FAO

UNEP

STRATEGIES AND RECOMMENDATIONS FOR MYCOTOXIN CONTROL IN TANZANIA

Report prepared for
the Government of Tanzania

Centre for International Projects
USSR State Committee for Environment Protection

Moscow, 1989

FAO/UNEP/USSR/Tanzanian Project
FP/7101/86/03

"IMPROVEMENT OF MYCOTOXIN CONTROL IN TANZANIA"

STRATEGIES AND RECOMMENDATIONS FOR MYCOTOXIN CONTROL IN TANZANIA

Report prepared for
the Government of Tanzania

Centre for International Projects
USSR State Committee for Environment Protection

Moscow, 1989

Table of Contents

1. INTRODUCTION

At present, a new branch of biology is rapidly developing, namely mycotoxicology which is the science dealing with toxic metabolites of microscopic fungi (moulds) - mycotoxins. The problem of mycotoxins attracts such a great attention on the part of specialists in various fields of knowledge due to, first, indisputable evidence of their real danger to human health; second, their extremely wide, practically world-wide spread and, third, a rather considerable economic losses inflicted by them.

In diet as in all other areas of life, there is no such thing as zero risk. "The authorities should firmly resolve to not unerringly take a reassuring stance. This not only does not reassure, it increases the public's lack of trust. Everything that can be done to reduce risk must of course be done, after which we must be brave enough to tell people not only what has been done but also what cannot be done".

2. REVIEW OF THE MYCOTOXIN PROBLEM

2.1. How Mycotoxins Are Produced in Agricultural Crops

Toxicogenic moulds represent a group of microscopic fungi the number of which now amounts to about 25.000 detected micromycetes contaminating raw agricultural commodities and process food products. According to FAO, more than one billion tons of the world food commodities worth an estimated 20 billion US dollars annually are subject to the risk of mould and mycotoxin contamination. Estimated losses due to mould contamination in peanuts constitute 4.2%, maize - 3%, beans - 12%, rice - 5% and soybeans - 3%.

The most dangerous for human and animal health are micromycetes related to Aspergillus, Penicillinum and Fusarium species which produce mycotoxines. Mycotoxins are natural contaminants of all types of agricultural commodities and foodstuffs. Approximately, 200 mycotoxins have been isolated and identified. The most notorious among mycotoxins are aflatoxins representing a group of highly toxic and carcinogenic substances that produces a pronounced hepatotrophic effect when administer to laboratory animal. Aflatoxins may contaminate under the proper environmental conditions a wide variety of agricultural commodities and foodstuffs. It should be noted that aflatoxin producing fungi may contaminate foodstuffs at any stage of their production and storage. Moreover, aflatoxins can get into human food supply by consuming milk and tissues of animals that were fed with aflatoxin contaminated feed.

Aflatoxins developing in agricultural products in various regions of the world depends on many factors. The major factors are: (a) occurrence of micromycete toxic strains in arable lands and pastures and level of mould contamination in plant substrata (both food and feed) and (b) degree of aeration, temperature of the environment, relative humidity, etc.

The taxonomic nature of micromycetes and their development in foodstuffs depend on ecological conditions we can forecast, with certain degree of confidence. For example, the optimum growth of A.flavus is at a relative air humidity of 80%, whereas in order for Fusarium fungi to produce zearalenone and trichothecenese the relative air humidity should be 95%. Temperature is one of the major factors bearing on toxin synthesis by microscopic fungi. In general the optimum temperature for the growth and development of fungi is about 27°C, though some species of mould can slowly develop at 0°C. The optimum temperature for the development of A.flavus aflatoxin varies in the range of 13°C to 45°C. Other critical factors influencing the production of toxins by fungi are genetic ones (not all the strains are toxicogenic), mechanical damages in initial products, the composition of the inter-grain atmosphere (oxygen, carbon dioxide tensions), inter-species completion, pH, and presence of pesticides and/or heavy metals.

Because of breath and grouth peculiarities characteristic for moulds, considerable losses in dry matter and degradation of food quality are noted. As the result of volatile compounds being removed by micromycetes from food raw materials the organoleptic qualities of food and feed proteins are decreased, starch and fat components and essential amino acids such as lysine and arginine are lost, and consequently the initial volume of foods and feeds is reduced.

Thus micromycetes of Fusarium, Aspergillus and Penicillium species producing the greatest number of mycotoxins are the cause of most known mycotoxicoses. Aflatoxins B_1, B_2, G_1 and G_2, can contaminate a wide range of products, especially maize and other grains, peanuts, cotton seeds, tree nuts, oilseed, cereal meals, pulse and dried figs. The incidence of aflatoxins in some commodities, e.g. oats, barley, wheat, rice and soybeans is limited to a few occurrences at low levels.

2.2. Impact of Mycotoxins on Human and Animal Health

The animal and human diseases caused by mycotoxins are called mycotoxicoses. Diagnosing mycotoxicoses in humans or animals is a highly complex problem. The toxin itself is often present at very low concentration and mycoflora which produced the mycotoxicosis is often distant or no longer present (destroyed in cooking, for example).

It has been documented that human and animal nutritional status has a major impact on the toxicity carcinogenic of mycotoxins. It has been reported that aflatoxins must undergo metabolic transformation within the organism before it become active. In 1973, R.G.Garner showed that aflatoxin B_1 oxidized in reaction to liver enzymes, and that the ensuing product could have a mutagenic and carcinogenic effect on DNA.

All mycotoxins detected as natural contaminants have a negative impact on livestock. The losses due to mycotoxin contamination can cause high livestock mortality. Mycotoxin contamination at low level can be insidious and result in lowered livestock performance. It is difficult to evaluate losses due to reduced livestock performance but they are undoubtedly the main reason for losses in economy and commerce. In 1983 the poultry industry of the United Sates reported lost an estimated 3% of poultry (in live weight) due to mycotoxin contamination of feeds, which amounted to 232.000 tons valued at 143 million US dollars. According to their degree of susceptibility to aflatoxins, animals can be arranged in the following sequence: pigs, ducklings, turkeys, gelded pigs, cattle, horses and sheep. It is established that young animals and especially embryos are more sensitive to aflatoxin action than adults.

Cases of pathology in animals have led to the discovery of aflatoxins producing liver cancer in animals. Some evidence of this phenomenon was provided by epidemiologic surveys on human, carried out in Uganda, Mozambique, Tanzania and Kenya in 1971-1974. Acute intoxication of the human organism was registered when aflatoxins had been consumed with food in doses from 1 to 5 ppb, that manifested itself in characteristic injuries to liver of animals; in particular, proliferation of liver cells surrounding the portal vein and of bile duct cells, and fat infiltration of liver cells in general were noted. Severe intoxication led to lethal outcome. Chronic intoxication can produce liver cirrhosis and cancer. Of special importance is cumulative effect of small aflatoxin doses consumed with food at regular intervals. Tumours are more often caused by regular consumption of small quantities aflatoxin than by a single dose.

It is no easy to extrapolate the discovered aflatoxin effect on the animal organism to people. However, there are cases of lethal intoxication of people by aflatoxins. For example, the etiology of liver cirrhosis in children in India was attributed to the presence of aflatoxins in breast milk; also several cases of encephalitis with lethal outcome, known as the Rey syndrome, are considered to be caused by the consumption of aflatoxin contaminated food. Similar effect was observed in monkeys when they are administered with aflatoxin in doses of 4-13 μg/kg body weight.

It has been established that primary liver cancer is most widely spread in geographical zones with tropical and subtropical climate and rarely occurs in countries with cold and temperate climate. However, the fact that the geographical distribution of this disease coincides with those regions of the world where - along with aflatoxin contamination of foodstuffs (maize, peanut, cassava) - deficiency of proteins in local population diet, severe cases of virus hepatitis of the B_1 type and excessive consumption of alkaloids and tannins are observed makes it difficult to assert that aflatoxins are the main agents responsible for primary liver cancer.

Human mycotoxicoses are even more difficult to diagnose as compared to those in animals. Careful epidemiologic survey would be required to identify cases of acute intoxication among human population. In recent years a link has been established between the consumption of aflatoxin contaminated food and occurrence of specific diseases which are characteristic of tropical countries.

It was believed earlier that kwashiorkor was caused only by protein deficiency. However, nowadays it has been established that this disease stems from a number of other etiological factors, aflatoxin being among them. Autopsies performed on children who died of protein/caloric deficiency (marasmus), kwashiorkor marasmus or kwashiorkor in South Africa, Liberia and Nigeria have also revealed the presence of aflatoxins in the liver. Aflatoxins or the aflatoxin metabolites were found in cases of death from kwashiorkor marasmus, but not in death from marasmus. The aflatoxins would accumulate in the liver, augmenting the toxic effect. It has been postulated that the combination of kwashiorkor and aflatoxins might cause juvenile cirrhosis. Children with kwashiorkor would therefore be at greater risk from the toxic effect of aflatoxins than would healthy children. Protein deficiency intensifies the toxic effect of aflatoxins on the human organism. In general, very marked vitamin A deficiency is also found in countries where food is heavily contaminated with aflatoxins. The interaction of aflatoxins and nutritional deficiencies should be examined with great care in national evaluations of the possible impact of mycotoxin contamination of the food supply.

So, for the purpose of detecting aflatoxicosis among population, epidemiologic survey is the best means for assessing the hazards related to the consumption of food contaminated with mycotoxins.

2.3. Economic Losses Associated with Mycotoxin Contamination

2.3. Economic Losses Associated with Mycotoxin Contamination

The economic damage caused by mycotoxins is expressed not only in direct loss of foods and feeds but also in reduction in their nutritional value and in death, reduced weight gain and reproduction of farm animals. Moreover, economic and commercial losses caused by mycotoxins are borne throughout all the chain beginning with production of food raw materials and ending by their consumption including export and import. This fact is now generally recognized. Nevertheless, in their efforts to collect information for the analysis of the mycotoxin problem world-wide, investigators experience certain difficulties since a number of countries prefer to disclose no information on this problem for fear of commercial consequences.

At the Second Joint FAO/WHO/UNEP International Conference on Mycotoxins (Bangkok, 1987) information was consolidated, pertaining to damage to economy of each country, caused by food and feed contamination with mycotoxins (see Table 1).

Considering the fact that mycotoxins are dangerous for people and animals and inflict heavy economic losses a number of countries have taken proper preventive measures against contamination of agricultural products with mycotoxins. A large number of importing countries have recently established rigid norms for maximum admissible levels of aflatoxin contamination in agricultural products, mainly in grain and oilseeds.

The countries exporting the above products are usually developing ones procuring most of their income by export of food raw materials and fodder. Thus, in 1985 it was registered that 10% to 50% of all grains imported from African and Far East countries were contaminated with mycotoxins. The Food and Drug Administration in Washington, USA, publish monthly information on arrested imported foodstuffs, the level of contamination in which exceeds the US aflatoxin standards in force. For instance, from October 1979 to September 1980, 6838 consignments of foodstuffs from developing countries were rejected for the total value of 206 million dollars.

From October 1980 to September 1981, the total number of detained consignment grew up to 8974, their value amounting to 253.5 million dollars.

According to the Food and Drug Administration (FDA), in 1985 in the Philippines only the losses caused by aflatoxin contamination of copra varied from 22 to 38 million dollars. A high level of aflatoxin contamination in copra have also been discovered in India.

There is also a well-known instance of aflatoxin contaminated maize being shipped from Asia to Costa Rica. The whole shipment was eliminated. So, the total loss apart from the cargo cost included expenses for the shipment by sea, labour, storage, etc. (Report by Joint FAO/WHO Commission of experts on food safety, 1983).

The total value of several consignments of pistachio nuts with high level of aflatoxin contamination delivered from Iran and Turkey and rejected by the US border control was estimated at about 5 million dollars.

The problems related to export of peanut from developing countries deserve special mention.

Thus, for example, 70% of the Senegalese peasant population which number one million people are engaged in peanut production. Export of peanuts is the main income source for the agricultural sector of Senegal, ensuring 3/4 of its monetary income and constituting about 50% of the national income.

As importing countries are introducing ever more rigid norms regulating aflatoxin content in peanuts and some of them have gone further than that forbidding any import of peanuts at all, the export capabilities of producing countries become rather limited. In 1975, 63% of all peanuts consumed in France had been imported from Senegal. In 1980, this amount dropped down to 20%, whereas in 1981 the volume of peanuts imported from Senegal did not exceed 1/4 of its level in 1980.

Table 1

Types of losses and costs associated with contamination of foods and feeds by mycotoxins - expressed in general terms
(Joint FAO/WHO/UNEP Conference on Mycotoxins document MYC-4c, 1977)

Bearer of Losses and Costs		Losses and Costs
1. National Level	Primary producer	- Outright food/feed losses - Contaminated crops provide less income and may lead to potential loss of outlet - Reduce productivity of livestock leads to less - income from animal products; smaller litters; reduced work output
	Middleman	- Less income from producers refused, condemned or sold at a discount - Storage, transport and packing costs on such products - Potential loss of outlet, trading reputation and also of raw material source
	National Exchequer	- Lower foreign exchange earnings from reduced exports Costs involved in shipment or trans-shipment, sampling, analysis, etc. of exported goods that are subsequently refused import entry; potential loss of overseas outlets - Costs of detoxification or reconditioning abroad; - Increased costs for food and feed imports; staple food subsidies - Increased costs of surveillance and control - Increased need for expenditures on human and animal health facilities and activities - Increased costs involved in training and extension programmes
	Consumer human or animal	- Consumption may lead to impaired health and productive capacity - Lack of food may lead to undernutrition or higher food prices resulting from outside purchase of foods and feeds - Possible medical and veterinary costs associated with the above
2. International Level		- Reduction in supplies for meeting needs or demands for different commodities; possibilities of price fluctuations - Potential problems would be the increased difficulty involved in arriving at sound international agricultural production adjustments and commodity and food security agreements

A high level of aflatoxin contamination in peanuts has also been registered in South-East Asia countries. For instance, in Thailand the level of aflatoxin contamination in peanuts was as high as 12300 μg/kg and that for peanut oil in Indonesia - was 100 μg/kg. In India aflatoxin contamination in peanuts reached 2600 μg/kg.

Maize is an important staple food for the population of many developing countries. Considerable concentrations of aflatoxins have been found in maize from countries of South-Asia. In India where contaminated maize was the source of acute hepatitis with high lethal outcome, the concentration of aflatoxin in some samples was as high as 12500 μg/kg. In Thailand the concentration of aflatoxin B_1 in 35% maize samples averaged 400 μg/kg and in the Philippines 94% of the tested maize consignments contained on the average 77 μg/kg of aflatoxin though samples were found containing up to 1330 μg/kg of aflatoxins. In the consignments of maize from Australia which caused toxicoses in farm animals the aflatoxin concentration was 340 μg/kg. A high level of aflatoxin contamination in maize used for food purposes was also the cause for aflatoxicoses among population of Kenya, Mozambique, Uganda, Swaziland, Ghana and Nigeria. In Mexico and Guatemala the aflatoxin content in cooked maize products (tortillas) varied from 200 to 400 μg/kg.

Concentration of aflatoxins in other grains is relatively low. Thus, the aflatoxin content of wheat consignments from North and Central America countries did not exceed 10 μg/kg, but in wheat samples from Pakistan concentrations of aflatoxin varied from 5 to 340 μg/kg. The maximum level of aflatoxin contamination in wheat was registered in Australia when one sample showed it to be 700 μg/kg. Data on aflatoxin contamination in other grains are relatively scarce. There is evidence of aflatoxin presence in barley, millets, oats. All the samples of sorghum from Uganda and Nigeria contained aflatoxins in concentrations of 30 to 211 μg/kg. Compared to maize and peanut, rice is less susceptible to aflatoxin contamination. However, in Thailand aflatoxin contamination in rice reached 600 μg/kg and in Costa/Rica and Taiwan - 200 μg/kg.

The above data on the world-wide distribution of mycotoxins justifies the conclusion that in regard to agricultural products both producing and importing countries suffer direct and indirect economic losses and face health problems stemming from mycotoxin contamination of food raws and foodstuffs.

3. MONITORING AND NATIONAL LEGISLATION ON MYCOTOXIN CONTROL

Food contamination monitoring, which yields information on the levels of contaminants in food and time-trends in contamination, is important for ensuring the safety of food supplies and for management of food and agricultural resources. Monitoring can reveal rising trends in food contamination, thus enabling preventive and control measures to be initiated before contamination becomes so serious or widespread that it threatens human health or causes serious losses.

When establishing or improving programmes intended for monitoring of mycotoxins, many governments consider them as a component of the activity in the field of food safety and food control. Monitoring may be carried out for a variety of purposes:

- to establish a baseline and determine changes in the levels of a contaminant in food with time, thus providing, inter alia, a means of detecting increasing levels of contaminants in food before they become so high that when ingested they pose a direct threat to human health;

- to give an indication of the effectiveness of measures introduced to reduce food contamination;

- to check that the levels of contaminants in food do not exceed established standards, i.e. for what may be termed regulatory or compliance purposes. In this context, "mycotoxin monitoring" is synonymous with "mycotoxin control", but mycotoxin control is a broad term and includes many activities in addition to those related to mycotoxin monitoring. However, monitoring is a more long-term activity designed to provide baseline data and to show time-trends in mycotoxin contamination, whereas mycotoxin control activities are generally designed with more immediate objective of preventing food contamination which is unfit for human consumption, reaching the consumer. Control activities include regulatory actions, e.g. acceptance/rejection, legal action, etc. Some mycotoxin control activities may satisfy the above definition of monitoring. For example, the inspection of imported peanuts or maize when they are examined for the presence of aflatoxins may be regarded both as food control and monitoring.

In their effort to find an effective solution to the problem of safety of foodstuffs from pollution with foreign substances, many countries have established national systems of control or monitoring of mycotoxins in agricultural products. The advisability of setting up such systems of control and/or monitoring of mycotoxins is substantiated below.

As awareness of the risks associated with contaminated food increases internationally, the demand that food be monitored and controlled is growing. A country which does not have a system for the mycotoxin control of imports for contaminants will find it difficult to prevent itself being used as a dumping ground for substandard food rejection by other countries. In addition, a country without a system to control mycotoxins in the food it exports to ensure that it meets the requirements of prospective importers runs the risk of having it rejected and suffering economic losses.

Besides ensuring the safety of food for domestic consumption, the existence of a well-run mycotoxin control system increases confidence in the quality of the food a country exports and is likely to facilitate international trade and yield better economic returns for the exporting country. The economic importance of a control system for mycotoxin contamination is likely to increase, especially for countries which derive a major part of their income from the export of food or spend a lot of foreign exchange on food and feed imports.

3.1. Organisation of a Control System for Mycotoxin Contamination in Agricultural Products

The experience of many countries where control systems for mycotoxin contamination of agricultural products have been developed and brought into effect showed that the organization of a national mycotoxin control system should include the following basic steps:

- gather background information for the implementation of a control system;
- establish at the national level of an institutional framework for mycotoxin control implementation;
- develop an organisation of analytical services;
- develop a quality assurance programme;
- training of national experts and organisation of public information;
- identify agricultural products which are most susceptible to mycotoxin contamination;
- establish a maximum limit for mycotoxin contamination in agricultural commodities and process food products.

3.1.1. Gathering Background Information for the Implementation of a Mycotoxin Control

Extensive knowledge related to the storage and distribution of commodities from producers to consumers must be thoroughly understood before designing a monitoring programme that will protect humans against the risk of mycotoxin contamination. The firs step in organizing a national system of control for mycotoxin contamination of agricultural products must be collection and analysis of information on basic types of agricultural commodities that are produced in the country, conditions of crop harvesting, storage and distribution. At this stage, an assessment should be made of the availability of scientific background and laboratory facilities on which a national system of mycotoxin control will be based. A national system of mycotoxin control in agricultural commodities will be effective only when it reposes on a thorough analysis of the above information and gives due account to social, economic, hygienic and other aspects of the problem.

3.1.2. Institutional Framework in Establishing a System of Aflatoxin Contamination Control

The establishment of a national system of aflatoxin contamination control in agricultural commodities envisages designation of a leading national institution responsible for the planning and implementation of the programme of aflatoxin control, e.g. country's health, agriculture or environment protection ministry. Such a central body will serve as a focal point for gathering, consolidation and scrutiny of the aflatoxin control results and on this basis develop adequate measures for abating mycotoxin contamination levels in food and feed.

The structure of such a state body should include a special workgroup whose task is to plan, bring into practice, evaluate and coordinate programmes for the control of mycotoxin contamination in foods and feeds. In addition to designated civil servants, the workgroup should also include scientists - experts on various aspects of the mycotoxin problem. It is also advisable to develop a multilevel national network functioning as described below.

The consolidation of data and the analysis of the nationwide situation are carried out by the leading laboratory to which local (primary level) laboratories expeditiously send all data on quantified levels of mycotoxin contamination in foodstuffs.

The statistically processed information on the frequency and levels of mycotoxin contamination in agricultural commodities and process foods are subsequently sent to the government body which is a responsible for the food quality and safety control; this body develops the necessary preventive measures designed to reduce the level of mycotoxin contamination. The introduction of those measures into the practice of enterprises are fulfilled through agencies responsible for the production, purchase and distribution of foodstuffs. Only using such a feedback it is possible to make the control and monitoring system effective, since the control alone does not allow one to reduce the mycotoxin contamination level in food raw materials and foodstuffs.

3.1.3. Organization of Analytical Service

The crucial step in the establishment of a mycotoxin control system is the development of analytical services that have capabilities of direct collection and mycotoxin analysis.

It is advisable to develop a multilevel analytical service that is composed of laboratories using conventional screening techniques to analyze mycotoxin samples and those laboratories that using quantitative methods and developed technologies such as high pressure analytical instruments. This is particularly important for countries with limited analytical facilities. A mycotoxin analytical service unit should establish expertise in the following areas:

- sampling and preparation of samples for mycotoxin analysis;
- laboratory analysis of samples.

Sampling and preparation of samples for analysis

This is one of the most important stages in the control system since it has a considerable bearing on the accuracy of analysis. Here, the problem is that it is difficult to recommend a uniform method of sampling and preparation of specimens applicable for all situations. Nonetheless, sampling should be performed respecting the following guidelines.

A representative selection of samples is of paramount importance. The main factors which should be taken into consideration while collecting samples from a consignment of agricultural products are their number, volume of each sample, its homogeneity and qualitative representation of the total consignment. Considering that mycotoxin contamination can affect foodstuffs at any stage of their production, samples should be taken at each stage, e.g. prior to harvesting, in the storage period, prior to distribution to the population.

One of the most common sources of analytical error and one that is frequently overlooked is sampling for the laboratory analysis, including both parent-lot sampling and subsampling. A sample submitted to a mycotoxin laboratory for an analysis should be representative of the lot from which it had been taken. This may seem simple but, in practice, drawing a representative sample from a large lot of agricultural commodity can be quite a challenge.

Organization that is responsible for both collection and analysis of samples, should establish a sampling protocol.

Appropriate attention should be given to the size of a sample and how it should be drawn, and to the statistical sampling. The quality assurance protocol should include instructions for handling, shipping and storage of samples.

It is essential that the sample be prepared to achieve homogeneity and treated in such a manner that prevent a change in the original level of mycotoxin contamination. Failure to achieve homogeneity at this point of sample preparation will affect results of the analysis regardless of the analytical method used.

In summary, to ensure a good sample management programme, it is essential to establish a procedure for sample collection, documentation, preservation and transportation of samples to the laboratory. Any deviation from established procedures should be justified and documented.

Laboratory Analysis of Samples

It is more important to detect high concentration levels in greater number of samples than to analyze fewer samples using highly sensitive and sophisticated methods. This is especially true for countries with limited analytical facilities. At the same time, highly reliable methods for detection, identification and quantification of mycotoxins should be used because "simple" methods usually lead to increase in false-positive and false-negative results which is undesirable both from the viewpoint of food safety and economics of agricultural production.

These alternative problems are usually resolved by creation of a multistage monitoring system with a gradually increasing analytical capability of laboratories: from laboratories using simple screening methods to those having high pressure liquid chromatographs.

A country introducing a mycotoxin control system, and national legislation of aflatoxin analysis methods should first consider the following aspects:

a) sensitivity of the method;

b) selectivity of the method to various types of agricultural products;

c) costs involved;

d) adaptability of the method for routine analysis.

The development and implementation of analytical services for collection and analysis of samples of agricultural products should be consistent with basic standards established and recognized by the international community. This is particularly important for the development of an export-import relations between countries.

3.1.4. Implementation of a quality assurance programme

The development of reliability mycotoxin control system requires the implementation of an adequate assurance programme. The quality assurance programme in a mycotoxin control has two primary functions. First, the programme should monitor the reliability (truth) of the results submitted. The second function is the control of quality to meet the programme requirements of reliability. For example, the processing of a blend and spiked sample is the measurement of quality, while the use in the analysis of high quality silica gel plates is a control measure.

The quality control and assurance programme may be implemented both within a laboratory and at the inter-institutional level. Moreover, there exist international analytical quality assurance programmes, such as e.g. the Mycotoxin Check Sample Programme organised by the International Agency for Research on Cancer and the Smalley Check Sample Programme sponsored by the American Oil Chemists Society (AOCS).

While developing a quality assurance programme, an account should be taken of the following critical points prompted by the methodology of mycotoxin determination:

- sample collection;
- sample preparation;
- sample analysis;
- inadvertent errors;

- instrumentation;
- analysts.

Thus in the analysis of representative samples, procedures intended for establishing the suitability of a method for a particular sample should include analysis of positive control samples using at least one of the following approaches:

- spike recovery;
- comparison with an official or standard method.

The spike recovery is a technique commonly used to validate mycotoxin methods: the pure mycotoxin standard is added to and immediately mixed with the sample matrix. Mycotoxin methods should be validated over the concentration range that is suspected to occur naturally. The comparison technique is also currently used to validate a mycotoxin method: it includes a comparison of the precision and accuracy of a method with those of the official or standard method, such as CB-method for aflatoxin analysis. To properly evaluate a method, an authentic standard should be used and a blank control sample should always be analyzed with the sample.

In this context, it is advisable to set up, under the governmental body responsible for the implementation of national mycotoxin control, a workgroup whose task would be to coordinate the quality assurance programme.

3.1.5. Training of National Experts and Organization of Public Information

An important role in the mycotoxin control system is the training of national personnel. A country developing a mycotoxin control programme should have a system for training national personnel. Such a system should be a multistage system one that include both training of personnel skilled in using simple analytical screening techniques and experts that will ensuring the quality control of the production of agricultural commodities and process foods.

It is important to train managers that will organize the implementation of monitoring programme. Managers should also take an active part in the decision-making process as regards to the policies and the national food programme.

Informational and educational mycotoxin control activities aimed at people directly involved in the agricultural production are on essential element of control programme.

Educational activities on mycotoxin control should include training programmes on myootoxins in curricula of national agricultural, veterinary, medical, chemical and food production schools and universities.

Informational activities on mycotoxin control should focus on the circulation of knowledge to the public on problems related to hazards of mycotoxin contamination in foods and feeds.

Informational centres should use all available means including talks at all levels, local-language pamphlets, audio-visual aids, etc. for circulating popular-scientific literature on problems of foodstuffs' safety.

3.1.6. Establishment of Maximum Limits for Mycotoxins in National Agricultural Products

General distribution of microscopic fungi and the possibility of fungal contamination of food raw materials and foodstuffs at any stage of their production makes it practically unrealistic to avert totally the contamination of food with mycotoxins. At the same time, the task set for the bodies responsible for the quality control and safety of foodstuffs is to prevent contaminated food from entering the human diet. Therefore, an important step in securing safety of foodstuffs and agricultural raw materials is to enforce limits for mycotoxins concentrations in the above products.

Development of a national system of mycotoxin contamination control in agricultural commodities should include the establishment of maximum permissible concentrations of mycotoxins in basic agricultural products. The establishment of the above limits should be based on a thorough analysis of experimental data on the incidence, extent and levels of mycotoxin contamination in basic types of national agricultural products consumed in the country.

It should be noted that the development and enforcement of a national legislation on maximum permissible concentrations of mycotoxins must take into account not only criteria for assessing mycotoxin hazards to human health but also economic and ecological peculiarities of the country.

Appropriate control of food contamination with mycotoxins ensure regular verification of the levels of specific foodstuffs' contamination with mycotoxins thus enabling the identification of situations with exceeded limits of mycotoxin content in food.

When such cases have been reported, adequate measures should be immediately taken in order to rule out the consumption of contaminated products by man or animals.

3.2. Measures for Prevention of Mycotoxin Contamination of Agricultural products

The prevention of mycotoxin contamination in agricultural products is an essential element of the monitoring programme. It is the most effective means for reducing the mycotoxin contamination in foodstuffs. However, in many developing countries this stage of monitoring programme is actually ignored. This is mainly due to the lack of financial resources needed for the introduction of new farming technologies.

Almost all preventive measures are aimed at precluding the formation of conditions that are favourable for the emergence and growth of fungi.

At the national level, current information concerning limits set for mycotoxins in food and feedingstuffs is available from the health or agricultural departments. The purpose of this chapter is to recommend practices for the prevention of mycotoxins in food, animal feed and their products. The recommendations given below on the prevention of mycotoxin contamination of agricultural products reflect the experience gained in this field of human knowledge which is further consolidated in official publications by international organisations, specifically by FAO and UNEP.

The main preventive measures are:

A. Measures for the control of field infection of standing crops by fungi:

- to reduce fungal damage by the proper use of approved fungicides, and other appropriate practices integrated into a pest control programme;
- to use approved fungicides, as appropriate, to reduce or prevent moulding of crops, selecting the fungicidal treatment appropriate to the crop in hand;
- to sow crops at the recommended spacings for the species and varieties grown in order to avoid overcrowding of plants;
- to remove or destroy wild grasses in the vicinity of crops to eliminate potential reservoir of fungal inoculum;
- to remove or destroy weeds during the lifespan of the growing crop to prevent them from competing with the crop;
- to practise crop rotation as a routine;
- to irrigate the entire crop evenly, ensuring that individual plants have an adequate supply of water;

- to destroy or bury all dead organic matter, crop residues and alternative host plants together with fungi-infected plant material before preparing the ground for a new crop;

- to sow and harvest at times which avoid, as far as practicable times when mould infections are more likely to occur;

- to avoid mechanical damage to crops during cultivation;

- to harvest crops at full maturity.

B. Recommendations for harvesting and drying:

- harvest crops at full maturity;

- avoid mechanical damage during harvesting;

- dry crops immediately after harvesting, particularly if crops are harvested at high moisture levels; sorting of grain after harvesting;

- dry crops as rapidly as possible, caution, sun drying in high humidity is likely to result in mould infestation of the crop;

- avoid re-wetting the crop during and after the drying process by ensuring adequate protection from rain during sun drying, and by avoiding conditions of high humidity induced by the use of covers upon which water vapour condenses when the air temperature falls at night;

- dry crops to safe moisture levels before storage.

C. Measures to be taken for storage of crops:

- ensure that storage structures are dry and do not permit the entry of water either by seepage of ground water or other leakage;

- stack bagged grain on dunnage or pallets to avoid upward movement of ground water, unless the floor incorporates a membrane impermeable to water vapour;
- control insect infestation in both storage structures and stored bulk grain by preventive/corrective treatment with approved insecticides;
- store at low temperature whenever possible, as fungal growth resulting in mycotoxin contamination is correlated with temperature increase; certain Fusarium species are an exception to this general rule in that they can produce mycotoxins at low temperatures.

D. Measures to be taken at farm storage level:

- to fumigate and dry produce that were infected by insects in the field before storage;
- winnow and sieve out immature, discoloured and broken kernels;
- store the produce in moisture-proof structures or container which are amenable to fumigation treatment;
- inspect the stored produce regularly, using suitable fumigants to control any insect infestation where necessary.

E. Measures to prevent contamination of produce with mycotoxins during transportation:

- check and correct undesirable conditions in commodities during transport;
- disinfect empty transport containers and vehicles periodically with a suitable approved fumigant or other pesticide;

- avoid reabsorption of moisture during shipment or other transportation by the use of tarpaulin, by ballooning or by using airtight containers as appropriate;

- utilize insect-proof or insect-resistant packaging materials or containers rendered insect- and rodent-repellent by chemical treatment.

F. Measures to prevent pollution of agricultural produce for post-harvest processing including decontamination:

- avoid mechanical damage to crops during threshing or decortication;

- protect crops during processing from any conditions which favour fungal growth;

- expedite those stages of processes that necessarily involve some rehydration of the raw material;

- segregate by physical means the damaged portion of any crops before processing commences;

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

Application of the entire set of the above preventive methods against mycotoxin contamination of agricultural products is not always feasible due to:

a) different economic capabilities of the crop-producing developing countries, and

b) conventional specific practices of crop cultivation, harvesting and transportation.

Nonetheless, the system of methods proposed makes it possible within the limits of our current understanding of the problem, to ensure effective protection of agricultural products against contamination with mycotoxins.

3.3. Current Limits and Regulations on Mycotoxins

As it is impossible to exclude entirely the contamination of agricultural products with mycotoxins and hence, contamination of food raw materials and fodders, the main emphasis in the prevention of human and animal mycotoxicoses should be made on the control of mycotoxin contamination in agricultural products and the establishment of safe mycotoxin concentration levels for various foods and feeds.

In the days of the early food regulations, the protection of food was mostly a local affair and municipal ordinances were promulgated for the purpose. Inspections were relatively simple as there were no auxiliary sciences. Much later, when bacteriology, chemistry and microscopy developed, plans for statutory regulations gradually developed in many countries, leading in the beginning of the 20th century to the adoption of official food legislation. These days, the food laws not only prohibit the introduction, delivery for introduction or receipt in commerce of adulterated and misbranded food, but they often include specific legislation that imposes limits on tolerances on the concentrations of specific contaminants of foods. Such contaminants may be of industrial or natural origin. Of the natural contaminants, the mycotoxins are the most recent to be considered. After the discovery of aflatoxins in the early 1960s, specific mycotoxin legislation was developed in several countries, initially referring only to aflatoxins.

Early in the 80th the first attempt was made to prepare a review on current regulations pertaining to mycotoxin contamination levels in agricultural products and foodstuffs, based on the relevant legislation in force in various countries. Subsequently, the legislation on this subject underwent certain amendments and clarifications, and now the regulations were adopted by producing and importing countries, which referred to agricultural products. At the Second International Conference on Mycotoxins Sponsored jointly by FAO/WHO/UNEP in 1987 new data were presented on maximum tolerance concentrations of aflatoxins in food raw materials, foodstuffs and feeds which had been established by national legislation in various countries (see Table 2).

Nevertheless, at present there is no specific international guideline on maximum tolerance limits.

In comparison with 1981, the number of countries knows to have in force or proposed aflatoxin regulations for foodstuffs has increased from 39 to 50. In addition, several countries have expanded their regulations to specify more types of foodstuffs. As in 1981, the maximum limits for aflatoxins in food (aflatoxins B_1 or the sum of aflatoxins B_1, B_2, G_1, and G_2) vary from zero detectable up to 50 μg/kg. Some countries have a zero tolerance, which is in practice the limit of detection of the method of analysis employed. Unless a method of analysis is specified, these countries are actually using a "sliding standard", because the limits of detection of analytical procedures tend to go down continuously. Of the countries that attach a numerical value to their tolerance, Austria and Switzerland have the lowest tolerance values for the aflatoxin B_1.

The tolerance level for the aflatoxin B_1 of 5 μg/kg is most often applied by authors of aflatoxin regulations for foodstuffs. In those countries that apply limits for the sum of aflatoxins, such a uniformity in tolerance values does not occur. It is debatable, whether a tolerance for the sum of aflatoxins, which requires more analytical work than for the aflatoxin B_1 alone, contributes significantly to better protection of Public Health than a tolerance for the aflatoxin B_1 alone. The aflatoxin B_1 is the most important of the aflatoxins, considered from both toxicology and occurrence viewpoints.

Table 2 Aflatoxin in foodstuffs. Maximum tolerated levels

Country	Tolerance (μg/kg) (B_1)					Tolerance (μg/kg) ($B_1 + B_2 + G_1 + B_2$ +)					Remarks
	Peanuts, peanut products, other nuts	All foods	Maize and other cereals	Milling a shelling products	Children foods	Peanuts, peanut products, other nuts	All foods	Maize a. other cerals	Milling a. shalling products	Children foods	
Argentine	5	2	5	-	-	20	-	20	-	-	
Australia	-	-	-	-	-	15	5	-	-	-	
Austria	-	1	-	2	-	-	5 $(B_1+G_1+G_2)$	-	5 $(M_1+B_1+B_2+G_1+G_2)$	0.02	
Belgium	-	5	-	-	-	-	-	-	-	-	
Brazil	-	15	-	-	-	-	30	-	-	3	
Canada	-	-	-	-	-	15	-	-	-	-	
Republic of China	50	-	50	-	-	-	-	-	-	-	
Colombia	-	-	-	-	-	10	-	30	-	-	$(B_1+B_2+G_1+G_2)$ for sesame-20
Cuba	-	-	-	-	-	zero	-	zero	-	-	
Czechoslovakia	-	5	-	-	1	-	10 $(B_1+G_1+G_2)$	-	-	2 $(B_1+G_1+G_2)$	
Dominica rep.	-	-	-	-	-	zero	-	zero	-	-	
Finland	-	-	-	-	-	-	5	-	-	-	
France	-	-	-	-	-	-	10	-	-	-	$(B_1+B_2+G_1+G_2)$ for infant food-5.
Federal Rep. of Germany	5	-	5	-	-	10	-	10	-	-	The same for sesame, apricot,peach pits
German Democratic Rep.	-	5	-	-	-	-	15	-	-	-	
Hong Kong	-	-	-	-	-	20	-	-	-	-	$(B_1+B_2+G_1+G_2+M_1+M_2)$
Hungary	30	5	-	-	-	-	-	-	-	-	
India	-	30	-	-	-	-	-	-	-	-	
Israel	-	-	-	-	-	20	-	-	-	-	
Ireland	-	5	-	-	-	-	10	-	-	-	
Italy	-	-	-	-	-	50	-	-	-	-	
Japan	-	10	-	-	-	-	-	-	-	-	
Jordan	15	-	15	-	-	30	-	30	-	-	
Kenya	-	-	-	-	-	20	-	-	-	-	The same for vegetable oil
Luxembourg	5	-	-	-	-	-	-	-	-	-	
Malawi	5	-	-	-	-	-	-	-	-	-	peanuts for export
Malaysia	-	-	-	-	-	-	15	-	-	-	
Mauritius	5	5	-	-	-	15	10	-	-	-	$(M_1+M_2+B_1+B_2+G_1+G_2)$
Mexico	-	-	-	-	-	-	20	-	-	-	
The Netherland	5	5	-	-	-	-	-	-	-	-	
New Zeland	-	-	-	-	-	15	5	-	-	-	
Nigeria	-	20	-	-	-	-	-	-	-	-	Infant food-zero
Norway	-	-	-	-	-	5	5	-	-	-	
Peru	-	-	-	-	-	-	5	-	-	-	
The Philippines*	-	-	-	-	-	20	-	-	-	-	* for export
Poland	-	zero	-	-	-	-	-	-	-	-	
Portugal	25	20	-	-	-	-	-	-	-	-	Infant food B1-5
Romania	-	zero	-	-	-	-	-	-	-	-	
Singapore	-	zero	-	-	-	-	zero	-	-	-	
South Africa	-	5	-	-	-	-	10	-	-	-	
Surinam	5	-	-	-	-	-	-	-	-	-	
Sweden	-	-	-	-	-	-	5	-	-	-	
Switzerland: Existing regulations	1	-	2	-	-	5	-	5	- $(B_1+G_1+G_2)$	-	
Proposed regulations	-	1	2	-	-	-	5 $(B_1+G_1+G_2)$	-	-	0.01	
Thailand	-	-	-	-	-	-	20	-	-	-	
USSR	-	5	-	-	-	-	-	-	-	-	
UK	-	-	-	-	-	10	-	-	-	-	
USA	-	-	-	-	-	-	20	-	-	-	
Yugoslavia	-	-	1 (B_1+G_1)	-	-	-	-	-	-	-	Beans 5 (B_1+G_2)
Zimbabwe	5	-	5	-	-	4 (G_1)	-	4 (G_1)	-	-	

The research work conducted by the US Food and Drug Administration (FDA) on estimated risks at various levels of contamination of aflatoxin B_1 has also shown a zero gain in public heath at level of 20 ppb.

The Joint FAO/WHO Codex Alimentarios Commission is continuing its work for developing internationally agreed limits for aflatoxin contamination which would be uniform and reassemble together with recognized methods of analysis and sampling.

3.4. Urgency for Creating Mycotoxin Contamination Control System in Tanzania

It is obvious that the problem of mycotoxins threatens both producers and consumers of agricultural products. The producer and consumers in each country should possess adequate information on the mycotoxin problem and corresponding services for its positive resolution.

Establishment of a mycotoxin contamination control system could provide to safe guard to health and improve the management of food and agricultural resources. The mycotoxin control system is a reliable way of determining time-trends in food contamination.

In addition to helping to prevent contaminated food from reaching the consumer and providing a warning that the food contamination problem is increasing and/or becoming critical, a mycotoxin contamination control system is needed to give an indication of the effectiveness of measures introduced to reduce contamination. In this context, a mycotoxin contamination control system is needed to assess the impact of the introduction of new substances or practices in agriculture, food processing, food handling, etc. on food contaminants levels. A mycotoxin contamination control system is of undoubted economic importance for countries which depend on the export of agricultural products for a large part of their national income.

As more countries institute control systems to prevent the importation of contaminated food, it becomes increasingly important for the exporting countries to check that their products meet the requirements of the prospective importers. Countries that do not have a mycotoxin control service to check its exports for contaminants runs a grave risk of having them rejected and suffering heavy economic losses.

Thus, the establishment of a mycotoxin contamination control system is an economically viable enterprise, since it secures the safety of agricultural production for local consumption, on the one hand, and guarantees a high quality of exported products, on the other.

4. FAO/UNEP/USSR/TANZANIA PROJECT "IMPROVEMENT OF MYCOTOXIN CONTROL IN TANZANIA"

The experience of a number of countries has shown that the solution to mycotoxin problem in a developing country depending wholly on its own potential is a rather complicated or even impracticable task. Only through assistance from international organizations possessing great experience in conducting various activities aimed at ensuring food safety and their close cooperation with the governments of interested countries it is possible to achieve positive shifts and eventual resolution of the mycotoxin problem.

Taking this into consideration, in 1987 FAO, UNEP, UNEPCOM (USSR) and the Government of Tanzania initiated a project on "Improvement of Mycotoxin Control in Tanzania".

4.1. Objectives of the Project

The purpose of the project was to establish a mycotoxin control at the country level, with special attention to monitoring, enforcement of standards, legislation, and the practical utilization of recommendations on preventive measures.

The project document gives the following statements of objectives:

A. Long-term objectives:

Improvement of food safety at country level.

B. Short-term objectives:

To strengthen the capabilities for mycotoxin control in Tanzania through:

- recommendations for improvement of legislation and standards;
- training of manpower;
- establishment of laboratory facilities;
- recommendations for improvement of preventive measures.

The implementation of the project was carried out under a close collaboration among the international organizations involved and the governmental, scientific, agricultural and other appropriate official bodies of the country.

4.2. Mycotoxin Control Activities in Tanzania.

In the process of implementation of the international project "Improvement of Mycotoxin Control in Tanzania" the following activities were carried out:

- collection, processing and analysis of information on mycotoxin problem in the country with the assistance of consultants from international organizations;
- selection and designation of interested organizations which subsequently directly coordinated project activities in that country;

- elaboration of a coordinated workplan, determination of the institutional framework and the country's requirements in equipment and trained personnel;

- technical and consultative assistance in establishing the leading laboratories in the field of mycotoxin control;

- provision of some materials and equipment for the Government Chemical Laboratory (GCL) in Tanzania for the execution of direct control over the agricultural products contamination by aflatoxins;

- training of national personnel in the monitoring of agricultural products contamination by aflatoxins and other toxins at all levels - from decision-makers down to practical workers: this includes training in sampling and analysis of contaminated and uncontaminated samples as well as training of specialists for the Government Arbitration Laboratory;

- preparation of a manual on methods of sampling and chemical analysis of agricultural produce for the presence of aflatoxins with due account for specific conditions of the country;

- collection of reliable statistical data on the frequency, extent, and levels of mycotoxin contamination of food products with a view to identify species which are most prone to mycotoxin contamination, with due account to the ecological peculiarities of the country;

- preparation of an information booklet on the problem of mycotoxins intended for those engaged in farming practices in Tanzania;

- assistance in the development of recommendations on the improvement of the national legislation governing Maximum Permissible Concentrations of mycotoxins in various agricultural products;

- to develop recommendations on organization and introduction of a mycotoxin monitoring programme with due account for the climatic and social conditions in Tanzania with a view to ensure safety of food from aflatoxin contamination.

4.2.1. Collection, processing and analysis of information on the mycotoxin problem

No detailed information on the mycotoxin problem in Tanzania was available prior to the commencement of the project. There were only data obtained under the Food Contamination Monitoring Programme (FAO) which indicated the occurrence of aflatoxins in beans, maize and products of their processing (boiled food, bread, etc.). The research carried out at Uyole Agricultural Centre in Mbeya region, Tanzania, showed the possibility of maize contamination by Aspergillus species.

Studies by Prof. Hiza of the Ministry of Health (Tanzania) revealed the incidence of liver cancer in young adults under the age of 25 to be higher in certain areas of the dry central regions such as Dodoma which is believed to be due to the consumption of aflatoxin-contaminated groundnuts. However, no experiments to correlate the liver cancer occurrences with contaminated groundnut consumption were carried out.

At the first stage of the project it was appropriate fo fulfil the selection, correlation and analysis of the data related to the problem of mycotoxins in Tanzania - the task which was carried out in 1985 by the FAO and UNEPCOM consultants in close cooperation with Tanzanian specialists. This effort resulted in obtaining a clear pattern of mycotoxin contamination of agricultural produce in Tanzania substantiated by a scientific report on the subject. The report gives a detailed account of the present situation with mycotoxin contamination of agricultural produce both nationwide and in specific regions regarded as major food and feed producers. It also carries an assessment of the specific critical points in the technology, cultivation, harvesting, storage and transportation of the produce as well as estimates on the country's research, technological and economic capabilities for establishing a national system of mycotoxin contamination control.

4.2.2. Designation of interested organisations for coordinating project activities in Tanzania

In Tanzania, the control of safety of basic foodstuffs is the responsibility of the Ministry of Health. The programme of food safety control is brought into effect by the Government Chemical Laboratory (GCL). In this connection, the Government of Tanzania designated the GCL as the basic organization responsible for the implementation of the project.

In further activities on the establishment of a national system, of mycotoxin contamination control in agricultural produce, the Government Chemical Laboratory may become the leading research institution responsible for the implementation of the mycotoxin control programme.

4.2.3. Technical and consultative assistance in establishing national laboratories

In the years preceding the initiation of the FAO/UNEP/USSR project "Improvement of Mycotoxin Control in Tanzania", the country lacked the laboratory and research base for conducting systematic analysis aimed at mycotoxin control.

In this context, the first stage in the project activities was devoted to studies of the research and technical capabilities of the GCL, identification of critical points in the GCL material and technical basis and compiling the list of what was most needed to successfully achieve the project objectives. In this line, some technical assistance was rendered to the GCL by supplying it with required laboratory equipment and chemicals. In addition, deliveries were made of cars for the collection of samples, refrigerators for storage of samples, air conditioners and other relevant equipments. The Laboratory's high pressure liquid chromatograph which had not been in working condition was repaired, brought into operation and supplied with necessary spare parts. This enables the Government Chemical Laboratory to proceed with more efficient analysis of foodstuffs contaminated with aflatoxins.

Thus, the GCL which is the national-largest laboratory for the food quality control has been provided with material resources necessary for systematic analysis of mycotoxin contamination.

4.2.4. Training of national cadre of specialists

With a view to train Tanzanian national personnel capable of dealing with mycotoxin contamination control of agricultural products, three research fellows have been trained in the USSR, and a training course on mycotoxin control as well as on-site training of technical personnel at the leading national laboratories have been organized in Tanzania.

As the result of 2-month fellowship training in Moscow at the Institute of Nutrition (USSR Academy of Medical Sciences) which is the leading Soviet institution in mycotoxin research, three specialists from the GCL have been trained who are now capable of providing further training to local personnel, giving consultative assistance on the subject to interested institutions and individuals, and acting as organizers of the national mycotoxin control system.

The FAO and UNEPCOM consultants, assisted by the above specialists, organized and conducted 4 training courses on the mycotoxin problem for national personnel.

The courses were held at the GCL with the result of 14 specialists trained in methods of grain sample collection and 15 - in methods of chemical analysis for mycotoxin. Moreover, a seminar on methods of grain sample collection has been organized in Zanzibar including training of 8 fellows from the Zanzibar GCL.

The trainees were selected from among the staff-members of those institutions which would be responsible for the in-field mycotoxin control.

Thus, a qualified personnel capable of organizing and operating the monitoring system has been established in the country.

4.2.5. Preparation of a manual on aflatoxin control with due regard for local conditions

In order to facilitate the task of mycotoxin control, need was felt for a manual containing quidelines on sampling and chemical analysis of specimens of agricultural products for the presence of aflatoxins and giving due account for specific geographic and social features of Tanzania.

Taking into account that correct methodology is a necessary condition for the effective functioning of analytical survey in a system of mycotoxin control, special attention has been given to a proper choice of sampling techniques and analytical procedures well suited for the analysis of aflatoxins in agricultural produce. For this purpose, a good number of techniques have been tested designed for analyzing aflatoxins in agricultural products and adopted as official analytical procedures in the systems of mycotoxin control actually in force in such countries as the USA, the USSR, Great Britain, Denmark and others.

As the result, two methods of aflatoxin analysis have been given preference as meeting basic requirements set for the aflatoxin analysis and local conditions. These are:

1) CB-method for the analysis of maize;

2) water-acetone method for the analysis of groundnuts and other crops with high oil content.

Both methods are based on the aflatoxins' ability to produce a fluorescence when exited by the long-wave UV-light and include the following stages:

- aflatoxin extraction from the sample;
- purification of the extract from proteins, lipids, pigments;
- separation, identification and quantification of aflatoxins by thin layer chromatography (TLC).

Both methods are excellent for determining aflatoxins in agricultural products, do not require sophisticated equipment, are relatively inexpensive, easily duplicated and allow determination of aflatoxins at levels which are lower than the limits of tolerance established in the majority of countries.

The work carried out by the FAO/UNEP consultants in close collaboration with Tanzanian specialists laid foundation for the establishment of a national system of mycotoxin control. This includes a manual on sampling and analysis of agricultural produce for the presence of aflatoxins which gives an up-dated coverage of such important aspects of mycotoxin analysis as sampling of food/feeds, chemical analysis, data treatment, quality assurance and basic safety precautions in the analysis of mycotoxins. The manual may be recommended for the use in Tanzania as "official methods" in a national system of aflatoxin contamination control in agricultural products.

4.2.6. Preparation of an information booklet

An information booklet intended primarily for Tanzanian farming cooperatives has been drafted and published on the evaluation and prevention methods of mycotoxin contamination of agricultural products. in addition to an emphasis on the importance of the mycotoxin control for the national economy and public health, the booklet presents a description of means and ways of preventing contamination of agricultural products with toxic moulds at stages of cultivation of basic crops, their harvest, storage and transportation. Special attention is given to methods of control and to preventive measures against mycotoxin contamination of foods and feeds in countries of tropical regions based on a thorough analysis of the current world situation in this field.

4.3. Analysis and Interpretation of Current Data on Mycotoxin Contamination in Tanzania's Food Supply

Extensive knowledge on the production, storage and distribution system is required before a monitoring programme for mycotoxins can be developed and implemented. Particularly, knowledge related to the storage and distribution of commodities from producers to consumers must be thoroughly understood before designing a monitoring programme that will protect humans against the risk of mycotoxin contamination.

Information relevant to the structure of Tanzanian agriculture and indicative of specific ecological and social features of the country was collected, analyzed and consolidated in the form of a survey reported herein.

4.3.1. Agricultural production, environmental and social data on Tanzania

The United Republic of Tanzania is situated to the South of Equator and occupies the area of 942,800 square km, of which 881,300 square km is land. Most of its land lies over 200 m above sea level, and much of the country is higher than 2,000 m. Woodland, bushland and savannah grassland are predominant types of vegetation (Fig. 1).

The climatic conditions in Tanzania are typical for tropical regions. However, considerable difference in geographical latitudes determine significant range of temperatures, humidity and precipitations in various regions of the country. There are four seasons there: predominantly warm and dry season from January to March; heavy rains from April to May; cold and dry season from June to September; and a slightly rainy season from November to December.

The population of Tanzania is estimated to be over 22 mln. In Tanzania, 85% of the population live in villages and are engaged in agricultural production at farmer/peasant level. However, the urban population has been increasing at a tremendous rate (1948 - 2.6%, 1967 - 6.2%, 1978 - 12%, 1985 - 15%).

In Tanzania agriculture is the backbone of the economy. Thus, the export of agriculture products accounts for 80% of the total Tanzanian export. Export crops are greatly depended upon as source of foreign exchange to finance productive activities and other essential services. For example, Tanzanian export crops (mainly cotton, coffee, tea, sesame, oilseeds and oilnuts) account for 75% of the total foreign exchange earnings (see Tables 4, 5).

Table 4

Exports of cash crops (1981-1985)
(quantity in '000' metric tons)

Year	Cotton	Coffee	Tea	Tobacco
1981	44.09	60.72	14.08	10.61
1982	36.76	52.23	11.43	10.06
1983	39.51	46.4	16.65	5.57
1984	27.40	52.70	11.11	3.51
1985	26.03	43.63	11.12	6.41

Source: E.A.C. Annual Trade Reports,
Tanzania Trade Reports

In order to ensure self-sufficiency in food production in 1984 Tanzanian National Food Strategy was enunciated. However, at present this problem cannot be resolved due to subsistence nature of peasant farming, insecure harvest owing to wide fluctuations in weather conditions and lack of sufficient grain reserve to relieve periodic shortage.

During the last 30 years, grain yields in the country dropped on the average by 14% (1952 - 1,271 kg/ha, 1985 - 1,091 kg/ha) which have led to a decrease in the annual income and living standards of the population.

Table 5

Oilseeds and Oilnuts Exports during 1975-1985
(quantity in metric tons)

Year	Sesame	Sunflower	Castor seeds	Kopok seeds	Copra	Palmnuts
1975	3089	2313	3000	203	-	83
1976	700	335	1196	34	-	-
1977	200	100	2600	170	322	-
1978	3022	4450	2155	205	5247	1000
1979	4802	141	6080	420	2177	1000
1980	8838	150	1810	623	2069	1031
1981	14070	-	1008	-	-	-
1982	2117	-	-	-	-	-
1983	2000	-	154	-	1000	-
1984	650	-	50	-	-	-
1985	15	-	1725	-	-	-

Source: E.A.C. Annual Trade Reports,
Tanzania Trade Reports
Period of reference: calendar year

Seventy five per cent of the foodstuffs in the country are grown, stored and consumed within the households and only 25% is marketed. The share of collective and state-owned agricultural enterprises is minimal and their output is equal only to 5% of the gross national agricultural production.

In Tanzania two types of agricultural activities are practised:

- traditional or peasant agriculture, in which mechanized aids are rarely used, and the work performed depends mostly on muscular energy; and

- organized or plantation agriculture, in which more mechanized and new agricultural techniques are employed.

For crop production pattern, the following four agroclimatic-political regions may be recognized, although in some of the regions several ecological zones with altitudes ranging from 500 m to 3.000 m exist:

1. Coastal regions of Dar-es-Salaam, Morogoro, Tanga, Lindi and Mtwara.

2. Dry Central and North-Western regions, consisting of Shinyanga, Mwansa, Mara, Singida and Dodoma.

3. Northern and Southern highlands of Arusha, Kilimanjaro, Iringa, Mbeya, Rukwa and Ruvuma.

4. Islands of Zanzibar and Pemba.

In most regions food production is only for local needs, although grain surpluses are produced in such regions as Ruvuma, Iringa, Mbeya, Rukwa - usually called the Big Four.

The production of the most important crops in 1985-1986 was as follows (in thousand tons): maize - 2670; millets - 300; sorghum - 384; cassava - 1499; oilseeds - 395; rice - 417; wheat - 98.

The domestic food production shortage has resulted in a raising trend in grain import (see Table 6). The country imports mainly maize, rice, wheat.

According to data supplied by the Tanzanian Ministry of Agriculture and Livestock Development (Figures 2, 3) the top place in the country's crop production belongs to maize. In 1981-1986 the level of its production almost doubled. Over 1,576,000 ha of arable land were planted with maize in 1985/86, whereas all other grains (sorghum, millet, paddy and wheat) accounted for only 1,108,000 ha. Maize is grown in 20 agricultural regions of the county of which Iringa, Arusga, Mbey, Ruvuma and in recent years Shinyanga, Kilimanjaro and Tanga are reputed as main maize-producing regions (Fig. 4).

Table 6

Food Imports and Food Aids in 1981/82-1985/86
(quantity in '000' metric tons)

Year	Maize			Rice			Wheat		
	Comm*	Aid	Total	Comm*	Aid	Total	Comm*	Aid	Total
1981/82	80.0	151.7	231.7	50.0	16.5	66.5	-	70.9	70.9
1982/83	17.0	106.4	123.4	-	45.2	45.2	3.4	2.0	11.4
1983/84	125.1	69.2	194.3	30.4	26.7	57.1	-	46.3	46.3
1984/85	111.1	26.5	137.6	20.5	25.1	46.6	-	33.5	33.5
1985/86	22.6	3.0	25.6	19.5	22.2	41.7	-	21.7	21.7
Total	355.8	356.8	712.6	120.4	136.7	257.1	3.4	174.4	183.8

* Commercial

In recent years there has been an increase in oil seeds and oil nuts production in Tanzania (Fig. 3). Thus, in 1985/86 it amounted to 400,000 tons, as much as was produced in 1981/82. These crops account for more than 700,000 ha of agricultural land. The main producing regions are Mtwara, Dodoma, Tabora, Shinvanga, Tanga and Lindi (Fig. 5). Besides, Zanzibar is the main producer of copra most of which is exported.

The basic traditional staple crops are also cassava produced at the level of over 1,600,000 tons/year, wheat - about 50,000 tons/year, etc. (Figures 6, 7).

Most of the post-harvest agricultural operations are carried out manually and there seems to be a poor storage of food grains. Often, storage of food grains just after harvest is carried out in the open with improper drainage at the bottom and inadequate covering at the top, thus being exposed to danger of accumulating moisture during unfavourable weather conditions.

For example, in 1986 the Ruvuma produced a total of 51,221 tons of corn and that year about 14,044 tons remained stored in local godowns. This is the corn that is most susceptible to mycotoxin contamination. Regional officials stated that 6,000 tons of corn in Ruvama region had been destroyed during that season due to improper storage facilities.

According to official data, estimated post-harvest storage losses of grains amount to 20-30% of the harvested produce. Hence, it can be stated that storage and drying of agricultural produce are carried out mostly by such methods which do not ensure protection from mould fungi and, consequently, from contamination by their secondary metabolites, i.e. mycotoxins.

Currently, Tanzania is undergoing an economic recovery programme in the rehabilitation of its agriculture production system. This programme is designed for Tanzanians to utilize the abundant arable land to attain self-sufficiency in food. In terms of increased agricultural production capacity, Tanzania is in a very favourable position, because only 6 out of 40 million hectares of arable land are currently being cultivated. While the potential agricultural production system seems very promising with respect to Tanzania's ability to produce an increased amount of agricultural products, the infra-structure of the Tanzanian marketing system is underdeveloped. Deficiencies identified by senior level government officials include lack of a sufficient number of quality godowns, inadequate road and transportation, and a centralized marketing system that is not flexible enough to efficiently move agricultural products from producers to consumers. These deficiencies, particularly the lack of quality godowns, are critical factors that will determine the levels of mycotoxin contamination in Tanzania's food supply.

The Tanzanian Government should be commended for present efforts associated with the improvements in storage and transport facilities. The Government, under a pilot programme assisted by FAO has built 47 godowns in the major agricultural production areas.

These storage facilities have a collective capacity to hold 12.400 tons. An adequate supply of quality storage facilities will greatly reduce the quantity of agricultural products that are susceptible to mycotoxin contamination.

The Tanzanian marketing and distribution system is highly centralized and controlled through various governmental departments.

The distribution system basically consists of the farmers selling corn to a cooperative union that resells to the district level that in turn resells to the regional level. The regional level sells the corn to the National Milling Corporation, a governmental agency that is responsible for milling and processing the corn. After processing, the National Milling Corporation sells the corn to National Distributors Ltd., a government agency that is responsible for the distribution of corn to consumers.

In this regard, it can be said that the protection of agricultural products against contamination by foreign toxic substances including mycotoxins, and increased quality of foodstuffs are possible only subject to the establishment of a nationwide control system.

4.3.2. Representative sampling of the agricultural products for aflatoxin contamination analysis

The selection of agricultural crops for aflatoxin contamination analysis was done on the basis of information on the agricultural production in the country (section 4.3.1.).

The most attention was paid to that types of the crops which, on the one hand, are mostly affected to the risk of aflatoxin contamination and on the other hand they are traditional food products for the population.

The traditional staple crops for local population are maize, wheat, groundnuts, bananas and beans.

Fig.1. The Map of Tanzania.

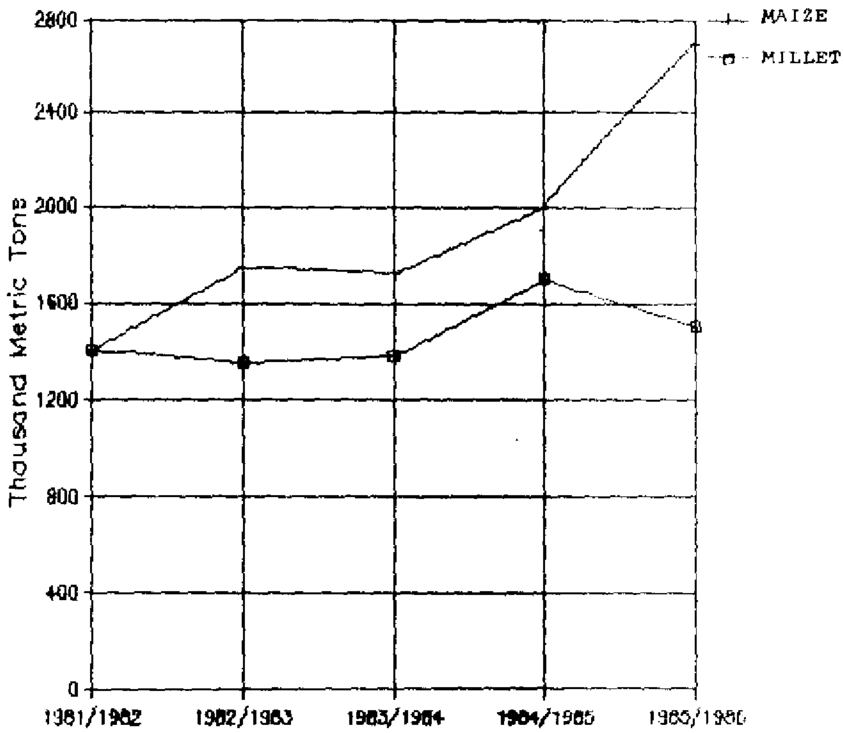

Fig.2. Crop production of Tanzanian Mainland.

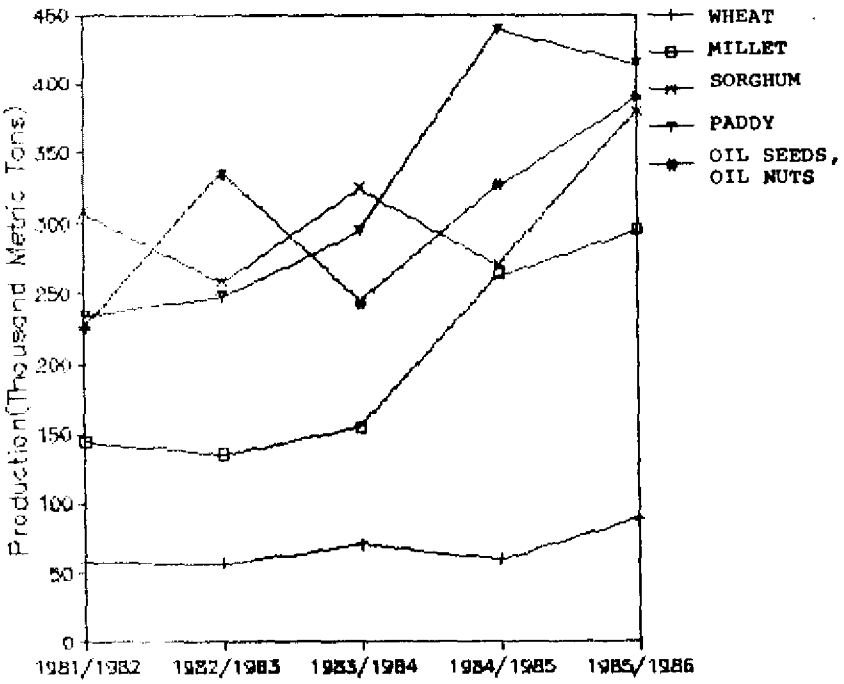

Fig.3. Crop production of Tanzanian Mainland.

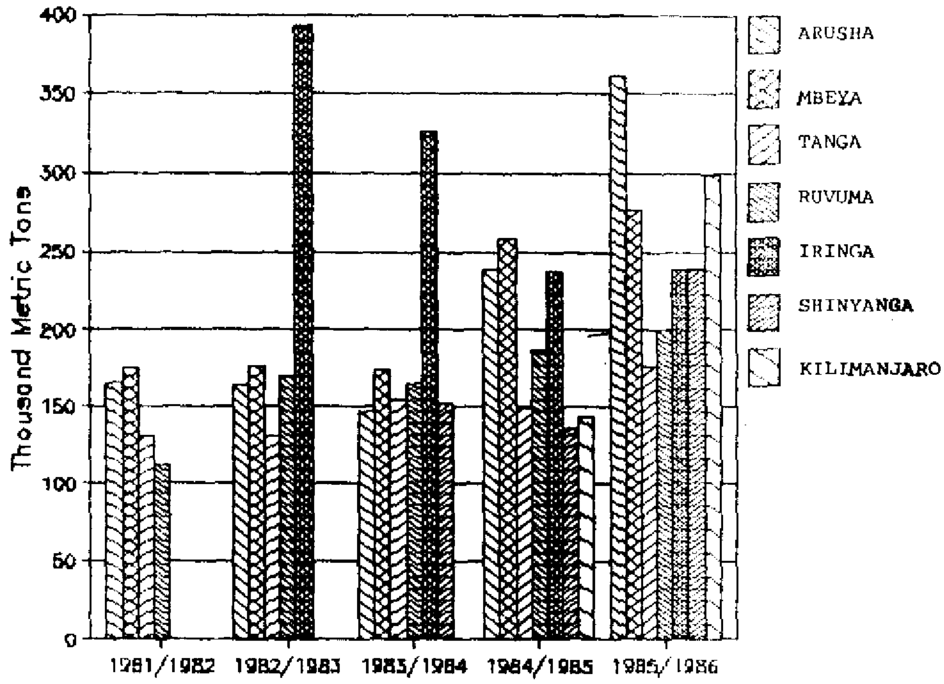

Fig.4. Production of maize (Regionwise).

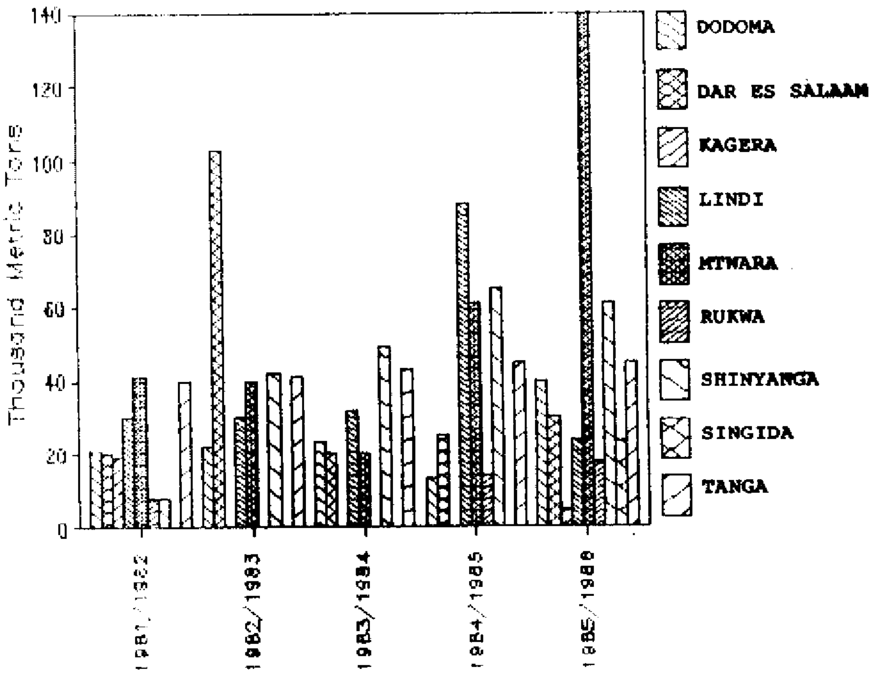

Fig.5. Production of Oil-Seeds and Oil-Nuts (Regionwise).

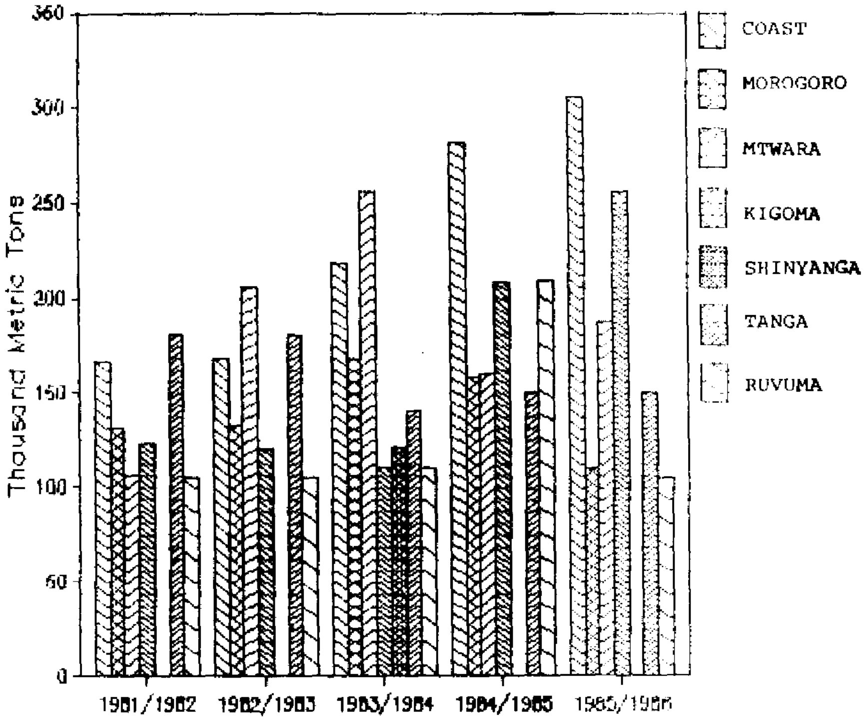

Fig.6. Production of Cassava (Regionwise).

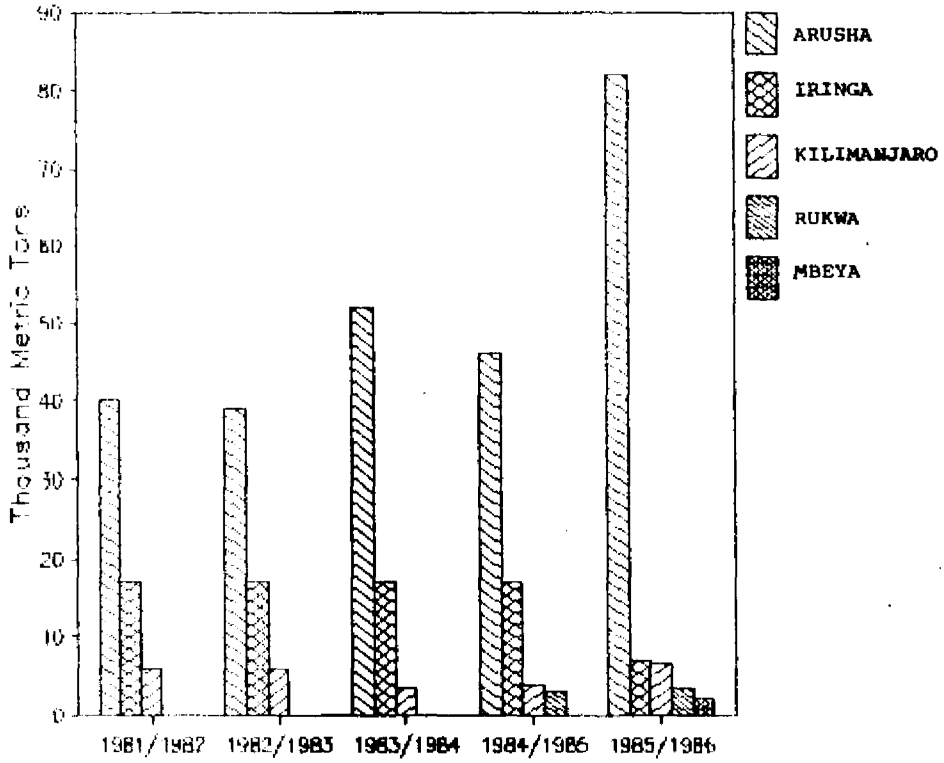

Fig.7. Production of Wheat (Regionwise).

Taking into consideration that maize is more susceptible to aflatoxin contamination and its consumption increases with the growth of population the priority in study has been given to maize.

As opposed to maize which is consumed only locally, most of the oil seed and oil nut yields are exported to other countries. That is why the crops of oil seeds and oil nuts, being highly susceptible to aflatoxin contamination, are the main crops studied for the frequency and level of aflatoxin contamination.

Sampling took place, first of all, in the main regions producing agricultural products which were subjected to the utmost risk of aflatoxin contamination (maize, nuts) and in the urban ones with high level of food consumption as well as in the places of the main import of those products (big cities, ports).

The basic producing and consuming regions where representative samples were collected had been united in the following groups:

1. Arusha + Kilimanjaro.

2. Dar-es-Salam + Tanga.

3. Dodoma + Tabora.

4. Ruvuma + Mbey.

5. Zanzibar.

Collection of the representative samples was carried out in accordance with the recommendations mentioned in section 3.1.1., page 16.

Totally 1446 representative samples of 19 agricultural crops and roducts of their processing were collected throughout the country.

More than a half (52.1%) of the above samples accounted for grains. In fact, the aflatoxin contamination has been analyzed in 578 samples of white and yellow maize (40.0%) as well as in

175 representative samples of other cereals (12.1%). The number of samples of oil seeds and products of their processing made up 36.6% of the total quantity of the analysed samples.

To obtain the information of the real situation on contamination of agricultural production in Tanzania and to develop recommendations on organisation of mycotoxin monitoring programme all the representative samples were subjected to aflatoxin chemical analysis.

4.3.3. Assessment of the Incidence, Extent and Level of Mycotoxin Contamination in Agricultural Produce in Tanzania

Chemical analysis of 1446 representative samples of the basic types of agricultural products was carried out taking into consideration the recommendations attached to section 3.1.1. of the present report and it included quantitative determination both of aflatoxin B_1 and aflatoxins B_2, G_1, G_2. It was because of the reason that a number of the agricultural crops especially oil crops are effected to the risk of contamination both by aflatoxin B_1 and aflatoxins B_2, G_1 and G_2. Moreover it was necessary to have an experimental data of extent and level of aflatoxin contamination in agricultural produce in Tanzania in order to prepare in the future the recommendations on the improvement of the national legislation governing maximum permissible concentrations of mycotoxins in various agricultural products.

One has to mention that AQAP conducted in the course of the experimental researches in Tanzanian Government Chemical Laboratory gave positive estimation of the analytical service.

Analysis of the experimental data statistically processed showed that cereals and oil-production crops are the most frequent subjects to the aflatoxin contamination (see Table 7).

Among cereals the incidence of aflatoxin contamination was found to be in yellow maize (23.6%), white maize (11.2%), and millet (17.7%). It would be noted, that with the exception of one sample of wheat imported from Canada and contaminated with aflatoxin B_1 at the level of 15 ppb, all samples of wheat and wheat product were found to be free of aflatoxins. Analytical results also showed that rice was not contaminated with aflatoxin except for one sample of rice cake from Zanzibar with the level of aflatoxin B_1 contamination of 10 ppb. Of 41 samples of sorghum only one proved to be contaminated at the level of B_1 = 2.2 ppb, and B_2 = 1.3 ppb.

It should be especially noted, that 16% of samples of yellow maize were contaminated with aflatoxin B_1 at the level of above 5 ppb, and the content of total aflatoxin superior to 20 ppb in the samples amounted to 7% of the total number of samples under study.

As compared with the yellow maize, the white maize is less subject to the aflatoxin contamination at the levels exceeding the maximum allowable concentrations (B_1 > 5 ppb, >AT > 20 ppb). For example, 6% of the total number of studied samples contain more than 5 ppb of aflatoxin B_1 and only 1% of samples was contaminated at the level above 20 ppb of total aflatoxin.

Among the oil-producing crops, samples of groundnuts and copra were most contaminated with aflatoxins, 50.0% and 40% respectively. Moreover, it should be noted, that 45% of samples of ground-nuts were contaminated by aflatoxin B_1 at the level above 5 ppb. Besides 36% of groundnut samples showed total aflatoxin concentration above 20 ppb. The incidence of copra and copra products contamination was 40.8%. The aflatoxin concentration in copra and products of its processing was above 20 ppb for total aflatoxin and found in 4.1% of samples.

As regards sunflower, 10.8% of samples were contaminated by aflatoxin B_1 at the level from 4.4 ppb to 80.0 ppb. On the other hand, samples of such oil-producing crops as sim , cloves, castor seeds, cotton seeds were found to be aflatoxin-free.

Analysis of the experimental data of legumes and other products (Table 7) showed the following: aflatoxins were registered only in pea samples and no in other legumes samples. Thus in samples from Dodoma the level of aflatoxin contamination was 9.9 ppb for B_1, whereas in Dar-es-Salam one sample was contaminated at the level of

8.8 ppb for B_1 and the other contained aflatoxin B_1 + B_2 at the concentration of 7.2 ppb. In 75 samples of beans, aflatoxins were not found.

Analytical results obtained for samples of bananas, coriander, cardamon, cassava supported the view (in circulation in the relevant world literature) that these varieties of agricultural products are not subjected to aflatoxin contamination. Besides that, the studied 24 samples of green coffee grown in Tanzania showed that the Tanzanian coffee is not subjected to aflatoxin contamination. Therefore, it can be stated that the above products do not require tests on aflatoxin contamination.

Subsequent pages of the report are devoted to discussion of the results of research on aflatoxin contamination of white and yellow maize, groundnuts, and copra.

A. White maize

This crop is an important and traditional food for the population of Tanzania. Therefore the white maize was subjected to the most thorough analysis for aflatoxin contamination. Altogether, 472 representative samples of white maize have been analyzed particularly of the 1987 and 1988 crop harvests.

The samples were collected in the major regions where white maize is cultivated (Arusha, Kilimanjaro, Mbeya, Iringa, Ruvuma, Dodoma) and also in the regions with high urban population (Dar-es-Salaam, Tanga) where white maize is mostly imported from other regions of Tanzania.

In Tanzania the maize is harvested both by mechanical means, e.g. combine harvesters in large scale fields, and also by manual labour at small scale farms. In many regions the harvest is transported by wheel burrows and carts alongside lorries. A traditional method of drying the harvest before storage is by natural heat (drying in the sun) and in houses heated by fire (smoking).

The harvest in Tanzania is distributed in the following way:

- part of the harvest is supplied to the National Milling Corporation;
- part of the harvest is sold by the farmers to cooperative unions;
- part of the harvest is used by local consumers;
- in some cases part of the harvest is exported to the neighbouring countries, such as Zambia or Kenya.

Experimental data on the incidence and level of contamination of white maize in different regions of Tanzania are shown in Tables 8 and 9.

Taking into account that cereals are most frequently contaminated with aflatoxin B_1 as compared with other crops, the situation with white maize contamination with aflatoxin B_1 and total aflatoxins (B_1 + B_2 + G_1 + G_2) was studied separately.

Arusha and Kilimanjaro. Of 165 samples no more than 5 (4.2%) proved to be contaminated with aflatoxin. The contaminated samples contained mostly aflatoxin B_1 at the level from 3.0 to 62.9 ppb. In 4 samples alongside aflatoxin B_1 the aflatoxin B_2 was traced at the level from 2 to 10 ppb, and only one sample of the 1988 harvest was contaminated with total aflatoxin with B_1 = 9.3 µg/kg, B_2 = 10.1 µg/kg, G_1 = 6.5 µg/kg, and G_2 = 0.7 µg/kg. The mean aflatoxin content in the analyzed samples did not exceed 1 µg/kg. However of the 7 contaminated samples 57.1% contained aflatoxin B_1 at the level above 5 ppb, while 42.9% of the contaminated samples contained total aflatoxin at the level above 20 ppb.

Ruvuma and Mbey. Together with Arusha and Kilimanjaro this region is one of the major producers of white maize in Tanzania. 101 samples were collected and analyzed there. The mean level of contamination is also higher in this region and amounts to 1.7 µg/kg for B_1 and 1.9 µg/kg for total aflatoxin. In all contaminated samples the aflatoxin B_1 was present at the level from 1.2 to 19.4 ppb. In 11 contaminated samples aflatoxin B_1 and aflatoxin B_2 were registered at the level from 1 to 5 ppb. The results obtained show (Table 8) that 10% of the analyzed samples were contaminated with aflatoxin B_1 at the level from 6.2 to 19.4 ppb. Higher incidence and level of contamination of white maize by aflatoxin in the above mentioned region as compared with Arusha and Kilimanjaro can be possibly due to poor storage and transportation of the harvest.

Dar-es-Salaam and Tanga. In these regions with very high level of urban population white maize consumption increases. Apart from the local crop harvested here white maize is imported from other regions of Tanzania. High incidence and level of aflatoxin contamination of white maize emphasizes the need for white maize control for aflatoxin contamination, especially at the National Milling Corporation and in large cooperative unions.

B. Yellow maize

Yellow maize is mostly imported from other countries and then distributed among the regions in Tanzania. For example, yellow maize imports in 1986/1987 totalled 93 thousand tons (commercial - 85 thousand, aid - 8.8 thousand tons).

Traditionally yellow maize and popcorn are used in Tanzania in the following pattern:

a) for human consumption (flour and seeds for cooking);

b) for animal feeds (poultry and dairy cows).

Samples of yellow maize for analysis were collected in different regions of the country in 1987-1988.

The yellow maize contamination was studied for both aflatoxin B_1 and also total aflatoxin (Tables 10, 11).

The highest incidence and levels of contamination were recorded in samples from Dar-es-Salaam - Tanga and Ruvuma - Mbeya. In these regions 10% of samples were contaminated at the level above 25.7 ppb for aflatoxin B_1 (Dar-es-Salaam - Tanga) and above 33.8 ppb for aflatoxin (Ruvuma - Mbeya).

It should be especially noted that only the samples collected in Ruvuma - Mbeya were contaminated not only by aflatoxin B_1 and B_2 but also by G_1 and G_2. For example, one sample of maize for human consumption contained aflatoxin = 346.7 ppb (B_1 = 227.5 ppb; B_2 = 59.3 ppb; G_1 = 53.9 ppb; G_2 = 6.0 ppb). Such a situation may occur due to poor storage and transportation of yellow maize in the Ruvuma - Mbeya region. Thus, the analysis of 106 samples of yellow maize showed a 25.6% incidence of aflatoxin contamination. The level of aflatoxin in the contaminated samples, in particular, in those from imported yellow maize, was determined to be at a very high level. For example, 68% of contaminated samples contained aflatoxin B_1 at the level above 5 ppb, and in 32% of the same samples the total aflatoxin concentration was above 20 ppb (Table 17).

In conclusion, the yellow maize is more subjected to aflatoxin contamination than white maize, and therefore is more hazardous to the population health. Special attention should be given to the aflatoxin control in imported consignments of maize grain which appears to be frequently contaminated.

C. Groundnuts

Major regions producing groundnut in Tanzania are Mitwara, Lindi, Ruvuma, Mbeya, Rukiva, Dodoma, Singida, Tabora, Shinyonga, Mara and Mwanza.

Harvesting is done at optimum time when the soil is still soft to avoid spouting. Groundnuts are normally harvested by carefully digging around the plants using a hand hoe then pulling out the plant. This method assures the total collection of all the nuts.

There are two methods of drying the nuts to avoid moulding:

1) pods are plucked from the plants and spread on mats to dry on raised platforms;

2) the plants are turned upside down exposing the pods to the sunshine for a few days in the field.

The groundnut harvest in Tanzania is usually transported in the following manner:

1. trucks are used to transport the groundnuts to market, National Milling Corporation, etc.;

2. wheel burrows are mainly used to ferry the harvest at short distances;

3. donkeys are occasionally used to transport groundnuts;

4. villagers carry groundnuts on their heads in small quantities especially for home use.

Groundnuts in Tanzania are mostly used for food. The harvest is distributed in the following pattern:

- part of the harvest is supplied to the National Milling Corporation;
- part of the harvest is sold by farmers on the market;
- part of the harvest is sold to local farmers being the large consumers.

In the recent years a trend is observed to sell groundnuts to the neighbouring countries where groundnuts are purchased at a better price than within the home country.

Representative groundnut samples were collected in the major groundnut producing regions and in Dar-es-Salaam and Tanga where groundnuts are brought from other country's regions and sold to the population usually through local markets. Statistical data on the incidence and levels of contamination of groundnuts in major producing regions of Tanzania are shown in Tables 12 and 13.

It was found that both in the studied regions and throughout the country the incidence and levels of contamination of groundnuts are extremely high.

Dar-es-Salaam + Tanga. The highest incidence of contamination (58.4%) is recorded in this region as compared with other parts of the country. Moreover, the level of contamination in the analysed samples collected mostly at the city markets were the highest. For example, the mean level of contamination by aflatoxin B_1 = 112 ppb, and in 10% of the analysed samples the aflatoxin B_1 concentration was 297.6 - 1600 ppb.

Almost all the samples were also contaminated by aflatoxin B_2, G_1 and G_2. The mean level of contamination of groundnuts total aflatoxin was 163.3 μg/kg, and occasionally total aflatoxin = 2027.9 ppb, which is 100 times higher the commonly accepted maximum allowable concentration for aflatoxin (20 ppb). Besides that, almost in 77% of samples the total aflatoxin contamination was above 20 ppb.

Arusha-Kilimanjaro. The incidence and level of groundnuts contamination by aflatoxin is lower in this region as compared with Dar-es-Salaam + Tanga, however, the statistical analysis of results (Tables 13 and 14) show that in both regions there is a danger to consumers due to high aflatoxin contamination of groundnuts.

Dodoma + Tabora. These are the major groundnut producing regions in Tanzania. Representative samples were collected mostly in farms of individual owners and Cooperative Union. Results of chemical analysis are shown in Tables 13 and 14. It can be clearly seen that 50% of the analysed samples were contaminated with aflatoxin with the mean level of contamination of aflatoxin B_1 = 30.3 ppb and total aflatoxin = 45.8 ppb. The maximum contamination level recorded in the region was aflatoxin B_1 = 355.5 ppb and total aflatoxin = 660.7 ppb.

The fact that the highest contamination of groundnuts is observed in the Dar-es-Salaam + Tanga region is due to the fact that during the harvest transportation trucks are not covered well (well protected from the rain and night moisture and daylight heat), and also during poor storage directly in the markets there is a growing risk of additional aflatoxin contamination of groundnuts.

D. Copra and Copra Products

Zanzibar is the major copra producer in Tanzania. There are also considerable copra plantations on the Mafia iceland (Mainland).

The bulk of copra produced is intended for export. Within the country copra is used both for human consumption and as the animal feed, and also perfume industry. Copra is the raw material for coconut oil which is used for food purposes and to manufacture high grade soap. It is also widely used as a component to produce animal feeds for dairy cows, pigs, etc.

Domestic sale prices for copra before 1986 were as follows:

1983/1984 - 10.00 sh/kg
1984/1985 - 20.00 sh/kg
1985/1986 - 24.00 sh/kg

However starting from 1987 sale prices for copra started decreasing. This is possibly due to increased palm oil production in Malaysia, and higher oil production from different oil crops in Europe, and also decreased consumption use in developed countries.

The marketing of copra is official and is usually carried out from village level up to cooperative levels and then exported.

Lower copra exports can increase the storage period under the conditions favourable for growth of fungi and mycotoxin production.

In view of the above mentioned and growing risk of copra contamination by mycotoxins the incidence and levels of contamination was studied for copra and main products of its processing. The data obtained as a results of investigating copra, copra cake and copra oil in Zanzibar (Table 7).

Over 34% of the analyzed samples of copra were contaminated by aflatoxins. The mean level of contamination was below 2 ppb for aflatoxin B_1 and 4 ppb for total aflatoxin. However 10% of the analyzed samples showed aflatoxin B_1 contamination within the range from 6 ppb to 16.6 ppb with the total aflatoxin ($B_1 + B_2 + G_1 + G_2$) varying from 10.2 to 58.6 ppb.

More than 57% contaminated samples of copra showed aflatoxin B_1 concentration above 5 ppb, and in 14% of samples the total aflatoxin ($B_1 + B_2 + G_1 + G_2$) exceeded 20 ppb (Tables 15 and 16).

The incidence of contamination of copra cake bu aflatoxins is almost 2 times as high as that of copra. It was found that as compared with copra the mean level of copra cake contamination by aflatoxin B_1 and total aflatoxin was 2 and 1,5 times higher.

A higher contamination of copra cake as compared with copra is possibly due to differences in the biochemical composition and also worse conditions of storage.

In Tanzania copra cake is mostly used as a fertilizer and occasionally as animal feed additives. There are no official channels for marketing copra cake. All this leads to poor storage during which copra cake is subjected to a heavier aflatoxin contamination.

The above results support views published in the relevant literature that copra, like other oil-producing crops, is highly susceptible to aflatoxin contamination. This in turn suggests the necessity of a systematic control of aflatoxin contamination in this crop.

To clear out the situation with aflatoxin contamination of basic agricultural crops a statistical analysis was carried out based on the experimental data (Tables 15 and 16). It was shown that the incidence of white and yellow maize contamination, as well as that of groundnuts and copra of the 1986/1987 harvest was lower as compared with the 1987/1988 harvest. However the levels of contamination by aflatoxin of the above crops in 1986/1987 were higher than in 1987/1988 harvest.

To sum up the results of investigations (Tables 7-17) carried out within the framework of the FAO/UNEP/USSR/Tanzania project the following conclusions can be made. In Tanzania there exist a dangerous situation with aflatoxin contamination of such agricultural products as white and yellow maize, groundnuts and copra, that are the traditional foodstuffs of the Tanzanian population.

The research-based findings point to a necessity of urgent steps to be taken in Tanzania for setting a nation-wide system of aflatoxin contamination control in basic Tanzanian foods and feeds produced for both consumption inside the country and export.

The need for a national system of aflatoxin monitoring is also prompted by the fact that the Food Quality Control Act in force in Tanzania since 1978 does not stipulate that aflatoxin control shall be effected in agricultural produce.

Taking into account the summarizing character of the above research into aflatoxin contamination of basic Tanzanian crops harvested within the period 1986-1988 as well as the experience of many industrialized and developing countries in legislation on aflatoxin monitoring in food and feed products, it is advisable for Tanzania to establish the maximum tolerated aflatoxin concentrations in agricultural products at the levels of 5 ppb of aflatoxin B_1 or 15 ppb of total aflatoxin for basic food products.

Regarding feeds, the following levels are advisable:

- Straight feedingstuffs	50 μg/kg (B_1)
- Compete feedingstuffs for cattle, sheep and goats (except dairy cattle, calves and lambs)	50 μg/kg (B_1)
- Complete feedingstuffs for pigs and poultry (except young animals)	20 μg/kg (B_1)
- Other complete feedingstuffs	10 μg/kg (B_1)
- Supplementary feedingstuffs for cattle, sheep and goats (except dairy animals, calves and lambs)	50 μg/kg (B_1)
- Supplementary feedingstuffs for pigs and poultry (except young animals)	30 μg/kg (B_1)
- Other supplementary feedingstuffs	10 μg/kg (B_1)
- Groundnut, copra, palm kernel, cotton seed, abassu, maise and products derived from the processing thereof	200 μg/kg (B_1)

The recommended limits on aflatoxin levels in food products and fodder are safe as regards human health and appear to be economically sound in relation to export/import food programmes.

Table 7. **Contamination of Agricultural Production with Aflatoxins in Tanzania**

n/n	Type of agricultural products	Total sample number	Contaminated samples	% of total samples, in which AT B_1>5ppb *	% of total samples in which ΣAT>20ppb *	Min-Max concentration of AT in contaminated samples, ppl: B_1	Min-Max concentration of AT in contaminated samples, ppl: $B_1+B_2+G_1+G_2$	Notes
	CEREALS							
1	White maize	472	53	6.0	1.0	1.1-62.9	1.1- 69.5	
2	Yellow maize	106	25	16.0	7.0	0.9-297.0	1.1- 346.7	
3	Wheat and wheat prod	38	1	-	-	15.0	-	Imported Canada
4	Rice and rice prod	58	1	-	-	10.0	-	Rice cake Zanzibar
5	Millet	34	6	8.8	0	2.3-12.9	4.4- 17.0	
6	Sorghum	41	1	-	-	2.2	3.5	Sorghum Dodoma
7	Barley	4	0	-	-	-	-	
	OIL SEED AND THEIR PRODUCTS							
1	Groundnuts	202	101	45.0	36.0	1.1-1600	2.1-2027.9	
2	Copra and copra prod	169	69	22.5	4.1	0.5-37.5	1.5- 58.6	
3	Sunflower	129	14	8.0	3.0	3.5-40.0	4.4- 80.0	Local product
4	Sim Sim	14	0	-	-	-	-	
5	Other oil seeds	15	0	-	-	-	-	Cloves, castor and cotton seeds
	LEGUMES							
1	Peas	28	3	7.0	-	3.0- 9.9	7.2- 9.9	Local products
2	Beans	75	0	-	-	-	-	
	OTHER PROD							
1	Coffee	24	0	-	-	-	-	
2	Cassava	10	0	-	-	-	-	
3	Dried vegetables	27	0	-	-	-	-	
	T O T A L	1446						

* According to the Codex Alimentarius Commission document in force, the maximum limit of total aflatoxins($B_1+B_2+G_1+G_2$) for food for human consumption is 20ppb. The recommended level to be adopted in the nearest future is 5 ppb aflatoxin B_1 for food products.

AO

Table 8. **Frequency and level of white maize contamination with B1 aflatoxin in major regions of Tanzania in 1987-1988**

No.	Region	Number of studied samples	% of contaminated samples	B1>5ppb, % of contaminated samples	Level of contamination with AT B1, ppb				
					Arithmetic mean, $\bar{X}$	Standard deviation, S	Median, M	90-th percentile	Overall range
1.	Arucha + Kilimanjaro	165	4.2	57.1	0.74	5.6	<1	<1	62.9
2.	Ruvuma + Mbey	101	26.7	55.6	1.7	3.8	<1	6.2	19.4
3.	Dodoma + Tabora	162	6.8	36.4	0.4	2.0	<1	<1	22.5
4.	Dar-es-Salam + Tanga	44	19.2	62.5	2.0	8.2	<1	4.2	53.0

AO

Table 9. **Frequency and level of white maize contamination with aflatoxins in major regions of Tanzania in 1987-1988**

No.	Region	Number of studied samples	% of contaminated samples	AT>20ppb, % of contaminated samples	Level of contamination with ΣAT, ppb				
					Arithmetic mean, $\bar{X}$	Standard deviation, S	Median, M	90-th percentile	Overall range
1.	Arucha + Kilimanjaro	165	4.2	42.9	0.9	6.4	<1	<1	69.5
2.	Ruvuma + Mbey	101	26.7	0	1.9	4.8	<1	7.1	19.4
3.	Dodoma + Tabora	162	6.8	9.1	0.6	2.7	<1	<1	26.9
4.	Dar-es-Salam + Tanga	44	19.2	12.5	2.1	8.2	<1	4.7	53.0

Table 10 **Frequency and level of yellow maize contamination with B_1 aflatoxin in major regions of Tanzania in 1987-1988**

No.	Region	Number of studied samples	% of contaminated samples	$B_1 \geq 5$ ppb % of contaminated samples	Level of contamination with AT B_1, ppb				
					Arithmetic mean, $\bar{X}$	Standard deviation, S	Median, M	90-th percentile	Overall range
1.	Arucha + Kilimanjaro	39	13	100	1.5	4.5	<1	6.2	24.3
2.	Dar-es-Salam + Tanga	24	33	75	22.1	66.6	<1	25.7	297
3.	Dodoma + Tabora	18	11.1	0	0.4	1.3	<1	3.6	4.0
4.	Ruvuma + Mbey	21	33.3	71.4	14.6	49.7	<1	13.1	227.5
5.	Zanzibar	4	75.0	33.3	12.1	22.6	1.25	28.1	46.0

Table 11 **Frequency and level of yellow maize contamination with aflatoxins in major regions of Tanzania in 1987-1988**

No.	Region	Number of studied samples	% of contaminated samples	$\Sigma AT > 20$ ppb % of contaminated samples	Level of contamination with AT ($B_1+B_2+G_1+G_2$), ppb				
					Arithmetic mean, $\bar{X}$	Standard deviation, S	Median, M	90-th percentile	Overall range
1.	Arucha + Kilimanjaro	39	13.0	80.0	2.0	6.2	<1	9.5	33.0
2.	Dar-es-Salam + Tanga	24	33.0	50.0	22.4	66.8	<1	27.4	297.0
3.	Dodoma + Tabora	18	11.1	0	0.56	1.6	<1	3.8	6.0
4.	Ruvuma + Mbey	21	33.3	42.9	22.7	75.2	<1	33.8	346.7
5.	Zanzibar	4	75.0	33.3	12.1	22.6	1.25	28.1	46.0

AO

Table 12 **Frequency and level of groundnuts contamination with aflatoxins in major regions of Tanzania in 1986-1988**

No.	Region	Number of studied samples	% of contaminated samples	>AT>20ppb, % of contaminated samples	Level of contamination with AT ($B_1+B_2+G_1+G_2$), ppb: Arithmetic mean, $\bar{X}$	Standard deviation, S	Median, M	90-th percentile	Overall range
1.	Arucha + Kilimanjaro	58	37.9	72.7	66.3	212.5	<4	119.3	1383
2.	Dar-es--Salam + Tanga	89	58.4	76.9	163.3	352.2	10.6	402	2028
3.	Dodoma + Tabora	46	50.0	69.6	45.8	120.3	<4	93.9	660.7
4.	Zanzibar	9	44.4	25.0	38.4	109.2	<4	39.8	329.5

AO

Table 13 **Frequency and level of graund-nuts contamination with aflatoxin B_1 in major regions of Tanzania in 1986-1988**

No.	Region	Number of studied samples	% of contaminated samples	B_1>5ppb % of contaminated samples	Level of contamination with AT B_1, ppb: Arithmetic mean, $\bar{X}$	Standard deviation, S	Median, M	90-th percentile	Overall range
1.	Arucha + Kilimanjaro	58	37.9	95.5	54.9	191.7	<1	76.6	1290
2.	Dar-es--Salam + Tanga	89	58.4	92.3	112.0	248.3	8.8	297.6	1600
3.	Dodoma + Tabora	46	50.0	87.0	30.3	73.6	<1	73.3	355.5
4.	Zanzibar	9	44.4	50.0	30.2	86.2	<1	31.4	250

Table 14 **Frequency and level of contamination of copra and products of its processing with aflatoxin B_1 in major regions of Tanzania in 1987-1988**

No.	Product	Number of studied samples	% of contaminated samples	Level of contamination with AT B_1, ppb				
				Arithmetic mean, $\bar{X}$	Standard deviation, S	Median, M	90-th percentile	Overall range
1.	Copra	123	34.1	1.8	3.2	<1	6.0	16.6
2.	Copra cake	39	66.7	3.8	6.0	3.6	5.0	37.5
3.	Copra oil	Only one sample was contaminated with AT B_1 at the level of 3 ppb						

Table 15 **Frequency and level of contamination of copra and products of its processing with aflatoxins in major regions of Tanzania in 1987-1988**

No.	Product	Number of studied samples	% of contaminated samples	Level of contamination with AT ($B_1+B_2+G_1+G_2$), ppb				
				Arithmetic mean, $\bar{X}$	Standard deviation, S	Median, M	90-th percentile	Overall range
1.	Copra	123	34.1	3.8	8.4	<4	10.2	58.6
2.	Copra cake	39	66.7	5.6	6.4	5.7	8.7	37.5
3.	Copra oil	Only one sample was contaminated with AT B_1 at the level of 3 ppb						

Table 18 Frequency and level of contamination of Tanzanian staple crops with aflatoxin B_1

No. crop	Number of studied samples	% of contaminated samples	B_1 >5ppb, % of contaminated samples	Level of contamination with AT B_1, ppb				
				Arithmetic mean, $\bar{X}$	Standard deviation, S	Median, M	90-th percentile	Overall range
1. White maize								
Harvest of:								
1987	199	9.5	79.0	1.1	5.4	<1	<1	62.9
1988	259	12.7	36.4	0.7	2.5	<1	2.9	32.1
2. Yellow maize								
Harvest of:								
1987	39	25.6	70.0	8.4	36.7	<1	9.5	227.5
1988	53	17.0	55.6	1.1	2.9	<1	4.1	13.3
3. Groundnuts								
Harvest of:								
1987	71	40.8	96.6	109.3	272.9	<1	353.3	1600
1988	114	57.9	87.9	41.7	80.2	5.6	156	533.3
4. Copra								
Harvest of:								
1987	51	47.1	54.2	2.4	3.7	<1	7.5	16.6
1988	72	61	77.8	1.3	2.8	<1	5.2	12.0

Table 17 **Frequency and level of contamination of Tanzanian staple crops with aflatoxins**

No. crop	Number of studied samples	% of contaminated samples	AT>20ppb, % of contaminated samples	Level of contamination with AT (B_1+B_2+G_1+G_2), ppb: Arithmetic mean, $\bar{X}$	Standard deviation, S	Median, M	90-th percentile	Overall range
1. White maize								
Harvest of:								
1987	199	9.5	10.5	1.3	6.0	<1	<1	69.5
1988	259	12.7	6.1	0.9	3.3	<1	2.9	32.1
2. Yellow maize								
Harvest of:								
1987	39	25.6	30.0	11.7	55.6	<1	12.2	346.7
1988	53	17.0	11.0	2.2	6.4	<1	6.9	35.4
3. Groundnuts								
Harvest of:								
1987	71	40.8	79.3	155.3	381.3	<4	641	2028
1988	114	57.9	69.7	63.6	132.9	7.6	245.7	1010
4. Copra								
Harvest of:								
1987	51	47.1	25.0	6.6	12.0	<4	27.0	58.6
1988	72	25.0	0	1.7	3.4	<4	7.4	12.7

Table 18 Frequency and level of contamination of Tanzanian grain and oil crops with aflatoxin B_1

No. Crop	Number of studied samples	% of contaminated samples	B_1 > 5ppb, % of contaminated samples	Level of contamination with AT B_1, ppb				
				Arithmetic mean, $\bar{X}$	Standard deviation, S	Median, M	90-th percentile	Overall range
1. White maize	472	11.2	52.8	1.0	4.6	<1	2.0	62.9
2. Yelloy maize	106	25.6	68.0	8.6	39.1	<1	9.6	297
3. Groundnuts	202	50.0	90.1	73.3	200.6	<1	196.4	1600
4. Copra	123	34.1	57.1	1.8	3.2	<1	6.0	16.6
5. Copra-cake	39	66.7	53.9	3.8	6.0	3.6	5.0	37.5
6. Sunflower	129	10.8	71.4	1.1	4.5	<1	3.6	40.0

Table 19 Frequency and level of contamination of Tanzanian grain and oil crops with aflatoxins

No. Crop	Number of studied samples	% of contaminated samples	>AT>20ppb, % of contaminated samples	Level of contamination with >AT (B_1+B_2+G_1+G_2), ppb				
				Arithmetic mean $\bar{X}$	Standard deviation S	Median, M	90-th percentile	Overall range
1. White maize	472	11.2	9.4	1.1	5.2	<1	2.0	69.5
2. Yelloy maize	106	25.6	32.0	10.5	46.7	<1	14.2	346.7
3. Groundnuts	202	50.0	72.3	103.1	271.6	<4	308	2028
4. Copra	123	34.1	14.3	3.8	8.4	<4	10.2	58.6
5. Copra-cake	39	66.7	3.9	5.6	6.4	5.7	8.7	37.5
6. Sunflower	129	10.8	28.6	2.0	8.6	<1	4.5	80.0

5. RECOMMENDATIONS

The implementation of the FAO/UNEP/USSR project "Improvement of Mycotoxin Control in Tanzania" showed that the resolution of the problem of aflatoxin contamination of agricultural produce is highly topial for Tanzania. Investigations carried out under the project pointed to substantial levels of aflatoxin contamination of cultivated grain crops (maize in particular) and oil-seeds (especially groundnuts) which are staple crops and foodstuffs in Tanzania. Therefore, a guaranteed safety of foodstuffs and agricultural raw materials may be achieved only through the enforcement of a national system of mycotoxin contamination control.

Such a system, besides positive contribution to solving social and medical aspects of the problem, will enable an efficient address to ecological problems related to production, storage and distribution of agricultural products, including their export and import. The establishment of a mycotoxin contamination control system will also have an economic impact ensuring the safety of foodstuffs for local consumption and a high quality of exported products.

The following recommendations can be made for consideration by the Government of Tanzania:

1. that the Government of Tanzania establishes a system of aflatoxin control at the national level. Coordination between the Ministry of Health and the Ministry of Agriculture and Livestock Development in running the mycotoxin control programme should be improved. **The system should include the following:**

   - collection of representative samples and their preparation for the analysis;

   - laboratory analysis of samples;

- processing and consolidation of analytical data in order to establish a real pattern of mycotoxin contamination in agricultural products for specific regions and the entire country;

- development of strategies aimed at effective settling of the mycotoxin problem in the country, including measures to prevent mycotoxin contamination along the food chain from the field and farm level to storage, transportation and distribution;

- enforcement of maximum levels of mycotoxin in food and feed products in order to protect consumer's heath and facilitate national and international trade with safe food and feedingstuffs.

2. that the Government of Tanzania maintain a national mycotoxin monitoring laboratory (i.e., the Government Chemical Laboratory (GCL)) which is well fitted out with necessary equipment, supplied with required chemicals, and also staffed with adequately trained laboratory personnel. It is further recommended that the Government provides necessary infrastructure to support the mycotoxin monitoring laboratory. It appears advisable to provide also support to the regional laboratories of Ashura, Mbey and Zanzibar for their efficient participation in adequate sampling and screening of foods for mycotoxins in the overall mycotoxin programme in which the GCL should act as programme coordinator.

3. that a monitoring programme be established on the following commodities including their by-products:

   - cereals: maize, rice, wheat, millet, sorghum;

   - oilseeds/nuts (groundnuts, copra, cotton seed).

4. that the Government, taking into account specific ecological and social features of the country, enforces maximum limits of aflatoxins in food and feedingstuffs to be further updated with official documents issued by the Codex Alimentary Commission.

The recommended levels to be adopted are as follows: 5 ppb aflatoxin B_1 for food products or 15 ppb total aflatoxins. The level for feeds can follow the EEC proposal:

- straight feedingstuffs	50 µg/kg (B_1)
- complete feedingstuffs for cattle, sheep and goats (except dairy cattle, calves and lambs)	50 µg/kg (B_1)
- complete feedingstuffs for pigs and poultry (except young animals)	20 µg/kg (B_1)
- other complete feeding stuffs	10 µg/kg (B_1)
- supplementary feedingstuffs for cattle, sheep and goats (except dairy animals, calves and lambs)	50 µg/kg (B_1)
- supplementary feedingstuffs for pigs and poultry (except young animals)	30 µg/kg (B_1)
- other supplementary feedingstuffs	10 µg/kg (B_1)
- groundnut, copra, palm kernel, cotton seed, babassu, maise and products derived from the processing thereof	200 µg/kg (B_1)

5. that the Government of Tanzania adopts official analytical procedures for aflatoxin analysis. The recommended official produces were tested and effectively applied under the project activities. They are recommended for adoption by the Government of Tanzania and presented in the Manual on "Sampling of Agricultural Products and Their Analysis for Aflatoxin Determination".

6. that the Government of Tanzania establishes, through appropriate coordination between the ministries and institutions concerned, a mycotoxin prevention programme. The programme should aim at letting the population understand, in particular through adequate extension training, and be guided by the following instructions:

- good agricultural practices should be utilized so as to reduce and/or eliminate, where possible, pre-harvest and post-harvest contamination of food crops. These practices include the development and use of adaptive and resistant varieties, crop rotation, proper harvesting system, optimum and uniform irrigation and appropriate plant protection measures, including a sound and safe use of pesticides/chemicals;

- crops should be dried as quickly as possible and rewetting of the crop during or after drying should be avoided;

- storage practices at the farm, in the market and in the warehouses should ensure a dry and clean storage of crops; practical storage facilities should be developed that will minimize losses of food and feeding stuffs through mould growth and insect, rodent, bird damage;

- transportation practices, locally, nationally and internationally should ensure safe moisture levels during shipment;

- post-harvest processing should be performed so as to protect crops from any conditions that may encourage growth of fungi, including segregation of the damaged portion of the crop.

7. that the Government of Tanzania introduces through the Ministry of Health and the Ministry of Education at both school and university levels, courses related to mycotoxin contamination, prevention and control. It is recommended that the Government develops through the bodies concerned (and specifically the Ministry of Information), educational programmes on aflatoxin hazards (using radio, press and similar). It is recommended that information booklet "Mycotoxin" for farmers prepared in the course of implementation of the project should be widely circulated among farmers by extension workers.

Зак. № 79 I50 экз.