Challenges of Mycotoxins
Prevention and Control in Food and Feed in Thailand

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Content

• Current situation of mycotoxins contamination in Thailand
  • In foods
  • In animal feeds
• Prevention and control
  • By Laws, regulation and guideline
  • By food safety management system
  • By research
• Challenges and Needs
## Aflatoxins Contamination in Thailand

Number of unacceptable dried food samples at total aflatoxin > 20 ug/kg

<table>
<thead>
<tr>
<th>Sample</th>
<th>Unacceptable %</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2008</td>
</tr>
<tr>
<td>Nuts/pulses</td>
<td></td>
</tr>
<tr>
<td>Peanut</td>
<td>15% (88/583)</td>
</tr>
<tr>
<td>Soybeans</td>
<td>(0/27)</td>
</tr>
<tr>
<td>Others</td>
<td>(0/81)</td>
</tr>
<tr>
<td>Rice and products</td>
<td>(0/90)</td>
</tr>
<tr>
<td>Corn and products</td>
<td>(0/3)</td>
</tr>
<tr>
<td>Cereal</td>
<td></td>
</tr>
<tr>
<td>Sesame</td>
<td>(0/35)</td>
</tr>
<tr>
<td>Job tear</td>
<td>(0/24)</td>
</tr>
<tr>
<td>Chili and products</td>
<td></td>
</tr>
<tr>
<td>Dried</td>
<td>1.8% (8/446)</td>
</tr>
<tr>
<td>Paste</td>
<td>(0/38)</td>
</tr>
<tr>
<td>Spices</td>
<td>(0/479)</td>
</tr>
<tr>
<td>Others</td>
<td>(0/106)</td>
</tr>
<tr>
<td>Total</td>
<td>5% (96/1912)</td>
</tr>
</tbody>
</table>

*Source: Bureau of Food and Water Sanitation (2008-2009)*
Prevalence of aflatoxin in peanut taken from 5 markets in Bangkok (2014)

<table>
<thead>
<tr>
<th>Peanuts</th>
<th>IAC</th>
<th>Aflatoxins concentration (ppb)</th>
<th>Prevalence (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Min</td>
<td>Max</td>
<td>Mean</td>
</tr>
<tr>
<td>Raw (N=20)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vicam</td>
<td>&lt;0.093</td>
<td>303.6</td>
<td>37.7</td>
</tr>
<tr>
<td>KU-AF02</td>
<td>&lt;0.093</td>
<td>359.3</td>
<td>41.4</td>
</tr>
<tr>
<td>Roasted (N=20)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vicam</td>
<td>0.7</td>
<td>41.6</td>
<td>18.0</td>
</tr>
<tr>
<td>KU-AF02</td>
<td>0.7</td>
<td>45.4</td>
<td>18.2</td>
</tr>
<tr>
<td>Ground (N=20)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vicam</td>
<td>0.9</td>
<td>362.5</td>
<td>68.2</td>
</tr>
<tr>
<td>KU-AF02</td>
<td>1.0</td>
<td>502.7</td>
<td>78.8</td>
</tr>
</tbody>
</table>

Source: Kuprasertying, P. unpublished data
Aflatoxins contaminated in husked rice and color rice in 2011

AFB₁ Concentration

0-0.15 ppb.  N=24

0.16-1.50 ppb.  N=27

1.51-8.92 ppb.  N=3

Lamtaweejaloen, P. et al., 2013
Deoxynivalenol in Corn and Wheat Products (2013)

**Corn and Corn Products (N=218)**

- Dried seeds corn: 60
- Cereal beverage: 14, 4
- Corn flour: 18, 0
- Cereal: 20, 4
- Snack: 31, 5
- Corn feed: 109, 7

**Wheat and Wheat Products (N=174)**

- Wheat flour (factory): 2
- Wheat bran (factory): 3
- Wheat seed (factory): 3, 1
- Cereal: 12, 0
- Wheat flour: 16, 2
- Wheat all-purpose flour: 18, 0
- Spaghetti: 20, 4
- Dry noodles: 24, 0
- Bread: 24, 0
- Snack: 37, 5

*No found, found*
<table>
<thead>
<tr>
<th>Province</th>
<th>DON contamination level (ppm) (Positive/total sample)</th>
<th>Survey 1</th>
<th>Survey 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phetchabun</td>
<td>0.66, 5.66, (2/6)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nakhon ratchasima</td>
<td>0.42, (1/6)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tak</td>
<td>ND, (0/6)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Loei</td>
<td>0.23, (1/6)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chiangrai</td>
<td>ND, (0/6)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nakhonsawan</td>
<td>ND, (0/4)</td>
<td>0.21, 0.52, (3/4)</td>
<td></td>
</tr>
<tr>
<td>Phitsanulok</td>
<td>0.62, (3/4)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Phayao</td>
<td>ND, (0/4)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Phrae</td>
<td>ND, (0/4)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Saraburi</td>
<td>ND, (0/4)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chiangmai</td>
<td>ND, (0/4)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Kamphaengphet</td>
<td>ND, (0/4)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Source: Mahakarnchanakul et al. (2014)
Contamination in Feedstuffs in Thailand from years 2008-2011

Tangmunkhong, P., 2011

RAW MATERIALS N=5527

2008 2009 2010 2011 (7 months)

AFLATOXIN ZEARARENONE FUMONISIN T-2/TH-2 TOXIN

COMPLETE FEEDS N=2358

2008 2009 2010 2011 (7 months)

AFLATOXIN ZEARALENONE FUMONISIN T-2/TH-2 TOXIN

- Level of aflatoxin >20 ppb, zearalenone level >1000 ppb, fumonisin level >1,000 ppb and T-2/HT-2 toxins level >100 ppb
Currently Prevention and Control Measure of Mycotoxins in Food and Feed in Thailand

- By Laws, regulation and guideline
- By food safety management system
- By research
Thai Laws and Regulations

- **Ministry of Public Health**
  - Bureau of Food, FDA  Notification under MOPH or FDA

- **Ministry of Agriculture and Cooperatives**
  - Agriculture Commodities and Food Standards (ACFS)
  - Department of Livestock Development
    - Notification under the MOAC

- **Notification under MOPH (No. 98) B.E. 2529 (1986) entitled Contaminants in Foods**
  - Aflatoxins: 20 μg/kg
  - Others mycotoxins: none

- **Notification under MOAC B.E. 2537 (1994) entitled Property of deteriorated feed**
  - Aflatoxins: 30-200 μg/kg
What approach to choose in quality assurance with respect to mycotoxins?

• Good Agricultural Practice (GAP)
• Good Storage Practice (GSP)
• Good Manufacturing Practice (GMP)
• Monitoring mycotoxins in process at critical steps or at CCP
• HACCP
Mycotoxins Control and Prevention in Thailand

Farming
GAP
GSP

Food processing
GMP/HACCP

Finished product
Food Laws
GAP = Good Agricultural Practice

- Good Agriculture Practices for Food Crops TAS 9001-2009
- First Announce for use in November 6, 2003
- Improved in 2009 and 2013
- Based on Codex and ASEAN Guideline
  - ASEAN: Good Agricultural Practices for the Production of Fresh Fruits and Vegetables in the ASEAN region (ASEAN GAP).
GMP = Good Manufacturing Practices

Good manufacturing Practices for Peanut Shelling Plants  TAS 4901-2012

This standard is based on the information of the following documents:

In 2013: ACFS revised the PEANUT KERNEL : MAXIMUM LEVEL OF AFLATOXIN
Receiving of in-pod peanut (%moisture, % defect)

Conditioning

Storage of in-pod peanut (%moisture)

Shelling and sizing (%moisture after shelling)

Receiving of peanut kernel (%moisture, %defects)

Sorting

Good peanut kernel

Packing

Defected peanut kernel

Keeping in separate container

Storage of peanut kernel (%moisture)

Transporting of peanut kernel (%moisture)

Flow chart of the operation of peanut shelling plant
5 สารปนเปื้อน

ปริมาณของพลาทอกซินทั้งหมด (total aflatoxin) ในผลิตภัณฑ์สุ่มคุณภาพ 1 และขั้นคุณภาพ 2 ต้องไม่เกิน 20 μg/kg (ไมโครกรัมต่อกรัม หรือ รหัส)

ปริมาณของพลาทอกซินทั้งหมดที่ปนเปื้อนได้ในผลิตภัณฑ์ที่เกี่ยวกับการนำเข้า ให้เป็นไปตามข้อกำหนดในกฎหมายที่เกี่ยวกับการกำหนดอุปกรณ์ที่เกี่ยวกับสารปนเปื้อน

6 สารพิษตกค้าง

ให้เป็นไปตามข้อกำหนดในกฎหมายที่เกี่ยวกับการขึ้นกําหนดใน กฎบ 9002 มาตรฐานสินค้าเกษตร เรื่อง สินค้าเกษตร ปริมาณสารพิษตกค้างสูงสุด และ กฎบ 9003 มาตรฐานสินค้าเกษตร เรื่อง สินค้าเกษตร ปริมาณสารพิษตกค้างสูงสุดที่ปนเปื้อนจากสาเหตุที่ไม่อาจหลีกเลี่ยงได้
## Tolerances of peanut kernels by classes

<table>
<thead>
<tr>
<th>Defects</th>
<th>Class 1</th>
<th>Class 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mouldy kernels</td>
<td>0</td>
<td>0.1</td>
</tr>
<tr>
<td>Damaged kernels</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- from chill injury</td>
<td>0.5</td>
<td>1</td>
</tr>
<tr>
<td>- shrivelled kernels</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>- from pests</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>- from machines</td>
<td>0.5</td>
<td>1.5</td>
</tr>
<tr>
<td>- germinating kernels</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Broken kernels</td>
<td>0.5</td>
<td>1.5</td>
</tr>
<tr>
<td>Foreign matters</td>
<td>0</td>
<td>0.5</td>
</tr>
<tr>
<td>Peanut pods and shells</td>
<td>0.5</td>
<td>1</td>
</tr>
</tbody>
</table>

- **Note:** Peanut kernels in Class 1 and Class 2 are used as food. Aflatoxin content of peanut kernels in Class 1 and Class 2 shall not exceed 20 μg/kg.

The kernels lower quality than of Class 2 shall not be consumed or processed into peanut product for human consumption, except that they are used as feed. They could be pressed or extracted for edible oil, but the oil shall be refined before being used for human consumption.
Photos of dried in-shell peanut and peanut kernels

Appearances of dried in-shell peanuts*
A. Germinated  B. Moldy  C. Cracked  D. Discoloured compared with good

Appearances of peanut kernels*
A. Good  B. Shrivelled  C. Moldy  D. Broken  E. Damage caused by pests
Size code of peanut kernel*
A. Size code 1   B. Size code 2   C. Size code 3   D. Size code 4   E. Size code 5

* Source Data from the report of a project of the National Bureau of Agricultural Commodity and Food Standards in collaboration with Khon Kaen University on the Analysis/Revision of Information on Characteristics, Quality and Safety to Establish the Standard for Peanuts

In 2013 ACFS announces for opinion to set mandatory standards for agricultural products on peanut: Terms of Aflatoxin.
http://www.acfs.go.th/read_news.php?id=11455&ntype=01
การจัดทำแผนกลยุทธ์ที่ที่ข้อมูล

1. ขอบข่าย

1.1 ข้อมูลผลิตภัณฑ์สุขอนามัยครอบคลุมที่อยู่ในสภาพทั้งพื้นที่และแปลงถึงกลุ่ม ประเภทใน

2. บทนำ

ความหมายของคำที่ใช้ในแผนกลยุทธ์สุขอนามัยนี้ ดังกล่าวไปถึง

2.1 วัตถุประสงค์: แผนกลยุทธ์ในการจัดทำแผนกลยุทธ์ที่อยู่ในสภาพทั้งพื้นที่และแปลงถึงกลุ่ม หรือใช้ผลิตภัณฑ์ที่ผลิตออกและอยู่ในสภาพทั้งพื้นที่หรือแปลงแกล้ง โดยให้สูง อาจสร้างผลลัพธ์ความ

3. กุญแจการที่ดีในการ
Quality Control and safety of Animal Feeds

Toxicological and Biochemical unit 3 (mycotoxins)

- Mycotoxins
  - Aflatoxin
  - Ochratoxin
  - Zearalenone
  - Fumonisin
  - T2 toxin
  - DON

Mycotoxins: Techniques and analysis

<table>
<thead>
<tr>
<th>Mycotoxins</th>
<th>Fluorometry</th>
<th>ELISA</th>
<th>HPLC</th>
<th>LC-MS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aflatoxin (total) Ochratoxin Zearalenone Fumonisnin</td>
<td>DON T-2 toxin</td>
<td>Aflatoxin B₁ Aflatoxin M₁ Ochratoxin</td>
<td>Aflatoxin B₁ Aflatoxin M₁ Deoxynivalenol Zearalenone Fumonisnin</td>
<td></td>
</tr>
</tbody>
</table>
Considerations of Mycotoxin level are acceptable to standards of quality feed

Refers to the value of the forage quality analysis is based on Act B.E. 2545(2002) and following the publication of The Commission of European Communities (EC) or trading partners

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Aflatoxins</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.1 Complete feed for duck</td>
<td>≤ 30 ppb</td>
<td>-</td>
</tr>
<tr>
<td>1.2 Fish meal, concentrate feed for duck</td>
<td>≤ 40 ppb</td>
<td>-</td>
</tr>
<tr>
<td>1.3 Soybean meal, rice bran, defatted rice bran oil, concentrate feed for chicken, pigs and complete feed for newborn pigs to 15 kilograms</td>
<td>≤ 50 ppb</td>
<td>-</td>
</tr>
<tr>
<td>1.4 Corn meal, concentrate feed for Cattle, complete feed for chicken and excess 15 kilograms pigs</td>
<td>≤ 100 ppb</td>
<td>-</td>
</tr>
<tr>
<td>-----------</td>
<td>----------------------</td>
<td>------------------</td>
</tr>
<tr>
<td>2. Aflatoxin B₁</td>
<td>-</td>
<td>≤ 20 ppb</td>
</tr>
<tr>
<td>2.1 Raw material feeds, coconut meal, palm meal, cotton seeds meal</td>
<td>-</td>
<td>≤ 50 ppb</td>
</tr>
<tr>
<td>2.2 All feeds</td>
<td>-</td>
<td>≤ 50 ppb</td>
</tr>
<tr>
<td>2.3 Feed for dairy cattle</td>
<td>-</td>
<td>≤ 5 ppb</td>
</tr>
<tr>
<td>2.4 Feeds for calf</td>
<td>-</td>
<td>≤ 10 ppb</td>
</tr>
<tr>
<td>3. Ochratoxin A</td>
<td>-</td>
<td>≤ 20 ppb</td>
</tr>
<tr>
<td>3.1 Cereal and product</td>
<td>-</td>
<td>≤ 0.25 ppb</td>
</tr>
<tr>
<td>3.2 Concentrate feed and complete feed for pig</td>
<td>-</td>
<td>≤ 0.05 ppb</td>
</tr>
<tr>
<td>3.3 Poultry</td>
<td>-</td>
<td>≤ 0.1 ppb</td>
</tr>
<tr>
<td>4. Zearalenone</td>
<td>-</td>
<td>≤ 2 ppm</td>
</tr>
<tr>
<td>4.1 Cereal and product</td>
<td>-</td>
<td>≤ 3 ppm</td>
</tr>
<tr>
<td>4.3 Concentrate feed and complete feed for gilts pigs</td>
<td>-</td>
<td>≤ 0.1 ppm</td>
</tr>
<tr>
<td>4.4 Concentrate feed and complete feed for sow and breeding pigs</td>
<td>-</td>
<td>≤ 0.25 ppm</td>
</tr>
<tr>
<td>4.5 Concentrate feed and complete feed for calf, cattle, sheep, lamb</td>
<td>-</td>
<td>≤ 0.53 ppm</td>
</tr>
<tr>
<td>5. Deoxynivalenol</td>
<td>-</td>
<td>≤ 8 ppm</td>
</tr>
<tr>
<td>5.1 Cereal and product</td>
<td>-</td>
<td>≤ 12 ppm</td>
</tr>
<tr>
<td>5.2 Corn and product</td>
<td>-</td>
<td>≤ 5 ppm</td>
</tr>
<tr>
<td>5.3 Concentrate feed and complete feed</td>
<td>-</td>
<td>≤ 0.9 ppm</td>
</tr>
<tr>
<td>5.4 Concentrate feed and complete feed for pigs</td>
<td>-</td>
<td>≤ 2 ppm</td>
</tr>
</tbody>
</table>
Management STRATEGIES of mycotoxin control and prevention

• At primary Production
  GAP
  Management of insect infestation
  Crop resistance

• At storage
  • Temperature and humidity
  • Binding compounds
  • Chemical method - *ammoniation & ozonization*
  - *antifugal agents, Natural products (essential oils, microbial metabolite products)*

• Process Inactivation by heating, washing
• Develop the practical tools for mycotoxins detection
Reduction of aflatoxin in peanuts and chili under various cooking processes:

- Boiling peanuts
- Roasting peanuts and chili
- Stir-frying chili
- Frying peanuts and chili
Reduction of AFB₁ in dried peanut
A. Spiked with standard AFB₁
B. Natural AFB₁ contaminated
C. Moldy with AFB₁ producing strains

Reduction of AFB₁ in dried chili
A. Spiked with standard AFB₁
B. Natural AFB₁ contaminated
C. Moldy with AFB₁ producing strains

Cooking Methods and Temperature (°C)  
Source: Oudcomething P. and W. Mahakarnchanakul et al. (2012)
Study of Aflatoxin Contamination in Raw Peanut Supply Chain in Thailand

Structure of raw peanut supply chain in Thailand

Data from Saetan, S. et al., 2007
The wholesalers and shelling plants concerned about aflatoxin and knew that selection could prevent the contamination. While at the retailer and restaurants mostly did not know what is aflatoxin and did not know how to prevent.

The probability of peanuts samples contaminated with aflatoxin exceed 20 ppb at shelling plants, at wholesalers and retailers were at 0.64, 0.37 and 0.98.

<table>
<thead>
<tr>
<th>Sources (number of samples)</th>
<th>good appearance peanut (%)</th>
<th>aflatoxin contaminated peanuts (%)</th>
<th>Aflatoxin levels in good appearance peanuts (ppb)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shelling Plants (40)</td>
<td>65.58</td>
<td>34.42</td>
<td>5.7 – 258.88</td>
</tr>
<tr>
<td>Wholesalers (40)</td>
<td>48.05</td>
<td>51.95</td>
<td>1.5 – 84.14</td>
</tr>
<tr>
<td>Retailers (40)</td>
<td>46.77</td>
<td>53.23</td>
<td>7.58 – 1024.22</td>
</tr>
<tr>
<td>Retailers in Bangkok (220)</td>
<td>80.37</td>
<td>19.63</td>
<td>0.3 – 16364.9</td>
</tr>
<tr>
<td>- August – September 2005 (100)</td>
<td>86.67</td>
<td>13.33</td>
<td>0.3 – 165.6</td>
</tr>
<tr>
<td>- November – December 2005 (120)</td>
<td>74.47</td>
<td>25.53</td>
<td>22.7 – 16364.9</td>
</tr>
</tbody>
</table>
Group 1

k. Kernels with normal appearance

Group 2

j. Discolored peanut kernels (dark < 25%)

Group 3

a. Shriveled kernels

b. Kernel damaged by machine (complete kernels)

c. Kernel damaged by machine (broken/split kernels)

d. Imperfect skin kernels

e. Discolored kernels (dark > 25%)

f. Irregular-shaped kernels

g. Kernels damaged by insect

h. Germinated kernels

i. Moldy kernels

Saetan, S. et al., 2011
Research of Mycotoxins in Thailand

Academic Laboratory

• Kasetsart University

• Developing test kits for Mycotoxin Detection
  • Immunoaffinity column for Aflatoxin (KU-AF2)
  • ELISA test kit for Zearalenone (KU-ZEA1)
  • Immunostrip test for Zearalenone (KU-ZEA2)

• Mycotoxins Reference Material
  • Aflatoxins in peanut flour (RM KU-AF03)
  • Zearalenone in corn flour (RM KU-ZEA01)
  • Ochratoxin A in corn flour
  • Mixed mycotoxins AOZ in corn flour
Mycotoxins Research in Thailand

• Mahidol University (2008): Exposure assessment of aflatoxin on red curry paste
  • consumption red curry paste were 0.6147 and 0.6071 ng/kg bw/day (aged 6-60 yrs), respectively.
  • estimated risks of liver cancer were 2.27 and 2.26 cases per 100,000 persons per year

• Kasetsart University (2013): Risk assessment of deoxynivalenol on cereal and cereal products

• Agriculture Commodities and Food Standards (ACFS)(2013): risk assessment of aflatoxin in peanut in Thailand
  • http://www.acfs.go.th/read_news.php?id=11455&ntype=01
  • to consider the setting limit compare between 15 and 20 ppb
Challenges approach to choose and Needs in control and prevent mycotoxins contamination in food and feeds in Thailand

- Practically management in farm under Thai GAP
- Support facilities for Good Storage Practices
- Inspection and advisory opinion from authorities and academic & research institutes
- Cooperation from all stakeholders
- Food safety education
- Monitoring mycotoxins in shelling plants, whole sale markets and at process
- Monitoring at critical steps or at CCP
- Non costly tools for mycotoxins detection
- Incentive for the good quality commodities
- Conducting risk assessment in mycotoxins
THANK YOU