakes of goundnut or cottonseed. These processes also come nearest to meeting the criteria given above. It should be noted that they are designed and meant for aflatoxins only.

6. EXTRACTION OF OILS BY POLAR SOLVENTS

6.1 Aflatoxins are most soluble in polar solvents. However, it has been noted that during industrial extraction, technical hexane, although non-polar, dissolves a small quantity of aflatoxins which is later found in the unrefined extracted oil. Through the use of caustic soda during refining of the oil, any aflatoxins present in the crude oil are completely eliminated.

6.2 A reduction of aflatoxin content of unrefined hydraulic pressed groundnut oil can be achieved by filtration, using a filter aid to remove particulate matter which contains about 65% of the aflatoxin in the oil. In pilot plant studies in India, nearly complete removal has been obtained with a special absorption filter unit which is said to be mounted easily in place of the conventional cotton cloth filter. Particulate matter is first removed, followed by absorption of dissolved aflatoxin. Industrial installations have not been reported but would appear feasible in oil mills equipped with filter presses.

6.3 A simple method for inactivation of aflatoxin in oil reported from India is exposure of the oil in glass bottles to bright sunlight for at least one hour. Aflatoxin is photodegraded and is reported to lose its toxicity. The method, suitably modified, is possibly useful for local production units, with relatively small expenditure for capital equipment. An obvious requirement is predominantly sunny weather during the processing season. The effect of such exposure on quality of the oil may need to be considered because oxidative degradation of vegetable oils may be photoactivated.

7. EXTRACTION OF OILSEED CAKES BY POLAR SOLVENTS

7.1 A number of proposed solvent systems (Vorster 1966), and in particular a hexane-acetone-water (50-485-1.5) mixture, have been studied though mostly at the laboratory level. Attempts to apply them on an industrial scale have been made in France (Prevot, 1974), and the results may be summarised as follows:

- detoxification by polar solvents on an industrial scale using solvents was not comparable with that obtained in the laboratory,
- needed additional investment — based on technological requirements for adequate operations (toasters, larger rectification columns and desolventizers) — is very substantial, making an economic evaluation of the process essential.
- a rise in operating expenses also will be incurred, in particular to cover greater energy requirements and increased loss of solvents,

— with acetone containing or developing mesityl oxide (an impurity), in certain cases a disagreeable odor is imparted to the product, due to reaction with sulfur-amino acids from the oilseed cake.

7.2 The principal advantages of eliminating aflatoxins through extraction by means of a polar solvent are a) preservation for food and some animal feed purposes of nutritional properties of proteins as they are not broken down and b) removal of the toxin in its primary form thus avoiding the possibility of hazard from a degradation product of aflatoxins.

8. DETOXIFICATION OF OILSEED CAKES USING AMMONIA

8.1 Most trials have been applied to oilcakes from groundnuts and cottonseed. From those performed on a pilot scale (Gardner et al, 1971) on cottonseed cake in the United States (US Pat. No. 3 429 709: conditions being ammonia pressure of 48 pounds per square inch, 118° C, 30 minutes of contact time) it may be concluded that the treatment is effective and innocuous as demonstrated by both short and long-term rat feeding tests. At present two plants are in operation in the USA for the treatment of cotton seed cake and cottonseed by ammoniation.

8.2 In France the industrial treatment of groundnut cake has involved the following conditions: oilseed cakes containing 12-15% of water, ammonia gas under pressure of 2 to 3 atmospheres, reaction time between 15 and 30 minutes, temperature about 90°C under intermittent agitation (French Pat. No. 2 184 439). The main part of the ammonia which has not reacted is recovered and recycled (Lesieur et Collin 1976). Residual ammonia is removed from the cake through forced ventilation and recovered by absorption.

8.3 The nutritional and toxicological evaluation of the product obtained with the French process have been studied thoroughly. The available lysine value does not appear to be affected by the treatment, but cystine may be decreased to the extent of 15 to 30%. In any case the detoxification reaction is irreversible.

8.4 The changes in the molecule of aflatoxin B_1 during ammoniation has been studied by Cucullu et al. (1976) who identified two decomposition products: aflatoxin D_1 and a compound "206". The first stage of the detoxification is achieved through the opening of the lactone ring of aflatoxin B_1 and the formation of an ammonium salt. (Under acid conditions the lactone ring closes again and aflatoxin B_1 is reformed). In a second stage there follows a series of irreversible reactions which lead to aflatoxin D_1 through decarboxylation or to compound "206".

8.5 Nutritional trials with rats showed no difference between the control diet and a diet enriched with ammoniated cakes if the deficit in cystine is corrected. For cakes intended as feed for ruminant animals, amino acid supplementation is not essential.

8.6 Short and long term toxicological studies have been performed on the detoxified product and have led to the conclusion that the product is innocuous; the toxicity and carcinogenicity of the contaminated groundnut oilseed cake disappear after the treatment (Frayssinet et al. , 1976). The treated product was acceptable to laboratory animals, fowl and farm animals.

8.7 The use of this detoxification process has been recommended in France by an Interministerial and Interprofessional Commission on Animal Feed. Tentative approval for the use of cottonseed meal detoxified by ammoniation has been given in the United States by the U.S. Food and Drug Administation. Final approval awaits the completion of a comprehensive animal testing programme in which the meat and eggs of chickens fed ammoniated cottonseed are fed to rats in life-time feeding tests.

9. DETOXIFICATION OF MAIZE USING AMMONIA

9.1 A detoxification process for maize has been developed based on use of aqueous ammonia under atmospheric pressure (Ciegler, 1976). The process does not raise technological problems, but the maize obtained after treatment is discoloured, thus restricting its use to animal feed. The mechanism of inactivation has been studied (Beckwith et al. , 1975). The aflatoxin B_1 combines with protein macro-molecules and thereby becomes inactive. Toxicological evaluation of the end product is underway.

10. DETOXIFICATION OF OILSEED CAKES USING METHYLAMINE AND CALCIUM HYDROXIDE

10.1 Detoxification trials have been carried out on an industrial scale (Giddey et al., 1976; Pat. CH 566-110; US 3 890 452, 1974). Both investment and maintenance costs are reasonable. With very slight modifications, the equipment may be installed in a standard vegetable oil factory.

10.2 The chick-embryo toxicological test showed the elimination of aflatoxin but not necessarily the absence of carcinogenic degradation products. The nutritive value of the product is, however, lowered by the process. More tests have to be carried out to permit a sound toxicological evaluation of the treated product.

11. DETOXIFICATION OF OILSEED PROTEIN ISOLATES USING HYDROGEN PEROXIDE

11.1 A detoxification method worked out and patented by the Central Food Technological Research Institute, Mysore (Sreenivasamurthy et al, 1967) consists of the treatment of isolated groundnut protein for human food with hydrogen peroxide. This method is utilised in India on a commercial scale, and daily production is reported to be 2-5 tonnes of toxin-free protein. The cost of the treatment represents about 15% of the cost of the isolated oilseed cake proteins.

12. OTHER DETOXIFICATION PROCESSES

12.1 Other methods have been reported for example the Japanese patent (Aibara, 1976) describing the elimination of aflatoxins using solvent extraction by a water-methoxymethane mixture. The process is still under study. Another method of detoxification of groundnut proteins using sodium hypochorite has been studied. Trials on an industrial scale have not yet been undertaken.

13. TECHNICAL CONSIDERATIONS FOR THE AMMONIA PROCESS

13.1 In the inactivation of aflatoxin by the ammonia process, it is essential that the ammonia penetrates throughout the oilseed cake. In this way an alkaline environment is created, causing the opening of the lactone ring of the aflatoxin molecule, i.e. the first step in its destruction.

13.2 Practically important technical considerations include the following:

— In the oilseed cakes the toxin is distributed in a very heterogeneous manner and it is dispersed in the mass of the product.

— When water is added to the hot oilseed cake, there is a tendency to solidify and to form blocks. (The phenomenon is most striking in solvent extracted oilseed cakes where the oil content is less than 1%).

— For these reasons, a gas must be utilised in order to improve contact with the molecule; hence the use of ammonia under pressure.

— The optimum moisture content of the product for detoxification is about 15%. Addition of water to achieve this level permits the incorporation of ammonia in a liquid form after its capture into water. Furthermore, energy consumption to bring the oilseed cake back to the 12% moisture needed for commercial purposes will not be very high.

— It is necessary to keep the mass of product under powerful agitation in order to ensure uniform distribution of moisture, otherwise the product will aggregate and form an extremely hard mass. The method calls for the utilisation of explosion-proof equipment, leak-proof valves and closures in order to avoid air pollution and to ensure, through appropriate protective measures, the long term industrial use of the plant.

13.3 The practical application of the method on a large scale in developing ıntries poses some technological economic and safety problems which should not be minimised. ɔse include:

— Installations for the production of ammonia under pressure.

— Capital investment, maintenance of equipment.

— Assurance of safety, absence of pollution (e.g. the problem of possible leakage of ammonia gas requires special attention in order to avoid accidents).

ECONOMIC CONSIDERATIONS FOR THE AMMONIA PROCESS

14.1 According to the French ammoniation process (Lesieur and Colin, 1976) an tallation capable of treating oilseed cake at a rate of 600 tons/24 hours represents an estment of about FF 8,500,000 to 9,500,000 (US$ 1,713,000 to 1,900,000). This estimate based on a source of ammonia being located not too far from the plant. The cost of the ıtment, without amortisation of the equipment is estimated at between FF 20 and 25 (US$ 4 to ɔer tonne of oilseed cakes . This price includes consumption of ammonia, maintenance and rgy utilisation in the context of an African vegetable oil factory which makes use of ındnut shells for fuel. On this basis, the treatment represents about 2 to 3% of the value the oilseed cake.

15. PUBLIC HEALTH CONSIDERATIONS

15.1 A series of studies on nutritional and toxicological aspects of ammoniated groundnut and cottonseed meals have shown the products to be safe as animal feed. However, one study (Sinnhuber, 1976) on rainbow trout fed milk from cows that had received ammoniated cottonseed meal in their rations showed a small but significant incidence of liver cancer. Rainbow trout are highly sensitive to the effects of aflatoxin, responding to fractional parts per billion in the diet. The effect from milk was attributed either to undetected aflatoxin residues in the milk or to degradation products of aflatoxin.

15.2 Aflatoxins are sensitive to oxidative and to alkali treatments. Both treatments lead to the opening of the lactone ring of the toxin which permits reactions leading to detoxification. Chemicals which have been successfully used so far on commercial scale are hydrogen peroxide (oxidant) in a rather restricted application, and ammonia (alkali). The reaction in both cases lacks specificity.

15.3 The ammonia process has been more thoroughly studied for its nutritional and toxicological effects for use in production of animal feed and has been employed in U.S.A. on a commercial scale for treatment of cottonseed and cottonseed cake. The hydrogen peroxide method has also been studied to some extent for nutritional and toxicological effects, and has been accepted for use in production of food ingredients in India.

15.4 The choice of the method will depend upon a number of factors, i.e. capacity of the plant required for commercial operations, capital investment vis-a-vis size of operations availability fo raw materials, use of end product, level of sophistication of technology most suitable to the environment, technical expertise available and above all the cost of treatment per unit material within the scale of operation.

16. LOCATION OF DETOXIFICATION UNITS

16.1 For obvious reasons it would appear to be most advantageous to locate the detoxification units within or close to oilseed processing plants/areas. If appropriate technology for detoxification is used, the needs for training can be usually be met and the operation in the long run will be economically viable. Quality control and, when necessary, detoxification prior to shipment will have added advantages in maintaining markets and returns especially for a country for which materials like groundnut oil and cake are important export earners.

16.2 In the case of commercial partners in international trade, it is often necessary to reach prior agreement on the acceptable level of aflatoxin in the produce, particularly when the regulations are not uniform. This, in turn, may sometimes determine the detoxification techniques to be used and may lead to a better definition of the parameters to be applied in evaluating the effectiveness of the process and the nutritional, toxicologica and economic implications.

16.3 Consideration might also be given to locating detoxification units in industrialized importing countries whereaflatoxin levels and prices to consumers could be adjusted in the context of a new and more just economic order without detriment to the exporting developing country. This might also reduce the risk of recontamination.

17. FEASIBILITY OF COMBINING SORTING AND DETOXIFICATION

17.1 The principle is tempting. A segretation system of some sort would be used to separate out as fully as possible the aflatoxin contaminated portions from produce so that this quantity alone would need to be detoxified. This, however, supposes the application of an effective segregation method. Separation may be feasible for hand-picked selected (HPS) groundnuts which are homogeneous as to variety and appearance (colour). Separation is less likely to be possible for groundnuts normally available in developing countries for oil extraction, as the seeds are often heterogeneous and differently coloured. It may also in any event prove difficult to transfer without modification to a developing country a process used in the United States such as electronic sorting.

17.2 Groundnuts are grown on larger farms in the U.S.A. mostly for direct human consumption. The conditions in which they are grown relate to a mechanized type of agriculture, while in Africa for example there are numerous producers working on small pieces of land. Most of the time different varieties are grown by the same or by different producers, and this contributes to heterogeneity of produce received at the oil mill. Planting dates may vary, and therefore harvesting may be done under different conditions. There is not an equal shortage of labour in developing countries: moreover, maintenance and operation of electronic sorting equipment call for investment in trained personnel of a high level of technical skill.

17.3 These considerations are among those on basis of which a developing country will have to decide whether, in its particular circumstances and needs, a combined system of physical separation of contaminated portions of produce (including possibly electronic sorting) and detoxification by chemical means (e.g. by ammoniation) is warranted.

18. LOOKING AHEAD

Research and experimentation in the field of mycotoxins decontamination (including detoxification) continue at a rapid pace, and some new developments with practical implications are likely to come to fruition in the not too distant future.

ANNEX TO MYC-6

AFLATOXINS

PROTOCOL FOR SAFETY STUDY OF DETOXIFIED OILSEED CAKES OR OF FEED RATIONS CONTAINING SUCH PRODUCTS

I - EFFECTIVENESS OF DETOXIFICATION PROCESS APPLIED

First of all it is necessary to demonstrate the effectiveness of the detoxification method. For this purpose the following steps are essential.

A) First must be undertaken a physico-chemical analysis for the mycotoxins normally associated with the product, using an official method wherever possible. The analysis work should be carried out concurrently by at least two laboratories. It should involve examination for aflatoxins B_1 and G_1 and possibly also B_2 and G_2.

B) Where analysis indicates successful detoxification, a confirmatory biological test is carried out on one-day-old ducklings; after sacrifice, a histological examination is made of the liver and kidneys.

C) Next must be ascertained what happens to the aflatoxins (at least B_1) and, where applicable to substances formed by the detoxification treatment, as well as the risks and the conditions of reversibility of reactions to form the same toxic substances.

D) The general nutritive value is assessed, and the amino acid composition determined. The treated oilseed cake should be incorporated in a balanced diet in order to detect any adverse nutritional changes which could have been introduced by the detoxification process. The protein efficient ratio (PER) is determined for the rat, chicken and duckling. The test on the duckling will permit an assessment of any residual toxicity as well as of feed efficiency.

II - DETAILED TESTING OF ANIMAL FEED *

Included in detailed tests are various studies which may be undertaken at one time or sequentially as may be necessary.

The aim will be to determine all of the following: a) possible residues in the feed of the material used for treatment; b) the chemical transformations which may have been introduced in the feed; and c) the level of contamination by fungal spores which could lead anew to formation of aflatoxins if the storage conditions are not satisfactory.

A) COMPOSITION

1. An analysis is made for residues of the material used for the treatment. Presence or absence should be indicated. Any transformation products should be identified and, if possible, a material balance should be established and the course of all parts followed.

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* It is understood that Part II of this protocol, the detailed tests of the treated product, will not be undertaken unless the effectiveness of the detoxification treatment has been established. Depending on the detoxification methods applied, modifications may be introduced based on expert advice.

2. Next is the chemical analysis of the components of the feedstuff. In this, particular attention should be paid to components which are susceptible to quantitative or qualitative changes because of the detoxification process, for example by applying reactions known to determine the availability of nutrients, such as essential amino acids.

3. Microbial counts of revivable microorganisms are made, with special attention to aflatoxin producing mould species,and employing normal conditions of storage of the feedstuff.

B) NUTRITIVE VALUE

This value will be estimated through:

1. Total feed efficiency studies to be carried out on at least two species of animals, rat and a farm animal likely to receive the experimental feed in its diet.

2. Specific measurement of the availability of components subjected to modifications as a result of the treatment.

C) TOXICITY

Absence of toxicity in the detoxified product is demonstrated throug acute, medium and long term studies on animal species sensitive to the mycotoxins involved.

1. Acute Toxicity

This includes the necessary testing of extracts of the product in chicken embryos, and three (3) other types of tests among them those recommended for carrying out in trout, duckling, bacilli, larva of Artemia salina, rabbit, and certain sprouting plants. Histology of the liver and kidneys of experimental animals is systematically included at the end of each test.

2. Chronic Toxicity

Cancerogenic, teratogenic and all other effects are determined in the rat. Fertility and reproduction characteristics are followed up over two generations at least.

If possible, a study of transmitted toxicity should be done on ducklings, using milk from animals fed on a diet containing treated oilseed cakes. At the end of the trials, examinations are made for pathological and other changes of liver and kidneys of experimental animals as well as of the controls.

ANNEX VII

FOOD AND AGRICULTURE ORGANIZATION
OF THE UNITED NATIONS - Rome

WORLD HEALTH ORGANIZATION
Geneva

UNITED NATIONS ENVIRONMENT
PROGRAMME - Nairobi

Agenda Item 7

MYC-7

JOINT FAO/WHO/UNEP CONFERENCE ON MYCOTOXINS
Nairobi, Kenya, 19-27 September 1977

SURVEILLANCE AND CONTROL MEASURES TO REDUCE CONTAMINATION BY MYCOTOXINS

SUMMARY

This document focuses on the critical considerations and implementation of a mycotoxin surveillance system as part of the food control programmes to protect the consumer and avoid food losses at the national level. Ways must be found to elicit producer cooperation. Surveys are needed as first steps. In view of likely constraints, a gradual development towards surveillance coverage is indicated in most developing countries.

N/G5483

SURVEILLANCE AND CONTROL MEASURES TO REDUCE CONTAMINATION BY MYCOTOXINS

1. BACKGROUND

1.1 Over the past decade it has become clear that the aflatoxins and several other fungal toxins (mycotoxins) can contaminate segments of the human and animal food chain to an extent not realised before the mid-1960s. Although knowledge of the health risks that may be associated with this form of food and feed contamination is far from complete, available information, particularly on the aflatoxins, has led public health officials, animal health scientists, and food control authorities in many nations to institute various types of mycotoxin research and control programmes. Among these, aflatoxins have seen by far the greatest survey and surveillance activities.

1.2 It will be useful to set forth some key facts and generalizations which have led to concern about mycotoxins and to activities designed to control hazards particularly from aflatoxin contamination.

1.2.1 The hepatotoxic and carcinogenic aflatoxins have been more fully studied and evaluated than any other mycotoxins. Although the risks to health, and potential for reducing productivity of humans and of livestock exposed to aflatoxins through food or feed are not yet quantifiable.

1.2.2 Some of the most important plant foods consumed by humans (e.g. oilseeds and grains which contribute significant protein and calories to the diet) are susceptible to aflatoxin contamination. The highest levels and incidence of contamination are found in tropical and semitropical regions, although aflatoxin has been found in foods produced in temperate zones. Chemical analysis is necessary to determine whether crops produced in any specific region are susceptible to aflatoxin contamination. Information on occurrence of aflatoxins developed thus far suggests that it would be prudent for countries interested in protecting consumer and animal health and productivity to assume some degree of contamination in certain domestically produced or imported crops, until and unless analytical surveys prove otherwise.

1.2.3 Aflatoxin contamination of crops can take place in the field, or during harvest and storage, or even at a later point prior to consumption. Some of the factors leading to contamination are within human control, others are beyond it. A certain level of aflatoxin contamination of foods and feeds is probably unavoidable. To achieve the maximum possible protection from this hazard, human intervention and control are necessary at several different points in the production, marketing, processing and distribution of susceptible commodities.

1.2.4 Several mycotoxins other than the aflatoxins have been identified as food and feed contaminants. Some of these mycotoxins are currently undergoing toxicological and/or epidemiological study to learn more about the risks they pose to human and animal health and productivity. This research activity, not yet complete, may reveal that for some countries one or more of these mycotoxins may be more important food or feed contaminants than the aflatoxins. Furthermore, some of the human and animal diseases not yet discovered may be found to involve mycotoxins.

1.2.5 The possible human and animal health risks and economic problems associated with aflatoxin contamination of foods and feeds have prompted several countries to establish and enforce aflatoxin regulatory programmes for some domestic and imported commodities. At present no regulatory controls exist anywhere in the world for any of the mycotoxins other than aflatoxin. However, some of the other mycotoxins are expected to come under control programmes when more information becomes available, before the end of the present decade.

1.2.6 International trade in a number of commodities (ground nuts, ground nut cake, copra, cottonseed cake, maize and other grains, Brazil nuts, filberts and pistachio nuts) has already been adversely affected by aflatoxin regulation. Yet increased regulatory activity is expected. Producer countries expecting to remain competitive in international trade will have to introduce some form of aflatoxin surveillance activity to protect trade in exported commodities.

1.3 The above facts and generalizations suggest several approaches that food control authorities may take to enter into surveillance activities. The steps include definition of objectives for control of aflatoxin and of measures to meet such objectives; establishment of limits in food and feed for aflatoxins or other mycotoxins shown to warrant protective action; design and implementation of aflatoxin (mycotoxin) surveys; and finally aflatoxin (mycotoxin) regulatory surveillance programmes.

2. NEED AND INCENTIVES FOR MYCOTOXIN SURVEILLANCE AS PART OF FOOD CONTROL PROGRAMMES

2.1 The aflatoxin problem most clearly demonstrates. for the reasons set forth in paragraph 1.1 , why surveys should be mounted and surveillance initiated where needed. Failure to do so is undesirable from the standpoint of human and animal health and productivity, and is economically counter-productive.

2.2 Incentives to action can derive from two sources: a) the conviction of food regulatory authorities that control of mycotoxins is important to human and animal health and productivity; and b) the rejection of commodities offered for export.

2.2.1 The first source will not generate much action unless and until the basis of such a conviction is documented more substantially than it is now. An education programme would be needed, preferably at the international level, to lay this documentation before individual governments. Such an education programme would be of little value unless it also included possible approaches or solutions to the problem.

2.2.2 The second source has already served as an incentive to surveillance activities in some countries. Rejection of export crops by other countries can be a very strong incentive to action, yet few countries so far appear to have been affected to the point where national surveillance programmes are begun. It may be valuable for international organizations such as FAO to be ready to offer technical aid in setting up export inspection systems to producing countries suffering rejection of export crops. Experience suggests that direct contact among experts is one effective approach to the development of programmes to control the export quality of commodities. Clearly, however, where such a need arises, governments also have an obligation to see that domestic consumers will benefit from control activities.

3. ESTABLISHING AND STRENGTHENING MYCOTOXIN SURVEILLANCE — A GRADUAL APPROACH

3.1 Government planners would need to be informed thai it is entirely feasible, even desirable, to enter into aflatoxin surveillance and control with modest resources. By proceeding gradually, in stages, building on the experience gained at each stage, progress from one stage to the next can be made at a rate commensurate with the resources available and the severity of the problem. Food control authorities may be less reluctant to establish mycotoxin surveillance programmes if they can be made to recognize that a stepwise approach, less than all-

encompassing in the early stages, can be meaningful and effective.

3.2 Entry into a programme must begin with establishment of food control laboratories, (if none already exists) and the training of inspectors and analysts in the principles and practices of sampling, sample preparation and mycotoxin analysis. The need for the development of technical competence is obvious. The training activities called for to meet this need may be more effectively carried out in permanent training centres devoted to training in all types of food control analysis.

3.3 The following stages leading to a mycotoxins surveillance programme can be identified.

Stage I:

- Establish the technical skills necessary to implement a surveillance and control programme (see paragraph 3.2).

Stage II:

- Test selected imported commodities for aflatoxin contamination.
- Test selected export commodities before they leave the country.
- Conduct a survey to determine the incidence and level of occurrence of aflatoxin contamination in selected foods moving in domestic commerce.
- Evaluate the information obtained.

Stage III:

- Establish and enforce specific aflatoxin regulatory programmes, directed at those commodities determined to be of significant concern (Stage II, last item).

Stage IV:

- Increase analytical capability, increase laboratory facilities to cope with the programmes of Stage III.
- Establish modest research and limited surveillance programmes to determine whether mycotoxins other than aflatoxins occur in any important foods or feeds.

Stage V:

- Expand import and export testing programmes to cover all products susceptible to aflatoxin contamination.
- Expand domestic surveillance of human food to include all commodities known to be susceptible to contamination and that are important in domestic commerce.
- Expand domestic surveillance for aflatoxin in other foods and feeds not now known to be susceptible to contamination but which should be examined because of their importance in the life and economy of the country.

Stage VI:

- Develop surveillance of other mycotoxins in stages, as above.
- Continue aflatoxin regulatory programmes to ensure that all susceptible foods and feeds moving in commerce are in compliance with regulations.

3.4 All of the activities suggested under Stage II can be conducted with modest resources and without seriously affecting domestic commerce. Regulatory controls should normally not be instituted at this early stage, but only after survey analytical data have been accumulated (see paragraph 6.3). Aflatoxin limits can be usefully imposed at Stage II for export crops, to prevent economic losses due to rejection, but in most cases not for imported or domestic commodities. To set limits for export commodities, a knowledge of the aflatoxin restrictions imposed by importing countries is necessary. Thus, Stage II activities should present few barriers to countries that have no aflatoxin control programme but recognize the need to get started.

3.5 Initial regulation at Stage II should be focused on food rather than feed. This is a major step. It requires that food lots found to be contaminated above established limits be diverted to feed or sometimes even to non-feed uses, or if imported, be prohibited from entry. Thus to move to Stage III requires a willingness to act officially on the basis of analytical findings and an operational plan to minimize food losses. However, if the groundwork has been carefully laid out in Stages I and II and aflatoxin enforcement limits have been set on the basis of the information collected then the move to Stage III should present only minimum difficulty.

3.6 The move to Stage III is necessary because without it the institution of these programmes will have little effect. Regulation not only protects consumers but will also set in motion other control programmes that should, in the end, minimize the need for regulatory actions. Countries that have had to develop export control operations may find the transition from Stage II to Stage III less difficult, because they are already conducting some form of regulation.

3.7 At Stage IV, technical skills and laboratory facilities are increased and some investigational programmes on other mycotoxins are initiated. At Stage V the aflatoxin regulatory programmes are expanded to cover all commodities known to be susceptible to aflatoxin contamination. This activity is a more comprehensive version of the Stage III programme; its development is strictly dependent on the availability of resources. General surveillance of commodities continues at this Stage to determine the need to introduce regulatory controls. The final Stage VI completes the regulatory control of the aflatoxin problem and begins the control of other mycotoxins, where warranted.

4. THE PROBLEM OF LIMITS

4.1 Specific single aflatoxin limits or tolerances cannot be proposed *a priori*. Instead of a single limit, the definition of three distinct and general categories of food and feed usage is recommended, each with its own acceptable level of contamination. The premises upon which this approach rest are: a) some degree of aflatoxin contamination is unavoidable everywhere, and b) in many ways, the institution and enforcement of regulatory controls can be more important than the specific aflatoxin limits in themselves.

4.2 Three categories of usage can be proposed:

I. Commodity intended for direct human consumption.

II. Commodity intended for use as a ration of dairy cattle and other animals used for milk, and for starter rations.

III. Commodity intended as feed for all other livestock and poultry.

The aflatoxin limits are lowest in category I, intermediate in II and highest in III. A commodity exceeding the highest limit would be diverted to non-feed uses or possibly destroyed.

4.3 The information needed to establish these limits derives from health effects of the aflatoxins in humans and animals, the effects of enforcement on food/feed availability, and to the quantitative relationships between the level of aflatoxins in animal feed and the resulting residue levels in edible animal tissues, milk and eggs. (Information on the health effects of aflatoxins is not discussed in this paper; appropriate sources will have to be consulted for guidance.)

4.4 Establishment of appropriate aflatoxin limits is dependent on the availability of survey analytical data on the occurrence of aflatoxins in foods and feeds. These data will allow an estimate of the effects of enforcement on the availability of food including animal products, and of feed. It is for this reason that surveys are necessary before regulatory enforcement is initiated.

4.5 The usefulness of having three categories for aflatoxin limits will be put in question if systems can not be devised and operated to ensure that susceptible commodities are examined for aflatoxin and that contaminated products are channelled into those food or feed uses appropriate to the degree of contamination observed. The value of this approach is that it provides the greatest protection where it is needed most (human food), and at the same time provides useful outlets for the disposal of all but the most highly contaminated products. Food and feed losses are thus minimized. It may be, however, that a rather more sophisticated food distribution and surveillance system is required to ensure that the necessary channelling takes place than is available in many countries. This point warrants a great deal of thought and discussion.

5. CHOICE OF COMMODITIES FOR MYCOTOXIN SURVEYS

5.1 As indicated at Stage II, activities should start with a testing programme, with limited surveys. Such surveys should be directed initially at those commodities which, based on the experience of countries with established surveillance, are known to be susceptible to contamination. The assumption is that such an approach makes best use of resources. In-depth surveys can thus cover the few commodities known to be important rather than a large number of commodities of unknown susceptibility. Commodities shown to be susceptible in some countries or circumstances include groundnuts, cottonseed, coconuts, sunflower seeds and their various products, maize, rice, other grains, tree nuts, and dried fruits. Each of these commodities is assigned to appropriate food or feed usage category. For milk, dairy products, eggs and meat, the limits are controlled by setting limits on the feed.

5.2 The decision as to which susceptible commodities should be examined, and in what sequence and depth, rests ultimately with the regulatory authorities of individual countries. Decisions must also be made whether or not to examine commodities for which no information is available but which are important to the life and economy of the nation.

The point bears repeating, however, that intensive investigation initially of a few selected commodities will provide better information upon which regulatory limits can be established. The more quickly and reliably appropriate limits can be established, the more quickly can regulatory activity begin. Rapid movement to regulation, even if directed at only one commodity, is desirable since other more critical control activities will be set in motion only when regulation is in effect.

6. PROBLEMS OF SURVEYS AND USE OF THE DATA

6.1 Several problems arise in the planning and conduct of surveys and the evaluation of analytical data. The most important of these problems by far is that of lot sampling. Whether food lots are sampled before export, at import, or while they are moving in domestic commerce, the acquisition of representative lot samples is one of the most difficult tasks of a survey and, in some instances, an appreciable part of its cost. Sampling plans developed by IUPAC for groundnuts[1] can be recommended as the basis for establishing lot sampling plans for similar commodities. These call for relatively large lot sample sizes; smaller samples will suffice for commodities expected to have greater homogeneity of contamination. Certain practical considerations may also suggest that lot sample sizes for survey purposes can be smaller than those that may ultimately be required for regulatory purposes. One of the significant gaps in our knowledge is inadequate lot sampling for different commodities as part of survey or surveillance activities. One approach would be to organize an international team of experts to confer on the subject of sampling total production as well as lots for aflatoxin surveys or surveillance and to make specific recommendations for sampling the various susceptible commodities. Additionally this same group could be charged with defining research projects that will be necessary to complete our knowledge of this subject. Food control authorities must be persuaded that adequate lot sampling is necessary if such activities are to have any meaning. The natural tendency to reduce lot sample sizes for convenience and economy must be seen as potentially dangerous because highly misleading data may be generated. These aspects deserve further consideration and discussion.

6.2 Less important perhaps than the problem of lot sampling, but also in need of further definition, is the question of the number of samples of any one commodity that can be taken as being representative of the production of a specific area or country. Limited resources usually dictate the number of samples that can be examined in a survey. An attempt should be made to determine the degree to which these samples represent total production. Statistical survey design that takes into account production data, year-to-year variation, etc., is obviously indispensable, but further guidance and general agreement seem needed also in this area.

6.3 Certainly the most sensitive problem that arises is that of interpreting and acting on the analytical results of aflatoxin surveys. A survey will reveal whether an aflatoxin problem exists, how large it is, and perhaps provide some information on the regional and year-to-year variations. Regulatory discretion then enters: whether or not to use this information to establish enforcement limits and to give direction to future regulatory programmes as well as follow-up activity on products derived from the commodities surveyed. For example, a survey may show that aflatoxin contamination of maize grown in some areas occurs at exceedingly high levels and rates. Uncovering such a situation would create an enormous dilemma for food control officials. Yet it may be possible to set limits for different categories of use of a commodity (see paragraph 4.2) even though these limits may have to be considerably higher than those enforced by some countries now regulating aflatoxin contamination. Regulatory programmes will have to be designed to ensure minimum or even no loss of food by seeing to the proper channelling of contaminated materials. The major goal would be to ensure that humans receive the lowest possible level and frequency of exposure.

6.4 If contamination is so severe that it appears that human health cannot be well protected even when the channelling programme is in operation, then the effectiveness of regulatory surveillance as a control mechanism is considerably reduced. Prevention of

1/ Technical Report No. 10, International Union of Pure and Applied Chemistry, 1974.

contamination then becomes central to control. It may be useful to have international organizations such as FAO and WHO specify the conditions under which emergency action to control contamination and exposure should be taken, what this action should be, and how it could be undertaken effectively and expeditiously.

7. PASSING FROM SURVEYS TO SURVEILLANCE

The movement toward regulation, as discussed earlier, is made when the government of a country is prepared to enforce specific limits. Regulatory surveillance has problems almost identical to those discussed previously for surveys designed to gather data and so will not be repeated. One source of confusion which international action and cooperation can help eliminate is that stemming from the failure of parties involved in food trade to agree on uniform plans of lot sampling for regulatory purposes. Without such an agreement an exporting country is at a definite disadvantage. The Codex Alimentarius Commission may be a useful forum for arriving at agreement concerning sampling plans for export trade.

8. QUALITY CONTROL: A GOVERNMENT-PRODUCER INTERFACE

It is recognized that surveillance is only one aspect of control of aflatoxins . Another, very crucial part is to elicit producer cooperation in controlling aflatoxin problems. An integrated, multi-component control system will need to be developed with built-in options for the proper channelling of contaminated materials at critical control points. Specific "national quality control" schemes must be designed and educational programmes mounted to show producers and middlemen how sampling and analysis can be used at different points in the marketing and processing of groundnuts, maize, tree nuts and fabricated weaning and infant foods in order to guide the proper channelling of contaminated materials and to ensure that finished products meet prescribed limits.

9. MYCOTOXINS OTHER THAN AFLATOXINS

9.1 Compared with aflatoxins, far less is known about the occurrence in foods and feeds of citrinin, ochratoxin, patulin, penicillic acid, sterigmatocystin, T-2 toxin and zearalenone. All are known however to be environmental contaminants, and all are undergoing toxicological or epidemiological investigation. The development of guidelines or suggested tolerance limits for some of these toxins is expected to be completed in several countries before the end of the decade. Problems similar to those now associated with aflatoxin are certain to arise.

9.2 Prudence therefore suggests that a modest research and survey programme be initiated at Stage IV (see paragraph 3.3) to determine whether any of these toxins present problems. A review of available information together with knowledge of local agricultural and food handling practices should provide guidance for the development of projects relevant to needs.

9.3 Consultation with local veterinary and medical authorities can help to pinpoint diseases of unknown origin for which a mycotoxin involvement may be hypothesized. Similarly, international bodies such as WHO and FAO might assemble information on diseases of humans and animals that are of unknown origin and identify those for which a mycotoxin hypothesis may be warranted. Such work including investigations are needed before one can begin to estimate the extent to which mycotoxins contribute to disease. In turn clear identification of mycotoxin-induced diseases can provide the greatest possible incentive for the initiation of survey and regulatory control activities.

10. GUIDELINES

Guidelines have been prepared for participants in this Conference, which deals in greater depth with many of the concepts and problems included in this paper. Reference should be made to this document "Mycotoxins Surveillance — A Guideline" as an aid to fuller understanding and the discussion of approaches to reduce risk of contamination by mycotoxins through surveillance and control measures.

ANNEX VIII

FOOD AND AGRICULTURE ORGANIZATION
OF THE UNITED NATIONS - Rome

WORLD HEALTH ORGANIZATION
Geneva

UNITED NATIONS ENVIRONMENT
PROGRAMME - Nairobi

Agenda Item 8

MYC-8

JOINT FAO/WHO/UNEP CONFERENCE ON MYCOTOXINS

Nairobi, Kenya, 19-27 September 1977

EXTENSION AT NATIONAL LEVELS TO SOLVE PROBLEMS OF CONTAMINATION BY MYCOTOXINS

SUMMARY

This document discusses means for extending information on the prevention and control of mycotoxins in food and feeds to all segments of the population ranging from the farmer to the consumer. Emphasis is placed on the role of national and local institutions including agricultural extension and community health and welfare services, farm and trade organizations, schools, governmental agencies and the mass media.

The valuable assistance of Prof. J.W. Dickens, USDA, Agricultural Research Service, Southern Region, North Carolina State University, and Dr. F.R. Senti, USA, in the preparation of this document is gratefully acknowledged.

EXTENSION AT NATIONAL LEVELS TO SOLVE PROBLEMS OF CONTAMINATION BY MYCOTOXINS

1. BACKGROUND

Although mould in foods and feeds have long been recognized as generally undesirable, it is only recently that their serious effects on man and animals have been recognized. Mycotoxi present in many mouldy food and feedstuffs have been demonstrated to cause sickness and death in farm animals and also in humans. At lower levels they may not cause overt signs of illness but experiments and practical experience have shown that they can cause reduced growth rate in young animals, lowered feed efficiency, depressed egg production in poultry and lowered resistance to infectious disease.

Considerable information has been developed concerning the conditions that lead to mould growth and mycotoxin contamination at the various stages of growing, harvesting and storage of crops on the farm, and on the practices that can be followed to avoid or minimize contamination. There is also information on the levels of mycotoxins in feeds that can be safely fed to different farm animals. Safe storage and handling practices for the storage and transport of agricultural commodities by commercial buyers and distributors are known. Precautions to take in the selection of foodstuffs by the housewife in order to minimize mycotoxin risk,and to be exercised in the storage of prepared foods, also are known. These are the kinds of information that need to be more widely disseminated and made use of to protect human and animal health and avoid food losses in the developing countries. In order to be applied the information must be communicated to the potential users in an effective fashion. While it should not be the intention to alarm the general population unnecessarily, national authorities must ensure that both the producer and the consumer are provided adequate information about the hazards of mycotoxins in the national food supply and the means available to prevent or control such hazards and the resultant economic losses.

2. MEANS FOR EXTENSION OF INFORMATION

In brief outline, the following institutions can be effectively utilized in extending information on mycotoxins to potential users:

a) Agricultural extension service

Many countries now have this service staffed with agronomists and other professionals who advise the farmer at grass root level on cultural practices for improving crop yields. With additional training, these agents also could instruct the farmer in practices that would minimize mycotoxin contamination in harvesting and particularly in storage of crops.

To be effective, the extension agent must have direct and frequent contact with the farmers in the area he serves. The extension system must provide for communicating to the agent the most recent information on potential hazards of mycotoxins and on improved practices for mycotoxin control at regular intervals. In some countries this is accomplished by having a mycotoxin expert at the state level who channels information to the extension agents that serve at the local or district level and are in direct contact with the farmers.

b) Home demonstration agents, community workers

In some countries these agents are part of the agricultural extension service. In others they may be attached to departments of public health or to autonomous councils or commissions concerned with food and nutrition matters. Wherever placed, the function of such agents is to instruct primarily farm or rural families in matters relating to food, food preparation, food preservation, nutrition, mother-child care, sanitation and hygiene or matters relating to family welfare. They provide an excellent means for instructing families concerning the hazards of moulds in foods and ways to avoid them.

c) Farm organizations

The services of farm organizations such as cooperatives organized in the farmers interest for the buying of farm supplies for agricultural operations or selling of farm commodities can also be enlisted for carrying information to the farmer on mycotoxins. These organizations become particularly concerned and effective in communicating mycotoxin information if grade standards are set that place a discount on mouldy farm products. They must be supplied information from a reliable source and in a form usable to the farmer and commodity handlers. Agricultural marketing services, agricultural colleges, state and local extension agents are possible sources of this information.

d) Industry and trade organizations

Grain millers, oilseed crushers, grain handlers, storage operators, food and feed processors and similar commodity groups often form industry or trade associations in order to meet problems of common interest more effectively. Within an overall national programme for the protection and control of food supplies mycotoxin-contaminated commodities present problems to members of each of them. The association provides an effective instrument for extending pertinent information on methods for detecting and segregating and disposal of contaminated commodities, processing techniques for reducing contamination, and practices for preventing mould growth in their storage and transport facilities. Industry or trade associations respond quickly to regulatory control and the governmental regulatory agency can have an important role in extending information to them.

e) Schools, teachers training institutes, health services

These institutions provide channels for reaching the urban consumer and the general public on the hazards of mycotoxins. To do so, appropriate information must be incorporated into the school curricula and health programmes.

f) Radio and television

The wide distribution of radios and the increasing number of televion sets in community centers in the developing countries provide an economical and effective means for reaching a large number of people, ranging from the farmer to the consumer. Information tailored to meet farm needs can be presented on existing farm programmes and programmes on food and health can be designed to reach the housewife and general consumer. TV affords a medium for visual demonstration of many aspects of effective mould prevention and control such as improved storage structures, postharvest drying methods, protection and handling of prepared foods and the like.

3. REACHING THE FARMER

Since toxicogenic moulds may grow on food crops before harvest and during harvesting, handling, drying, and farm storage, it is imperative that farmers be encouraged to reduce the risk of mycotoxin contamination. Fortunately, many practices which reduce the risk of mycotoxin contamination also increase crop yields and protect against crop losses. Although many moulds may not produce mycotoxins, the farmer should be encouraged to prevent all damage whenever possible and to remove mouldy products at every opportunity.

Agricultural extension workers are in an excellent position to educate farmers about potential risks of fungal contamination of crops to man and animal and should practice prevention and control measures for mycotoxins. These workers have special training in education techniques for the rural population they are concerned with, they have established rapport with the farmers, and they are familiar with agricultural practices in their geographical area. Their basic knowledge about climate, irrigation, use of pesticides, disease

control, crop harvesting, crop drying, crop storage, and other good agricultural and animal husbandry practices will facilitate their training in the principles of mycotoxin control and the transfer of this information to the farmers. Many post harvest operations in developing countries are carried out by women. Special attention needs to be given to educate them about the risks of mycotoxin contamination and the means for their prevention and control. If the equivalent of a good agricultural extension service does not exist in a country, development of such a group of agri ltural educators is highly recommended as a means to increase agricultural production and improve the standard of living in rural areas.

4. REACHING THE "MIDDLEMEN"

People or organizations (marketing boards, etc.) who buy produce directly from the farmers and accumulate large lots for further distribution should be educated about the mycotoxin problem. They are usually in a much better position than anyone else to segregate lots of mouldy product from lots of non-mouldy product as they are received from the farmers. In addition, price discrimination against mouldy products will encourage the farmer to avoid mould damage. A word of caution is required here to see that the farmer is not exploited on this score. It is often necessary to use the mechanism of regulated markets to ensure fair play. Knowledgeable middlemen and regulated market functionaires can perform an important educational function as they deal with farmers. Since known analytical tests for mycotoxins probably are not applicable at this level of the production system, it appears that grade standards and pricing will have to discriminate against moulding and high moisture rather than against specific mycotoxin contamination. Discount for moisture content should primarily reflect the cost of drying to a safe storage level. However, moisture content plays a critical role in the development of fungal contamination and rapid drying to safe moisture levels should be encouraged at harvest and at any other point in the marketing system where high moisture produce is encountered.

Middlemen also engage in transportation and storage of large lots of agricultural produce. Mould growth often occurs during transportation and storage due to inadequate protection of the products from rain, moisture condensation, insect infestation, rodents and other causes of moulding. Due to blending procedures and grade tolerances, where the latter exist, very little economic penalty has been incurred by most middlemen; so they have failed to place proper emphasis on reducing the amount of moulding which has occurred. General ignorance of conditions that favor mould damage also has contributed to the problem. Control of the mycotoxin problem will require examination of all practices in the transportation, storage and marketing system and correction of those practices which allow moulding.

Procedures to educate middlemen in good agricultural production and marketing practices are less clear than for the farmer or the processor. Middlemen will be forced to recognize the concern about mycotoxins expressed by their customers, the processors or the consumers, or even more effectively by regulatory agencies. In cases where industry organizations exist, such as associations of oil millers, roller millers, or grain handlers, these can provide a means for extending information on mycotoxins from governmental agencies, agricultural colleges and the like. Another source of information is the agricultural extension agent, since most grain/oil seed buyers and handlers deal directly with the farmer or their co-operatives. In those cases where more technical knowledge is required, the extension worker can refer the middlemen to agricultural universities or to other sources of information. After training, the middlemen can provide valuable assistance to the extension worker by helping educate the farmer about the control of moulds and mycotoxins.

5. REACHING THE PROCESSOR

Processors often have an opportunity to divert lots of mycotoxin-contaminated produce to non-food uses, to remove mycotoxin-contaminated kernels from the lots during processing, to extract mycotoxins from contaminated products with solvents, or to destroy mycotoxins in the products with chemical or physical treatments. An adequate quality control programme in conjunction with these processing techniques will help assure the consumer of safe food products. A vigilant quality control programme in regard to purchases of food

products by the processors will inturn encourage the use of careful production, handling and storage procedures by farmers and middlemen.

A comprehensive governmental programme of surveillance and control of food products which go directly to the consumer is considered essential and will encourage processors to employ methods to prevent mycotoxin contamination of their products. Seminars, workshops and conferences sponsored by regulatory agencies, public health agencies or industry and trade groups, can serve to educate processors about ways to prevent and control mycotoxin problems. Normally, it is advisable to give highest priority to training of those in managerial or supervisory positions. Once management recognizes the economic costs and health risks associated with the mycotoxin problem they will probably arrange for necessary quality control programmes and training of employees.

6. REACHING THE CONSUMER

In developing countries a high percentage of the consumers consists of either subsistance farmers or landless workers in rural areas. In theory, these consumers have an opportunity to reduce mycotoxin contamination in their food by careful production harvesting, drying, handling and storage to prevent moulding and by careful sorting to remove that portion of the crop that inadvertently becomes mouldy. However, people who eat locally produced food do not benefit from quality control programmes of industry or even of regulatory agencies. If they are not properly educated concerning the dangers of mouldy food or if they fail to heed the warning, they may consume food that is highly contaminated with mycotoxins. This obviously offers the biggest challenge to national authorities. The economic lot of these consumers further aggravates the situation.

Since these consumers of local produce are located in rural areas all state agencies, extension agents, community workers and welfare organizations concerned with agricultural development have a responsibility to educate this group of consumers. Education of women and children needs special emphasis so that the consumption of such contaminated goods is avoided and food losses are reduced. Storage at the farm or household level would call for attention. Economic support for improved storage structures, even though limited, would go a long way in getting the message accepted.

In countries with good food control programmes, consumers in urban areas would generally benefit from surveillance and control for mycotoxins in food and also from processing techniques designed to remove mycotoxins from food. However, processing and blending operations may conceal evidence of mould from the consumers; so in many cases they must rely upon tests by government regulatory agencies to insure the safety of their foods. Since some foods are not processed and some may mould in the home after processing, the urban consumer should be warned to discard mouldy food. Also, education about the danger of mycotoxins will increase public support for regulatory agencies concerned with food control.

Properly trained public school teachers, public health workers, personnel of food control agencies and other appropriate personnel may be used to educate the urban consumer. Mass media may also be used to make the consumer aware of the mycotoxin problem.

7. GENERAL EDUCATION OF THE PUBLIC

In order to provide maximum protection from mycotoxins, the general public must be informed about the health risk associated with the consumption of even small amounts of some mycotoxins. Such education will be made difficult by the insidious nature of many types of mycotoxicoses, since a direct cause and effect relationship between consumption of mycotoxins and subsequent illness is not readily apparent. Control of the mycotoxin problem is further complicated by the lack of practical methods to test for mycotoxins in small lots of food at the farm or at the consumer level. As a result, the public must be taught that even small amounts of mould growth can produce dangerous quqntities of mycotoxins, that all mouldy foods should be avoided, and that special care should be taken to remove all mouldy and discolored kernels from grains, oilseeds, and treenuts.

Danger of mycotoxin contamination in food exists from the time the crop is grown on the farm until the final food product is consumed. No practical method has been developed that would always prevent mycotoxin contamination of food crops or that would completely remove mycotoxin contamination from the final food products. Instead, a general programme must be used to prevent and remove mycotoxin contamination, whenever practical, throughout the production system from the farm to the consumer. Such a comprehensive programme requires a general public awareness of the dangers of mycotoxins and methods for its control. Public awareness of the problem will encourage support for government surveillance and control programmes for mycotoxins and exert pressure on each sector of food production, distribution and processing to employ practices which will reduce risk from mycotoxins.

Health protection of consumers, maintainance of animal productivity as well as tremendous savings of food can be achieved if the entire food industry, from the farmer to the final consumer, protects foods against insects, rodents, moulds and other factors which contribute to or cause mycotoxin contamination. The responsibility for such education should be shared by organizations such as schools, technical institutes, colleges and universities, teacher training institutes, health education and agricultural marketing agencies, agricultural extension services, consumer groups, and other private and government agencies. Innovative approaches are needed to cause people to change traditional practices which allow mould growth in food products and to change traditional food habits which may even encourage consumption of mouldy food. It probably will be best to work through established village or tribal leaders or through cooperatives, unions or similar local organizations. Such leaders, even when they are illiterate, may be more effective than trained specialists who are not so well acquainted with local attitudes and practices or who cannot gain the trust of the people.

8. INCENTIVES FOR REMOVAL OF MOULD CONTAMINATION

One of the most effective methods for reducing mycotoxins in the food supply is to encourage diversion of mouldy grain and oilseeds to non-food uses or to processing industries that recover one or more mycotoxin free products. Some economic incentive is necessary to encourage prevention and control of moulds, but too severe penalty may in fact lead to exploitation of the farmer or even be counter productive. When alternative markets do not exist for the mouldy product or if the price is much less than for non-mouldy products there is a large economic incentive to blend the mouldy product with the non-mouldy product so it can be marketed for food uses. In other cases, farmers with meagre income may be forced to retain the unmarketable, mouldy portion of this crop for his own food.

Education about the necessity to remove mouldy product from food channels will be far more effective if suitable alternative markets are developed for these products. Programmes of surveillance and control cannot effectively detect and remove lots with high concentrations of mycotoxins if they have been blended with other lots, or if the contaminated lots do not enter commercial channels of trade. When this happens, all the mycotoxin contaminated food continues to be consumed. Therefore, an education programme should stress alternative markets or uses for mouldy products. If these markets or uses are not available they should be developed. In some cases government subsidy may be necessary to encourage adoption of better drying and storage facilities by the farmer as well as diversion of mouldy product to acceptable uses.

9. PRIORITIES

Educational programmes are far more effective when specific, concise information is involved. Unfortunately, knowledge about many of the mycotoxins and their health significance is extremely vague. Aflatoxin is probably the best known mycotoxin, and considerable effort has been devoted to the development of methods for its prevention and control. Aflatoxin is often found in groundnuts, maize, cottonseed, pistachio nuts, and Brazil nuts. Other grains, treenuts and oilseeds may also be affected. It is therefore recommended that the initial educational efforts concentrate on aflatoxin in grains, oilseeds and treenuts. Surveys of local or traditional foods may bring out other potentially susceptible products or practices which would call for further educational efforts at the appropriate level.

ANNEX

FOOD AND AGRICULTURE ORGANIZATION
OF THE UNITED NATIONS - Rome

WORLD HEALTH ORGANIZATION
Geneva

UNITED NATIONS ENVIRONMENT
PROGRAMME - Nairobi

Agenda Item 9

MYC-9

JOINT FAO/WHO/UNEP CONFERENCE ON MYCOTOXINS

Nairobi, Kenya, 19-27 September 1977

PRIORITIES FOR RESEARCH AND TRAINING IN THE FIELD OF MYCOTOXINS

S U M M A R Y

This document outlines some of the priorities for research and training in the field of mycotoxins. Eight major areas are defined where further research is required with emphasis placed on aflatoxin. Training needs are indicated. The meeting of training needs is urgent for developing reliable information, e.g. through surveys, for introducing effective food control measures to deal with mycotoxin problems, and for prevention through extension activities.

W/G5533

PRIORITIES FOR RESEARCH AND TRAINING IN THE FIELD OF MYCOTOXINS

1. INTRODUCTION

1.1 Priorities for research and training in the field of mycotoxins in any country depend on the status of the research and control programmes that have been initiated, and the information that has been developed on the mycotoxin problem as it exists in that country. Considerable information on several mycotoxins has been reported in the technical literature that is widely applicable and obviously should be used to maximum extent. However, much research remains to be done to define the full ramifications of the mycotoxin problem and its effective control. This statement applies not only to the mycotoxins that have been found to have significant occurrence in foods and feeds but also to toxins known to be produced by moulds that occur in agricultural produce, but so far have not been surveyed for incidence.

1.2 Eight major research areas can be identified in the field of mycotoxins:

(i) Surveys to establish incidence and sites of occurrence of mycotoxins.

(ii) Design of sampling plans that will provide representative samples of lots of contaminated commodities.

(iii) Development of measures that can be applied to prevent the occurrence of mycotoxins in foods and feeds.

(iv) Development of new or improved processes for decontamination of commodities by removal of contaminated kernels.

(v) Development of chemical or solvent extraction methods for detoxification of contaminated products, particularly for mycotoxins other than aflatoxin.

(vi) Investigation of the adverse effects of feeds contaminated with mycotoxins on animal health and productivity and wholesomeness of animal products.

(vii) Mycotoxins in the food supply as related to human health.

(viii) Development of improved analytical methodology and detection methods.

1.3 In addition, research has an important role in the support of two activities that are essential to the elimination or reduction of mycotoxins in food and feeds. These are: (1) surveillance and control, and (2) extension and educational programmes. Research provides the former with analytical methods for detection and measurement of mycotoxins and the latter programmes with the factual information on mycotoxins that comprises the substance of these programmes.

1.4 To carry out these research, control and educational activities, professionals and technicians trained in a number of disciplines are required. In the discussion that follows, specific research activities and training needs will be identified for the areas listed above.

2. SURVEYS TO ESTABLISH INCIDENCE AND SITES OF OCCURRENCE OF MYCOTOXINS

2.1 The first step in the initiation of a mycotoxin programme is to establish the incidence and sites of occurrence of the mycotoxin. The outlines for such surveys have been given in Conference Document "Mycotoxin Surveillance - A Guideline" and discussed in Conference Document MYC-7, which deals with surveillance and control measures. The relatively high incidence of aflatoxin in warmer areas of temperate regions and in sub-tropical and tropical climates, and that of zearalenone and ochratoxin in cooler areas of the temperate regions suggest these mycotoxins for survey in countries with similar climates.

2.2 Decisions based on the evidence of mouldy crops must also be made on the site from which samples are to be collected. Experience has shown that aflatoxin contamination can occur in the field before harvest, during post-harvest drying, in farm and commercial storage, during marketing/distribution and in the home.

2.3 Further research is needed to determine the extent to which mycotoxins, in addition to aflatoxins, are formed in susceptible crops prior to harvest. There is evidence that zearalenone occurs in maize prior to harvest, but no extensive survey of maize samples collected at harvest has been conducted to determine the importance of its in-field contamination. Similarly, ochratoxin frequently occurs in barley grown in cool, rainy seasons in certain regions but it has not been determined whether toxin formation occurs in the field or after storage. The same statement applies to the trichothecenes and most other toxins.

3. DESIGN OF SAMPLING PLANS THAT WILL PROVIDE REPRESENTATIVE SAMPLES OF LOTS OF CONTAMINATED COMMODITIES.

3.1 The number and site of collection of subsamples that should be collected to obtain a representative sample of a lot of grain, oilseed or treenuts under examination is one of the most difficult parts of an analysis for mycotoxin content. In the case of aflatoxin, it has been determined that relatively few of the kernels of groundnuts and maize carry most of the aflatoxin. These kernels may not be uniformly distributed throughout the lot. The only scientifically based plan for obtaining representative samples of lots of food or feed is that which has been developed for shelled groundnuts. This is described in I.U.P.A.C. Information Bulletin, Technical Report, No. 10 (1974), "Development of a Method to Evaluate Sampling Plans Used to Estimate Aflatoxin Concentrations in Lots of Shelled Peanuts".

3.2 Research is needed on the distribution characteristics of aflatoxin in other commodities as a basis for the design of statistically valid sampling plans. Such plans are essential in reducing sampling error as a possible major source of variance in analytical results obtained by buyer and seller of a given lot of produce. The same statement applies to sampling plans in the analysis for other mycotoxins.

4. DEVELOPMENT OF MEASURES THAT MAY BE APPLIED TO PREVENT THE OCCURRENCE OF MYCOTOXINS IN FOODS AND FEEDS.

4.1 Research on storage

4.1.1 Much research has been conducted on the conditions necessary to prevent mould growth during storage of agricultural commodities. Several reference works are available on this subject. Research is needed, however, on ways to apply the principles that have been developed for appropriate storage practices in various countries. Such revalidation is extremely important if optimal conditions for storage are to be determined in respect of the environmental conditions of the country or group of countries concerned. This is a particularly vital area for work in many developing countries since mould infestation in storage occurs frequently and causes considerable loss from overt damage alone. To this must be added the losses incurred from market rejections and sickness in animals and humans resulting from mycotoxin contamination.

4.2 Research on the development of improved post-harvest drying practices

4.2.1 Mould growth and aflatoxin contamination have been demonstrated to occur during the drying of crops that are harvested at high moisture levels, especially in the

developing countries which are dependent upon sun-drying, even in unfavourable climatic conditions. Grains, oilseeds and other produce need to be dried quickly to safe moisture levels to prevent mould growth and mycotoxin formation. Groundnuts, maize, copra and cassava are particularly susceptible commodities. Drying with artificial heat is a technically feasible solution that has been widely practised in industrialized countries. It has, however, greatly increased in cost with recent rises in prices of fuels. Thus research on alternate methods and improved practices of post-harvest drying is now an area of importance to both industrialized and developing countries.

4.3 Methods for prevention of in-field mycotoxin contamination

4.3.1 In-field aflatoxin formation has been demonstrated to occur in groundnuts, maize, cottonseed, pistachio nuts and almonds; zearalenone contamination has been found in maize prior to harvest. The importance of the production of other mycotoxins, such as ochratoxin and the trichothecene toxins by mould infections in the field is yet to be determined by appropriate surveys.

4.3.2 In order to find methods for prevention of in-field mycotoxins development it is necessary to determine, for each crop, the ways in which pre-harvest contamination occurs. Once this is known, research is needed to find the most suitable means for preventing mycotoxin development.

4.3.3 Research approaches that may contribute to a solution include determination of environmental conditions that favour growth of the producing mould and toxin formation; effect of cultural practices; role of insect vectors; fungicidal control and development of resistant varieties.

4.3.4 In the search for resistant varieties, research efforts have demonstrated that strains of plants can be identified, through mass screening of collections of germ plasm from varieties of food grains and legumes, which are resistant to attack by a given fungus. In the case of aflatoxin, resistance may be of two kinds: (1) resistance of the seed (kernel) to attack by A. flavus and A. parasiticus, and (2) resistance to development of the mycotoxin by fungi which infect the grain. So far, the work done in this area has been very limited, and identifications have been made under one set of experimental conditions, but have not withstood the test of field trials, particularly when transferred from one country (U.S.) to another (India). In addition, resistance must be combined with good agricultural features of the plants in order to be of practical value. Further research is required, in this potentially promising area, to determine strains of plants which are resistant to the development not only of aflatoxin but also of other mycotoxins. When resistant strains are discovered they must be checked to ascertain also that the nutritive value of the crop is maintained.

4.3.5 Although not a solution to the problem, a significant contribution from research in this area would be the identification of climatic and other growing conditions that would be predictive of mycotoxin contamination at harvest. Farmers could then be warned of probable contamination in seasons in which these conditions prevailed. This would enable them to be better prepared to cope with the problem at harvest, analyzing the grain or other produce for mycotoxin, avoiding its consumption as food and limiting its use as feed for farm animals.

4.3.6 The importance of this research area to a particular country will depend on whether in-field contamination occurs under the growing conditions in that country. Even though contamination does occur at this site, priority for research may be greater in other areas because of their greater importance as sites of contamination. Surveys for mycotoxin incidence are needed to decide this question.

5. DEVELOPMENT OF NEW OR IMPROVED PROCESSES FOR DE-CONTAMINATION OF COMMODITIES BY REMOVAL OF CONTAMINATED KERNELS.

5.1 Although development and application of preventative measures are projects of high priority, some problems such as the prevention of in-field contamination of certain crops will likely require long-term research for solution. It also appears that circumstances such as unusual weather conditions, floods, etc., will arise, that will lead to unavoidable mycotoxin contamination. Even under the best conditions, foreseeable in the near future, some contamination appears probable and methods for de-contamination will be needed.

5.2 Physical techniques currently practised for reduction in aflatoxin content are screening to remove immature, shrivelled and broken kernels, weed seeds and foreign material, followed, in the case of groundnuts, by hand picking or electronic sorting. Air aspiration and flotation techniques have been used to remove kernels with ergot infection from wheat. For other commodities that have large kernels, research on improvements of current methods, or development of new methods for physical removal and segregation of aflatoxin-contaminated kernels may make these techniques more widely applicable.

6. DEVELOPMENT OF CHEMICAL OR SOLVENT EXTRACTION METHODS FOR DETOXIFICATION OF CONTAMINATED PRODUCTS, PARTICULARLY FOR MYCOTOXINS OTHER THAN AFLATOXIN.

6.1 Methods for physical segregation of contaminated kernels have limited applicability to commodities that have small kernels and do not apply to finely divided products such as oilseed cakes. For these products, as well as for the material rejected by screening, hand picking or electronic sorting, other methods of detoxification are needed. Ammoniation processes have been developed, or are in the final stages of development for the detoxification of groundnut cake, cottonseed and cottonseed cake and whole-kernel maize that are contaminated with aflatoxin. The treated oilcakes are intended for feed purposes. Hydrogen peroxide treatment is being practised for detoxification of groundnut protein isolates that are used as ingredients in human foods.

6.2 Solvent extraction methods have been developed for removal of aflatoxin from groundnut and cottonseed cakes, but have not been applied commercially. Solvent extraction has the advantage that the mycotoxin is removed thereby eliminating the possibility of toxicity from degradation or reaction products, but further research is required to find solvents which are cheap, readily available, efficient, do not leave toxic residues themselves and can be used repeatedly.

6.3 So far, research has been limited largely to aflatoxin and little work has been done on removal or chemical detoxification of commodities contaminated with other mycotoxins. Much research remains to be done in this area, both on improved processes for aflatoxin detoxification and on processes applicable to other mycotoxins. Particularly with a view to making them more economical, to come within the reach of co-operatives or small oil mills in developing countries.

7. INVESTIGATION OF THE ADVERSE EFFECTS OF FEEDS CONTAMINATED WITH MYCOTOXINS ON ANIMAL HEALTH, PRODUCTIVITY AND WHOLESOMENESS OF ANIMAL PRODUCTS.

7.1 The large livestock and poultry industries in many countries, increasing emphasis on animal feeds as an outlet for mycotoxin-contaminated produce rejected as human food and the possibilities of mycotoxin residues in meat, milk and other animal products are considerations that make this an important area for research.

7.2 Levels of mycotoxin in feed which cause growth depression, or other adverse effects in farm animals have been most extensively studied for aflatoxin; considerably less information is available for zearalenone, ochratoxin and T-2 toxin, and little or none for trichothecenes other than T-2 toxin, penicillic acid, citrinin and patulin. Further research is required on chronic toxicity studies which define the adverse effects at various levels of intake for the species of farm animals that may be exposed, and on the teratogenic and mutagenic effects of mycotoxins when administered orally to experimental animals. Carcinogenicity data on oral administration also is lacking or requires confirmation for all mycotoxins mentioned above except aflatoxin.

Possible synergism in the toxic effects of mycotoxins that occur together in naturally contaminated feedstuffs is another aspect of the mycotoxin problem about which little is known. Examples of mycotoxins that frequently occur together are citrinin and ochratoxin A, and zearalenone and deoxynivalenol.

8. MYCOTOXINS IN THE FOOD SUPPLY AS RELATED TO HUMAN HEALTH.

8.1 From the standpoint of human health, it is important to know the relationship between the concentration of mycotoxin in the rations fed to meat and dairy animals and poultry, and the concentration of mycotoxin or its animal metabolites that appear as residues in muscle, adipose and organ tissues or in milk and eggs. This feed/tissue ratio has been determined for aflatoxin in beef, swine, broiler muscle and organ tissues, cow milk and hen eggs. However, in view of the differences in feeds and feeding practices and possible breed differences in animals, these ratios may not be valid for all feeding situations and under all environmental situations. In the case of ochratoxin A, limited data are available for the feed/tissue ratio for swine. Little or no information is available on tissue residues in animals fed rations containing other mycotoxins.

8.2 Determination of the metabolic fate of mycotoxins in experimental animals and farm animals is another problem which merits research attention. The metabolic products which appear as tissue residues in farm animals are significant because of their possible toxicity. However, even in the case of aflatoxin, the most studied mycotoxin, only one metabolite has been determined in tissues for lack of adequate analytical methodology for the determination of other potential metabolites. Another aspect, also significant to human health, is the determination of the metabolites of carcinogenic mycotoxins that are produced in target organs of different animal species including sub-human primates. Elucidation is needed of their mode of intoxication thus providing a basis for estimating the susceptibility of humans to the mycotoxin.

8.3 The assessment of any relationship between mycotoxin consumption (exposure) and the various diseases, in the etiology of which they have possibly been shown to play some role, needs to be carried to conclusion. Additional evidence is needed to provide further scientific justification for any restrictive measures which, for the lack of definite data, may have been provisionally adopted.

9. DEVELOPMENT OF IMPROVED ANALYTICAL METHODOLOGY AND DETECTION METHODS

9.1 Rapid but accurate analytical methods are essential to both research, surveillance and control programmes on mycotoxins. Considerable progress has been made in the development of such methods for aflatoxin but there is need for comparable methods for other mycotoxins. There is a special need for analytical methods for the trichothecenes that are suitable for routine application and that will differentiate the several members of this group.

9.2 Simple, rapid methods for the qualitative detection of mycotoxin in agricultural produce are also needed. The methods should be capable of application by non-technical personnel such as farmers and grain buyers and should be used to signal the need for quantitative analysis. The bright greenish-yellow fluorescence (BGY) test for the presumptive presence of aflatoxin in maize and cottonseed is an example of the kind of screening test that would be useful for other mycotoxins.

10. TRAINING NEEDS

10.1 For the initiation of research in one or more of the areas discussed in the preceding section, professionals with advanced degrees and/or extensive previous experience in the area would be desirable for leadership positions. They should be assisted by junior professionals and technicians, the number depending on the breadth of attack and the urgency for solutions. The disciplines involved depend upon the research area but include chemists, plant breeders, plant pathologists, chemical and agricultural engineers, veterinarians and animal scientists, epidemologists and the like. Universities, colleges and technical institutes provide the basic training for these professionals in the respective undergraduate and graduate degree programmes. There are however several programmes, e.g. the initiation of surveys for incidence of mycotoxins, for which short training courses should suffice. Short courses also would meet the need for training extension agents, home demonstration and public health agents, community workers and practising veterinarians and prepare them for contributions in the control of mycotoxins as pointed out in the following sections.

10.2 A reference is also invited to Conference Document MYC-8 which deals with extension measures and should provide a link to the present discussions on the subject matter *per se*.

10.3 Training of technicians in analytical methodology

10.3.1 Training of technicians in analytical methods suitable for routine analysis of products for mycotoxins is an essential prerequisite to the initiation of surveillance or regulatory programmes for the control of mycotoxins. Present information indicates that aflatoxin is the mycotoxin most likely to be found in developing countries and is the first to be considered. However, one or more staff members should have training in analytical methods for several mycotoxins in addition to aflatoxin in order that exploratory studies could be undertaken to determine their possible occurrence in local produce.

10.3.2 Instruction in analytical methods might be accomplished by short-term training courses offered by the science departments in local colleges or universities, or by regional research centres. In some cases, in developing countries, it may be more economical to send a senior chemist abroad for training, who could then train junior personnel.

10.4 Training of the project leader in design of surveys

10.4.1 Surveys for the incidence of a mycotoxin in a commodity should be statistically based and the responsible project leader should have training, or the services of a statistician, in the design of a survey that will provide an accurate representation of the situation that exists. Important considerations are such matters as the number, size, site and dates that samples should be collected in relation to total production or quantity of the commodity that is marketed, varieties and growing areas, storage time and location, and other variables that may affect mycotoxin contamination of the commodity investigated.

10.4.2 A statistician trained in the design of biological experiments who would provide training or consultative services might be available in the science departments of local universities or colleges, state departments of agriculture or public health agencies, or at regional research centres.

10.5 Training of extension agents and field inspection force

As part of an effective mycotoxin control programme, agricultural extension agents need to have training in preventative measures that farmers can employ to minimize mycotoxin contamination in the growing, harvesting, drying, transportation and storage of susceptible crops produced in the localities they serve. Field inspectors enforcing mycotoxin control programmes or carrying out sampling surveys should have a similar training. In view of the relatively large number of extension agents and field inspectors who need to be trained, it would appear desirable for extension services and food control organizations to organize short-term training courses on mycotoxins, jointly where possible. Well-established principles of harvesting, drying, storage practices and other prevention techniques, that are generally applicable would be included in these courses. However, emphasis should be placed on local practices that surveys of mycotoxin incidence have shown to be the most frequent causes of contamination. Information on mycotoxins as related to farm animal feeding practices also should be extended as should the dangers to the health of the local populations. For the programme to be most effective, there should be close liaison and exchange of information between the extension service, food control agencies that conduct surveys, and those responsible for research on prevention of on-farm contamination.

10.6 Training of home demonstration agents, public health agents and other community workers.

10.6.1 These agents whose normal duties are to instruct families in matters which relate to food, food preparation, food preservation, nutrition, sanitation and hygiene or matters relating to family welfare can, with additional training, instruct families concerning the hazards of moulds in foods and ways to avoid them. Training should include instruction in proper storage of foods in the home, recognition of mould and selection of sound food either from home storage or in the market place, hazards of storing left-over cooked foods, and related matters.

10.6.2 A method of training these agents would be for the employing agency, as suggested in the case of the extension service, to organize appropriate short-term training courses. Since the information presented would be similar for the different agencies, they might cooperate in organizing training courses and sharing responsibility for holding them at various locations and times that would be most convenient to the participating agents.

10.7 Training of veterinarians in diagnosis of mycotoxicoses

10.7.1 Outbreaks of mycotoxicoses in farm animals are definitive evidence of the occurrence of high levels of a mycotoxin in feed that the affected animals have received. Diagnosis of a disease outbreak as a mycotoxicosis and identification of the responsible contaminated feedstuff are important in preventing further livestock losses. Training of veterinarians should emphasize:

(a) Clinical and post mortem pathological diagnosis of mycotoxicosis in livestock and poultry.

(b) Biological laboratory methods for monitoring mycotoxin contamination of feed.

(c) Organization and methods of field surveillance and of feed.

(d) Identification of batches and quick retrieval of contaminated batches in emergency action.

10.7.2 The training should also include aspects of cooperation with chemical laboratories, and a thorough instruction on all statutory and legal provisions applicable under the laws and regulations of the country concerned. Such training might be offered in refresher courses provided by local schools of veterinary medicine or in special courses under the auspices of the official veterinary services.

11. The Conference may like to make recommendations on the overall needs for research and training in the field of mycotoxins, emphasizing priority actions and potentially promising approaches at regional, national and international levels, that might assist in containing the mycotoxin problem.

ANNEX X

JOINT FAO/WHO/UNEP CONFERENCE ON MYCOTOXINS

Nairobi, Kenya, 19 - 27 September 1977

LIST OF OTHER WORKING DOCUMENTS

MYC-3:	'Assessment and Control of Environmental Quality: Mycotoxins'
MYC-4a:	'Global Perspective on Mycotoxins'
MYC-4b:	'Health and Toxicological Aspects of Mycotoxins'
MYC-4c:	'Trade and Economic Aspects of Mycotoxins'
AGS:MISC/77/7:	'Draft of a Guideline: Recommended Practices for the Prevention of Mycotoxins in Food, Feed and their Products'
FAO Food Control Series No. 4:	'Mycotoxin Surveillance - A Guideline'
Conference Room Document:	'Low-Cost Technology for Crop Drying'

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4. Soybean production in the tropics, 1977 (E*)
5. Les systèmes pastoraux sahéliens, 1977 (F*)
6. Pest resistance to pesticides and crop loss assessment - 1, 1977 (E* F*)
7. Rodent pest biology and control - Bibliography 1970-74, 1977
8. Tropical pasture seed production, 1978 (E* F*** S***)
9. Improvement and production of food legume crops, 1977 (E*)

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2. Eradication of hog cholera and African swine fever, 1976 (E* F* S*)
3. Insecticides and application equipment for tsetse control, 1977 (E* F*)
4. New feed resources, 1977 (Tri*)
5. Bibliography of the criollo cattle of the Americas, 1977 (biling. E/S*)
6. Mediterranean cattle and sheep in crossbreeding, 1977 (E* F***)
7. Environmental impact of tsetse chemical control, 1977 (E* F***)
8. Declining breeds of Mediterranean sheep, 1978 (E*** F***)

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2. Report of the joint FAO/WHO/UNEP conference on mycotoxins, 1977 (E* F*** S***)
3. Report of the joint FAO/WHO expert consultation on the rôle of dietary fats and oils in human nutrition, 1977 (E*** F*** S***)
4. Specifications for the identity and purity of thickening agents, anticaking agents, antimicrobials, antioxidants and emulsifiers, 1978 (E*)

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