PN-ADC-893

RISK MANAGEMENT OF CHEMICAL HAZARDS IN THE FOOD INDUSTRY

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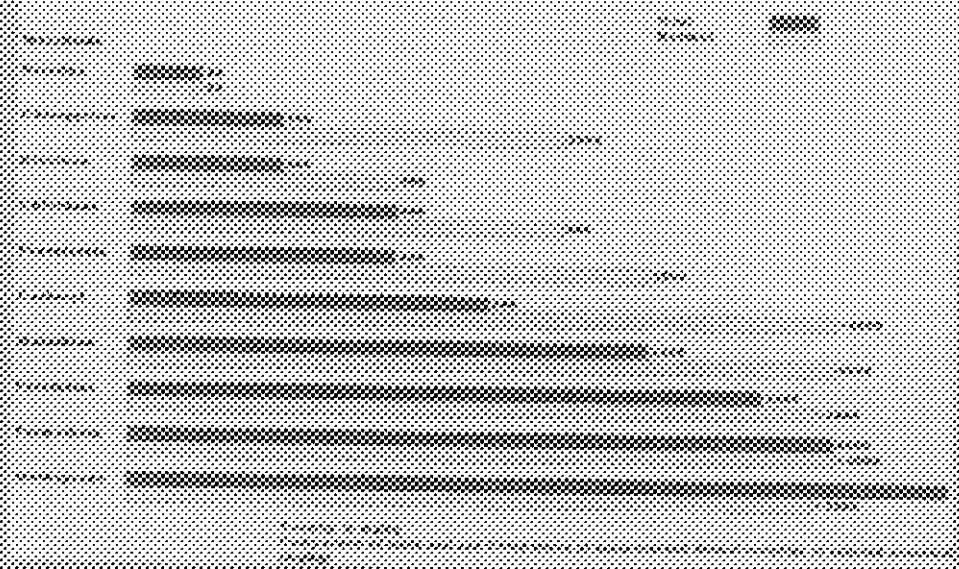

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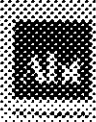

REBECA LOPEZ-GARCIA, Ph.D.
LOGRE International
Mar Arafura 61 Col. Popotla México, D.F. C.P. 11400
52-5-396-7019 52-5-396-0619
e-mail: rebecalg@df1.telmex.net.mx

EDUCATION

Ph.D. Food Science Concentration Toxicology **1998**
Minor: Environmental Studies
Louisiana State University
Dissertation: AflatoxinB_1 and Fumonisin B_1 Co-contamination:Interactive Effects, Possible Mechanisms of Toxicity and Decontamination Procedures.

Lic. Química **(Honors)-Equivalent to a B.S. (Chemistry/Food Science)** **1995**
Universidad La Salle, México

International Exchange Program **1994**
The University of Arizona

LANGUAGES

Spanish – Native speaker strong oral and written communication skills
English – Fully proficient. strong oral and written communication skills
French – Working knowledge

PROFESSIONAL EXPERIENCE

International Product Manager **1999-present**
Tate & Lyle Citric Acid

- Global technical support resource: Experience in solving spoilage problems in beverages (especially fruit juices), jams and jellies, canned products tortillas, development of confectionery products. Development of citric-based industrial cleaners, fertilizers and micronutrient solutions.
- Development of training seminars for salespeople
- Development of new technical literature, new applications and formulations
- Creation and maintenance of a global sales and marketing database
- Coordination of participation in major international food expositions

International Food Science Consultant **1996-present**
Independent work

- Main projects have included work helping food companies develop integrated management programs to minimize risks involved with mycotoxin contamination as well as control of other microbiological and chemical hazards. Solution of spoilage problems in fruit juices and dairy products.

Technical Marketing Manager **1998-1999**
Mexama S.A. de C.V. (Part of the Tate & Lyle Group)

- Establishment of a Marketing and Technical Service Department

Research Assistant **1995-1998**
Louisiana State University, Department of Food Science

- Development of international risk management programs for mycotoxins
- Technical assistance/consulting to food industry
- Evaluation of toxicity/mutagenicity of diverse compounds

Research Assistant **1993**
Instituto Nacional de Nutrición Departamento de Tecnología de Alimentos

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- Standardization of methods for the rheology laboratory. Assistant in the sensory evaluation laboratory.

TEACHING EXPERIENCE AND CERTIFICATES

International HACCP Alliance **1999**
Train the Trainer Certificate

Professor (adjunct) **1999-presen**
Universidad La Salle, México (School of Chemistry)
Food Toxicology, Meat Science and Technology
Committee to develop a Master's program in Food Science and Nutrition

FDA - Better Process Control School - Instructor **1997-presen**
The University of Arizona (Spanish), Louisiana State University (English)
Cámara Nacional de la Industria de Conservas Alimenticias (Spanish)

International Workshops/Symposia **1995-presen**
Experience teaching several practical international workshops in English and Spanish. Topics include: Sampling methods, risk management of Naturally-occurring toxicants, sanitation.

Teaching Assistant **1995-1998**
Louisiana State University, Department of Food Science
Food Chemistry, Food Toxicology, Introduction to Food Science

LEADERSHIP

Institute of Food Technologists

Continuing Education Committee	1999-200
Committee for Global Interests	1996-199
Student Association Strategic Planning Committee, Chair	1997-199
Strategic Planning Task Force	1996-199
Gulf Coast Section, Executive Committee	1996-199
Food Science Club, Louisiana State University, President	1996-199
Student Association Operations Chair	1995-199
Annual Meeting Committee, Chair Student Activities	1995-199
General Arrangements Committee, Chair Video Theater	1995-199
Founding Member, National Representative, Secretary, *Student Association Asociación Nacional de Tecnólogos de Alimentos*	1993-199

AWARDS

Best Doctoral Dissertation. Louisiana State University, Department of Food Science/Interdepartmental Program in Toxicology	199
Institute of Food Technologists Graduate Fellowships/Scholarships	1995-199
American Association of Cereal Chemists Graduate Fellowships	1996-199
Omicron Delta Kappa National Honor Leadership Society	199
Top Graduating Student – *Universidad La Salle*	199
Top Research Project f the Year-*Universidad La Salle*	199

PUBLICATIONS AND Publications in scientific journals and textbooks, editorials and articles

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PRESENTATIONS in trade journals. Scientific presentations at professional meetings

REFERENCES AND LIST OF PUBLICATIONS AVAILABLE UPON REQUEST

REGISTRATION INFORMATION

Name _____

Title _____

Company _____

Address _____

_____

TEL _____

FAX _____

Email _____

Attendees may register by calling in or faxing this registration to ALEB. They may also register on-site.

Registration Fee: There will be an 50LE registration fees for this program. Registrants will receive a course notebook, coffee breaks morning and afternoon and a certificate of participation following completion of evaluation forms.

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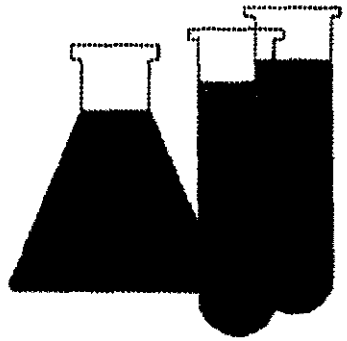
RISK MANAGEMENT OF CHEMICAL HAZARDS IN THE FOOD INDUSTRY



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CAIRO, EGYPT

USAID Project No. 263-0264

- February 22, 2001 at 10:00 at the ALEB Offices, Giza, Cairo

RISK MANAGEMENT OF CHEMICAL HAZARDS IN THE FOOD INDUSTRY

Food safety programs tend to concentrate on biological hazards since these are capable of causing short-term widespread foodborne illness. However, chemical hazards have also been associated with long term health effects. A good HACCP plan should consider all possible hazards, but the assessment and management of different risks need different approaches. Chemical hazards cannot be managed in the same fashion as microbiological or physical hazards. In order to make adequate decisions, it is important to understand the nature of the most common chemical hazards in the food industry as well as their overall impact on public health, food processing and international legislation. Even if these risks are considered on the hazard analysis of a HACCP plan, appropriate control measures and management may not belong in the plan itself. Therefore, prerequisite programs as well as other food safety considerations are essential for risk management of chemical hazards

This program will provide an overview of the most common chemical hazards present in food and food processing operations as well as their impact on public health. Furthermore, a practical approach to the management of these hazards in the food industry will be provided

PROGRAM

10:00	Introduction to food toxicology: The Risk/Benefit concept applied to food
10:30	The challenges of sampling and analysis of chemical hazards
11:00	Break
11:30	Mycotoxins of public health significance
12:00	Integrated mycotoxin management systems
12:30	Careful and rational use of pesticides
1:15	Break
1:30	Allergens: Addressing the needs of hypersensitive consumers
2:15	Contamination from Industrial wastes
3:00	Break
3:15	Safe chemical handling
4:00	Chemical hazards in the framework of HACCP plans

INSTRUCTOR

Dr. Rebeca Lopz-Garcia is the Principal in LOGRE International, a Mexico City based firm working in the areas of food safety and risk assessment. Prior to establishing LOGRE, Dr. Lopez-Garcia was the International Product Manager for Tate & Lyle, a world supplier of citric acid, which included providing technical service to their clients. Her cients include Costco, Pillsbury, and the American Soybean Association.

MORE INFORMATION CONTACT:

Mr. Richard F. Stier
Director, Technical Services
Mr. Morad S. Ahmed
Co-Director, Technical Services
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EMAIL rfstier4@egyptonline.com
Morad@egyptonline.com

February 22, 2001 at 10:00 in the ALEB training room. 5th floor at 12 Dokki Street, Giza, Cairo

RISK MANAGEMENT OF CHEMICAL HAZARDS IN THE FOOD INDUSTRY

REBECA LOPEZ-GARCIA, Ph.D.

LOGRE INTERNATIONAL

INTRODUCTION

✓FOODS CONTAIN MIXTURES OF THOUSANDS OF INDIVIDUAL CHEMICALS

- TEXTURE
- FLAVOR
- COLOR
- NUTRITIVE VALUE

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INTRODUCTION

- ✓ CONSIDERABLE CONCERN
  - ❖ FOOD SAFETY PUBLIC SURVEYS
  - ❖ FOOD REGULATIONS AROUND THE WORLD
- ✓ CONCERNS ABOUT
  - ❖ PRODUCTS DERIVED FROM BIOTECHNOLOGY
  - ❖ PESTICIDE RESIDUES
  - ❖ ANTIBIOTICS
  - ❖ HORMONES
  - ❖ FOOD ADDITIVES
  - ❖ ENVIRONMENTAL CONTAMINANTS
  - ❖ NATURAL OCCURRING TOXINS

HAZARD VS. RISK

- ✓ HAZARD
  - ❖ ANYTHING THAT CAN CAUSE HARM
- ✓ RISK
  - ❖ THE PROBABILITY THAT HARM WILL OCCUR

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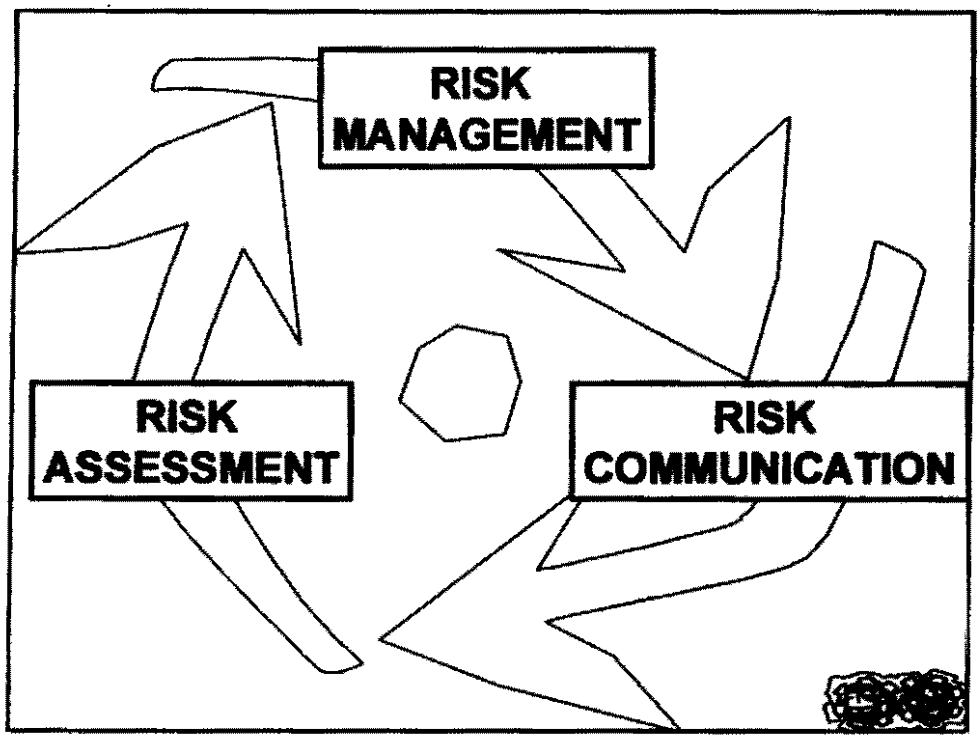

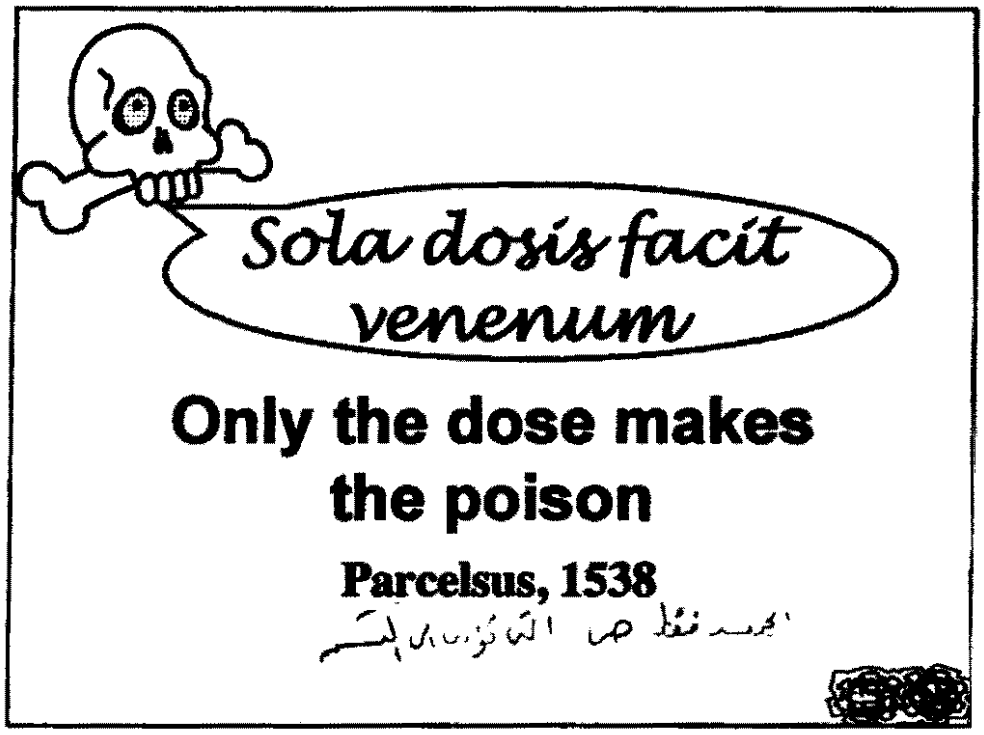

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Examples of Small Quantities

Unit	Example
1 ppm (1 part per million)	1 gram in a ton 1 mouthful of food in a lifetime
1 ppb (1 part per billion)	1 second in 32 years 1 pinch of salt on 2,000 pounds of potato chips 1,000 times less than 1ppm
1 ppt (1 part per trillion)	1 grain of sugar in an Olympic pool 1 needle in a 100, 000-ton haystack

RISK ASSESSMENT

- ✓HAZARD IDENTIFICATION
- ✓DOSE/RESPONSE RELATIONSHIP
- ✓EXPOSURE ASSESSMENT
- ✓RISK CHARACTERIZATION

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RISK ASSESSMENT

- ✓ MAXIMUM TOLERATED DOSE (MTD)
- ✓ LOWEST OBSERVED EFFECT LEVEL (LOEL)
- ✓ NO OBSERVED EFFECT LEVEL (NOEL)
- ✓ UNCERTAINTY FACTORS: 1-10,000
- ✓ MOST COMMON UNCERTAINTY FACTOR = 100
- ✓ NOEL/UNCERTAINTY FACTOR = ADEQUATE DAILY DOSE (ADI)

EXPOSURE ASSESSMENT

- ✓ CONCENTRATION OF CHEMICAL * AMOUNT OF FOOD CONSUMED
  - ❖ FOOD ADDITIVES: CONCENTRATION MAY BE CONSTANT
  - ❖ INCIDENTAL CHEMICALS (PESTICIDE RESIDUES, HORMONES, ANTIBIOTICS, ETC.): CONCENTRATIONS MAY VARY DRAMATICALLY
    - USE OF ASSUMPTIONS

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RISK CARACTERIZATION

- ✓ INVOLVES HAZARD IDENTIFICATION, DOSE/RESPONSE RELATIONSHIP AND EXPOSURE ASSESSMENT
- ✓ INVOLVES ALL UNCERTAINTIES
- ✓ QUALITATIVE ASSESSMENT (EXPOSURE ESTIMATES*CANCER POTENCY)

RISK MANAGEMENT

- ✓ CONSIDERATION OF RISK CHARACTERIZATION
- ✓ REGULATORY DECISIONS
- ✓ LEGISLATIVE MANDATE
- ✓ ECONOMIC, POLITICAL, TECHNOLOGICAL FACTORS

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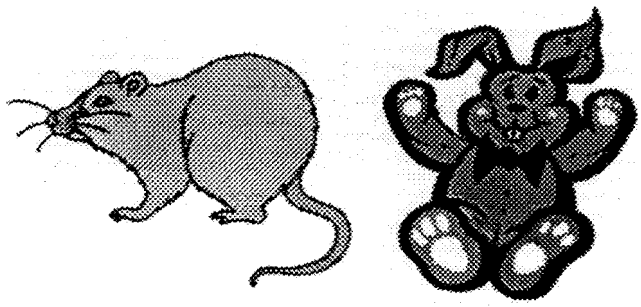
NEW CONCEPTS IN RISK MANAGEMENT

- ✓PREVENTION
- ✓INTEGRATED MANAGEMENT
- ✓HACCP
- ✓EXPORTATION

RISK COMMUNICATION

- ✓SOCIOLOGICAL COMPONENTS OF RISK ACCEPTABILITY



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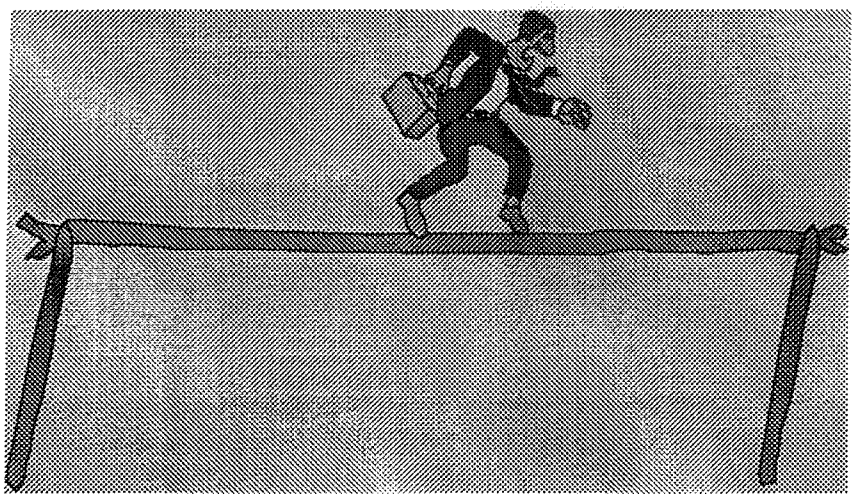
RISK COMMUNICATION

- ✓ PUBLIC OPINION
- ✓ CONSIDERATION OF RISK CHARACTERIZATION

RISK/BENEFIT DECISIONS



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New Challenges

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THE CHALLENGES OF SAMPLING AND ANALYSIS OF CHEMICAL HAZARDS

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SAMPLING PLANS

✓PRODUCER RISK

✓CONSUMER RISK

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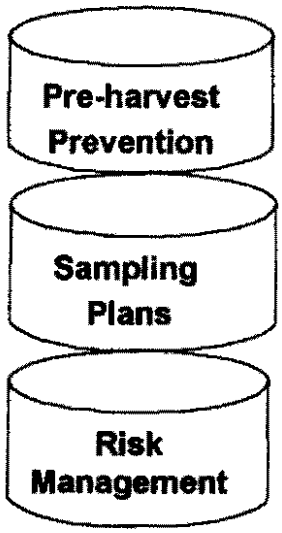
DECISION MAKING PROCESS



SAMPLING PLAN

- ✓TAKING A SAMPLE
- ✓PREPARATION OF SAMPLE
- ✓SAMPLE ANALYSIS

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SAMPLING PLANS

- ✓REGARDLESS OF PURPOSE
  - ❖REGULAR TESTING
  - ❖QUALITY CONTROL
  - ❖REGULATORY CONTOL
- ✓ADEQUATE SAMPLING PLANS MUST BE USED TO OBTAIN A VALID ANALYTICAL RESULT

يجب استخدام خطط العينات ملائمة للحصول على
نتائج تحليلية صالحة

العوامل التي ينبغي مراعاتها عند وضع خطة أخذ العينات

FACTORS TO CONSIDER WHEN DEVELOPING A SAMPLING PLAN

- ✓PURPOSE OF THE ANALYSIS
- ✓TYPE OF COMMODITY
- ✓TOXIN(S), CONTAMINANT
- ✓EXPECTED LEVEL OF CONTAMINATION
- ✓NATURE OF CONTAMINATION
- ✓COST

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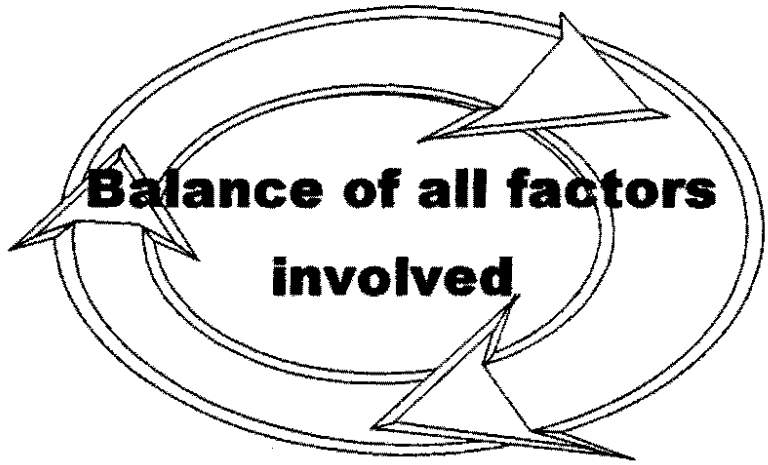
OBJECTIVE OF A SAMPLING PLAN

الحصول على جزء من منتج
معين يمثل الكل
أو الأهم بالكل

✓ OBTAIN A PORTION OF A PARTICULAR PRODUCT THAT REPRESENTS THE WHOLE LOT

DEVELOPING A SAMPLING PLAN



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DEVELOPMENT OF A SAMPLING PLANS

✓THEORY

✓PRACTICE

PROBLEMS ASSOCIATED WITH THE DEVELOPMENT OF A SAMPLING PLAN

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PROBLEMS ASSOCIATED WITH THE DEVELOPMENT OF A SAMPLING PLAN

- ✓ PRESENCE OF "HOT SPOTS" IN STORED GRAINS, OILSEEDS, PROCESSED FOODS AND FLOURS

السكوت متطاير الخواص او الخاص
HETEROGENEOUS CONTAMINATION

- ✓ THE CONCENTRATION OF AFLATOXIN IN INDIVIDUAL KERNELS CAN BE AS HIGH AS 1,100,000 ng/g
- ✓ A SINGLE CONTAMINATED GRAIN IN A 10,000 Kg LOT CAN CONTAMINATE THE WHOLE LOT TO AN APPROXIMATE CONCENTRATION OF 50 ng/g

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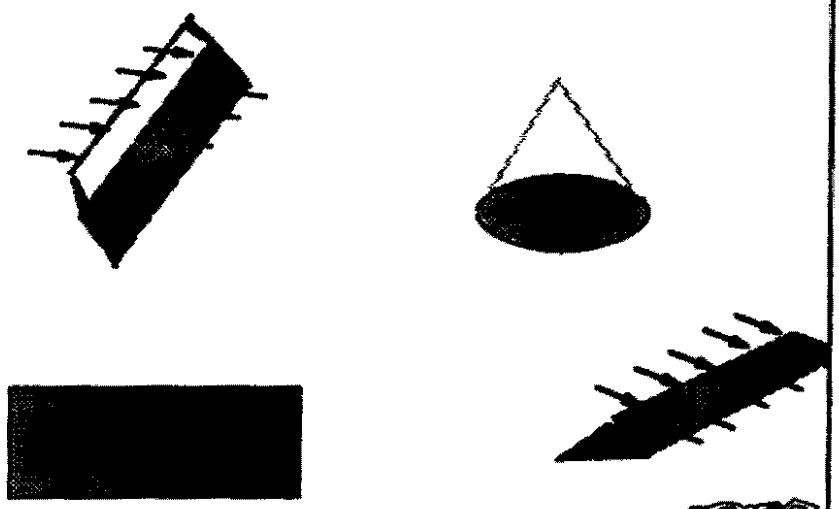
SAMPLING PROCEDURES

- ✓CONTINUOUS AUTOMATIC SAMPLING
- ✓PROBES IN A MASSIVE LOT
- ✓PROBES IN INDIVIDUAL BAGS

SAMPLING PATTERNS

Patrones de muestreo



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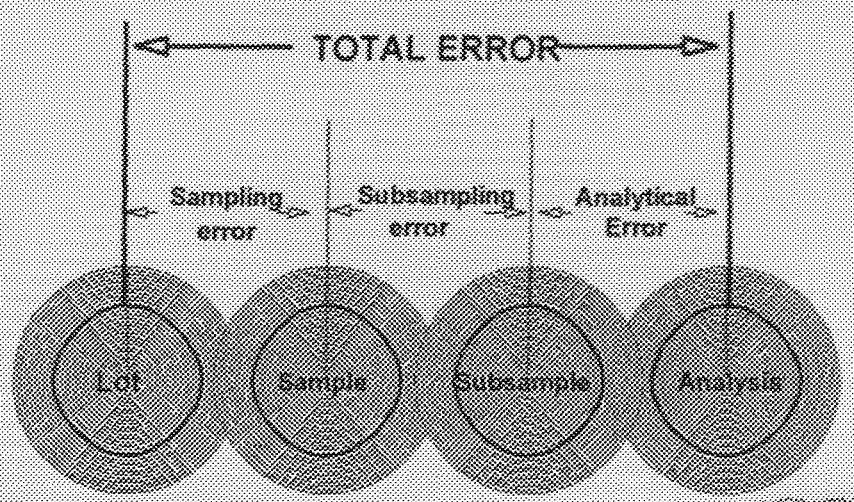
RELATIVE ERROR ASSOCIATED WITH SAMPLING



Whitaker, T.B., 1977

SAMPLE SIZE

- ✓ MUST BE REPRESENTATIVE
- ✓ LARGER SAMPLES INCREASE RESULT RELIABILITY
- ✓ A SAMPLE INCREASE RESULTS IN:
  - DECREASE IN REJECTION OF GOOD LOTS
  - DECREASE IN ACCEPTANCE OF GOOD LOTS
- ✓ DEPENDS ON PARTICLE SIZE

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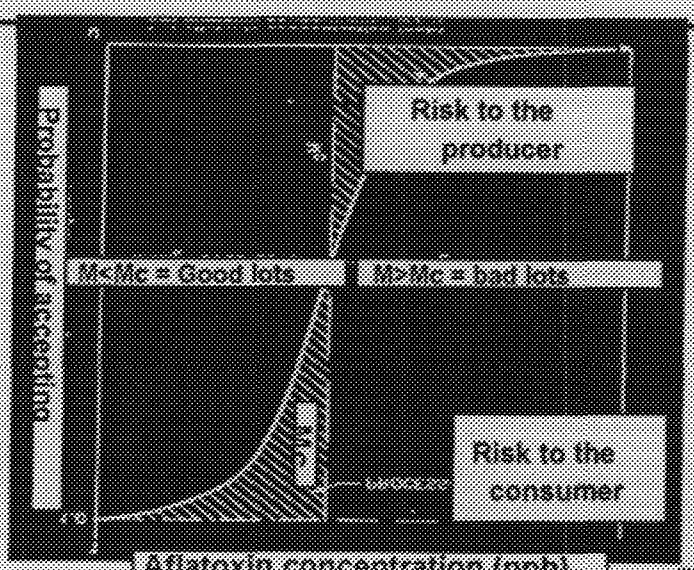
SAMPLING PLANS

✓RISK TO THE IMPORTER

✓RISK TO THE EXPORTER

OPERATIONAL CHARACTERISTIC CURVE



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STRATEGIES TO DECREASE THE ERROR ASSOCIATED WITH SAMPLING

- ✓INCREASE SAMPLE SIZE
- ✓INCREASE THE NUMBER OF SAMPLING SITES
- ✓USE CONTINUOUS AUTOMATIC SAMPLING

DEVELOPMENT OF A SAMPLING PLAN

- ✓IDENTIFICATION OF SAMPLING SITES
- ✓IDENTIFICATION OF SAMPLING SITE ACCORDING TO LOT SIZE
- ✓DETERMINATION OF SAMPLING METHODS
- ✓DETERMINATION OF SUBSAMPLE SIZE

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IDEAL SAMPLING

✓WHEN PRODUCT IS MOVING

- ❖TRANSPORTATION BANDS
- ❖LOADING/UNLOADING
- ❖FILLING/EMPTYING SACKS

FACTORS THAT DETERMINE THE SAMPLE SIZE

✓LOT ACCESIBILITY

✓AVAILABILITY OF EQUIPMENT

✓AVAILABILITY OF STORAGE SPACE AND SAMPLE PREPARATION

✓TIME

✓COST

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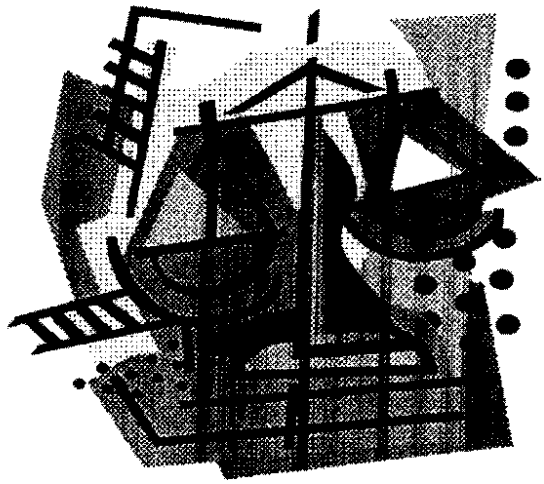
DECISION MAKING FOR EFFECTIVE SAMPLING



SAMPLE SIZE DETERMINATION

- ✓GENERAL RULE: 0.5 Kg for each 1000 Kg
- ✓IN BAGS, RECOMMENDATIONS VARY
  - ❖SMALL LOTS: ONE FOURTH OF ALL BAGS
  - ❖LARGE LOTS: SQUARE ROOT OF THE TOTAL NUMBER OF SACS

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AFLATOXIN IN COTTONSEED EXAMPLE SAMPLING PLAN

- ✓MAX. LOT SIZE: 100 MT
- ✓SAMPLE SIZE: AT LEAST 30 Lb (13.6 Kg)
- ✓10 3 POUND (1.4 Kg) PROBES INSERTED TO A DEPTH OF AT LEAST 50 IN. (1.27 M)

MANAGEMENT OF LARGE SAMPLES

- ✓CARE MUST BE TAKEN WITH SAMPLES FROM LARGE LOTS TO ENSURE THAT A SUBSAMPLE IS REPRESENTATIVE
- ✓SAMPLE MUST BE CAREFULLY MIXED TO ENSURE HOMOGENEOUS DISTRIBUTION IN THE SUBSAMPLE

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REPRESENTATIVE SAMPLE

- ✓ A REPRESENTATIVE SAMPLE MUST BE THE ACCUMULATION OF SMALL PORTIONS TAKEN FROM DIVERSE SITES OF THE SAME LOT

CONCLUSIONS

- ✓ SAMPLING PLANS ARE USUALLY COMPLEX
- ✓ DIFFERENT PLANS MUST BE DEVELOPED FOR DIFFERENT COMMODITIES
- ✓ SAMPLING IS USUALLY ONE OF THE MAIN SOURCES OF ANALYTICAL ERROR

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CONCLUSIONS

✓TIME AND COST ARE IMPORTANT FACTORS TO CONSIDER WHEN DEVELOPING SAMPLING PLANS

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MANAGEMENT = PREVENTION

REBECA LOPEZ-GARCIA, Ph.D.

LOGRE INTERNATIONAL

CHANGE OF PERCEPTION

- ✓RISKS CAN BE MANAGED THROUGH PREVENTION
- ✓ALTHOUGH ANALYSIS MAY BE USEFUL
- ✓IDEAL RISK MANAGEMENT NEEDS TO BE BASED ON PREVENTION

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RISK

- ✓THE CONCEPT OF ZERO RISK
- ✓NOT POSSIBLE TO ENSURE 100% SAFETY
- ✓WHAT TO DO?

CURRENT PRACTICES

- ✓PLEASE TAKE A MINUTE TO THINK ABOUT YOUR OWN COMPANY
- ✓WOULD YOU TRUST YOUR PRODUCTS IF THEY WERE NOT ANALYZED?

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CHEMICAL HAZARDS AND PREVENTION

- ✓ CHEMICAL HAZARDS ARE EXTREMELY DIFFICULT TO MANAGE THROUGH THE USUAL CONCEPTS OF:
  - ❖ PRODUCTION
  - ❖ SAMPLING
  - ❖ ANALYSIS

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THINK DIFFERENTLY

IT IS NOT EASY TO CHANGE THE WAY WE HAVE BEEN DOING THINGS

- ✓CULTURAL FACTORS
- ✓RESISTANCE TO CHANGE
- ✓LACK OF TRUST OF NEW METHODS

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DO YOU KNOW HOW TO CROSS YOUR ARMS?

NOW THINK ABOUT YOUR OWN OPERATION...

- ✓ HOW CAN IT BE IMPROVED?
- ✓ HOW CAN YOU PREVENT?
- ✓ HOW MUCH DO YOU SPEND ON ANALYSIS
- ✓ DO YOU ANALYZE FOR EVERY POSSIBLE HAZARD?

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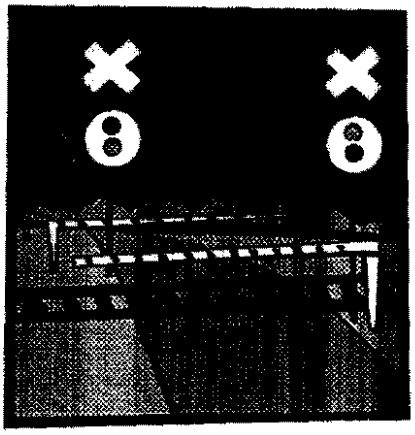
MANAGEMENT OF CHEMICAL HAZARDS



NEW CONCEPTS IN RISK MANAGEMENT

- ✓ GOOD AGRICULTURAL PRACTICES (GAP´S)
- ✓ INTEGRATED PEST MANAGEMENT (IPM)
- ✓ GOOD MANUFACTURING PRACTICES (GMP´S)
- ✓ HACCP

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NEW CONCEPTS IN RISK MANAGEMENT

- ✓ GOVERNMENT PROGRAMS
- ✓ INTERNATIONAL PROGRAMS
- ✓ GOVERNMENTS MUST WORK WITH INDUSTRY
- ✓ ESTABLISHMENT OF HURDLES THROUGHOUT THE PRODUCTION CHAIN

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INTEGRATED MYCOTOXIN MANAGEMENT SYSTEMS

أنظمة متكاملة لإدارة السموم الفطرية

REBECA LOPEZ-GARCIA, Ph.D.

LOGRE INTERNATIONAL

HUNGER AROUND THE WORLD

- ✓ 800 MILLION PEOPLE IN DEVELOPING COUNTRIES
- ✓ 37 MILLION PEOPLE IN DEVELOPING NATIONS
- ✓ 25-50% YEARLY CROPS CONTAMINATED WITH MYCOTOXINS

FAO, 1999; FAO, 1996

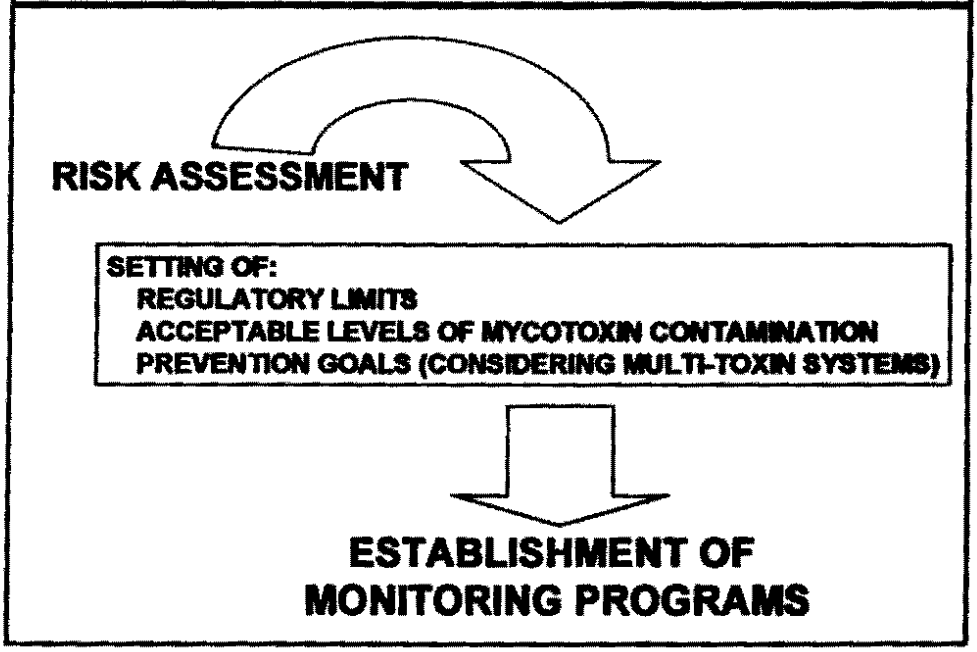
MYCOTOXINS

- ✓ CONTROL IS A KEY COMPONENT IN ANY PLAN TO INCREASE FOOD SECURITY
- ✓ SAMPLING AND ANALYSIS ARE COMPLEX OPERATIONS
- ✓ ESTABLISHMENT OF REGULATORY LIMITS IS NOT ALWAYS POSSIBLE AND/OR EFFECTIVE

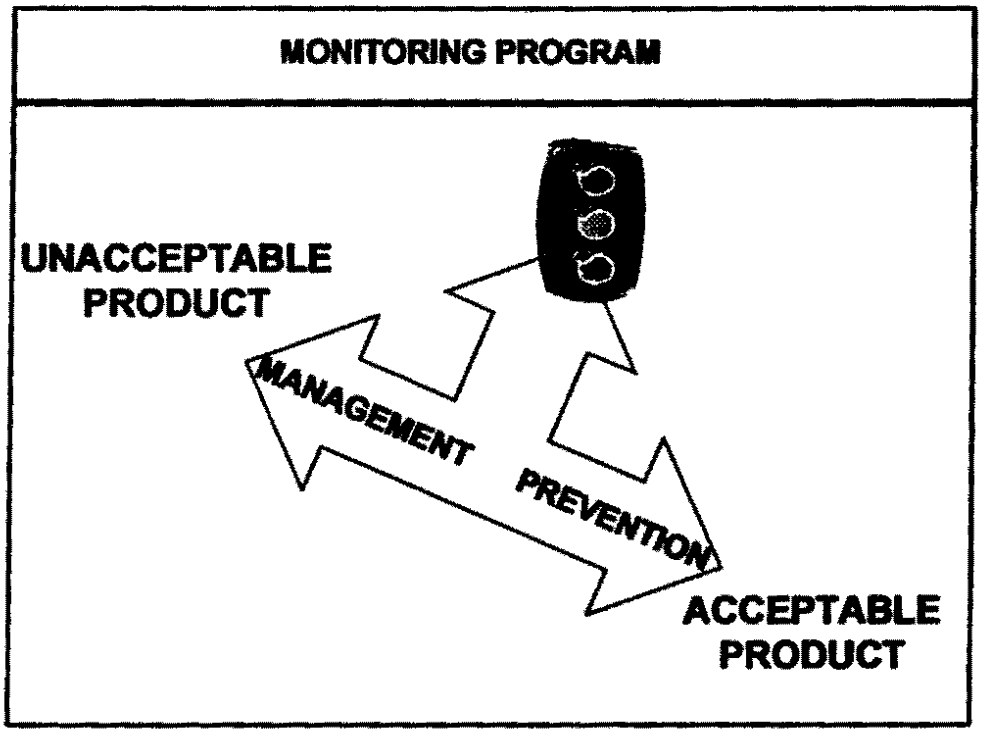
MYCOTOXINS

- ✓ACUTE EXPOSURE
- ✓CHRONIC EXPOSURE
- ✓PRESENCE IN ANIMAL PRODUCTS
- ✓MULTI-TOXIN SYSTEMS AND TOTAL DIET EXPOSURE

DECISION-MAKING PROCESS



MONITORING PROGRAM



MONITORING PROGRAMS – PRODUCT SEGREGATION

- ✓FOOD
- ✓FEED
  - ANIMAL PRODUCTS?
    - MILK, MEAT, EGGS
- ✓LESS RISK USES

MYCOTOXIN CONTROL

- ✓NEED FOR PLANS FROM DIFFERENT POINTS OF VIEW
- ✓NEED FOR CLEAR COMMUNICATION BETWEEN:
  - RESEARCH ORGANIZATIONS
  - PRODUCERS
  - ALL PEOPLE INVOLVED IN DIFFERENT STAGES OF THE PROCESS

A HACCP-BASED APPROACH

- ✓HACCP IS BASED ON PREVENTION AND VERIFICATION RATHER THAN MONITORING AND ANALYSIS
- ✓OBJECTIVE:
  - TO BE ABLE TO PRODUCE FOOD THAT IS SAFE TO CONSUME AND <u>TO BE ABLE TO PROVE IT</u>

THE SEVEN PRINCIPLES OF HACCP

- ✓ CONDUCT A HAZARD ANALYSIS
- ✓ DETERMINE THE CRITICAL CONTROL POINTS
- ✓ ESTABLISH CRITICAL LIMITS
- ✓ ESTABLISH MONITORING PROCEDURES
- ✓ ESTABLISH CORRECTIVE ACTIONS
- ✓ ESTABLISH VERIFICATION PROCEDURES
- ✓ ESTABLISH RECORD KEEPING AND DOCUMENTATION PROCEDURES

A HACCP-BASED APPROACH

✓ IN THEORY, THE PRINCIPLES OF HACCP ARE APPLICABLE TO EVERY STAGE OF PRODUCTION

- BASIC AGRICULTURE
- FOOD PROCESSING
- FOOD PREPARATION
- FOOD DISTRIBUTION SYSTEMS

SHORTCOMINGS OF HACCP AND MYCOTOXIN CONTROL

✓ LACK OF VERTICAL INTEGRATION

✓ SINGLE PLAN FOR PRODUCTION IS NOT POSSIBLE

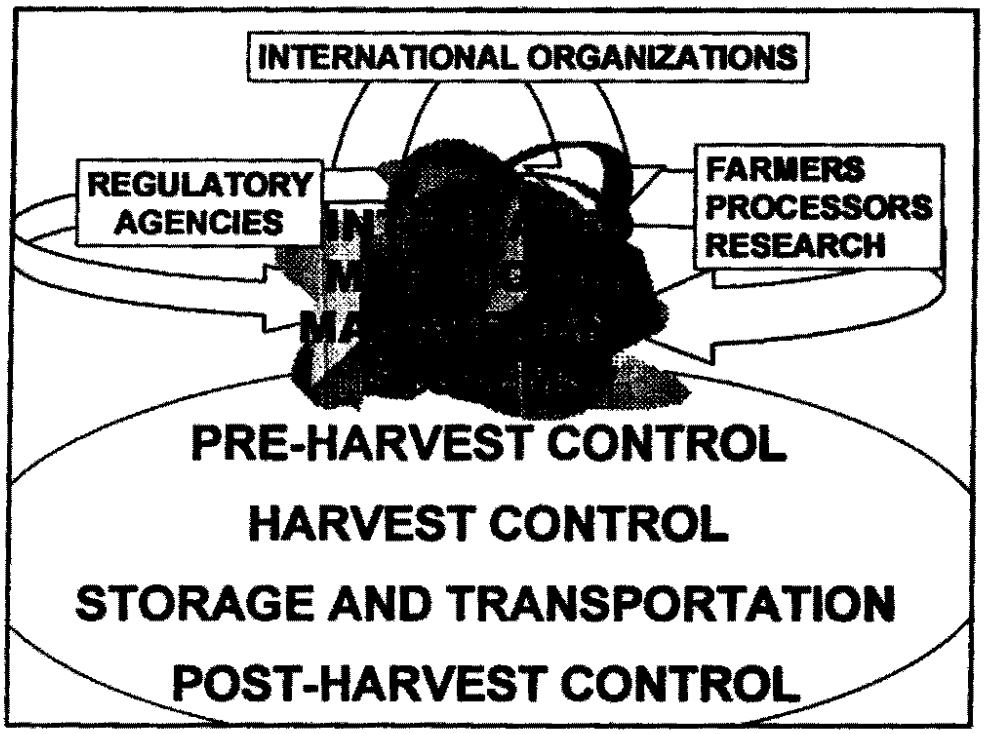
✓ DESIGNING CCP'S AND VERIFICATION PROCEDURES IS DIFFICULT

✓ CRITICAL LIMITS MAY NOT GUARANTEE ELIMINATION OF EXPOSURE

✓ MYCOTOXIN TOXICITY IS RELATED TO CHRONIC EXPOSURE

USING A HACCP APPROACH FOR CONCERTED CONTROL PLANS

- ✓ INTEGRATED MYCOTOXIN CONTROL SYSTEMS
- ✓ DEVELOPMENT OF SEVERAL CONTROL PLANS – BASED ON A "HACCP TYPE APPROACH"
- ✓ DEVELOPMENT OF "HURDLES" TO MINIMIZE POPULATION EXPOSURE



PRE-HARVEST CONTROL

✓PRE-REQUISITES

- GOOD AGRICULTURAL PRACTICES
- USE OF RESISTANT PLANT VARIETIES
- INTEGRATED PEST MANAGEMENT
- RATIONAL USE OF FERTILIZERS
- IRRIGATION, CROP ROTATION, TILLAGE

PRE-HARVEST CONTROL

✓ CONTROL PLAN 1

- HAZARD ANALYSIS
  - COMMODITY SUSCEPTIBILITY
  - TYPE OF MOLD(S) PRESENT
  - PESTICIDE/FERTILIZERS
  - ENVIRONMENTAL CONTAMINATS
- CONTROL POINTS?
  - NO VERIFIABLE CONTROL POINTS

HARVEST CONTROL

✓PRE-REQUISITES

- GOOD AGRICULTURAL PRACTICES
- TIMELINESS
- CLEANUP PROTOCOLS
- DRYING PROTOCOLS

HARVEST CONTROL

✓ CONTROL PLAN 2

- HAZARD ANALYSIS
- POSSIBLE CP?
  - MOISTURE CONTROL

MOISTURE CONTROL

FUNGUS SPECIES	MINIMUM MOISTURE CONTENT IN GRAIN
Aspergillus restrictus	13.5%
A. glaucus	14%
A. candidus	15%
A. ochraceus	15%
A. flavus	18%
Fusarium spp.	18-19%
Penicillium spp.	16.5-19%

(Gwinner et al., 1996)

MOISTURE CONTROL

- ✓ HIGH RELATIVE HUMIDITY LEADS TO A RISE IN MOISTURE CONTENT
- ✓ FUNGI GROW AT A RELATIVE HUMIDITY OF ABOVE 65-70%
- ✓ STORED PESTS FIND THE BEST CONDITIONS FOR DEVELOPMENT @ 28-33°C AND RELATIVE HUMIDITIES OF 60-80%
- ✓ IF NO MEASURES ARE TAKEN, CONSIDERABLE LOSSES/CONTAMINATION MAY OCCUR

MOISTURE CONTROL

PRODUCE	SAFE MOISTURE CONTENT
CORN	13%
WHEAT	13%
MILLET	13%
SORGHUM	13%
RICE	13%
COWPEAS, BEANS	15%
GROUNDNUTS	7%
COPRA	7%
PALM KERNELS	5%
COFFEE	13%

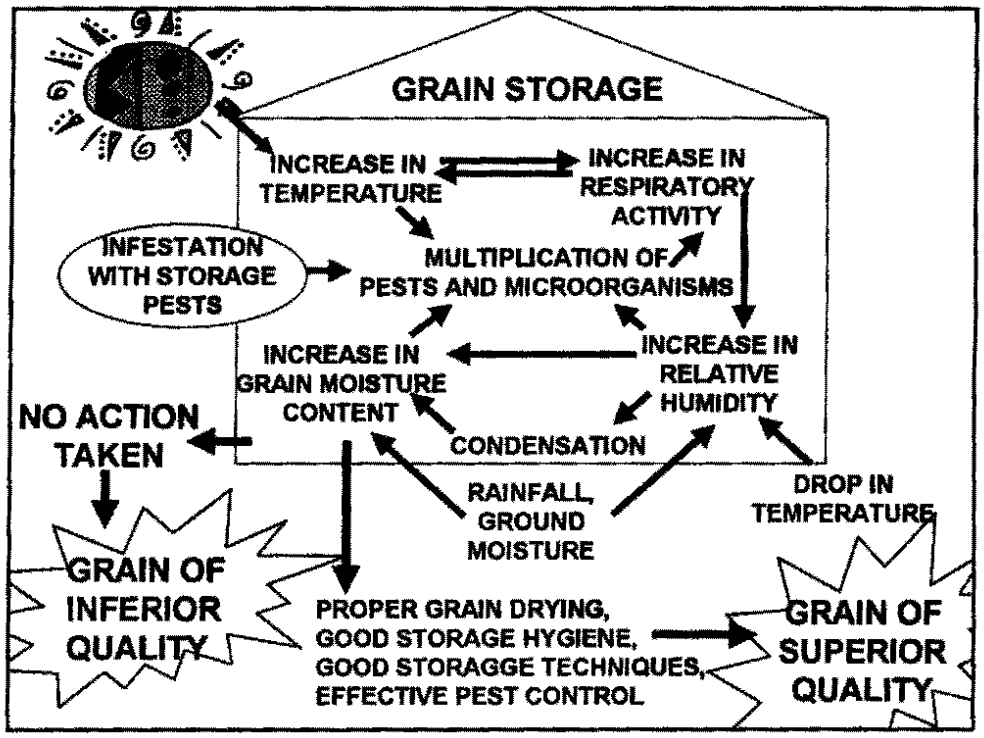
STORAGE AND TRANSPORTATION

✓PRE-REQUISITES

- GOOD MANUFACTURING PRACTICES
- STANDARD SANITATION OPERATION PROCEDURES
- PEST CONTROL
- SPECIFICATIONS FOR TRANSPORT

STORAGE AND TRANSPORTATION

- ✓ CONTROL PLAN 3
  - HAZARD ANALYSIS
  - POSSIBLE CP´s
    - MOISTURE CONTROL
    - ATMOSPHERE CONTROL



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POST-HARVEST CONTROL

✓PRE-REQUISITES

- GMP´S
- SSOP´S معايير العمليات الشيئية
- SPECIFICATIONS

NORMAL PROCESSING

✓ CONTROL PLAN 4a

- HAZARD ANALYSIS
- POSSIBLE CP´S
  - MOISTURE CONTROL
  - PROCESSING CONDITIONS

DECONTAMINATION/DETOXIFICATION

- ✓ CONTROL PLAN 4b
  - HAZARD ANALYSIS
  - POSSIBLE CP´S
    - DECONTAMINATION CONDITION(S)

POST-HARVEST MANAGEMENT

- ✓ USE PROCESSING AS A HURDLE, REGARDLESS OF THE LEVEL OF CONTAMINATION
- ✓ PROCESSING CAN BE A GOOD PREVENTION TOOL
- ✓ PREVENTION OF NEW MYCOTOXIN FORMATION

POST-HARVEST MANAGEMENT

✓DECONTAMINATION STRATEGIES
- PHYSICAL SEPARATION
- PHYSICAL DECONTAMINATION
- BIOLOGICAL DECONTAMINATION
- CHEMICAL INACTIVATION
- CHEMOADSORPTION

CRITERIA FOR ACCEPTANCE FOR MYCOTOXIN DECONTAMINATION PROCEDURES

✓ DESTROY, INACTIVATE OR REMOVE THE MYCOTOXIN

✓ NOT PRODUCE OR LEAVE TOXIC RESIDUES

✓ RETAIN NUTRITIVE VALUE AND ACCEPTABILITY

✓ NOT ALTER SIGNIFICANTLY TECHNOLOGICAL PROPERTIES

✓ DESTROY FUNGAL SPORES

DECONTAMINATION PROCEDURES

- ✓ LABORATORY CONDITIONS
- ✓ PILOT PLANT CONDITIONS
- ✓ INDUSTRIAL SCALE PROCESSING

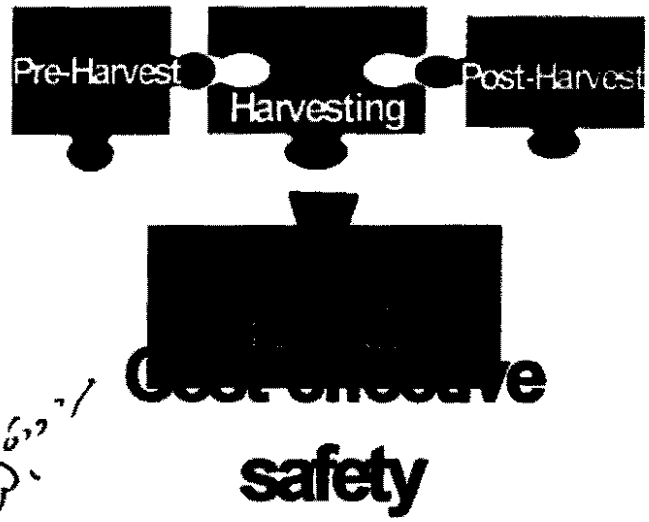
DECONTAMINATION PROCEDURES

✓**EVALUATION**

- **CHEMICAL MODIFICATION**
- **TOXIC/MUTAGENIC POTENTIAL**
- **TECHNOLOGICAL PROPERTIES**
- **SENSORY CHARACTERISTICS**
- **NUTRITIONAL QUALITIES**

Integrated mycotoxic management.

Integrated Mycotoxin Management



PHYSICAL METHODS OF MYCOTOXIN REMOVAL

- ✓ PRIMARY SOURCE OF REMOVAL
- ✓ DIFFERENT PROCEDURES DEPENDING ON THE TOXIN AND THE COMMIDITY
- ✓ INITIAL INVESTMENT FOR RELIABLE SEPARATION EQUIPMENT IS REQUIRED
- ✓ INEXPENSIVE MAINTENANCE
- ✓ FURTHER PROCESSING MAY BE REQUIRED

PHYSICAL METHODS OF MYCOTOXIN REMOVAL

✓ WET MILLING

- PROCESS WIDELY USED FOR CORN
- ESTABLISHED PROCESS THAT CAN BE USED FOR MANAGEMENT WITHOUT EXTRA COST
  - IMPORTANT TO IDENTIFY FRACTIONS THAT REMAIN TOXIC
  - TOXIC FRACTIONS MAY BE DIVERTED TO LESS RISK USES

PHYSICAL METHODS OF MYCOTOXIN REMOVAL

✓ DRY MILLING

- IMPORTANT SEPARATION PROCESS
- ESTABLISHED PROCESS THAT CAN BE USED FOR MANAGEMENT WITHOUT EXTRA COST
  - IMPORTANT TO IDENTIFY FRACTIONS THAT REMAIN TOXIC
  - TOXIC FRACTIONS MAY BE DIVERTED TO LESS RISK USES

PHYSICAL METHODS OF DETOXIFICATION

✓THERMAL INACTIVATION

- GOOD ALTERNATIVE FOR PRODUCTS THAT ARE USUALLY HEAT PROCESSED
- SOME MYCOTOXINS ARE STABLE AT PROCESSING TEMPERATURES

PHYSICAL METHODS OF DETOXIFICATION

✓IRRADIATION

- EFFECT IS RELATIVELY UNKNOWN
- HIGH COST
- CONSUMER ACCEPTABILITY ISSUES

PHYSICAL METHODS OF DETOXIFICATION

- ✓ ADSORPTION FROM SOLUTION AND COVALENT BINDING
  - GOOD ALTERNATIVES
  - APPROVED USES: ANTI-CAKING AGENTS
- ✓ SPECIFIC USE AS DECONTAMINATING METHOD IS APPROVED

BIOLOGICAL DECONTAMINATION

- ✓ GOOD OPTION FOR THE FERMENTING INDUSTRY
- ✓ IMPORTANT TO DETERMINE:
  - MYCOTOXIN STABILITY DURING THIS PROCESS
  - YEAST AVAILABILITY
  - YIELD AND DEVELOPMENT OF SECONDARY CHARACTERISTICS, i.e., FLAVOR COMPONENTS

BIOLOGICAL DECONTAMINATION

- ✓ SPECIFIC COMPOUNDS PRODUCED BY SELECTED MICROORGANISMS MAY BE THE ACTIVE DECONTAMINATING AGENTS
- ✓ WHEN THIS OCCURS, IT IS MORE EFFICIENT AND ECONOMICAL TO ADD THE ACTIVE INGREDIENTS DIRECTLY

CHEMICAL INACTIVATION

- ✓ AMMONIATION المعالجة بالأمونيا
  - – EVALUATED EXTENSIVELY
  - – HIGHLY EFFECTIVE FOR AFLATOXIN CONTROL
  - – PROCESS SUCCESFULLY USED IN SEVERAL COUNTRIES
  - – ECONOMICALLY ACCESSIBLE

CHEMICAL INACTIVATION

- ✓ NIXTAMALIZATION
  - EVALUATED EXTENSIVELY
  - EFFECTIVE FOR AFLATOXIN CONTROL, HOWEVER THE ORIGINAL AFLATOXIN HAS BEEN SHOWN TO REFORM ON ACIDIFICATION OF THE PRODUCTS
- ✓ USE OF ADDITIONAL CHEMICALS, i.e., HYDROGEN PEROXIDE AND SODIUM BICARBONATE TO MAKE THE CHEMICAL MODIFICATION PERMANENT

CHEMICAL INACTIVATION

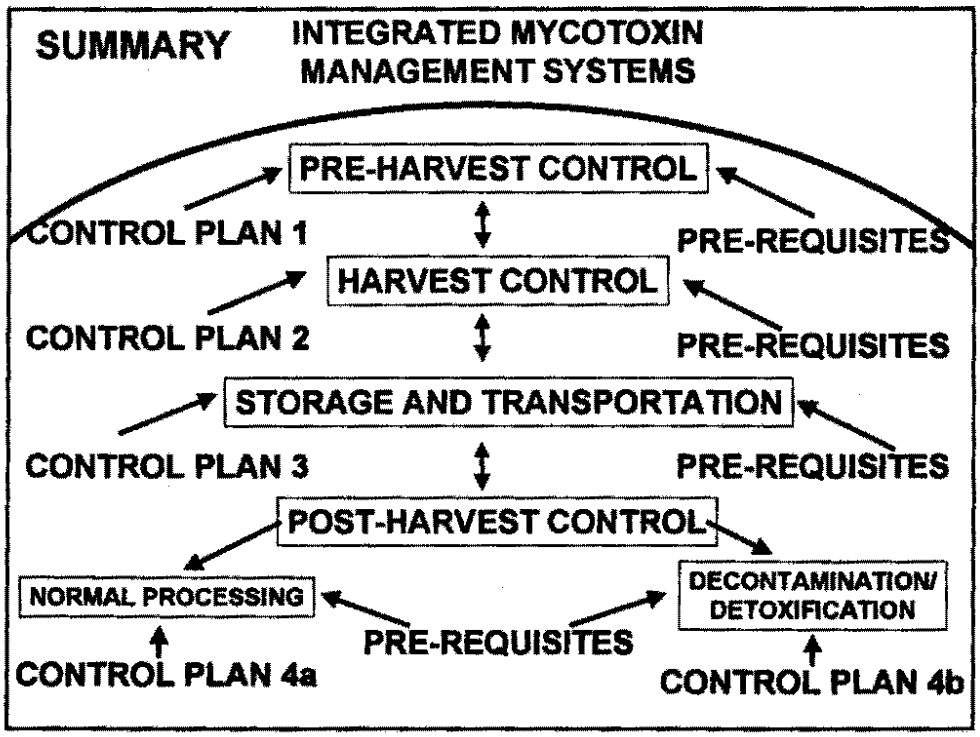
- ✓ USE OF SODIUM BISULFITE
  - EFFECTIVE IN AFLATOXIN DETOXIFICATION
  - PRACTICAL
  - EVALUATION OF SPECIFIC INDUSTRIAL APPLICATION IS NEEDED

CHEMICAL INACTIVATION

- ✓ USE OF FOOD GRADE CHEMICALS (ALONE OR IN COMBINATION
  - – HYDROGEN PEROXIDE (AFLATOXIN AND FUMONISIN)
  - – SODIUM BICARBONATE)AFLATOXIN AND FUMONISIN)
  - – SODIUM CHLORIDE (AFLATOXIN)
  - – ASCORBIC ACID (PATULIN)

CHEMICAL INACTIVATION

- ✓ USE OF FOOD GRADE CHEMICALS (ALONE OR IN COMBINATION
  - – DEVELOPMENT OF COST-EFFECTIVE PROCESSES THAT WILL PROVIDE A SAFER PRODUCT
- ✓ DEVELOPMENT OF COST-EFFECTIVE PROCESSES THAT WILL PROVIDE SAFER PRODUCTS
- ✓ ISSUE APPROVAL OF:
  - MODIFIED PROCESSES
  - USE OF FOOD ADDITIVES FOR DECONTAMINATION PURPOSES



CONCLUSIONS

- ✓ THERE IS NO SINGLE METHOD THAT WILL INSURE THE COMPLETE REMOVAL OF THE CONTAMINANT
- ✓ INTEGRATED MANAGEMENT WITH THE COMBINATION OF DIFFERENT METHODS CAN SIGNIFICANTLY REDUCE THE RISKS ASSOCIATED WITH MYCOTOXIN CONTAMINATION

CONCLUSIONS

- ✓ MYCOTOXIN CONTROL IS A COMPLEX ISSUE
- ✓ IT IS IMPORTANT TO DEVELOP CONCERTED PROGRAMS DEVISED TO REDUCE THE POTENTIAL EXPOSURE TO THESE COMPOUNDS
- ✓ A HACCP-BASED APPROACH COULD BE USEFUL IN DEVELOPING AN ENCOMPASSING CONTROL PROGRAM

CONCLUSIONS

- ✓ THE MOST PRACTICAL, COST-EFFECTIVE POST-HARVEST PROCEDURES AVAILABLE ARE:
  - PHYSICAL REMOVAL OF CONTAMINATED KERNELS, SEEDS OR NUTS (CLEANING AND SEPARATION)
    - CHEMICAL INACTIVATION –AMMONIATION
    - USE OF CHEMICALS NORMALLY USED IN INDUSTRIAL PROCESSES
    - REMOVAL OF THE CONTAMINANT BY CHEMISORBENTS

CONCLUSION

- ✓ IN AN IDEAL INTEGRATED MYCOTOXIN MANAGEMENT SYSTEM, MYCOTOXIN HAZARDS WOULD BE MINIMIZED IN EVERY PHASE OF PRODUCTION, HARVESTING, PROCESSING AND DISTRIBUTION

يتم الحد أو الأقلال من مخاطر السموم الفطرية ، وذلك
من خلال تطبيق النظام المتكامل للتحكم في السموم الفطرية ،
في كل مرحلة من الانتاج من الحصاد أو التصنيع والتوزيع

CAREFUL AND RATIONAL USE OF PESTICIDES

REBECA LOPEZ-GARCIA, Ph.D.

LOGRE INTERNATIONAL

DEFINITION

- ✓ SUBSTANCE OR MIXTURE OF SUBSTANCES INTENDED FOR PREVENTING, DESTROYING, REPELLING, OR MITIGATING ANY PESTS, AS WELL AS ANY SUBSTANCE OR MIXTURE OF SUBSTANCES INTENDED FOR USE AS A PLANT REGULATOR, DEFOLIANT OR DESICCANT

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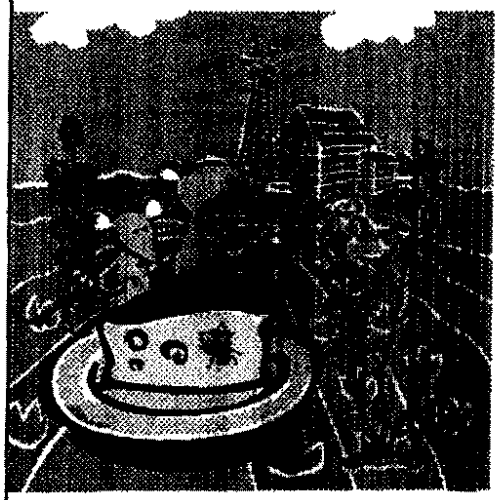
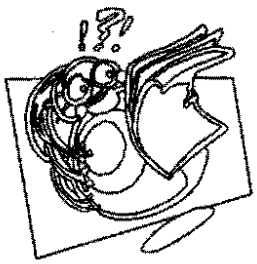
DEFINITION



PEST: ANY UNDESIRABLE INSECT, RODENT, NEMATODE, FUNGUS OR WEED

CIDE: TERM THAT INVOLVES SOME FORM OF KILLING

PEST-FACTS



» WORLDWIDE, THERE ARE OVER 100,000 SPECIES OF PESTS

» RECENT SWARMS OF LOCUSTS IN ETHIOPIA CAUSED THE DESTRUCTION OF 167,000 TONS OF GRAIN IN ONE MONTH – ENOUGH TO FEED ONE MILLION PEOPLE IN A YEAR

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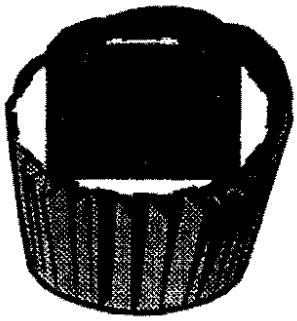
PEST FACTS



- ✓ IN THE U.S. THE ANNUAL CONSUMPTION OF INSECT PARTS IS 1 POUND IN PRODUCTS SUCH AS JELLY, JAMS AND TOMATO PASTE
- ✓ MOST GOVERNMENTS AND INTERNATIONAL ORGANIZATIONS HAVE IDENTIFIED THE NEED TO LEGISLATE FOR THE NUMBER OF HAIRS AND INSECT PARTS ALLOWED IN A PRODUCT

DIVERSE POSITIONS ON PESTICIDE USE

- ✓ CONSUMER
  - ❖ OBLIVIOUS
  - ❖ CONSUMER ACTIVIST GROUPS
- ✓ GOVERNMENT AND INTERNATIONAL ORGANIZATIONS
  - ❖ IDENTIFICATION OF NEED FOR LEGISLATION
- ✓ CAN THE AGRICULTURAL COMMUNITY PRODUCE ENOUGH FOOD?

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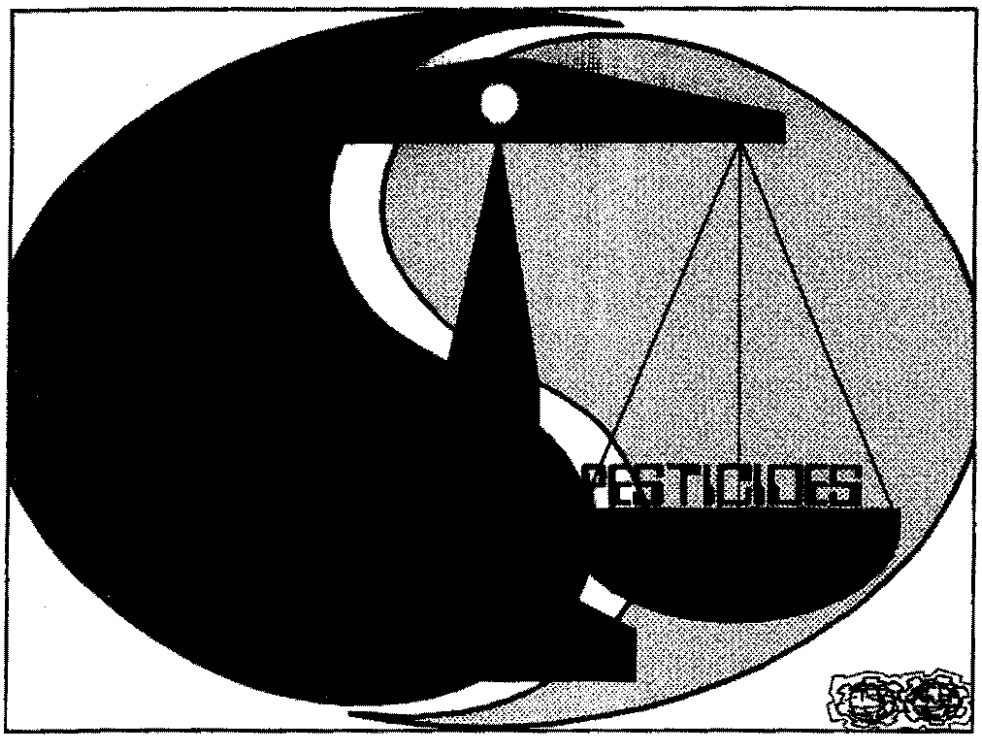

PESTICIDE BALANCE

- ✓ ATTEMPTS TO MAXIMIZE BENEFITS AND MINIMIZE RISKS TO PUBLIC HEALTH, AGRICULTURE, AND THE ENVIRONMENT SPARKED A CURRENT, ECOLOGICALLY SOUND SYSTEM FOR PEST CONTROL. (IPM)
- ✓ JUDICIOUS APPLICATION OF PESTICIDES
- ✓ GOAL OF SUSTAINABLE AGRICULTURE IS TO PRODUCE ADEQUATE AMOUNTS OF HIGH QUALITY FOOD WHILE PROTECTING RESOURCES

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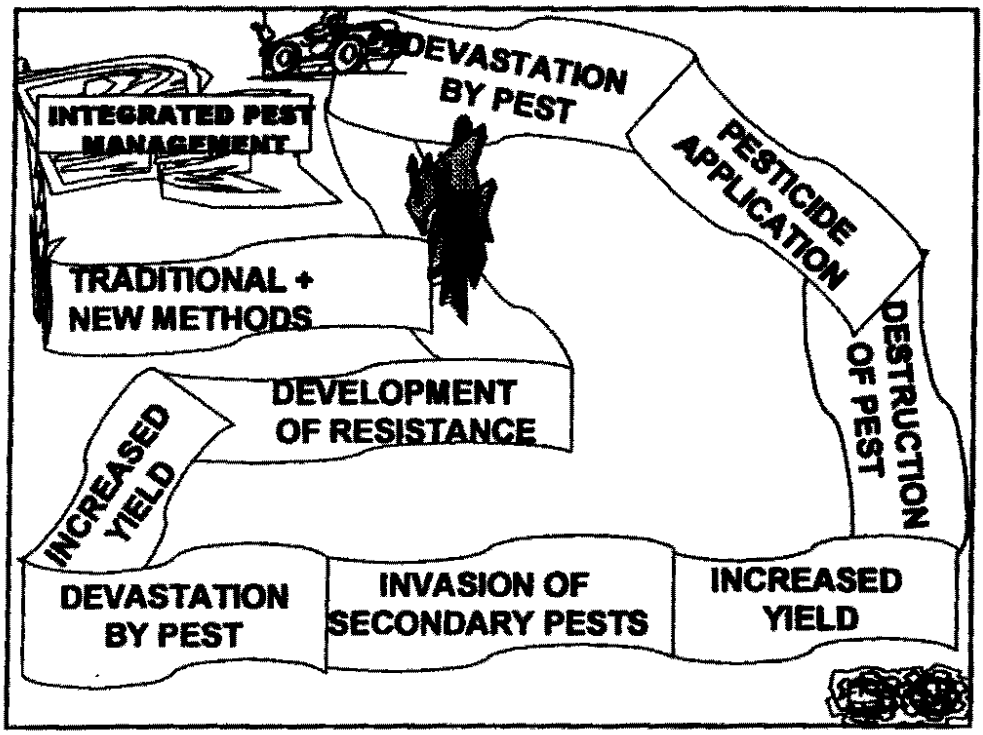
METHODS USED TO CONTROL PESTS BEFORE CHEMICAL PESTICIDES

- ✓ CROP ROTATIONS
- ✓ INTENSIVE CULTIVATION
- ✓ DESTRUCTION OF CROP REFUSE
- ✓ TRAP CROPS
- ✓ PRUNING AND DEFOLIATION
- ✓ VARYING PLANTING DATES
- ✓ HAND REMOVAL OF WEEDS AND INSECTS



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TYPES OF PESTICIDES

- ✓ STOMACH POISONS – INGESTED TO KILL PEST
- ✓ CONTACT PESTICIDES – ABSORBED THROUGH THE BODY WALL
- ✓ FUMIGANTS – ENTER THROUGH INHALATION
- ✓ DESICCANTS – REMOVE OR DISRUPT CUTICLE, BODY FLUIDS ARE LOST

MAJOR GROUPS OF INSECTICIDES

- ✓ BOTANICALS
- ✓ SYNTHETIC PYRETHROIDS
- ✓ INORGANICS
- ✓ ORGANOPHOSPHATES
- ✓ CARBAMATES
- ✓ CHLORINATED HYDROCARBONS
- ✓ FUMIGANTS
- ✓ INSECT GROWTH REGULATORS

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BOTANICALS

- ✓ OFTEN REFERRED TO AS "NATURAL" PESTICIDES
- ✓ PYRETHRUM IS A COMPOUND EXTRACTED FROM CHRYSANTHEMUM FLOWERS
- ✓ USED WITH A SYNERGIST (mkg264 OR PIPERONYL BUTOXIDE)

SYNTHETIC PYRETHROIDS

- ✓ MOLECULESHINS THAT MIMIC ONE OF THE SIX MOLECULES OF PYRETHRINS
- ✓ THESE ARE LONG LASTING COMPOUNDS, SO THERE IS POOR FLUSHING

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INORGANICS

- ✓OLDEST INSECTICIDES
- ✓SLOW ACTING
- ✓EXAMPLES: BORIC ACID, DIATOMACEOUS EARTH, SILICAEROGEL

ORGANOPHOSPHATES

- ✓ EFFECT ON THE NERVOUS SYSTEM (CHOLINESTERASE INHIBITORS)
- ✓ SHORT HALF-LIFE IN THE BODY
- ✓ NOT PERSISTENT IN THE ENVIRONMENT
- ✓ PARATHION (MOST TOXIC), MALATHION, DURSBAN, DIAZINON, ACEPHATE, DICHLORVOS

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CARBAMATES

- ✓ USED WHEN INSECTS HAVE DEVELOPED RESISTANCE TO ORGANOPHOSPHATES
- ✓ MODE OF ACTION SIMILAR TO ORGANOPHOSPHATES
- ✓ LOWER TOXICITY
- ✓ ALDICARB, BAYGON, SEVIN, FICAM
- ✓ 1985 ILLEGALLY APPLIED ALDICARB ON WATERMELONS CAUSED POISONING IN CALIFORNIA

CHLORINATED HYDROCARBONS

- ✓ FIRST GROUP OF SYNTHETIC ORGANIC INSECTICIDES
- ✓ ACCUMULATE IN FAT DEPOSITS (FOOD CHAIN ACCUMULATION) AND IN THE ENVIRONMENT
- ✓ MOST HAVE BEEN BANNED FROM INTERNATIONAL MARKETS
- ✓ DDT, DDE, DIELDRIN, CHLORDANE, LINDANE, BENZENE HEXACHLORIDE (HCH), ALDRIN, HEPTACHLOR, ENDRIN

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CHLORINATED HYDROCARBONS

- ✓MAIN SOURCE OF TOXICITY = DIOXIN (ALSO KNOWN AS TCDD)
- ✓ONE OF THE MOST TOXIC SUBSTANCES
- ✓RECENT FOOD SCARE IN BELGIUM

OTHER ACTIVE INGREDIENTS

- ✓SYNERGISTS
- ✓PETROLEUM DISTILLATES
- ✓REPELLENTS
- ✓ATTRACTANTS

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FUMIGANTS

- ✓ ETHYLENE DIBROMIDE – BANNED IN 1984 TO MEDIUM CARCINOGENIC RISK (MORE THAN SACCHARINE AND LESS THAN AFLATOXIN)
- ✓ TO REACH LEVEL OF STUDY, ONE WOULD HAVE TO EAT 400 MT OF FOOD EVERY DAY
- ✓ ACTIVE AS A GAS OR VAPOR
- ✓ EXTREMELY LETHAL
- ✓ LIQUID, SOLID, OR GAS STATE FOR USE

PHERORMONES

- ✓MIMIC NATURAL ATTRACTANTS USED BY INSECTS TO COMMUNICATE
- ✓SPECIES SPECIFIC

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INSECT GROWTH REGULATORS

- ✓ DISRUPT GROWTH AND DEVELOPMENT
  هرمونات الجيوفه
- ✓ MIMIC JUVENOIDS (JUVENILE HORMONES)
- ✓ GENTHROL, METHOPRENE

CHITIN INHIBITORS

- ✓ALSO INHIBIT GROWTH
- ✓INHIBIT MOLTING PROCESS
- ✓DISRUPT CHITIN SYNTHESIS
- ✓THE INSECT IS UNABLE TO SHED OLD SKIN DURING MOLTING

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HERBICIDES

- ✓ WHERE RAINFALL IS HEAVY, APPROXIMATELY 40% OF THE CROP PROTECTION $ IS SPENT ON HERBICIDES
- ✓ LOWER TOXICITY TO ANIMAL SPECIES
- ✓ ATRAZINE, SIMANZINE

MODES OF ACTION OF HERBICIDES

- ✓ INHIBITION OF PHOTOSYNTHESIS
  - ❖ UREAS, TRIAZINES, DINITROPHENOLS
- ✓ INHIBITION OF RESPIRATION BY BLOCKADE OF ELECTRON TRANSER FROM NADH
  - ❖ HALOPHENOLS
- ✓ GROWTH STIMULANTS "AUXINS"
  - ❖ BENZOIC ACIDS

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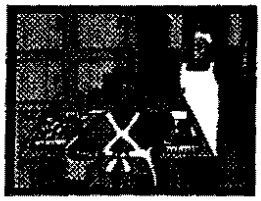
MODES OF ACTION OF HERBICIDES

- ✓ INHIBITORS OF CELL FUNCTIONS
  - ❖ CARBAMATES, DINITROANILINES, CHLORACETAMIDES, O-SUBSTITUTED DIPHENYL ESTERS
- ✓ INHIBITION OF LIPID SYNTHESIS
  - ❖ ALIPHATIC CHLOROCARBOXILIC ACIDS
- ✓ UNKNOWN MECHANISMS
  - ❖ COPPER SULFATES, SULFURIC ACID, SODIUM BORATES

FUNGICIDES

- ✓ USED TO TREAT SEEDS BEFORE PLANTING
- ✓ SEED THAT IS TO BE PLANTED SHOULD NOT BE EATEN
- ✓ ONE CASE OF POISONING... COMMERCIAL CLAIM, SEEDS ARE MORE "NATURAL" BECAUSE THEY ARE THE SAME THAT WILL BE PLANTED



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FUNGICIDES

- ✓HEXACHLOROBENZENE
- ✓PENTACHLOROFENOL
- ✓PHTALIMIDES
- ✓DITHIOCARBAMATES

RODENTICIDES

- ✓ZINC PHOSPHIDE
- ✓FLUOROACETATE
- ✓FLUOROACETAMIDE
- ✓ANTU
- ✓WARFARIN
- ✓DIPACINONE

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PESTICIDE FORMULATION

- ✓ EMULSIFIABLE CONCENTRATE (EC)
- ✓ SOLUTIONS (S)
- ✓ FLOWABLE MICROENCAPSULATED (FM)
- ✓ DUSTS
- ✓ WETTABLE POWDERS (SUSPEND)
- ✓ SOLUBLE POWDERS (DISSOLVED)
- ✓ BAITS
- ✓ GRANULES
- ✓ PELLETS
- ✓ FUMIGANTS

MONITORING RESIDUES

- ✓ "CASE OF THE SHRINKING ZERO"
- ✓ SETTING TOLERANCE LEVELS
  - ❖ MAXIMUM RESIDUAL LEVELS (MRL) ARE FAR BELOW THE ACCEPTABLE DAILY INTAKE (ADI)
- ✓ JUST BECAUSE ONE TOLERANCE LEVEL HAS BEEN SET FOR A GRAIN, DOES NOT MEAN THAT THE SAME PESTICIDE IS ALLOWED ON A FRUIT

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MONITORING RESIDUES

- ✓ LEVELS ARE KEPT AS LOW AS POSSIBLE
- ✓ IF A PESTICIDE IS USED ON MORE THAN ONE COMMODITY, THE WORST CASE SCENARIO IS CONSIDERED IN SETTING THE MRL

MONITORING RESIDUES

- ✓ CALCULATION MADE ASSUMING:
  - ❖ THAT THE RESIDUE AT THE TIME OF CONSUMPTION IS MAXIMUM
  - ❖ THAT ALL THE CROP HAS BEEN TREATED WITH THE PRODUCT RESULTING IN THE RESIDUE
  - ❖ THAT THE PERSON CONSUMES DAILY THE MAXIMUM PER CAPITA AMOUNT

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ESTIMATING MAXIMUM INTAKE

- ✓ OVERESTIMATES ARE THE RULE BECAUSE USUALLY ONLY 10-30% OF A CROP IS TREATED
- ✓ LEVELS AT THE TIME OF CONSUMPTION MAY BE ONLY 20-40% OF WHAT THEY ARE AT THE TIME OF HARVEST, AS PROCESSING, COOKING, FRYING AND BAKING REDUCE RESIDUE LEVELS
- ✓ AN UNDERLYING PRINCIPLE IS THAT FOOD IS THE UNIVERSAL ROUTE OF EXPOSURE, TOLERANCES MUST ERR ON THE STRICT SIDE

ESTIMATING MAXIMUM INTAKE

✓FOODS WITH RESIDUES EXCEEDING THE MRL WOULD NOT NECESSARILY BE TOXIC, ANYMORE THAN DRIVING OVER THE SPEED LIMIT MEANS THAT THERE IS A CERTAINTY OF HAVING AN ACCIDENT

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SPECIAL CONCERNS

- ✓ INTERNATIONAL COMMERCE OF PRODUCTS WITH PESTICIDES THAT HAVE BEEN BANNED
- ✓ IN 1989, OVER 18,000 SAMPLES OF FOOD WERE ANALYZED BY FDA:
  - ❖ 57% IMPORTED FOODS
  - ❖ NO DETECTABLE RESIDUES IN 61% OF SAMPLES
  - ❖ LESS THAN 4% IN VIOLATION
  - ❖ OVER 3% OF ALL VIOLATIONS:
    - NOT BECAUSE RESIDUES WERE ABOVE ALLOWED LEVELS
    - SPECIFIC PESTICIDE RESIDUES WERE FOUND IN FOODS FOR WHICH THE PESTICIDE WAS NOT REGISTERED

SIGNAL WORDS

- ✓ INDICATE HOW POTENTIALLY DANGEROUS THE PRODUCT IS TO HUMANS AND NON-TARGET ANIMALS

»DANGER

»WARNING

»CAUTION

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SIGNAL WORDS

✓**DANGER**

- ❖PESTICIDE IS HIGHLY TOXIC
- ❖HAS WORD "**POISON**" PRINTED IN RED
- ❖SKULL AND CROSS BONES

- ❖LD_{50} (0-5 mg/Kg)

SIGNAL WORDS

✓**WARNING**

- ❖MODERATELY TOXIC
- ❖LD_{50} (50-500 mg/Kg)

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SIGNAL WORDS

✓CAUTION

- ❖SLIGHTLY TOXIC
- ❖LD_{50} (500-5000 mg/Kg)

LABELING

✓PRECAUTIONARY STATEMENTS HAZARDS TO HUMANS AND DOMESTIC ANIMALS

- ❖CAUTION
- ❖ENVIRONMENTAL HAZARDS
- ❖PHYSICAL OR CHEMICAL HAZARDS

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LABELING

- ✓DIRECTIONS FOR USE GENERAL CLASSIFICATION
- ✓IT IS A VIOLATION OF FEDERAL LAW TO USE THIS PRODUCT IN A MANNER INCONSISTENT WITH ITS LABELING

LABELING

- ✓REENTRY STATEMENT
- ✓STORAGE AND DISPOSAL
- ✓RESTRICTED-USE: PESTICIDE
- ✓PRODUCT NAME

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LABELING

- ✓ACTIVE INGREDIENT ___ %
- ✓INERT INGREDIENT_____ %
- ✓TOTAL 100 %

- ✓THIS PRODUCT CONTAINS ____lbs. OF _____PER GALLON

LABELING

- ✓ KEEP OUT OF REACH OF CHILDREN
- ✓ CAUTION
- ✓ STATEMENT OF PRACTICAL TREATMENT:
  - ❖IF SWALLOWED _____
  - ❖IF INHALED _____
  - ❖OF ON SKIN _____
  - ❖IF IN EYES _____
- ✓ SEE SIDE PANEL FOR ADDITIONAL PRECAUTIONARY STATEMENTS

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LABELING

- ✓ MANUFACTURED BY: _____
- ✓ TOWN, STATE_____
- ✓ ESTABLISHMENT No._____
- ✓ EPA REGISTRATION NUMBER_____
- ✓ NET CONTENTS_____

LABELING

✓DIRECTIONS FOR USE:

❖COCKROACHES AND ANTS, SILVERFISH, CRICKETS.....

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LABELING

✓FOOD AREAS:

✓NON FOOD AREAS:

✓SPIDERS, TICKS, EARWIGS, FIREBRATS:

RECORD KEEPING

✓CLEAN AND CONCISE RECORDS ARE REQUIRED FOR EACH APPLICATION MADE, STATES MANDATE TE LENGTH OF TIME RECORDS ARE TO BE KEPT (2-5 YEARS). <u>SPECIFIC</u>

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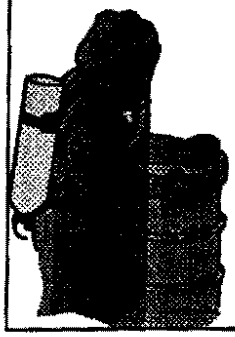
STORAGE OF PESTICIDES

- ✓ PROVIDE SEPARATE BUILDING, IF POSSIBLE
- ✓ PROVIDE MATERIALS TO HANDLE SPILLS
  - ❖ ABSORBENT MATERIALS
  - ❖ SAFETY EQUIPMENT
  - ❖ CONTAINMENT EQUIPMENT
  - ❖ FIRE FIGHTING EQUIPMENT
- ✓ ADEQUATE VENTILATION

PERSONAL PROTECTIVE EQUIPMENT

- ✓ KNOWLEDGE ABOUT THE CHEMICAL YOU ARE HANDLING MAY SAVE YOUR LIFE!



- ❖ PROTECTIVE CLOTHING
- ❖ PROTECTIVE EQUIPMENT
- ❖ OTHER PROTECTIVE GEAR
- ❖ PROPER DISPOSAL OF TOXIC WASTE

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CONCLUSIONS

- ✓ DIVERSE VARIETIES
- ✓ SEVERAL FACTORS TO CONSIDER
- ✓ ONLY INTEGRATED MANAGEMENT WILL HELP
- ✓ HARMONIZATION OF INTERNATIONAL LEGISLATION

MANAGEMENT

- ✓ INTEGRATED PEST MANAGEMENT
- ✓ SUPPLIER RELATIONSHIPS
- ✓ IN-HOUSE MANAGEMENT PROGRAMS
  - ❖ PROPER CHEMICAL STORAGE
  - ❖ WAREHOUSE ORGANIZATION
  - ❖ PERSONAL SAFETY

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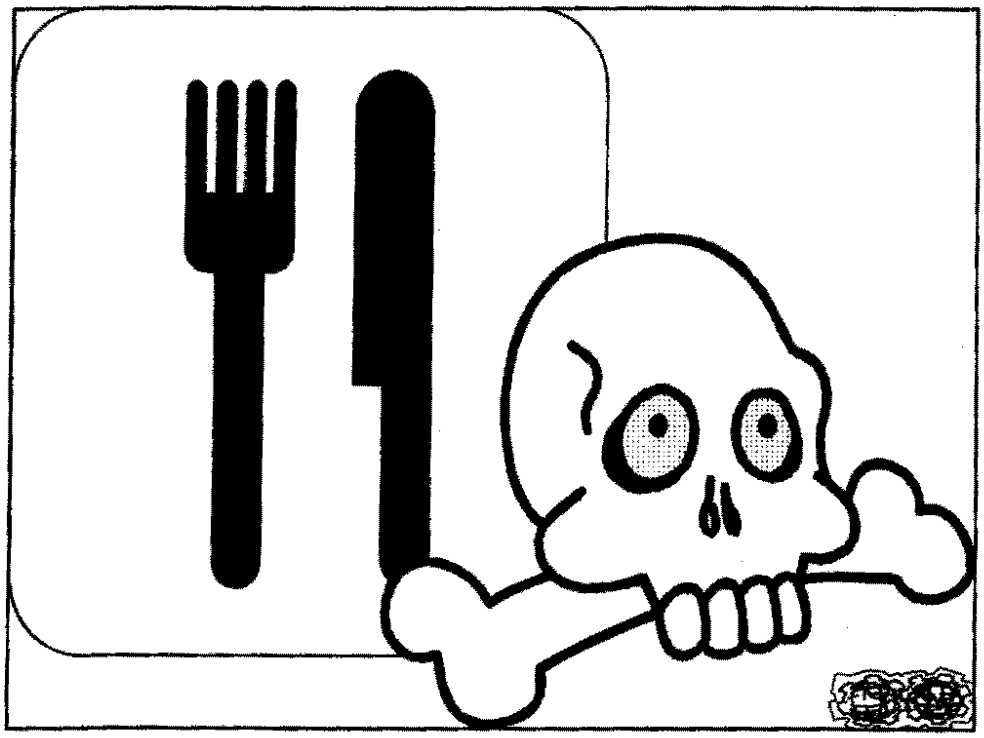

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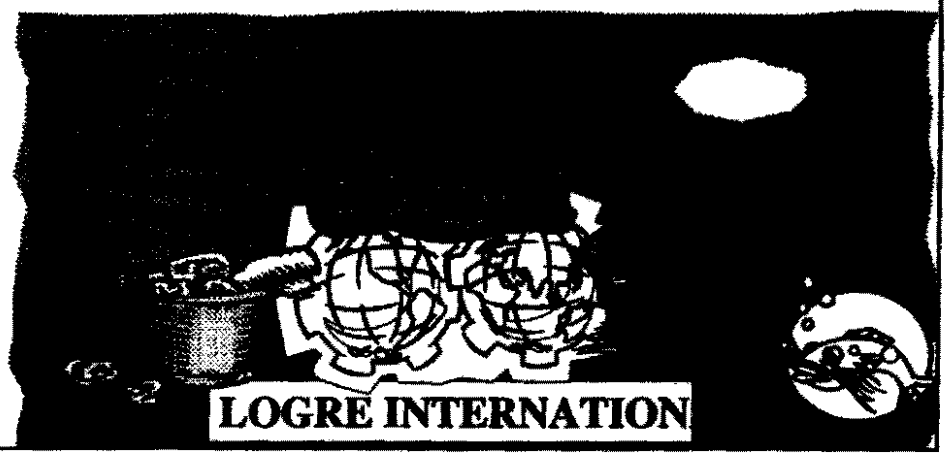
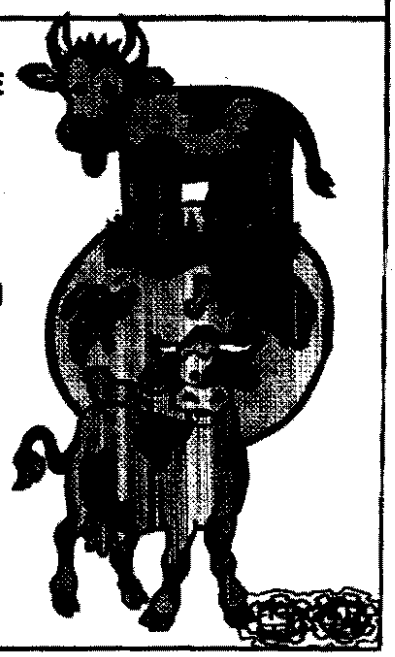
INCIDENTAL CONTAMINANTS CONTAMINATION FROM INDUSTRIAL WASTE

REBECA LOPEZ-GARCIA, Ph.D.



ANTIBIOTICS

- ✓ USED WORLDWIDE IN WORLDWIDE ANIMAL HUSBANDRY
- ✓ DIRECT GROWTH-PROMOTING EFFECT
- ✓ METABOLIC EFFECT RESULTING IN THE FASTER BUILDING OF TISSUE
- ✓ NUTRIENT-SPARRING EFFECT
- ✓ IMPROVED DIGESTION AND ABSORPTION
- ✓ ANTIBIOTIC EFFECT – ELIMINATES SUBLCLINICAL INFECTIONS



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ANTIBIOTICS

- ✓ DO NOT PROMOTE GROWTH IN GERM-FREE ANIMALS
- ✓ DISEASES CONTROLLED INCLUDE:
  - ❖ DYSENTERY
  - ❖ MYCOPLASMA
  - ❖ PNEUMONIA
  - ❖ LIVER ABSECESSES
- ✓ SPECIALLY USEFUL IN HIGH RISK SITUATIONS

ANTIBIOTICS

- ✓ CONCERN SINCE 1950´s
  - ❖ COMPROMISED MEDICINAL USES
  - ❖ TOXICITY OF THE ANTIBIOTIC ITSELF
  - ❖ ALLERGIC REACTIONS
  - ❖ ANTIBIOTIC RESISTANCE
- ✓ MINIMIZE EXPOSURE TO HUMANS
  - ❖ WITHDRAWAL TIMES
  - ❖ PRESCRIBED PROTOCOLS
  - ❖ ESTABLISHMENT OF RESIDUE TOLERANCES

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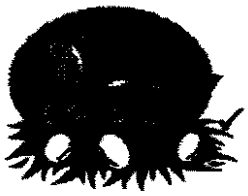
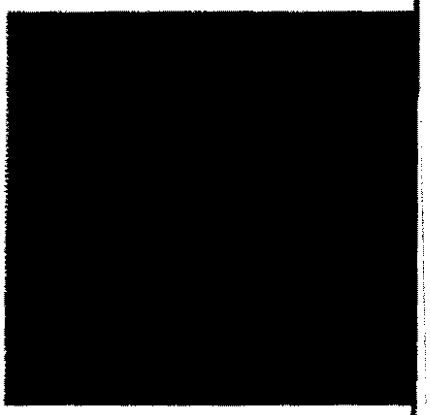
GROWTH PROMOTERS



- ✓ FEED ADDITIVES
- ✓ ALTHOUGH THE WHO/FAO JOINT EXPERT COMMITTEE ON FOOD ADDITIVES FOUND LITTLE RISK, THE EC HAS BANNED THE IMPORT OF MEAT FROM HORMONE TREATED ANIMALS

FERTILIZERS

- ✓ 16 NUTRIENTS ARE ESSENTIAL FOR PLANT LIFE
- ✓ 13 COME FROM SOIL
- ✓ ESSENTIAL NUTRIENTS ARE REQUIRED IN LARGE AMOUNTS



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FERTILIZERS

- ✓ CONCERN: EXCESSIVE USE OF NITRATE FERTILIZER
  - ❖ EFFECTS ON FOOD
  - ❖ EFFECTS ON WORKERS
  - ❖ EFFECTS ON GROUNDWATER (ALL NITROGEN FERTILIZER ORGANIC OR CHEMICAL INCREASE NITRATE LEVEL IN GROUNDWATER)
- ✓ NITRATE – NITROSAMINES – POWERFUL GASTRIC CARCINOGENS

FERTILIZERS

- ✓ COMMERCIAL FERTILIZERS MAY HAVE HIGH LEVELS OF CADMIUM (NATURAL COMPONENT OF PHOSPHATE ROCK)
  - ❖ HEAVY METAL
  - ❖ NOT READILY ELIMINATED
  - ❖ RAISES BLOOD PRESSURE
  - ❖ INTERFERES WITH METABOLISM OF OTHER DIVALENT METALS (CALCIUM, COPPER, AND ZINC)
  - ❖ HYPERTENSION, CANCER, CORONARY HEART DISEASE

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RISKS OF ORGANICALLY GROWN PRODUCE

- ✓ INCREASED RISK OF BIOLOGICAL AND MICROBIAL CONTAMINATION
- ✓ INCREASED RISK OF BIOCONCENTRATED POLLUTANTS
- ✓ DIFFICULTY OF ACHIEVING ADEQUATE YIELDS ON A WIDESPREAD BASIS

RISKS OF ORGANICALLY GROWN PRODUCE

- ✓ PATHOGENS SUCH AS LISTERIA AND SALMONELLA, ROUNDWORMS AND OTHER MICROBIAL DISEASES PASSED ON THROUGH MANURE
- ✓ RAW SEWAGE = POTENTIAL CARRIER OF PATHOGENIC MICROORGANISMS
- ✓ PROCESSED SEWAGE = SLUDGES

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RISKS OF ORGANICALLY GROWN PRODUCE

- ✓SLUDGES ARE FREE OF PATHOGENS
- ✓SLUDGES CAN BE A SOURCE OF HEAVY METALS AND OTHER TOXICANTS THAT ARE BIOCONCENTRATED
  - ❖COPPER, ZINC, LEAD, NICKEL, CADMIUM, CHROMIUM, MERCURY

FERTILIZERS

- ✓USE "ORGANIC" FERTILIZERS
  - ❖COMPOST
  - ❖HUMUS
- ✓CROP ROTATION
- ✓INTEGRATED MANAGEMENT

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HEAVY METALS

✓ METALS THAT ARE ESSENTIAL BUT ALSO TOXIC

- ❖ IRON, ARSENIC
- ❖ PROVISIONALMAXIMUM TOLERABLE INTAKE

METAL	PMTI (mg/Kg)
ARSENIC	0.002
COPPER	0.5
ZINC	1.0
TIN	2.0

HEAVY METALS

✓ METALS WITH CUMULATIVE PROPERTIES

- ❖ HAVE A PROVISIONAL TOLERABLE WEEKLY INTAKE

METAL	PTWI (mg/PERSON)
CADMIUM	0.5
MERCURY	0.3
LEAD	3.0

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POLYCHLORINATED BIPHENYLS (PCB´S)

- ✓ DISCOVERED AROUND THE 1900´S
- ✓ EXTREME STABILITY + NONFLAMABILITY = VALUABLE IN TRANSFORMERS, CAPACITORS AND OTHER ELECTRONIC PARTS
- ✓ VEHICLES FOR PESTICIDES AND PAINTS

PCB´S

- ✓ BEFORE 1974, 8 MILLION POUNDS WERE MADE IN THE U.S.
- ✓ DISCARDED WITHOUT ANY ENVIRONMENTAL CONSIDERATION
- ✓ WRONG ASSUMPTION: EXTREME STABILITY=LOW TOXICITY

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PCB´S

- ✓ 1966 FIRST CONTAMINATION OF WILDLIFE WAS DISCOVERED
- ✓ 1968 POISONING OUTBREAK AFFECTED 1,000 PEOPLE IN JAPAN AND CAUSED STILLBIRTHS AND BIRTH DEFFECTS TO CHILDREN WHOSE MOTHERS HAD BEEN EXPOSED THROUGH CONTAMINATED RICE OIL

"YUSHO DISEASE"

PCB´S

✓ SOURCES OF PCB´S IN FOOD:

- ❖ USE OF RECYCLED PAPER FOR PACKAGING
- ❖ PCB CONTAINING SILO COATINGS
  - – SILAGE – COWS – MILK (CONTAMINATED WITH PCB´S
- ❖ SOURCES ELIMINATED
- ❖ CURRENT EXPOSURE IS THROUGH FISH. LARGER FISH HAVE HIGHER LEVELS

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DIOXIN

- ✓ ALSO KNOWN AS TCDD
- ✓ EPIDEMIOLOGICAL STUDIES SHOW THAT DIOXIN CAUSES NON-HODGKINS LYMPHOMA
- ✓ NO ANIMAL EVIDENCE
- ✓ ACUTE TOXICITY

DIOXIN

- ✓ ONE OF THE MOST TOXIC SUBSTANCES
- ✓ LD_{50} 0.6 MICROGRAM PER KILOGRAM BODY WEIGHT IN GUINEA PIGS
- ✓ ACUTELY TOXIC DOSES VARY AS MUCH AS 1,000 FOLD AMONG SPECIES
- ✓ CANCER, BIRTH DEFECTS, DEPRESSION OF THE IMMUNE SYSTEM, DEATH

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DIOXIN

- ✓ KEY ENZYMES FOR DNA SYNTHESIS AND NERVE TRANSMISSION
- ✓ PSYCHIATRIC DISTURBANCES
- ✓ NEUROTOXIC EFFECTS
- ✓ LONG-TERM EFFECTS ON BEHAVIOR AND LEARNING

DIOXIN

- ✓ 1999 EUROPEAN INCIDENTS
- ✓ ACCIDENTAL EXPOSURE
- ✓ INCREDIBLE IMPACT ON ECONOMY, INTERNATIONAL TRADE, CONSUMER PERCEPTION

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DIOXIN

✓THE SAD STORY OF INDUSTRIAL ACCIDENTS

- ❖AGENT ORANGE
- ❖1976 – SEVESO, ITALY 37,000 PEOPLE EXPOSED
  - CHLORACNE AND LIVER TOXICITY
  - LOWER DEATH RATES THAN EXPECTED

DIOXIN - THE EUROPEAN STORY

✓ IMPORTANCE OF INFORMATION

✓ IMPORTANCE OF INFORMATION

✓ IMPORTANCE OF GOOD RECALL PROGRAMS

✓ IMPORTANCE OF GOOD RISK COMMUNICATION

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DIOXIN – THE VICTIMS??

- ✓ THE COCA COLA RECALL
- ✓ MASS HYSTERIA?
- ✓ ECONOMICAL LOSSES
- ✓ LACK OF CONTROL
- ✓ RECALL PROGRAMS
- ✓ CONSUMER MEMORY

RISK MANAGEMENT

- ✓ CONTROL OF OLD EQUIPMENT
- ✓ PREVENT OIL LEAKAGE – GMP´S
- ✓ CONTROL INDUSTRIAL WASTE
- ✓ CONTROL SOURCES OF CONTAMINATION

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POLYBROMINATED BIPHENYLS

✓ 1970´S

- ❖ MISTAKE WHEN FLAME RETARDANT WAS MIXED WITH FEED
- ❖ CONTAMINATION OF MEAT, MILK, EGGS
- ❖ 30,000 CATTLE; 6,000 SWINE; 15,000 SHEEP; 1.5 MILLION CHICKENS; 5 MILLION EGGS WERE DESTROYED

POLYBROMINATED BIPHENYLS

✓ CHANGES IN THE LIVER

✓ TUMORS

✓ TERATOGENICITY

✓ BIOCHEMICAL CHANGES

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INDIRECT ADDITIVES FROM PACKAGING

- ✓ CHEMICALS CAN MIGRATE OR LEACH
- ✓ CONTAMINATION BY PCB´S
- ✓ PHTALATES (PLASTICIZERS)
- ✓ USE ONLY APPROVED FOOD PACKAGING MATERIALS

SUMMARY

- ✓ INDIRECT CONTAMINANTS
- ✓ UNIQUE PROBLEMS
- ✓ DIVERSE RISKS
- ✓ ARRIVE BUT WERE NOT INTENDED
- ✓ MONITORING IS IMPORTANT

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SUMMARY

- ✓INTEGRATED MANAGEMENT
- ✓GOOD SCIENCE-BASED RISK/BENEFIT DECISIONS
- ✓UNBIASED DECISIONS WITH MAXIMUM INFORMATION

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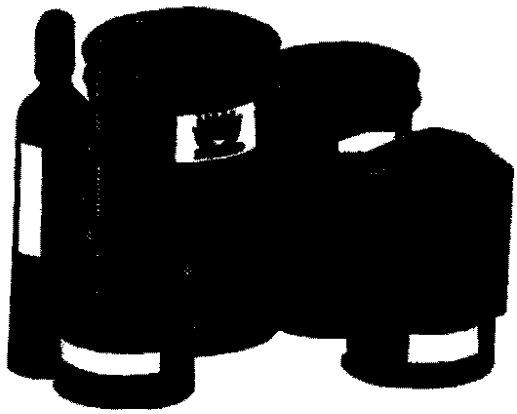
SAFE CHEMICAL HANDLING

REBECA LOPEZ-GARCIA, Ph.D.

LOGRE INTERNATIONAL

CHEMICAL SAFETY



SAFETY STARTS AT HOME!!!

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OCCUPATIONAL DISEASES

- ✓PREDISPOSING CAUSES
  - ❖SEX
  - ❖SEASON
  - ❖GENETICS
  - ❖PRE-EXISTING CONDITIONS
  - ❖AGE

OCCUPATIONAL DISEASES

- ✓MECHANICAL AND PHYSICAL DAMAGE
- ✓CHEMICAL AGENTS
- ✓PLANT POISONS
- ✓BIOLOGICAL POISONS

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PLANT DESIGN

- ✓USE OF CLOSED SYSTEMS
- ✓ADEQUATE VENTILATION
- ✓SUBSTITUTION OF HAZARDOUS MATERIALS

PERSONAL CLEANLINESS

- ✓ADEQUATE WASHING FACILITIES
  - ❖SUFFICIENT NUMBERS OF ADEQUATE SHOWERS, LAVATORIES, CLEANSERS, TOWELS
  - ❖EDUCATION
  - ❖PERIODIC INSPECTION

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MAJOR CAUSES OF EXPOSURE TO PESTICIDES

- ✓ ACCIDENTAL OR SUICIDAL
- ✓ OCCUPATIONAL
- ✓ BY-STANDER EXPOSURE TO DRIFT FROM SPRAYING OPERATIONS
- ✓ CONSUMPTION OF FOOD WITH RESIDUES

OCCUPATIONAL EXPOSURE

- ✓ PROBABLY THE WORST PROBLEM INVOLVED WITH CHEMICAL HAZARDS
- ✓ DAILY EXPOSURE WITHOUT PROTECTION

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ESTIMATED SURFACE AREA OF EXPOSED PARTS OF A BODY

SURFACE	SURFACE AREA (SQUARE FEET)	% OF TOTAL
FACE	0.70	22
HANDS	0.87	27.6
FOREARMS	1.30	41.3
BACK OF NECK	0.12	3.8
FRONT OF NECK AND "V" OF CHEST	0.16	5.1

OCCUPATIONAL EXPOSURE

- ✓ACUTE INTOXICATIONS
- ✓CHRONIC DISEASES
- ✓ACCIDENTS

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THE BEGINNING...

✓ PREVENTION

- ❖ EXPOSURE CAN BE PREVENTED
- ❖ INFORMATION
- ❖ KNOWLEDGE
- ❖ TRAINING

STEP #1

✓ KNOWLEDGE

- ✓ BE AWARE OF EVERY CHEMICAL USED IN YOUR FACILITY
- ✓ CONDUCT A HAZARD ANALYSIS
- ✓ START AN MSDS FILE (MATERIAL SAFETY DATA SHEET)
- ✓ READ THE MSDS, FOLLOW INSTRUCTIONS
- ✓ DEVELOP WORKING RELATIONSHIPS WITH SUPPLIERS

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STORAGE

- ✓FOLLOW STORAGE RECOMMENDATIONS
- ✓NEVER STORE INCOMPATIBLE CHEMICALS IN THE SAME PLACE
  - ❖FLAMMABLES
  - ❖CORROSIVES
  - ❖ACIDS, BASES

STORAGE

- ✓KEEP EVERYTHING LABELED PROPERLY
- ✓KEEP AN ORGANIZED FILE (DATES, AMOUNTS, USE, ETC.)
- ✓TRAIN PERSONNEL – CONTROL ACCESS TO WAREHOUSES

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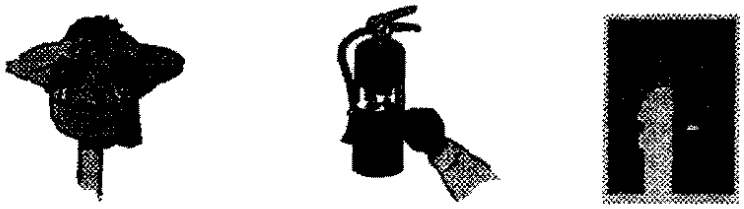
STORAGE

- ✓ WAREHOUSES SHOULD HAVE EMERGENCY EQUIPMENT READILY AVAILABLE
- ✓ IN AN EMERGENCY A FEW SECONDS ARE VITAL!



LABELS

- ✓ LABELS ARE ESSENTIAL!
- ✓ KEEP POISONS AWAY FOR ACIDS AND BASES
  - ❖ POISONS – THROW UP
  - ❖ ACIDS AND BASES – DON´T THROW UP!

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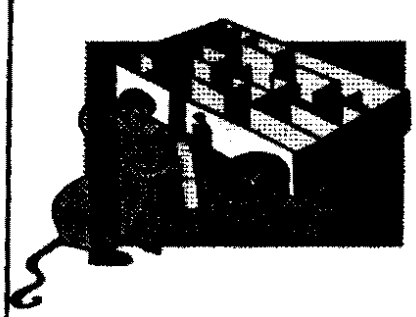
STORAGE

- ✓STORE CLEANING AGENTS, SANITIZERS, PESTICIDES COMPLETELY SEPARATE FROM FOOD INGREDIENTS
- ✓USE ONLY APPROVED PESTICIDES FOR WAREHOUSE FUMIGATION

RODENT TRAPS



- ✓ USE ONLY APPROVED CHEMICALS
- ✓ PHYSICAL TRAPS ARE RECOMMENDED OVER POISONS
- ✓ USE TRAPS THAT DO NOT ALLOW ANIMAL EXIT – EVEN WHEN USING POISONS
- ✓ SHOULD BE ANCHORED AND LOCKED

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PERSONAL PROTECTIVE EQUIPMENT (PPE)

- ✓ ESSENTIAL
  - ❖ PROCESSING FACILITIES
  - ❖ AGRICULTURAL FIELDS
  - ❖ ANALYTICAL LABORATORIES
  - ❖ RESEARCH FACILITIES
- ✓ CONSUMER PROTECTION STARTS WITH WORKER PROTECTION
- ✓ BE AWARE OF YOUR OWN SAFETY!

PERSONAL PROTECTIVE EQUIPMENT

- ✓ USE OF INADEQUATE EQUIPMENT IS <u>EXTREMELY DANGEROUS</u>
- ✓ FALSE SENSE OF SECURITY
- ✓ ORGANIC MERCURY CASE
- ✓ CONSULT MSDS, TALK TO YOUR SUPPLIERS

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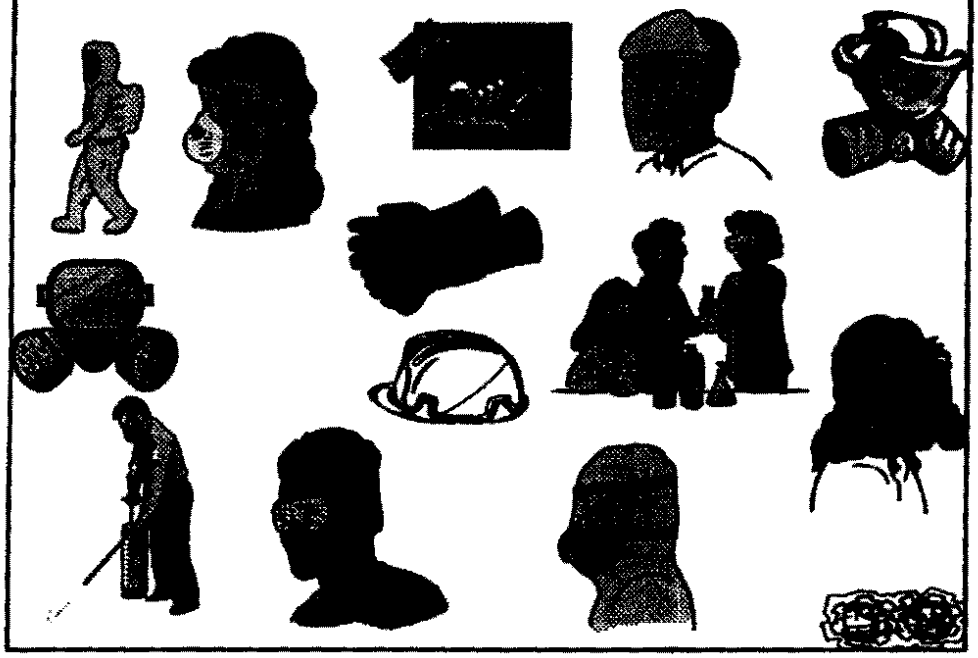
PERSONAL PROTECTIVE EQUIPMENT



PREVENTIVE MEASURES

- ✓SIMPLE PREVENTIVE MEASURES ARE EFFECTIVE
- ✓PROPER PLACEMENT OF EMPLOYEES
- ✓SAFE CHEMICAL HANDLING

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CONCLUSION

- ✓THINK SAFETY FIRST
- ✓BY PROTECTING YOUR OWN WORKERS, YOU PROTECT THE CONSUMER
- ✓IN-HOUSE HAZARD MANAGEMENT IS ESSENTIAL

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CHEMICAL HAZARDS IN THE FRAMEWORK OF HACCP PLANS

REBECA LOPEZ-GARCIA, Ph.D.

LOGRE INTERNATIONAL

INTRODUCTION

- ✓ BIOLOGICAL HAZARDS
  - ❖ WIDESPREAD FOODBORNE ILLNESSES
  - ❖ AFFECTING FEWER INDIVIDUALS
- ✓ CHEMICAL HAZARDS
  - ❖ ASSOCIATION WITH FOODBORNE ILLNESS
  - ❖ SUBSTANCIAL CONTROVERSY REGARDING ACTUAL RISKS
  - ❖ HAZARD ANALYSIS

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CHEMICAL HAZARDS

- ✓USE OF SOME CHEMICALS
  - ❖AGRICULTURAL PESTICIDES
  - ❖GROWTH REGULATORS

MAY NOT BE UNDER DIRECT CONTROL

- ✓OTHER CHEMICALS
  - ❖SANITIZERS, LUBRICANTS, ADDITIVES

LAWS AND REGULATIONS

- ✓REGULATORY AGENCIES RESPONSIBLE FOR DESIGNING LEGISLATION
- ✓APPROVED ADDITIVES
- ✓BANNED CHEMICALS

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NATURALLY OCCURRING SUBSTANCES

- ✓ PLANT TOXINS
- ✓ ANIMAL TOXINS
- ✓ MICROBIAL TOXINS
- ✓ PROHIBITED BEYOND A CERTAIN LEVEL (IF LEGISLATION IS AVAILABLE)
- ✓ TOTALLY AVOID PROBLEMATIC FOODS
- ✓ MANAGE UNAVOIDABLE CONTAMINANTS (i.e. AFLATOXIN)

ALLERGENS

- ✓ PREVENT CROSS-CONTAMINATION
  - ❖ STORE PROBLEM INGREDIENTS SEPARATELY
  - ❖ SCHEDULE PROCESS ACCORDINGLY
  - ❖ CAREFUL AND THOROUGH CLEANING OF EQUIPMENT
  - ❖ ESTABLISHMENT OF TRAFFIC PATTERNS

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INTENTIONALLY ADDED CHEMICALS

- ✓ADDITIVES SHOULD NOT BE USED TO SUBSTITUTE GMP´S
- ✓PRESERVATIVES DO NOT SUBSTITUTE SANITATION!
- ✓BEWARE OF WHAT YOU ADD

ANTIBIOTICS AND HORMONES

- ✓ASSURANCE THAT DRUGS ARE USED CORRECTLY
- ✓REGULATORY AGENCIES AND PRODUCERS SHARE RESPONSIBILITY
- ✓APPROPRIATE WITHDRAWAL TIME

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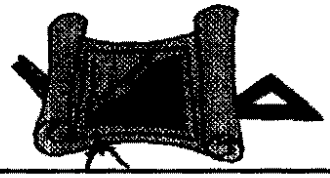
PESTICIDES

- ✓STRICT LEGISLATION
- ✓CONSIDERATION OF POTENTIAL OCCURRENCE OF ILLEGAL RESIDUES
- ✓CLOSE WORKING RELATIONSHIP WITH SUPPLIERS

DESIGNING A CHEMICAL CONTROL PROGRAM

- ✓ PRIOR TO RECEPT OF FOOD INGREDIENTS AND PACKAGING MATERIALS
- ✓ UPON RECEIPT
- ✓ DURING ESTABLISHMENT OPERATIONS
- ✓ DURING THE USE OF TOXIC CHEMICALS
- ✓ PRIOR TO THE SHIPMENT OF FINISHED GOODS



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PRIOR TO RECEIPT

- ✓ INVOLVE SUPPLIERS
- ✓ DEVELOP SPECIFICATIONS
- ✓ KEEP SPECIFICATIONS IN WRITING!
- ✓ "ONLY APPROVED PESTICIDES MAY BE APPLIEDTO AGRICULTURAL COMMODITIES"
- ✓ SANITIZING AGENTS MUST BE APPROVED

PRIOR TO RECEIPT

- ✓ OBTAIN A LETTER OF GUARANTEE
- ✓ CERTIFY OR QUALIFY SUPPLIERS
- ✓ SUPPLIERS WITH HACCP PLANS

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UPON RECEIPT

- ✓ INSPECTION
- ✓ REJECT SUSPICIOUS SHIPMENTS
- ✓ THE CONTROLS INSTITUTED PRIOR TO RECEIPT OF INGREDIENTS AND SUPPLIES ELIMINATE THE NEED TO ROUTINELY TEST RECEIVED MATERIALS
- ✓ PERIODIC SAMPLING AND TESTING MAY BE APPROPRIATE

ESTABLISHMENT OPERATIONS

- ✓ ONLY APPROVED CHEMICALS USED IN FOOD ESTABLISHMENTS
- ✓ ASSIGN A KNOWLEDGEABLE INDIVIDUAL RESPONSIBILITY FOR ALL CHEMICALS RECEIVED, STORED AND USED ARE APPROVED
- ✓ CONTROL IN-HOUSE USE OF CHEMICALS
- ✓ DEVELOP LOGS TO RECORD USE OF SPECIAL CHEMICALS (NITRATES, SULFITES, ALLERGENIC PRODUCTS)
- ✓ IN-HOUSE AUDITS

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STORAGE

- ✓ CROSS-CONTAMINATION
- ✓ CONTAINERS
- ✓ WAREHOUSES
- ✓ SEPARATE STORAGE OF HAZARDOUS CHEMICALS
- ✓ COVER PACKAGING MATERIALS
- ✓ COMMON SENSE, STRICT ADHERENCE TO cGMP'S

SANITATION AND MAINTENANCE

- ✓ ALL CHEMICALS SHOULD MEET REGULATORY REQUIREMENTS
- ✓ FDA PUBLISHES A LIT OF SPECIFIC APPROVED CHEMICAL COMPOUNDS
- ✓ IF QUESTION ARISES, THE SUPPLIER SHOULD BE ABLE TO PROVIDE A LETTER FROM A REGULATORY AGENCY ASSURING THAT THE CHEMICAL IS APPROVED

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CHEMICAL RESIDUES

- ✓MISUSE OR NEGLIGENT USE MAY CREATE POTENTIAL HAZARDS
- ✓STANDARD SANITATION OPERATING PROCEDURES
- ✓TRAIN INDIVIDUALS

PRIOR TO SHIPMENT

- ✓INSPECT ALL VEHICLES
- ✓VEHICLES SHOULD BE FREE OF CHEMICAL OR OTHER OBJECTIONABLE ODORS AND RESIDUES OF UNKNOWN MATERIALS
- ✓CAREFUL INSPECTION AND DOCUMENTATION

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SUMMARY

- ✓USE ONLY APPROVED CHEMICALS
- ✓DEVELOP AND SIGN SPECIFICATIONS
- ✓KEEP AN INVENTORY OF ALL POTENTIALLY HAZARDOUS CHEMICALS

SUMMARY

- ✓ REVIEW PRODUCT FORMULATIONS
- ✓ REVIEW PROCEDURES FOR RECEIVING, STORING, AND USING HAZARDOUS CHEMICALS
- ✓ AUDIT
- ✓ APPROPRIATE IN-HOUSE TESTING
- ✓ EMPLOYEE TRAINING
- ✓ UPDATED REGULATIONAS AND INFORMATION

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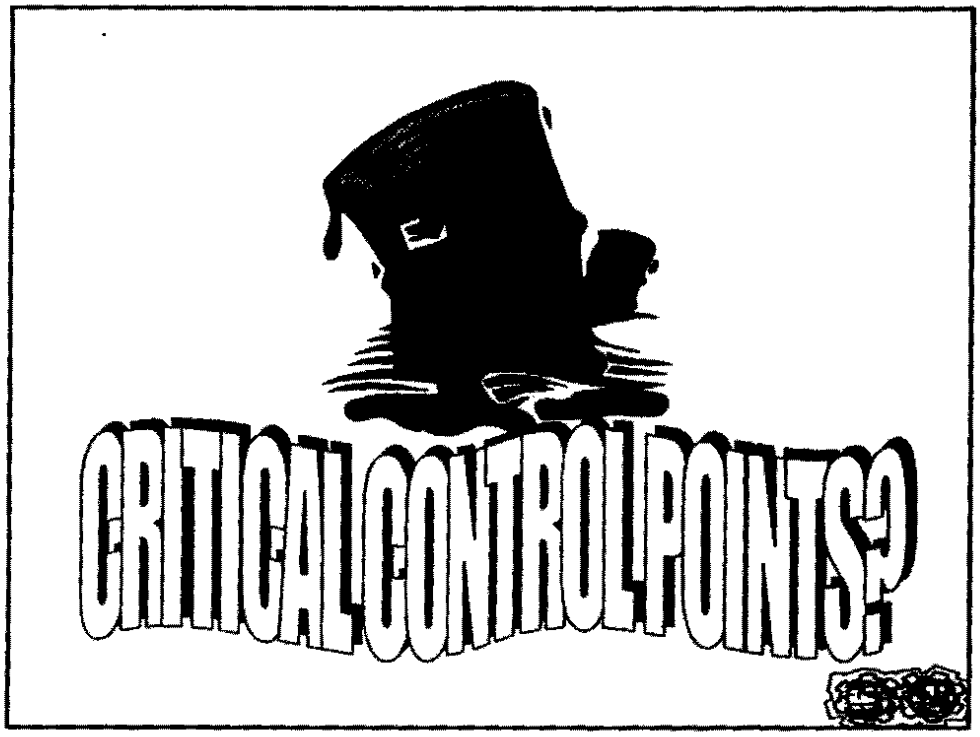

CHEMICAL HAZARDS

- ✓ CAN YOU CONTROL THEM?
- ✓ CAN YOU AVOID THEM?
- ✓ IF YOU CAN CONTROL, CAN YOU ESTABLISH A LIMIT?
- ✓ CAN YOU ADJUST TO STAY WITHIN THE LIMIT?
- ✓ CAN YOU QUANTIFY AND RECORD
- ✓ CAN YOU VALIDATE?

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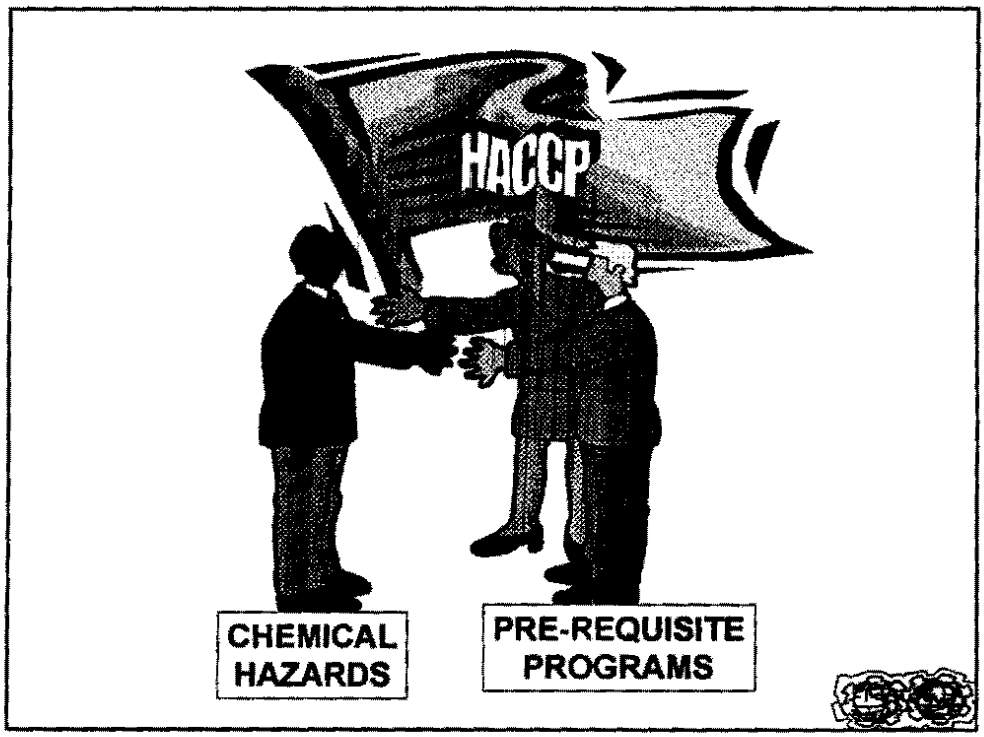

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Integrated mycotoxin management systems

R. Lopez-Garcia, D.L. Park and T.D. Phillips

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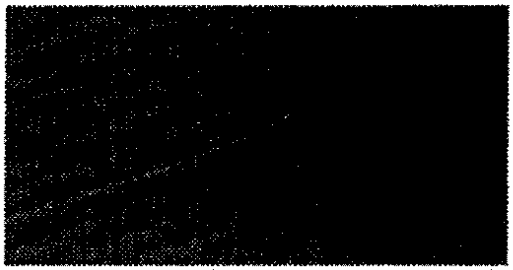
Timothy D. Phillips is Professor of Toxicology, Intercollegiate Faculty of Toxicology (Department of Veterinary Anatomy and Public Health), College of Veterinary Medicine, Texas A&M University, College Station, Texas, United States.

Mycotoxins are toxic secondary metabolites produced by certain fungi in agricultural products that are susceptible to mould infestation. Their production is unavoidable and depends on a variety of environmental factors in the field and/or during storage. Mycotoxin contamination is unavoidable and unpredictable, which makes it a unique challenge to food safety (Park and Stoloff, 1989; FAO, 1997). New mycotoxins and co-contamination of known mycotoxins are being discovered at high rates. Considerable evidence supports an association between mycotoxins and certain animal syndromes (CAST, 1989). Although definitive evidence on the cause and effect relationship of mycotoxins and human diseases is limited, this does not necessarily imply that dietary exposure does not represent a potential risk.

Unfortunately, information on toxicity, stability and extent of occurrence is limited for many of the mycotoxins that have been identified. The decision-making process for their control is, therefore, complicated (Park and Stoloff, 1989). In addition, there have been several reports on the co-contamination of various toxins, such as aflatoxin B1/fumonisin B1, ochratoxin A/aflatoxin B1, ochratoxin A/citrinin, ochratoxin A/deoxynivalenol, ochratoxin A/penicillic acid, ochratoxin A/T-2 toxin/aflatoxin/cyclopiazonic acid, aflatoxin/kojic acid, aflatoxin B1/deoxynivalenol, and aflatoxin B1/T-2 toxin (Lopez-Garcia and Park, 1998). The presence of multiple toxins in the same system is a new cause for concern, since toxicological information on the effects of simultaneous exposure is still very limited. However, in a diverse human diet, exposure will be to multiple toxins at low concentrations and intermittent rates over long periods of time. The ultimate effect of such constant exposure is still unknown. Although it is difficult to predict the effect of multiple toxins, certain *in vitro* studies can help to forecast the outcome. Recent studies have shown that simultaneous exposure to aflatoxin B1 and fumonisin B1 may elicit responses that are different to those arising from exposure to the toxins individually (Lopez-Garcia, 1998; Burgos-Hernandez, 1998). This effect could be caused by the combination of a multitude of factors which may include direct chemical interaction or enhancement/inhibition of different

metabolic pathways. The overall response may be owing to equilibrium of several reactions. Direct chemical reaction, as well as involvement in mechanistic pathways, may participate in the interactive effects of these two toxins. Different responses were observed depending on different combination ratios. Therefore, different levels of contamination can pose different health hazards.

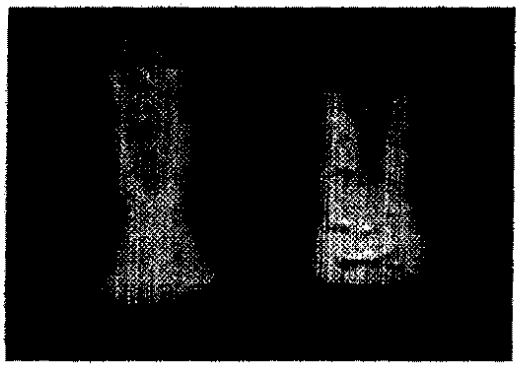


Peter J. Cotty/ United States Department of Agriculture

1. Aspergillus flavus, *primary mould responsible for aflatoxin contamination in numerous agricultural commodities, including maize, peanuts, tree nuts and cottonseed*

David M. Wilson/University of Georgia, Tifton

2. Aspergillus flavus-*contaminated maize showing the heterogenous nature of mould infestation*



Leonard Stoloff/United States Food and Drug Administration

3. Aflatoxin-free (upper) and contaminated (lower) maize in daylight and under ultraviolet light showing diffusion of aflatoxin to interior of kernel with no apparent mould damage

FOOD SAFETY PROGRAMMES

Mycotoxins cannot be considered a group of toxicants on the basis of their mechanism of action because they are very chemically diverse. For the same reason, it would be impossible to develop one single control method that would ensure the reduction of every mycotoxin present in every agricultural commodity. In addition, mycotoxin contamination is heterogeneous in nature, so sampling and analysis are complicated by the presence of "hot spots". Considering all these factors, it can be concluded that the development of food safety programmes for mycotoxin control is not a simple issue (Park, 1993; Park and Liang, 1993).

One possible approach to management of the risks associated with mycotoxin contamination is the use of an integrated system. The proposed control programme for processed foods and feeds should be based on the Hazard Analysis and Critical Control Point (HACCP) approach and should involve strategies for prevention, control, good manufacturing practices and quality control at all stages of production, from the field to the final consumer. Prevention through pre-harvest management is the best method for controlling mycotoxin contamination but, when contamination does occur, the hazards associated with the toxin must be managed through post-harvest procedures, if the product is to be used as human food or animal feed. Ideally, the risks associated with mycotoxin hazards should be minimized at every phase of production. Control parameters for the processing of commodities that are susceptible to mycotoxin contamination would include time of harvesting, temperature, moisture during storage and transportation, selection of agricultural products prior to processing, processing/decontamination conditions, temperature, addition of chemicals, and final product storage and transportation.

In integrated mycotoxin management, each phase of production should follow most of the steps outlined in Box 1. The concept behind an

integrated management system is similar to a "hurdle" effect, where at each phase of production, i.e. pre-harvest, harvest and post-harvest processing, the risks are minimized (Lopez-Garcia and Park, 1998).

BOX 1
PHASES IN A FOOD SAFETY MANAGEMENT PROGRAMME

When developing a food safety management programme for naturally occurring toxicants, different phases such as the ones outlined below should be considered (Park and Stoloff, 1989; Park, 1993).

Setting of regulatory limits:
- commodity surveys to determine contamination levels;
- dietary intake surveys to determine consumption levels;
- evaluation of toxicological data:
- establishment of analytical capabilities;
- availability of food/feed supply based on different regulatory limits.

Establishment of a monitoring programme:
- establishment of a sampling plan:
sample collection;
preparation of test portion;
analysis of test portion;
- permitted uses of mycotoxin-contaminated products.

Control through good agricultural practices

Control through processing:
- good manufacturing practices;
- quality control.

Decontamination through specific treatments:[1]
- evaluation of the final product;
- designation of use of treated product.

Consumer/producer education

[1] Chemical decontamination procedures are usually applied to animal feeds only.

PRE-HARVEST CONTROL

Prevention through pre-harvest control is the first step in ensuring a safe final product. While an association between mycotoxin contamination and inadequate storage conditions has long been recognized, studies have revealed that some seeds are contaminated with mycotoxins in the field. During the growing period, the seeds are exposed to environmental factors, such as weather, that are impossible to control. Once the crop becomes infected under field conditions, fungal growth will continue during post-harvest stages and storage. Thus, pre-harvest management is focused on controlling critical factors that have been shown to enhance mycotoxin production. Some of the most common strategies used for pre-harvest management are:

- *Management of insect infestation.* Although it has been reported that damage is not a prerequisite for aflatoxin formation, the incidence of *Aspergillus flavus* and *A. parasiticus* is usually higher in damaged kernels. Insect-damaged kernels are routes for infection and are likely to dry to moisture levels that are more favourable for the growth of *A. flavus* and aflatoxin production than of other fungi. Control of insect infestation may, therefore, help to prevent *A. flavus* and *A. parasiticus* proliferation and subsequent aflatoxin production.
- *Management of crop residues and crop rotation.* Inoculum potential is a prerequisite for *Aspergillus* infection and subsequent aflatoxin production. Soil type and condition, as well as availability of viable spores, have been considered important factors in aflatoxin production. When the crop is harvested, some residues remain on the field. These provide an environment that is conducive to the survival of fungal spores and the subsequent infection of the next crop. Proper management of crop residues would help avoid this problem.
- Crop rotation has also been recognized as an important factor in the spread of the inoculum. Adequate rotation may, therefore, aid the prevention of mycotoxin contamination. For example, field trials have reported that a maize-soybean rotation yielded a less extensive outbreak of *Fusarium* than did maize-maize planting operations.
- *Irrigation and soil condition.* Soil fertility and drought stress have been found to be contributing factors in pre-harvest aflatoxin contamination of maize. Moisture and temperature play the most important roles in the planning of any control strategy for fungal development. High moisture and high relative humidity are essential for spore germination and fungal proliferation. Therefore, adequate efforts should be made to avoid extreme conditions of either drought or excessive moisture. Some studies have shown that drought stress followed by high-moisture conditions is ideal for *Fusarium moniliforme* proliferation and fumonisin production. When this type of weather condition is present, it can be assumed that some degree of mycotoxin contamination will occur and other prevention/management strategies should be explored.

Development of resistant plant varieties

There has been extensive research on the development and promotion of plant varieties that are naturally resistant to fungal infection. Host resistance may present a promising strategy for the pre-harvest prevention of mycotoxin contamination. Until recently, the search for naturally resistant maize genotypes had not been successful. However, during extensive field testing, maize breeding populations with aflatoxin resistance have been identified. Genetic studies of these specific populations have yielded useful information for the development of resistant lines. Studies have identified the chromosome regions

associated with aflatoxin resistance. This line of research is, therefore, a good option for future pre-harvest control and prevention of mycotoxin formation.

Genetic engineering has also been useful in the development of host resistance through the addition or enhancement of antifungal genes. Many endogenous compounds with low molecular weight and biomacromolecules in kernel tissues have been identified as antifungal compounds. Enhancing the production of these compounds may also enhance resistance to mycotoxin contamination. There may be toxicity implications associated with these antifungal compounds.

HARVEST CONTROL

During harvesting, it is important to control factors such as timeliness, clean-up and drying of the agricultural product. Such control is essential for preventing mycotoxin formation during storage. Studies have shown that the timing of harvesting greatly influences mycotoxin production. In some geographical regions, the planting date should be selected to take advantage of periods of higher rainfall.

Harvesting should take place as soon as the crop is fully grown and the crop cycle is completed. Studies have reported that crops left on the field for longer periods of time may present higher levels of toxin contamination. Adequate drying is also essential to prevent fungal proliferation during storage.

POST-HARVEST CONTROL AND DECONTAMINATION

Although prevention is the best control strategy, mycotoxin contamination will still sometimes occur. Post-harvest control and decontamination procedures represent, therefore, an important tool in avoiding consumer exposure. Several decontamination strategies have been reported for various mycotoxins, and specific information on each method is readily available in the literature. Some traditional processing methods are good either for physically separating toxins or for chemically inactivating them. However, the effectiveness of each processing method should be evaluated for the specific commodity and toxin present in the system.

BOX 2
CRITERIA FOR EVALUATING MYCOTOXIN REDUCTION OR DECONTAMINATION PROCEDURES

Procedures for the evaluation and acceptance of given mycotoxin reduction or decontamination should (Jemmali, 1979; Park *et al.*, 1988; Jemmali, 1989):
- inactivate, destroy or remove the toxin;
- not produce or leave toxic residues in the food or feed;
- retain nutritive value and food/feed acceptability of the product;
- not alter significantly the technological properties of the product;
- destroy fungal spores, if possible.

COMMON POST-HARVEST STRATEGIES

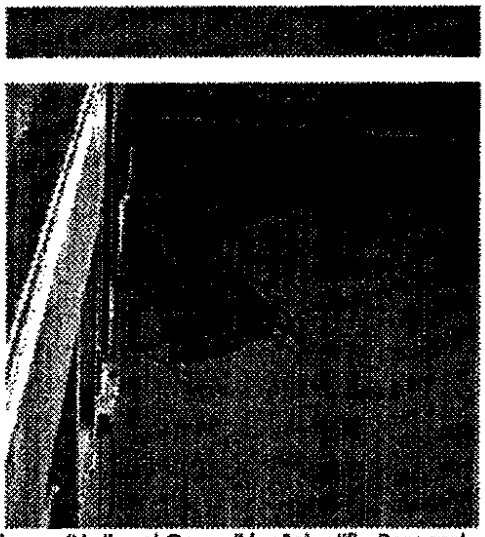
Physical methods of mycotoxin removal

Once a contaminated product has reached a processing facility, clean-up and segregation are the first control options. These procedures are usually non-invasive and, except for milling, will not alter the product significantly. In some cases, these are the best methods of reducing mycotoxin presence in final products. For example, when peanuts are processed, a significant amount of aflatoxins can be removed by electronic sorting and hand-picking (Table 1) (Dickens and Whitaker, 1975; Kirksey, Cole and Dorner, 1989). Separation of mould-damaged maize (Figure 4) and/or screening can significantly reduce fumonisin and aflatoxin concentrations (Bennett, Rottinghaus and Nelson, 1992; Murphy, Rice and Ross, 1993). In addition, the removal of rot from apples significantly reduces the patulin content in the final product (Lovett, Thompson and Boutin,1975). Although some contamination may persist, physical removal represents a good alternative for industry (Lopez-Garcia, Park and Gutierrez de Zubiarre, 1999; Lopez-Garcia and Park, 1998).

TABLE 1
Effectiveness of post-harvest aflatoxin management strategies at the processing level[1]

Technology	Aflatoxin level (µg/kg)	Reduction (%)	Cumulative reduction
Farmer's stock	217.0	-	-
Belt separator	140.0	35	35.0
Shelling plant[2]	100.0	29	54.0
Colour sorting[2]	30.0	70	86.0
Gravity table[2]	25.0	16	88.0
Blanching/colour sorting	2.2	91	99.0
Colour re-sorting[2]	1.6	27	99.3

[1] Results from the processing of a 40 000 kg segregation I lot of contaminated peanuts.
[2] Data based on medium-category peanuts only.
Source: Park and Liang, 1993.



Henry Njapau/National Council for Scientific Research, Zambia

4. Mould-damaged maize in a ship's hold (typical hot spot); process of physical separation of damaged from intact kernels

Milling is traditionally used for grain processing. This method will separate the grain into different fractions (Bennett and Anderson, 1978; Bennett *et al.*, 1976; Bennett and Richard, 1996; Bennett *et al.*, 1978; Seitz *et al.*, 1986; Schroeder, Boller and Hein, 1968). It is, therefore, important to identify the fractions that remain toxic so that they can be diverted to lower-risk uses or subjected to decontamination procedures (Scott, 1984; Wood, 1982).

Physical methods of decontamination

Some phases of industrial processes can reduce specific mycotoxins to a certain degree through thermal inactivation, but some mycotoxins are chemically stable and will not be completely destroyed at processing temperatures. Thus, thermal inactivation for a particular toxin should be evaluated for the temperatures of a specific process. Roasting is a good method for such commodities as peanuts and coffee. As mentioned before, if a traditional processing method is an effective decontamination procedure, it should be the first choice for management of a particular product (Lopez-Garcia and Park, 1998).

Irradiation may also be an option for mycotoxin control. A completely satisfactory way of destroying mycotoxins that have already been formed has not been identified. However, irradiation may be considered as a method to control mycotoxin-producing moulds in certain products (Lopez-Garcia and Park, 1998).

A novel approach to the prevention of aflatoxin intoxication in some animals is the dietary inclusion of aflatoxin-selective clays that tightly bind these poisons in the gastrointestinal (GI) tract, significantly decreasing their bio-availability and associated toxicities (Phillips, Clement and Park, 1994). These methods aim at preventing the

deleterious effects of mycotoxins by sequestrating them to various sorbent materials in the GI tract, thereby altering their uptake and disposition to the blood and target organs. In pioneering studies, a phyllosilicate clay which was commonly used to reduce caking in animal feeds (NovaSil or hydrated sodium calcium aluminosilicate [HSCAS] clay) was reported to adsorb aflatoxin B1 with high affinity and high capacity in aqueous solutions (including milk); reduce markedly the bio-availability of radio-labelled aflatoxins in poultry; diminish significantly the effects of aflatoxins in young animals such as rats, chicks, turkey poults, lambs and pigs; and decrease the level of aflatoxin M1 in milk from lactating dairy cattle and goats. The effects of HSCAS clay in the diet did not alter the hyperoestrogenic effects of zearalenone (Grant, 1998; Grant and Phillips, 1998; Machen *et al.*, 1988; Lemeke, Grant and Phillips, 1998; Ramos and Hernandez, 1996).

A variety of other HSCAS binding agents are purported to adsorb aflatoxins, as well as other chemically diverse mycotoxins such as T-2 toxin, ochratoxin, deoxynivalenol, zearalenone and fumonisins. It is, therefore, possible that these agents may be non-selective in their action and pose significant hidden risks arising from their interaction with critical nutrients, etc. In addition, *in vitro* (test-tube) evidence indicated that some of these binders may provide little (if any) protection from aflatoxins or other mycotoxins.

Granulated activated carbon (GAC) has also been studied for its ability to bind aflatoxins, both *in vivo* and *in vitro*. Results from studies using GAC varied widely according to the type of activated carbon used. Activated carbon has also proved effective in reducing patulin in naturally contaminated fruit juices (Sands, McIntyre and Walton, 1976; Walton, Sands and McIntyre, 1976; Decker, 1980).

Clay and zeolitic minerals comprise a broad family of functionally diverse silico-aluminosilicates. Although, these agents have shown promising effects on the binding of mycotoxins, there may be significant risks associated with the inclusion of non-selective clays (or other adsorbents) in the diet. Aflatoxin adsorbents should be rigorously tested, with particular attention to their effectiveness and safety in aflatoxin-sensitive animals and their potential for interaction with nutrients.

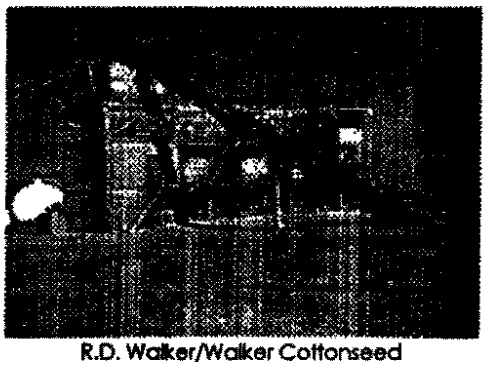
Biological decontamination

Biological methods have been explored as options for mycotoxin decontamination. In the fermenting industry it has been found that aflatoxins are not degraded during fermentation; although the toxins are absent from the alcohol fraction after distillation. Aflatoxins are usually concentrated in the spent grains. When contaminated products are used for fermentation, it is therefore important to determine the end use of the contaminated by-products. It should be emphasized that biological methods demonstrating effective decontaminating properties usually depend on specific compounds produced by selected microorganisms.

When a specific compound is found to be a good decontaminating agent, it is usually more efficient and economical to add the active agent directly. Studies suggest that certain fungi, including *A. parasiticus,* degrade aflatoxins, possibly through fungal peroxidases. Fermentation with yeasts has also been effective in destroying patulin and rubratoxin B (Lopez-Garcia and Park, 1998).

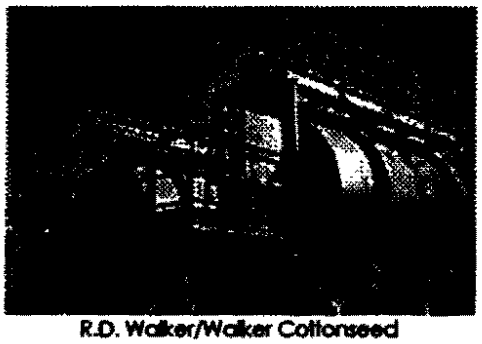
Chemical inactivation

Numerous studies have evaluated the use of chemicals for the inactivation and hazard reduction of selected mycotoxins. Most studies have, however, focused on aflatoxins and application to animal feeds. Ammoniation is the chemical method that has received the most research attention. Extensive evaluation of this procedure has demonstrated that it is an efficacious and safe way of decontaminating aflatoxin-contaminated feeds. More than 99 percent effective, this process has been used selectively with success in the United States, France, Senegal, the Sudan, Brazil, Mexico and South Africa, in some cases for almost 20 years. The two ammoniation processes primarily used for aflatoxin contamination in maize, peanuts, cottonseed and meals are: high pressure/high temperature(HP/HT); and atmospheric pressure/ambient temperature (AP/AT) where the HP/HT process is used for feedmill operations (Figures 5 and 6) and AP/AT is primarily for on-farm use (Figure 7). The AP/AT process is limited to dealing with aflatoxins in whole-kernel seeds/nuts. Ammoniation has been shown to be less effective against fumonisin decontamination. For aflatoxin control, however, practical applications together with research results strongly support the use of ammonia treatment. Other chemical-based procedures utilizing, for instance, monomethylamine, lime or urea/urease have been reported. In-depth reviews and articles have been published and these can be used as a basis for policy-making decisions (Lopez-Garcia, Park and Gutierrez de Zubiarre, 1999; Lopez-Garcia and Park, 1998; Park *et al.*, 1988; Park and Stoloff, 1989; Phillips, Clement and Park, 1994; Piva *et al.*, 1995).



R.D. Walker/Walker Cottonseed

5. *Ammonia mycotoxin decontamination plant (Walker Cottonseed, Stanfield, Arizona) using the high temperature/high pressure process*



R.D. Walker/Walker Cottonseed

6. Mobile ammonia mycotoxin decontamination unit capable of on-site processing using the high temperature/high pressure process

Ralph L. Price/University of Arizona, Tucson

Douglas L. Park/Louisiana State University, Baton Rouge

7. Ambient temperature/atmospheric pressure mycotoxin decontamination process showing addition of aqueous ammonia and bagging operations

Nixtamalization, the traditional alkaline treatment of maize used to manufacture tortillas in Latin America, partially degrades aflatoxins and fumonisin, but the residual molecules can either be regenerated by digestive processes or become more toxic (Price and Jorgensen, 1985). The addition of oxidizing agents, such as hydrogen peroxide, has been shown to be an effective aid in nixtamalization. These chemicals degrade aflatoxins and fumonisin, thereby reducing toxicity (Lopez-Garcia, 1998; Burgos-Hernandez, 1998). Some recent studies have shown that hydrogen peroxide and sodium bicarbonate are effective for simultaneous degradation/detoxification of aflatoxins and fumonisin.

Other chemical processes that have shown promise in controlling aflatoxins are the use of sodium chloride during thermal processing, sodium bisulphite at various temperatures and ozonation. Wet and dry milling processes, which are widely used for maize and cereal grains, have been shown to result in reduced mycotoxin levels (zearalenone, fumonisins, aflatoxins, trichothecenes and ochratoxin A) in several fractions such as milling solubles, gluten, fibre, starch and germ (Lopez-Garcia and Park, 1998).

Processing alters food matrices into different complex systems. It also adds new ingredients and conditions. These new factors change the environment, and innumerable new interactions may take place. Exploring the application of known food additives to the control of mycotoxins during processing may provide new opportunities for risk management by chemical methods.

CONCLUSIONS

Mycotoxins are a chemically diverse group of fungal metabolites that have a wide variety of toxic effects. In a normal varied human diet, constant exposure to low levels of several toxins is possible. Information on the potential interactions among all these compounds is still very limited. Furthermore, some mycotoxins, such as aflatoxin B1, are known to be associated with animal and human disease. The development of practical control and management strategies is, therefore, essential to ensure consumer safety. Because of the unpredictable, heterogeneous nature of mycotoxin contamination, 100 percent destruction of all mycotoxins in all food systems is not considered a practical option. However, a practical approach would be the use of a HACCP-based "hurdle" system, in which contamination is controlled throughout production and post-production operations. An example of this is presented in Table 1 - the procedures referred to are used by the peanut industry in the United States in processing peanut butter for human consumption.

Integrated mycotoxin management systems should consider control points from the field to the consumer. This type of management system considers the communication between experts in pre-harvest, harvest and post-harvest control. With this approach, every phase of production would help reduce the risk, so by the time the final food or feed reaches the consumer the hazards associated with mycotoxin contamination have been minimized. These concepts are summarized in Table 2.

Continued research is required in these areas to provide more effective management of the risks posed by mycotoxin contamination. In the meantime, procedures that have proved effective for specific mycotoxins and/or commodities should be evaluated for other applications.

TABLE 2

Purpose, status and application of pre-harvest, harvest and post-harvest procedures for removing mycotoxins from human foods and animal feeds

Procedure	Mycotoxins	Commodities	Purpose/status/application
Pre-harvest			
Reduction of insect infestation	Aflatoxins, fumonisins	Maize, cottonseed	Avoid insect infestation which can serve as a vector for mould invasion to agricultural commodities; use integrated pest management control programmes
Crop rotation	*Aspergillus*, *Fusarium* toxins	Maize, soybean	Limit mould inoculum in the field
Irrigation	*Aspergillus*, *Fusarium* toxins	Maize, cottonseed, peanuts, tree nuts	Avoid drought stress during crop growth
Planting of resistant varieties	Aflatoxins	Maize	Strong potential for control of mycotoxin formation during crop growth
Harvesting operations			
Timeliness of clean-up and drying of commodities	Aflatoxins	Maize	Reduce exposure to toxigenic moulds and and moisture levels in commodities
Post-harvest procedures			
Physical separation of damaged, immature and mould-infested kernels, nuts, seeds, etc.	Aflatoxins, fumonisins	Maize, peanuts	Effective in reducing mycotoxin levels in final product; mycotoxins can diffuse into apparently good commodities
Thermal processing	*Aspergillus*, *Fusarium* toxins	Maize, cereal grains, coffee	However, many mycotoxins are thermally stable
Dietary mycotoxin-selective clays	Aflatoxins, *Fusarium* toxins, ochratoxin A	Maize	Strong potential and application for clays shown safe and effective; some non-selective clays may pose significant risk by binding critical nutrients, etc.
Chemical inactivation by ammoniation	Aflatoxins, fumonisins	Maize, peanuts, cottonseed and meals	Feed mill and farm applications
Chemical inactivation by ozonation	Aflatoxins	Maize	Strong potential; more research needed
Nixtamalization with addition of hydrogen peroxide and sodium bicarbonate	Aflatoxins, fumonisins	Maize	Minor modification of an industrial process; good potential practical application

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Summary/Résumé/Resumen

Integrated mycotoxin management systems

Naturally occurring toxicants pose a unique challenge to food safety. They are unavoidable and their occurrence is unpredictable. The destruction of contaminated products or their diversion to non-human uses is not always practical and could seriously compromise the food supply. Procedures for the prevention of mycotoxin formation in the field as well as during storage have been developed but, in spite of these efforts, contamination continues to occur. The hazards associated with toxins must, therefore, be managed through appropriate post-harvest procedures if the safety of food and feed is to be assured. One approach to the management of the risks associated with mycotoxin contamination is the use of an integrated system. The proposed control programme would entail strategies for the prevention of mycotoxin formation, the establishment of regulatory limits and monitoring programmes, and the use of processing and decontamination operations to remove, destroy or inactivate the toxins while, at the same time, preserving an adequate, safe and wholesome food supply.

Systèmes de gestion intégrée des mycotoxines

La présence naturelle de toxiques est inévitable et imprévisible, et pose un problème spécifique en matière d'innocuité des aliments. La destruction des produits contaminés ou leur affectation à des usages non humains n'est pas toujours pratique, et peut compromettre gravement les approvisionnements alimentaires. Des procédures destinées à éviter la formation de mycotoxines su le terrain comme pendant l'entreposage ont été mises au point; toutefois, malgr tous ces efforts, la contamination continue de se produire. Il faut donc gérer les dangers liés aux toxines au moyen de mesures après récolte appropriées si l'on veut s'assurer que le produit destiné à la consommation humaine ou animale soit réellement sain. L'utilisation d'un système intégré est une approche possibl de la gestion des risques associés à la contamination des mycotoxines. Le programme de lutte proposé comporte des stratégies pour la prévention de la formation des mycotoxines, l'établissement de limites réglementaires et de programmes de suivi, et le recours à des opérations de transformation et de décontamination pour retirer, détruire ou désactiver les toxines tout en préservant la qualité et l'innocuité des approvisionnements en denrées alimentaires.

Sistema integrado de gestión de micotoxinas

Las sustancias tóxicas de origen natural son inevitables y su presencia es imprevisible, y por lo tanto plantean un problema especial para la inocuidad d los alimentos. La destrucción de los productos contaminados o su utilización con fines distintos del consumo humano no siempre es posible y puede poner en grave peligro el suministro alimentario. Se han elaborado procedimientos para prevenir la formación de micotoxinas tanto en el campo como durante el almacenamiento, pero a pesar de estos esfuerzos se siguen produciendo casos de contaminación. Por consiguiente, para asegurar la inocuidad de alimentos y piensos, el peligro asociado con las toxinas debe afrontarse también mediante procedimientos aplicados después de la cosecha. Un modo para afrontar los riesgos asociados con la contaminación por micotoxinas consiste en utilizar un sistema integrado. El programa de control propuesto entrañaría estrategias para impedir la formación de micotoxinas, el establecimiento de límites reglamentarios y programas de vigilancia y la utilización de operaciones de elaboración y descontaminación para eliminar o inactivar las toxinas conservando al mismo tiempo un suministro suficiente de alimentos inocuos y sanos.