

Role of Research and Development for Food Safety and Food Security in Thailand

Supannikar Sribuathong* and Sudsai Trevanich

Department of Food Science and Technology, Faculty of Agro-Industry, Kasetsart University,
Phaholyothin Road, Jatujak, Bangkok, 10900, Thailand

The Thai government has established policies on food safety and food security in order to increase global awareness of these issues. A food-safety policy was declared in 2004, primarily to promote Thailand as the “kitchen of the world,” and a food-security policy was issued in 2008 to secure safe agricultural and food products. To achieve these goals, effective collaborations have been implemented among multiple organizations as networks in Thailand, including government agencies and the primary-production, food-manufacturing, food-supply and consumer sectors. Research and development (R&D) is one effective way to manage food-safety and food-security problems. The main topics of food safety research in Thailand are innovative preventive measures and rapid detection methods for agents in the food chain that cause food-borne illnesses. R&D on food security has focused on sustainable development based on the so-called “sufficiency economy”, and has focused on a combination of traditional and innovative biotechnology in all primary-production sectors. In conclusion, the success of R&D on food safety and food security in Thailand is dependent on many important factors, such as capacity-building, strengthening of joint collaboration among various sectors, and accessible communication with all related organization networks.

Key words: food safety, food security, risk assessment, Pre-HACCP program, biotechnology development, sustainable development

1. Introduction

Thailand is recognized as one of the highest-ranking producers of various foods and agricultural products among developing countries. Thailand meets the dietary needs of many countries around the world by exporting large quantities of processed food and agricultural products, such as canned pineapple, pineapple juice, pineapple juice concentrate, frozen shrimp, rice, sugar cane, cassava, longan, durian, and mangosteen (Fig. 1). In 2008, Thailand became the 13th-largest food exporter in the world, and the value of Thai agricultural and food exports accounted for 60 percent of Thailand’s total goods exports that year. In 2008, Thailand exported 700 billion baht of food and employed 13 million people in the agriculture sector

(Inside Thailand, 2009). In 2009 and 2010, Thai food exports are estimated to reach 722 and 750 billion baht, respectively (RNCOS, 2009).

The world’s food market is changing fast nowadays because of rapid developments in global science and technology; consequently, food safety and food security are becoming top priorities for consumers (Bumatay *et al.*, 2008; International Association for Cereal Science and Technology, 2009). Food safety has been a global concern for a long time, as evidenced by the vigorous activities of the Food and Agriculture Organization (FAO) and the World Health Organization (WHO). Food security has been defined by the FAO as a state in which all people at all times have physical and economic access to sufficient, safe and nutritious food needed to maintain a healthy and active life (FAO Corpo-

Received: October 26, 2009, Accepted: November 16, 2009

*Corresponding author: Department of Food Science and Technology, Faculty of Agro-Industry, Kasetsart University, 50 Phaholyothin Road, Jatujak, Bangkok, 10900, Thailand.

Tel: +66-2562-5020, Fax: +66-2562-5021, E-mail: g5090010@ku.ac.th

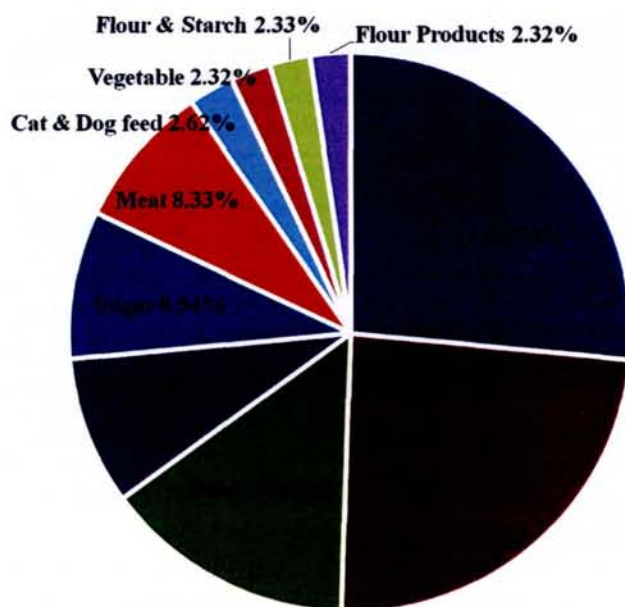


Fig. 1. Top ten food-export markets of Thailand in 2009 (Jan.-July).

Source: Food Intelligence Center (2009).

rate Document Repository, 2004).

The Thai government has increased the implementation of food control systems in order to secure for all citizens access to sufficient amounts of food, food safety, balanced nutrition, and foods that they prefer. In addition, factors determining whether these rights can be provided should be considered in order to ensure food safety and food security at national and regional levels (NEAT Working Group on East Asian Food Security, 2009). These factors include outbreaks of food-borne illness, terrorism, climate changes, biofuel issues, research and development (R&D), and regulation. To accomplish these goals, the Thai government has established policies and strategies for food safety, and food security. The Thai government is thus promoting domestic and international trade as well as consumer confidence.

Research and development (R&D) is a fundamental key to solving these food-safety and food-security problems. R&D also facilitates knowledge-sharing among stakeholders in all networks of R&D related organizations, thus enhancing their awareness of food-safety and food-security issues. Transparency of communication about food safety and food security among various sectors enables them to influence policies and support Thailand in

becoming one of the world's leading food exporters. Therefore, this report describes the role of R&D in food-safety and food-security management systems in Thailand.

2. Policies, Laws and Standard Regulations for Food Safety and Food Security in Thailand

Due to a rapid increase in world population and advanced developments in global science and technology, conventional approaches to systems for food safety and food security may no longer be effective for managing both newly emerging food hazards and the chronic staple food crises. Organizations for management of food safety and food security share responsibility for these objectives. Throughout the many processes that food undergoes, from farms to consumers, cooperation is crucial among organizations involved in the food production chain. Key organizations and the Thai government have approved of a number of laws and regulations on food safety and food security, and these are enforced by various agencies and ministries (Tables 1 and 2).

Various ministries, including the Ministry of Public Health (MOPH), the Ministry of Agriculture and Cooperatives (MOAC), the Ministry of Industry (MOI), and the Ministry of Commerce (MOC), are working together to create procedures for management of food safety and food security in Thailand. The MOPH and MOAC are the two main ministries responsible for implementing various systems for management of food safety and food security. These systems include Hazard Analysis Critical Control Points (HACCP) and their prerequisite programs: Good Manufacturing Practice (GMP), Good Hygienic Practice (GHP), and Good Agricultural Practice (GAP). At the farm level, these systems are controlled by MOAC, the Department of Agriculture (DOA), the Department of Fisheries (DOF), and the Department of Livestock Development (DOL). At the food import and processing level, legal food control operations are managed by the Thai Food and Drug Administration (FDA) and the Provincial Public Health Offices of MOPH, with the support of the food analytical services of the Department of Medical Sciences (DOMs) and accredited laboratories. Another organization, the Department of Health

Table 1. Laws and regulations on systems for management of food safety and food security in Thailand

Agencies and Ministries	Responsibilities	Food Laws or Food Regulations
Ministry of Public Health (MOPH): Food and Drug Administration (FDA) -Food Control Division -Import and Export Inspection Division	1. Control of food products: -Imported food products -Processed food products -Distribution 2. Domestic consumption 3. Certificate of Free Sale	Mandatory Regulation -Food Act B.E. 2522 (1979)*
Ministry of Agriculture and Cooperatives (MOAC): -Dept. Fisheries -Dept. Livestock -Dept. Agriculture -National Bureau of Agricultural Commodity and Food Standards (ACFS)	1. Control of agricultural products: Exported food products 2. Health certification of raw materials and processed food 3. Being a focal point of CODEX, OIE, IPPC and TBT-SPS	Voluntary Regulation -Agricultural Standards Act B.E. 2551 (2008)** -Plant Variety Protection Act B.E. 2542 (1999)* -Fisheries Act B.E. 2490 (1947)* -Ministerial Regulation Regarding Importation From and Transit Through the Kingdom of Thailand of Animal Carcasses B.E. 2544 (2001)* -Hazardous Substances Act (concerning pesticides for agriculture) B.E. 2535 (1992)* -Feed Quality Control Act B.E. 2542 (1999) *
Ministry of Industry (MOI): Thai Industrial Standard Institute (TISI)		Voluntary Regulation -Industrial Product Standard Act B.E. 2511 (1968)*
Ministry of Commerce (MOC):		Voluntary Regulation -Controlling Importation and Exportation Goods Act. B.E. 2522 (1979)*

* Source: Modified from FAO corporate document repository (2004).

** Source: Agricultural Standard Act B.E. 2551 (2008).

(DOH), works cooperatively with the Bangkok Metropolitan Administration (BMA) at the food-distribution level (fresh markets, supermarkets, street vendors and restaurants) to strictly control food safety and operations in order to promote quality, hygiene and safety of food in Thailand

Food safety management systems in Thailand have recently been strengthened. On July 24, 2001, the Thai FDA issued GMP regulations for 54 types of food. Despite assistance from the Thai government, including low-interest loans and free consul-

tations, implementation of GMP was still not completed nationwide during its early stages. The Thai FDA is attempting to overcome such obstacles and is planning to extensively implement GMP regulation for all food sectors in the near future. The Thai FDA is also now considering issuing HACCP regulations for frozen food industries in Thailand. Most large processors of export food in Thailand do not oppose the implementation of such food-safety management systems. In March of 2004, before the Agriculture Standard Act B.E. 2551

Table 2. Key elements of food-safety and food-security plans

Sector	Agencies	Food Safety Responsibilities
Legislation	-FDA (MOPH) -ACFS (MOAC) -TISI (MOI)	Develop food laws and regulations (Table 1)
Laboratories	-Dept. of Medical Science (MOPH) -TISI (MOI) -Dept. Scientific Service (Ministry of Science and Technology; MOST) -National Food Institute (MOI)	Provide analytical services and laboratory accreditation
Monitoring and surveillance	-FDA (MOPH) -Dept. Health (MOAC) -Dept. Fisheries (MOAC) -Dept. Agriculture (MOAC) -Dept. Livestock (MOAC) -TISI (MOI)	Conduct monitoring, sampling, inspection, investigation and surveillance
Implementation of food safety and security systems	-FDA (MOPH) -ACFS (MOAC)	Register premises and products, implement GAP, GHP, GMP and HACCP
Food inspection and certification	-FDA (MOPH) -ACFS (MOAC) -Dept. Health (MOAC)	Establish an accrediting body, certifying bodies, and a certification system
Education and training	-FDA (MOPH) -ACFS (MOAC) -Dept. Health (MOAC)	Conduct training, build materials capacity
Information sharing	-FDA (MOPH) -ACFS (MOAC)	Establish a food-safety network and a rapid-alert system
Research and Development	-National Food Institute (MOI), -Institute of Nutrition, Mahidol University, -Institute of Food Products Research and Development (IFRPD), Kasetsart University, -Dept. Health (MOAC) -Thailand's National Research Universities	Conduct research on risk analysis and product safety, develop biotechnology for sustainable food
International participation	-ACFS (MOAC) -TISI (MOI) -FDA (MOPH)	Be a contact point for Codex, ASEAN and ISO, and be an enquiry point for SPS
Consumer participation in food safety and food security	-FDA (MOPH)	Promote consumer awareness/perception and consumer potential, conduct public-relations campaigns and activities to promote food safety
Food Safety and security management System	Cooperation among the relevant 14 Ministries and 4 Councils/Committees	Set up compliance policies; administer warnings, prosecution, punishment and fines

Source: Thailand Country Food Safety Framework Profile -Country Overview (2009).

(2008) was promulgated, the “Road Map of Food Safety” was implemented as a framework for the control of safety of food and agricultural products at the operational level throughout the food chain, from primary food production to the processing, distribution and consumption of food (Srithamma *et al.*, 2005, Roitner-Schobesberger *et al.*, 2008). This framework defines distinct roles and responsibilities for each food-control organization through reorganization of the food-control system in Thailand. The framework thus mitigates lack of coordination, duplication of regulatory activity, and redundant actions by food-control authorities involved in policies and monitoring. Use of this framework is expected to protect consumer health from unsafe food and agricultural products. In

addition, a new governmental unit, the National Bureau of Agricultural Commodity and Food Standards (ACFS), has been established in the MOAC. The ACFS is responsible for coordination of collaboration among authorities who are responsible for standards of agricultural commodities and food. The roles of the ACFS have been demonstrated to improve standardization in Thailand and harmonize national standards and regulations with international standards (FAO Corporate Document Repository, 2004). In 2008, the MOAC issued the Agricultural Standards Act B.E. 2551 (2008), built on the four strategies of food safety, food security, food quality and food education, in order to ensure the food security of agricultural and food products (Fig. 2.).

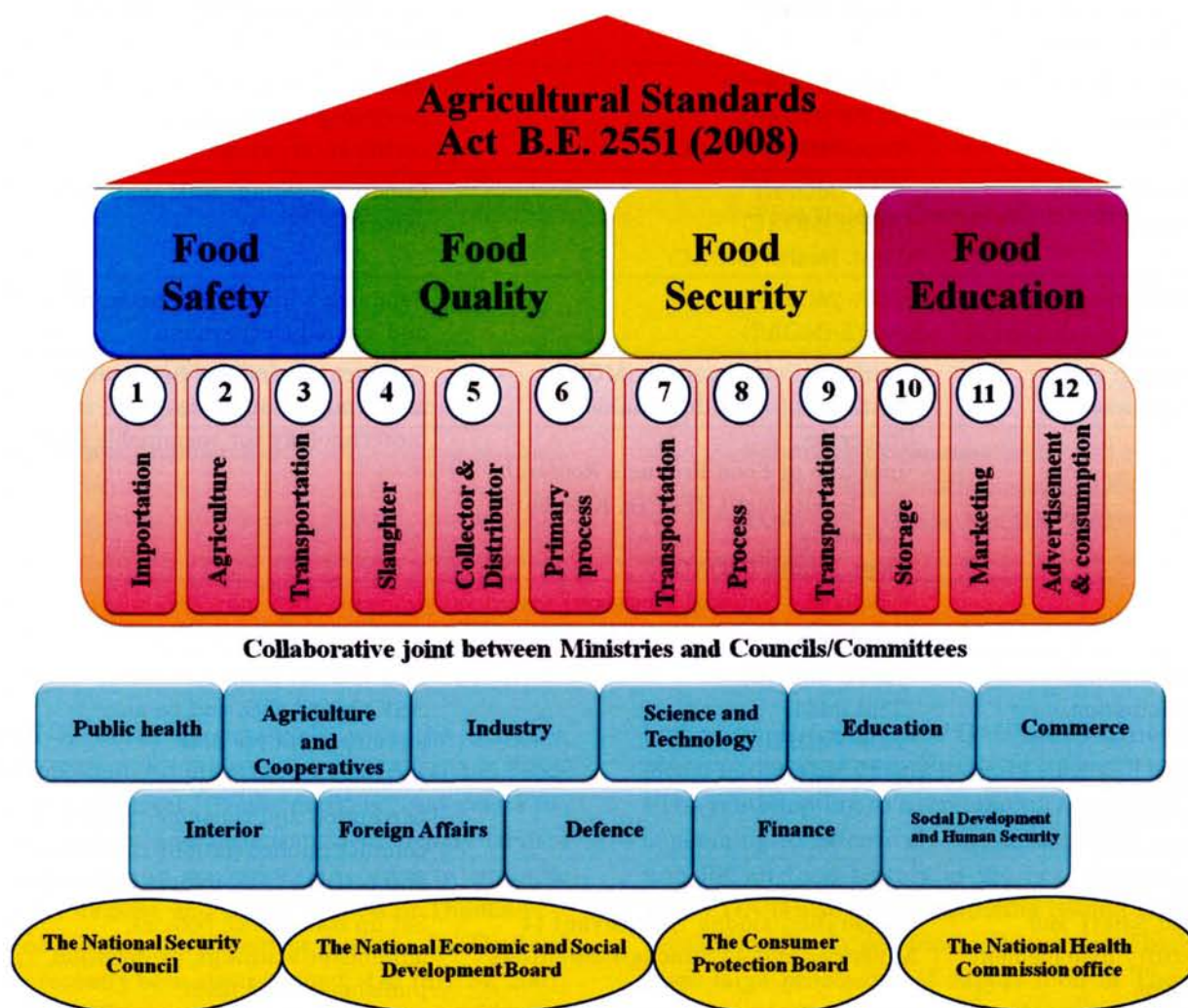


Fig. 2. Structure of the Agricultural Standards Act B.E. 2551.

Source: Modified from Agricultural Standards Act B.E. 2551 (2008).

This year, the Thai government is reviving the Thai Food-to-the-World Project in order to maintain Thailand's image as the "kitchen of the world." This revival is being implemented by the upgrading of Thai food production standards, the building of recognition of Thailand as a leading food exporter, and the increasing of the competition edge of Thai food industry by the creation of a database that links production to research, innovation and technology (SMEs Today, 2009).

In addition, a joint meeting of the 14th Summit of Association of South East Asian Nations (ASEAN) Member States was held in Thailand in March of 2009, and a meeting of the ASEAN Plus Three countries group on East Asian food security was held in Japan in July of the same year. In these meetings, participating countries agreed to adopt the ASEAN Integrated Food Security (AIFS) Framework and the Strategic Plan of Action on Food Security in the ASEAN Region (SPA-FS) in order to develop regional cooperation in food security (Statement on Food Security in the Asian Region, 2009; NEAT Working Group on East Asian Food Security, 2009).

3. Current Research and Development of Food Safety and Food Security in Thailand

Research and development (R&D) is fundamental to solving many "food-safety and food-security problems" in most countries. In Thailand, R&D related to food safety and food security is crucial in order to meet international standard requirements, remain competitive, and maintain a leading world position in the production and export of agricultural food products. The Thai government needs to provide sufficient grants to support private and public researchers in the various goals that R&D has focused on. These goals include finding ways to improve food safety by controlling food hazards and food defenses; increasing sufficient, safe and nutritious agricultural and food production by using new technology; developing a sustainable, bio-based agro-economy; promoting natural alternatives and organic production (Tanticharoen, 2004; International Association for Cereal Science and Technology, 2009); and training and communicating with consumers and stakeholders (Fig. 3).

3.1 R&D Projects on Systems for Control of Food Safety and Food Security

The evolution of the system for control of food safety in Thailand has shifted from hazard-based to risk-based decision-making and from "in-chain" to "end-of-chain" quantitative guidance (Food Control in Thailand, 2006; Srikaeo, 2009).

Research projects on risk assessment in Thailand, such as "Study of food safety system project" are focused on food safety status of various foods, risk assessment and risk management on hazardous food contamination from environment and the use of pesticides, veterinary drugs, additives and ingredients, as well as setting network research and food safety management (Center for System Research in Food Safety and Nutrition, 2009). Research efforts currently focus on evaluation of molecular methods such as Polymerase Chain Reaction: PCR techniques to detect and identify bacterial pathogens (*Salmonella* sp., *Listeria monocytogenes*, and *Escherichia coli* O157: H7, etc.) in a variety of food products and in the application of quantitative microbial risk assessment in the evaluation of food borne microbiological hazards (Saiyudthong and Trevanich, 2008; Trevanich *et al.*, 2010; Mahakarnchanakul *et al.*, 2010).

Additional research efforts include the development of effective hazard-reduction methods, sensors that provide information about packaging, predictive models for growth and inactivation of pathogenic bacteria and some spoilage microorganisms in food, and rapid monitoring techniques for controlling, preventing and identifying the sources of food hazards throughout the food chain (Bunditamorn and Trevanich, 2008; Suppadit and Trevanich, 2008; Srikaeo, 2009). Moreover, new challenge methods have studies for improved health benefits, preservation and safeguarding of food; for examples; use of natural phytochemicals in Thai herb as antimicrobial preservative in storage of food product and food packaging films and coatings, and use of selected starter culture in fermented products. In addition, the government has provided comprehensive programs to train and upgrade the expertise and skills of food inspectors (FAO Corporate Document Repository, 2004; Tongson *et al.*, 2005; Sribuathong and Trevanich, 2008; Nopwinyuwong *et al.*, 2010).

In order to support main domestic agri-food

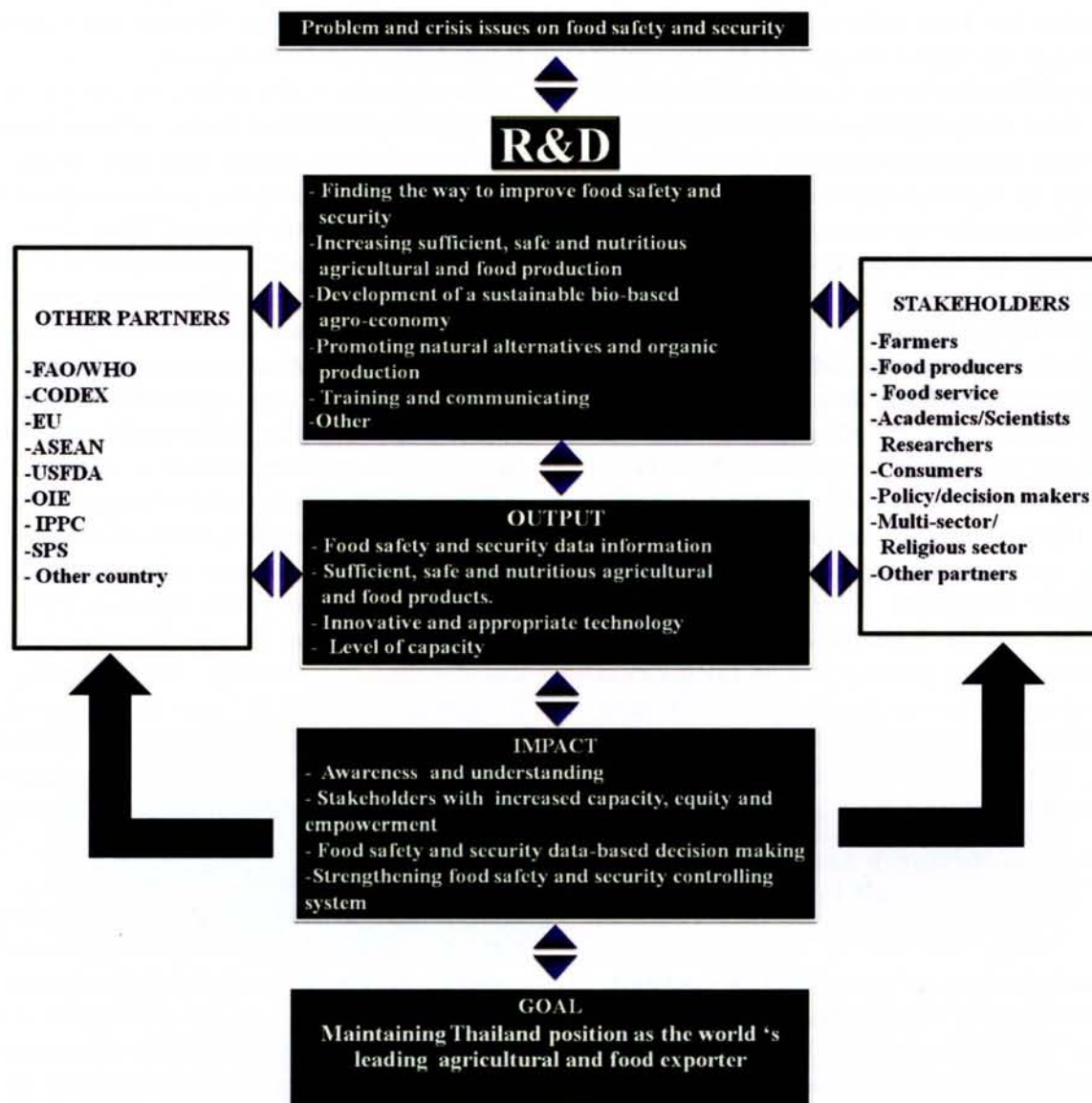


Fig. 3. Research and development framework for food safety and security.

businesses (small and medium enterprises, or SMEs), training and education programs related to food safety have been provided for food-safety personnel in the food industry. The Pre-HACCP program has been developed to prepare food producers and food employees and develop the potential of entrepreneurs in SMEs in order to improve future food safety assurance systems, including GMP and HACCP. This program has also provided training for trainers so they can become professional academicians and consultants. The Pre-HACCP was funded by the National Food Institute and conducted by collaboration between Kasetsart Univer-

sity and other academic institutes during fiscal the year 2007-2008. The project consisted of two main activities. The first activity included training and a workshop course on food-safety management. The second activity was an on-site consultation program directed by food safety experts. These activities were implemented to train personnel in SME food industries to prepare GMP, Standard Operating Procedures and Sanitation Standard Operating Procedures documents and encourage them to practically implement these documents in their food-processing operations. Finally, the SME food industries that meet the requirements of the Pre-

HACCP guidance will receive the symbol “Pre-HACCP” (Mahakarnchanakul *et al.*, 2009).

3.2 R&D Projects on Systems for Control of Food Security

R&D on Thailand’s food security has focused on applications of biotechnology development and have sought solutions to various practical problems. Plant transformation is a feature application of molecular biology and genetic engineering that promotes production of transgenic plants with superior properties, including resistance to diseases, insect pests and abiotic stress, and promotes improvement of functional and nutraceutical properties (Tanticharoen, 2004; IPM-DANIDA, 2004). For example, a transgenic tomato plant has been developed to control a serious viral diseases of tomato, and a transgenic rice plant with higher content of a desirable aromatic compound has been patented (Vanavichit *et al.*, 2008).

The Royal Development Projects have emphasized the application of sustainable development based on a framework by Royal King Bhumipol to make Thailand self-sufficient. This “King’s New Theory” has been implemented through an integrated farming pattern by appropriately dividing land into four parts, which are a water source, an integrated farm, a rice field and a residential area. These four parts are based on the ratio of 30: 30: 30: 10. (Office of the Royal Development Projects Board; 2004). In addition, Royal development and usage of the Vetiver grass project, the Tung Kula Rong Hai Development Project, land-use planning for watershed management projects, soil and water conservation projects, etc., were launched to demonstrate agricultural techniques and provide information for land users and farmers in order to maintain food production levels and land resources (Kachondham and Viravathana, 2005; National Sustainable Development Strategy, 2006).

4. Joint Collaboration among Multi-Sector Partners and Other Partners on Food Safety and Food Security in Thailand

R&D projects in Thailand are promoted to encourage close collaboration and create a network among the public and private sectors and civil society to address challenges related to food safety

and food security. In order to improve food safety and food security, exchange technology and information, and provide support, international aid is being provided to Thailand, its partners (such as CODEX, ASEAN, World Health Organization (WHO), and other parts of the United Nations (UN)).

Together with other research institutes and universities in Thailand, the Knowledge Network Institute of Thailand (KNIT) launched collaborations among multi-institutional research projects on food safety, such as the Food-Safety System Study of Thailand and the Joint Center for Nutrition and Food Safety. The purpose of these projects is to study systems for risk assessment, risk management, monitoring, and traceability of meat, seafood, dairy products, cereal, fruit, vegetables, and their products, as well as street food (FSN Center KNIT, 2009).

In addition, Thailand formed collaborations among other organizations to implement food-security projects such as the AIFS Framework, the ASEAN Food Security Information System (AFSIS), the ASEAN Plus Three Emergency Rice Reserve (APTERR), and the East Asia Emergency Rice Reserve (EAERR). The purpose of these projects is to share experiences and best practices, support development of agricultural productivity (through greater investment, improved research and development, enhanced agricultural innovation, and knowledge management), and strengthen farmer organizations (ASEAN Food Security Information System (AFSIS), 2009., NEAT Working Group on East Asian Food Security, 2009; Statement on Food Security in the Asian Region, 2009).

5. Education and Communication about Food Safety and Food Security in Thailand

Education and communication about food safety and food security are gateways for sharing information through various media such as television, radio, websites, pamphlets, newspapers, and message alerts. The Thai government realizes the importance of effective communication (Takeuchi and Boonprab, 2006). Interactive websites related to education and communication about food safety and food security have been launched. These websites include those of the Center for System

Research in Food Safety and Nutrition (FSN), the Food Alert System of Thailand (FAST), and AFSIS. Various media are provided with food-safety and food-security information, such as news updates about development research and data, food strategies and policies, food standards and regulations, training, e-learning, food alerts and recalls, malnutrition preventive measures, and ways to promote consumption of nutritious food. This information enhances awareness among consumers and food processors, increases capacity, equity and empowerment of stakeholders to development, enables support of government planning and policy decision-making, and strengthens systems for controlling food safety and food security (Fig. 3).

6. The Key to Success in R&D of Food Safety and Food Security in Thailand: Improvement of Capacity-Building, Human Resources and Laboratory Performance

The Thai government has developed the capacity of R&D by supplying laboratories with funded programs, high-performance instruments and the necessary equipment and facilities. In 2009, the government established Thailand's National Research Universities and initiated research promotion in higher-education projects to deliver world-class research performance and to respond to government policies for excellent economic development and solving of the country's problems. This project has received a budget of approximately 9,000 million baht to support the National Research University and approximately 3,000 million baht to promote research activities at the university level (Office of the Higher Education Commission, 2009).

7. Conclusion

Various agencies share responsibility for the system of managing food safety and food security. To achieve the goal of being "kitchen of the world" by sufficiently producing safe and nutritious agricultural and food products, R&D will become a key source of public information about new technology, food safety, food security, and will promote dissemination of such information to all stakeholders. This promulgation of information promotes awareness about food safety and food security, increases

capacity, equity and empowerment of all stakeholders, promotes the framing of policies, and empowers systems for controlling food safety and food security.

Acknowledgements

The authors thank the Agricultural and Forestry Research Center, Japan, for its financial support. The authors are also grateful to the Department of Food Science and Technology, Faculty of Agro-Industry, Kasetsart University for providing technical knowledge, and to the Graduate School of Kasetsart University, Thailand for its useful comments. Any opinions, findings, conclusions and errors expressed in this material are those of the authors and do not necessarily reflect the views of the supporting organizations.

References

- Agricultural Standards Act B.E., 2551, 2008. National Bureau of Agricultural Commodity and Food Standards, Ministry of Agriculture and Cooperatives. http://www.acfs.go.th/eng/agri_std.php; retrieved September 12, 2009.
- ASEAN Food Security Information System (AFSIS), 2009. <http://afsis.oae.go.th/>, retrieved October 1, 2009.
- Bumatay, E.L., Sulabo, E.C. and Regalado, J., 2008. Perspectives of ASEAN students on food safety in the 21st century. *USM R & D*. 16 (2), 13–24.
- Bunditarnorn, D. and S. Trevanich, 2008. Use of simple micro-titer plate assay for assessment of biofilm-forming bacteria in high risk area of frozen seafood plant. *International Conference Investing in Food Quality, Safety and Nutrition: Lessons learned from current food crisis*, Jakarta, Indonesia.
- Center for System Research in Food Safety and Nutrition, 2009. <http://www.knit.or.th/foodsafety/index.html>; retrieved October 2, 2009. (In Thai)
- FAO Corporate Document Repository, 2004. Strengthening official food safety control services: Second FAO/WHO global forum of food safety regulators, Bangkok, Thailand, 12–14 October 2004. <http://www.fao.org/docrep/meeting/008/ae183e/ae183e00.htm>; retrieved September 5, 2009.
- Food Control in Thailand, 2006. http://www.fda.moph.go.th/eng/eng_food/foodcontrol.htm; retrieved September 5, 2009.
- FSN Center KNIT: Center for System Research in Food Safety and Nutrition, KnowledgeNetwork Institute of Thailand, 2009. Food safety network. <http://www.knit.or.th/foodsafety/docs/2.%20Food%20safety%20network.pdf>; retrieved September 10, 2009.
- Inside Thailand, 2009. Thailand striving to boost food security and safety. <http://thailand.prd.go.th/print.php?id=4387&type=inside>; retrieved September 9, 2009.

- International Association for Cereal Science and Technology, 2009. Food security - critical research and development project needs for a safe, sustainable and sufficient food and feed supply with focus on cereal grains, crops, and plant based foods & feed expert summit, Vienna, Austria.
- IPM-DANIDA, 2004. Pesticides-health surveys. Data of 606 farmers in Thailand. Report62 by the IPM DANIDA project: "Strengthening farmers' IPM in pesticide intensive areas. [http://thailand.ipm-info.org/documents/Health_data_606_\(English\).pdf](http://thailand.ipm-info.org/documents/Health_data_606_(English).pdf); retrieved November 29, 2009.
- Kachondham Y. and Viravathana, N., 2005. Food security in Thailand. In: V. S. Vyas (Ed.), Food security in Asian countries in the context of millennium goals. 1st Academic foundation, Published jointly by Academic foundation, New Delhi and the Asian Development Research Forum (ADRF) and The Thailand Research Fund (TRF), Bangkok, Thailand in cooperation with the International Development Research Centre (IDRC), Canada.
- Mahakarnchanakul, W., Varunyanond, W., Vibulsresth, P., Hiraga, C., Wongkhalaung, Stonsaovapak, S., Boonyaratanakornkit, M., Yunchalad, M. and Trevanich, S., 2009. The enhancing of food safety management system for SME food industry in Thailand through "Pre-HACCP". PACCON 2009 Abstracts (Pure and applied chemistry international conference). 34.
- Mahakarnchanakul, W., W. Ountoum, S. Stonsaovapak, N. Pirapatrungsuriya, P. Choo-in and T. Borisuit, 2010. Risk evaluation of popular ready-to-eat food sold in Bangkok. Asian J. Food & Agro-Industry 3 (1).
- National Sustainable Development Strategy, 2006. Report of the Inception Workshop on National Sustainable Development Strategy (NSDS) for Thailand. Bangkok, Thailand. <http://www.rrcap.unep.org/nsds/uploaded/files/file/gms/th/report/NSDS-TH-Meeting%20Report.pdf>; retrieved September 10, 2009.
- NEAT Working Group on East Asian Food Security, 2009. http://www.ceac.jp/e/pdf/neat_07wg01.pdf; retrieved September 7, 2009.
- Nopwinyuwong, A., S. Trevanich, P. Suppakul, 2010. Development of a novel colorimetric indicator label for monitoring freshness of intermediate-moisture dessert spoilage. Talanta.
- Office of the Higher Education Commission, 2009. Thailand's national research universities. <http://www.scribd.com/doc/20616709/Thailand-Research-University->; retrieved September 5, 2009. (In Thai)
- Office of the Royal Development Projects Board; 2004. The Royal Development Study Centres and the Philosophy of Sufficiency Economy for the Ministerial Conference on Alternative Development: Sufficiency Economy. <http://www.sufficiencyeconomy.org/old/en/files/14.pdf>; retrieved November 17, 2009.
- Vanavichit, A., Tragoonrung, S., Toojinda, T., Wanchana, S. and Kamolsukyunyong, W; National Science & Technology Development Agency. Transgenic rice plants with reduced expression of Os2AP and elevated levels of 2-acetyl-1-pyrroline. US Patent 7,319,181 B2, 2008. January 15, 2008.
- RNCOS, 2009. Thailand food export to touch 750 billion baht mark next year. <http://www.rncos.com/Blog/2009/09/Thailand-Food-Export-to-Touch-750-Billion-Baht-Mark-Next-Year.html>; retrieved September 12, 2009.
- Roitner-Schobesberger, B., Darnhofer, I., Somsook, S., Vogl, C.R., 2008. Consumer perceptions of organic foods in Bangkok, Thailand. Food Policy. 33, 112-121.
- Saiyudthong, S., S. Trevanich, 2008. Effect of various stresses on efficiency of RAPD-PCR for specific detection of antimicrobial drug-resistant *Salmonella* Enteritidis. Programme and Abstract Book, The 21st International ICFMH Symposium, Evolving Microbial Food Quality and Safety, Aberdeen, Scotland. - Aberdeen: IUMS - ICFMH, The 21st International ICFMH Symposium "Evolving microbial food quality and safety", 2008-09-01/ 2008-09-04.
- SMEs Today, 2009. Thai taste-global taste. <http://www.sme.go.th/files/sme-today-book/2552/mar2552/70-73-Thaitaste-Globaltaste.pdf>; retrieved September 5, 2009. (In Thai)
- Sribuathong, S. and Trevanich, S., 2008. Potential use of *Leuconostoc lactis* isolated from fermented broken rice as a single starter culture for small-scale production of Thai fermented rice noodle. Programme and Abstract Book, The 21st International ICFMH Symposium, Evolving Microbial Food Quality and Safety, Aberdeen, Scotland. - Aberdeen: IUMS - ICFMH, The 21st International ICFMH Symposium "Evolving microbial food quality and safety", 2008-09-01/ 2008-09-04.
- Srikaeo, K., 2009. Risk based food safety management: a new approach for Thai food industries. PACCON 2009 Abstracts (Pure and Applied Chemistry International Conference). 34.
- Srithamma, S., Vithayarungruangsri, J. and Posayanonda, T., 2005. Food safety programme: a key component for health promotion. <http://www.fda.moph.go.th/project/foodsafety/HealthPromotion2.pdf>; retrieved September 7, 2009.
- Statement on Food Security in the ASEAN Region, 2009. <http://www.mfa.go.th/web/35.php?id=21940>; retrieved September 7, 2009.
- Suppadit, P. and Trevanich, S., 2008. Isolation and identification of Coliforms and *Escherichia coli* in frozen ready to eat food under long term storage. International Conference Investing in Food Quality, Safety and Nutrition: Lessons learned from current food crisis, Jakarta, Indonesia.
- Takeuchi, M.T. and Boonprab, K., 2006. Food safety situations in Thailand with regard to their Thai's food safety knowledge and behaviors. Kasetsart J. (Nat. Sci.). 40, 222-228.
- Tanticharoen, M., 2004. Research and development on agricultural biotechnology in Thailand. National Center for Genetic Engineering and Biotechnology, National Science and Technology Development Agency, Bang-

- kok Thailand. http://home.biotec.or.th/newscenter/Uploads/WE_pic/radC261F.pdf; retrieved September 5, 2009.
- Thailand Country Food Safety Framework Profile - Country Overview, 2009. <http://aadcp.aseanfoodsafety.net/Portals/0/Documents/Thailand%20Country%20FS%20Framework21.pdf>; retrieved October 2, 2009.
- Thongson, C., Davidson, P.M., Mahakarnchanakul, W. and Vibulsresth, P., 2005. Antimicrobial effect of thai spices against *Listeria monocytogenes* and *Salmonella* Typhimurium DT104. *J. Food Protect.* 68 (10), 2054–2058.
- Treanich, S., Tiyapongpattana, S. and Miyamoto, T., 2010. Application of an optimized 18-h method involving one step culturing and single primer-based PCR assay for detection of *Salmonella* spp. in foods. *Food Control* 21, 593–598.