Application of food safety risk assessment in identifying effective control measures during the animal production phase

AIMS Project
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Dao tao danh gia nguy co an toan thuc pham tai cac cho

VOV.VN - Các hoc vien tham gia khoa hoc nay duoc gioi thieu tong quan ve cac benh lien quan den thuc pham.

Lan dau tien mot khoa dao tao danh gia nguy co an toan thuc pham tai cac cho duoc t o chuc cho cac chuyen gia y te cong cong va thu y Viet Nam.

Khoa hoc dien ra tu 28/6 den 7/7 do Trung tam Nghien cuu Y te Cong cong va he sinh thai (Truong Dai hoct Y te Cong cong Ha Noi) phoi hop voi Viet Chanh nuoi Quoc te va Dai hoct Rakono Gakuen (Nhật Ban) to chuc tai Ha Noi.

Dia chi tu the

Thanh niem nguoi Dao, 17 tuoi, bit bong chien phai cat 2 tay!

Nhiem lòng truc tinh canh be 20 thang tuoi bit bong toan than

Tim nguoi than

Mot phu nu SN 1974 timkiem che me nguoi Viet Nam

Tim mo liet s'Lai Bien

Cua so tinh yeu

Hoc cach hoa thuan voi me chang

Người "trám chở" cho tinh yêu

Tinh say lụi gián
Objective of this talk

• To share ideas for application of food safety risk assessment in improving food safety by controlling hygiene in the animal production phase
Outline

• Food safety risk assessment
  – Why important?
  – Risk assessment
  – Logic tree (event tree, fault tree)
  – Description of value chains
  – Field survey- importance of diagnostic tests
  – Construct and run a risk model

• How food safety risk assessment can be applied to improve farm hygiene?
Why food safety?

• Every year, at least 2 billion cases of diarrhea occur and 1.5 million children under 5 yrs die worldwide

• Poor, young, elderly, pregnant women and immune-suppressed most affected

• Food borne diseases include non-diarrheal severe zoonoses
Why animal source foods?

• Two-thirds of human pathogens are zoonotic – many of these transmitted via animal source food

• Animal source food is a single most important cause of food-borne disease

• Many food-borne diseases cause few symptoms in animal host

• Many zoonotic diseases controlled most effectively in animal host/reservoir
Dominance of informal markets in developing countries

“Absence of structured sanitary inspection”
Informal ≠ Illegal
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OIE Import Risk Analysis

Risk assessment

- Release assessment
- Exposure assessment
- Consequence assessment

Risk management

Risk communication

Hazard identification

Risk assessment

Risk management

Risk communication
OIE Risk analysis for antimicrobial resistance

Hazard identification → Risk assessment → Risk management

- Release assessment
  - Use of antimicrobials at farm and selection of resistant bacteria
- Exposure assessment
  - Food chain and consumption of the foods contaminated
- Consequence assessment
  - Weaker response of antimicrobials in treatment

Risk communication
HACCP 12 step roadmap

Task 1. Assemble HACCP team
Task 2. Describe product
Task 3. Identify intended use
Task 4. Construct flow diagram
Task 5. On-site confirmation of flow diagram
Task 6. List all potential hazards associated with each step, conduct a hazard analysis, and consider any measures to control identified hazards (Principle 1)
Task 7. Determine Critical Control Points (Principle 2)
Task 8. Establish critical limits for each CCP (Principle 3)
Task 9. Establish a monitoring system for each CCP (Principle 4)
Task 10. Establish corrective actions (Principle 5)
Task 11. Establish verification procedures (Principle 6)
Task 12. Establish documentation and record keeping (Principle 7)
Ensuring the Safety of Japanese Livestock Products

- In order to prevent health problems caused by livestock products, integrated risk-reduction hygiene management (food chain approach) is needed up to the point where food is served on the table through regional cooperation at each stage including the production stages.
- Therefore, MAFF provides support for hygiene management at the production, manufacturing and processing stages.

**Food Chain**

- **Production stage**
  - Manufacturing, processing and distribution stages
  - Consumption stage

**Supply of safe livestock products through integrated hygiene management from farms to consumers**

Supporting the efforts to link HACCP (Hazard Analysis and Critical Control Points) at different stages (production, processing and distribution stages)

**Production farms**

1. Checking the general hygiene management program
2. Conducting hazard analysis and creating hazard lists
3. Creating a hygiene management plan
4. Verifying the implementation situation for hygiene management

**Dairy factories, meat processing plants, etc.**

1. Checking the general hygiene management program
2. Conducting hazard analysis and creating hazard lists
3. Creating a hygiene management plan
4. Verifying the implementation situation for hygiene management

**Consumers**

Appropriate storage, cooking, etc. in accordance with the type of food

**Support for introducing HACCP**

- MAFF
  - Creation and dissemination of certification criteria
  - Training on-site managers and leaders
  - Support for facility development

- MHLW

**Regulation and monitoring**

- MAFF, etc.
  - Regulation and monitoring based on the Food Sanitation Act, etc.
  - Approval of the Comprehensive Sanitation Management and Production Process
  - Information provision and risk communication through websites
Advanced Hygiene Management based on HACCP approach at Production Stage “Farm HACCP”

- Advanced Hygiene Management Guidelines based on HACCP approach at Farm Level developed (FY2002~)
- HACCP approach at Farm Level shared and promoted among local stakeholders: livestock hygiene service centers, livestock producers, livestock industry organizations, veterinarians, etc.
- Certification criteria for being recognized as “HACCP Farm” established and a certification system developed (FY2009~)
- Training for “Farm HACCP advisors” (FY2008~) and pilot project involving whole food chain (production stage, the processing, distribution to consumption stages) started (FY2009~)
- Certification of HACCP Farms by certification organizations started (FY2011~)

(As of July, 2013)

**Promotion of “Farm HACCP”**

- **Farm HACCP advisors**
  - Advice, Monitoring, Testing and Improvement

  - Creation of an implementation manual by each farmer
    - Hazard factor survey (Salmonella, E. coli O157, antibacterial agents, etc.)
    - Hazard analysis (HA)
    - Setting critical control points (CCP)
    - Creation of an implementation manual

- **Implementation**
  - Implementation of hygiene management based on the manual

- **Verification**
  - Appropriate revision of the manual

- **Certification as “HACCP Farm”**
  - Valid for 3 years

- **Certification organizations**
  - 2 orgs approved

- **No. of farms working on HACCP approach**: 4,587

- **Feedback including abattoir inspections**

- **No. of farms certified**: 27
  - Dairy 3, Beef 2, Pig 16, Layer 6

**Building trust of consumers in livestock products**

**Production of safer livestock products which meet consumer high demand**

**Advanced Hygiene Management Guidelines Based on the HACCP approach**, model requirements for controlling or reducing hazards are developed for each type of livestock.
Codex Alimentarius Commission
Food safety risk analysis
A tool for decision-making under uncertainty

*Risk is a probability of occurrence of a scenario and its size of impact (Vose, 2008)
Food safety risk analysis
in informal marketing system

Participatory methods

Risk Assessment
Risk Management
Risk Communication
What are participatory methods?

- Participants discuss problems
- Several formats:
  - Rapid rural appraisal
  - Participatory rural appraisal
  - Key-informants interview
Codex Alimentarius Commission
Risk assessment framework (CAC/GL-30 (1999))

- Hazard identification
- Hazard characterization
- Exposure assessment
- Risk characterization
Statement of purpose of risk assessment

- Clear statement of the specific purpose of the particular risk assessment
- Output form
  - Prevalence of illness
  - Annual incidence rate (e.g. case/10,000)
- Preliminary investigation phase may be required
Hazard identification

- The identification of biological, chemical, and physical agents –
- capable of causing adverse health effects –
- and which may be present in a particular food or group of foods
Exposure assessment

• Assessment of the extent of actual or anticipated human exposure

• Based on potential extent of **food contamination** by a particular agent or its toxins, and on **dietary** information
Hazard characterization

- Qualitative or quantitative description of the severity and duration of adverse effects that may result from the ingestion of a microorganism or its toxin in food

- A dose-response assessment should be performed if the data are obtainable
Factors that need to be considered in hazard characterization

- Factors related to the microorganism
  - Speed of replication
  - Virulence and infectivity
  - Delay of onset following exposure
  - Attributes altering pathogenicity, e.g., high fat content of a food vehicle

- Factors related to the host
  - Genetic factors
  - Host susceptibility characteristics
    - Age, pregnancy, nutrition, immune status etc.
  - Population characteristics
    - Population immunity, access to and use of medical care etc.
Dose-response Assessment

- Determination of the relationship between the magnitude of exposure (dose) to a chemical, biological or physical agent and the severity and/or frequency of associated adverse health effects (response)

**FIGURE 3.1.** Adverse response as a result of increasing dose.
Risk characterization

- Integration of previous three steps
- A qualitative or quantitative estimate of the **likelihood and severity** of the adverse effects which could occur in a given population
- Degree of confidence: **uncertainty and variability** (stochastic model)
- Influence of factors to the risk estimate: **sensitivity analyses**
Types of risk assessment and their outputs

• Qualitative
  – Eg). high, middle, low, negligible

• Quantitative
  – Deterministic (point estimate)
  – Stochastic (probability distribution)
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What is the implications of a cow harbouring EC O157:H7 on safety of informally marketed milk?
Fault tree analysis in food safety

• How the illness can occur

Onset of illness → Infection → Ingestion → Purchase or Production

Preceded by Purchase

Direction of identification and diagraming
Value chain

A producer <-> A consumer
Value chain

Producers ↔ Middle men ↔ Consumers
Actors in informal milk sales in Kampala, Uganda

- Shop with a bulk cooler
- Shop with a small refrigerator
- Boiling centre
- Trader with cans on a bicycle
- Roadside vendor
- Roadside vendor

- Plus milk retail shop without refrigerator and dairy farmers selling at farms
Quantitative dairy value chain in Kampala, Uganda

Field survey – Importance of diagnostic tests

Nyama-choma in Tanzania

My bitter experience in *Campylobacter* risk assessment...

<1st survey for prevalence>
High prevalence using culture without rigorous identification

<2nd survey for MPN>
Low prevalence using PCR after culturing
Constructing a risk model

• Model value chains which include
  – Mixing
  – Separation
  – Growth
  – Inactivation

• In a stochastic model, computer simulation is used (I show you a demo briefly..)
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How food safety risk assessment is applied to improve farm hygiene?
(An example)

Hazard identification

• Hazard
  – *Staphylococcus aureus* enterotoxin
  – Produced by *S. aureus* when the concentration in milk exceeds $10^{6.5}$ CFU/ml

• *S. aureus* is known to be prevalent in milk in Ethiopia by previous reports
Fault tree: understanding the logic of illness

Illness due to Staphylococcal poisoning due to milk consumption

- A consumer is susceptible to SAET
  - SA multiply to reach enough cfu producing ET
    - Milk contains SA
      - Milk contains SA at production
        - Milk shed by SA Mastitis cow
          - Infected cow
        - Milk contaminated by a farmer
          - Human source
      - Milk contaminated with SA
        - By traders/handlers
          - Human source

Initiating event
Exposure assessment

**Dairy value chain - RRA and interviews**

- Liquid raw milk sold to urban consumers
  - Dairy production in and around DZ by Ada Dairy Cooperatives farms
    - Urban dairy production
      - 19258
      - Restaurants Cafeterias
        - 2940
          - 75
            - Cafeterias before processing
      - Farm gate sales
        - 1960
      - Home consumption
        - 1960
        - 12398
        - 400
        - Processed milk
      - Collection centers
        - 4553
        - Traditional processing sold to urban
        - Home consumption
    - Peri-urban dairy production
      - 4553
      - Home consumption
      - Other processing plant in Addis Ababa
        - 50
          - Addis Ababa
Contamination rate - a survey

<table>
<thead>
<tr>
<th></th>
<th>Isolation of S aureus</th>
<th>Boiling before sales</th>
</tr>
</thead>
<tbody>
<tr>
<td>Milk collection centre (n=25)</td>
<td>18 (70.4%)</td>
<td>0</td>
</tr>
<tr>
<td>Dairy farm (n=170)</td>
<td>74 (43.6%)</td>
<td>0</td>
</tr>
</tbody>
</table>

Risk mitigation by consumers - participatory and interviews

<table>
<thead>
<tr>
<th></th>
<th>Boil milk before consumption</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dairy farming households (n=170)</td>
<td>116</td>
<td>68.2</td>
</tr>
<tr>
<td>Consumers (n=25)</td>
<td>16</td>
<td>64.0</td>
</tr>
</tbody>
</table>
Hazard characterization

Growth model: Fujikawa and Morozumi (2006) modified logistic model

Log of cfu/ml of *Staphylococcus aureus* in milk

- Lag phase
- Exponential growth phase
- Stationary phase

Cfu/ml

[Graph showing the growth of *Staphylococcus aureus* in milk with logarithmic scale on the y-axis and hourly progression on the x-axis]
Risk mitigation by traditional milk fermentation - Modeling using reported data (Gonfa et al., 1999)

Bacteria growth stops at pH 4.9

\[
\frac{1}{\text{pH}} = 0.002 \times t \ (\text{h}) + 1.187 \quad (\text{df}=3, \ r^2=0.90, \ p=0.009)
\]

Source: Makita et al., 2012
Int. J. Food Microbiol.
Stop of growth of S. aureus in milk by low pH

Hazard characterization

Stop of bacterial growth due to milk fermentation

Log of cfu/ml of S. aureus at room temperature

Stop of bacterial growth due to milk fermentation
Risk characterization

- Each of them are **uncertainty** distributions
- The variety of uncertainty distributions shows **variability**
- Variability in this case is the growth speed of *S. aureus*
Risk characterization

- Training for hygienic milking
- Separation of cows with mastitis
- Temperature control

Sensitivity analysis

- It provides efficient control options

Initial bacteria population
- Temperature
- Prob. SA has SE genes
- Prob. farmers boil
- Prob. consumers boil
- Store milk 3,4 days
- Contamination, farm
- Contamination, farm
- Consume on day 0
- Prob. centres boil
- Contamination, centre
- Store milk 1,2 days

Sensitivity Tornado

Mean of Incidence rate

-0.5
0
0.5
1
1.5
2
2.5
Conclusion

• Food safety is important in public health

• Risk assessment is useful in identifying factors reducing the risk, including animal production phase

• Improvement of farm hygiene contributes food safety