Climate Change Impacts on Food Security and Nutrition

Warapa Mahakarnchanakul, Ph.D
Center for Advanced Studies for Agriculture and Food (CASAF)
Dept. of Food Science and Technology, Kasetsart Univeristy
warapa.m@ku.ac.th

Outline

- Climate change impact to human health through food
- How to manage climate change impact to human health
  - Microbial ecology changes
  - Chemical use in Agriculture
  - Food safety management
- Recommendation

Health Effect due to Climate and Environmental Change

- Climate change
- Stratospheric ozone depletion
- Forest clearance and land cover change
- Land degradation and desertification
- Wetland loss
- Freshwater depletion and contamination
- Urbanization and its effects
- Damage to coastal reefs and ecosystem

- Direct health effects

Floods, heatwaves, water shortage, landsides, exposure to ultraviolet radiation, exposure to pollutants

- Ecosystem-mediated heath effect

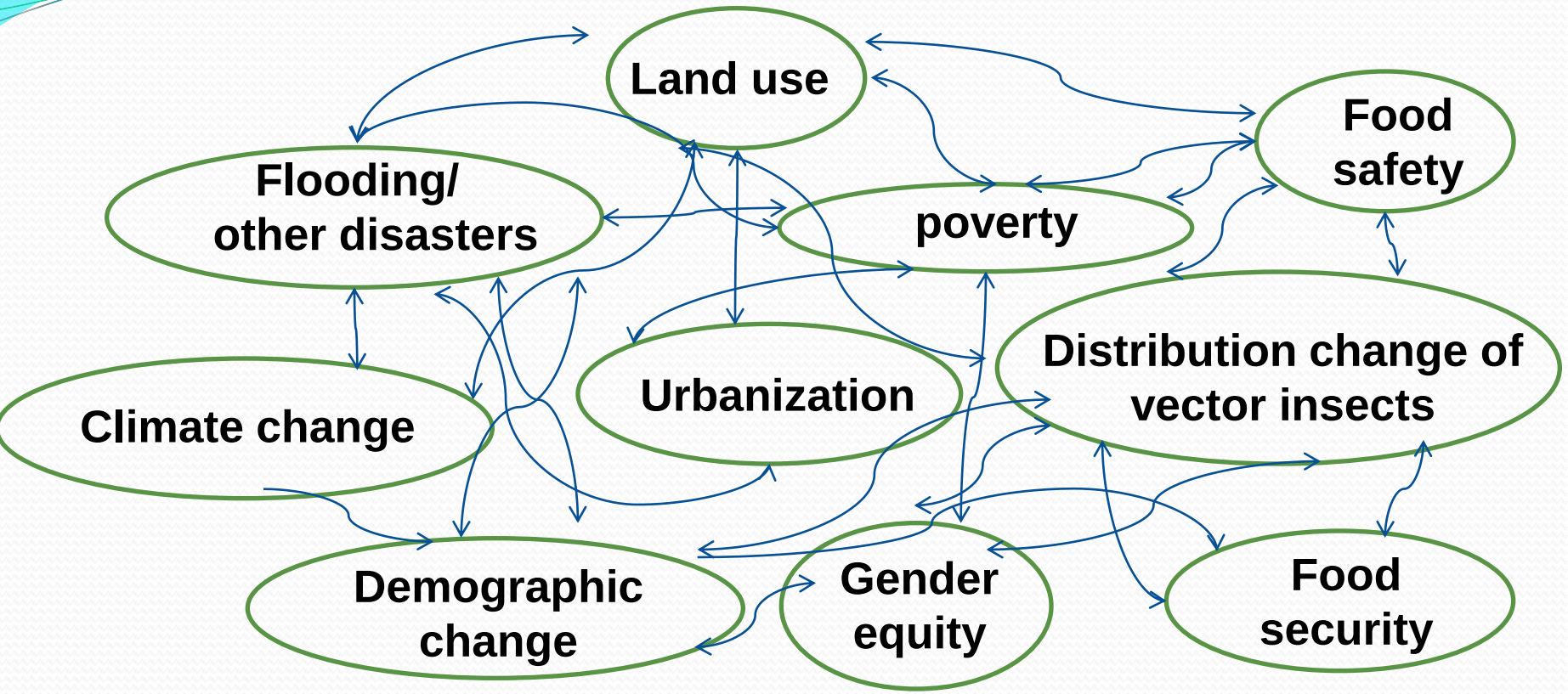
Altered infectious disease risk, reduced food yields (malnutrition, stunting), depletion of natural medicines, mental health (personal, community), effects of aesthetic or cultural impoverishment

- Indirect, deferred, and displaced health effects

Diverse health consequence of livelihood less, population displacement (including slum dwelling), conflict, inappropriate adaptation and mitigation

Modified from Dr. Fumiko Kasuga , 7th Asian Conference on Food and Nutrition Safety, Penang Malaysia.Oct 11-13,2016

Inter-related Factors



- **Many factors are related each other and have impacts on human health and FOOD SAFETY**

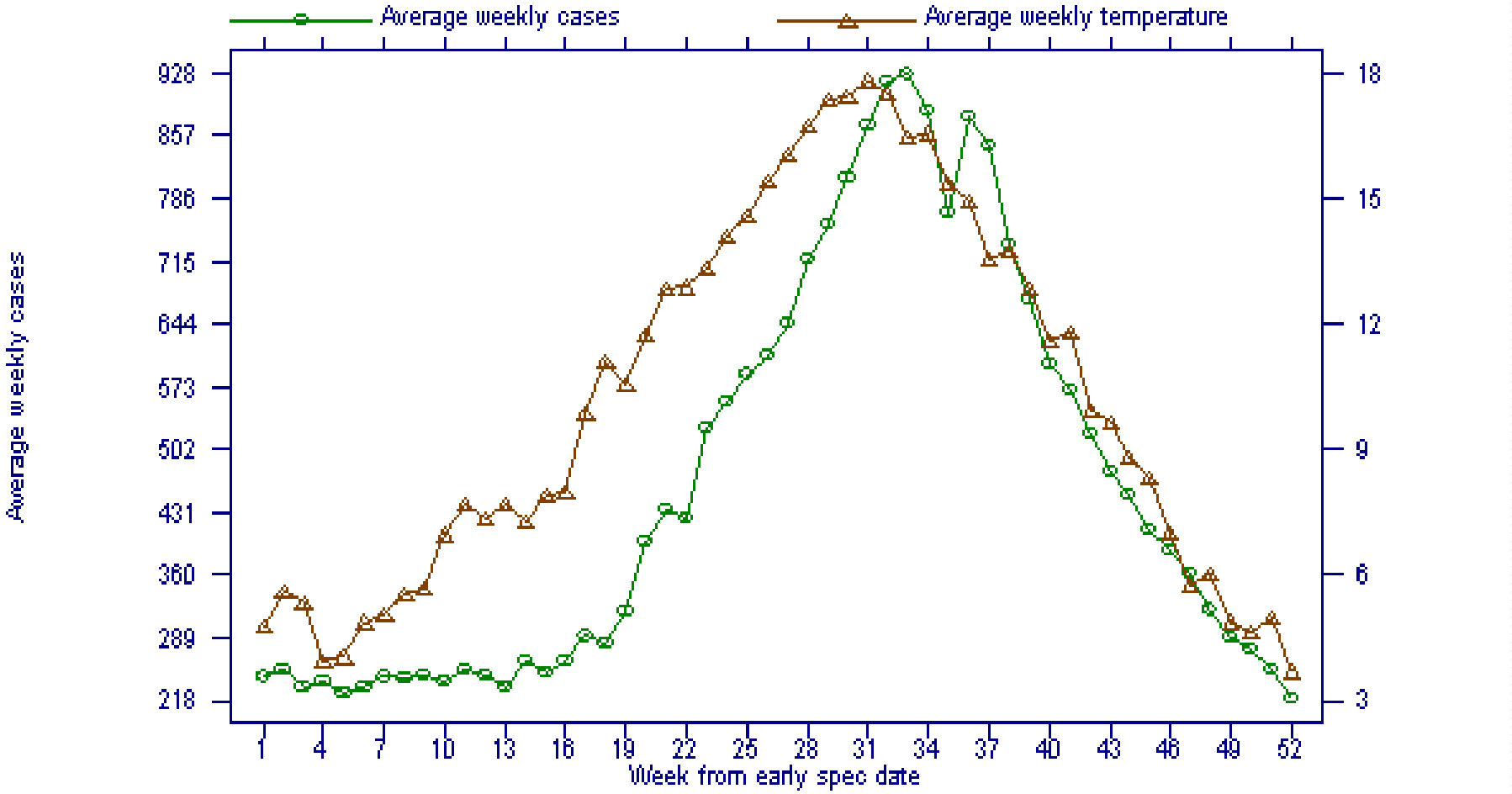
Modified from Dr. Fumiko Kasuga , 7th Asian Conference on Food and Nutrition Safety, Penang Malaysia.Oct 11-13,2016

Climate change effects on microbial ecology

- **Losses of people and economics losses**
- **Consequences spreading of food and waterborne diseases e.g. gastroenteritis diseases frequently after flooding Salmonellosis and Vibriosis**
- **Elevated ambient temperature increased likely hood *Campylobacter* and *Salmonella* transmission.**
- **Seasonal variation in the cholera patients in Bangladesh can be explained by temperature and rainfall.**

Tirado et al. 2010. Climate Change and Food Safety: A Review. Food Res. Inter. 43:1745-1765.

Salmonellosis are preceded by weeks of elevated ambient temperature



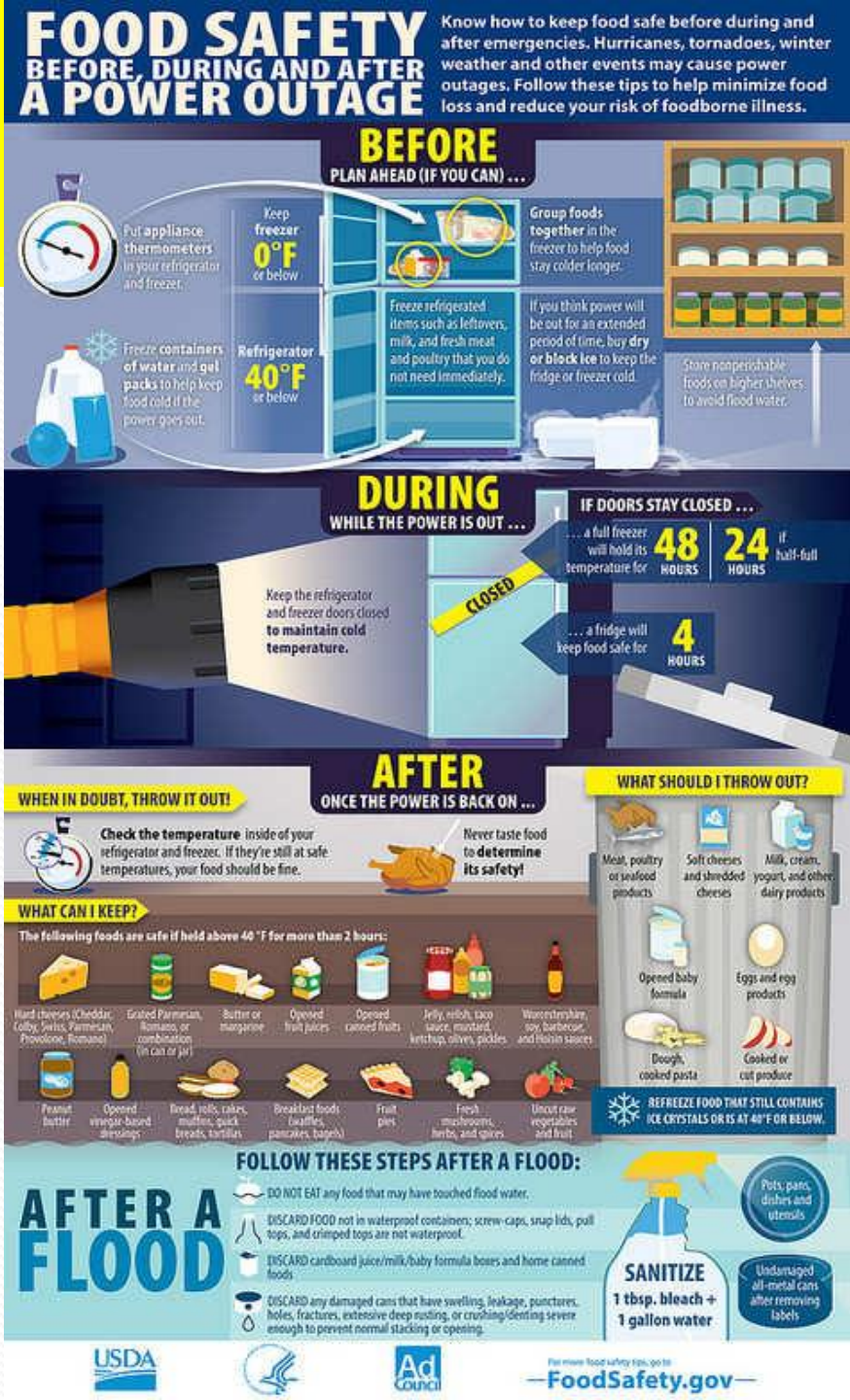
(Kovats *et al*, 2003)

Seasonality and temperature effects on foodborne disease

- Salmonellosis associated with outdoor temperature when temperature greater than 7.5 ^{o}C
- Salmonellosis incidence in 5 cities in Australia (D'Souza *et al.*, 2003)
- a positive association between monthly Salmonellosis notifications and mean monthly temperature of the previous month.
- policy on food preparation and distribution.
- increase risk particularly from bacterial foodborne illness.

Climate change and impact on Food Handling Processing and Trading

- Risks associated with storage and distribution of food commodities.
- Reduced the availability and quality of water challenge to hygiene management.
- Higher temperature around the time of consumption are important and reinforce the need for further education on food handling behavior.



Tirado et al. 2010. Climate Change and Food Safety: A Review. Food Res. Inter. 43:1745-1765.

Climate change effects on water and food supplies

- **Drought could reduce drinking water supplier and crop yields.**
- **Increase world food insecurity.**
- **Declining fisheries which contribute to protein shortage.**
- **Increased risks of food-borne illnesses.**

Other Potential Impacts of Climate Change on Food Safety

- Impacts on microbial evolution and stress response.
- Bacterial mechanisms allow them to survive and grow under unfavorable or "stressful" condition.
- Pathogens with documented stress tolerance responses (temperature, pH) such as:
  - enterohemorrhogic *E.coli*
  - *Salmonella*
  - *Listeria monocytogenes.*

Survival of acid-stressed cell and non acid-stressed cell of *Listeria monocytogenes* after expose to lethal acid (pH3.5)

Exposure time (h)	*Listeria monocytogenes* count (Log CFU/ml)[a]	
	Acid-stressed cell	Non acid-stressed cell
0	4.72 ± 0.15^{Aa}	4.38 ± 0.56^{Aa}
0.5	4.05 ± 0.10^{Ab}	3.42 ± 0.15^{Ba}
1.0	3.04 ± 0.04^{Ac}	2.13 ± 0.19^{Bb}
1.5	2.00 ± 0.19^{Ad}	0.60 ± 0.51^{Bc}
3.0	ND^{Ae*}	ND^{Ac}
5.0	ND^{Ae}	ND^{Ac}

Pongkanpai, V., W. Makakarnchanakul and W. Garnjanagoonchorn. 2013. Acid and Heat Tolerance of Acid-stressed *Listeria monocytogenes* Inoculated in Broth and Shrimp Model. Journal of pure and applied microbiology. Vol. 7(2): 837-843

Mycotoxins

Moulds and mycotoxins of world-wide importance		
Mould species		**Mycotoxins produced**
Aspergillus	***parasiticus***	**Aflatoxin B_1 B_2 G_1 G_2**
	flavus	**Aflatoxin B_1 B_2**
Fusarium	***sporotrichiodes***	**T-2 toxin**
	graminearum	**Deoxynivalenol (nivalenol)** **Zearalenone,**
	moniforme (verticillioides)	**Fumonisin B_1**
Penicillium	***verrucosum***	**Ochratoxin A**
Aspergillus	***ochraceus***	**Ochratoxin A**

Jaykus et al. 2009. Climate Change Implications for Food Safety. fao.org/docrep/fao/010/i0195e/i0195e00.pdf, 17 Oct 2016.

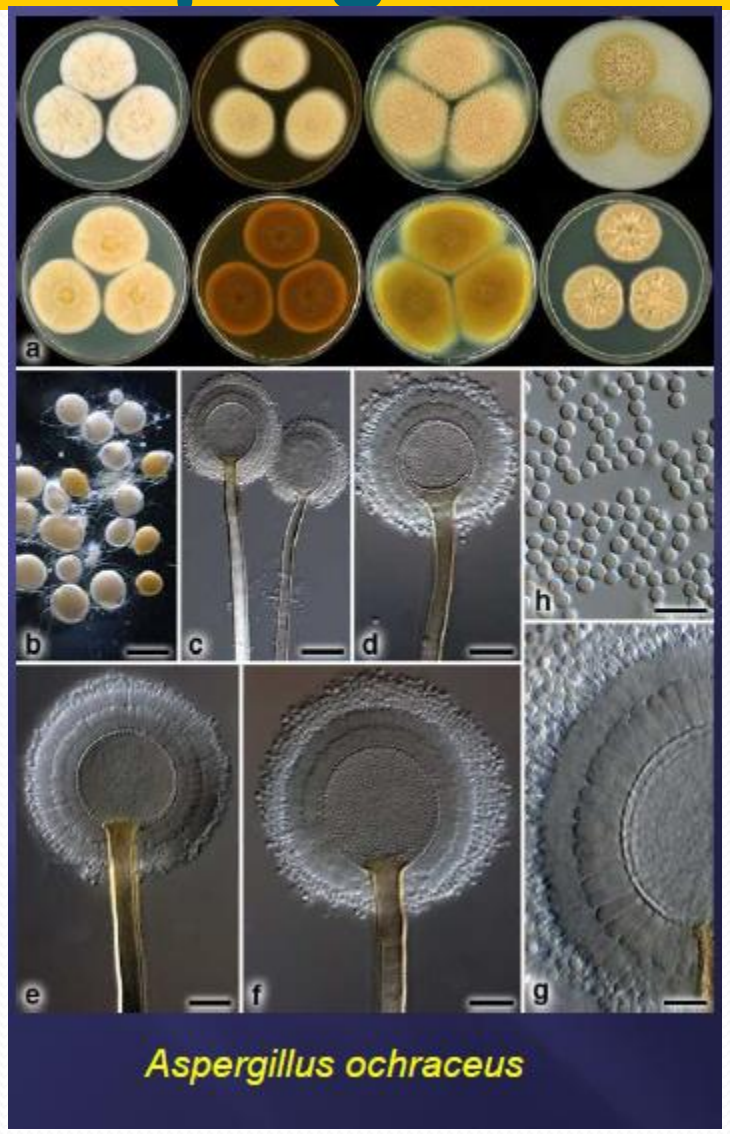
Particular mycotoxins may cause carcinogenic, immunosuppressive, neurotoxic, estrogenic and teratogenic activity

Fusarium toxins in Maize

- *F. graminearum*
  - predominate in the warmer temperature region (25-28 °C)
  - produce either deoxynivalenol (DON) or nivalenol (NIV) and Zearalenone (ZEA)
- *F. culmorum*
  - more common in the cooler regions
  - produce only DON and ZEA
- As a series of warm European summers the occurrence of *F.culmorum* is replace by *F. graminearum*, the species that is more virulent plant pathogen .
- A shift to NIV/ZEA pattern from DON/ZEA pattern in Europe and Asia.

Paterson and Lima. 2010. How will climale affect mycotoxins in food?. Food Res. Inter. 43:1902-1914.

The Yellow Aspergilli and ochratoxin



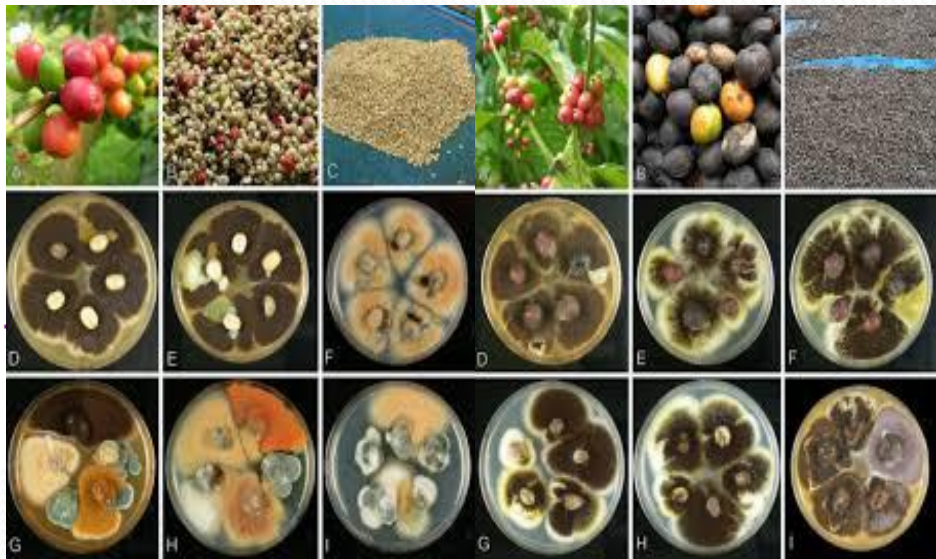
Identification of the mould isolates from Thai coffee

- More than 1,000 isolates were obtained
- All these strains were grown on various agar media and examined by light and scanning electron microscopy
- Extracts of DNA were made from a selected number of strains and specific genes were analyzed.
- Extracts of colonies on media were made and the secondary metabolites were examined.
- All these data were analyzed and it was shown that two new species from Thailand were discovered.

Isolation, identification and toxigenic potential of ochratoxin ...
orbit.dtu.dk/en/...and...of-**ochratoxin**...**coffee**.../export.html
Isolation, identification and toxigenic potential of **ochratoxin** A-producing Aspergillus species from **coffee** beans grown in two regions of Thailand. / **Noonim**, P.

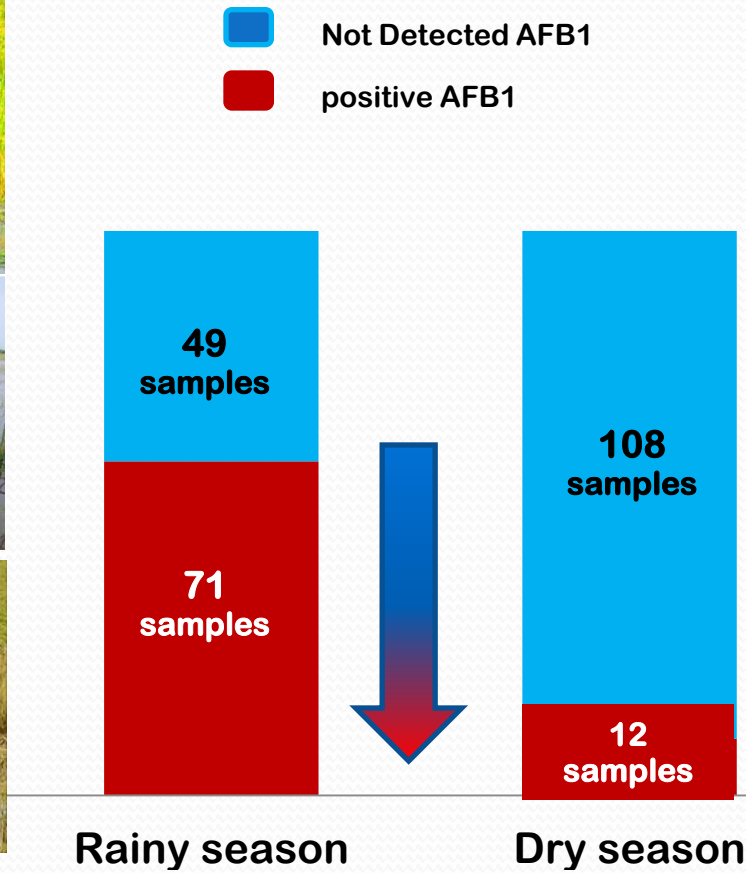
Aspergilli and ochratoxin A in coffee. › Research Explorer
https://pure.knaw.nl/...**ochratoxin**-a...**coffee**(d86b3cd9.../export.html
Noonim, O, Mahakarnchanakul, W, Varga, J & Samson, RA 2008, 'Aspergilli and **ochratoxin** A in **coffee**.'. in J Varga & RA Samson (eds), Aspergillus in the ...

Enumeration of Ochratoxin a Producing Fungi in Thai Coffee ...
books.google.com/.../Enumeration_of_**Ochratoxin**_a_Producing_Fu.html?i...
Enumeration of **Ochratoxin** a Producing Fungi in Thai **Coffee** Beans. Front Cover. Paramee **Noonim**, Mahāwitthayālai Kasētsāt. Department of Food Science and ...



Paramee Noonim Kasetsart Univ. Dissertation 2008

Seasonal influence on the amount of AFB1 in brown rice



Iamtaweejaroen, P., P. Kooprasertying, T. Maneebun, N. Anukul. and W. Mahakarnchanakul. 2016. Exposure to aflatoxin B1 in Thailand by consumption of brown and color rice. Mycotoxin research 32(1): 19-25.

Mycotoxins Control and Management

Farming

Food processing

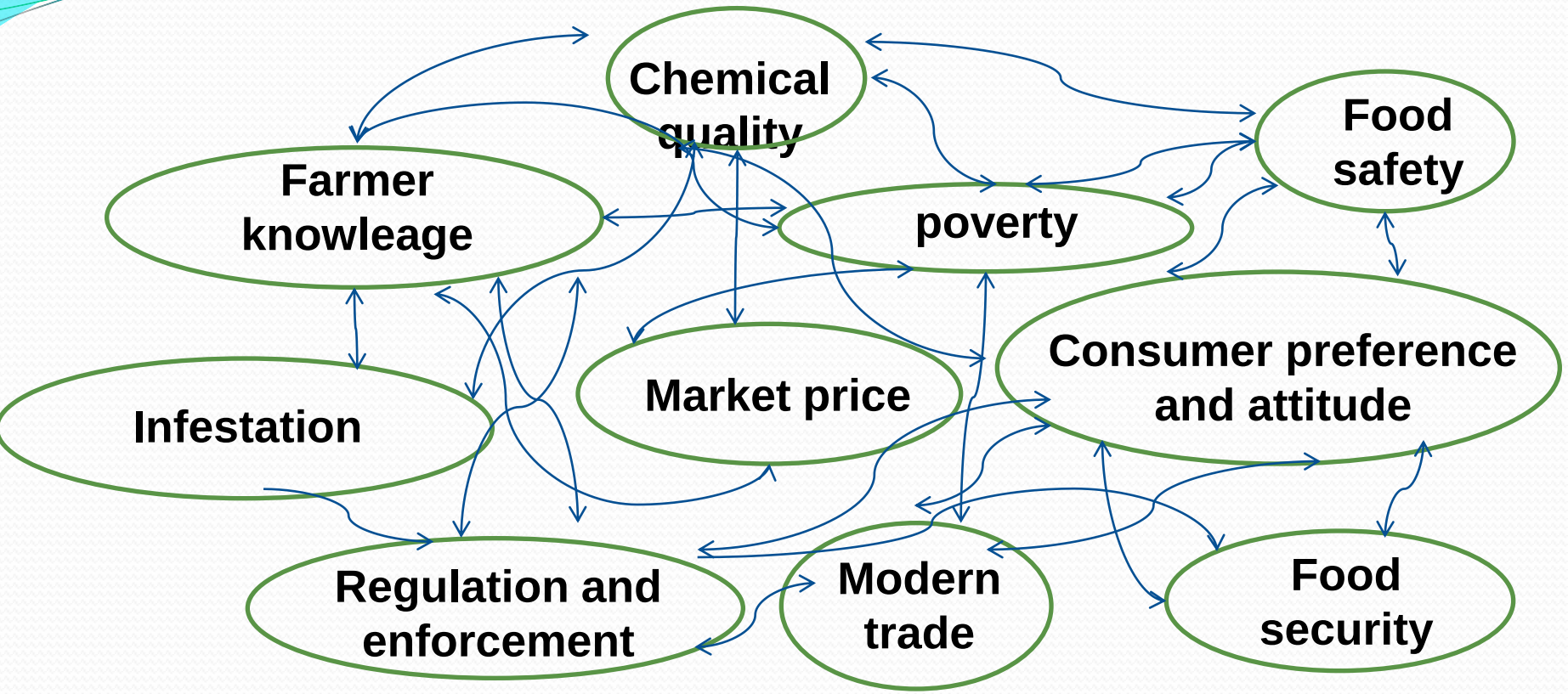
Finished product

GAP → GMP/HACCP → Standard Regulation

Climate change and its impact on Agricultural

- **Crop production**
  - **direct → microbial population of soil, air and water**
  - **direct →population of pests and vector**
  - **indirect → the occurrence and diseases from fungi, bacteria, viruses and insects**
- ***Demand for the fertilizers may cause the higher trace impurity in crop .***
- ***Demand for the organic produce may cause the problem of foodborne diseases due to consumption of fresh produce***
- ***Increasing of pesticide application cause the residue in fresh produce.***
- **And greater risks due to increase produce consumption.**

Inter-related Factors



- **Many factors are related each other and have impacts on human health and FOOD SAFETY**

Modified from 7th Asian Conference on Food and Nutrition Safety, Penang Malaysia.Oct 11-13,2016

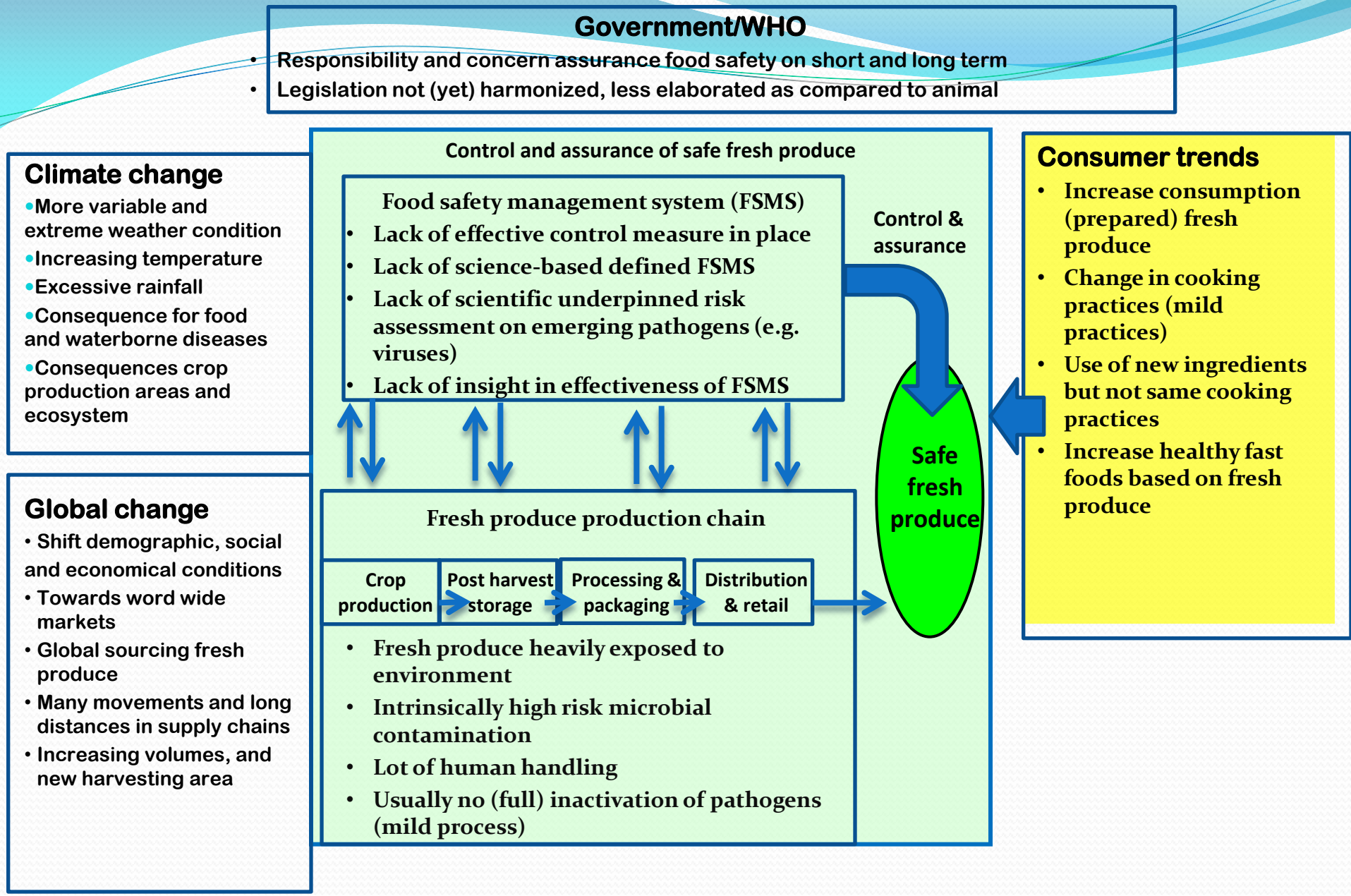


Fig Inventory of various conditions and developments which influence the vulnerability of fresh produce food chain(Jacxsens et al. 2010. Food Res. Inter. 43:1925-1935)

วิภาวดี อ้นท้วม น้าทิพย์ ขันตยาภรณ์ และวราภา มหากาญจนกุล. 2553. ผลของอุณหภูมิเก็บรักษาต่อการรอดชีวิต ของ *Escherichia coli* และ Salmonellae ในปุ๋ยมูลสัตว์. *ใน* เรื่องเต็มการประชุมทางวิชาการของมหาวิทยาลัยเกษตรศาสตร์ ครั้งที่ 48: สาขาอุตสาหกรรมเกษตรกรุงเทพ. มหาวิทยาลัยเกษตรศาสตร์. หน้า 401-40

Survival of Mixed Pathogens in Dried Animal Fertilizers

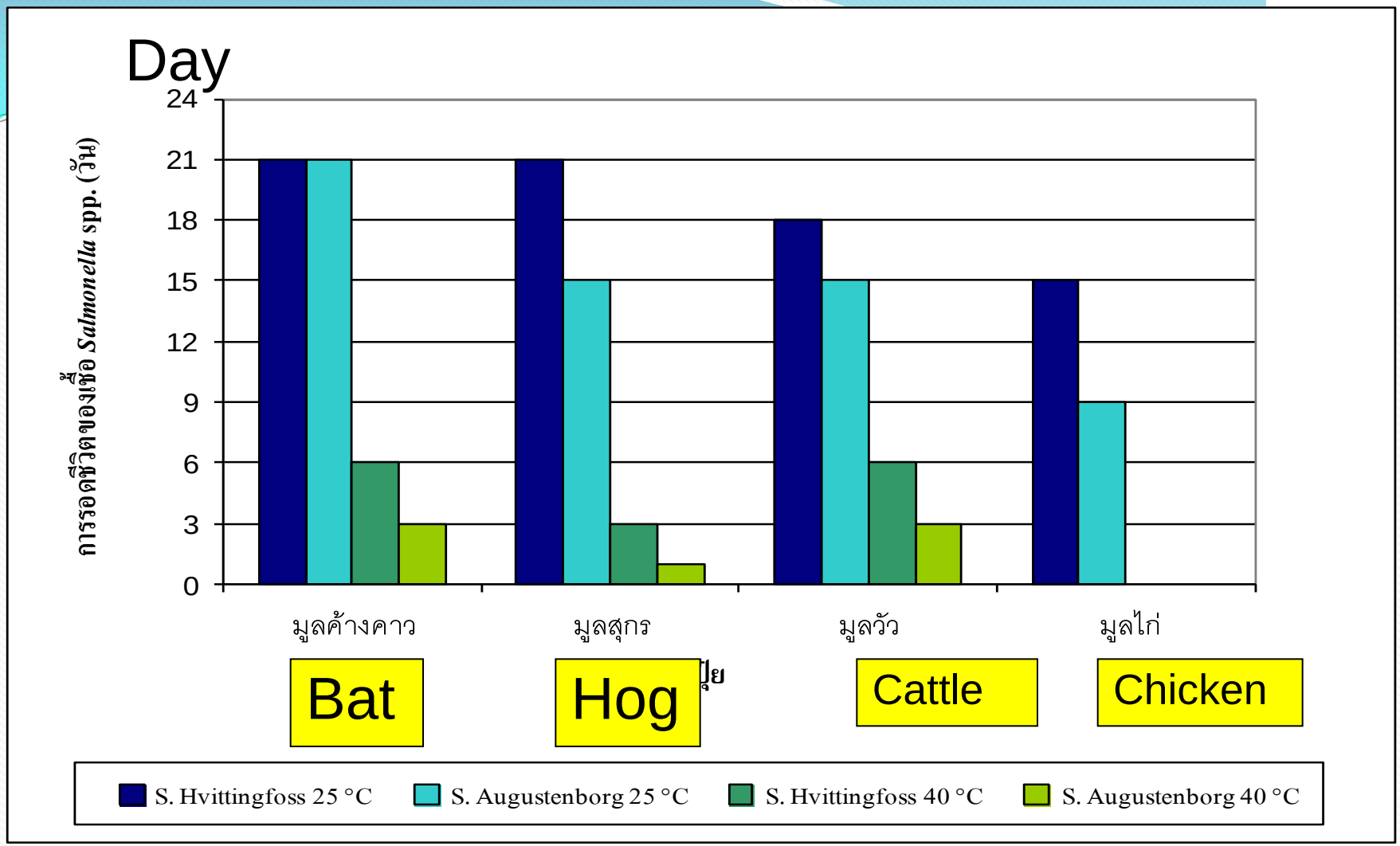
: *Salmonella* spp. and *Escherichia coli*

- ***S.* Hvittingfoss + *E. coli***
- ***S.* Augustenborg + *E. coli***

25±2°C

40±2°C

- **4 type of fertilizers**
- **(autoclaved) :**
  - **Bat**
  - **Hog**
  - **Cattle**
  - **Chicken**

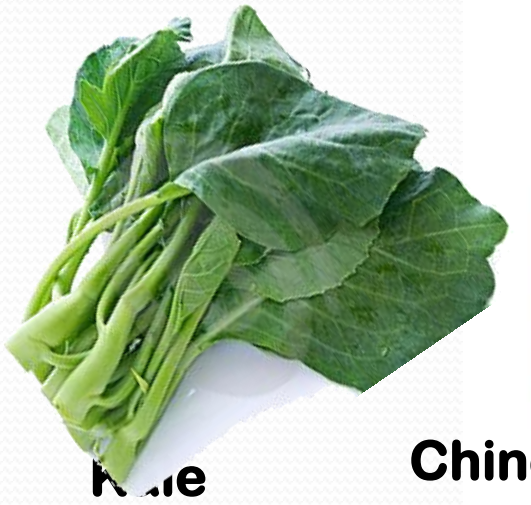


Survival of *S.* Augustenborg and *S.* Hvittingfoss in dried animal fetilizers during Storage at 25C and 40C

วิภาวดี อ้นท้วม น้าทิพย์ ขันตยาภรณ์ และวราภา มหากาญจนกุล. 2553. ผลของอุณหภูมิเก็บรักษาต่อการรอดชีวิต ของ **Escherichia coli** และ **Salmonellae** ในปุ๋ยมูลสัตว์. *ใน* เรื่องเต็มการประชุมทางวิชาการของมหาวิทยาลัยเกษตรศาสตร์ ครั้งที่ 48: สาขาอุตสาหกรรมเกษตรกรุงเทพ. มหาวิทยาลัยเกษตรศาสตร์. หน้า 401-40

- การประยุกต์ใช้สารออกซิไดส์ซิ่งในการล้างเพื่อลดสารตกค้างกลุ่มออร์กาโนฟอสเฟตในผักสด
- อัจฉรา และ วราภา, 2555

Coriander



Kale

Chinese cabbage

Chili

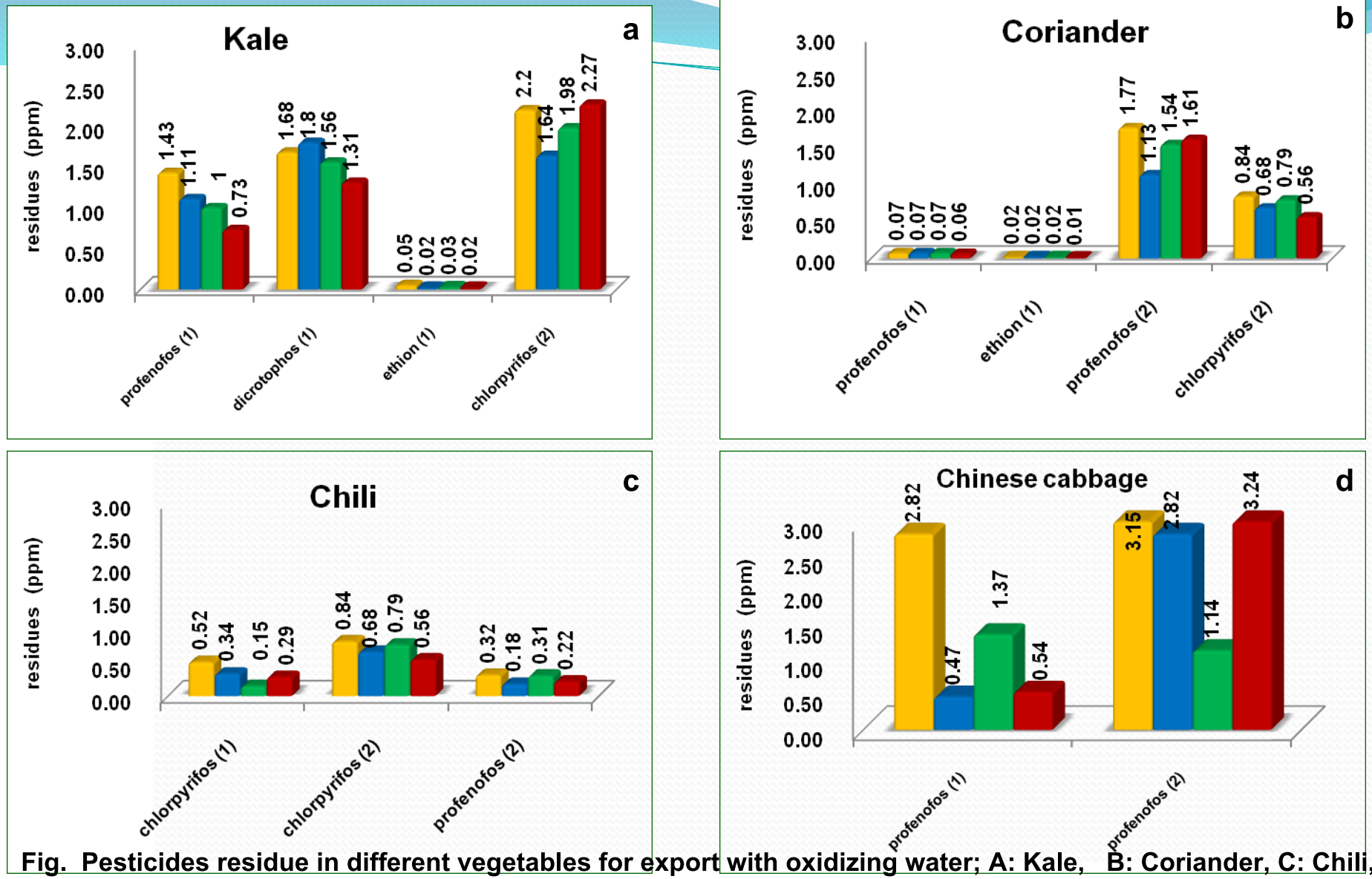


Fig. Pesticides residue in different vegetables for export with oxidizing water; A: Kale, B: Coriander, C: Chili, and D: Chinese cabbage at 10 min ; ( ) EO -water ( ) ClO_2 ( ) ozonated and ( ) non washed

Atchara Sankom. 2013. Residual Degradation of Organophosphate Pesticides and Efficiency of Oxidizing Agents to Reduce Its Residues on Chinese Kale from Field Trials. VBFoodNet, Conference Proceedings, Hanoi University of Agriculture, Vietnam.

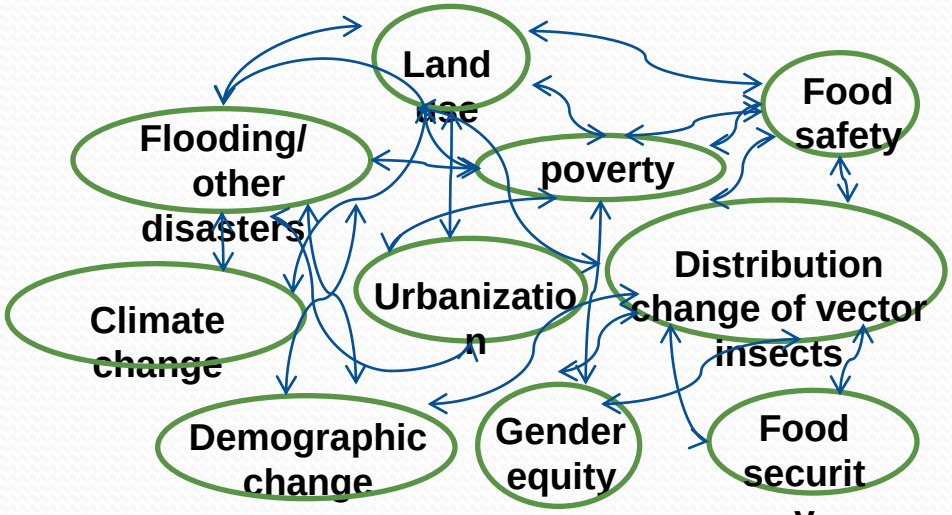
Has science changed (improved) the real world?

- Stopping global environmental change? No
- Support people to have better life? Yes and No

- Something has been lacking …..
  - Lack of collaboration with other disciplines within science e.g. social and natural sciences.
  - Science only cannot solve societal problems- need collaboration with stakeholders in the society and wisdom in the society.

Linking Food Safety Risk Assessment to Environmental Risk Assessment

Public health burden



Food Safety Objective

GHP

GMP

GHP

HACCP

Code of practice

Modified from Dr. Fumiko Kasuga 7th Asian Conference on Food and Nutrition Safety, Penang Malaysia.Oct 11-13,2016

Recommendations and Policy Propose

- Interdisciplinarity
- Application of Good Practices
- Surveillance and monitoring
- Risk assessment
- Predictive modeling
- New technology
- Capacity building
- Risk communication
- Intra- and International engagement

Havelaar et al. 2010. Future Challenges to Microbial Food Safety. International Journal of Food Microbiology. 139:s79-s94.

Recommendations

- **Interdisciplinarity**
  - **need to intensify the efforts to implement of food safety management system.**
  - **need for input and coordinate between all sectors in the “farm to fork” food chain.**
  - **need to promote interdisciplinary approaches to addressing challenges affecting food safety given the inter-relationships among environmental impacts, animal and plant health impacts and food hygiene.**

Recommendations

- Application of Good Practices
  - Good hygiene practices
  - Good agricultural practices
  - Good animal husbandry practices
  - Good aquaculturure practices
  - Good manufacturing practices
  - Good storage practices
  - etc.
  - Adjusting and applying the principle regarding changes in the occurrence and prevalence of food hazards as well as insects or other pest and their vectors.
  - Require applied research to better understanding the new ‘dynamics” and evaluate different approaches for controlling the problem.
- Developing a policy frameworks to help small and less developed businesses to overcome the constraints and encourage founding good practices programes




Recommendations

- **Surveillance and monitoring, Risk assessment, Predictive modeling**
  - **Is essential for the early identification of emerging diseases and trends**
  - **the resource for planning and measuring the impact of control strategies.**
  - **Integrated monitoring and surveillance of human and animal disease, food contamination and environmental health is critical**

Recommendations

- **Surveillance and monitoring, Risk assessment, Predictive modeling**

  - **Monitoring and surveillance programmes of country need to be reviewed and amended to address emerging hazards arising from global climate change.**
  - **The data generated from these programmes contributes significantly to predictive modeling and risk assessments.**
  - **Information should be shared both at national and international level.**

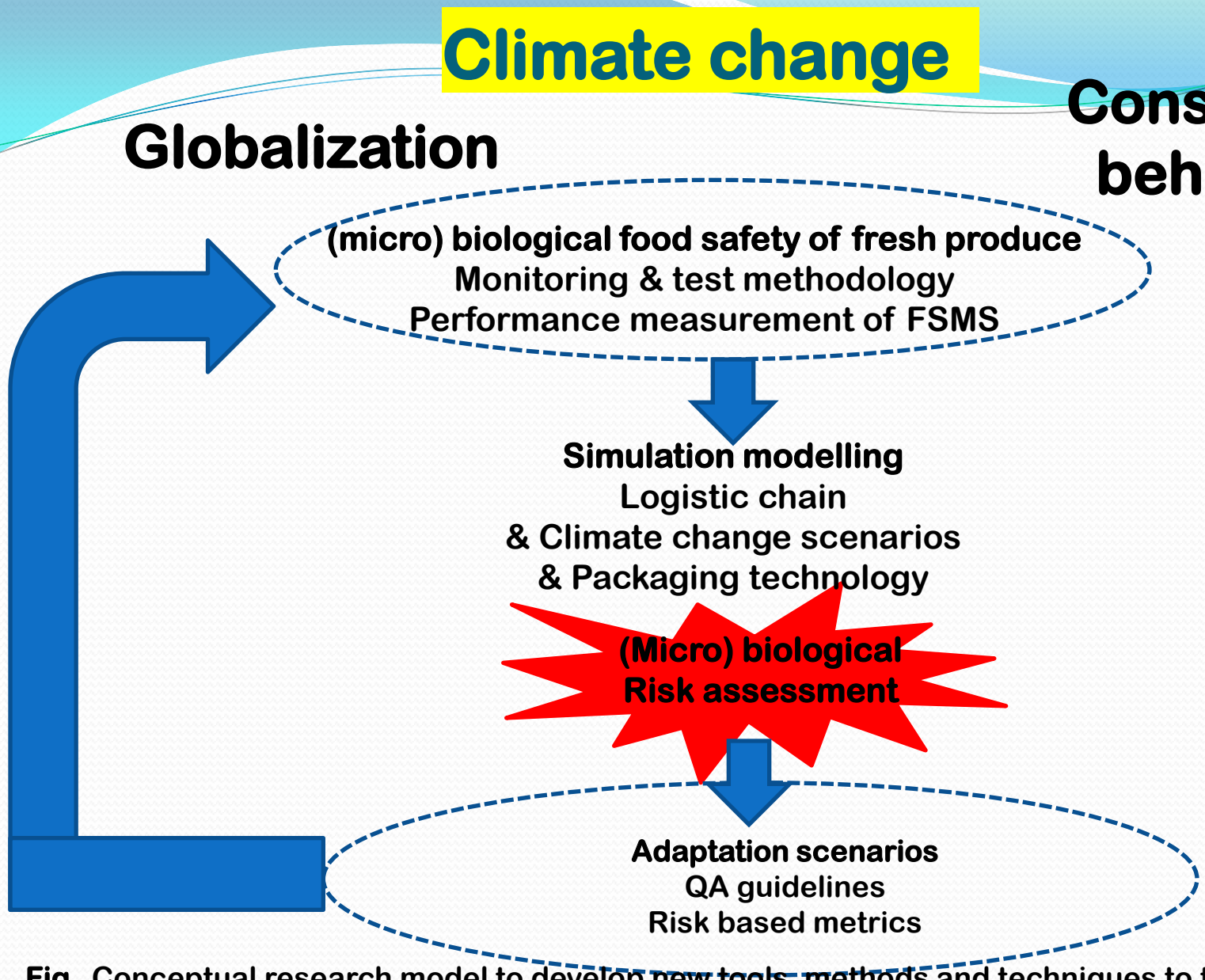


Fig Conceptual research model to develop new tools, methods and techniques to tackle the impact of climate change, globalization consumer trends on microbiological risk of fresh produce

Jacxsens et al. 2010. Simulation Modelling and Risk Assessment as Tools to Identify the Impact of Climate Change on Microbiological Food Safety- The Case Study of Fresh Produce Supply Chain. Food Res. Inter. 43:1925-1935.

Recommendations

- **New technology and investment in scientific and technical capacities**
  - **A number of science and technologies play a major role to understand and deal with the food safety challenges**
  - **Influence the prioritisation of research investments**
  - **Investment in human resource development**
  - **Use of available competencies at national level by encouraging linkages between government services, universities, private sector association**
  - **Food safety capacity building by training and education**

Recommendations

- **Risk communication**
  - **Education of consumers**
  - **Inform the risks to public health help to reduce both the use and trade of substandard food**
  - **Inform the emerging risks related to climate change and variability**
  - **Strengthened dialogue with the public**

What food safety specialists can do..

- Keep our eyes widely open to identify new trends and affecting factors
- Work with other scientific disciplines and other partners .
- Interdisciplinary approach
- Co-creation of knowledge with stakeholders in the society:

  Transdisciplinary approach, stakeholder engagement
  - Co-design: research planning (incl. theme, methods)
  - Co-production: research conduct
  - Co-delivery: application of the research products in the society

Modified from 7th Asian Conference on Food and Nutrition Safety, Penang Malaysia.Oct 11-13,2016

References

Jaykus, L.-A. *et al*. Climate Change: Implication for Food Safety. FAO document.

Paterson, R.R.M. and N. Lima. 2010. How will climate change affect mycotoxin in food? Food Research International. 43:1902-1914

Havelaar, A. H. *et al*. 2010. Future challenges to microbial food safety. Inter. J. of Food Microbiol. 139:S79-S94.

Tirado, M.C. *et al*. 2010.Climate change and food safety: A review. Food research International. 43: 1745-1765.

Dr. Fumiko Kasuga , 13 Oct 2016. Environmental Change and Food Safety. Presentation slides at 4th Asia-Pacific International Food Safety Conference & 7th Asian Conference on Food and Nutrition Safety. October 11-13, 2016. Penang, Malaysia