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Workshop on Improving Safety of Fresh Fruit & Vegetables in Southeast Asia

November 24-28, 2014
Santa Rosa City, Laguna, Philippines

WORKSHOP REFERENCE MATERIALS





This publication includes papers prepared for presentation at the workshop subjected under FFTC's publication guidelines and miscellaneous information regarding the workshop such as the program, list of participants, and background notes.

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The Organizers

Food and Fertilizer Technology Center (FFTC) for the Asian and Pacific Region

The Food and Fertilizer Technology Center (FFTC) was established in 1970 to act as a clearing house for the research carried out in the Asia-Pacific Region and to help bring the results to extension workers and farmers. The creation of the Center was in response to severe periodic shortages of both food and fertilizer in the 1970s. It was apparent at that time that lack of technical information among farmers was the basis of the problem, compounded by an inadequate fertilizer supply and a shortage of improved seeds. The underlying motive for the creation of the Center was the concern about food shortages in the densely populated Asian countries.

For the past 44 years, FFTC has played an immensely important and productive role in collecting, exchanging, and disseminating information and technologies on a very wide range of modern agriculture and agriculture-related topics, covering the full spectrum of small farm needs and activities relevant to the Asia-Pacific Region. This integrated technology approach is what makes FFTC a unique international center. While most agricultural research centers are specialized and study a single crop or a single agro-ecological zone, FFTC offers practical technologies that are matched to the reality of the region's small-scale farmers whose farm incomes are determined by total farm production.

By far, one of FFTC's most significant milestones, and for which it is now widely recognized, is laying the foundation for an established mechanism for technology transfer within the region. Through its various activities like seminars, training courses and workshops, thousands of scientists, administrators, policymakers, and extension workers not only had the chance to learn about the latest developments in the field of agriculture, but equally important, they had the opportunity to learn from their more advanced neighbors and to meet experts from other countries.

Through its various activities, FFTC has accumulated a huge body of knowledge and information on agriculture made possible through the works of hundreds of people from member-countries and partner-institutions. Disseminated through publications, training courses and demonstration projects, and through its website and database, these knowledge and information have given countless resources-poor farmers and extension specialists, in the region, new opportunities and new solutions to their problems.

Opening Remarks

Dr. Takashi Nagai
Deputy Director, FFTC

Dr. Patricio Faylon, Executive Director of PCAARRD, Dr. Leah Buendia, Director of Policy Coordination and Monitoring Division, officers and staff of PCAARRD, Dr. George Kuo, FFTC consultant and my colleague in the Center, seminar participants from various countries of Asia and the Pacific, colleagues, friends, ladies and gentlemen, a pleasant good morning to all of you.

Perhaps among the many international seminars and workshops which FFTC has conducted for this year, this seminar on “Improving Safety of Fresh Fruit and Vegetables in Southeast Asia” ranks as one of the most practical and relevant meetings we have had. Why did I say that? This is because food safety in fresh fruit and vegetables is now one of the most talked about issues of our time, especially in the light of outbreaks of foodborne illnesses in various parts of the world. The *E.coli* in lettuce, *Salmonella* in cantaloupe, *Cyclopora* in berries, microbial hazards in packing veggies and countless other incidents all pose dangerous threats to human health, making food safety a serious issue in our region’s agriculture.

Experts have said time and again that failure to protect the safety of food leads to a decline in consumer confidence in the safety of many food products as it also threatens the economic vitality of agriculture industries. This has now become a serious concern for both the government and agriculture industries as the fresh food market faces the biggest challenge in the area of food safety from pre to post harvest. Countries need to define priorities and goals towards ensuring that our agri produce are not only safe and fresh, but have also passed international food safety standards. They’re also supposed to be traceable and packaged well.

FFTC and PCAARRD have gathered the experts in this field to help fulfill the objective of this seminar to provide a venue for sharing experiences, including policies, regulatory frameworks, and monitoring and evaluation strategies on food safety and implementation of quality assurance mechanisms in the fresh agri products industry.

On behalf of Director Huang and the staff and management of FFTC, I would therefore like to formally open this international seminar and welcome all of you. I’d also like to thank our FFTC consultant and colleague, Dr. George Kuo,for organizing this seminar, and our partners in PCAARRD, headed by Dr. Leah Buendia, for their support and cooperation in mounting this event. Let’s give them a big round of applause.

I wish you all a fruitful, productive and successful seminar, and may we all enjoy the warm hospitality of our Filipino hosts.

Thank you very much and have a wonderful day!

Philippine Council for Agriculture, Aquatic and Natural Resources Research and Development (PCAARRD)

PCAARRD is one of the sectoral councils under the Department of Science and Technology (DOST). PCAARRD was established on June 22, 2011 through the consolidation of the Philippine Council for Agriculture, Forestry and Natural Resources Research and Development (PCARRD) and the Philippine Council for Aquatic and Marine Research and Development (PCAMRD).

The Council formulates policies, plans, and programs for science and technology-based research and development (R&D) in the different sectors under its concern. It coordinates, evaluates, and monitors the national R&D efforts in the agriculture, aquatic, and natural resources (AANR) sectors. It also allocates government and external funds for R&D and generates resources to support its program.

PCAARRD is engaged in active partnerships with international, regional, and national organizations and funding institutions for joint R&D, human resource development and training, technical assistance, and exchange of scientists, information and technologies.

It also supports the National Agriculture, Aquatic and Resources Research and Development Network (NAARRDN) composed of national multi- and single-commodity and regional R&D centers, cooperating stations, and specialized agencies.

As such, PCAARRD has been a potent arm in catalyzing the Philippine AANR sectors toward self-sufficiency and global competitiveness.

Welcome Remarks

Dr. Patricio S. Faylon
Executive Director, PCAARRD

Good morning to all guests and participants. I am honored to welcome you to this international workshop on "Improving Safety of Fresh Fruit and Vegetables in Southeast Asia," with eight country-participants attending the workshop.

For more than four decades, FFTC has played an important role in collecting, exchanging, and disseminating information that cover modern agriculture and agriculture-related topics which also address small farm needs and activities relevant to the Asian and Pacific region. PCAARRD, as a DOST Council with banner programs on strategic research and technology transfer, looks up to FFTC's mechanism of collecting, exchanging, and disseminating S&T information on improved and advanced technology which requires a systematic institutional cooperation and complementation among the ASPAC countries.

I would like to acknowledge the efforts of the FFTC for its continuous promotion of technologies and innovations which greatly benefit scientists, administrators, policymakers and extension workers. We are given a chance to learn about the latest developments in fruit and vegetables, and in the field of agriculture, the opportunity to learn from our experts from Asian countries, and at the same time, for everyone to share their own experiences and expertise.

We are all gathered here today because we share the same goal of improving the state of livelihood of our small-scale farmers on fruit and vegetables. The rapid industrialization and urbanization have resulted to increase in the consumer demand for fresh fruit and vegetables. On the other hand, the production and marketing of fruit and vegetables for domestic and export markets is a significant source of income for small-scale farmers in Southeast Asian countries, as well as one of the largest sources of employment in the rural areas.

The fruit and vegetables industry comes with risks, specifically in food safety for the consumers. The risks include harmful chemical residues and dangerous biological and chemical contaminants during handling, transportation, storage, and retailing.

The fruit and vegetables industry in developing countries has a growing export market. But these markets impose high and stringent safety standards which may also require high cost for the farmers. It is a challenge to the S&T community to convince farmers and producers to meet such standards.

This workshop will provide a venue for exchanging up-to-date and practical information about the safe production, handling, storage, and transport of fresh fruit and vegetables for contributing towards the formulation of harmonized food safety guidelines in Southeast Asia. I also hope that in this activity, we'll be able to come up with recommendations for the "ASEAN 2015: Strengthening the Regional Food Safety".

PCAARRD has come up with various industry strategic S&T programs or the ISPs which define the targets for each industry and pinpoint the aspects of the industry where S&T will make a difference. These ISPs include programs on vegetables that seek to increase yield of conventional and organic vegetables while reducing postharvest losses. This will enhance availability of high-quality and safe vegetables. We hope we can share our experiences on these programs with all of you, and in turn, receive some information on how we can continuously improve these initiatives.

With the leadership of FFTC and with the inventive minds of our presenters today, I know that all of us participating in this workshop are prepared to open up to new practices. The experts from the Asia Pacific Region are here to help us explore technologies and innovative ways to promote the safety standards to our farmers and improve the fruit and vegetable industry in the Region. Again, welcome and thank you all for coming. May we all have a fruitful workshop ahead of us.

Background of the Workshop

Among many countries in Southeast Asia, the production and marketing of fruit and vegetables for domestic and export markets is a significant source of income for small-scale farmers, as well as one of the largest sources of employment in the rural area. On the other hand, rapid industrialization and urbanization with increasing wealth have created increasing demands for fresh fruit and vegetable productswhich greatly render health benefits for the consumers. Nevertheless, potential risks of food safety in fresh fruit and vegetables could occur throughout the marketing chain. Imprudent applications of chemical fertilizers and pesticides on cropland during production may result in dangerous levels of chemical residues in fresh horticultural products. Also fresh fruit and vegetable products could be exposed to harmful biological or chemical contaminants during handling, transportation, storage and retailing. Thus, consumers are likely vulnerable to unsafe fresh horticultural productswhich may not be apparent in the appearance of the product. This applies both to consumers in producer households and to consumers purchasing from the market.

In recent years, exports of fresh fruit and vegetables to developed country markets have emerged as a potential major source of export growth for many developing countries. Exploiting this potential, however, poses many challenges. The capacity of exporting countries to enter these markets depends on their ability to meet stringent safety standards imposed by importing countries. Not only are these standards rigorous, but are also increasingly demanding. They now go well beyond traditional quality standards, as suppliers must pay close attention to the responsible use of agrochemicals, energy, water and waste. These standards are significantly higher than those prevailing in developing countries. And they are subject to frequent changes and are, ultimately, often difficult and costly to meet. Nonetheless, it is expected that improving the ability to meet food quality and safety standards for fresh fruit and vegetables will facilitate greater international market access, reduce the impact of price competition, stimulate investment and mitigate risk, leading to increased exports.

Food safety, as a hidden quality, is the responsibility of all actors in the whole food chain of fresh fruit and vegetables. Thus it is imperative to collaboratively work on a strategic framework for the prevention of harmful contamination from farm to plate that involves promotion and implementation of good practices and safety assurance systems throughout the agri-food chain based on Good Agricultural Practices (GAP), Good Manufacturing Practices (GMP), the Hazard Analysis and Critical Control Point (HACCP) System, the Quality and Safety Assurance System, and other efficient and appropriate notification systems for potential hazards. This workshop aims to exchange up-to-date and practical information about the safe production, handling, storage, and transport of fresh fruit and vegetables for contributing towards the formulation of harmonized food safety guidelines in Southeast Asia. Related to the latter, the ASEAN Economic Community Blueprint highlights food safety as a paramount concern in the agriculture sector (ASEAN Secretariat 2008), and envisions 2015 as the year of strengthening regional food safety system by the ASEAN Community.

Objectives of the Workshop

1. To share experiences on policy formulations, regulatory frameworks, monitoring systems, prevailing practices, and research and development to ensure safety of fresh fruit and vegetables

2. To formulate collaborative strategic directions to enhance harmonization of safety standards for fresh fruit and vegetables in Southeast Asia

Expected Outputs

1. Extension of promising strategic frameworks, field-tested technologies and monitoring systems related to enhanced food safety of fresh fruit and vegetables
2. Partnership contributing to the safety and competitiveness of fresh fruit and vegetables from Southeast Asia
3. Recommendations for "ASEAN 2015: Strengthening the Regional Food Safety"

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SESSION 1: COUNTRY REPORTS

REGIONAL COLLABORATION IN ENSURING FOOD SAFETY IN ASEAN FRUIT AND VEGETABLES

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ABSTRACT

In regional programs related to food safety, ASEAN member-states (AMS) apply the principles that underlie the SPS Agreement within the purview of the World Trade Organization (WTO). Food safety-related collaboration in the region, therefore, is guided by the risk analysis paradigm. Risk analysis ensures a science-based and transparent mechanism for managing the risks of food-borne diseases in a regime of globalized trade in food.

Cognizant of capacity-building needs in risk assessment which is requisite to the establishment of maximum residue levels (MRLs) for pesticides, for example, the ASEAN implemented the two-year project on "Strengthening ASEAN Risk Assessment Capability to Support Food Safety Measures Project" under the ASEAN-Australia Development Cooperation Program (AADCP). This project was supervised by the ASEAN Secretariat and the ASEAN Expert Group on Food Safety (AEGFS) of the Senior Officials Meeting on Health Development (SOMHD) in cooperation with ASEAN Food Safety Network (AFSN) of the Senior Officials Meeting of the ASEAN Ministers on Agriculture and Forestry (SOM-AMAF) and the ASEAN Subcommittee on Food Science and Technology (SCOST). Recently, the 9th ASEAN SOMHD established the ASEAN Risk Assessment Centre (ARAC) and tasked the ASEAN Experts Group on Food Safety (AEGFS) to develop operationalization procedures.

Risk management in fruit and vegetables in the ASEAN is guided by the document "ASEAN Common Principles for Food Control Systems", with requirements defined by the ASEAN Sectoral Working Group on Crops (ASWGC), working with the AEGFS, the Prepared Foodstuff Product Working Group (ACCSQ-PfPWG) of the ASEAN Consultative Committee on Standards and Quality (ACCSQ), the ASEAN Task Force on Codex (ATFC), the ASEAN Ad-hoc Working Group on Food Irradiation (AWGFI), and other specialized task forces.

The regional collaboration on ensuring the safety of fruit and vegetables alone involves the participation of a number of sectoral bodies, giving rise to the challenge of ensuring the iteration and interaction needed for deciding on the best risk management option. To ensure a cohesive approach in addressing issues in food safety on a regional basis, AFSN was established through a resolution of the 25th meeting of the AMAF in 2003. Serving as the repository of information on food safety programs, AFSN has risk communication as its principal function.

ASEAN has made significant headway in the area of food safety, but the region realizes the need for accelerating harmonization and ensuring technical equivalence in food safety measures. The region has identified the need for equity and inclusion as it moves towards the free movement of food in the region with the creation of the ASEAN

Economic Community.

POLICIES AND REGULATIONS ON GAP AND GHP IMPLEMENTATION FOR IMPROVING FRUIT AND VEGETABLES PRODUCT SAFETY IN INDONESIA

Yul Harry Bahar
Executive Secretary for Directorate General of Horticulture,
Ministry of Agriculture of the Republic of Indonesia,

ABSTRACT

Indonesia already has policies and regulations on Good Agriculture Practices (GAP) and Good Hygiene Practices (GHP) for improving fruit and vegetables safety. This paper describes, in detail, the various policies and regulations which have been implemented by the Indonesian government in relation to agricultural food safety. It also describes the implementation activities being done to fully sustain the said policies.

Keywords: Fruit and vegetables, food safety, GAP, GHP, sustainable agriculture

INTRODUCTION

Horticulture is one of the prominent and important natural resources which has many functions and offers different kinds of products. It has high diversity of crops and products which comprise of fruit, vegetables, medicinal crops, floriculture, various mushrooms, and aquatic plants in different specific molds. Horticulture can be utilized to support and generate many kinds of businesses as well as environmental and social activities for the improvement of human welfare and generate farmers'/growers' economic situation.

Since there are a lot of horticultural species, characteristics and varieties, therefore it can be used as direct food resource, raw materials for manufacture of food, medicinal and herbal crops, and aesthetic and ornamental crops. Below are the major various functions of horticulture:

1. Acts as a source of carbohydrates, proteins, fats, and fiber for food;
2. Acts as a main source of vitamins, minerals, enzymes, hormones, anti-oxidants, and a good source of specific natural active element for medicinal and human health;

3. Supports the protection and improvement of the environment and helps mitigate its harmful environmental impacts;
4. Supports the cultural and religious events and activities through its various important components; and
5. Improves the condition of living environment its aesthetics, freshness, and overall beauty.

Fruit and vegetables are the main group of horticulture which can be utilized as fresh products for consumption or as processed foods. About eight million of Indonesian farmers are related to the fruit and vegetables business, therefore the Ministry of Agriculture has been paying much attention in the development of these commodities. Many kinds of activities and facilities have been done for the development of the fruit and vegetable industry, such as provision of technical guidance on production development, improvement of management system, improvement of the seedling system and industries, pest and disease control, mitigation of environmental impacts, strengthening the farmer's institution, intensification of promotion and education, etc. Such fruit and vegetable development activities have been planned, managed, and directed through integrated, efficient, sustainable, and environmentally friendly approaches.

There are 60 kinds of fruit and 80 kinds of vegetables which are mandated by the Directorate General of Horticulture to be developed. However, only 26 kinds of fruit and 25 kinds of vegetables have been recorded for data compilation. Based on the 2013 data, fruit production was recorded at 18,288,279 tons, and harvesting area was 82,9563 ha. Meanwhile vegetable production was recorded at 11,558,449 tons, and harvesting area was 1,099,846 ha. On the average, during the last five years, fruit production and harvesting area increased by about 0.31% and 1.21%, respectively. Meanwhile, vegetable production and harvesting area increased to about 2.13% and 0.52%, respectively. In general, Table 1 summarizes the performance of fruit and vegetable production and harvesting areas over the last five years.

Table 1. Performance of fruit and vegetable production and harvesting areas

No	Group of Commodities	Years					Ave. Inc (%)
		2009	2010	2011	2012	2013	
	Harvesting area (ha)						
1	Fruit	626,430	667,872	822,604	819,049	829,563	1.21
2	Vegetables	1,078,159	1,110,586	1,080,243	1,089,409	1,099,846	0.52
	Production (ton)						
1	Fruit	18,663,900	15,490,373	18,313,507	18,916,731	18,288,279	0.31
2	Vegetables	10,628,285	10,706,366	10,871,224	11,263,972	11,558,449	2.13

MOA has decided that the implementation of GAP and GHP for fruit and vegetables are very much important in order to increase production and improve the quality and performance of the products. By implementation of GAP and GHP, the products can meet the market and consumption demand as well as meet the agreement with other countries (including AEC). The objectives of fruit and vegetable GAP-GHP implementation are:

1. Increase the production, productivity, and quality of the products as well as improve the competitiveness of horticultural products;
2. Improve the efficiency and optimum use of natural resources, including the implementation of sustainable agricultural development system;

3. Decrease production losses and increase product durability;
4. Provide good-quality food and improve product safety for consumers;
5. Improve the working safety and health of the farmers and workers

Aside from the reference to Horticulture Laws, the Ministry of Agriculture has formulated some policies, rules and regulations, and programs in order to lead and guide the GAP and the GHP implementation. Some activities related to fruit and vegetables GAP and GHP implementation have also been addressed to guide and assist the farmers, growers, businessmen working in horticulture, etc.

RULES AND REGULATIONS

Indonesia has already had the special law on horticulture development that is **Law No. 13 in 2010** concerning **Horticulture** (famous as **Horticulture Law**). This law is the fundamental regulation, and it should be used as basic reference in the formulation of policies, rules, programs and activities on horticultural development.

Some rules of horticultural development stated in these laws which are directed to GAP and GHP implementation for improving fruit and vegetable product safety, and directly linked to horticultural development are as follows:

1. Horticulture cluster development

Horticulture development should be carried out through cluster approach (at national, provincial and district levels, respectively) by considering and referring to land use development plan, by provision of facilities and infrastructure, and by provision, facilitation, and support to the horticulture businessmen. The program and activities in the stated horticulture should also be carried through integrated approach and also by involving people's participation.

2. Implementation of GAP

Horticulture cultivation and farming should be carried out by considering and applying the GAP method and principles besides considering the market demand, efficiency, competitiveness, environmental functions, and local wisdom.

3. Implementation of GHP

Harvesting and postharvest handling should be carried out by implementing the good harvesting and postharvest handling practices (GHP). The postharvest handling activities should also be carried out in the horticulture packing house.

4. Environmentally friendly horticulture agribusiness

Horticulture development should be implemented through environmentally friendly principles and should consider local wisdom. Horticulture land preparation activities must emphasize the sustainable environmental function, and should be done by utilizing the environmentally friendly tools, inputs and machineries.

5. Horticulture inputs and facilities

Utilization of horticulture inputs and facilities (such as seedlings, fertilizers, growth control materials, pest control materials, tools and machineries) should apply the technology which has already considered the local specific climate and land conditions, promotion of environmentally friendly products, more emphasis on the utilization of domestic products which should meet high-quality standards.

6. **Integrated horticulture development**

Horticulture development is more emphasized as integrated farming approach through mixing with other crops and/or integrated with other related business. The government will encourage and give priority facilitation to the farmers, growers, or farmers' group who carried out the integrated horticulture agribusiness.

7. **Prominent horticulture commodities and products**

The government and/or local government should decide the prominent horticulture commodities and product which should have high competitiveness, and the selection should also consider the local wisdom of the people who develop those commodities and products.

8. **Business partnership development**

Horticulture agribusiness should be implemented through partnership pattern by involving the micro, small, medium-, and large-scale horticulture enterprises. Business partnership pattern can be implemented through; nucleus estate smallholders (NESH), sub-contract, general trading, franchise, product distribution and marketing agencies cooperation, and other partnership models.

9. **Increasing the consumption level**

The government and local government are able to support the increasing number of people's consumption level; decide putting fruit and vegetables as prominent crops, decide the consumption level targets, as well as involve the horticultural aspect on the education curricula in various school levels.

As a follow-up to the direction as stated in the Horticulture Law, some Minister of Agriculture Decrees related to Horticulture GAP and GHP implementation were formulated and released. Such decrees are as follows:

1. Minister of Agriculture Decree, No 60 in 2006 concerning "Guidelines for Good Agriculture Practices for Fruit". This decree is not used anymore because it was revised and improved to become Minister of Agriculture Decree No 48 in 2009.

2. Minister of Agriculture Decree No 48 in 2009 concerning the "Guidelines for Good Agriculture Practices for Fruit and Vegetables".
   - Objectives: to produce safety and good-quality products, to produce through environmentally friendly approach, maintaining natural resources sustainability, maintain worker welfare, and product competitiveness.
   - Targets: farmers and growers, associations, farmer's groups, and the products are supplied to export, modern markets, hotels, restaurants and catering services.
   - Scope of guidelines consists of 20 aspects (related to: criteria, registration and certification, inputs and facilities, cultivation activities, worker welfare, waste management, controlling and traceability, internal evaluation and closing).
   - Comprise of 100 parameters to be valued, divided into 14 parameters are musts, 54 are mostly requested (at least 60% completed), and 32 parameters are requested (at least 40% completed)

3. Minister of Agriculture Decree No 62 in 2010 concerning "Guidelines for Application Method of Farm Land and Field Registration System on Fruit and Vegetables Good Agriculture Practices (GAP) Implementation".

- Objectives: prepare for quality guaranty system, to make easier for traceability process, encouraging for market access acceleration, as well as improving the product quality and safety.
- Targets: establishing the quality warranty system, more easy on applying the quality traceability, easiness on market access, as well as reaching the standards for quality and safety products.
- Stipulation for land and estate registration process: know well about the GAP principles, has the SOP on specific commodity and location, know well about the IPM principles, as well as the recording system and notes.
- Scope of guidelines consist of vegetable land and fruit estate land registration process, number of registration certificate and explanation letter, surveillance system, as well as validity and expiration of the certificate.
- Registration and certification: vegetable land and fruit estate land which already met the GAP condition can give the GAP Registration Certificate by the Provincial Agriculture Services, vegetable land and fruit estate land which already has the registration certificate, can be processed to the certification process by the competent institutions.
- So far, the GAP Registration Process and Certificate Release are provided free of charge, and this process can be followed by conducting the technical guidance for improvement.

4. Minister of Agriculture Decree No 73 in 2013 concerning "Guidelines for Horticulture Good Handling Practices and Horticulture Packing House Management".

- Objectives: Maintain and improve the product quality and performance, decrease the product losses, quarantine the product safety for consumption, protect the workers' safety and health, conduct environmentally friendly harvesting and postharvest handling activities.
- Targets: increasing the horticulture product value-added and competitiveness, improve the harvesting and post harvest handling as well as management of packing house.
- Scope of guidelines including several aspects such as: group of commodities, harvesting process, postharvest process, packing house management, human resources competence and qualification, process of packing house registration, traceability, worker safety and health, sanitation and hygiene, and also environmental management.
- Implement horticulture harvesting and postharvest handling, and horticulture packing house registration as voluntary and dynamic, activities, should be adjusted accordingly.

IMPLEMENTATION ACTIVITIES

The regulation of GAP and GHP for fruit and vegetables are relatively new even though they have been initiated several years ago. GAP has been implemented since 2008, while GHP has been in existence since 2012. Both of them are not mandatory. The implementation has been socialized, learned and carried out gradually in some production areas. So far, the GAP-GHP implementation is mostly emphasized to the selected targets, and is as follows:

1. Growers, farmers' group and farmers who supply the products to supermarkets, hypermarkets, modern markets, hotels, restaurants or for export purposes.

2. Growers, farmers' group and farmers who supply the raw materials for factories or industries.
3. Farmers' groups or union of farmers' groups or farmers' cooperatives who receive the facilities, aid and assistance from the government and local government program and budget.

Some activities which have been done to encourage the GAP implementation of fruit and vegetables are:

1. Socialization of the GAP guidelines to the extension workers, farmers, farmers' groups, growers and other stakeholders;
2. Conducting Training of Trainers (TOT) on GAP guidelines to the technical staff (at central, provincial and district levels), field extension workers, and the field pest control observers;
3. Formulation of Standard Operation Procedures (SOPs) on the GAP implementation which was made based on specific location and commodities;
4. Conducting Training for Farm Registration Auditors concerning the "Guidelines for Application Method of Farm Land and Field Registration System" on Fruit and Vegetables Good Agriculture Practices (GAP) Implementation;
5. Conducting GAP Implementation Field School in selected production cluster areas and the selected commodities;
6. Carrying out the demonstration plot and pilot project on GAP Implementation in some selected production cluster areas and selected commodities;
7. Provision of technical assistance and extension to the target groups on GAP implementation; and
8. Provision and aiding the farm facilitation (farming inputs and extension materials) for farmers and farmers' groups who have applied the GAP.

Some activities have also been carried out to encourage the fruit and vegetables GHP Implementation. They are as follows:

1. Socialization of the GHP guidelines to the extension workers, farmers, farmers' groups, growers and other stakeholders;
2. Conducting Training of Trainers (TOT) on GHP guidelines to the technical staff (at central, provincial and district levels), field extension workers, and field pest control observers;
3. Carrying out the demonstration plot and pilot project on GHP Implementation in some selected production cluster areas and the selected commodities;
4. Provision of technical assistance and extension to the target groups on GHP implementation;
5. Provision and aiding of postharvest handling facilitation (tools, machineries and extension materials) for farmers and farmers' groups who have applied the GHP; and
6. Conducting the intensive promotion of fruit which have already been carried in the GAP and GHP to the traders, industry and consumers.

In order to strengthen and support fruit and vegetables GAP and GHP implementation, some facilitation and incentives have been given to the growers, horticulture farmers and farmers' groups who have already carried out the GAP and GHP Implementation. Some kind of facilitation and incentives are as follows:

1. Provision of assistance and aid (grant basis) consisting of production inputs (seed, fertilizer, etc), farm tools and machineries, shading net, postharvest handling tool, packing house, warehouse, etc.;
2. Obtaining Certification Number on Registration of GAP Implementation for the vegetable farm land and fruit estate land free of charge;
3. Obtaining Certification Number of Packing House Registration on the packing house which already conduct the GHP Implementation free of charge; and
4. Provision of reward/appreciation and incentives to the growers, farmers, champion and farmers' groups.
5. Promoting fruit and vegetable products which already carry out the GAP and GHP to the traders and consumers; and
6. Conducting the training and comparison studies for the champion, technical staff and field extension workers, to the advanced growers which already carried out the GAP and GHP, event comparative study abroad (Malaysia, Singapore and Thailand).

As result of the horticulture development program and activities conducted in the various production centers and clusters, so far, many of fruit estate land and vegetable farm land which have already been well implemented through the GAP, and also many of them have been registered by the respective Provincial Agriculture Services office, and coordinated by DG Horticulture, and furthermore they got the register number certificate of GAP. Total number of GAP registered for fruit estate land and vegetable farm land shown in Table 2.

Table 2. Number of GAP registered for fruit estate land and vegetables farm land

No	Years	Fruit Estate (land unit)	Vegetable Farm (land unit)	
1	2009	5 741	-	5 742
2	2010	6 404	83	6 487
3	2011	6 858	918	7 776
4	2012	7 511	973	8 484
5	2013	7 983	856	8 839

The number of horticulture growers or producers who got the GAP certification is still limited. Since 2009 to 2013, the total number of GAP certification released is 506 units. This is because the growers or producers have to pay to get the GAP certification, and most of them said the payment is expensive (compared to the GAP-GHP registration which is free of charge). On the other hand, the costumers said that the GAP-GHP registration is enough for them. The total number of GAP Certification for horticulture products shown are in Table 3.

Table 3. Number of GAP certification for horticulture grower and producers

No	Years	Prima 3 Certificates (unit)	Prima 2 Certificates (unit)	Total Certificates (unit)
1	2009	21	-	21
2	2010	52	-	52
3	2011	95	-	95
4	2012	158	1	159
5	2013	176	3	179

PROBLEMS AND CONSTRAINTS

1. Mostly, the GAP-GHP implementation, as well as GAP Registration and Certification, are conducted at the production centers and clusters in Java and Bali remove space, other provinces are not so much well-attended and not so seriously conducted.
2. Not enough or low price incentives and appreciation for GAP-registered farms and GAP-certified products, it means the consumers and costumers' respect for the product which have already been implemented by the GAP and GHP, are not so good.
3. Difficulties to change the paradigm and habits of the farmers/growers/producers, as well as farmers' groups and cooperatives, in conducting farm recording, (while recording is very much important component of GAP-GHP), especially the conduct of product traceability.
4. Limited GAP Field Schools, demonstration plots, pilot project activities due to limited support and budget allocated to the Directorate General of Horticulture. Meanwhile, support and cooperation with the related agencies and private sectors are also limited.
5. Under the Ministry of Agriculture, the horticulture commodities development is not the prominent and priority sector as well as limited supporting activities by the other related institution (they are also mostly emphasized on food crops development).

CONCLUSION

1. Indonesia paid attention and seriously supported the implementation of fruit and vegetables GAP, since several years ago (2006), the event on the implementation has been conducted gradually and not as mandatory basis.
2. Some important rules and regulations related to GAP and GHP were formulated and realized, in terms of horticulture law, several Minister of Agriculture decrees, implementation guidelines and SOP.
3. Ministry of Agriculture (c.q Directorate General of Horticulture) policies for supporting the implementing ofGAP and GHP have been carried out through some program and activities in the horticulture production centers and clusters, such us: training, extension, field schools, facilitation and grand aid, product promotion, appreciation to the producers, etc.
4. Result of GAP implementation shows a lot and the increasing number of fruit estate land and vegetable farm land which got the certificate of GAP Registration Number. Meanwhile the GAP certification and horticulture packing house registration are still limited.
5. Improvement and support to the implementation of fruit and vegetable GAP and GHP are still very much important and required. Coordination among institutions and integration among the activities should be done in order to accelerate and broaden the GAP-GHP implementation.

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SAFETY OF FRESH FRUIT AND VEGETABLES IN MALAYSIA

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ABSTRACT

There has been an increase in the volume of fresh fruit and vegetables traded worldwide. The increase in volume and expansion has been significantly important for many countries especially developing countries like Malaysia. In all markets, whether they are in developed or in developing countries, the issues remain the same: food safety, quality, and reliability of supply.

Production of fruit and vegetables should be geared toward increasing high quality and safety produce in the markets instead of just emphasizing the quantity alone. Fruit and vegetables are perishable in nature. Losses resulting from inadequate post-harvest handling, storage and improper marketing system result in diminished returns for producing countries. International markets have rejected exports of fruit and vegetables containing non-authorized pesticides, with pesticide residues exceeding permissible limits, with inadequate labelling and packaging requirements, with contaminants exceeding regulatory levels, without the required nutritional information, and/or with inadequate general quality.

To reduce the risks from contamination associated with production and trade of fresh fruit and vegetables and to promote market opportunities, The Government of Malaysia has launched the Malaysian Farm Accreditation Scheme (SALM) by the Department of Agriculture (DOA) under the Ministry of Agriculture aimed toward giving recognition to farms which adopt Good Agricultural Practices (GAP) in producing fruit and vegetables of high quality and safe to consumers. However, the food safety and quality control in Malaysia is under the Ministry of Health, so Malaysian food safety system operates by entrusting different authorities with the task of ensuring food safety at different stages, throughout the food chain to avoid and to control hazards.

Keywords: Quality, postharvest handling, pesticides residues, contaminants, regulatory

INTRODUCTION

Fresh fruit and vegetables are highly perishable in nature. Proper handling practice is essential to avoid any undesirable changes that may reduce their quality and safety during handling, distribution, and marketing. Although postharvest handling covers all activities from harvesting to marketing, the technique varies according to the type of produce, mode of transportation, market destination, and consumer requirements. It may cause even faster deterioration if the produce is not properly prepared according to their requirements. For example, produce such as carambola, duku langsat/dokong, broccoli, cauliflower, and cabbage could not be washed as washing may cause contamination and rotting of the produce. Hot water treatment is suitable only for papaya and chili, while vapor heat treatment is currently applicable for mango. Different produce require different storage temperatures, and hence not suitable to be mixed in one cold room. Moreover, produce that are classified as ethylene producers, should be separated from produce sensitive to ethylene to avoid ripening during storage. Generally, handling technology of produce for export to distant markets and by sea is more sophisticated as compared with technology for distribution to local markets and export by air. It is very important for packers and exporters to use the correct technology as required by the specific market.

Food safety for fresh fruit and vegetables refers to quality of the food and production, distribution, and consumption practices that prevent the contamination and deterioration of the food (Prabhakar, Sano, and Srivastava, 2010). Safety factors in fruit and vegetables include naturally-occurring toxicants, such as glycoalkalosids in potato; natural contaminants, such as fungal toxins (mycotoxins) and bacterial toxins and heavy metals (cadmium, lead, mercury); environmental pollutants; residues of pesticides; and microbial contamination. While health authorities and scientists regard microbial contamination as the number one safety concern and many consumers rank pesticide residues as the most important safety issues (Kader and Rolle, 2004). This paper will focus on policies and strategies have been established, in order to produce safe fruit and vegetables.

TRENDS IN FRUIT AND VEGETABLES CONSUMPTION

Under the Tenth Malaysia Plan (2011-2015), agriculture has been identified as the Third Engine of Growth after manufacturing and services. With regard to agricultural industries, plans have been made to increase the area of production to cater the expanding demand for fresh and processed products both for the local and export markets. Realizing the significant contribution of fruit and vegetables production in the economic development of the country, the Malaysian government is implementing several policies to enhance the development of the industry. The Agro-Food Policy (2011-2020) is directed towards increasing production to meet the rising demand for high quality, nutritious, and safe produce in the market. As a result, the total area under fruit production has increased tremendously from 116,858 hectares in 1980 to 291,500 hectares in 2000 and has achieved 373,200 hectares in 2010. In terms of production quantity, more than 1.33 million metric tons of fruit were produced in 2005, 1.8 million metric tons in 2010 and is estimated to rise to 2.1 million metric tons in 2015. Meanwhile, the current vegetables production is estimated around 53,000 hectares including highlands production. The production of vegetables is estimated to be nearly 1.0 million metric tons in 2012.

Food safety and quality have become a serious concern in the production and marketing of fruit and vegetables. With the global trade liberalization through the World Trade Organization (WTO) and the ASEAN Free Trade Area (AFTA), it justified the need for higher quality and safer produce in the market, in order to be competitive in the domestic and international markets. Furthermore, many consumers have changed their lifestyles and growing concern towards healthy living and demanding for wholesome, tastier, healthier, nutritious, and safer foods. Similar trends have shown in Malaysia consumers where the fruit and vegetable consumption per capita shows an increasing trend over the years. Fruit consumption had increased from 80.4 kg in 2008 to 93.0 kg 2012, while per capita of vegetables had increased from 45.8kg in 2001 to 54.7 kg in 2012 (Rozhan, 2014).

POLICY AND LEGISLATION ASSOCIATED WITH FOOD SAFETY OF FRUIT AND VEGETABLES

Government policy

The safety of fruit and vegetables in Malaysia is currently upheld through co-operation between the food quality control Division (FQCD), Ministry of Health (MOH) as the lead agency for food safety and the DOA, Ministry of Agriculture, and agro-based industries and the Ministry of Natural Resources and Environment (Chandran, 2013). The FQCD's main objective is to protect the public against food related hazards and fraud as well as to motivate, promote the preparation, handling, distribution, sale, and consumption of safe and quality food. The DOA is one of the departments under the Ministry of Agriculture, and Agro-based Industries which is responsible to ensure safety of fruit and vegetables from farm to table. The Ministry of Natural Resources and Environment, has been tasked to deal with Genetically Modified Food (GMO).

For fruit and vegetables the safety aspect and traceability are currently given more priority by the respective government and non-government authorities in the international and domestic trades for consumers' protection. Good Agricultural Practices (GAP) are therefore one of the key strategies for the development of successful fruit and vegetables industry in Malaysia. The Department of Agriculture (DOA) Malaysia launched the Malaysian Farm Certification Scheme for Good Agricultural Practices (SALM) in early 2002. The scheme aimed towards giving recognition to farms which adopt GAP in producing fruit and vegetables of high quality and safe for consumers. In August 2013, Malaysian Good Agricultural Practice (MyGAP) was launched. MyGAP is rebranding of SALM, Farm Practice Scheme (SALT), and Malaysian Aquaculture Farm Certification Scheme (SPLAM). MyGAP is a comprehensive certification scheme for planting, aquaculture, and livestock to certify commercial farms which adopted GAP to produce high quality and safe produce for the markets. The MyGAP incorporates highly recognized guidelines including the EUREPGAP/GLOBALGAP, CODEX, Malaysian Standards, and other international code of practices. The farm refers to both practices either organic or inorganic. Major aspects under the scheme include conditions relating to the environmental setting of the farm, farmer's adherence to GAP, and safety of the produce. It should be noted that the scheme also incorporated traceability and workers welfare within the rules or protocols required. This scheme has received overwhelming responses from the growers in the country, particularly on the produce targeted for international and regional markets.

Strategic plan in marketing fresh produce has also been adopted through the launching of the Malaysia's Best branding program by the Federal Agricultural Marketing Authority (FAMA) in 2003. This program is targeted towards promoting and marketing of high quality and safe produce, preferably from SALM farms, using Malaysia's Best stamp of approval. The program is not only intended for the application of a common brand for Malaysian fresh produce, but also as an assurance that the produce sent to consumers are delivered in excellent quality and are safe. In order to improve the efficiency and effectiveness of agricultural products marketing, the Grading, Packaging, and Labelling (GPL) Regulation have been introduced by FAMA in 2008. This regulation will be able to trace the origin of the products for safety and food hygienic purposes.

Grade standards recognize the degree of quality in a produce. Standards also help the producers and handlers to perform better job in preparing and labeling fresh fruit and vegetables for market, and more importantly they provide a basis for pricing and payments rewarding better quality. Malaysian standard Quality Certification is benefiting the health and safety of the public, protecting the consumers, facilitating the domestic and international trade, and furthering international cooperation in relation to standard and standardization. Standard Industrial Research Institute of Malaysia (SIRIM) is appointed by the Department of Standards Malaysia to be the sole agency to develop and manage Malaysia standards (Ahmad Tarmizi, Abdullah, and Mohd Salleh, 2007).

Apart from the efforts to increase fruit and vegetables production, access to external markets is also important. The demand for fruit and vegetables are increasingly seen and exploiting this opportunity, however, poses many challengers. As the movement of fruit and vegetables into the importing countries, Sanitary and Phytosanitary (SPS) agreement has to be considered. SPS measures are imposed against quarantine pests where the pests are not present in importing countries.

Legislation

Food safety is addressed throughout the food chain from farm to table. The establishment and updating of food safety legislation throughout the food chain is essential in establishing an effective food safety system. Food safety legislation has been developed and updated taking into consideration specific needs of consumers and food producers, development in technology, emerging hazards, changing consumer demands, and new requirements for trade, harmonization with international and regional standards, obligations under the WTO agreements, as well as social, religious, and cultural habits (Anonymous, 2011).

The mandate for food safety rests with the Ministry of Health (MOH) and other government agencies which are also responsible for food safety in the country. Table 1 shows the summary of responsibilities of various governmental agencies on food safety aspects in Malaysia. The Food Act 1983 and the Food Regulations 1985 are the Malaysian food legislations that form the backbone of the food safety programme. The objective of the Food Act 1983 and the Food Regulations 1985 is to ensure that the public is protected from health hazards and fraud in the preparation, sale and use of foods, and for matters connected therewith. It is enforced by the Ministry of Health and the Local Authorities. The legislation, applicable to all foods sold in the country either locally produced or imported, covers a broad spectrum from compositional standards to food additives, nutrient supplements, contaminants, packages and containers, food labelling, procedure for taking samples, food irradiation, provision for food not specified in the regulations and penalty.

Table 1. Responsibility of different government agencies on various food safety aspects in Malaysia.

Sector	Agency	Food Safety Responsibilities
Legislation	MOH	• Reviewing and updating Food Act 1983 and Food Regulations 1985 • Promulgation of the following legislations: - Food Hygiene Regulation - Food Analyst Regulation - Food Import Regulation - Food Irradiation Regulation - Food Analyst Act - Genetically Modified Food Regulation • Harmonization of Food Regulations 1985 with Codex and ASEAN standards.
	MOA	• Reviewing and updating: - Veterinarian Surgeon Act 1974 - Animal Ordinance 1953 - Fisheries Act 1983 - Animal Feed Act
Laboratories	MOH MOA	• Setting up food lab and conduct analysis for purpose of enforcement and monitoring

	CDM	• Analyses for food safety monitoring • Identification and optimizing utilization of all facilities under all relevant ministries, agencies, private laboratories, etc.
Monitoring and surveillance	MOH MOA	• Conduct studies to strengthen monitoring and surveillance activities • Food Consumption Pattern • Guidelines on Risk Management • Conduct risk assessment for purposes of food safety management decisions • Monitoring & surveillance of zoonotic/animal diseases
Implementation of food safety system	MOA JAKIM MOH DSM	• Ensure safe food products through certification schemes • Strengthening the implementation of food safety system • Utilizing guidelines, certification, accreditation and policy building: - Farm Certification Scheme - Good Agriculture Practice - Aquaculture Farm Certification Scheme (GAqP) - Good Husbandry Practice - Certification of Abattoirs and Processing Plants - Good Manufacturing Practice in animal feed - Guideline on Organic Farming - Veterinary Health Mark Scheme (VHM) - Halal Certification Scheme - HACCP Certification Scheme - ISO MS 9000, 14000, 17025 Quality System
Food inspection and certification	MOA JAKIM MOH DSM	• Farm Certification Scheme • Good Agriculture Practice • Aquaculture Farm Certification Scheme (GAqP) • Good Husbandry Practice • Certification of Abattoirs and Processing Plants • Good Manufacturing Practice in animal feed • Guideline on Organic Framing • Veterinary Health Mark Scheme (VHM) • Halal Certification Scheme - HACCP Certification Scheme • ISO MS 9000, 14000, 17025 Quality System
Education and training	MOH MOA MARDI	• Training of relevant stakeholders in food safety system • Food Handlers Training and Training of Trainers • Human Resource Development e.g. in HACCP, ISO, auditors • Training of enforcement personnel for prosecution purposes • Training and extension program on GAP, GAHP, VHM, GAqP by respective agencies • HACCP - Auditing and verification
Information sharing	MOH MOA	• To make available relevant details on food safety to relevant agencies, consumer, public, etc • Inter-agency information sharing through website and linkage with local, regional and international organizations i.e. OIE, Codex and IPPC
Research and Development	MOH UPM UKM MOA	• To upgrade capability in handling new emerging issues • Strengthen research methodologies • Research and development in food safety by relevant agencies to meet current needs and interest • Strengthening collaboration among relevant agencies • Conduct animal disease investigation and diagnosis
International participation	MOH DSM MOA	• To ensure relevant programmes related to food safety is been acknowledge and participate if necessary Malaysia continues to play an active role in Codex and other international activities on food safety **1. Codex** The Codex Contact Point with Ministry of Health serves as the Secretariat of the National Codex Committee as well as the

		Contact Point for other international food safety activities. In parallel with Codex, Malaysia is continuously formulating national positions through the National Codex Committee, 21 Codex Su-Committees and 3 Task Forces **2. ASEAN** Food safety and Codex activities are addressed mainly in SOM-HD and to some extent in SOM-AMAF through the ASEAN Expert Group on Food Safety, ASEAN Task Force in Codex, etc **3. APEC** Malaysia is an active member and participant of the Sub-Committee on Standards and Conformance (SCSC) **4. WHO/FAO** Malaysia has served in expert consultations on food safety as well as consultancies in food safety and Codex under WHO and FAO **5. Bilateral arrangements for attachments** There are bilateral arrangements between Malaysia and other countries for attachment of officers to relevant agencies on food safety **6. WTO/SPS** The Focal Point for food safety, animal health and plant health has been established for at relevant agencies and coordinates by the Ministry of Agriculture as the National Enquiry Point and National Notification Point **7. OIE/SPS** Malaysia is an active member and participant of OIE
Consumer participation in food safety	MOH MOA	• To strengthen consumer group participation in food safety issues • Development of appropriate education materials for various stakeholders • On-going dissemination of information to NGOs, industries, consumers and consumer group • Consumer education through use of IT, mass media, campaign etc

Since food safety is addressed throughout the food chain, legislations pertaining to food safety under the jurisdiction of other agencies are also enforced by the relevant agencies. At the primary production level, the Pesticide Act 1974, the Fisheries Act 1983, the Veterinary Surgeon Act 1974, and the Animal Ordinance 1953, all under the Ministry of Agriculture and Agro Based Industry are implemented. At the processing and retail levels, apart from the Food Act 1983 and the Food Regulations 1985, other legislations that were mentioned earlier are also applicable to a certain extent. The Trade Description Act under the Ministry of Domestic Trade and Consumer Affairs also play an important role in terms of protecting consumers from misleading and false labelling of food product.

PREVAILING MONITORING SYSTEM

The implementation, monitoring, and enforcement of the law at the stage of agricultural food supply, primary and secondary food processing, local and international market food distribution, food retailing, and domestic food production is also charged under FSQD at MOH. The Food Act 1983 and the Food Regulations 1985 of Malaysia govern the various aspects of food safety and quality control including food standards, food hygiene, food import and food exports, food advertisement, and accreditation of laboratories. FSQD implements an active food safety program which includes routine compliance, sampling, food premises inspection, food import control activity and licensing of specified food substances required under the Food Act 1983 and its regulation 1985.As preventive approach, the FSQD has been implementing food handlers training program, vetting of food labels, giving advice to the industry and consumers, and food scheme such as Health Certification and HACCP certification.

For production of fruit and vegetable, DOA regulators are responsible for inspecting and auditing the performance of the food system through monitoring surveillance activities and for enforcing legal and regulatory requirements**.** For imported fruit and vegetables (including seeds into Malaysia) it is governed by the plants (import and export) Regulations 1981. This regulation is formulated to prevent introduction of pests and diseases from foreign countries. All produce must conform to the phytosanitary requirements that are specified in the permits applied. Most of the phytosanitary measures are carried out in the countries of origin and therefore would require certificating documents from the country of origin. Similarly, for fruit and vegetables for export, the government also requires phytosanitary certification of the produce before exportation. The Malaysian Phytosanitary Certification Assurance (MPCA) Scheme aims to maintain and expand an existing market access, to overcome prevailing phytosanitary and quality problem. DOA is the implementers of this scheme and is responsible for the preparation of regulation and enforcement.

RESEARCH AND DEVELOPMENT EFFORTS RELATED TO FOOD SAFETY CONTROLS OF FRUIT AND VEGETABLES

These are some of the research and development activities which are aiming for improving quality as well as safety of fruit and vegetables.

Planning for postharvest quality

Selection of seeds is one of the important criteria in determining postharvest performance of any commodities including fruit and vegetables. Cultivars chosen for certain traits may be suitable for small- scale production and domestic market, but would be disastrous choices for the distant market. Farm management may have dramatic impacts on postharvest quality.

Reduction of postharvest losses

The characteristics of fresh produce which are highly perishable and susceptible to physical and mechanical injuries, accelerate both physiological and microbiological decay. Because of these reasons, produce needs proper handling, packaging, and transportation systems. In addition, the marketing system for the commodities is operated by many individual entrepreneurs resulting in frequent handling and transfer of the goods from middleman to another. Improper execution of these systems may cause damage to the produce, enhance deterioration, allow undesirable ripening process, trigger physiological and biochemical changes, reduce quality and shorten shelf life, resulting in high rejection and spoilage, and losses. Worldwide postharvest fruit (and vegetables) losses are as high as 30 to 40% and even much higher in some developing countries. Although, limited information is available on postharvest losses in Malaysia, the losses have been estimated at 20 to 50%, depending on the perishability of the produce, handling method, market distance, and management of the produce right after harvesting up to delivery to the consumer. Preventive measurements in reducing postharvest losses should be taken throughout the handling chain. Knowledge and information on the causes of physical, mechanical, and physiological injuries need to be delivered to the operators and handlers involved in the operation.

Quality Assurance System

Consistent quality is the key factor to sustain the consumer demands and to be competitive in the global market. Quality Assurance (QA) system is established in the horticultural industry in Malaysia covering postharvest and fresh-cut processing in order to deliver produce of high quality and safe for human consumption. The components in QA system include control of raw materials upon arrival at packinghouse, control of handling and processing operations, management of finished-produce, and sanitation at the packinghouse and processing plant. The system incorporated the highly relevant and recognized standards such as Codex, HACCP, and the Malaysian Standards. This QA system serves as a management tool to support operation, preparation, and maintenance of produce for both fresh and fresh-cut. The total quality assurance approach is recommended to be used continuously in the horticulture industry to ensure consistent product quality and safety, and hence increase buyer's confidence to consume the produce.

Maintenance of quality and safety

Delivering high quality produce is extremely essential for successful marketing of agricultural produce in the competitive market worldwide. Quality of produce should be maintain along the handling and marketing chains to ensure the produce received is in good condition and accepted by the buyers. This could be done by proper harvesting, handling, preparation, storage, and transportation systems. Harvesting should be done at the right stage of maturity, followed by appropriate packinghouse operations such as sorting, cleaning, washing, disease treatment, disinfestation, grading, and packaging. Distribution to markets should be done soonest possible to ensure the produce is delivered on time. Produce should be managed correctly in storage and market displays to provide fresh, quality, and safe produce to the consumers.

Fresh-cut processing

Fresh-cut fruit are ready-to-eat products, while still maintaining the freshness, flavor, aroma and their nutritional values. It also offers convenient and easy in serving portions for larger and difficult fruit which require peeling. In Malaysia, the fresh-cut products have been in the market since early ‘80s, however, the previous outlets are limited mostly at mini-markets, supermarkets, and by street hawkers. For these market sectors, the fresh-cut products are prepared mainly by the hawkers themselves or supermarket workers with limited knowledge in fresh-cut processing, storage, and sanitation. Recently, the demand for fresh-cut fruit and vegetables is rapidly increasing due to the consumer's trend on ready-to-use, quality, and safe products. The demand is expanding not only within the traditional market outlets, but also in other market sectors such as food services, fast foods, hypermarkets, and food processors. Research on fresh-cut fruit and vegetables focus towards the determination of suitable maturity and varieties, method of preparation, prevention of discoloration and microorganisms, technique of packaging and storage, and establishment of quality assurance system. The processing involves in the preparation of fresh-cut produce would basically depend on the type of fruit, and the way they are normally consumed. Currently, the fresh-cut technology has been developed for pineapple, citrus, durian, jackfruit, and mangosteen. The fresh-cut processing consists of cleaning, washing, temporary storage, ripening, peeling, cutting, immersing in solutions containing calcium chloride and acid ascorbic followed by draining, packing and storage. The fresh-cut pineapple, citrus, durian, jackfruit, and mangosteen could be stored at 2 ºC for duration of 2-3 weeks. Handling trials of fresh-cut pineapples, jackfruit, and durian were conducted successfully in the Netherlands and Hong Kong. For fresh-cut vegetables, cabbage, onion, chili, long bean, cucumber, and others have been developed.

Cold chain handling system

Cooling the produce rapidly after harvest and maintaining at the required temperature during handling chain help to avoid deterioration, maintain quality, and extend shelf life of fresh produce. The low temperatures should be maintained continuously throughout handling, distribution, and marketing activities by implementing a total cold chain system. This system includes pre-cooling after harvesting, packinghouse operations under low or air-conditioned temperature, pre-cooling after packaging, delivering using refrigerated transport, keeping in refrigerated storage, and displaying under chilled temperatures. Recently, cold chain system is becoming an important technique in delivering of highly perishable fruit in Malaysia. The system is a necessity in tropical countries like Malaysia, where the surrounding temperatures are relatively higher as compared to the requirements for the fresh produce.

Export technology

There is a need to verify the feasibility of the technology developed in the laboratory under the actual commercial environment. Several export trials by sea have been conducted since 1984 on bananas (Hong Kong, Japan, United Arab Emirates [UAE] and Denmark), pineapples (Saudi Arabia, United Kingdom and Germany), carambola (Hong

Kong and Belgium), papayas (Hong Kong, Saudi Arabia and UAE), melons (Hong Kong), and ginger (United Kingdom). These trials were conducted by MARDI in collaboration with private companies, farmers, and other relevant agencies. Recently, shipment of several commodities in one container or mixed loads was also conducted to the UAE. Three fruit types namely pineapples, carambola, and pummelo were mixed-loaded into a 40-foot refrigerated container set at 8°C and transported by sea to Dubai. The technique was able to maintain the quality of all fruit upon arrival, as well as after one week additional storage in a warehouse at Dubai. The technique could be used to cater to small market demands of more than one commodity per consignment, as well as to deliver several produce together in one container to new markets or during low production season.

CONCLUSION

The safety and quality of fruit and vegetables will be improved by the implementation of food safety policy and legislation of horticulture produce. This will benefit all parties involved in producing fruit and vegetables from farm to table including farmers, workers, produce handlers, marketers, and consumers.

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R AND D UPDATES: IMPROVING SAFETY ON FRUIT AND VEGETABLES

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ABSTRACT

The fruit and vegetables industry in the country play an important role in the food security and healthy lifestyle of many Filipinos, especially with increasing consumer demands for varieties and availability of clean and safe fresh produce. As a tropical country, the Philippines is blessed with diverse species of fruit and vegetables which are available the whole year round. In spite of its versatility to grow and adapt in adverse conditions, these high value crops are posed with production constraints such as incidence of pests and diseases , poor quality produce due to postharvest losses, and inadequate soil nutrients. Therefore, the Industry Strategic Science and Technology Program (ISPs) for fruit and vegetables were crafted and will be transformed into doable research and development programs to develop scientific and technology based solutions towards increased productivity and reduced postharvest losses in order to produce clean and safe vegetables for consumption. The science- based technologies and practical solutions will cover the following disciplines: (1) varietal improvement through traditional breeding approach; (2) use of biological and microbial agents and judicious use of synthetic insecticides or fungicides against major pests and diseases of fruit and vegetables; (3) proper pre- and post handling practices and (4) adoption of Good Agricultural Practices (GAP).

This paper will discuss the science and technology based interventions that will address the food safety concerns in the consumption of fruit and vegetables to allay fears of the consumers. The identified research gaps in the technology chain of the ISPs for fruit and vegetables will be developed through the implementation of research and development programs by our key partners from the state and universities and colleges in the selected regions of the country where the majority of fruit and vegetables are grown. Some bilateral arrangements with international research partners are also designed to access and exchange new techniques and approaches on food safety concerns which can strengthen the development of science-based solutions.

Keywords: fruit and vegetables, postharvest practices, GAP, research and development

INTRODUCTION

The Philippines is predominantly an agricultural country which covers 47% or 30 million hectares and endowed with diverse species of fruit and vegetables. These crops play an important role in food security towards self-sufficiency. Food security exist when all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food that meet their dietary needs and food preferences for an active and healthy life (FAO, 2006). The World Health Organization (WHO) has introduced food- based dietary guidelines as a resource by achieving good health by the public and as a resource for the any country to develop their own dietary guidelines (WHO, 1998). Therefore, each country has set the food consumption guidelines on a per capita basis and these two major commodities create higher consumers demand because of their nutritional value which are rich sources of vitamins, minerals, protein and dietary fiber.

The role of fresh fruit and vegetables in nutrition and healthy diets is well recognized nowadays and more advocacy programs are being initiated to encourage consumers to eat more because the daily consumption is very low. According to Food and Nutrition Research Institute (FNRI, 2009), the Filipinos average intake for vegetables of 106 grams (g) per capita per day is made up of green leafy and 30g for yellow vegetables , 76g for other vegetables. While the intake of fruit amounts to 77g per capita per day. This is way below the daily requirement because as a general requirement, fruit and vegetables must be consumed at a level of 400g daily , but may vary by population age group which ranged from 350+ to 650+ g daily per capita consumption (Lock, *et al.*, 2005)

Moreover, together with increasing consumer demands for variety and availability of produce, the opening of the ASEAN Economic Integration and the changing structure of global trade require the strict implementation of GAP towards increased productivity and food safety of the produce.

Therefore, the development of science and technology based approaches through the implementation of the ISP for Fruit and Vegetables must be given utmost attention to address food safety in the production of fruit and vegetables.

INDUSTRY STRATEGIC S&T PROGRAM (ISP) for FRUIT AND VEGETABLES

The Philippine Council for Agriculture, Aquatic and Natural Resources Research and Development (PCAARRD), one of the sectoral councils of the Department of Science and Technology (DOST), crafted different ISPs to provide science solutions that are integral to achieving the development goals of the Philippines. PCAARRD aims to deliver these solutions through the National Innovation System (NIS), as founded on its mandates as a science planning and coordination council. PCAARRD, thus, presents the ISPs to (1) set the vision and direction for S&T for the agriculture, aquatic, and natural resources sectors, and (2) influence other NIS actors to align their collective efforts towards such S&T vision. The ISP describes the targets for each industry and pinpoints the aspects of the industry where S&T will make a difference. Moreover, the ISP encapsulates and proposes how the vision can be operationalized through specific activities under each of the major banner programs. Overall, the ISP is PCAARRD's contribution in shaping and forging desired societal outcomes:

ISP for vegetables

The ISP outcomes for vegetables are:

- Increased yield by at least 20%
- Reduced pests and diseases by 20%
- Reduced postharvest losses by 20%
- Increased per capita consumption

The ISP will cover the *pinakbet* and *chopsuey* type vegetables. Tomato will be given top priority with a production volume of 203,578 mt valued at Php6.4B or US$ 0.15B (BAS 2011). The increasing production volume will reduce the importation of processed tomato products, worth Php754 million or US$ 17.14 million (FAO, 2012). Other priority vegetables are white potato, bitter gourd, onion, and garlic.

In general, the vegetables are planted in about 144,409 hectares (ha) with major areas in SOCCSKARGEN (Region XII, located in Central Mindanao), CALABARZON (Region IV-A), Central Luzon, CAR, Ilocos Region, and Cagayan Valley, with value of production for major vegetables at Php14.7 B pesos or US$0.34 (2011) and the volume of production is 674,329 MT (2011). In the Philippines, vegetable farming is an important source of livelihood program and mostly used for crop diversification system. Some 600,000 (ha) are being cultivated to vegetable crops, producing over 4.8 M tons of vegetables that include tomato, garlic, onion, cabbage, and eggplant. But vegetable farming in the Philippines is an intensive activity because of the high incidence of pests and diseases and postharvest losses. The pressure to sustain the steady supply of vegetables and increased yields has resulted in heavy usage of pesticides which posed hazards to health and food safety.

With the ISP for Vegetables, where R&D, technology transfer, capacity building and policy advocacy initiatives have already been considered, there is still a need for the industry to benchmark with leading countries to keep abreast and be competitive by learning how other countries are doing to further improve our technologies thereby enhance productivity and further develop the industry in partnership with the private sector and other stakeholders.

ISP for fruit

Banana

The ISP outcomes for banana are:

- Reduced incidence of *Fusarium* wilt tropical race 4 on Cavendish in Mindanao by 90-95% in 2015
- Increased average yield of Lakatan (from 21.58 MT/ha to 34.52 mt/ha) by 2015
- Reduced incidence of banana bunchy top virus (BBTV) in Lakatan (from 70% to 20%) by 2020
- Develop early fruiting dwarf Saba by 2020

The Philippines is the 3rd largest producer of banana in the world next to India and China (FAO, 2010). Banana is the 4th largest agricultural produce of the Philippines in 2011 recorded at 9.16M MT valued at US$ 2.32B. The country is the 4th largest exporter of banana in 2010 (1.59M NT; US $319M) next to Ecuador, Costa Rica, and Columbia (FAO, 2010). There are three major cultivars that are commercially grown in the country.

1. *Cavendish*

The major variety of banana produced in the Philippines (51%) is Cavendish. It generates 329,648 jobs in the country providing Php42.3B in annual wages. Total investment to the industry is Php82.4B. In 2012, revenue reached Php74.4B. The industry is threatened by *Fusarium* wilt (FW) tropical race 4, a disease caused by a soil-borne pathogen, *Fusariumoxysporum f. sp.* cubense (Foc) which could thrive in the soil for years, causing banana plants to wilt and make the plantation unproductive.

The ISP aims to reduce the incidence of FW on Cavendish in Mindanao by 90-95% through the use of resistant varieties which are market-acceptable and through the application of microbial agents as part of the integrated management of the disease. Likewise, the pseudo stem of bananas can be a good source of fiber. Hence, an affordable automated decorticating machine will be developed for processing banana and pineapple fibers, to replace the hand stripper, with improved productivity and product quality.

2. ***Lakatan***

The Lakatan variety is a popular dessert banana in the Philippines which contributes 10% of the total banana production. It is very susceptible to major diseases such as banana bunchy top disease (BBTD), Sigatoka, and FW. With the ISP, the incidence of banana bunchy top virus (BBTV) in Lakatan is hoped to be reduced from 70% to 20% through the use of BBTV-resistant Lakatan mass produced using shoot-tip culture and through the application of best cultural management practices.

3. *Saba*

The Saba variety is a major cooking-type banana produced in the Philippines which comprises 29% of the total banana production. It is used in the production of banana chips, a major export product of the Philippines. In 2010, the Philippines exported 28,084 MT chips/ crackers valued at Php1, 816.76M with Vietnam, USA, and China as the major markets. One of the major concerns of the banana chips industry is the lack of supply. Thus, the ISP aims to develop a dwarf Saba which can bear fruit earlier at 12-18 months than the traditional Saba at 18-24 months.

Mango

For mango, the ISP outcomes are:

- Increased yield by 57% (from 5.82 MT/ha to 9.11 mt/ha) by 2015, and by 90% (from 5.82 MT/ha to 11.11 mt/ha) by 2020
- Reduced postharvest losses by 50% (from 40% to 20%) by 2015, and by 65% (from 40% to 14%) by 2020
- Enhanced capability of mango growers on Integrated Crop Management (ICM), Postharvest Quality Management (PQM), and GAP

The Philippine 'Carabao 'mango ranks 12th in the top world producer and 1.86% share in the world mango production (FAO, 2012). It is the 3rd most important fruit crop in the Philippines based on export volume and value (FAO, 2011). It has eestablished its domestic market as fresh produce and with bright opportunities for the international market both for fresh or processed form. Majority of the processed mangoes are exported as dried (56%), juices and concentrates (39%) and puree (5%) valued at US$242.

For the past years, investments on R and D have been poured in by PCAARRD and other international donors to develop technologies to address production constraints such as incidence of pests and diseases, poor cultural management, and high postharvest losses. The packages of technologies through scientific approaches and adoption by farmers resulted in high yields and good quality fresh produce mangoes. But in spite of ready packages of technologies, the target to increase yields and produce good quality produce has not been attained. An impact assessment conducted by the Socio-economic Research Division (SERD) of PCAARRD revealed that the non-adoption of technologies and limited resources of the farmers are the causal factors. The ISP aims to develop converge of technologies for adoption through a clustering approach or to be adopted by S and T model farms.

RESEARCH AND DEVELOPMENT ACTIVITIES

The ISPs for fruit and vegetables are translated into research and development programs through a technological chain approach composed of different disciplinary areas such as production of planting materials, varietal improvement, cultural management, pest management, postharvest handling, and value adding. Each component of the technological chain will provide science based practical solutions which are generated from the research and development activities experimented and tested by the members of the network composed of State Universities and Colleges (SUCs) and other research partners from international organizations. But the varietal improvement, integrated pest management (IPM) and postharvest handling are the three major technology chain components can address the food safety of the produce.

A. The national vegetables R and D program

There are about 43 major kinds of vegetables grown in the country. Aside from these, 250 lesser-known species are utilized as vegetables, mostly in the rural areas. The major vegetables are generally grown during the dry season when their production is ideal, resulting to high yields and low prices. During the wet season, production is generally difficult, so that supply is low and prices are high. This is especially true for the seasonal crops like tomato, onion, garlic, and cabbage.

The main goal of the ISP is to increase vegetables production and consumption. To achieve this goal, three objectives are set: (1) increase per capita consumption of vegetables, (2) enhance access to high quality and safe vegetables in food retail, and (3) improve the efficiency and sustainability of vegetable farming.

The following strategies to address the main goal of the vegetable industry are : (1) implement a participatory marketing and promotion program; teach the health benefits of vegetable consumption and the 'how-tos' in preparing tasty and safe vegetable dishes; (2) promote school and home gardens using participatory approaches; (3) support the development and upgrading of supply chains to ensure delivery of quality and safe food; (4) strengthen regulatory functions of government agencies tasked to implement food safety standards, pesticides maximum residue limits, mycotoxins limits, and other regulations related to food quality and safety; (5) support the development of organic and "green" standards and marks in local production; (6) assist small-scale vegetable farmers in meeting the required and consistent supply volumes thus ensuring their participation in the supply chain; (8) promote the adoption of productivity-enhancing and cost-reducing crop production technologies.

To realize the NVRDP's vision of a healthy populace having access to safe and quality vegetables, a conceptual framework for the NVRDP was drawn up to outline possible courses of action or approaches to meet this vision (Fig. 1). These approaches focus on RDE in the following areas:

Varieties: improved yield and disease resistance for ampalaya; improved varieties for pole sitao through participatory breeding; new varieties of field beans and sweet peas; adapted varieties of major tropical vegetables

IPM products: inducers of SAR for selected insect pest and diseases of tropical vegetables; biological control agents for selected semi-temperate crops; grafting technology for selected high value crops

Postharvest products: coatings to improve shelf-life; natural agents to prevent discoloration, maintain quality, and reduce pesticide residues

It is believed that having addressed these areas of concern, a stable supply of safe, affordable, quality vegetables is a distinct possibility in the near future, with consumers having increased preference for vegetables as part of their daily diet. By the same token, the industry is primed to benefit from reduced cost of production, higher yield in the off-season, environment-friendly pest control, improved quality of fresh and safe vegetables, and improved supply chain efficiency.

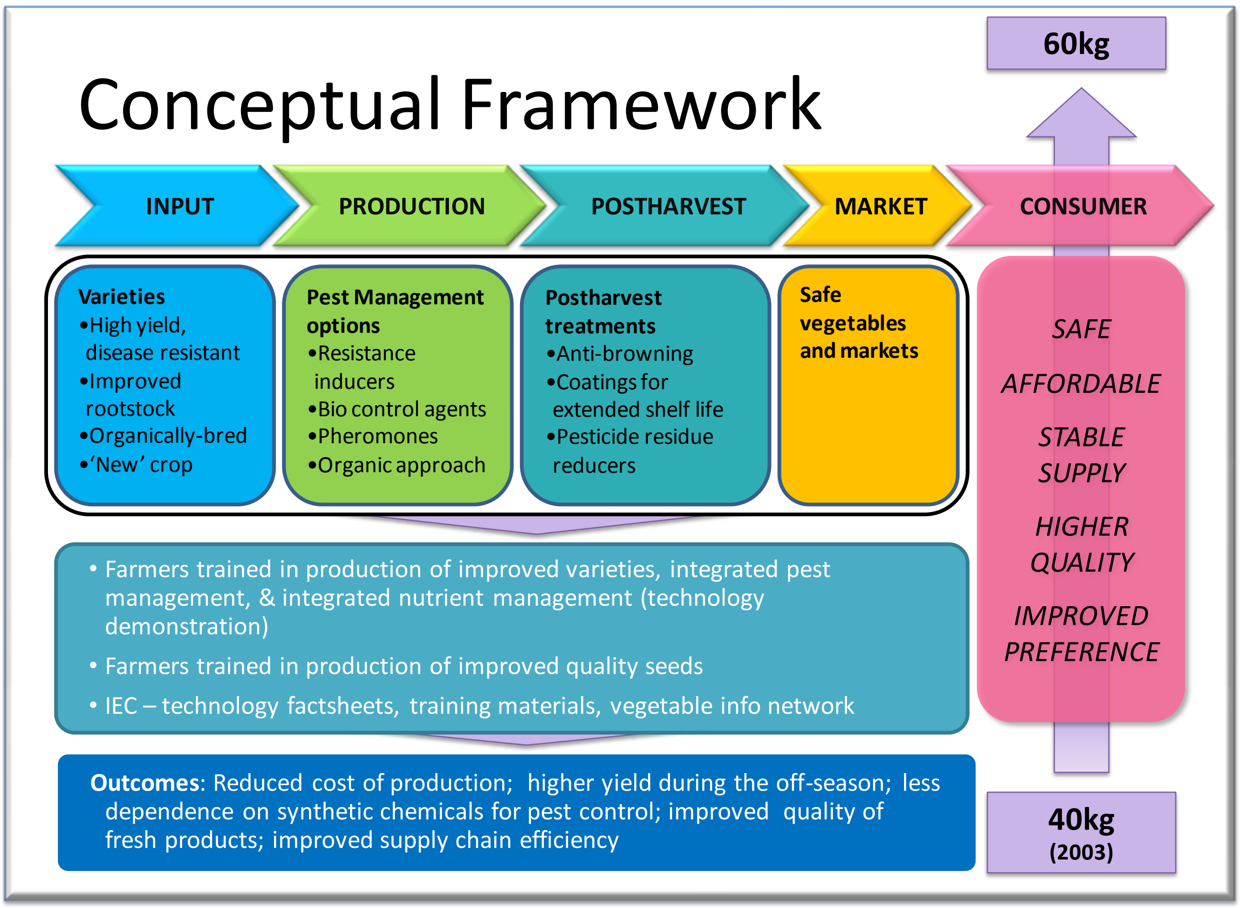

Fig. 1. ISP vegetables conceptual framework.

A.1 Important issues affecting vegetable production

Crop protection. Control of pests and diseases in vegetables in the Philippines is generally through the use of chemical pesticides. Use of pesticides is excessive. Spraying ranges from 20-72 times in eggplant, 16-32 times in tomato and even as much as 2-3 times a day in onion in the case of General Santos City (Table 1). Regulation in the use of pesticides and pesticide residue on vegetables is almost non-existent. Food safety in terms of pesticide residue and environmental protection are issues that have to be addressed urgently. The desired situation is reduced pesticide application up to 50%.

***Postharvest losses*.** Significant losses are observed in major vegetables (Table 1). Postharvest losses range from 30-50% due to poor handling, packaging, transport and storage As much as 50% was lost in eggplant while around 30% losses were observed in tomato, onion, garlic, cabbage, and pechay. The overall target is to reduce these losses by 20%.

Table 1. Frequency of chemical spraying and postharvest losses in vegetable crops.

Crop	Frequency Of Spraying	Postharvest losses
Eggplant	20-72x	5-50%
Tomato	16-32x	30%
Onion	7-10x (sometimes 3x a day)	12-38%
Garlic	7-10x	12-38%
Cabbage	20x	20-27%
Pechay	2-5x/week	20-27%
Squash	rare	

A.2 Identified information and technologies for fresh and safe quality vegetable produce

The reduction of crop losses due to pests and diseases is a critical factor in maintaining the productivity in highland vegetable production system. Therefore, there is a need to obtain greater yields and to produce attractive vegetables that command higher prices and encourage farmers to apply prophylactic sprays of pesticides to prevent damage by these biotic stresses. To reduce application of pesticides new potential BCA were identified by Villanueva (Annual Report, 2014):

- *Bacillus* sp. , *Pseudomonas* sp, and *Flavobacterium* sp., rootknot nematode of tomato and carrots
- *Bacillus* sp. – clubroot, Alternaria leaf spot and cabbage worms in Chinese cabbage
- Indigenous entomopathogenic nematodes (EPN) for rootknot nematode in tomato and carrots, cutworm and cabbage worms in Chinese cabbage
- *Numoraea* sp- pod borer in snap beans
- M*etarrhizium* sp.- cabbage worms in chinese cabbage, root knot nematode in tomato and carrots
- *Verticillium* sp.- rust and pod borer of snap beans
- *Numoraea* sp and *Metarrhizium* sp mass produced in rice grains for powdered formulation and in rice bean broth for foliar spray
- *Verticillium* sp.- mass produced in potato broth for foliar spray
- Indigenous EPN mass produced in lesser wax moth larvae (*A. grisella*) for soil and foliar application

BCA-based technology is comparable to the Organic Farmers' Practice but return to cash expense was 30.19 % higher in Chinese cabbage and 8.37% higher in carrots. Moreover, the use of botanical extracts reduced cost of production and minimizes the use of synthetic insecticides against insect pests and diseases (cercospora leaf spot, anthracnose, phomopsis blight, flea beetles, aphids, cabbage worm) of pechay, lettuce, pole sitao, eggplant, and bush string beans.

On the other hand, the use of grafting technology to reduce disease infection through the use of rootstocks with resistance to *R. Solanacearum* confirmed that hot pepper and eggplant lines are promising. The technique of using the tube grafting compared with cleft grafting technique for sweet pepper production provided more than 90% survival, early flowering and higher yields (Rosales, *et al*., 2014).

The studies on the use of edible coatings or dipping/washing solutions (Nuevo, 2014) showed that coating with combination of iota- and kappa-carrageenan with citric acid improved the textural quality by reducing the degree of shrivelling and incidence of disease, and thus, prolonging the shelf life of intact tomatoes. Carrageenan-coated tomatoes can be stored for up 10 days under ambient condition (29-33°C) while the uncoated samples can only be stored for 6 days.

Intact eggplant dipped in blended gumamela flowers when used as coatings had lower disease incidence which contributed to better visual appearance and extended shelf life of 1 day.

On biotechnology as a tool towards breeding for disease resistance specifically for squash and tomato, Galvez, *et al*. (2014) identified mutant tomato plants and M2:3 families with very high resistance against Tomato leaf curl virus infection; validation in larger sample size (number of progenies) under controlled disease screening of its confirmed resistance is being validated.

B. The national mango research and development program

The Philippines ranks 9th among the top producers of mango in the world, with 2% share in production (FAO 2010). Mango is the third most important fruit crop based on export volume in the Philippines, next to banana and pineapple. It has very high potential as fresh or processed export product to other untapped export destinations.

However, mango production in the Philippines is still constrained by a number of problems that limit its full potential. These include occurrence of pests and diseases, poor nutrition, low adoption of improved technologies, and postharvest losses, that cause substantial reduction in fruit yield and quality. The ISP for mango aims to address these problems by providing science solutions in the form of S&T interventions with corresponding resources to achieve the desired targets.

To address the production constraints, we embarked and invested on two major programs titled "National Science and Technology Program for 'Carabao' Mango" and "Advancing the Philippine Mango Industry: Production of Export Quality Mangoes".

Identified information and technologies on mango

Development of controlled-atmosphere (CA) storage chamber for delayed ripening and prolonged storage life of 'carabao' mango

1. CA storage with “Carabao” mango fruit was designed and the system provided and maintained the following conditions: chamber temperature of 11-12°C; mango pulp temperature of 12.6-13.2°C; % relative humility (RH) of 87-92%; %O_2 of 5-7%; and %CO_2 of 3-5%. Esguerra (2011) reported that the results showed that at 15 days in CA storage, 75% of the fruit were still green and 50% were yellow at 21 days. At 30 days, 100% of the fruit were fully yellow (ripe), with firm flesh and in marketable condition.

2. Mangoes placed in CA chamber free of anthracnose and harvested at the right time (120 days after flower induction [DAFI]) remained green up to 20 days of storage, other fruit harvested at 140 DAFI showed ripening after 20 days of storage.

Fig. 2. At the 10th day in CA storage, 75% of the fruit on the breakers stage, 25% passed the breaker stage.

Fig. 3. At the 20th day, 58% of the fruit have traces of green color.

Integrated disease management of anthracnose and stem-end rot of ‘carabao’ mango

1. The proper use of fungicide under field condition can control 90-96% incidence of anthracnose.
2. Under moderate to high disease pressure, application of either protectant (mancozeb) or systemic (azoxystrobin) at 7-, 10- and 14-day spray interval starting from 35 DAFI up to fruit maturity significantly reduced anthracnose incidence and severity by 95-99%.
3. Under low pressure disease, two sprays of mancozeb can also provide acceptable level of protection against fruit rot.
4. Under low to moderate disease pressure, spray combination of mancozeb-azoxystrobin applied at young fruit stage (35 to 70 DAFI) or before bagging significantly reduce fruit rot incidence ranging from 5 to 15% and disease severity by 1%.
5. New systemic fungicides: pyraclostrobin and triflozystrobin were found effective against anthracnose and scab under field conditions and can be used as alternative to azoxystrobin.

Postharvest management of anthracnose and stem-end rot of `carabao’ mango fruit

1. High temperature short-term dip (HTSTD), a modified heat treatment, consisted of dipping mango fruit within 36 hrs after harvest for 30 seconds to one minute in water heated to 59-60°C was developed. The disease pressure influenced the extent of disease control in the field hence appropriate preharvest fungicide management should be implemented.

2. Postharvest heat treatments need to be combined with fungicide (125 ppm azoxystrobin) to obtain the desired 0-2% disease incidence at the ripe stage for long term low temperature storage (21-28 days at 10-13°C) followed by 3-4 days ripening in ambient conditions.

Fig. 4. Quality of ‘Carabao’ mangoes subjected to different time-temperature combinations.

Future research directions beyond 2015

The identification of resistant varieties through selection breeding will be pursued by collecting and screening of different strains of local varieties, conduct of molecular assisted breeding method, and use of diagnostic kit to identify the best quality planting materials and adoption of packages of technologies on a wider scale through S and T commercial farm or clustering approach of mango growers. The outcome will redound to increased productivity and reduced postharvest losses that will result in prefect quality and safe mangoes for local and international market.

C. The banana R and D program

The Philippines is the 3rd largest producer of bananas in the world next to India and China (FAO, 2010). Banana is the 4th largest agricultural produce of the Philippines in 2011 recorded at 9.16M MT valued at US$ 2.32B. The country is the 4th largest exporter of banana in 2010 (1.59M MT; US $319M) next to Ecuador, Costa Rica, and Columbia (FAO, 2010).

The ISP for banana will cover three major cultivars (Cavendish, Saba, and Lakatan) which have different concerns that need food safety procedure in terms of producing good quality fruit. The production constraints which affect the yield performance and quality of fruit for fresh and process consumption are the occurrence of *Fusarium* wilt tropical race 4 for Cavendish, the banana bunchy top virus for Lakatan, and long maturity duration of Saba. Among local cultivars, Cavendish had the highest share of production (40 %) followed by Saba (35%) , Lakatan (12%), Latundan (8%), and Bungulan (2%) had very minimal share out of the area planted. The 10-15% are managed by commercial plantations; 85-90% by smallhold growers.

Identified information and technologies to address food safety in the banana production

1. The development of protocol to produce clean tissue culture and distribution of planting materials to avoid spread of the banana bunchy top virus is well established. Figure 5 shows the flow of planting materials from the tissue culture to the field with integrated disease management and proper nursery management.

2. Identified new mutant lines of lakatan through irradiation techniques with resistance to BBTV produced. Lower BBTV incidence observed in "bulk' lines compared with "single" lines and "mono" crop control.

3. Identified promising GCTV clones with resistance to *Fusarium* Wilt tropical race 4 with similar yield traits and fruit quality. Based on the initial results of the experiment (Herradura, 2014), GCTCV 218 has lower *Fusarium* wilt incidence in seven experimental sites except in one site (Asuncion site). GCTCV 218 was preferred by three farmer co-operators based on the horticultural characteristics such as having more robust pseudostem, better hand formation, and more uniform hand size with fruit bunches comparable to GrandNaine.

4. The basal application of MykoVAM and Trichoderma during transplanting while the effective microorganism active solution (EMAS), *Bacillus subtilis* and PGPR as soil drench method reduced the susceptibility of Grand Naine variety to FW.

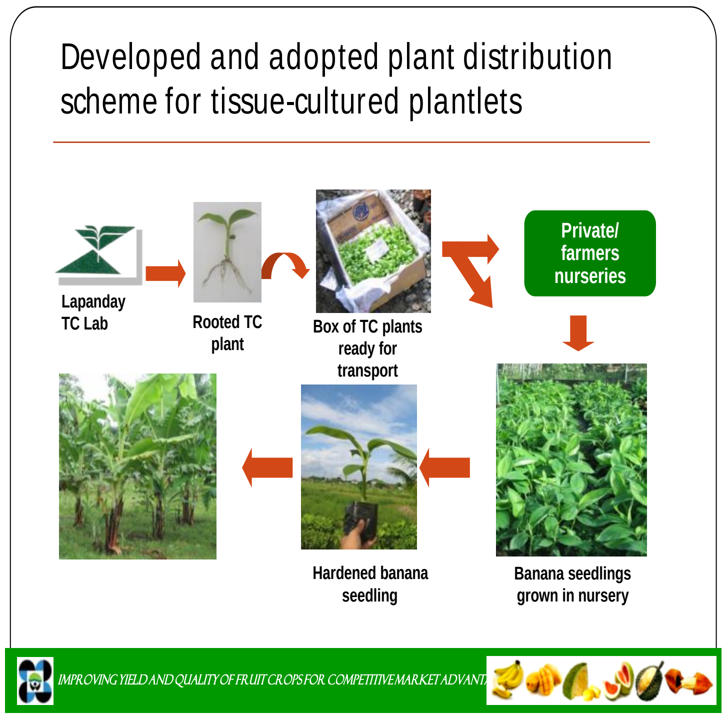

Fig. 5. Distribution system of clean tissue culture planting materials.

With the available S and T interventions along the technological chains, convergence of technologies will be designed for upscaling of packages of technologies in large banana plantation areas with clustering approach of the banana growers.

CONCLUSION

PCAARRD ISPs on fruit and vegetables have identified technologies which can address the food safety concerns of the produce through the inclusion of specific science based and technological approaches in the development of GAP. Since there are still remaining identified research gaps in the technology chain of the ISPs for fruit and vegetables, strong collaboration and full commitment with our key partners from the state universities and colleges

(SUCs) in the selected regions of the country where the majority of fruit and vegetables are grown must be enhanced. Some bilateral arrangements with international research partners like the Bioversity International, Asian Vegetables Research and Development Center—The World Vegetable Center (AVRDC), Taiwan Agricultural Research Institute (TARI) and the like, must be designed to access and exchange new techniques and approaches on food safety concerns which can strengthen the development of science based solutions. Therefore, it may be emphasized that food safety for the fruit and vegetable production through adoption of GAP is extremely important to meet the challenges in the opening of trade among and between ASEAN countries.

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MONITORING SYSTEM ON FRUIT AND VEGETABLES

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ABSTRACT

This paper aims to discuss the efforts done by Philippine government agencies in its efforts to systematically monitor the fresh fruit and vegetables that are sold in public local markets as well as those intended for exports. It focuses on the various responsibilities and accomplishments of these government agencies and identifies its strengths and weaknesses.

INTRODUCTION

In the Philippines, the Department of Agriculture (DA) is the regulatory body in charge with fresh and minimally processed agricultural commodities whereas the Department of Health is in charge with the processed ones. The agencies under the DA are still operating by commodity basis. Thus, we have the Bureau of Plant Industry (BPI), Bureau of Animal Industry (BAI), Bureau of Fisheries and Aquatic Resources (BFAR), and others. The BPI is mandated to ensure safe supply of fresh fruit and vegetables to local and foreign consumers under Republic Act (R.A.) No. 7394 dated July 1991, also known as The Consumer Act of the Philippines. In the recently approved R.A. 10611, also known as the Food Safety Act of 2013, BPI is mandated to develop and enforce food safety standards and regulation for plant food in the primary production and postharvest stages of the food supply chain. BPI shall monitor and ensure that the relevant requirements of the law are complied with by farmers and food business operators.

To keep up with the changing times, the different government agencies underwent rationalization of their functions. For BPI, the Rationalization Plan (RA) was approved last October 10, 2013. The Laboratory Services Division, a division of the BPI, is now known as the Plant Product Safety Services Division (PPSSD). The PPSSD is mandated in ensuring plant product safety through formulation of food safety protocols for fresh and minimally processed agricultural produce and monitoring of compliance with safety schemes as supported by its laboratory activities.

The hazards mostly associated with plant food are pesticide residues, mycotoxins, cyanide, heavy metals, and microbiological contamination such as salmonella and coliform.

MONITORING SYSTEM

Monitoring, as defined in the Food Safety Act, is the systematic gathering of data through sampling of commodities as well as food-borne diseases, collation and interpretation of collected data.

At present, PPSSD has six (6) laboratories that conduct monitoring nationwide (See Table 1). The food safety areas covered are pesticide residues, aflatoxin, salmonella, coliform and microbial count on minimally processed fruit and vegetables.

Monitoring is conducted on local commodities, both for local and foreign consumption, and on imported commodities.

The central laboratory is located in BPI's main office in San Andres, Manila, where the Contaminants Laboratory is situated. The Pesticide Analytical Laboratories, with its area of coverage is also given in Table 1.

Table 1. PPSSD laboratories

Laboratory	Area of coverage for local commodities
National Pesticide Analytical Laboratory (NPAL)	NCR, Regions 3, 4, 5
Baguio Pesticide Analytical Laboratory (Baguio PAL)	Regions 1, 2, CAR
Cebu Pesticide Analytical Laboratory (Cebu PAL)	Regions 6, 7, 8
Cagayan de Oro Pesticide Analytical Laboratory (CDO PAL)	Regions 9, 10, CARAGA
Davao Pesticide Analytical Laboratory (Davao PAL)	Regions 11, 12, ARMM
Contaminants Laboratory • Aflatoxin • Microbiological Analysis	Nationwide

Monitoring for local consumption

a. Pesticide Residues

Five (5) pesticide analytical laboratories are conducting monitoring activities in their area of coverage. Priority crops, or those crops consumed by ordinary Filipinos everyday, are collected by the staff in major public markets / trading posts and fields and are brought to the laboratory for analysis. The DA identifies the following priority crops: salad; chopsuey, and "sinigang" vegetables.

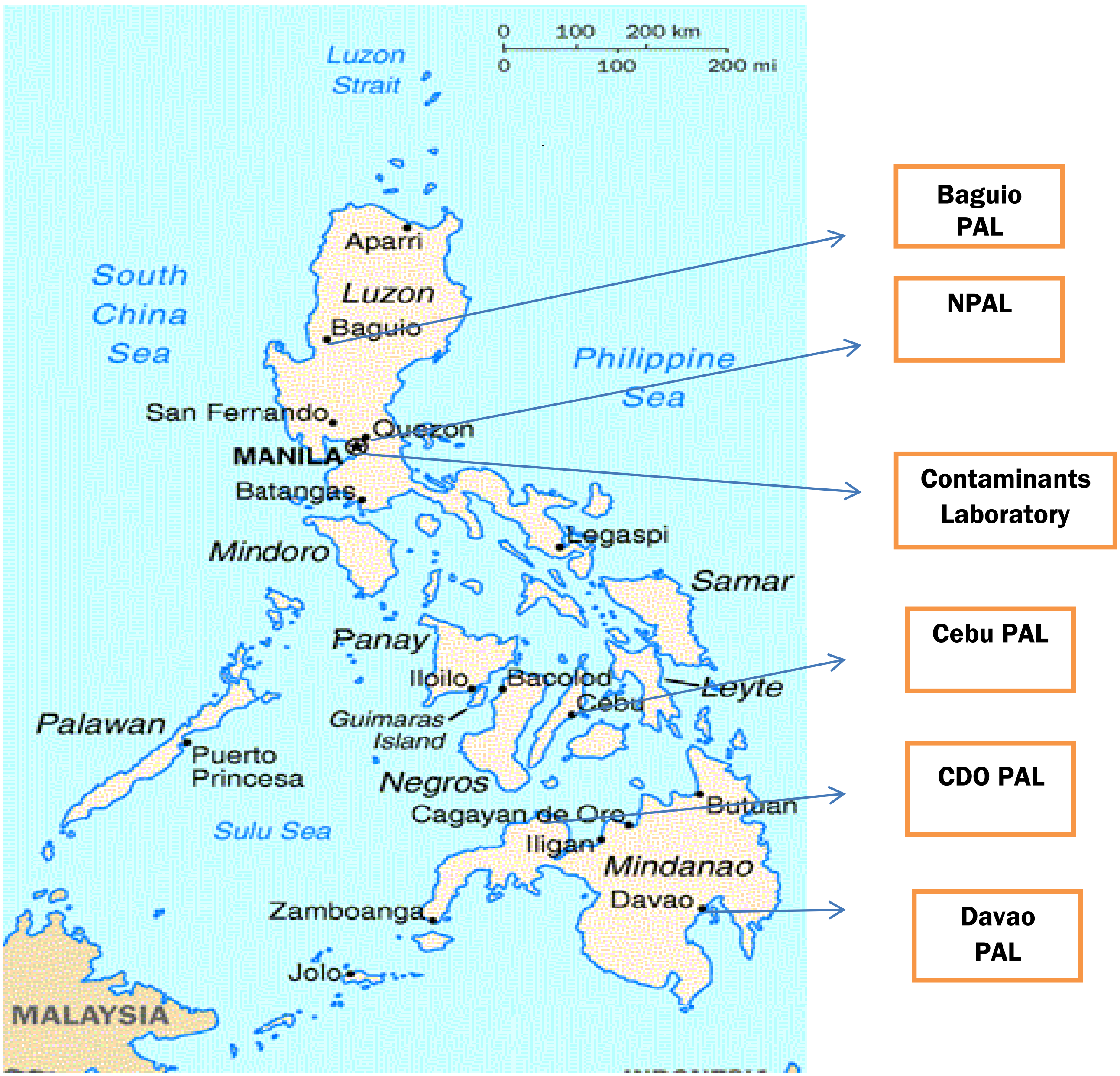

Fig. 1. Map showing the location of the different laboratories

A farmer survey on the most commonly used pesticides in the different localities is conducted by the laboratories. The results of the survey are used to determine the target pesticides in the multi–residue analysis conducted by the satellite laboratories.

The conduct of monitoring is coordinated with the local government unit (LGU) and / or the DA Regional Field Office (RFO). The results of analysis are communicated to these offices.

b. Chemical and microbiological contaminants

Aflatoxin in peanuts, salmonella and coliform in fresh fruit and vegetables are monitored in the local markets nationwide by the staff of the Contaminants Laboratory.

Minimally processed fruit and vegetables are the ready–to-eat commodities found in supermarkets that are collected and analyzed for salmonella, coliform and microbial count. These include salad mix, fruit, and even corn-in-the-cob. The results of analysis are reported, especially the positive ones, to the company supplying these products in the market.

Monitoring for export

At present, monitoring of commodities for export is only done on crops as requested by the importing country. Japan, our major trading partner, has requested the BPI to conduct analysis on mango, okra and asparagus intended for export. The extent of monitoring differs as follows:

- mango – mandatory monitoring of all batch/lot for certain pesticides and reject the ones that fails
- okra and asparagus – monitoring includes inspection of field and packing house and random sampling of the crop for testing.

All of these activities are in partnership with the National Plant Quarantine Services Division, also under BPI.

Monitoring of imported commodities

At present, imported commodities are sampled by the Plant Quarantine Officers and are submitted to the laboratory for testing. Fruit like apples, pears, and grapes are the priority since these are consumed fresh. Ginger, onions, and peanuts are also tested.

CONCLUSION

Monitoring for pesticide residues started when a GTZ project begun in the late 1970s. Equipment was donated by the project as well as the capacity building of the staff. In 1996, the Bureau received a JICA grant and the whole system underwent rehabilitation. We received infrastructure, equipment and capability building. Last year, 2013, we received another grant from Japan’s 2KR project, where the Bureau got more sophisticated equipment for pesticide residue analysis.

With the passage of the Food Safety Act (FSA), the Bureau has to ensure food safety on all possible hazards including contaminants like mycotoxins, heavy metals, salmonella and coliform. PPSSD, at present can only do salmonella, coliform, microbial count, and "thin layer chromatography" analysis of aflatoxins. The laboratory lacks a densitometer to quantify the findings. It also, lacks capability to analyze other mycotoxins and heavy metals. We requested funding to start implementation of the FSA in 2015. Funds needed to procure the necessary equipment, upgrade the laboratory facilities, and improve the capability of the analysts.

The monitoring system being followed by the BPI needs to be improved. One area we need advice on or further training on is the sampling design to be followed in the local markets. At present, our inspector just buys from one (1) kilo of the commodity from three vendors in public markets. Is this enough? Are the data generated reliable and useful? What are the possible uses of these data?

COUNTRY REPORT ON FRUIT AND VEGETABLES CONSUMPTION IN THAILAND

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ABSTRACT

An increasing demand of fresh fruit and vegetables consumption brought awareness on limited production value for those which are locally consumed in Thailand. It also brought awareness on the export value of some fruit and vegetables. Besides the limitation on production value, people are getting concerned over the safety of the produce, specifically on microbiological contaminants and pesticide residues of fresh fruit and vegetables. There are two major Thai government agencies which are responsible for the safety of produce based on its stage in the food chain. These are the National Bureau of Agricultural Commodity and Food Standards and the Thai Food and Drug Administration. Sodium chlorite at 50 ppm and 10% hydrogen peroxide were two sanitizers suggested for microbial decontamination in the produce. Ozone treatment at 1 ppm for 10 minutes showed high efficiency in the reduction of pesticide residues.

Keywords: fruit, vegetables, produce, Thailand, consumption, government, monitoring, safety

INTRODUCTION

Thailand is one of the large produce suppliers in the world. Around one-third of the Thai population are farmers: 5.8 million farms, around 23 million farmers out of 65 million people. Around 40% of the total area are agricultural: 20.85 million hectares agricultural area from 51.31 million hectares of total area. An average farm size is around 3.7 hectares. In 2013, total value of agricultural product exports of Thailand as reported by the Center for Agricultural Information Office of Agricultural Economic amounted to US$39,314 million. Agricultural product exports ranking from the highest export value were natural rubber, rice and fish, cassava, sugar, fruit, shrimps, chicken meat, vegetables and all their corresponding by-products, and residues and waste, prepared animal fodder. Export value of fruit and products is US$2,509.85 million, mostly pineapples in airtight containers which cost US$468.47 million. Whereas, export value of vegetables and by-products is US$648.489 million which is mainly composed of mostly baby corn amounting to US$53.32 million. Food safety in fruit and vegetable products is an issue people are most concerned with Thailand. Produce exports were frequently challenged with an increasing stringent food safety regulation and quality requirements from foreign markets. Thailand has developed the National Good Agricultural Practices program which emphasize on safety of produce as part of its food safety policy. National Good Agricultural Practices (GAP) has been introduced to all farms (Wannamolee W. 2008). Farmers who completed the requirements of the National GAP will be certified by the National Bureau of Agricultural Commodity and Food Standards under the Ministry of Agriculture and Cooperatives. Therefore, the National GAP program is considered as a significant part of food safety for either as high quality fresh consumption, or as high quality raw materials for food processing.

TRENDS IN FRUIT AND VEGETABLE CONSUMPTION IN THAILAND

The Department of Health, Thailand, recommends Thai people to consume fruit and vegetables at least 400 grams per day to reduce risks of cancer and heart disease. Nonetheless, produce supplied to the Thai market will be monitored especially on its chemical and biological contamination in order to control their safety. In addition, consumers are suggested to thoroughly wash, clean, and cook their produce prior to consumption. If fresh produce are preferred, consumers are recommended to purchase from a reliable brand or market. According to Thai recommendation for 400 grams of fruit and vegetable a day, in 2013, consumption demand per year on produce in Thailand will be around 9.5 Megatons. The highest demand, around 3.7 Megatons, is from the central part of Thailand. The demand from other parts was at 2.8, 1.7, and 1.3, respectively from the North-Eastern, Northern, and Southern part of the country, (Saleepan S. 2014). Various kinds of fruit and vegetable products such as fresh, juice, and processed produce have been provided in the market. Nevertheless, the demand for fresh produce consumption as mentioned previously is only about 43% of the production in Thailand. Value of some Thai fruit and vegetable productions in 2012 reported by Office of Agricultural Economics, Thailand, are shown in Table 1. The data was ranked by production value.

Table 1. Value of some Thai fruit and vegetables production in 2012

Type of Fruit or Vegetables	Production Value of Whole Produce (ton per year)	Production Value of Edible Portion from Whole Produce (ton per year)
Pineapple	2,450,000	808,500
Longan	854,000	854,000
Durian	527,327	174,018
Rambutan	335,745	251,809
Baby corn	322,690	242,018
Gros Michel banana	233,200	233,200
Shallot	228,221	228,221
Mangosteen	219,072	164,304
Tangerine	185,084	185,084
Potato	154,849	154,849
Longkong	123,663	123,663
Lime	121,384	121,384
Tomato	110,720	110,720
Dried chili	110,720	110,720
Guava	99,575	99,575
Garlic	85,354	85,354
Lychee	65,965	65,965

Onion	54,300	54,300
Total	6,281,869	4,067,683

Source: Saleepan S. (2014)

In addition, the report from the National Health Examination Survey Office in the year of 2008-2009 revealed that around 82% of Thai citizens are over 15 years old. They have been found to consume fruit and vegetable less than the recommendation. Though, in the next two years, 2010-2011, around 75% of the Thai citizens still consumed the produce less than the recommendation. The National plan to enhance produce consumption includes, but not limited to, public relations on benefits of produce consumption, develop a consumer network on produce consumption, law implementation, or national policy on fruit and vegetable production for household consumption

POLICY AND LEGISLATION ASSOCIATED WITH FOOD SAFETY OF FRUIT AND VEGETABLES

The National Bureau of Agricultural Commodity and Food Standards (ACFS) under the Ministry of Agriculture and Cooperatives is a Thai government agency and a Codex Contact Point of Thailand. One of their major responsibilities is standard setting for agricultural systems, commodity and food items, and food safety. Thai agricultural standards can be divided into three groups: commodity standards, system standards, and general standards (Pongsapitch P. 2011, Saikaew P. 2014). Commodity standards are the standards particularly on an individual produce. Each commodity standard includes scope, definition, minimum requirement and classification for its quality, packaging, contaminant limits and pesticide residues, hygiene, marking and labeling, official inspection or certification mark, and analysis and sampling methods. Examples of some commodity standards from about 58 standards are shown in the Table 2. System standards are detailed in a good practice in general and some major produce. Each system standard includes scope, definition, requirements and inspection methods, and judgment criteria. Example of some system standards from about 61 standards are shown in the table 3: General standards are detailed mainly on food safety such as Maximum Residue Limits (MRLs) of pesticides and methods of analysis. Examples of some general standards from about 21 standards are shown in the Table 4: Besides setting up the standards, ACFS has been designated to monitor and accredit a certified body in the area of agricultural commodities and food products. ACFS also offer training courses for laboratories to improve their standard performance to comply with international standards.

Table 2. Examples of some commodity standards announced by the National Bureau of Agricultural Commodity and Food Standards, Thailand.

Commodities	Standard Number
Longans	TAS 1-2546
Mangosteens	TAS 2-2546
Durian	TAS 3-2546
Pineapples	TAS 4-2546
Mangoes	TAS 5-2546
Thai Hom Mali Rice	TAS 4000-2546
Asparagus	TAS 1500-2547
Peppers	TAS 1502-2547

Okra	TAS 1501-2547

Source: National Bureau of Agricultural Commodity and Food Standards (2013)

Table 3. Examples of some system standards announced by the National Bureau of Agricultural Commodity and Food Standards, Thailand.

Systems	Standard Number
Organic Agriculture Part I : The Production Processing Labelling and Marketing of Organic Agriculture	TAS 9000-2546
Good Agricultural Practices For Longans	TAS 1000-2546
Good Agricultural Pratices For Thai Hom Mali Rice	TAS 4400-2546
Good Agricultural Pratices For Food Crop	TAS 9001-2546
Good Agricultural Practices For Asparagus	TAS 2500-2548
Good Agricultural Practices For Okra	TAS 2501-2548
Good Agricultural Practices For Peppers	TAS 2502-2548

Source: National Bureau of Agricultural Commodity and Food Standards (2013)

Table 4. Examples of some general standards announced by the National Bureau of Agricultural Commodity and Food Standards, Thailand.

Food Safety Standards	Standard number
Pesticide residues : maximum residue limits	TAS 9002-2004
Pesticide residues : extraneous maximum residue limits	TAS 9003-2004
Working principles for risk analysis	TAS 9006-2005
Safety requirements for agricultural commodity and food	TAS 9007-2005
Pesticide residues : maximum residue limits	TAS 9002-2006
Principles for risk analysis of foodsl derived from modern biotechnology	TAS 9010-2006
Assesment of possible allergenicity	TAS 9011-2006
Guideline for the conduct of food safety sssesment of foods derived from recombinant-DNA plants	TAS 9012-2006
Guidelines for the conduct of food safety assessment of foods produced using recombinant-DNA microorganism	TAS 9013-2006
Phytosanitary measures : guidelines for surveillance	TAS 9014-2006
Principles and guidelines for the conduct of microbiological risk assessment	TAS 9015-2007
Principle for the establishment and application of microbiological criteria for foods	TAS 9016-2007

Source: National Bureau of Agricultural Commodity and Food Standards (2013)

MONITORING SYSTEMS ON CHEMICAL BIOLOGICAL CONTAMINANTS IN THAI PRODUCE

The food chain of fruit and vegetable begins at farms and ends at various destinations such as processing plants, exports, domestic markets, restaurants, and consumers. There are different Thai government agencies responsible for each point as produce production or consumption (Fig. 1.). Thai government agency which is responsible for food safety at the farms is the Department of Agriculture, Ministry of Agriculture and Cooperatives; at the primary processing plants or post-harvest processing plant is ACFS; at the food processing plant is the Thai Food and Drug Administration (Thai FDA), Ministry of Public Health. If the produce are being exported, the ACFS will be responsible for monitoring their safety. If the produce will be sold in domestic markets or consumed locally by Thai consumers, the Thai FDA will monitor their safety. If the produce are sold in local restaurants, the Bangkok Metropolitan Administration or other local provincial health offices will monitor their safety.

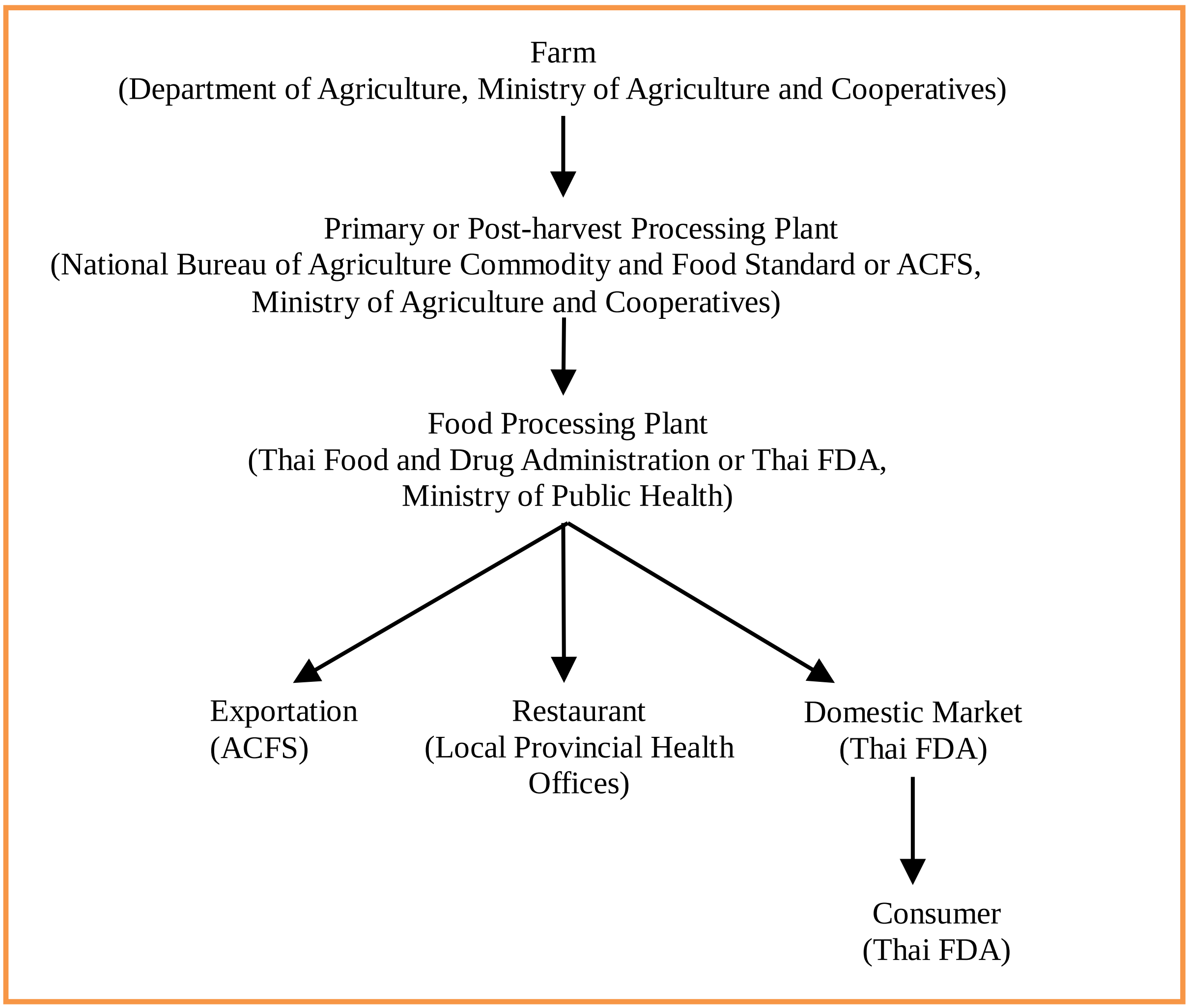

Fig. 1. Government agencies responsible for food safety at each point of food chain shown in parenthesis (Adapted from Thai FDA. 2007)

RESEARCH AND DEVELOPMENT RELATED TO FOOD SAFETY CONTROL ON FRESH PRODUCE

Mahakarnchanakul W. (2013) suggested an approach to remove pathogenic microorganisms in fresh produce by using various sanitizers. Since an increasing demand of high-quality produce all year round, natural fertilizers were used rather than chemical fertilizers. Improperly treated manure, sewage or irrigation water may be used in farms. In addition, most foodborne pathogens are ubiquitous in farm environment. Some pathogens such as parasites and viruses could be contaminated through farm workers. Therefore, *Salmonella* sp. and *Escherichia coli* were found in some produce such as coriander, sweet basil, and mint. Mahakarnchanakul W. (2013) reported that chlorination can reduce pathogens and other microorganisms on produce but they cannot be totally eliminated. Therefore, the control measure should be applied at a potential contamination point such as during harvesting, during processing, and distribution at retail markets, at food service, or household preparation. Nonetheless, there should be an awareness of site selection (due to land history and farm location) together with proper manure handling prior to planting (Rangraian A. *et. al*. 2000). *Escherichia coli* were found to be able to survive in animal fertilizers collected from bats, hogs, cattles, and chickens stored at room temperature better than the one stored at 40°C. The bacteria in fertilizers stored at room temperature can survive up to 12 days, whereas the bacteria in the condition at 40°C survived up to only 6 days. Therefore, high storage temperature could help decrease bacterial contamination in natural fertilizers. In addition to the contamination causes from the fertilizers, produce pickers and handlers could possibly cause pathogen contamination in the produce. Therefore, field management should be considered. For example, irrigation water should be treated to eliminate the pathogens. Field sanitation and hygienic training should be applied to the farm workers. Wildlife and animals living nearby the farms should be prevented from farm entrance or trespass. All activities as previously described should be record for further investigation in case of produce contamination has been found. Mahakarnchanakul W. (2013) reported that adding 50 ppm of sodium hypochlorite in wash water can prevent cross-contamination during the washing process. An application of water circulation system or routinely changing wash water helps reduce the cross-contamination during the washing process. Rangraian A. *et. al*. (2000) suggested chlorine strength for washing process of general crops is 50-500 ppm, for others such as cantaloupe, honeydew, lettuce, cabbage, leafy greens, and apples should be 100-150 ppm. Mahakarnchanakul W. (2013) showed that 200 ppm Sodium chlorite can reduce *S*. Typhimurium for 99.99% and *E. coli* for 98.85, better than the efficacy of 5 ppm chlorine (Table 5). Mahakarnchanakul W. (2013) further studied other sanitizers, sodium hypochlorite and peroxyacetic acid, the 50 ppm sodium chlorite shows higher percent reduction on *E. coli* tested on lettuce, corriander, and mint (Table 6). Though it shows a comparable percent reduction with peroxyacetic acid on cabbage. Two oxidizing agents, chlorine dioxide and hydrogen peroxide, were studied on its efficacy on microbial reduction in mangos. The highest log reduction, 0.51, was the mango fruit treated with 10% hydrogen peroxide for 30 minutes (Table 7). Though, hydrogen peroxide shows highly effective in microbial reduction, it could induce browning reaction in some produce such as mushrooms and shredded lettuce. Nonetheless, the exposure of strawberries and raspberries with hydrogenperoxide could cause color bleaching as of the loss of anthocyanin pigments from the produces (Mahakarnchanakul W., 2013). Other oxidizing agents such as ozone were used for reducing pesticide residues in fresh spur pepper. Mahakarnchanakul W. (2013) reported that spur pepper treated with 1 ppm ozone for 10 minutes show chlorpyrifos reduction for 42-89% and profenofos reduction for 21-66%. Whereas, 50-70 ppm acidified electrolite water and 100-200 ppm sodiumhypochlorite show low reduction efficiency compared to the ozone.

Table 5. Efficacy of sanitizers to reduce mixed *Escherichia coli* and *Salmonella*. Typhimurium contaminated

Type of Sanitizers	Concentration (ppm)	Produces	%Reduction	
			E. coli	*S.* Typhimurium
Sodium chlorite	200	Babycorn	98.85	99.99
Sodium chlorite	200	Asparagus	98.22	99.98
Chlorine	5	Babycorn	87.41	99.69
Chlorine	5	Asparagus	Note detected	99.64

Source: Mahakarnchanakul W. (2013)

Table 6. Percent reduction of *E. coli* after treated with various sanitizers for 15 minutes at room temperature

Sanitizers	Concentration (ppm)	Percent reduction of *E. coli* (logCFU/ml)			
		Lettuce	Cabbage	Corriander	Mint
Sodium hypochlorite	200	99.99	42.48	96.69	99.99
Sodium chlorite	50	99.99	99.2	99.99	99.99
Peroxyacetic acid	80	99.99	99.45	99.99	99.99

Source: Mahakarnchanakul W. (2013)

Table 7. Log reduction of Salmonellae artificially contamination in mango fruit

Treatment	Log Reduction at Different Treatment Periods		
	5 minutes	10 minutes	30 minutes
Tap water	0.05	0.05	0.07
5 ppm Chlorine dioxide	0.01	0.00	0.04
10 ppm Chlorine dioxide	0.06	0.05	0.17
20 ppm Chlorine dioxide	0.07	0.24	0.30
1% Hydrogen peroxide	0.02	0.06	0.06
5% Hydrogen peroxide	0.01	0.06	0.19
10% Hydrogen peroxide	0.21	0.30	0.51

Source: Mahakarnchanakul W. (2013)

CONCLUSION

As one of the large producers of fresh products, Thailand can produce fruit and vegetables roughly enough for domestic consumption, since 75% of Thai population consume produce less than 400 grams a day as per national recommendation. The national plan on public relations and education should be applied to enhance health awareness due to low fruit and vegetables intake per day. Regarding policies, legislation and monitoring for produce safety, ACFS, and Thai FDA are differentiated in terms of their responsibility according to the form of fruit and vegetable products. ACFS is mainly responsible for the fresh produce and the primarily on post-harvest processed produce. Thai FDA is mainly responsible for processed produce through food processing plants. The control measures for biological and chemical hazard in produce are sanitizers and oxidizing agents. Sanitizers either at 50 ppm sodium chlorite or 10% hydrogen peroxide is a good choice for microbial reduction. For chemical residues reduction or pesticide reduction, the treatment with 1 ppm ozone for 10 minutes is suitable for the above mentioned purpose.

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SAFETY VEGETABLE RESEARCH AND PRODUCTION IN VIETNAM: STATUS AND SOLUTIONS

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ABSTRACT

In agricultural production, vegetables are important and considered high economic-value crops. Favorable natural and climatic conditions allow Vietnamese farmers to cultivate most of the vegetable species recognized in the world. There are about 80 vegetable species that are cultivated in Vietnam, of which 30 species are considered main crops which account for 80% of the total vegetable cultivation area and productivity. In 2012, the total area for vegetable production reached 827,000 ha, producing a yield of 13.232 million tons. Together with the development of society, demand for safe vegetables is increasingly huge; research on and production of safe vegetables had led to certain achievements. Advancements in safe vegetable production and VietGAP implementation has been applied and brought about high economic benefit to producers. Among those, net house and low-tunnel vegetable production are the most suitable and profitable techniques. These had been applied at large scale of thousands hectare each year, enabling year-round vegetable production. Tomato grafting (tomato/eggplant rootstock) is also another successful technology which contributes to the development of counter-season tomato production, increasing economic benefit of tomato production to 1.5-1.7 times higher than that in main-season production. In addition to technical advancements, concerns of production organization, support policies and management, and markets have been paid proper attention, promoting development of the vegetable production.

Keywords: vegetable, safe vegetable, VietGAP, GAP

INTRODUCTION

Vegetable production plays an important role in agriculture in Vietnam. Vegetables are not only good source of food for daily diet – of which the annual increase in demand per capita doubles the rate of population growth (FAO, 2006) – but also a source of raw material for the processing industry. In addition, vegetable commodities offer great potential for export with high comparative advantages.

The same as other countries all over the world, vegetable production in Vietnam has been encouraged by technological development in all terms of crop varieties, cultural protocols and postharvest technology which is the prerequisite for improvement in crop yield, quality, and production efficiency.

Nevertheless, intensive cultivation, particularly in increasing use of fossil fuels, undermines sustainability and imbalance of nature. Specifically, if they are not controlled, stages of the production will possibly increase the risk of unsafety to vegetable products and to the environment. Therefore, safe vegetable production is not only based on demands and objectives, but is also very widely used in the orientation of vegetable research and production in Vietnam

SAFETY VEGETABLE RESEARCH AND PRODUCTION IN VIETNAM STATUS AND SOLUTIONS

Vegetable production in Vietnam

The territory ranging on 15 latitudes brings about diversified climatic conditions which enables Vietnamese farmers to grow most of the vegetable species recognized in the world. There are about 80 vegetable species that are cultivated in Vietnam, of which 30 species are main crops accounting for 80% of the total vegetable cultivation area and productivity. The total area for vegetable production in 2013 reached 834,500 ha, producing a productivity of 14.500 million tons. This made the amount of vegetable production per capita approximately 150kg/person/year which was higher than the world's average value, and double the value of 10 nations in the ASEAN. The greatest share in the success of vegetable production in Vietnam belongs to the application of new varieties, particularly the use of F1 hybrid seeds (Table 1).

Table 1: Vegetable production in VN by regions 2008-2013

Region	2008		2010		2012		2013
	Area (1000 ha)	Production (1000ton)	Area (1000 ha)	Production (1000ton)	Area (1000 ha)	Production (1000ton)	Area (1000 ha)
Whole country	722.58	11,511	780.10	12,935	829.00	13,992	834.5
Red River Delta	156.14	2,962	166.20	3,378	177.92	3,581	160.3
North mountain	101.63	1,215	103.60	1,287	115.70	1,443	124.25
North Central coast	80.76	826	84.00	905	86.196	0,992	94.7
South Central coast	46.65	695	65.10	887	64.841	0,911	65.8
Central high land	67.08	1,482	78.30	1,726	86.742	2,005	90.4
South East	70.92	940	129.50	932	58.524	0,955	71,8
Cuu long River Delta	198.40	3,393	221.80	3,822	239.965	4,172	227,2

Source: GSO 2008 – 2010, CPD 2013, CPD 2014

According to the report of Crops Production Department (CPD) - MARD, in 2013, total vegetable production area has reached about 834,500 ha (increased 5.5 thousand ha in comparison to 2012), producing yield of 177.5 quintal/ha (increased 5.53% in comparison to 2012), productivity of 14.5 million tons (increased 3, 7% in comparison to 2012). The production area in the North accounts for 379,300 ha, with the yield of 157 quintal/ha and productivity of 5.95 million tons; meanwhile, the South contributes 455,000 ha, potentially yielding 186 quintal/ha, achieving productivity of 8.48 million tons.

At present the, Mekong River Delta is the largest area for vegetable production in Vietnam (An Giang, Soc Trang, Tra Vinh, Vinh Long provinces), followed by the Red River Delta (Hanoi, Ha Nam, Thai Binh, Hung Yen), North Central Coast (Thanh Hoa, Nghe An), South East (Bắc Giang, Phú Thọ). Provinceswhich produce the highest yield – 200 quintal/ha in average- are Lam Đong, Đak Lak (Central Highlands), Hai Duong, Thai Binh, Hai Phong (Red River Delta), Tra Vinh, An Giang, Kien Giang (Mekong River Delta), Ho Chi Minh City (South East).

Safe and VietGAP vegetables research and production in Vietnam

Program of safe vegetable development was launched in the 1990s, beginning with Hanoi. Technology is the leading solution and has significantly contributed to the development of safe vegetables. In addition to programs at governmental, ministerial, and provincial levels, there have been numerous projects sponsored by international organizations working in this field. The research has focused on the following aspects:

- Identifying threats and/or sources of contamination to fresh vegetables which are later helpful for finding the correction action. The research mainly pays attention to identify contamination sources in terms of chemicals (pesticide residues, heavy metals, nitrate), micro-organisms (E. coli, helminth eggs, samonella), and, physical contaminations (pieces of glass, rocks, soil, plastic...). Objective and subjective reasons, including contamination of cultivation environment, inappropriate cultivation protocols have been determined.
- Production planning. Based on investigation data of contamination sources presenting within the cultivation environment (soil, water, air), land demand, market demand, the provinces have established production plans at different levels. Up to this time, many provinces have approved a long-term planning to 2020, including Hanoi, HCMC, Thai Nguyen, Bac Giang, Đa Lat. Numerous districts have also developed detailed plan. Among the concerns, distribution and quality management in production, handling and distribution of vegetables are paid the most attention.
- Developing protocols of cultivation, handlings for safe and VietGAP vegetables. The MARD has issued the first national general standard protocols for safe vegetables (prepared by FAVRI in 1996) as decision number 1208 KHCN/ QD dated July 15th 1996). After that, the provinces issued standards for specific crops. Hanoi issued more than 30 protocols for vegetables during the period from 1998-2000, Da Lat 16 protocols (2002), HCMC 22 protocols. On January 28, 2008, MARD promulgated decision 379 on VietGAP for safe fruit and vegetable production. Many national standards of selecting sites of production, handling safe vegetable production were also established.. Two VietGAP protocols for tomato and cucumbers by FAVRI (2009) were agreed to be applied in practice by the Department of Crop (Decision 369/QĐ-TT-CLT dated September 28, 2009)
- Demonstration establishment. Most of the subjects and projects established demonstration pilot sites focusing on different aspects of production at different scales. The subjects focused on establishing demonstration of production and handling management; meanwhile the projects focused on improving linkages between production and markets. Large projects such as CIDA (Canada), ADDA (Denmark) established pilots at large scale in different areas in the country. The demonstrations had influences on cultivation customs and awareness of farmers in vegetable production areas.

Till now, most research focuses on the technical aspects. Developmental aspects, such as production management, distribution; supply and production monitoring system, handling and postharvest management, haven't been paid enough attention.

On January 28, 2008, the MARD promulgated Decision 379/QĐ-BNN-KHCN on implementing GAP for fresh fruit and vegetables. However, result of the six-year implementation was not as good as expected. According to data of DCP (2013), 376 safe vegetable demonstrations achieved VietGAP certificate, with a total area of 1,897.82 ha – accounting for 0.23% oft he total vegetable area. In 2010, safe vegetable production in the Red River Delta accounted for only 8%; that proportion inVN was 2% (Dept of Plant Protection) (Table 2).

Table 2: Area of safe vegetable demonstrations achieved VietGAP certificate by 2013

TT	Crops	Unit	Area (ha)	Ratio (%)	No of Demonstrations achieved VietGAP certificate
1	Vegetable	Ha	1,897.82	0,23	376
2	Fruit	Ha	6,663.58		444
3	Rice	Ha	1,334.80		18
4	Tea	Ha	4,205.44		116
5	Coffee	Ha	4.00		4
	Total	ha	14,105.64		

Source: CPD 2014

Reasons of small proportion of safe vegetable production were identified as follows:

- Scatering and small-scaled production; poor cultural techniques . Poor farmers' awareness;
- Regional planning safe vegetable production has been approved currently by only 5/63 provinces;
- Support policies on safe vegetable production have yet to be applied in localities;
- Weak state's human resource in management and monitoring;
- VietGAP protocol is not really suitable for production condition in Vietnam and there is lack of technical guidance for specific crops;
- Lack of/weak linkages between producers, traders and market; no quality standards to distinguish from normal vegetables resulting in small economic value, hence not promoting production.;
- Poor capability of private certification bodies; and
- Lack of wholesale markets for safe vegetables meanwhile purchasing in conventional markets is common

Setting a goal to promote safe vegetable production, the DCP has simplified VietGAP so as to make it easier for farmers to implement and satisfy the requirements of production, handling, recording.

3. Application of high technologies in vegetable production in Vietnam

3.1 Application of new varieties

According to the report on performance of science and technology tasks specified in Resolution 26/NQ/TW of the Central Committee for Agriculture, Farmers and Rural Areas, during the period from 2008 to 2013, Vietnam had 396 crop varieties approved, of which 102 varieties were rice, 27 corn, 25 beans, 13 root/tubers, 15 vegetables, 10 edible mushrooms and other crop species.

There are three groups of vegetable varieties cultivated in Vietnam:

- *Local varieties:* A vast majority of local varieties are OP varieties which have long cultivation history. Thirty percent of commodity vegetables belong to this group. Vegetatively-reproduced vegetables, such as kangkong, celery, katuk, onion, garlic, Sang vegetable (*Melientha suavis*), Bo Khai (*Erythropalum Scandens Blume*) maintain their characteristics over generations. Many of them are considered local specialties. Meanwhile, varieties of sexual production usually show gradual decrease in growth and development, yield and quality, and degeneration, particularly pollinating varieties. Many local vegetable varieties of high quality have been paid more attention and rehabilitated by researchers and farmers, i.e. Lien Chieu kangkong, Đông Dư green mustard, Tu Lien radish, Thanh Tri common bean (Hanoi), Ly Son garlic (Quang Ngai), Thai Binh radish, Hoa Binh green mustard, Man Son La cucumber, Thanh Hoa cucumber, Sang vegetable (*Melientha suavis*), Bo Khai (*Erythropalum Scandens Blume*), Mong green mustard, Bong Dien dien (*Sesbania Sesban)* in Mekong River Delta. This development should be encouraged to enlarge the production area of indigenous vegetables to 40- 45% of agricultural land area, and to avoid indigenous genetic loss due to prevalence of introduced varieties.

- *Introduced varieties*: Due to vernalization, these varieties bloom only when there is long-lasting cold period in which the temperature is lower than 10 degrees Celcius depending on the origin. Most of those vegetables belong to *Brassicaceae, Umbelliferae, Alliaceae* families*which* include cabbage, kohlrabi, cauliflower, Chinese cabbage, onion, leek, carrot Some of them can flower in the condition of high mountainous areas (higher than 1000m), but breeding and preserving seeds in such condition requires great effort. Demand for seeds of vegetables belonging to this group accounts for 17-22% of total vegetable production area. Currently, the seeds – mostly F1 hybrid - are mainly imported from Japan, South Korea, the Netherlands, and partly from China. Commercial production of vegetables of this group generally concentrates in Lam Dong province and Red River Delta. In the future, the share of these introduced varieties in vegetable production in Vietnam will likely remain since they are mainly consumed in the domestic market which is relatively stable. Before being officially imported, cultivation and economic value of these varieties and their seeds must be tested with the application of VCU so as to avoid risks to farmers.
- *Domestically-bred varieties*: The group includes fruit vegetables of *Solanaceae*, *Cucurbitaceae*, *Fabaceae* families: tomato, chilli pepper, eggplant, cucumber, bitter gourd, water melon, muskmelon, momordica, peas, beans, cowbean, green soybean these fruit vegetables can be used in fresh form (domestic market and export) and as raw material for processing. Vegetable commodities/products of this group, including both fresh and processed ones, dominate the export turnover of the vegetable production industry in Vietnam. Except for those of *Fabaceae and Cucurbitaceae* (momordica), a vast majority of this group are F1 hybrid. Their share in vegetable production in Vietnam is gradually increasing. Production area of vegetables of this group explains approximately 50% total land area of vegetables and the proportion is expected to remain in the coming years.

Despite of the encouragement to conduct research on breeding of these vegetable varieties, and has been the attention of many organizations and institutes in Vietnam, proportion of introduced varieties is still very high, particularly to two tomato varieties Anna of Simminis Co. mainly cultivated in Lam Dong, and Salvior of Sygenta Co. in the North – which account for half of the total tomato production area in the country. The other tomato varieties which are developed by institutions under VAAS (Vietnam Academy of Agriculture), HUA (Hanoi University of Agriculture), Thai Nguyen University, and domestic companies contribute to only 20% of the production. The situation is the same to other crops. However, the prospect will possibly improve in the coming years since domestic hybrid will replace imported seed – which results from higher investment in breeding.

3.2 Technologies

Seedling production

Over 70% of vegetables are transplanted from seedlings. Therefore, vegetable seedling production is considered a specific industry. Producing seedlings in the nursery has various advantages:

- Saving vegetable seed s: hybrid seeds of many of vegetables are costly. Sowing seeds in trays or in humus germination media in the nursery will improve the germination rate, vitality of seedlings and increase production efficiency.
- Tending seedlings in the nursery with protection is easier and saving labor of watering and applying fertilizers.

In the intensive production area in the South, there have been establishments/companies which are specialized in providing seedlings to a large areas of production, up to half a million hectares. In Lam Dong province, particularly, there are more than 30 enterprises operating under this form, such as Phong Thuy Company

(Đuc Trong district) – which produces approx. 20 million seedlings of high quality, earning tens of billions VND each year. Mechanization has been applied in various stages of the seedling production procedure, i.e. producing media, sowing, tending seedlings.

Seedling production industry in the North is less developed than that in the South. Traditional techniques dominate most of the seedling production stages: sowing seeds on beds with protection. Even in large-scaled enterprises as in Mr Nguyen Van Nghiem's establishment in Từ Hồ, Mỹ Văn (Hưng Yên provice)which annually produces millions of seedlings of tomato, brassica, cucurbit, most of the techniques are manual. Farmers who planted, for example, spice vegetables, Dong Du green mustard (Gia Lam), also produce the seed themselves by saving seeds from the previous seasons. In Vinh Phuc province, the situation is better since the seedlings are produced in net-houses and partly use plastic trays for seedling germination.

Since 2005, grafting technique has been applied in production of vegetable seedlings, particularly in tomato seedling production. The techniques use varieties which are resistant to soil-borne diseases, especially bacterial wilt caused by *Ralstonia solanacea*. Most of tomato production areas in Lam Dong – which makes up 5000 ha/year – apply this technique. It also has been developed in Moc Chau district (Son La province) with capacity of 2-3 millions of seedlings per year, and other provinces of Hải Dương, Vĩnh Phúc, Bắc Ninh but at smaller scale. Total area of tomato production using grafted technique in Vietnam reached 7000-8000 ha/year. By using this technique in offseason tomato production, the famers income can increase by 1,5-1,7 time compared with non-grafted tomato production in the main season.

High-tech cultural techniques

Applying high technologies in safe vegetable production is the appropriate and necessary direction. This is also the common development trend of urban and peri-urban horticulture in the world. Many completely-imported models have been implemented in Hanoi, Hai Phong, Nghe An (from Israel), in Binh Duong, Đa Lat (from Australia), but the efficiency is very small. Therefore, various research works have been carried out in order to improve the efficiency. The research focuses on the following techniques:

- Nutrient film technique (NFT): replacing metal pipes with plastic ones, developing nutrient solutions for the crops at different stages of development, and improving the net-houses. The studies were conducted by HUA (2004-2007), FAVRI (2008-2010), and Thai Nguyen University (2011-2012) Experiments carried in those institutions and in the demonstration model established in Hoai Duc-Hanoi by the Agricultural and Environmental Institute produced a yield of 200 tons lettuce/ha/10 harvest seasons, green mustard: 140 tons/ha/5harvest seasons. Other kinds of vegetables, such as celery, kangkong, spice vegetables also produced high yield and efficiency, satisfying safety requirements and are produced all-year round..
- RtoW or growing crops in nutrient media with drip irrigation for fruit vegetable crops: tomato, cucumber, capsicum, melon has been studied in terms of identifying crop varieties and media; preparing nutrient solution; cultivation techniques, net-house structure. The application has brought about high efficiency. Tropical Flower Company (Moc Chau district, Son La province) produced tomato at the yield of 230-260 tons/ha, cucumber 13-150 tons/hawhich are 5-7 times higher than production in open fields. Da Lat GAP company (Lac Duong district, Lam Dong province) also achieve the same result. The reality has shown that this technology is more efficient when it is applied in the condition of highland areas where the weather is cool and temperate.
- Safe vegetable production in net-houses and low net tunnels: this technology is suitable and popular in Vietnam. One of the first demonstrations of producing vegetables in net-houses was established under cooperation between FAVRI and GINO Co., with equipment from Taiwan. More than 20 vegetable species were cultivated within 3 ha of net-houses in GiaLam (Hanoi) during the period of 1995-1996, providing a

basis for further current research and development. In Da Lat, after the implementation of producing flowers in net-houses of Hasfarm – a Dutch Co. in 1994, many net-houses with frames made of bamboo were built for vegetable production, bringing about high efficiency. Currently, there are over 50% of vegetable production carried out in net-houses (approx. 500 ha), producing significantly higher yield and quality. Safe vegetable production in low tunnel net is much developed in the provinces of Red river delta and it's suitable for year-round vegetable production. Area of vegetable production using this technique reached 1000 ha/year.

A survey of economic benefit of safe vegetables in Ho Chi Minh City in 2010 showed that safe vegetable production in net-houses brought about significantly higher efficiency than in open fields. Safe vegetable production in net-houses enabled 5 cycles of production which yields 75.6 tons of vegetables per hectare and gains revenue of 230 million dong/ha, of which 114 million dong was net profit. Meanwhile, safe vegetable production in open fields allowed only three production cycles with the yield of 35.2 tons/ha, earning a revenue of 98 million dong/ha and 34 million dong of net profit.

The MARD has currently developed a plan for an agriculture high-tech application area to submit to the government. Many provinces have been planning the high-tech area and sought for support from the government to establish the high-tech area for agriculture, such as Phu Yen, Nghe an, Binh Duong, Gia Lai… in general, there are demonstrations of high-tech area for agriculture which have been developed in provinces of Lam Dong, HCMC, Bac Ninh.

3.3. Postharvest technologies

- *Preservation technologies*. Until now, research missions regarding research and applying technologies to preserve fresh vegetables have been carried out at two stages of the production cycle:

+ Pre-harvest stage: includes identifying harvest maturity, particularly to fruit vegetables (cucumber, bitter gourd, squash, okra; covering to avoid influence of rains and wind to leafy vegetables and spices, and covering sweet-tasting fruit, i.e. melons, capsicum In addition, there are recommendations in using adsorption ethylene, ethylene inhibitors (ReTain, 1-MCP) to decrease the rate of ripening These area measures to maintain appearance and quality of vegetables before and at the harvest time increasing value to the commodities.

+ Selection of preservation measures are selected based on types of fresh vegetables and purposes of preservation. Room-temperature preservation is used for transportation and/ore storing for processing. Meanwhile, cold-temperature preservation is mostly used in storehouses and supermarkets. Temperature and humidity for each type of commodity are also identified.

+ Modified atmosphere preservation is widely employed together with the use of PE (LDPE and HDPE). The technology allows changing the composition of the air, creating a suitable environment and preventing penetration of micro-organisms.

+ Cold storage combined with MAP is used to double preservation life in comparison with normal preservation

+ Controlled atmosphere preservation has been tested on various kinds of vegetables , but the application is limited due to high investment requirement

- *Processing technologies*: are long-term preservation, usually from 6-12 months. Current studies have improved the appearance of processing industry:

+ Use appropriate temperature to sterilize canned products so as to maintain their quality

+ Use bio-products during treatment of raw materials instead of chemicals to have safe and more-natural products.

+ Processed vegetables which have been studied and had processing protocols are: pickles (cucumber capsicum, tomato, baby corn, bamboo shoot), beverage (squash, pennywort, mixture of vegetables); dried vegetables (chilli pepper, onion, garlic); frozen products (vegetable corn, sweet corn)

Solution to develop safe vegetables in Vietnam

Textual documents, capacity building, coordination mechanisms.

- Continue to review and sufficiently issue provisions, especially the technical regulations in the entire chain;
- Train and invest in capacity building of certification bodies
- Issue written agreements on the mechanism of coordination between the Ministry of Health, Ministry of Industry and Trade and the Ministry of Agriculture and Rural Development on chain control.

Organizing production

- Support the initial infrastructure, training, guiding the organization and operation of organizations (cooperatives, cooperative groups,)
- Support training, completing apparatus for associations

Technical aspects

- Organize assessment, analysis of hazards of food safety in the entire chain;
- Train, guide, monitor facilities that operate advanced quality control system (VietGAP, GMP, SSOP, HACCP);
- Establish and multiply demonstrations of safe production
- Monitor, evaluate to classify and certify meeting food safety requirements in the entire chain
- Publicize results, monitoring, assessment and classification of production and trading facilities/enterprises;
- Deploy confirmation of the origin of products, control along the chain;
- Have strict sanctions for cases violated.

Science and Technological aspects

Apply advances in production, processing products to ensure food safety;

Research, transfer and apply production and processing technologies towards mechanization;

Trade promotion, product advertisement

- Support to establish linkage among production, distribution and retailing of actors in the chain;
- Establish media products to advertise products, how to identify the products
- Organize trade fairs, international and national symposia to introduce products;

Proposal for scientific and technological solution to safe vegetable development

Production planning

At present, there are two main vegetable production areas in Vietnam

- Concentrated and intensive vegetable production in the peri-urban and industry zones: accounts for 40% and 45% of total land area and productivity, respectively, in Vietnam. Vegetables in these areas are mainly used for local consumption, thus types of vegetables are diversified. High land use coefficient (4.5 production cycles/year) and high intensive production cause increasing risk to food safety.

Besides, due to high urbanization, the land area for agricultural production is gradually decreased; meanwhile demand for vegetables is increasing. This leads research on vegetables to focus on the aspects below:

+ high-tech vegetable production: with covering, hydroponics technique to leaf vegetables, RtoW to increase yield (3-8 times higher than production in open fields) and ensure food safety.

+ production management and linkage between production and market: a major part of vegetable production in Vietnam is at household level which is an obstacle to application of high technology to practice, and causes difficulties in monitoring and inspecting production. Research on production management, handling and distribution of the vegetables as well as ensure appropriate benefits amongst producers, traders and consumers are driven to sustainable production.

- Cereal-intercropped vegetable production areas: located in Red River Delta and Mekong River Delta. The production in these areas supplies vegetables which are in demand in domestic markets, processing and export.

Research directions for these areas:

+ Use of new varieties, mostly F1 hybrid seed of high yield, quality and resistant to pests and diseases, satisfying market demand.

+ Complete safe protocols for specific kind of vegetables in specific localities. Research on organic production includes studies on bio-fertilizers, bio-pesticides, bio-products for fresh vegetable preservation

+ Postharvest technologies: includes handling, packaging, and industrial processing. Particularly, processing should focus on export products, such as pickled, dried and paste products.

- In order to meet the requirements of agriculture in general and crop production in particular, many localities which have relative advantages and favorable natural conditions have developed specialties, indigenous vegetables of high nutrition and medicinal value. This is also the common development trend in the world. The World Vegetable Center (AVRDC, 2012) estimates that proportion of indigenous vegetables should account for 30% of households' daily vegetables. These vegetables have existed in the locality for generations so that they are able to adapt to the local natural conditions, and accumulate nutrients and medicinal chemicals, creating specific flavor. Indigenous vegetables can be found everywhere in Vietnam. However, the most concentrated areas are those in the North and Mekong riverside. The research aspects on indigenous vegetables are:

+ Investigating, identifying and determining the nutrition contents, medicinal value and agro-characteristics of the vegetables so as to use them in specific areas:

+ Research on propagating methods and cultivation protocols for high-value indigenous vegetables.

+ Research on postharvest technology and market (mostly export) for the indigenous vegetables.

In the future, this indigenous vegetable production will bring about high efficient and of high market demand.

Safe vegetable production technology

This is the most important stages related to types of vegetables, cultivation conditions and market requirements. The research, hence, should be completed after different cultivation stages.

Main research aspects:

- To complete cultivation protocols for specific vegetables grown in open fields. Currently, the MARD (Department Of Crop Production) has issued two protocols for safe tomato and cucumber production implementing VietGAP and standards for production, handling and distribution. These standard protocols need to adapt to specific cultivation areas and specific vegetables.

- To safe vegetable production in protected areas, i.e. in the net-houses, greenhouses, which requires high investments, cultivation protocols needs to bring about high yield that relatively equals to potential yield so as to get appropriate capitals and profit. High technologies, such as NFT, RtoW, need to be adapted to specific vegetable production. Besides, materials used for construction of the net-houses/greenhouses should be also paid more attention to be suitable for climatic condition of the production sites (high land, flatted areas).

- *Research on bio-products for vegetable production.* These are bio-pesticides, bio-organic fertilizers, growth regulators. Despite of their profit, these products are used at a small proportion in comparison with other agro-chemicals; and a major part is imported from other countries at high price. In order to encourage the application of these bio-products, research for specific kinds of vegetables and pest/diseases are required and the price needs to be affordable to the producers.

- *Organic vegetables production* is a part of safe vegetables production, but at higher requirements. Research to be based for promulgation of standards should focus on production conditions, market requirements and economic benefit.

Postharvest technologies

- *Preservation technologies*. Since vegetables contain high content of water and susceptible to pest and diseases, research on vegetables has currently paid attention to ways to prevent harmful organisms, decrease respiratory rate and evaporation. The most common measures are cold storage, freeze drying, films and chemical treatment. Use of synthetic chemicals in storage is not recommended on vegetables. Selection of storage technologies should be based on purposed of storage: short term for local consumption, long-term for distant transportation or export.

- *Handling technologies*. In industrial processing, the technologies are usually accompanied by suitable equipment, following below respects:

+ Handling raw materials for export and industrial processing: pickled cucumber and capsicum, dried onion, garlic, capsicum...

+ Processing technologies can be manual or semi-automatic. The products are pickles of cucumber, tomato, baby corn, chili, tomato, momordica pastes; dried garlic, onions, potato, and chili producing beverages from vegetables such as momordica, tomato, squash. Concern regarding food safety of these products should be paid attention

+ Handlings are required before distribution. This can include harvesting.

CONCLUSION

Vegetable production is a sector which is done through the application of high technologies. Safe vegetables and VietGAP vegetables are paid attention by researchers but its development depends on other managerial factors.

In order to provide safe commodities to consumers, vegetables need to go through various stages in the production cycles and distribution. Violation of each stage will have impact on the quality of the products and health of the consumers.

As an important part in household daily diet, and with the high productivity 140-150 kg/person/year – which is high in the world – the concerns of vegetable production are to improve quality for fresh and processed vegetables. This is decided by two factors: diversification and safety of vegetables. Research on vegetables in the coming years will still focus on the aspects mentioned above.

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SESSION 2:
THEMATIC PRESENTATIONS

SAFETY OF FRUIT AND VEGETABLES ON MARKET OPPORTUNITIES

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ABSTRACT

To ensure safety of fruit and vegetables, the implementation of Good Agricultural Practices (GAP) and other related standard schemes is a key to get market access, especially to modern trade. Governments in many countries in Southeast Asia introduce national GAP schemes to farmers to products that are safe from chemical residue limits, as well as biological and physical contamination. Other players in the supply chain such as processors, retailers, and consumers look at certification and more emphasis on traceability system. Consumers would like a safety mark and information on product's origin to be on the package. Safety standard thus, is one of the factors affecting competitiveness in agrifood trade.

INTRODUCTION

Fruit and vegetables are mostly sold in traditional markets in most countries in Asia, although the growing of supermarket chains and growing trends of urban lifestyle result in an increasing market share of fruit and vegetables through modern trade. On the other hand, in developed countries, produce are sourced through complex sources in different parts of the world. Market power, therefore, is in the hands of retail business with major private certificate schemes playing role in fruit and vegetables export especially from Asia in which safety is often times more voluntary than mandatory.

This paper will review the link of food safety with standard scheme, status of regional scheme and will pick some analysis of behaviors and trends that drive the market of fresh produce.

GAP AND ASEAN GAP

Good Agricultural Practices (GAP) has been widely implemented in fruit and vegetables production to ensure food safety. It is these practices that need to be applied in the farm during preproduction, production, harvest, and postharvest phases. In many cases, such practices also help to protect the environment and safety of the workers.

At the farm level, the scope covers both the farm and the pack house level. The focus at the farm level is concentrated on the following: environmental hygiene; hygienic production; maintaining food safety during handling; cleaning maintenance; and personal hygiene. At the pack house, the focus are mainly centered on uniform flow of produce without back tracking to cross contamination, control of postharvest treatment and handling, maintenance and sanitation, and personal hygiene.

In Asia, GAP has been introduced to growers as a practice to produce safe fruit and vegetables from pesticide residue.

ASEAN countries have made significant progress in improving safety of agricultural produce through the implementation of GAP. National GAP standard schemes were developed in many countries in the ASEAN, for example Q-GAP (Thailand), VietGAP (Vietnam) and SALM (Malaysia).

Some of the schemes undertaken have become successful in raising the awareness and are well accepted by domestic buyers. However, the national GAP standards of other ASEAN countries, namely Brunei Darussalam, Cambodia, Laos PDR, and Myanmar are still at various stages of development.

The ASEAN GAP was adopted in 2006 and was launched in 2008 by the ASEAN Senior Officials Meeting-Ministers on Agriculture and Food (SOM-AMAF) to enhance harmonization of national GAP programmes within the ASEAN region. It specifically focuses on fresh produce as stated in the objectives that it aims at enhancing the safety and quality of fruit and vegetables for consumers and facilitating the trade of fruit and vegetables regionally and internationally (Sareen, 2014).

Toward the single economy among ASEAN countries by 2015, ASEAN GAP will become an important benchmark for ASEAN member countries who already have their national GAP and for those who do not have, can choose to adopt this regional standard. It is also bench marking with other international standards such as the GLOBAL GAP so that it may be recognized by World Trade Organization (WTO) as an international trading standard. In terms of policy implementation, it should be practically accepted between partners for cross-border trade of fresh produce (Sareen, 2014).

Global Food Safety Initiative (GFSI), a business driven initiative hosted within 'The Consumer Goods Forum', does benchmark with existing food safety standards that are used starting with the farm and progressing through food distribution, manufacturing, wholesale, and retail. It successfully agreed with 7 major global retailers (TESCO, Walmart, Metro, Carrefour, Migros, Royal Ahold, and Dalhaize) to accept GFSI benchmarked for food safety schemes. GFSI is not just another food safety standard, but also provides guidance.

FOOD SAFETY OF FRUIT AND VEGETABLES

Three categories of food safety hazards under ASEANGAP are; 1) chemical, 2) biological and 3) physical.

Chemical hazards mainly focus on agrochemical residues in produce that exceed maximum residue limits (MRL). In biological hazard, the common types of pathogenic micro-organisms associated with fresh fruit and vegetables are: *Salmonella, Escherichia coli (E. coli), Shigella* and *Listeria monocytogenes* (Sareen, 2014). In the US, the top causes of outbreaks between 1990 and 2005 in fresh produce by numbers are *Norovirus* (40%), followed by *Salmonella* (18%), E. coli (8%) and *Clostridium* (6%) and among the fresh produces, most of outbreaks were caused by green based salads contamination (Dewaal and Bhuiya, 2009).

Fresh fruit and vegetables can be contaminated through direct contact of produce with the hazards or indirectly through the produce coming into contact with contaminated soil, water, people, equipment, materials, fertilizers and soil additives, packing materials, transportation vehicles, and so on.

MARKET AND BEHAVIOR

Information from Fresh Trend in 2002 said consumers would like fresh produce packaged stating whether chemical treatment was used (90.7%), followed by organically grown (86%) and country of origin (85.9%) while those stating nutritional value comes at less priority (77.1%) (Cook, 2007).

Besides, a survey in April 2014 in almost 500 of senior executives of food, drinks, and consumer goods manufacturers, found that these business leaders cited traceability and transparency as their top goal for their company (44%). Other goals included were lead reducing waste and emissions (42%) and sustainable sourcing (41%). The same survey reported wellness (47%) and securing food safety (46%) as their top goals for the next 12 months (Anonymous, 2014).

Food safety outbreak is a nightmare for food producers. It damages business as well as the brand. Many incidents of food safety outbreaks of fresh produce caused by unintentional foodborne pathogens, while outbreaks of food with more and more cases have been found to be caused by intentional food fraudwhich many can be traced back to lack of knowledge (Anonymous (2), 2014).

Higher price and brand names are not direct signs of safer food. Consumers want to see evidence on product labels indicating that their food has passed some kind of independent safety certification process. Moreover, slightly more than one-third of consumers are willing to pay for a premium in upwards of 30% more for food with a safety certification label (Cameron, 2010).

A recent paper on consumer research has found the reasons why there are consumers who are willing to pay more for an ethnic standard. It said that ethical consumption is motivated by a need for consumers to turn their emotions about unethical practices into action. Three common emotions driving ethical behavior are contempt, concern, and celebration (Gopaldas, 2014). For example, anger can motivate consumers to reject unethical products, while joy and hope can lead consumers to cultivate ethical habits and increase participation.

'Food safety management system (with certificate) can help to get market access, and not only needed when there is a demand from client', an executive of a supermarket chain in the UK said.

CONCLUSION

Efforts have been exerted to make National, Regional, and International safety standard schemes work so that our fruit and vegetables are safe for consumption. GAP scheme is available in most fresh produce in exporting countries in Asia. Processors, retailers, and consumers look at food safety and traceability as their top priorities. Although, food certification and food testing companies are quietly benefiting from food safety awareness, it is also clear that a safety standard is needed to gain trust, and create market opportunities.

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PROMISING NEW TECHNOLOGIES FOR ASSURING FOOD SAFETY

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ABSTRACT

Four promising new technologies for assuring food safety are introduced. 1) Fluorescence fingerprint technique was applied to detect food hazards. It is nondestructive and a quick measurement. As examples of food hazards, detection of mycotoxins in wheat flour and prediction of aerobic bacteria population on beef surface are shown. 2) High electric field alternating current (HEF-AC) technique provided effective inactivation of B. subtilis *spores in orange juice. HEF-AC technology can be scaled up and can be applied to consecutive processing, making it a suitable inactivation technology for practical use. Besides, HEF-AC retained more fragrance and nourishment components than ultra-high temperature. 3) The development of the multiplex PCR detection kit for four pathogenic bacteria in food samples is shown. When the kit was used to detect the pathogenic bacteria, one cell per 25 g of sample was detected within 24 h. There was excellent agreement between the multiplex PCR assay and the conventional method. The detection kit will be valuable as a screening method for foods contaminated with these pathogens. 4) Liquid chromatography Orbitrap–mass spectrometry is a powerful technique that has very high sensitivity and selectivity. Its application enabled detection of several mycotoxin derivatives without chemical standards.*

Keywords: fluorescence fingerprint, high electric field alternating current, multiplex PCR detection, liquid chromatography orbitrap–mass spectrometry

INTRODUCTION

Food safety is a scientific discipline describing handling, transportation, storage and retailing of food in ways that prevent foodborne illness. This includes numerous routines that should be followed to avoid potential health hazards. Potential risks of food safety in fresh fruit and vegetable products are contamination of harmful biological or chemical agents during handling, transportation, storage, and retailing. In order to share experiences on research and development to ensure safety of fresh fruit and vegetables, here I introduce here four promising new technologies for assuring food safety.

Fluorescence fingerprint

Fluorescence is well known technique in analytical chemistry. Its measurement is made by a pair of stimulus and response which are excitation light and fluorescence spectra. However, if we can have more information from the sample, we could have more precise or more identification at the same time. That is the reason we introduced fluorescence fingerprint (FF), in other words, excitation emission matrix. Fig.1 shows the principle of data acquisition for fluorescence fingerprint. Scanting of excitation wavelength produces a lot of fluorescence spectra. They can be a three dimensional volume data consisting of an excitation wavelength axis, an emission wavelength axis and a fluorescence intensity axis. This is FF. The top view of the graph (contour map) shows an original pattern which reflects samples is optical property. Conventional fluorescence analysis usually uses only one peak. However, not only peak, but also other points could have some related information to the objective. In addition, as all data is recorded in digital value, we can extend the analysing area to the whole area using a powerful computing PC (Shibata *et al.* 2011; Kokawa *et al*. 2011; 2012; Oto *et al.* 2012).

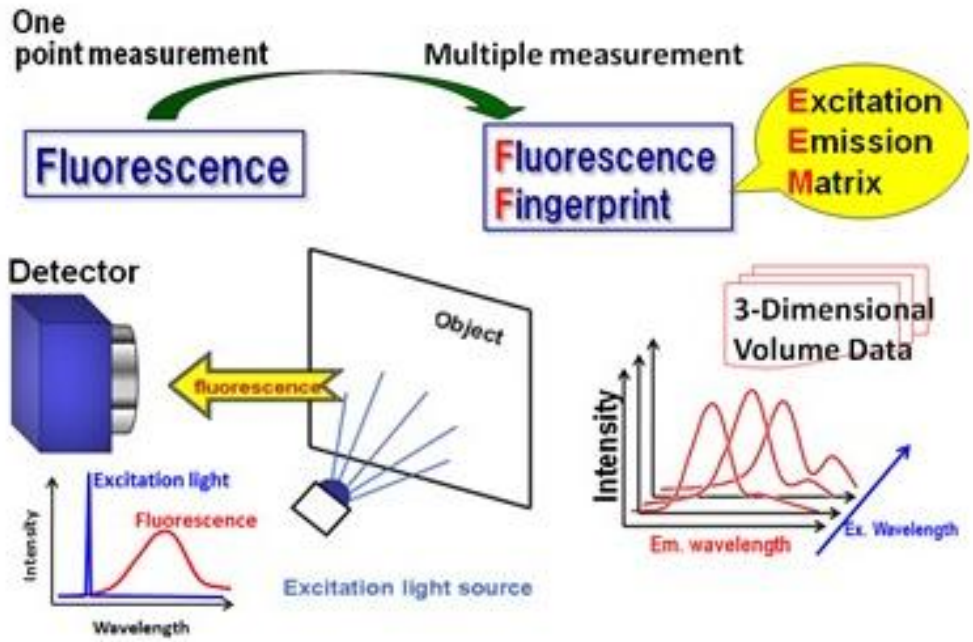

Fig. 1. Fluorescence fingerprint

The quantification models were developed using partial least squares (PLS) regression with leave-one-out cross validation to the FF data of the calibration samples. The performance of PLS models depends on the number of latent variables (LVs) used. The optimum number of LVs was determined by minimizing the root-mean-square error of the prediction of cross-validation. The calibration model was applied to the validation dataset to evaluate the accuracy of the model. The fitting of the calibration model to the calibration and validation datasets was finally evaluated by the coefficient of determination (R^2), standard error of calibration (SEC), and standard error of prediction (SEP) .

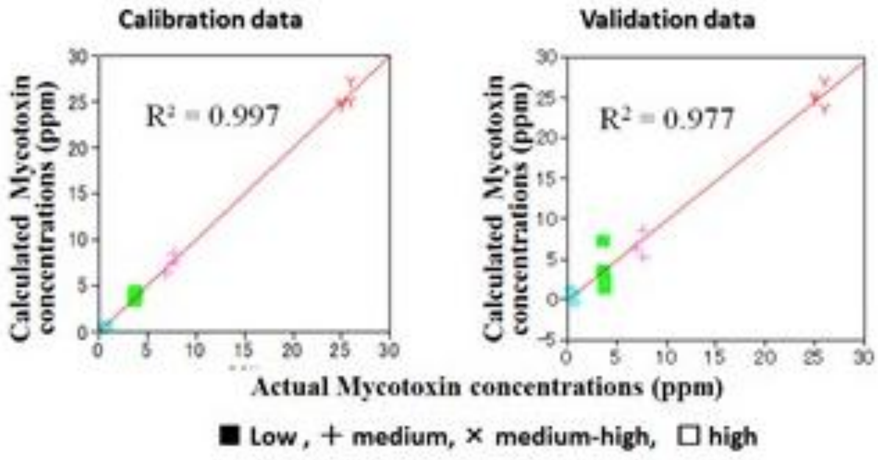

Fig. 2. Prediction of DON

In Japan, the most common contaminated mycotoxin in wheat is deoxynivalenol (DON). Concomitant contamination of other mycotoxins such as nivalenol (NIV) and zearalenone (ZEA) are also found. The wheat samples were artificially contaminated with *Fusarium graminearum* in the field. Four different levels (Low, medium, medium-high, and high) of contaminated wheat were harvested. They were ground into flour by the milling machine. To predict quantitative contamination level, PLS regression was applied. Actual contamination level was measured by HPLC-UV. Fig. 2 is the prediction of DON concentration in contaminated wheat flour. Both calibration and validation datasets show significant correlations between actual values and predicted values. However, degree of contamination is different from DON. FF also reflects on these contaminations. There could be created the model to predict for NIV and ZEA from the identical FF. The results of NIV and ZEA prediction have good correlations with chemical analyses, indicating that the FF can predict DON, NIV, and ZEA concentrations at the same time.

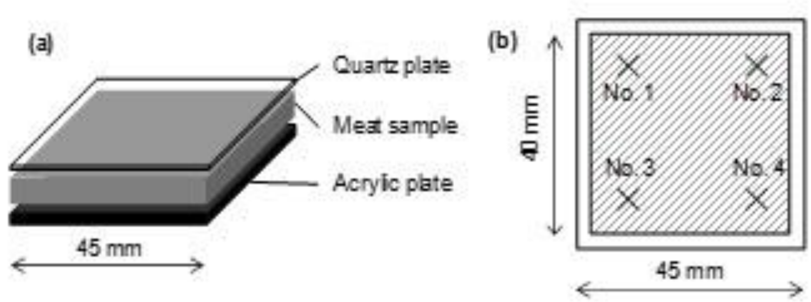

Fig. 3. Sample preparation for FF and APC measurement (Cross mark No. 1-4: FF measurement positions, Shaded area: swab both surfaces of meat and quartz plate for APC measurement)

Lean beef pieces were purchased from a local meat store and they were cut into 45 x 45 x 8 mm pieces. Samples were stored aerobically by putting them into sterilized plastic Petri dishes with lids. Each lot of beef samples were stored in an incubator at 15 °C and analyzed after 0, 12, 24, 36, and 48 h of storage. Samples were placed between quartz plate and an acrylic plate (Fig. 3a) and mounted in the sample holder in the spectrophotometer. A Fluorescence spectrophotometer mounted with a front-surface sample holder was used to measure FF. FFs were measured in the range of 200 ~ 900 nm for both excitation and emission wavelengths. Four locations (Fig. 3b), cross marks, No.1 - 4) were measured for one sample at room temperature. A total of 240 FFs (4 lots x 5 different time of storage x 3 samples x 4 positions) were collected. After FF measurements, 40 mm squared areas on both quartz plate and beef sample were wiped with a sterile swab (Fig. 3b, shaded area). To ensure adequate sampling, the sample was swabbed in a horizontal pattern and again in a vertical pattern, while being rotated between the index finger and thumb in a back and forth motion. Serial dilutions of the swab sample were prepared with the phosphate buffer solution in which the swab was immersed, then aerobic plate count (APC [CFU/cm^2], CFU: Colony forming unit) were determined by incubating 1 ml of appropriate dilution on PetrifilmTM Aerobic count plates for 48 hr at 35 °C . A total of 60 APCs (4 lots x 5 different time of storage x 3 samples) were determined through the entire experiment.

PLS regression was applied to FF to develop a model for the prediction of aerobic plate count (APC). In this case for the beef meat, prediction model for the aerobic plate count was made with seven latent variables (LV)which gave best result with highest correlation and lowest SEC. From the result for validation set, good correlation (R^2 = 0.819) and small SEP (SEP = 0.752 log [CFU/cm^2]) were obtained and the accuracy of the model was verified.

High electric field alternating current

Heating has been generally used for inactivating micro-organisms in foods, but heat treatment of foods also destroys delicate fragrance components and useful functionality components. Therefore, a high electric field pulse, a high-intensity light pulse and radioactive rays have been researched and developed both domestically and abroad as non-thermal inactivation methods, but these methods are expensive and their use is limited to food industry applications that demand large-scale processing.

Internal heating caused by an electric current has been used for 100 years and can be divided into two types, microwave heating and ohmic heating. Microwave heating technology has spread from industrial use to home use with products employing electromagnetic energy at a frequency of 2.45 GHz for heating food. The ohmic heating method is older than microwave heating and was reportedly used to inactivate micro-organisms in milk in 1920. However, ohmic heating using a high frequency of around 20 kHz has become a useful technology in the food industry and has been used to process fish cake since 1990 because of the increased stability and increased energy efficiency. It had been believed for a long time that micro-organisms in food were inactivated by the electrical effects of ohmic heating. However, ohmic heating did not induce electrical effects for inactivation, and Imai *et al.* reported on the characteristics of the breakdown of the cell membrane when an electric field was used in the ohmic heating of vegetables, where the voltage in a cell was close to 1 V.

A high electric field pulse, a non-thermal inactivation technology, inactivates micro-organisms in foods using high-voltage pulse sterilization with a very narrow pulse width (less than 10 μs) and high electric field strength (more than 10 kV/cm).

A potential difference is induced between the two ends of the cell membrane when a high-strength electric field is used on a cell for sterilization. A hole subsequently opens in a local fragile site of the membrane by electricity perforation through a mechanism called electroporation. Hulsheger *et al.* reduced *Escherichia coli* two orders of magnitude when they applied 30 pulses of 30 µs width in a 12 kV/cm electric field. Qin *et al*. succeeded in reducing *Escherichia coli* six orders of magnitude by applying 60 pulses with 3 µs width in a 40 kV/cm field. Pothakamury *et al.* applied 50 pulses at 16 kV/cm to *Staphylococcus aureus* in a food model of milk and reduced the bacteria by four orders of magnitude. Electroporation is known to be generated on a cell membrane when an electric potential exceeding 1 V per cell is applied. Uemura et al. developed a high electric field alternating current (HEF-AC) technology that combined ohmic heating and a high electric field. HEF-AC was originally designed to inactivate *Escherichia coli* in liquid foods by Uemura and Isobe (Uemura and Isobe, 2002). The inactivation was caused by a combination of electric field effect and Ohmic heating effect. Geveke *et al*. applied a 20 kHz, 18 kV/cm electric field called a radio frequency electric field to *E. coli* in apple juice at a moderately low temperature of 50°C, reducing the *E. coli* to 3 log by the high electric field effect. High-voltage pulses were not able to inactivate spores (Geveke *et al.*, 2006). Uemura et al. used a HEF-AC with an electric field of 10 kV/cm on *Bacillus subtilis* spores that were added to orange juice and reduced the number of bacteria by four orders of magnitude by heating the electrode exit to 120°C (Uemura and Isobe, 2003). Inoue *et al*. used a HEF-AC on various microorganisms, including the highly heat-resistant spores that were added to a model liquid, and reduced the bacteria by over three orders of magnitude (Inoue *et al*., 2007). With HEF-AC, rapid heating at temperatures higher than 100°C was required to inactivate *B. subtilis* spores in a short time. In this study, we inactivate *B. subtilis* spores in a orange juice by a practical scale HEF-AC and compare the quality change of HEF-AC treated orange juice with a ultra high temperature (UHT) treated one.

Fig. 4. outlines the HEF-AC setup. Raw orange juice in a tank is fed at a constant flow rate of 100 L/hour. The internal pressure in the pipe between the feeder pump and the relief valve is controlled at 0.5 MPa by the pressure of the valve. The AC power supply had a 2,000 V maximum output voltage, 50 kW maximum output power and a 20 kHz square-wave AC. An electric treatment unit was constructed with a parallel plate electrode made of titanium (6.0 mm in width and 32 mm in length, with 4.0 mm between electrodes) and a surrounding insulator made of Teflon (Fig. 5).

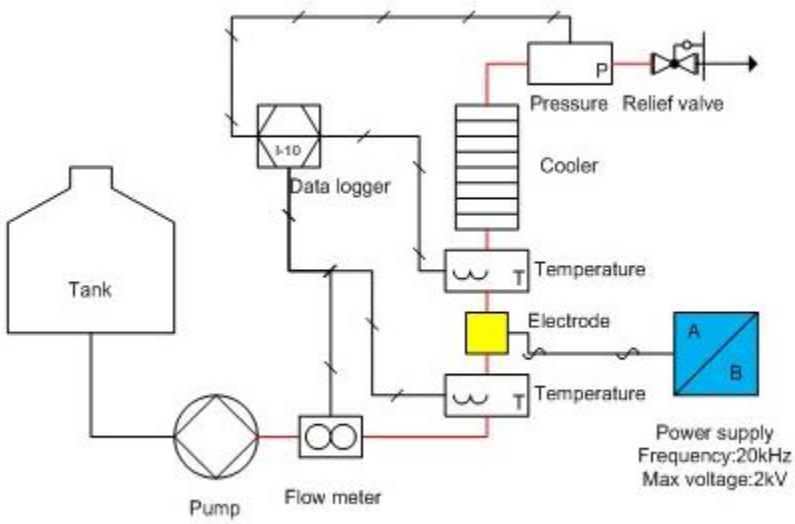

Fig. 4. HEF-AC setup

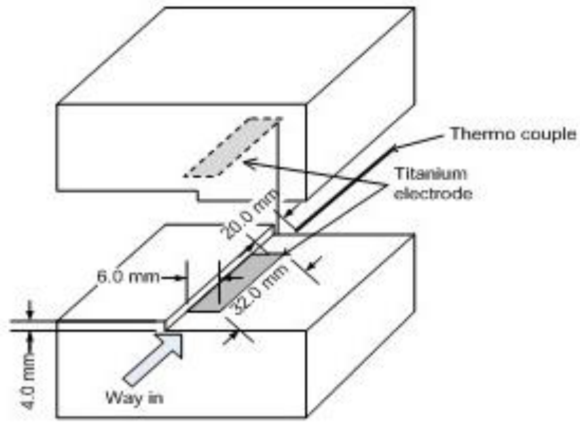

Fig. 5. Longitudinal section of electrode unit

Inactivation of B.subtilis spores

An electric field of 2.8 kV/cm to 3.0 kV/cm was applied to 10^6 cfu/mL *B. subtilis* spores in the orange juice (Fig. 5); the outlet temperature and the sterilization effect are presented in Fig. 6. The sterilization effect increased when the electric field strength applied by the HEF-AC increased, and the electrode exit temperature rose from 110°C to 120°C. The sterilization effect increased with increasing outlet temperature, and the spores were reduced by four orders of magnitude at 120°C.

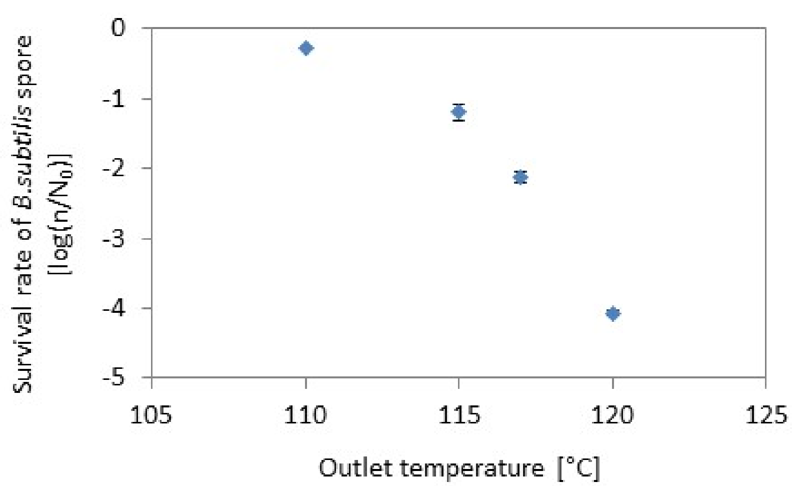

Fig. 6. Viability loss of *B. subtilis* spores in orange juice using HEF-AC at different outlet temperature (n: Viable counts at indicated temperature, N_0: Initial viable counts)

Quality change of orange juice

The comparison of the content of linalool and limonene was documented. They are fragrance components of orange juice after the HEF-AC and UHT treatments. These results demonstrate that 24% more linalool and 15% more limonene remained in the orange juice after HEF-AC treatment than after UHT treatment. The results the effects on β-carotene, hesperidin, and L-ascorbic acid content in orange juice after HEF-AC treatment and UHT treatment indicate that 25% more β-carotene, 18% more hesperidin, and 8% more L-ascorbic acid remained in the orange juice after HEF-AC treatment than after UHT treatment.

The results revealed that HEF-AC treatment clearly retained more functional components of orange juice compared to conventional UHT treatment. Most likely, this was due to the fact that the holding time, in case of HEF-AC was almost ten times shorter than in the case of UHT treatment, so that HEF-AC preserved these functional components.

Multiplex PCR detection of pathogenic bacteria

Foodborne illness caused by *Salmonella* spp., *Listeria monocytogenes*, or *Escherichia coli* O157:H7 is a major public health concern worldwide. There are approximately 1.4 million cases of illness annually, resulting in 1,000 deaths. To prevent these outbreaks, the ability to rapidly detect these pathogens in food is critical.

Reliable detection techniques are a prerequisite for the detection and identification of these pathogenic bacteria in foods, food sources, and food processing plants. Because the conventional culture method for detecting pathogens (Fig. 7., Left side) is time consuming, results are frequently not available until the food has been either released to the market or consumed, thus increasing the risk of transmission of pathogens. Pathogens are often present in very low numbers against a background of indigenous microflora, rendering the recovery of target organisms difficult. Rapid and sensitive assays with high specificity are required for the detection of pathogenic bacteria in foods and other types of samples. The polymerase chain reaction (PCR) is a biochemical technology in molecular biology used to amplify a single copy or a few copies of a piece of DNA across several orders of magnitude, generating thousands to millions of copies of a particular DNA sequence. PCR-based methods have the potential for the rapid and sensitive detection of foodborne pathogens. Because PCR can target unique genetic sequences, such as the virulence genes of microorganisms, it has the advantage of being an extremely specific assay.

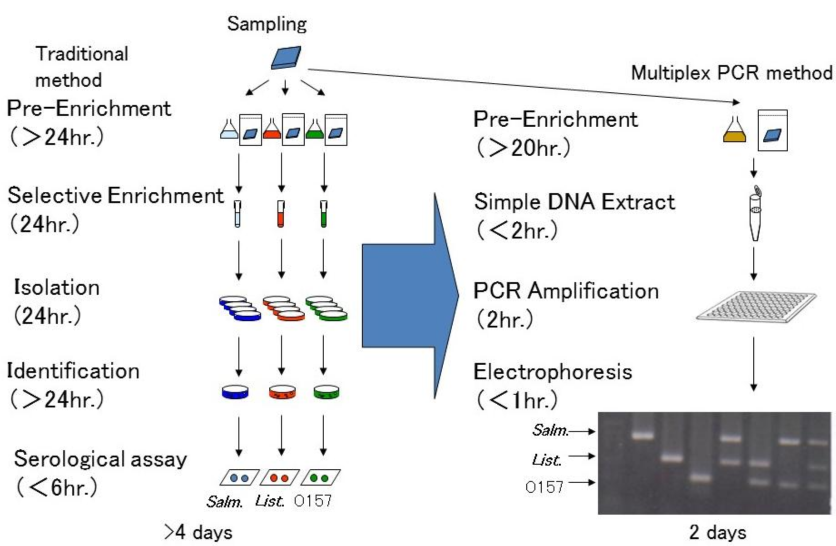

Fig. 7. Schematic representation of detection procedure of conventional culture method and multiple PCR method

The multiplex PCR method is capable of determining the presence of *Salmonella* spp., *L. monocytogenes*, and *E. coli* O157:H7 directly from enrichment cultures by targeting the specific DNA sequences of each pathogen (Kawasaki *et al*., 2005). This multiplex PCR method was used to detect pathogens in spiked pork samples, and the detection sensitivity for each pathogen was 1 CFU per 25 g food sample after enrichment for 24 h. Moreover, there was excellent agreement between the results of the multiplex PCR and the conventional culture method in naturally contaminated meat samples.

The schematic representation of the conventional culture method and the multiplex PCR detection method is shown in Fig. 7. This multiplex PCR method is simple to use, and the results are typically available within 24 h compared to at least four days for the conventional culture method. The multiplex PCR detection protocol consists of three steps: 1) pre-enrichment culturing, 2) simple DNA extraction, and 3) multiplex PCR detection. Firstly, an enrichment medium allows the simultaneous growth of *Salmonella* spp., *L. monocytogenes*, and *E. coli* O157:H7 for subsequent detection of each pathogen using a multiplex PCR assay with similar sensitivity. Secondly, a simple DNA extraction method ensures the high sensitivity of the multiplex PCR assay. Finally, the multiplex PCR component concentrations have been optimized for the specific detection of *Salmonella* spp., *L. monocytogenes*, and *E. coli* O157:H7. The results of limit of individual target strains for multiplex PCR shows that the correct PCR product was clearly detected in each of the target genomic DNA samples estimated to contain 1 cell/PCR (10^3 CFU/ml of culture) (Kawasaki *et al.* 2005).

This multiplex PCR detection method has high sensitivity, since one cell per PCR reaction tube was detectable. Therefore, the multiplex PCR is a useful method for the rapid screening contaminated food for *Salmonella* spp., *L. monocytogenes*, and *E. coli* O157:H7. There have been many reports on pathogen detection using PCR methods for various foods, such as chicken, milk, ground beef, etc. (Thomas *et al*., 1991; Croci *et al*., 2004). However, many of these reports described detection from pure cultures or from a specific food matrix. There have been few reports describing sample treatments conducted prior to PCR to remove PCR inhibitors from a variety of food matrices followed by the detection of pathogenic bacteria.

To evaluate the practical use of the multiplex PCR method for detecting the three pathogens in foods, the conventional culture method was compared to the PCR assay using 75 commercial food samples (Table 1). For *E. coli* O157:H7, one sample (pork intestine) was found positive using the multiplex PCR method, but this *E. coli* isolate was confirmed to be *E. coli* O55 by the conventional culture method and serological testing. Of the 75 food samples, 13 were found positive for *Salmonella* spp. by the multiplex PCR method, but only nine samples were positive by the conventional culture method. For *L. monocytogenes*, 15 samples were positive by the multiplex PCR assay compared to 14 samples by the conventional culture method.

Table 1. Results obtained with the multiplex PCR and conventional culture methods from the retail food samples

Sample	*Salmonella* spp.		*Listeria monocytogenes*		*E. coli* O157:H7	
	PCR	Conventional	PCR	Conventional	PCR	Conventional
Chicken	12 / 37	9 / 37	11 / 37	11 / 37	0 / 37	0 / 37
Pork	1 / 14	0 / 14	1 / 14	2 / 14	1* / 14	0 / 14
Beef	0 / 7	0 / 7	2 / 7	1 / 7	0 / 7	0 / 7
Minced meat (Pork and Beef)	0 / 3	0 / 3	1 / 3	0 / 3	0 / 3	0 / 3
Sea food	0 / 5	0 / 5	0 / 5	0 / 5	0 / 5	0 / 5
Others	0 / 9	0 / 9	0 / 9	0 / 9	0 / 9	0 / 9
Total	13 / 75	9 / 75	15 / 75	14 / 75	1 / 75	0 / 75

* : O55 was detected from culture method

The multiplex PCR assay was also performed on spiked frozen food samples. The detection frequency of the pathogens from 28 samples stored at -20 ^{0}C for periods of two weeks and two months was documented. The detection rate for each pathogen using multiplex PCR was higher than that of the conventional culture method in all the post-storage frozen samples. The detection rate decreased using both methods on samples stored for two months at -20 ^{0}C compared to those stored for two weeks. This was evident particularly for *Salmonella Enteritidis* since detection by the culture method declined considerably after frozen storage. The detection rate for each pathogen by multiplex PCR was greater than 75% for all food samples after frozen storage for two months (Kawasaki *et al.*, 2009).

Detection of mycotoxin derivatives by high-resolution LC-Orbitrap MS

Liquid chromatography–mass spectrometry (LC-MS) is an analytical chemistry technique that combines the physical separation capabilities of liquid chromatography with the mass analysis capabilities of mass spectrometry. LC-MS is a powerful technique that has very high sensitivity and selectivity and so is useful in many applications. Its application is oriented towards the separation, general detection and potential identification of chemicals of particular masses in the presence of other chemicals (i.e., in complex mixtures), e.g., artificial chemicals from natural-products extracts, and pure substances from mixtures of chemical intermediates. The Orbitrap (Fig. 8), a new type of mass analyzer, has drawn attention due to its analytical performance in terms of resolution and mass accuracy. Here I show the case of mycotoxin derivatives as an example (Nakagawa *et al.* 2011; 2012; 2013).

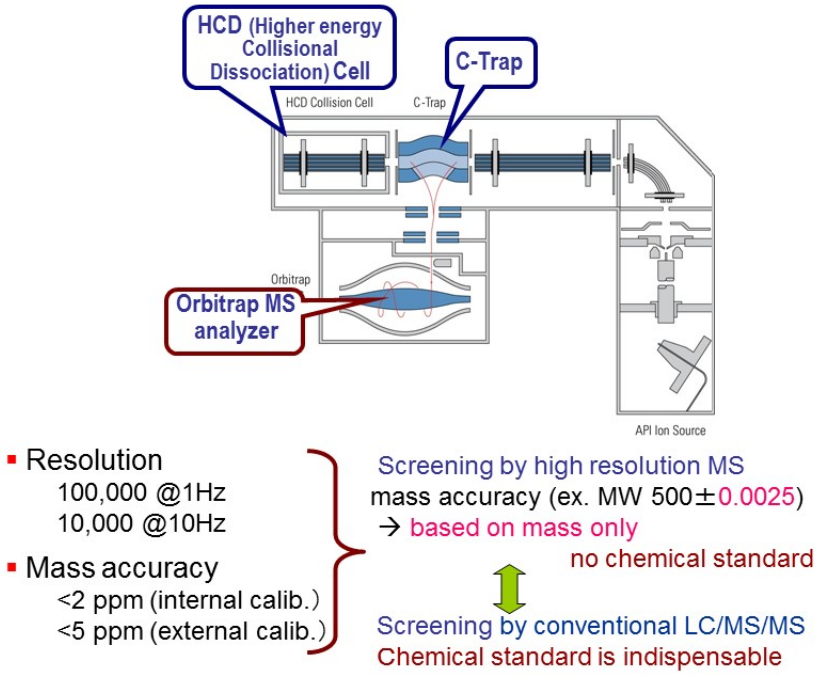

Fig. 8. High resolution LC-Orbitrap MS

Fusarium fungi are known as plant pathogens infecting cereals, and some of them produce mycotoxins such as trichothecenes and zearalenone. For these mycotoxins, several glucoside derivatives are reported and known as "masked mycotoxins". Since the hydrolysis of masked mycotoxins releasing their aglycons was reported, these glucosides are considered to present an additional potential risk for mycotoxins. In addition, trichothecenes are sesquiterpenoid mycotoxins composed of some groups, we expected that glucoside derivatives derived from various trichothecenes would be found in nature. Screening of new masked mycotoxins was performed by means of LC-Orbitrap MS. With the accurate mass and high-resolution (AM/HR) measurement, the detection of compounds whose chemical standards are not available is possible. The identification was carried out on the basis of characteristic ions and fragmentation patterns observed with LC-Orbitrap MS. Masked mycotoxins derived from type B trichothecenes (fusarenon-X and NIV) in wheat grain that was artificially infected with *Fusarium* fungi were detected. Masked mycotoxins derived from type A trichothecenes (T-2 toxin and HT-2 toxin) in commercially available corn powder reference material were also detected. Corn powder was naturally contaminated with type A trichothecenes. Although the absolute structures were not clarified except for the T-2 toxin-glucoside, 3-OH glucosylation seems to be the most probable based on the fragment profiles and concomitant detection of deoxynivalenol-3-glucoside (DON3Glc) in the identical samples. The amount of these masked mycotoxins was estimated according to an extrapolation based on the molar ratio DON3Glc/DON in each sample. These findings indicate that not only type B, but also type A trichothecenes are naturally glucosylated in plants such as wheat and corn. Although the existence of these masked mycotoxins is not currently included in the risk evaluation, more analytical and toxicological studies are needed to determine their prevalence in foods and the relevance for human health.

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IMPROVING PESTICIDE RESIDUE DETECTION PROTOCOL FOR FRUIT

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ABSTRACT

Previous studies have shown that none of the residual pesticides chlorpyrifos, deltamethrin, fenitrothion, fenpropathrin, iprodione, and kresoxim-m was significantly reduced when apples were subjected to simple washing with water. This study aims to develop methods for the multi-residue analysis of pesticides in fruit and vegetables. In particular, selected fruit (apples, persimmons, peaches, and oranges) were subjected to various types of pesticide application. Almost all pesticides give satisfactory results in terms of selectivity, accuracy, and precision.

INTRODUCTION

In order to boost food production, pesticides are, in many cases, repeatedly applied during the entire growing season and sometimes even at the fruiting stage. As many as 1000 compounds are applied to agricultural crops to control undesirable pests. Fresh vegetables and fruit are the important part of a healthy diet but they can also be a source of toxic substances such as pesticides at the same time. Generally, fresh vegetables and fruit are consumed just after washing with water. In particular, fruit are usually eaten this way.

Previous research reported that none of the residual pesticides, chlorpyrifos, deltamethrin, fenitrothion, fenpropathrin, iprodione, and kresoxim-m was significantly reduced when apples were subjected to simple washing with water. It is, therefore, very important to know how much amount of pesticides are contained in fruit and vegetables, and thus also important to develop multi-residue analysis methods. Some research groups claimed that sugar contents, thickness of lipid layer, and acidity of the extract have significant effects through analytical results.

The amount of these parameters in a particular matrix can vary depending on variety and location. Therefore, it is still necessary to develop methods for the multi-residue analysis of pesticides in market fruit and vegetables available in a particular region. The selected fruit (apples, persimmons, peaches, and oranges) for this experiment are widely grown and consumed in various ways in Korea. Although various types of pesticides are applied during the entire growing season, the literatures on multi-residues pesticide analysis that cover wide range of pesticides are still limited. We reported here a method dealing with diversified pesticides in several fruit matrices. QuEChERS method developed by Anastassiades, Lehotay, Štajnbaher, & Schenck, has been served as a template for modification of multi-residues pesticide analysis method due to its simplicity and flexibility. Modified versions of the original unbuffered QuEChERS method were developed by Lehotay, Maštovská & Lightfield using acetate, and Anastassiades, Scherbaum, Tasdelen, & Štajnbaher using citrate buffering conditions.

Since then, a number of modified versions have been successfully applied for extraction of pesticides from a variety of foods, mainly from fruit and vegetables. The use of QuEChERS method was also extended for the determination of pesticide residues in diversified foods such as cereal grains, olives, fish oils, and ginseng powders. The method was even used for the extraction of pesticides in various soil types. Since it was developed, electrospray ionization (ESI) based liquid chromatography tandem mass spectrometry (LC-MS/MS) has been intensively used for the analysis of thermally labile and/or nonvolatile organic molecules including pharmaceutically active compounds, veterinary drugs, antibiotics, and pesticides.

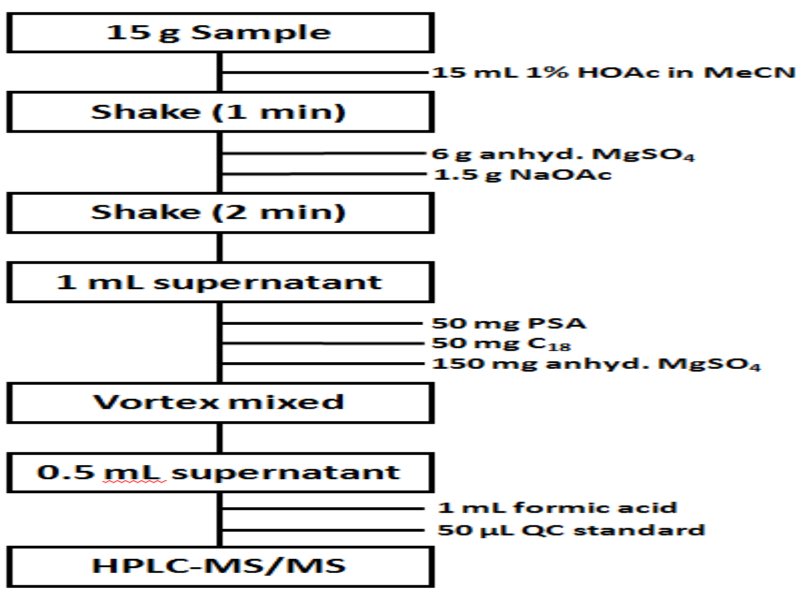
Simultaneous analysis of as many as 100-300 pesticides with better data quality and efficiency can be achieved using LC-MS/MS which is designed to have superior sensitivity. On the other hand, the development of data acquisition software such as DMRM (dynamic multiple reaction monitoring), Scheduled MRM and Timed Selected Reaction Monitoring provided the effective determination of many pesticides on LC-MS/MS. We developed a new LC-MS/MS method for the determination of 74 pesticides using DMRM data acquisition mode. Analytical results obtained from the DMRM data acquisition mode were the results of two MRM transitions to identify target pesticide compounds in order to meet the European Union criteria for the mass spectrometric identification of target compounds (European Commission Council Directive 96/23/EEC and 2002/657/EC). Target pesticides analyzed in this experiment are widely used for controlling pests on fruit grown in Republic of Korea. Maximum residue limits (MRLs) for those pesticides are already set as well.

GENERAL METHOD

For sample extraction and dispersive solid phase extraction steps, QuEChERS products, Restek Q-sep Q 150 containing 6 g anhydrous $MgSO_4$ plus 1.5 g anhydrous NaOAc in 50 mL plastic centrifuge tube and Rstek Q-sep Q 251 containing 150 mg anhydrous $MgSO_4$ plus 50 mg primary secondary amine (PSA) and 50 mg C_{18} were supplied by Restek (Bellefonte, PA). Persimmons, peaches, apples, and oranges were obtained from local suppliers in Republic of Korea. To prepare stock solutions of individual standards, all standards were dissolved in acetonitrile to get 1000 ppm except carbendazim which is dissolved in methanol to get 200 ppm.

The appropriate volume of each stock solution was mixed together and diluted with acetonitrile to get 20 ppm mixture of all 74 target pesticides. Working standard solutions were diluted from 20 ppm mixed standard using acetonitrile. LC-MS/MS analysis was performed using an Agilent Technologies model 1200 series HPLC coupled to an Agilent 6410 triple-quadrupole mass spectrometer. Instrument parameters were: gas temp 350 ˚C, gas flow 10 L/min, and nebulizer 50 psi. N_2 gas was used as nebulizer gas. Ionization was done by electrospray ionization at positive mode. Analyte separation was achieved by C18 phase, 3 µm, 100 x 3 mm i. d. Column temperature was set at 40 ˚C. Mobile phase consisted of water buffered with 10 mm ammonium formate (solvent A) and MeCN (solvent B). The LC gradient for the separation was: from 0 to 2 min, a linear increase of B from 5 to 70%; isocratic from 2 to 10 min (30% A: 70% B); from 10 to 15 min, a linear increase of B from 70 to 90 %; from 15 to 20 min, a linear increase of B from 90 to 95%. Initial conditions were re-established in 3 mins and it was maintained for 2 mins. Post running time was set for 5 mins resulting to a total run time of 30 mins. The flow rate of mobile phase was 0.2 ml/mins. Sample injection volume was 10 µL. Data processing was performed in MassHunter Workstation data acquisition software using DMRM mode. Cycle time was 500 ms and min/max dwell was 10.39 ms/246.5 ms with delta retention time of 1.2 mins. Peak areas of each pesticide were directly used as the signals for quantitative analysis using matrix matched calibration standards. Standard mixtures of 74 pesticides and internal standard (TPP) were initially determined for mass spectra, retention times, optimum voltages for fragmentor and collision cell, and precursor and product ions at positive mode using full scan. Acquisition time, flow rate, and gradient were also optimized using standard mixtures at MRM mode. The fragmentor voltage that gave most intense peak of precursor ion was selected first. Then, the most intense ion pairs were selected as quantifier and qualifier ions and the collision energy that gave the most intense area of those ions were selected for the analysis.

After satisfactory results were determined, standard mixtures were tested again using DMRM mode at 1.2 mins of delta retention time. Instrument within-run precision was obtained from detector response to internal standard (TPP) at each set of run for MDLs determination where concentration of TPP was adjusted to be at the same level. Chopped samples were homogenized by Artlon gold mix homogenizer and kept in the freezer at –20 ˚C until used. A 15 g of homogenized samples were weighed into 50 mL empty polypropylene centrifuge tubes. A 100 µL of desire concentration of pesticide mixture were spiked for recovery test samples and 100 µL of acetonitrile for matrix blanks, reagent blanks, and screening samples, respectively. The content was then vortex mixed for 30 s to spread pesticide thoroughly in the sample prior to pipetting 15 mL of 1% HOAc in acetonitrile into the samples. In brief, solvent separation was achieved by mixing and shaking with 6 g anhydrous $MgSO_4$ and 1.5 g NaOAc. Extract clean-up was done by mixing 1 mL sample extract with 150 mg anhydrous $MgSO_4$, 50 mg PSA, and 50 mg C_{18}. A 50µL TPP and 1 mL of 0.1 % formic acid for all samples, 50 µL standard solutions for matrix matched standard or 50 µL acetonitrile for reagent blank, matrix blank, and spiked sample were added into final extract of 0.5 mL before filtered with 0.2 µm PTFE filter. Schematic diagram of the analytical procedure regarding extraction and clean-up is presented in Fig. 1. A 15 mL aliquots of distill deionized water were used as sample for reagent blank.



All the fruit samples were screened for pesticides using the above sample preparation method. The samples free from pesticides were selected to use as control sample. But in the case of persimmons, it was hard to find pesticide free samples. Some of target pesticides were found to be considerably high concentration. For example, detector signals for dinotefuran in persimmons were as high as the signals for 5 ng/mL spiked matrix matched standard. Experimental concentration of 5 ng/mL spiked matrix matched standard was 0.16 ng/mL. But the other persimmon samples contain higher pesticides both in numbers and concentration. Therefore, sample containing dinotefuran was selected as control sample. For recovery test and determination of MDLs of this pesticide, another persimmon sample which is free from dinotefuran but contains other target pesticides was used as control sample. Method validation was carried out to evaluate the performance of the method using the following parameters: method detection limits (MDLs), method quantification limits (MQLs), selectivity, accuracy, and precision. To this point, MDLs and MQLs determination, and recovery test at two fortified spiking levels were conducted. Determination of MDLs and MQLs were carried out following U. S. EPA protocol (Federal Register, U.S. Code of Federal Regulations, Part 136, Appendix B). To determine MDLs and MQLs, 5 spiking levels (0.5, 2, 5, 10 and 50 ng/g) with 8 replicates for each level were performed using all fruit samples of persimmons, peaches, apples and oranges. Spiked samples (n = 8) were passed through all steps described in sample preparation procedure and analyzed in LC-MS/MS. Data were organized in excel spread sheet and calculated for recoveries, standard deviation (SD), relative standard deviation (%RSD), signal to noise ratio (S/N), MDLs and MQLs. S/N was obtained by dividing mean recovery concentration by SD. MDLs were calculated by multiplying SD with student t-value (2.998) for n-1 (7) degree of freedom at 99% confidence levels. For calculation of MQLs, SD was multiplied by 10. For recovery test, 6 levels (0.5, 2, 10, 50, 100, and 400 ng/g) of fortified spiking with 4 replicates for each fruit were carried out. Matrix matched standard solutions for calibration was prepared using respective matrix extract of persimmons, peaches, apples and oranges. Newly prepared calibration standards were used for each set of run. TPP was used as internal standard to check the stability of instrument within each run and also among a series of run. Detector signals for internal standard were not used neither for calibration curves nor calculation of recoveries of pesticides but used for elimination of outliers along with signals for matrix and reagent blanks.

For selectivity study, blank extracts of sample matrices, without spiking standard solution but internal standard to check instrument stability, were analyzed in LC-MS/MS using the developed analytical method. Consecutive analysis of matrix match standards was also carried out to check if there is any false signal in the blank extract. The developed method was applied for the analysis of residues of target pesticides in blind-incurred fruit samples collected from various regions in the Republic of Korea. Ten samples each of apples, persimmons, peaches and oranges are used for residue analysis. Sample preparation and quantitative analysis were conducted using the same procedure as described in materials and method section. Duplicate samples of each fruit were analyzed and the amount of pesticides detected was determined using matrix match standard calibration curve.

DISCUSSION

It was found that using DMRM mode improved performance of the instrument. Better peak shape and higher response were observed. When data acquisition was performed at MRM mode, cycle time was found to be 1200 ms even though dwells for all pesticides were set at 2-5 ms. When it was done at DMRM mode, cycle time was reduced to 500 ms and dwell for each pesticide ranged from 10.39 to 246.5 ms as described above in instrument and data analysis section. This improved the chromatographic data (peak area, peak shape etc.). Fragmentor voltage, collision energy for product ions and retention time at DMRM mode for each pesticide are reported in Table 1 along with MRM transitions and pesticides' information. As described in Table 1, detector response to internal standard TPP was obtained from each set of run for MDL determination. The results of MDLs were counter checked using the following criteria: 10 x MDL > spiking level > MDL; 120% > recovery % > 70%; S/N between 5 and 10. Once the calculated MDLs values were in agreement with those criteria, the results were selected as MDLs and MQLs for respective pesticides.

Table 1. Instrument performance data calculated from detector response to internal standard

No.	Pesticides Information				MRM Transitions			Collision Energy (V)		Fragmentor Voltage	Retention Time (min)	Ionization Mode
	Compound Name	CAS no.	M.F.	M.W.	Precursor	Quantifier	Qualifier	Quantifier	Qualifier			
1	Acetamiprid	135410-20-7	$C_{10}H_{11}ClN_4$	222.7	223.1	126	56	15	15	80	6.294	Positive
2	Azoxystrobin	131860-33-8	$C_{22}H_{17}N_3O_5$	403.4	404.1	372.1	344.1	10	15	120	8.986	Positive
3	Bifenazate	149877-41-8	$C_{17}H_{20}N_2O_3$	300.4	301	198	152.9	4	30	75	9.942	Positive
4	Bitertanol	70585-36-3	$C_{20}H_{23}N_3O_2$	337.4	338.2	99.1	70.1	8	4	80	10.277	Positive
5	Boscalid	188425-85-6	$C_{18}H_{12}Cl_2N_2O$	308.76	343	307.1	271	12	28	160	9.681	Positive
6	Carbaryl	63-25-2	$C_{12}H_{11}NO_2$	201.2	202.1	145.1	127.1	3	30	54	7.653	Positive
7	Carbendazim	10605-21-7	$C_9H_9N_3O_2$	191.2	192.2	160.1	105.1	15	42	98	5.87	Positive
8	Carbofuran	1563-66-2	$C_{12}H_{15}NO_3$	221.3	222.2	165.1	123.1	5	20	85	7.473	Positive
9	Chlorantraniliprole	500008-45-7	$C_{18}H_{14}BrCl_2N_5O_2$	483.15	482	450.9	283.9	13	9	110	8.252	Positive
10	chlorfluazuron	71422-67-8	$C_{20}H_9Cl_3F_5N_3O_3$	540.7	542	385.1	158	18	20	134	18.561	Positive
11	chlorpyrifos	2921-88-2	$C_9H_{11}Cl_3NO_3PS$	350.6	350	198	97	18	33	88	18.672	Positive
12	Clofentezine	74115-24-5	$C_{14}H_8Cl_2N_4$	303.1	303.1	138	102.1	10	38	105	14.182	Positive
13	Clothianidin	210880-92-5	$C_6H_8ClN_5O_2S$	249.7	250	169.1	132	8	12	86	6.145	Positive
14	Cyazofamid	120116-88-3	$C_{13}H_{13}ClN_4O_2S$	324.8	325.1	261	108	5	5	100	11.539	Positive
15	Cyproconazole	94361-06-5	$C_{15}H_{18}ClN_3O$	291.8	292.2	125	70.1	16	30	100	8.96	Positive
16	Cyprodinil	121552-61-2	$C_{14}H_{15}N_3$	225.3	226.1	108	93	30	40	120	12.256	Positive
17	Deltamethrin	52918-63-5	$C_{22}H_{19}Br_2NO_3$	505.2	522.8	280.6	181	15	50	110	20.718	Positive
18	Dichlorvos	62-73-7	$C_4H_7Cl_2O_4P$	221	220.8	127	108.9	17	17	80	7.186	Positive
19	Difenoconazole	119446-68-3	$C_{19}H_{17}Cl_2N_3O_3$	406.3	406.1	250.9	75	25	108	144	12.064	Positive
20	Diflubenzuron	35367-38-5	$C_{14}H_9ClF_2N_2O_2$	310.7	310.8	157.8	140.8	10	32	92	10.081	Positive
21	Diniconazole	83657-24-3	$C_{15}H_{17}Cl_2N_3O$	326.2	326.1	159	70.1	31	24	131	11.266	Positive
22	Dinotefuran	165252-70-0	$C_7H_{14}N_4O_3$	202.2	203.1	157.1	129.1	3	6	80	5.658	Positive
23	EPN	2104-64-5	$C_{14}H_{14}NO_4PS$	323.3	324.1	296.1	157	7	20	113	15.452	Positive
24	Ethaboxam	162650-77-3	$C_{14}H_{16}N_4OS_2$	320.4	321.1	237.1	183	15	20	110	7.519	Positive
25	fenarimol	60168-88-9	$C_{17}H_{12}Cl_2N_2O$	331.2	331	268.1	139	22	37	145	9.264	Positive
26	Fenazaquin	120928-09-8	$C_{20}H_{22}N_2O$	306.4	307.2	161.1	57	15	20	120	19.282	Positive
27	Fenbuconazole	114369-43-6	$C_{19}H_{17}ClN_4$	336.8	337.2	125	70.1	37	22	133	9.83	Positive
28	Fenothiocarb	62850-32-2	$C_{13}H_{19}NO_2S$	253.4	254.1	160.1	72.1	4	12	85	11.507	Positive
29	Fenpropathrin	64257-84-7	$C_{22}H_{23}NO_3$	349.4	350.2	125	97.1	15	35	110	19.876	Positive
30	Fenpyroximate	134098-61-6	$C_{24}H_{27}N_3O_4$	421.5	422.2	366.1	135	15	40	130	18.912	Positive
31	Fenthion	55-38-9	$C_{10}H_{15}O_3PS_2$	278.3	278.9	246.8	168.9	9	16	80	12.988	Positive
32	fluacrypyrim	229977-93-9	$C_{20}H_{21}F_3N_2O_5$	426.39	427.2	205.1	145.1	2	23	79	15.528	Positive
33	Fludioxonil	131341-86-1	$C_{12}H_6F_2N_2O_2$	248.2	265.8	228.8	184.8	7	24	60	8.746	Positive
34	Flufenoxuron	101463-69-8	$C_{21}H_{11}ClF_6N_2O_3$	488.8	489	158	141	16	48	138	17.619	Positive
35	fluquinconazole	136426-54-5	$C_{16}H_8Cl_2FN_5O$	376.2	375.7	348.7	306.8	18	25	140	9.801	Positive
36	flusilazole	85509-19-9	$C_{16}H_{15}F_2N_3Si$	315.4	316.1	247.1	165.2	14	25	138	9.769	Positive
37	Forchlorfenuron	68157-60-8	$C_{12}H_{10}ClN_3O$	247.7	248.1	155.1	129.1	12	12	95	7.385	Positive
38	Hexaconazole	79983-71-4	$C_{14}H_{17}Cl_2N_3O$	314.2	314.1	159	70.1	31	18	120	10.734	Positive
39	Imibenconazole	86598-92-7	$C_{17}H_{13}Cl_3N_4S$	411.7	411	171	125	15	20	100	15.299	Positive
40	Imidacloprid	138261-41-3	$C_9H_{10}ClN_5O_2$	255.7	256.1	209.1	175	10	10	80	6.238	Positive
41	Indoxacarb	144171-61-9	$C_{22}H_{17}ClF_3N_3O_7$	527.8	528.1	202.9	149.9	41	21	110	14.8	Positive
42	Iprodione	36734-19-7	$C_{13}H_{13}Cl_2N_3O_3$	330.2	329.8	244.8	173.8	8	28	90	10.509	Positive
43	Kresoxim-m	143390-89-0	$C_{18}H_{19}NO_4$	313.4	314.1	222.1	116.1	8	33	83	12.11	Positive
44	Mepanipyrim	110235-47-7	$C_{14}H_{13}N_3$	223.3	224.1	106	77	25	30	120	10.595	Positive
45	Metconazole	125116-23-6	$C_{17}H_{22}ClN_3O$	319.8	320.2	125	70.1	44	27	114	10.8	Positive
46	Methidathion	950-37-8	$C_6H_{11}N_2O_4PS_3$	302.3	303	145.1	85.1	1	15	59	9.132	Positive
47	Methomyl	16752-77-5	$C_5H_{10}N_2O_2S$	162.2	163.1	106.1	88.1	4	3	45	5.953	Positive
48	Methoxyfenozide	161050-58-4	$C_{22}H_{28}N_2O_3$	368.5	313	149	91	5	25	100	9.972	Positive
49	Myclobutanil	88671-89-0	$C_{15}H_{17}ClN_4$	288.8	289.2	125.1	70.1	38	15	110	9.219	Positive
50	Novaluron	116714-46-6	$C_{17}H_9ClF_8N_2O_4$	492.7	493.1	158.1	141.1	16	53	120	14.411	Positive
51	Pendimethalin	40487-42-1	$C_{13}H_{19}N_3O_4$	281.3	282.2	212	194.3	4	16	133	18.665	Positive
52	Phenthoate	254642	$C_{12}H_{17}O_4PS_2$	320.4	321.1	107.1	79.1	25	45	85	13.013	Positive
53	Phosphamidon	13171-21-6	$C_{10}H_{19}ClNO_5P$	299.7	300.1	174.1	127	8	15	115	6.603	Positive
54	Pirimiphos-m	29232-93-7	$C_{11}H_{20}N_3O_3PS$	305.3	306.1	164.1	108	20	30	135	16.065	Positive
55	Prochloraz	67747-09-5	$C_{15}H_{16}Cl_3N_3O_2$	376.7	376.1	308	70.1	5	23	93	11.135	Positive
56	Prothiofos	34643-46-4	$C_{11}H_{15}Cl_2O_2PS_2$	345.2	344.8	274.6	240.7	14	12	85	21.758	Positive
57	Pyraclostrobin	175013-18-0	$C_{19}H_{18}ClN_3O_4$	387.8	388.1	194.1	163	10	15	120	13.393	Positive
58	Pyridaben	96489-71-3	$C_{19}H_{25}ClN_2OS$	364.9	365.2	309.1	147.1	7	22	96	20.619	Positive
59	Pyridaphenthion	119-12-0	$C_{14}H_{17}N_2O_4PS$	340.3	341.1	205.1	189.1	20	20	130	9.539	Positive
60	Pyrimethanil	53112-28-0	$C_{12}H_{13}N_3$	199.3	200.1	183	107.1	25	25	120	9.553	Positive
61	Simeconazole	149508-90-7	$C_{14}H_{20}FN_3OSi$	293.4	294.2	73.1	70.1	32	14	120	9.215	Positive
62	Spirodiclofen	148477-71-8	$C_{21}H_{24}Cl_2O_4$	411.3	411.1	313	71.2	5	15	110	20.751	Positive
63	Tebuconazole	107534-96-3	$C_{16}H_{22}ClN_3O$	307.8	308.2	125.1	70.1	45	23	125	10.035	Positive
64	Tebufenozide	112410-23-8	$C_{22}H_{28}N_2O_2$	352.5	353.2	297.2	133.1	5	15	90	11.346	Positive
65	Tebufenpyrad	119168-77-3	$C_{18}H_{24}ClN_3O$	333.9	334.2	145.1	117.1	25	40	150	16.657	Positive
66	Teflubenzuron	83121-18-0	$C_{14}H_6Cl_2F_4N_2O_2$	381.1	380.7	157.9	140.9	14	42	110	14.576	Positive
67	Tetraconazole	112281-77-3	$C_{13}H_{11}Cl_2F_4N_3O$	372.1	372.1	159	70.1	40	23	124	9.374	Positive
68	Thiacloprid	111988-49-9	$C_{10}H_9ClN_4S$	252.7	253	186	126	10	20	90	6.572	Positive
69	Thiamethoxam	153719-23-4	$C_8H_{10}ClN_5O_3S$	291.7	292	211	181	20	9	80	5.927	Positive
70	Thiodicarb	59669-26-0	$C_{10}H_{18}N_4O_4S_3$	354.5	355.1	108.1	88.1	9	9	85	6.924	Positive
71	Triadimefon	43121-43-3	$C_{14}H_{16}ClN_3O_2$	293.8	294.1	197	99	11	48	105	9.617	Positive
72	Triadimenol	55219-65-3	$C_{14}H_{18}ClN_3O_2$	295.8	295.9	226.9	70	2	5	75	8.743	Positive
73	Trifloxystrobin	141517-21-7	$C_{20}H_{19}F_3N_2O_4$	408.4	409.1	206.1	186.1	10	15	120	15.505	Positive
74	Triflumizole	99387-89-0	$C_{15}H_{15}ClF_3N_3O$	345.7	346.1	278.1	73.1	3	10	88	13.299	Positive

In most cases, MDLs are less than 10 ng/g. In many cases, they were even less than 1 ng/g. Selectivity of the method was tested by analyzing blank extract of real fruit samples and compared them with standard spiked extract, matrix match standard. It was observed as signal for pesticide, denotefuran because it couldn't be seen in other sample extracts of persimmon (Fig. not shown). But those samples showed signals for some other pesticides and thus, was not used for selectivity evaluation. In all fruit samples, the signal at retention time 13.05 min represent internal standard (TPP) which was spiked to check instrument stability. Therefore, it can be concluded that there were no false signals due to matrices at the same retention time of the target pesticides and the selectivity of the developed method was totally reliable for the analysis of those pesticides. Recovery tests were carried out to evaluate the accuracy and precision of the developed method. Six levels of fortified spiking for each fruit were carried out and two spiking levels in which 5 to 10 times MQLs of respective pesticide is fallen were selected as fortified spike levels of that pesticide for the determination of recovery and % RSD. The results of recovery tests were briefly presented in Table 2.

Table 2. Recovery profile of target pesticides in apple, peach, persimmon, and orange matrices

Recovery range (%)	(%) of total pesticides analyzed							
	AP		PC		PS		OR	
	Low spike	High spike	Low spike	High spike	Low spike	High spike	Low spike	High spike
<70	1.35	0.00	0.00	0.00	1.35	1.35	0.00	0.00
70-80	4.05	2.70	4.05	4.05	1.35	0.00	2.7	1.35
80-90	28.38	21.62	14.86	9.46	9.46	12.16	8.11	2.7
90-110	59.46	70.27	77.03	77.00	81.10	86.49	82.43	94.59
110-120	5.41	1.35	2.70	1.35	6.76	0.00	5.41	0.00
>120	0.00	0.00	0.00	0.00	0.00	0.00	1.35	1.35
NA	1.35	4.05	1.35	8.11	0.00	0.00	0.00	0.00

Table 3. Repeatability profile of target pesticides in apple, peach, persimmon, and orange matrices

%RSD	(%) of total pesticides analyzed							
	AP		PC		PS		OR	
	Low spike	High spike	Low spike	High spike	Low spike	High spike	Low spike	High spike
0 to 5	45.95	51.35	29.73	48.65	60.81	86.49	44.59	71.62
5 to 10	25.68	27.03	45.95	32.43	31.10	8.11	36.49	22.97
10 to 15	21.62	8.11	10.81	9.46	6.76	4.05	13.51	4.05
15-20	5.41	9.46	12.16	1.35	1.35	1.35	5.41	1.35
>20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
NA	1.35	4.05	1.35	8.11	0.00	0.00	0.00	0.00

As shown in the table, more than 59 % of target pesticides fell between recoveries of 90 and 110 % in all fruit matrices at both spiking levels. The method was most effective for analysis of pesticides in persimmon. In this matrix, the fractions of pesticides which recoveries fallen between 90 and 110 % were 81.10 and 86.94 % at low and high spike, respectively. The method was not applicable to certain pesticides in particular matrix such as bifenazate and fenazaquin in apples and peaches, cyprodinil in peaches, and etc. as can be seen in Table S-2 where detailed analytical results were reported.

The reason why these pesticides were not applicable in this method can be attributable to matrix effect exerted ionization suppression, analyte instability and low ionization efficiency or combine effect of these factors as reported by Klein & Alder. Although significant matrix interference was observed for bifenazate in apples and peaches, it was not observed in persimmons and oranges. This revealed that co-eluting matrix components from apples and peaches interfered the ionization process making analytes instable. Significant differences in MDLs and MQLs values in different matrices were noted. For example, those of carbofuran, chlorpyrifos, and fenpropathrin in apples and peaches also supported the statement of the matrix effect. However, except for these pesticides, the results of other pesticides showed good recovery. These results revealed that ionization efficiency and/or stability of pesticides depends not only on the matrix where they were extracted but also on the pesticides themselves. Greater than 71 % fraction of target pesticides in all fruit at both spiking levels gave <10 % RSD. There were no pesticides where RSD was > 20 % showing good repeatability of the developed method. Particularly in persimmons and oranges, 93.26 % (average of 2 spiking levels) and 87.8 % fraction of pesticides showed < 10 % RSD with no pesticides for which method was not applicable in these matrices. Unlike in persimmons and oranges, the method was not applicable for analysis of some pesticides in apples and peaches giving unreliable results of both recovery and RSD.

Almost all pesticides give satisfactory results in terms of selectivity, accuracy, and precision. At fortified spike, recovery range falls between 65.14 % and 136.5 % in all fruit with RSD value of less than 20%. Regression coefficients of the calibration curves are greater than 0.99.

CONCLUSION

In all cases, these results imply that the developed method can be applied for the analysis of residual pesticides in four experimental fruit at ng/g level. Among the observed pesticides, 18 pesticides in 9 apple samples, 10 pesticides in 10 persimmon samples, 12 pesticides in 7 peach samples and 14 pesticides in 10 orange samples are found. The most frequently found pesticides are difenoconazole, 6 times in apple and 8 times in persimmon; bitertanol, 4 times in peach; and methoxyfenozide, 5 times in orange. The detailed results of the amount and numbers of pesticides contained in each fruit sample are listed in Table 3 along with their MRL values available for respective fruit.

As can be seen in Table 3, the concentration of pesticides found in all fruit samples are less than their MRL values except for thiamethoxam in the persimmon sample. The concentration of this pesticide in the examined sample is almost the same with its MRL value regulated in persimmon.

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EXTENSION OF GOOD AGRICULTURAL PRACTICES TOWARDS SAFETY OF FRESH FRUIT AND VEGETABLES

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ABSTRACT

In order to achieve sustainable agriculture, developed countries currently emphasize the implementation and validation of Good Agriculture Practice (GAP). GAP is a collection of practice principles to apply for agricultural production, resulting in safe agricultural products. At present, "quality agriculture" is an important agricultural policy in Taiwan and is the main theme of "quality agriculture". The content of healthy agriculture includes the validation systems of GAP, Ji-Yuan-Pu in Chinese; Traceable Agricultural Products (TAP); Organic Agriculture; and Certified Agricultural Standards (CAS). Among these, the GAP label is the most commonly accepted safe validation certificate for agricultural products since its application procedure is simple, easy, and free for farmers. Located in the subtropical region, the temperature and humidity in Taiwan are favorable for the occurrence and spread of pests, therefore pest control is the most serious problem for the cultivation of crop in Taiwan. Although the use of chemical pesticides is convenient, fast, and effective, the overuse of chemicals resulted in resistance to pesticides, pesticide residue on agricultural products as well as environmental pollution. Thus, healthy agriculture emphasizes the establishment and extension of crop health management systems for efficient and effective pest control. Integrated Pest Management (IPM) is the most important executive strategy to ensure safe agricultural products. The Taiwan government has established the pest diagnosis services as well as the pest monitoring and alert system for pest and disease prevention and control. Besides, academies, agricultural institutes, and District Agricultural Research and Extension Stations (DARESs) in Taiwan especially, focus on the development of IPM technologies, including field sanitation management, breeding of pest resistance, cultivation management such as crop rotation, green manure crops, sod cultivation, management of soils and seedbeds, rational fertilization, non-pesticide control of pests such as physical, biochemical, biological measures, and economical and safe application of pesticides. We transferred these technologies to farmers for application through professional education courses and multiple public media. The agricultural agencies also execute the practices of random inspection of pesticide residue, the follow-up education, the infraction judgment and penalties, etc. to ensure the marketing of safe agricultural products. Till the end of 2013, the GAP-certificated production areas for fruit and vegetables have reached a total of 25,649 hectares and the certified TAP and organic crop production areas are 6,542 and 5,821 hectares, respectively. According to the most recent data, the rate of fruit and vegetables that passed the pesticide residue inspection at both production and distributing sites has increased to >96%. This has well safeguarded the consumers' health in Taiwan.

Keywords: safe agricultural products, good agricultural practice, integrated pest management, non-pesticide control, farmers' education, pest monitoring and alert system

INTRODUCTION

"Agricultural products safety and traceability" has been a main concern for the general public in many countries around the world since consumers are becoming increasingly aware of food safety. Reflecting this global trend and consumers' demand, the government continues to focus on promoting healthy agriculture in Taiwan. At present, "quality agriculture" is Taiwan's core agricultural policy. It consists of three main themes: healthy agriculture, excellent agriculture, and LOHAS (lifestyles of health and sustainability) agriculture. In terms of healthy agriculture, it includes the certification systems for "the label of Ji-Yuan-Pu safe fruit and vegetables" (GAP), the Traceable Agricultural Products (TAP), the CAS Taiwan Premium Agricultural Products, and the organic agriculture [20]. Located in subtropical region, the temperature and humidity of Taiwan are both favorable for the occurrence and spread of pests, therefore pest control is the most serious problem for the cultivation of crops in Taiwan.

Thus, implementation of healthy agriculture is highly related to plant protection work. Taiwan has been promoting crop health management measures for a long time which are based on the concepts of the Integrated Pest Management (IPM) to develop and extend various non- pesticide technologies for improving crop health and reducing the use of chemical pesticides.

The overall goals are to protect environments, reduce pesticide residue, and ensure consumers' health. IPM is the most important executive strategy in conducting crop health management. It means integration of available production techniques especially appropriate biological control measures to keep pests at levels that are economically justified and minimize risks to humans and the environment. The main principles are (1) Accurate and economical use of chemical materials, (2) Choosing right materials carefully and optimizing effectiveness by combining different materials, (3) Emphasis of mass production and application of natural enemies and beneficial micro organisms as well as the establishment of environmental conditions that is suitable for crop growth but pest propagation, (4) By using appropriate crop rotation and cultivation model to optimize and maintain soil fertility, (5) Keep economic benefits, and high crop yield is not the ultimate goal for production, (6) Reducing interventions against sustainable ecological environments, and (7) Preventing or postponing resistance of pests to pesticides or biological control methods [27,38].

SAFETY CERTIFICATION SYSTEMS AND RESIDUAL PESTICIDES INSPECTION FOR AGRICULTURAL PRODUCTS IN TAIWAN

Good Agriculture Practice (GAP) label

In Taiwan, "the label of Ji-Yuan-Pu safe fruit and vegetables" is abbreviated to the GAP label. Internationally, GAP is the abbreviation for Good Agricultural Practice which applies sustainable agriculture methods to crop cultivation. The purpose of GAP is to protect crops from pests and increase crop quality through rational and environmentally-friendly application of agricultural materials (i.e. fertilizers and pesticides) at appropriate timing and sites for specific crop varieties. Thus, the GAP label is a certificate for high-quality agricultural products produced in accordance with Taiwan Good Agricultural Practices (TGAP) [7, 40]. The GAP label certification which took effect in 1993 not only represents safe agricultural products, but is also regarded as recognition of farmers' contribution. To produce safe agricultural products, the primary principle is to reduce dependency on pesticides. If farmers have to use chemicals, registered pesticides should be applied in a manner that leaves residues below the Maximum Residue

Limits (MRL). Furthermore, farmers have to keep records of the pesticide usage with details of the kinds, quantities, and effectiveness of the pesticides.

The regulation for the management of the GAP label was formulated in 2009 by the Council of Agriculture (COA), Executive Yuan, ROC (Taiwan). The applicants are limited to registered agricultural production and marketing groups or farms that are supervised by the COA on the pest control and safe use of pesticides. The residual pesticides on their agricultural products also should pass the pesticide tests in order to obtain the GAP label (7). The applicable products are positively listed by the COA. They include mainly fresh vegetables and fruit as well as some specialties, cereal crops and self-produced processed agricultural products. The GAP label issued by authorized agencies facilitates the sale of high-quality agricultural products and therefore ensures consumers' health.

Figure 1. (A) The GAP label

Figure 1A shows the GAP label. The two green leaves represent agriculture. The three red circles have double meanings. One is to emphasize the practices of the "rational pest control", "use of recommended pesticides", and "compliance with safe duration between pesticide application and harvest". The other is to indicate this product is "supervised", "inspected", and "regulated" by the COA. The nine identification numbers at the bottom represent counties/cities, crop categories, and regulated running numbers, respectively. Each label is owned by a specific farmer so that consumers can access the website (http://gap.afa.gov.tw/faq/) to trace the names of the producers, the crops, and the agricultural production and marketing groups by the identification numbers.

Our government currently keeps promoting the GAP label validation system. To ensure the credibility of this system, we investigate the applications carefully as well as strengthen the inspection of the label usage and pesticide residue. The GAP label is very popular because it's simple, easy, and use free application procedure. It has become the foundation of a healthy agriculture policy in Taiwan. At the end of 2013, there are 2,126 certified GAP production and marketing groups with a total production area up to 25,649 hectares and annual yield of approximately 550,000 tons. These numbers have increased year by year as shown in Table 1. To facilitate the visibility of the label, we promoted the mother-baby package for vegetables and fruit with the GAP label for wholesale markets. In 2013, 22,774 tons of vegetables and fruit have been sold to our consumers through 137 chain supermarkets and 2,300 convenience stores (32).

Table 1. The number of production and marketing groups certificated with GAP and production area from 2007 to 2014 in Taiwan.

Year	Category of Crops	Number of GAP Groups	Area (ha)
2007	Vegetables	180	2,511
	Fruit	556	5,150
	Total	736	7,661
2008	Vegetables	367	3,965
	Fruit	655	10,406
	Total	1,022	14,371
2009	Vegetables	608	5,906
	Fruit	918	13,237
	Total	1,526	19,143
2010	Vegetables	698	6,424
	Fruit	1,067	15,393
	Total	1,765	21,817
2011	Vegetables	761	6,736
	Fruit	1,189	16,489
	Total	1,950	23,225
2012	Vegetables	820	7,582
	Fruit	1,264	17,491
	Total	2,084	25,073
2013	Vegetables	840	7,739
	Fruit	1,286	17,910
	Total	2,126	25,649
2014 (To October 6)	Vegetables	1,109	14,165
	Fruit	1,111	14,177
	Total	2,220	28,342

Traceable Agricultural Products (TAP) label

Good Agricultural Practice (GAP) and Traceability are currently two main management systems for safe agricultural products in the world [16]. The former is to reduce the risk of production and the latter, to clarify the responsibility of all participants involved in production and sales. The purpose of traceability systems is to clarify responsibilities, remove unsafe products, reduce consumers' risks, and reduce economic losses of qualified producers caused by lack of consumers' confidence. In Taiwan, the COA combined GAP and Traceability systems to manage risks and to ensure safety of agricultural products. In 2007, Taiwan also announced the "Traceable Agricultural Products Certification Management Regulations" and started to implement the voluntary Traceable Agricultural Products (TAP) system for farmers.

The system emphasizes the comprehensive records of agricultural products in the process of production, post-harvest treatments, processing, transportation, and sales. TAP combined the principles from the two international regulation systems (GAP and Traceability) for agricultural products to manage the entire process from production to sales of agricultural products.[28,40] According to "Traceable Agricultural Products Certification Management Regulations", the production process of agricultural products should follow the standard operation procedures and models required by the central competent authority, and the production process flowcharts, risk management tables, production and delivery recording sheets, and the records of cultivation management, fertilization methods, pests control, etc. have to be kept for reducing the risk.[4] The applicants can be individuals, production and marketing groups, unions, and farms. The government subsidizes part of the certification fee. After submitting the applications, the authorized TAP certificate agencies verify that the applicants implement all TGAP operation recommendations. The authorized agencies for certification have to meet the requirements of ISO GUIDE 65 and the specific requests by the COA. They also have to be approved by the International Accreditation Forum Multilateral Recognition Arrangement (IAF) and the COA for their independence and ability to certify TGAP applicants.

Traceability systems can keep track the entire processes of agricultural products from production to sales. The information is open, transparent, and traceable in order to enhance consumers trust in the certified products [18]. Consumers can access the "TAP website" (http://taft.coa.gov.tw/) to trace the farmers' production records for the agricultural products with the TGAP label (shown in Figure 1B). Till the end of Dec in 2013, the TAP-certificated production area is 993 hectares of vegetables, 945 hectares of fruit trees, 1,518 hectares of cereal crops and specialties, 2,841 hectares of rice, 231 hectares of organic rice, 23 hectares of organic vegetables and fruit, 6.8 hectares of organic cereal crops and specialties. The gross value of production has reached a total at NT$ 2.522 billions [32] (Table 2) and the numbers keep increasing.

Figure 1. (B) The TAP label

Table 2. The production area certificated with TAP in Taiwan from 2007 to 2013.

Category of Crops		Certificated Area (ha)						
		2007	2008	2009	2010	2011	2012	2013
General crops	Vegetables	160	1,095	783	675	920	897	993
	Orchards	525	3,110	3,069	2,449	1,540	1,455	945
	Grains and special crops	134	909	1,306	1,419	1,578	1,831	1,518
	Rice	420	3,402	2,761	3,637	3,533	3,052	2,841
	Edible flowers	-	-	-	-	-	-	0.3952
	subtotal	1,239	8,516	7,919	8,180	7,571	7,235	6,297
Organic crops	Organic vegetables and qrchards	23	26	25	21	16	17	23
	Organic grains and special crops	11	13	14	9	0.8	8.0	6.8
	Organic rice	211	367	400	320	351	270	231
	subtotal	245	405	439	350	368	295	260
Total		1,484	8,921	8,358	8,530	7,939	7,530	6,557

Organic agriculture label

Organic agriculture is a production management system that emphasizes water and soil resources conservation and ecological harmony. It is based on the principles of sustainable utilization of nature resources. Synthetic chemicals are prohibited. Since 2007, the “Agricultural Production and Certification Act” has started to implement in Taiwan and has also started to apply to organic agricultural products and their processed products. The certified products are labeled with the CAS Label adding the word of ORGANIC for consumers to recognize [6,9,26,37] (Figure 1C). The certification represents that the production, processing, packaging, transportation, and sales all comply with the regulations of organic farming and the certified products are free of chemical fertilizers, chemical pesticides, and food additives.

Figure 1. (C) CAS organic label

According to the statistics of Agriculture and Food Agency, COA, the current certified area for organic production is 5,821 hectares and covers 0.7% of the agricultural land area in Taiwan. The certified area increased 1.47 times compared with that (2,356 hectares) in the end of December, 2008. However, it is relatively low compared to Italy (9.1%), Spain (6.4%), and Germany (6.2%). The main organic crops are vegetables (36%), rice (30%), fruit trees (15%), tea (8%), and others (11%). The goal set for our organic agricultural area is 15,000 hectares in 2020.

CAS Taiwan premium agricultural products

Since 1989, Taiwan has started to promote the certification system of CAS (Certified Agricultural Standards) Taiwan Premium Agricultural Products. CAS is the symbol for the highest quality of the domestic agricultural products and their processed products in Taiwan. The applicants need to meet the following qualification requirements: (1) A factory (farm), farmer group or business entity established or registered in accordance with related regulations, (2) factory (farm) sanitation management and the sanitation and packaging of products in accordance with related regulations, (3) a factory (farm) and its products meet the certification criteria required by the central competent authority. Taiwan Premium Agricultural Products Development Institute is the current certification agency authorized by COA and is entitled to issue the CAS labels to the applicants. Currently, there are a total of 16 main CAS certified categories including meat, frozen foods, fruit and vegetable juices, quality rice, preserved fruit and vegetables, ready-to-serve meals, refrigerated foods, fresh edible mushrooms, fermented foods, snack foods, egg products, fresh-cut fruit and vegetables, aquaculture, forestry products, dairy, and feathers.

The CAS label emphasizes the qualification of software and hardware facilities, and the quality and sanitation of agricultural products. Its features using mainly locally produced raw materials, meeting hygiene and safety requirements, national quality standards, and label regulations. To ensure consumers' rights, the CAS label has been regulated under the "Agricultural Production and Certification Act". The "regulations for good agricultural products certification" and the "regulations for agricultural product labeling" have further reinforced the certification management and the product label audit [20].

Inspection and management for safe agricultural products

To improve the quality of domestic agricultural products and to provide safe foods for consumers, our governments regularly inspect the residual pesticides on fruit and vegetables, tea, rice, etc. at both production and distributing sites. In 2013, there are a total of 7,901 vegetables and fruit (3,483 of vegetables and 4,417 of fruit)which were examined for pesticide residue using chemical analyses. The rate of samples that passed the examination are 92.4% for vegetables and 93.6% for fruit (Table 3-4), respectively, and all the unqualified products were banned from marketing. At the end of August in 2014, there were 5,410 samples of vegetables and fruit inspected, and 5,199 samples (96.1%) passed the examination. According to regulations, the products that fail to pass the test should be destroyed or postpone their harvest. Relevant government agencies conduct follow-up education and investigate violating cases according to the law. Furthermore, the COA helps local farmers' associations, unions, and fruit and vegetable markets analyze the residue of some toxic pesticides by a quick biochemical method to preliminarily ensure the safety of agricultural products. In 2013, there are a total of 566,006 tests, and the passing rate was 99.1%. Through safety inspection and management, we ensure safe agricultural products and therefore effectively protect consumers' health.

Table 3. Random inspection of pesticide residues in pre-marketing vegetables at production and distributing sites from January to December, 2013.

Category of Vegetables	Results of Examination				
	Number of samples	Number of qualified samples	Percentage(%) of qualified samples	Number of unqualified samples	Percentage (%) of unqualified samples
Small leafy vegetables	887	824	92.9	63	7.1
Leafy package vegetables	173	167	96.5	6	3.5
fruit vegetables	930	829	89.1	101	10.9
Cucurbit vegetables	510	495	97.1	15	2.9
Root vegetables	699	665	95.1	34	4.9
Leguminous vegetables	219	175	79.9	44	20.1
Mushroom	48	46	95.8	2	4.2
Dried beans	11	11	100.0	0	0.0
Sugarcane	2	2	100.0	0	0.0
Processed foods	1	1	100.0	0	0.0
Others	4	4	100.0	0	0.0
Total	3,484	3,219	92.4	265	7.6

Table 4. Random inspection of pesticide residues on pre-marketing fruit at production and distributing sites from January to December, 2013.[a,b]

Category of fruit	Results of examination				
	Number of samples	Number of qualified samples	Percentage(%) of qualified Samples	Number of unqualified samples	Percentage (%) of unqualified samples
Large berries	859	812	94.5	47	5.5
Small berries	974	909	93.3	65	6.7
Citrus	802	768	95.8	34	4.2
Cucurbit fruit	244	233	95.5	11	4.5
Pome fruit	930	869	93.4	61	6.6
stone fruit	608	579	95.2	29	4.8
Nut fruit	0	0	0	0	0
Total	4,417	4,170	94.4	247	5.6

[a] According to the most recent data, the rate of fruit and vegetables that passed the pesticide residue inspection at both production and distributing sites has increased to >96%.
[b] Unqualified produces were banned from marketing and subjected to investigation.

DEVELOPMENT AND APPLICATION OF INTEGRATED PEST MANAGEMENT TECHNIQUES

Services of pest diagnosis and pest monitoring and alert system

The hot and humid weather in Taiwan and the rapid climate change in recent years have caused the fluctuation of primary and secondary pests in agricultural systems. Growth in international trade has also brought higher risk of the invasion, colonization, and dispersal of new pests which pose serious threats to crop production. By integration and application of monitoring and diagnosis techniques developed by agricultural and academic research institutes, the Bureau of Animal and Plant Health Inspection and Quarantine (hereafter referred to as the "BAPHIQ") has established a national system for the diagnosis, identification, notification, and early warning of crop pests. The BAPHIQ collaborates with different institutes to conduct periodic monitoring of important pests in various crops. The monitoring data and pest status information are promptly delivered to farmers and relevant plant protection authorities to assist the development of pest management strategies which help prevent the outbreak of plant epidemics.

To strengthen technical services of pest diagnosis and control, since 1985, "Crop Pest Diagnostic Service Stations" have been established in some universities and almost all agricultural research institutes and District Agricultural and Extension Stations (DARESs) around Taiwan. These stations provide free diagnosis and identification service and advices on pest control. Farmers can send the samples to the service stations for diagnosis. If needed, the researchers also conduct on-site investigation and diagnosis in the field. There are currently 26 "Crop Pest Diagnostic Service Stations" operating in different areas in Taiwan. The service station in Kaohsiung DARES had 8,209 diagnostic cases from January 2007 to December 2013. Statistics shows that 54.4% of the diagnostic cases (4,469 cases) were about fruit trees, and 22.5% of the cases (1,855 cases) were about vegetables, gourds, and fruit vegetables. Fewer cases were related to flowers, ornamental crops, and forest trees. In most cases, pathogens and insect pests were identified as the causative agents. Fewer cases were determined to be caused by physiological disorders [35].

The "Plant Pests Monitoring System" established in 1997 integrated the monitoring, surveillance, investigation, and reporting of plant pests in Taiwan. With internet connection, the plant pests monitoring work was modernized and computerized. After its establishment in 1998, the BAPHIQ started to collaborate with agricultural research institutes and DARESs, plant protection-related departments in universities, county/city governments, and bodies corporate, to conduct detection survey, active monitoring, pest notification, and early warning. In 2001, the BAPHIQ further established the "Plant Pests Notification System" which served as a nationwide information network for the diagnostic services, active monitoring, and reporting of plant pests. The system has made the communication of pest information more systemic and efficient [35] (Figure 2) and all the DARESs play critical roles in the operation of the system.

Figure 2. The network established in Taiwan to conduct active monitoring and alert of pests on major crops to prevent the outbreak of plant epidemics.

Field sanitation and soil management

The development and educational outreach of pest management techniques are fundamental solutions to the dependence on agricultural chemicals. Besides the rational use of pesticides, farmers can implement good cultural practices and field sanitation measures to alleviate pest problems. These include the maintenance of field environment with enough sunlight and ventilation and clean-up of plant residues (wilted branches, fallen leaves and fruit) so that the inoculum in the field can be greatly reduced. For example, the implementation of field sanitation in papaya and guava orchards greatly reduced the infestation of fruit by the pathogens of anthracnose, Phytophthora blight, black spot (Phyllosticta rot), guava scab, and oriental fruit fly. Sod cultivation is another important technique for soil management and pest control in orchards. Our results showed that sod cultivation helped maintain soil moisture, avoid the dispersal of soil-borne pathogens by rain splash, improve soil permeability, increase organic materials in the soil, lower soil temperature, prevent the nymphosis of some insect pests in the soil, and protect natural enemies. Farmers who adopted these techniques have benefited from efficient and effective pest control and also significantly reduced the use of chemical pesticides [38,39].

Breeding for pest resistance

The use of resistance cultivars to control crop pests is the most direct and effective non-pesticide pest management strategy [27]. Breeding for pest resistance usually takes a lot of time and effort. In Taiwan, breeding for disease and insect resistance has been a long-term goal of agricultural institutes, DARESs, and some private seed companies. For example, in the production of asparagus bean, *Fusarium* wilt caused by *Fusarium oxysporum* f. sp. *tracheiphilum* is a key limiting factor. Since there is currently no fungicide available for disease control, resistance breeding becomes a good and feasible strategy. To identify genetic resource for disease resistance, Kaohsiung DARES evaluated the resistance performance of previously collected Asparagus bean germplasm in disease nursery fields. Thirteen lines showing high resistance to *Fusarium* wilt were selected as rootstocks, and the scions of a mainstream susceptible variety "San chr ching pi" were grafted onto the rootstocks. By investigating the quality, yield, and disease incidence of the grafted lines, the effect of grafting on disease control can be determined. Our results based on several compatible scion/stock combinations showed that grafting has no adverse effect on taste and appearance. Compared to the susceptible variety (no grafting)which had an average disease incidence of 86.7%, the use of the highest resistant rootstock showed an average disease incidence of as low as 4.4% and a 2.3-fold increase in yield, suggesting the feasibility of applying grafting technique for controlling *Fusarium* wilt of asparagus bean. Kaohsiung DARES also works on the breeding of resistance against powdery mildew on muskmelon. Six highly resistant lines with good horticultural characteristics have been selected. The denomination, release, and popularization of these new resistant varieties will greatly reduce the application of fungicides in the field.

Development and application of non-pesticide agents

Due to increasing public awareness of environmental issues, the development and application of non-pesticide agents have become an important trend. After many years of efforts, the plant protection researchers in Taiwan have developed various types of non-pesticide techniques, targeting different pests with distinct characteristics. These techniques have been tested and validated to work well in pest control. The techniques have been transferred to farmers for application and therefore significantly reduce the use of chemical pesticides.

Phytophthora blight is a destructive fungal disease of a wide range of fruit trees, vegetables, and flowers. In Taiwan, the rainy and humid conditions are favorable for the formation and dissemination of the sporangia and zoospores of the pathogen, leading to a high risk of the outbreak and rapid spread of the epidemics [29]. Mixture of phosphorous acid and potassium hydroxide (H_3PO_3+ KOH) can be used to effectively control the Oomycetes pathogens. Farmers can dissolve an equal amount of commercialized phosphorous acid (industrial grade H_3PO_3, 95-99%) and potassium hydroxide (KOH, 95%) in water then 1:1000 diluted solution of the mixture is used for foliar spraying and 1:200 diluted solution for soil drenching. The mode of action is to activate defense mechanisms in host plants. Several important diseases caused by *Oomycetes* pathogens, such as downy mildew, *Peronophythora* downy blight, and *Albugo* white blister, can be prevented by using the technique. Phosphorous acid is also a disease control material approved for use in organic farming [1,8,27]. With efforts on extension and outreach, phosphorous acid has been commonly known and widely used by farmers.

In regard to the control of powdery mildew, although some fungicides have been approved to be used for this disease, our long-term trials showed that several non-pesticide agents were even more effective than the chemical fungicides. For example, cucumber is one of the crops of continuous-harvest type, and therefore the overdoses of pesticide residues have been a major concern of consumers.

Problems have arisen from time to time. Kaohsiung DARES selected several plant protection agents with no MRL (maximum residue limit) requirement and tested their efficacy on the control of powdery mildew of cucumber in multiple field trials across many years. These safe agents include carbonate, phosphate, mineral oil, copper agents, sulfur agents, agriculturally used antibiotics, potassium bicarbonate ($KHCO_3$), narrow range oil, Polyoxins, and netralized phosphorous acid, etc. All of these safe and less toxic agents have been waived for MRL requirement by the Ministry of Health and Welfare. According to the data of field trials, their effectiveness on the control of powdery mildew was not lower than the chemical pesticides in field trials (Table 5-7). For organic farming, the use of narrow range oil (200X) mixed with neutralized phosphoric acid (800X) in autumn and winter can effectively control downy mildew, powdery mildew, aphids, and some other small insects until the end of harvest. The research and application of these safe agents profoundly improved safety of fruit and vegetables especially for continuously-harvested crops.

Table 5. Control of powdery mildew on cucumber by using safe materials (1)

Treatments	Disease Severity (%)[a]				
	7 days after 1st spray	7 days after 2nd spray	7 days after 3rd spray	7 days after 4th spray	7 days after 5th spray
H_3PO_3+KOH (1:1) (800X)	7.9	15.1	25.4	25.8	50.6
Narrow range oil (200X)	6.5	11.6	15.4	27.4	63.0
80% Potassium bicarbonate SP (500X)	0.4	0.9	0.8	7.2	11.0
80% Wettable sulfur WDG (1,000X)	0.3	0.4	0.0	1.0	1.4
Bacillus subtilis(400X)	11.2	26.7	20.6	61.8	76.8
27.12% Tribasic copper sulfate SC (800X)	3.6	10.8	16.0	35.8	41.4
23% Azoxystrobin SC(2,000X)	8.1	24.7	19.8	63.4	80.0
CK	14.1	30.8	34.0	75.4	83.4

[a] The disease severity is 0% before treatment. Each experiment was conducted with 3 replicates.

Table 6. Control of powdery mildew on cucumber by using safe materials (2)

Treatments	Disease severity (%)[a]			
	Before spraying	7 days after 1st spray	7 days after 2nd spray	7 days after 3rd spray
Bacillus amyloliquefaciens PMB01 WP (10^7cfu/ml)	11.7	23.3	48.0	72.0
35.15% Sulfer + copper oxychloride SC(600X)	10.0	26.4	49.3	59.6
10% Polyoxins WP(800X)	11.7	9.2	18.7	16.9
Extract of plant ash (150X)	10.8	17.8	28.0	46.2
H_3PO_3+KOH (1:1) (800X)	11.7	13.6	28.7	43.8
Narrow range oil (500X)	7.5	30.3	37.3	51.1
80% Potassium bicarbonate SP(1,000X)	6.7	18.6	24.9	40.2
CK	13.3	35.3	53.3	76.7

[a] Each experiment was conducted with 3 replicates.

Table 7. Application of *Bacillus amyloliquefaciens* PMB01 to control bacterial wilt caused by *Ralstonia solanacearum.*[a]

Treatments	Disease Severity (%)						
	7 days after 1st spray	7 days after 2nd spray	7 days after 3rd spray	7 days after 4th spray	7 days after 5th spray	14 days after 5th spray	21 days after 5th spray
BaPMB01 (10^7 CFU/ml)	2.4a	3.2a	4.5a	5.4a	6.8a	7.3a	8.2a
Blank[*]	4.1b	7.7b	13.4b	19.0b	26.4b	32.6b	39.5b
CK	5.8b	10.1c	15.6c	22.7c	29.4.c	37.5c	43.2c

[a] Experiment was conducted with randomized complete block design (RCBD), each treatment was 120 plants with 3 replicates. BaPMB01 broth with 200 ~ 300ml of 10^7cfu / ml was drenched around the base of each tested plant. The disease severity is 2% ~3% before treatment. The same letters in the same column followed by the same letters were not significantly different according to LSD (p = 0.05) analysis.

[*] The treatment “Blank” was culture medium only.

Biological control

Beneficial microorganisms have been widely applied for disease management on crop production. Using *Streptomyces saraceticus* KH400, Kaohsiung DARES has developed disease-suppressive growing substratewhich is effective in controlling damping-off disease in vegetable seedlings (caused by *Rhizoctonia solani*). *Streptomyces*, belonging to Gram-positive bacteria, are the most frequently used beneficial microorganisms for disease control [27]. The antibiotics and lytic enzymes (such as chitinases and celluloses) secreted by *Streptomyces* spp. are harmful to soil-borne pathogens and parasitic nematodes. The beneficial bacteria are prevalent in native soil and can be activated by shrimp and crab shell powder. Upon induction by chitin-containing materials, *Streptomyces* spp. propagate, produce enzymes, and therefore inhibit diseases and parasitic nematodes.

Kaohsiung DARES has also developed effective biocontrol techniques against the 'incurable crop diseases' such as bacterial wilt and *Fusarium* wilt, using an indigenous strain (PMB01) of *Bacillus amyloliquefaciens* as the biocontrol agent. *Bacillus amyloliquefaciens* is a Gram-positive bacterium which shares similar morphological and functional characteristics with *B. subtilis.* It is known that *B. amyloliquefaciens* can produce many extracellular lytic enzymes (such as celluloses, proteases, lipases, and amylases) and antibiotics (such as iturin A, fengycin, and surfactin), and has great potential in crop disease control [11,25]. The causal agent of bacterial wilt, *Ralstonia solanacearum*, has a very wide host range, including over 200 host species and *Solanaceae* plants such as tomatoes, potatoes, eggplants, and peppers are the most seriously affected crops. *R. solanacearum* can survive in soil for more than 10 years and causes devastating crop diseases in the tropics, subtropics, and some temperate areas with humid and hot summers.

On the other hand, *Fusarium* wilt is a soil-borne disease caused by different forma specialis (f. sp.) of the fungal pathogen *Fusarium oxysporum.* It is considered a key limiting factor in the cultivation of beans and cucrbits. It infects plants by direct penetration of the root tips or cortex and the hyphae grow upwards in the vascular system, resulting in the death of infected plants. There used to be no effective control measures for both bacterial wilt and *Fusarium* wilt. After many trials in greenhouses and fields, Kaohsiung DARES found that *B. amyloliquefaciens* PMB01 reduced the severity of bacterial wilt and *Fusarium* wilt by over 70%[12]. Severity scores of bacterial wilt disease in tomato plants treated with and without PMB01 were 43.2% and 8.2%, respectively. Significant effect was also found for controlling *Fusarium* wilt of cucurbits. In cucumber, while the average severity of *Fusarium* wilt in non-treated plots was 47.7%, the average severity in PMB01-drenched plots was reduced to 11.6% (Table 9).

Table 8. Application of *Bacillus amyloliquefaciens* PMB01 to control *Fusarium* wilt caused by *Fusarium oxysporum f. sp. cucumerinum.*[a]

Treatments	Disease Severity (%)						
	7 days after 1st spray	7 days after 2nd spray	7 days after 3rd spray	7 days after 4th spray	7 days after 5th spray	14 days after 5th spray	21 days after 5th spray
BaPMB01 (10^7 CFU/ml)	5.1a	6.7a	7.2a	1.8a	9.4a	10.2a	11.6a
Blank*	8.9b	18.3b	22.6b	29.0b	36.7b	40.7b	43.7b
CK	12.5c	20.6b	25.5c	32.0b	38.5b	43.0c	47.7c

[a] Experiment was conducted with randomized complete block design (RCBD) with 3 replicates as described in Table 7. The numbers in the same column followed by the same letters were not significantly different according to LSD (p = 0.05) analysis.

*The treatment " Blank" was culture medium only.

Table 9. Application of *Bacillus amyloliquefaciens* PMB01 to control Fusarium wilt caused by *Fusarium oxysporum f. sp. tracheiphilum.*[a]

Treatments	Disease Severity (%)						
	7 days after 1st spray	7 days after 2nd spray	7 days after 3rd spray	7 days after 4th spray	7 days after 5th spray	14 days after 5th spray	21 days after 5th spray
BaPMB01 (10^7 CFU/ml)	0a	0a	0.5a	1.6a	2.0a	2.4a	3.2a
Blank[*]	0a	0.2a	2.7b	4.5b	12.6b	17.6b	24.7b
CK	0a	0.4a	2.8b	5.2b	15.7c	23.5c	29.4c

[a] Experiments was performed with randomized complete block design (RCBD), 3 replicates as described in Table 7. The numbers in the same column followed by the same letters were not significantly different according to LSD (p = 0.05) analyzing.
[*]The treatment " Blank" was culture medium only.

In asparagus bean, the severity scores of *Fusarium* wilt in non-treated and PMB01-drenched plots were 29.4% and 3.2%, respectively. Based on acute oral toxicity and pathogenicity study and acute pulmonary toxicity and pathogenicity study, *B. amyloliquefaciens* PMB01 is non-toxic to mammals. The abovementioned biological control technology has transferred to the industry and Kaohsiung DARES keeps working on preparing the data required for biopesticide registration. After completing the registration process, the commercialized product can be used by farmers in the near future.

In insect pest management, Kaohsiung DARES also developed the technique of using *Aschersonia* sp in biological control of whiteflies. Silverleaf whitefly (*Bemisia argentifolii*; Homoptera: Aleyrodidae) was identified for the first time in Taiwan in 1990. Since its invasion, the pest was found to infest and damage more and more crop species, including many vegetables, fruit, and flowers. Although many insecticides were approved and applied for its control, cases of whitefly resistance to insecticides have been reported worldwide. The evolution of insecticide resistance has resulted in increased use of chemicals. *Aschersonia* sp. is an entomopathogenic fungus which can infect silver leaf whitefly. Aiming to use *Aschersonia* sp. for biological control, Kaohsiung DARES started the collection of entomopathogenic fungal strains from several years ago. With continuous efforts to optimize the culturing and large-scale fermentation conditions, we hope that *Aschersonia* sp. can be widely used for field application in the near future.

Broad-sense biological control includes the use of antagonistic plants. In recent years, this method has been widely applied in the control of crop diseases caused by nematodes. Kaohsiung DARES evaluated the effect of using a natural antagonistic plant, African marigold, for controlling root-knot nematode in guava. The results showed that growing African marigold around the rhizosphere of guava plants significantly reduced the density of infective second-stage juveniles of root-knot nematode (the density was reduced from 128 to 32 juveniles per 100g soil) (Figure 3). It has been confirmed that planting African marigold around the rhizosphere of host plants is an effective and eco-friendly way for controlling soil-inhabiting nematodes. With efforts on extension and outreach, growing African marigold is now a commonly used biocontrol measures for guava farmers.

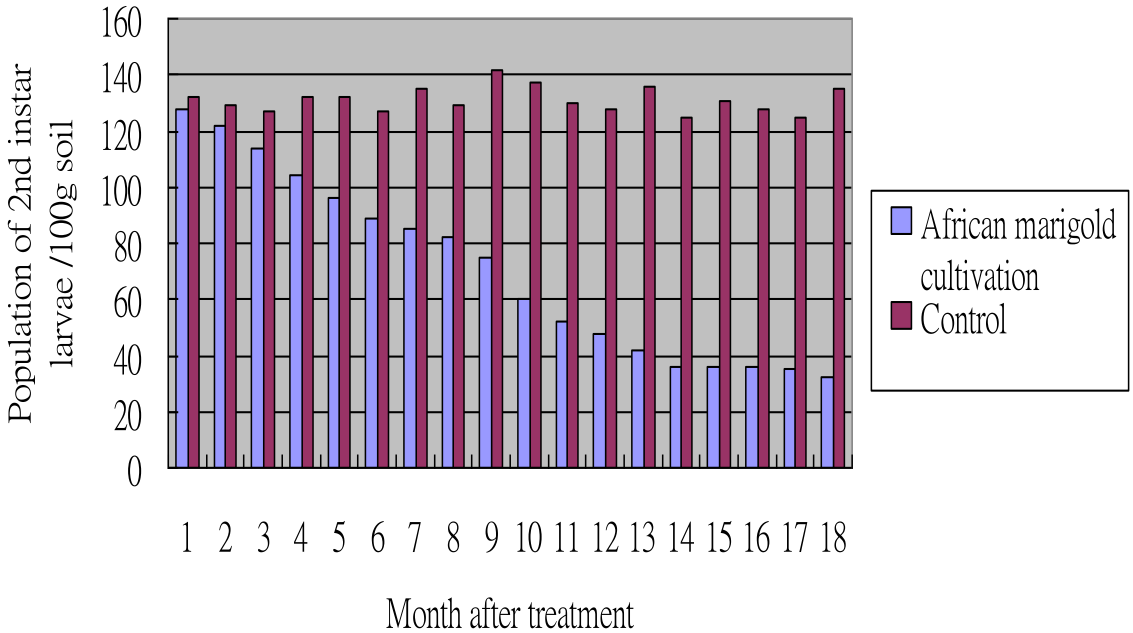

Figure 3. African marigold cultivation is effective on the of control root-knot nematode disease. The population of 2nd instar larvae was decreased from 128/100g soil to 32 /100g soil after 18 months.

Natural enemies: parasitoids and predatory insects

Beneficial microorganisms such as *Bacillus thuringiensis*, *Streptomyces* spp. and natural enemies, including parasitoids and predatory insects, have been commonly used as biological control agents. [10]. Among these, *Bacillus thuringiensis* has been widely used for a long time in Taiwan. Utilization of natural enemies for pest control is advantageous for reducing pesticide use. In Taiwan, Miaoli DARES has a biological control station that focuses on developing mass rearing technology and application of natural enemies of insects. There are also some scholars in other DARESs and academies working on natural enemies related to research and extension.

In a wide variety of parasitoids, the utilization of an artificially mass-reared indigenous parasitic wasp, *Trichogramma ostriniae*, is a common method to control Asia corn borers (*Ostrinia furnacalis*) in Taiwan. [17] Predatory insects covering 18 orders and nearly 200 families are also popular in Insecta. Important and common predators include dragonflies, mantises, ladybirds, epomis, hover flies, green lacewings, stink bugs, robber flies, wasps, ants, mites, etc.

In the application of predatory insects, take *Mallada basalis* and *Cantheconidea furcellata* for example, a green lacewing, *Mallada basalis* (Neuroptera:Chrysopidae), is a predator of spider mites, aphids, whiteflies, scales, psyllids, and many Lepidoptera and Coleoptera larva or eggs. The experiments conducted at KDARES showed that releasing *M. basalis* larva significantly reduced the population of aphids and spider mites in both of cucumber and asparagus bean greenhouses. *Cantheconidea furcellata* sting bug (Hemiptera: Entatomidae) is a common predator for Lepidoptera larva and various insects in the order Coleoptera, Hemiptera, and Homoptera. The experimental results showed that releasing *Cantheconidea furcellata* nymph or imago significantly reduced the population of *Diaphania indica*, *Maruca testulalis*, and *Euproctis taiwana* in both of cucumber and vegetable soybean fields.

Since the abovementioned predators can be mass-reared in a cost-effective manner, DARESs have been working on education and extension in mass production technologies and application models for farmers.

Sex pheromones and attractants

Insect sex pheromones have been widely used for pest monitoring and control in the field for over 20 years in Taiwan. To date, more than 10 insect sex pheromones are identified and synthesized. Using sex pheromones as a non-pesticide agent is environmentally friendly and can be concurrently applied to the field with other pest control methods, therefore it is one of the non-pesticide agents widely adopted by growers in Taiwan **[24]**.

Insect sex pheromones have high bioactivity and specificity and remain attractive for long period of time even at a low dosage [21], therefore they are widely used for pest monitoring for timing insecticide sprays resulting in the reduction of insecticide use in the field [21]. In Taiwan, insect species that are monitored using this technique include: *Spodoptera litura* (tobacco cutworm and armyworm), *Spodoptera exigua* (beet armyworm), *Helicoverpa armigera* (tomato fruit worm, corn earworm, cotton bollworm, and false tobacco moth), *Plutella xylostella*; (diamond-black moth), *Chilo suppressalis* (Asiatic rice borer), *Adoxophyes* sp., *Homona magnanima* (tea leaf-roller and tea tortrix), *Cylas formicarius* (sweet potato weevil), *Eucosma notanthes* (carambola fruit borer), and *Lymantria xylina* (casaurina tussock moth) **[19,21,22]**.

Besides pest monitoring, insect sex pheromone traps can also be used to attract male insects in the field to reduce the population of the next generation. In Taiwan, the insect pests that sex pheromones are used for monitoring or mass trapping include: *Spodoptera litura* (tobacco cutworm and armyworm), *Spodoptera exigua* (beet armyworm), *Helicoverpa armigera* (tomato fruitworm, corn earworm, cotton bollworm, and false tobacco moth), *Plutella xylostella*, (diamond-black moth), *Adoxophyes* sp., *Homona magnanima* Diaknoff (tea leaf-roller and tea tortrix), *Cylas formicarius* (sweetpotato weevil), and *Lymantria xylina* (Casaurina tussock moth) **[19,21,22]**. When using sex pheromone traps, insect behavior and the density of traps must be taken into account. In addition, the distance between 2 different sex pheromone traps should be greater to avoid interference with each other **[21]**.

Oriental fruit fly (*Bactrocera dorsalis*, OFF) which can infest 117 different plants is one of the major limiting factors for fruit production in Taiwan **[3]**. Even though the government and growers have put lots of efforts in the control of OFF, the population density of the insect is still high in fruit-producing areas in Taiwan as suitable environmental conditions and available host plants grown perennially favor its survival and infestation. Methyl eugenol, an attractant of male Oriental fruit flies, added with proper insecticide is used to trap and kill male OFF, and therefore reduces the population of offspring **[2,3]**. The long-efficacy trap for OFF invented by Kaohsiung KDARES consisting of 90% methyl eugenol and 5% Naled (EC) remains effective over six months in the field. It is normally deployed at a density of 4~6traps per hectare. The use of long-efficacy traps accompanied with field sanitation, fruit bagging and protective facilities provides the best pest control and yield benefit and drastically reduce the use of insecticides as well. It has been widely adopted by fruit growers in Taiwan **[13,14]**.

Economical and safe use of pesticides

Pesticides are essential materials for plant protection. However, inappropriate and excessive use of pesticides can cause harm to humans, agricultural products, and the environment. To ensure quantity and quality of agricultural crops as well as environmental sustainability, the academies and government institutes in Taiwan especially emphasize the research and extension of economical and safe use of pesticides. The main points for farmers' education include (1) Choosing the right pesticides: Only use approved pesticides, diagnose problems correctly, apply proper pesticides rationally, and alternate pesticides with different modes of action to prevent or postpone pest resistance to pesticides, (2) Proper Timing: Apply pesticides when pests in its early stages and use the minimum amount of pesticides to control pests, (3) Proper amount: Use application rates, intervals, and concentrations recommended by the Plant Protection Manual to avoid ineffectiveness or residual pesticides problems, (4) Identify pests-infested sites and apply pesticides on the main targeted sites for best protection, (5) Complying with safe duration between pesticide application and harvest and use safe materials the duration of which is either short or waived when crops are near harvest.

Taking Kaohsiung DARES as an example, in order to promote economical and safe use of pesticides, we not only provide free pest diagnostic and technical services, but also intensively monitor important crop pests and deliver the pest status information to farmers through multiple communication channels. Furthermore, our research focuses on developing safe pest control materials, evaluating efficacy of approved pesticides, screening safe and effective pesticides that can prevent multiple pests. Through education course, workshops and demonstration in the fields, farmers learn how to reduce the variety, amount, and application frequency of pesticides.

Farmers education and training

In recent years, the agricultural labor force is shrinking in the rural areas of Taiwan because young people are moving away from farming while the aging farmers are increasing. To ensure agricultural sustainability, our government especially focuses on the establishment of lifelong learning programs for farmers, including regular technical workshops and field demonstrations which emphasize crop health management technology, application for Ji-Yuan-Pu safe fruit and vegetables (GAP) label, and pesticide-safety related knowledge. A variety of training programs have also been designed to meet specific needs. To date, the COA has held the "The Farmers' Academy Program", a systematic education and training program mainly conducted by DARESs for the general public, particularly for young farmers. The courses include crop health management technology, good agricultural practices, and agricultural business management aiming to cultivate young farmers and strengthen agricultural competitiveness [30,36].

To take Kaohsiung DARES for example, 13 classes for the Farmers Academy Program and more than 60 workshops related to crop health management and agricultural production and marketing technology were held in 2013. We also compile the approved pesticides in the Plant Protection Manual and posted it on our official website for farmers' reference.

The hard copies are directly given to farmers in the workshops. Technical brochures of crop health management for important crops, agricultural newsletters, and agricultural journals containing abundant useful information about rational fertilization and health crop management are periodically published, delivered to farmers, and posted on the official website and on Facebook. We also provide farmers and consumers with updated information and consultation services via telephone, fax, and internet. By developing digital learning materials and making research/extension reports and other resources freely accessible online, we have greatly increased the efficiency of information dissemination and promoted the implementation of good agricultural practices for production of safe fruit and vegetables in Taiwan.

CONCLUSION

Located in the subtropical region, Taiwan's temperature and humid climate makes it susceptible to the spread of pests and hence the common use of chemical pesticides. How to strike a balance between crop production, safety of agricultural products and environmental conservation has long been a serious challenge for governing authorities of agriculture. For a long time, administrative and technical governing agencies have endeavored to build a system to promote healthy agricultural practices while at the same time, engage in research and promotion. Some of these practices include building a more comprehensive Agro-Pesticide Act, finding best practices and validation for agriculture, and research and development in pest prevention. The aim is to develop technologies and to promote the safe use and better management of chemical pesticides to balance the safety of agricultural products and environmental conservation. After years of hard work, chemical pesticide abuse has been significantly improved, and there is better safety of agricultural products.

Taiwan's production area spans across approximately 80 hectares, with a total of 779,375 farm households. On average, each household holds 1.1 hectares of farmland. Farmers on average are 63 years old, highlighting the issue of an ageing farmer population in Taiwan. Against this backdrop, governing authorities of agriculture have been proactive in establishing agricultural production and marketing groups to facilitate the education and training of farmers. Currently, the number of agricultural production and marketing groups has reached 6,271, with around 2,000 groups GAP-certified. However, most farmers are still not members of agriculture-related organizations, making communication relatively difficult. This creates a gap in the education and promotion of healthy agriculture practice. Therefore, improving the organization and education of farmers to practice healthy agriculture is an important work that needs to be completed in the future.

GAP, TAP, and CAS ORGANIC systems are the three agricultural product certification systems which are currently in place. However, the relatively complexity generates difficulties or confusion for farmers in applying the certification systems. Inspection and management measures of certification systems still need to be better developed, and this has resulted in certified products bearing residual pesticide higher than standards or even fraudulent use of the GAP labels. In this light, it is necessary to conduct a thorough review and to design an integrated and more efficient system to be better adopted by farmers. At the same time, an agricultural and food traceability system that is aligned with international practice is also needed. In terms of the technical development, Taiwan needs to further improve R&D in bio-agents and safe crop-protection products and to facilitate the producers to obtain permits for legal sale of such products so that chemical pesticides can be partially replaced. Furthermore, Taiwan also needs to reduce the use of chemical pesticides and fertilizers and to gradually develop its organic farming. It is hoped that through these practices, Taiwan will become a nontoxic agricultural island in the future.

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MANAGING TRACEABLE SYSTEM FOR ORGANIC FRUIT AND VEGETABLE PRODUCTS IN TAIWAN

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ABSTRACT

Organic agriculture emphasizes the balance of the ecosystem and the sustainability of the environment. If and only if humankind supports sustainable development of the environment, then the environment may feed us with enough and safe food permanently. In the past decades, organic products have becoming more and more popular around the world as well as in Taiwan. There are 5,951 ha of farmland were certified organic in Taiwan in 2013. Since the Organic Act enforced in 2007, all steps in the supply chain of organic products and its processed products must be in accordance with the act and certified by the control bodies approved by competent authority. It not only maintains the integrity of the organic process, but also provides consumers with a convenient and efficient way to trace back to the origins of products they have got. Furthermore, by taking advantage of the well-developed IT industry and cloud computing, QR code system has been incorporated as an easy and quick method for tracing organic products in Taiwan.

Keywords: organic agriculture, QR code, traceability, accreditation, certification

INTRODUCTION

Agriculture is the most basic economic activity as well as the most important food source for humankind. As long as you need to eat, you are unable to keep away from agriculture. Food stuff is all-important to human beings and most of us eat three meals a day even if we don't like to spend money. You can extend the lifespan of both yourself and our environment simply by following the principle of "paying attention to health and being eco-friendly" when you buy food stuff. World population is expected to reach 8.9 billion by 2050 (United Nations Department of Economic and Social Affairs, 2004). It has always been a big challenge for us to grow sufficient food and so will to be in the future. Basically, agricultural production is affected by factors, such as climate, soil, water, and microorganism, etc .which cause unstable yield. Therefore, farmers are forced to use chemical pesticides and fertilizers for protecting crops so as to ensure a stable quantitative and qualitative output. However, most chemical substances are harmful to human health, soil organism, and even the whole environment. We are devouring the resources on the earth regardless of the negative effects of chemicals which is visible or invisible, sensible, or insensible. Each meal of a person costs 800 liters of water, 1.3 liters of diesel, 10 kg of top soil, and 0.03 g of pesticide (Julian 2014). It's really a dilemma, considering food security, food safety, and natural resources at the same time.

The International Federation of Organic Agriculture Movements (IFOAM) has defined the term "organic agriculture". It is a production system that sustains the health of soils, ecosystems, and people. It relies on the ecological processes, biodiversity, and cycles to local condition rather than the use of inputs with adverse effects.

“Organic Agriculture” combines tradition, innovation and science to benefit the shared environment and promote fair relationships, and a good quality of life for all those involved. Also, IFOAM points out that organic agriculture is based on four principles. These principles are the roots from which organic agriculture grow and develop. First, the principle of HEALTH: Organic Agriculture should sustain and enhance the health of soils, plants, animals, humans and the whole planet as one and should be indivisible. Second, the principle of ECOLOGY: Organic Agriculture should be based on living ecological systems and cycles, work with them, emulate them, and help sustain them. Third, the principle of FAIRNESS: Organic Agriculture should build on relationships that ensure fairness with regard to the common environment and life opportunities. Fourth, the principle of CARE: Organic Agriculture should be managed in a precautionary and responsible manner to protect the health and well-being of current and future generations and the environment. Based on the definition and the core spirit of organic agriculture, it intends to create a world where people and all organisms can live their lives prosperously and permanently, where the environment surrounding us can feed us forever. So, the simplest definition for organic agriculture is that “under no circumstance should chemicals be involved in any part of the process of the organic product supply chain”. This definition and practice should be carried out during the organic operation around the world as well as in Taiwan.

While the economy and information technology have been improving, people are increasingly aware of the safety of agricultural products. Therefore, organic agricultural products have become familiar and popular in recent years around the world. A study shown in the “British Journal of Nutrition” states that organic crops and crop-based foods, including fruit, vegetables and cereals, are up to 60% higher in a number of key antioxidants than their non-organic counterparts. In addition to higher in antioxidants, organic crops contain significantly lower levels of toxic heavy metals (Baranski, 2014).

ORGANIC AGRICULTURE IN TAIWAN

The Council of Agriculture (COA) in Taiwan has established the necessary organic regulations and laws in 2007 in order to facilitate the development of organic farming. These regulations and laws are the basic principles for developing organic farming. COA is the accreditation body and the Taiwan Accreditation Foundation (TAF) has been authorized as the only compliance assessment organization for Accreditation body by COA. TAF manages all organic certification bodies, including production, processing, packaging, and distribution certification which are approved by the COA. The cultivation area of organic crops in Taiwan has been steadily expanding due to market needs, consumer awareness, health concerns, and environmental issues. Till the end of 2013, COA had approved 12 cropping certification bodies and one livestock certified body. The total area of organically certified cropping in Taiwan reached 5,951 ha which included rice (2,060 ha), vegetables (1,963 ha), fruit (835 ha), tea (448 ha), and others (645 ha) (Table 1). It's more than two times of the area of 2,356 ha 5 years ago in 2008. It even increased more than 5 times over the last decade, the area of 1,092 ha in 2003. However, the organic farming area in 2013 occupied only 0.7% of the total arable land in Taiwan. It's relatively low when compared to the percentage of Italy (1,167,000 ha, 9.1%), Spain (1,593,000 ha, 6.4%), Uruguay (930,000 ha, 6.3%), Germany (1,034,000 ha, 6.2%), Australia (12,001,000 ha, 2.9%), Argentina (3,637 ha, 2.6%) (Fig.1). On the other hand, Taiwan also imports certified organic products from other countries which are recognized as one with equivalent standards. For the management of imported organic agricultural products, the Agriculture and Food Agency (AFA) is responsible for accepting applications and for carrying review documents in regard to the issuance of certifications as required by the Imported Organic Agricultural Product and Organic Agricultural Processed Product Management Regulations. Most of the imports are from the USA, followed by New Zealand, Canada, Australia, and Germany. The import quantity reached 9,982 tons in 2013, up from 5,056 tons in 2007. It increased nearly two times in this six-year duration. The imported items were mainly cereal grains, processed grain products, and drinks.

Table1. The area of major crops organically cultivated in Taiwan. Unit: ha.

Year	Rice	Vegetable	Fruit	Tea	Others	Total
2007	843	438	258	125	349	2,013
2008	949	518	296	140	453	2,356
2009	1,085	913	289	169	504	2,960
2010	1,317	1,435	462	219	601	4,034
2011	1,653	1,692	613	263	794	5,015
2012	1,763	1,779	687	400	929	5,585
2013	2,060	1,963	835	448	645	5,951

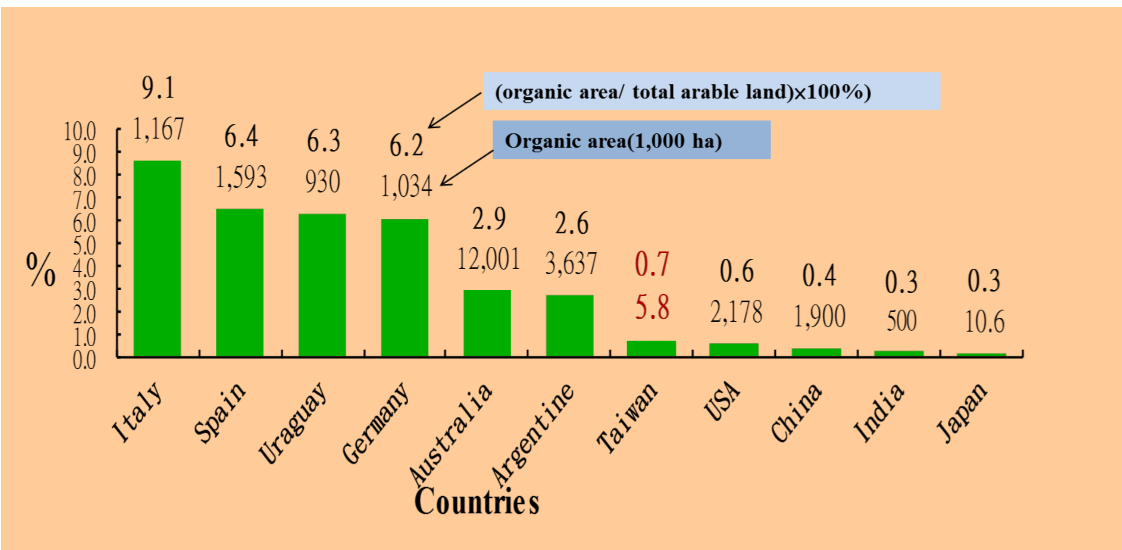

Fig. 1. The organic farming area and its percentage to the total arable land area in countries

It is convenient for consumers to choose organic agricultural products which are labeled "CAS Organic". In order to ensure the safety and quality of locally produced organic products as well as of the imported ones, and also to strengthen consumers' confidence and protect consumers' rights, COA establishes examination plans for the safety and labeling of organic products every year. About 2,000 products have been sampled from farms, markets and customs annually for examining pesticides and additives residue. The results showed that around 99% of the examined samples had complied with the Taiwan's organic regulations. More than 96% of the certified products in Taiwan have in accordance with the national pesticide MRL (maximum residue limit) (Table 2). The competent authority in Taiwan also proposed measures to boost the development of organic agriculture. Measures for promoting organic agriculture include assisting farmers to apply for certification of organic products, enlarging the specialized organic production zones, holding educational classes for farmers, upgrading related cultural techniques, and promoting the use of CAS organic logo. The Agency also encourages the involvement of religious groups, voluntary workers, and business sectors in the extension of organic agriculture production.

Table 2. The percentage of certified products met with the maximum residue limits of pesticide and chemicals.
Unit: %

Year	GAP	TGAP	Organic	Others
2010	93.3	---	99.4	91.8
2011	96.4	97.1	99.4	93.8
2012	96.1	100	99.1	93.3
2013	95.2	96.5	98.9	92.6

TRACEABLE SYSTEM FOR ORGANIC PRODUCTS IN TAIWAN

Ever since the "Agricultural Production and Certification Act" was enforced in January 2007, COA has further finalized nine daughter regulations, including the "Organic Agricultural Product and Organic Agricultural Processed Product Certification Management Regulations", and "Imported Organic Agricultural Product and Organic Agricultural Processed Product Management Regulations". This is to increase the international competitiveness of organic products. This provides an environment for further sustainable development of organic agriculture in Taiwan. The promotion of traceability in agricultural goods is one of the main itineraries on food safety projects in Taiwan. Taiwan has a well-developed Information Technology (IT) industry. By taking advantage of the industry, we introduce it to the organic agriculture community for tracing the growers or operators of organic products. A QR code system has been incorporated to the supply chain of organic products in Taiwan. Consumers can trace back origins by the QR code labeled on the products' containers or packages to know where the products come from immediately.

Traceability of the imported organic products

According to "Imported Organic Agricultural Products and Organic Agricultural Processed Products Management Regulations", once an agricultural product is to be imported and sold as organic, the importer shall complete an application form and attach the following documents in duplicate form and apply to one of the branches of AFA for reviewing prior to sale:

a. A photocopy of a company license or business registration demonstration document;
b. Certification demonstrates that the imported agricultural products or processed agricultural products have been granted as organic; The certification document shall include the following items:(1)The name and address of the agricultural product business operator;(2)The name and batch number of the product, and the percentage content of organic raw materials in processed agricultural products;(3)The weight or volume of the product;(4)The name of the importer or buyer; (5)The name and address of the certification body; (6)The date of issuance;
c. The photocopies of the import certificate slip of the import declaration.
d. Other documents required by the central competent authority.

The branch of AFA shall issue an organic labeling approval document to the applicant when the imported organic agricultural products have passed reviewing. The organic labeling approval document shall state the following items:

a. The name and address of the importer;
b. The name of the agricultural product operator in foreign countries;
c. The name and batch number of the products;
d. The weight or volume of the products;
e. The name of the certification body;
f. The number of the organic labeling approval document.

Before the imported organic products release to market, the language used for labeling shall be standard Chinese which may be supplemented by foreign languages or commonly used symbols. The container or packaging of imported organic agricultural products shall include the following statements on the labels at the time of sale:

a. Product name;
b. Names of ingredients;
c. Name, telephone number and address of the importer;
d. Place (country) of origin, except for those of which the labeling of production factories' addresses could signify the place (country) of origin;
e. Name of the certification body;
f. The number of the organic labeling approval document;

Thus, consumers or anyone can easily know the origin of the product and its certification body by just inspecting the container or package of the imported product. We can also trace back to find the name and address of the importer, certification body and the agricultural product business operator in foreign countries by inspecting the label on the package or by reviewing relevant documents (Fig. 2).

Fig. 2. The labeling of imported certified organic products which were sold as packaged goods.

Traceability of the locally produced organic products

According to Organic Agricultural Products and Organic Agricultural Processed Products Certification Management Regulations, when an organic agricultural product or organic agricultural processed product is certified, the certification body shall sign a contract with the applicant and issue an organic agricultural product certificate based on the categories of the organic products. The certificate shall state the following items:

a. The name and address of the agricultural product operator, and the name of its statutory responsible person;
b. Location of certification site;
c. The product category and item;
d. The period of validity;
e. The name of the certification body;
f. The certificate number.

The container or packaging of locally produced organic agricultural products shall include the following statements at the time of sale:

a. Product name;
b. Names of ingredients;
c. Name, address and telephone number of the agricultural product operator;
d. Place (country) of origin, except when the address of the production factory or certification site is labeled in a way that the place (country) of origin of the product can be identified;
e. Name of the certification body;
f. The certificate number of the organic agricultural product certification;

By means of the aforementioned labeling and displaying measures for packaged organic products (Fig. 3), consumers are well informed of the products they have got. They are able to know where the products come from and which organization certified it.

Fig. 3. The labeling of locally produced certified organic white fungus (*Tremella fuciformis*) which was sold as a packaged good.

Traceability of sold organic products in bulk

In the case of organic products to be sold in bulk at regular business places, a photocopy of the organic agricultural product certificate and a sign near the place of display and sale must be displayed to state the product’s name and the place (country) of origin (Fig. 4). Besides, the height and width of the characters for marking the place (country) of origin shall not be less than 3 cm.

Fig. 4. The display and sale of locally produced (left) and imported (right) certified organic product which were sold in bulk.

Tracing by QR code system

The IT industry and cloud technologies have been well-developed in Taiwan. They were widely used in many sectors, including restaurants, logistics, industries, marketing, etc. Mobile devices (smart phone or tablet) are very popular in Taiwan. Almost everyone has at least one such device on hand. If consumers can get more information about the organic products they bought easily and quickly, they get more detailed information about where the organic vegetables and fruit grow and who grows them. It will impact positively to consumers, subsequently increase the consumers’ interest in organic agriculture, and help boost the development of the organic industry. AFA has set up a simple web page for every certified organic farm under the Directory of Taiwan Organic Farm website (www.i-organic.org.tw). The operator of an organic farm may get a unique QR code from the website and print it on the container or package of their products. Consumers can read the product’s information on the simple web page right after shooting the QR code and connecting to the website (Fig. 5). Furthermore, the farm operators are allowed to offer more detailed information for their farms, such as farm locations and how to get there, how many kinds of crops they grow, when the crops would be harvested, and other information for promoting their farm and its products (Fig. 6). According to the result of a survey conducted by National I-Lan University, the more consumers know about the farms, the more they will love the products. So, it’s not only an efficient way for tracing the sources of the organic products, but also an efficient tunnel for communicating with consumers and promoting their products.

Fig. 5. The flow chart of QR code traceing of organic products

Fig. 6. Traceing the origin of organic products by QR code system.

CONCLUSION

Sustainability of agricultural management has long been a hot issue for governments, scientists and consumers for decades. FAO forecasts that the world population will reach 11 billion by 2050. It has always been a big challenge for us to grow sufficient safe food in the past as well as in the future. However, the agricultural production is affected by factors, such as climate, soil, water and microorganisms, etc. The food supply became more and more unstable due to the impact of the abovementioned factors which are beyond the control of human beings. That is why food prices fluctuate sharply these years. According to researches, food will change more in the next 100 years than it has in the last 1,000 years due to climate change and food shortage. More and more "unrecognizable" menu is going to appear in the future. Nevertheless, agriculture is still and will still be the major source of human food. Also, food safety will still be the top priority when consumers choose their daily needs. Henceforth, sustainable and integrated agriculture practices must be adopted to minimize the food hazards and maximize its safety. More and more people around the world pay more attention on the sustainability of our environment no matter where they are from or what they work for. So, organic agriculture is more and more popular in Taiwan as well as around the world. The basic principle for organic operation is that no chemicals, especially the fertilizers and pesticides, are allowed in any part of the supply food chain. The real meaning of organic agriculture emphasizes the balance of the whole ecosystem but not just the need of humans. Taiwan has exploited the cloud and IT technologies on the tracing and promotion of organic products. We think it is the beginning of incorporating modern advanced technology with the development of sustainable environment. We will get much smarter technologies to be used step by step in managing a green planet in the future. Human beings can't survive and be prosperous forever on the earth unless we manage the environment and all of the organisms properly and sustainably.

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DEVELOPMENT OF REGULATORY INFORMATION SYSTEM ON PESTICIDE PRODUCTS

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ABSTRACT

In subtropical and tropical environments, plant diseases, and pests often occur. It is almost impossible to cultivate crops without the application of pesticides. However, it is often questioned and becomes a concern to consumers on whether pesticides are properly controlled as well as whether pesticide residues of imported agricultural commodities comply with Maximum Residue Limits (MRLs). To pursue the production of safe fruit and vegetables, in addition to monitoring and regulating pesticide usage along with extension training of pesticide application, strict source regulations prior to pesticide registration can exclude poor pesticides from the market. Furthermore, prior regulation in pesticide registration coupled with marketing trace, regulation control of pesticide quality and sales, and cross-ministry cooperation to arrest illegal or counterfeit pesticides forms an efficient source regulatory system. To thoroughly implement the source management for safe agricultural commodities, important measures include: adopting "risk management" concepts through understanding farmer pesticide usage habits, providing extension education, actively promoting various safe agricultural commodity certification systems, and inspecting agricultural commodities before entering the market. In addition, agricultural commodities that enter the market are randomly sampled for inspection, and inspection results provide the regulatory system on whether blind spots were overlooked to pursue safety and overall health of consumers. To achieve the aforementioned source regulatory measures, establishment and support of various information systems are necessary. Nowadays, it is of absolute importance that regulatory authorities develop efficient and integral information system through modernized technologies. This paper introduces information systems of pesticide registration background information, pesticide quality regulation, establishment and evaluation of MRLs and field monitoring of pesticide residues.

Key words: pesticide residues, MRL, pesticide registration, pesticide specification, Information System, Taiwan

INTRODUCTION

Crops, like humans, are prone to diseases and pests at various stages throughout their development. In hot and humid subtropical and tropical environments such as Taiwan, the occurrence of plant diseases and pests are often that it is almost impossible to cultivate crops without applying pesticides. However, it is often questioned and has become a serious concern among consumers on whether pesticides are properly controlled as well as whether pesticide residues of imported agricultural commodities comply with Maximum Residue Limits (MRLs).

The safety of fresh fruit and vegetables are closely linked with the application of pesticides. The pursuit of safe fruit and vegetables rests on source management measures, including pesticide management, rational use of pesticides, and the monitoring of pesticide residues. To achieve the aforementioned source regulatory measures, the support of comprehensive information systems is of absolute necessity. This paper introduces information systems of pesticide registration background information, pesticide quality regulation, establishment and evaluation of Maximum Residue Limits (MRLs), and field monitoring of pesticide residues.

PESTICIDE REGISTRATION REVIEW AND THE ESTABLISHMENT OF ITS INFORMATION SYSTEMS

Although pesticides are important means for controlling crop diseases, pests and weeds to a certain extent enhance the growth and yield of forests and crops. But most pesticides possess certain degree of risks or hazards to humans, animals, or the environment due to its mode of action. Early registered organochloride insecticides are banned in Taiwan since the 1970s due to their persistent residue in the environment. Pesticides applied nowadays must undergo rigorous tests before being approved for usage.

Like all chemicals in our daily exposure, the poisonous pesticides are determined in the amount of exposure. To ensure the safety of pesticide application towards consumers, farmers, labor and environment, rational pesticide usage should be managed. As it is regulated in advanced countries worldwide, Taiwan has established the laws and regulations regarding pesticide management where all pesticides shall undergo tests of safety and efficacy and only those that pass the evaluation are permitted into the market for farmers to legally apply the pesticides into the fields.

Safeguard of pesticide registration

According to Taiwan's Agro-pesticide Management Act, it is required to obtain pesticide registration/license prior to the pesticide being imported, manufactured, and allowed to enter the market. The principle of issuing registration certificates is that through the data review of tests regarding the pesticide impact on mammals and environment, the data should provide evidence for efficacy of the applied pesticide and ensure it does not cause hazard or harmful impacts to humans, animals, and the environment. Pesticide registration requires a lot of test data that can be classified into the following six categories.

1) Physicochemical properties: the main purpose of this requirement is to confirm the “various components” of the pesticides to determine the “object” for the safety evaluation and effect assessment.
2) Toxicity to warm-blooded animals: the tests of warm-blooded animals consist of acute toxicity, carcinogenicity, embryonic malformation, chronic toxicity such as reproductive toxicity, mutagenicity, and biological metabolism. Those evaluated to be acute toxic, extremely hazardous or results in irreversible chronic damage cannot be registered as pesticides to ensure the safety of humans and animals.
3) Toxicity to aquatic, avian, and honeybees: the toxicity testing of native aquatics, avian and honeybees primarily aims at preventing the harmful impact of pesticides on the environment and ecosystem. Pesticides considered as highly hazardous to aquatics, avian, and honeybees are limited in the scope of application with warnings labeled on the product to avoid untended side effects.
4) Distribution and degradation in water and soil: the required distribution and persistency tests of pesticides in water and soil primarily aims at preventing compounds with environmental pollution potential from being registered to reduce and prevent pollution and harm to the environment.
5) Crop residues, plant, and animal metabolism: the required tests of field residue trials, plant and animal metabolism primarily aims at establishing the pesticide Maximum Residue Limits (MRLs) to regulate the usage of pesticides.
6) Pesticide efficacy and phytotoxicity: the required tests of pesticide efficacy and phytotoxicity primarily aim at

establishing the appropriate field application method to ensure the effectiveness to the control pests, rodents, and weeds.

The pesticides passing the registration review for entering the market must be those with no acute toxicity or chronic toxicity to humans and animals, and those causing no environmental pollution. Currently, there are 538 registered pesticides in Taiwan (367 pesticides based on active ingredients).

Pesticide registration management and relevant information inquiry systems

Pesticide registration review and management systems:

Pesticide registration requires fairly large and complex testing data for which the establishment of information management system not only manages the registration review and its data efficiently, functions such as backtracking and criteria search are also available during the registration review. Relevant systems include the image retrieval system of registration application document, registration data review management system, pesticide information query system (information such as physicochemical properties, specification, toxicology, pesticide efficacy, phytotoxicity and residual degradation), and pesticide registration/license issuance management system (Fig. 1), all of which can be used as future references for registration application of different formulation, pest control, and generic compounds. These information are extremely important references for the regulatory authority promotion of pesticide management and the establishment of management policy.

Fig. 1. Query and management system of pesticide registration/license issuance

Pesticide application information systems:

Once a pesticide passes the registration evaluation, the regulatory authority will request the expert group (the pesticides advisory committee and plant protection group) to establish a safe, economic and effective field application method based on the provided data. These field application methods are compiled in the “Plant Protection Manual” and “Pesticide Application Manual” provided to the public. Information provided in the “Plant Protection Manual” include various types of crop diseases, pests, weeds and rodents (scientific names and common names), target crops, occurrence ecology, route of transmission, pesticides control and dosage, dilution ratio, application methods, pre-harvest interval, and precautions. Information provided in the “Pesticide Application Manual” include pesticide mode of action code, product name, license permitted usage on certain crops, pests, pre-harvest interval, and Maximum Residue Limits (MRLs). Both manuals are provided in both paper printed and online edition (Fig. 2).

Fig. 2. Online edition of pesticide application manual

The online edition query is suitable for farmers and extension personnel. On the other hand, due to a more flexible query demand for managerial personnel and scientists, the "Plant Protection Information System" (Fig. 3) was developed. System users are able to apply various criteria for query based on individual cases which is convenient for scientists and regulatory authorities.

Fig. 3. Plant protection information system

Pesticide mode of action and chemical classification query system

Nowadays, the global pesticide application principle is to alternate the usage between pesticides with different modes of action due to the issue of pesticide resistance occurrence. Therefore, understanding pesticide modes of action is very important. Although there are currently 538 commercially available pesticides in Taiwan, pesticide laws and regulations have not yet imposed the mandatory requirement of labeling modes of action for each active ingredient. Therefore, the Taiwan Agricultural Chemicals and Toxic Substances Research Institute (TACTRI) have established the modes of action and chemical classification of all registered pesticides and those under registration for online query (Fig. 4). Users can retrieve information through pesticide name or pesticide classification.

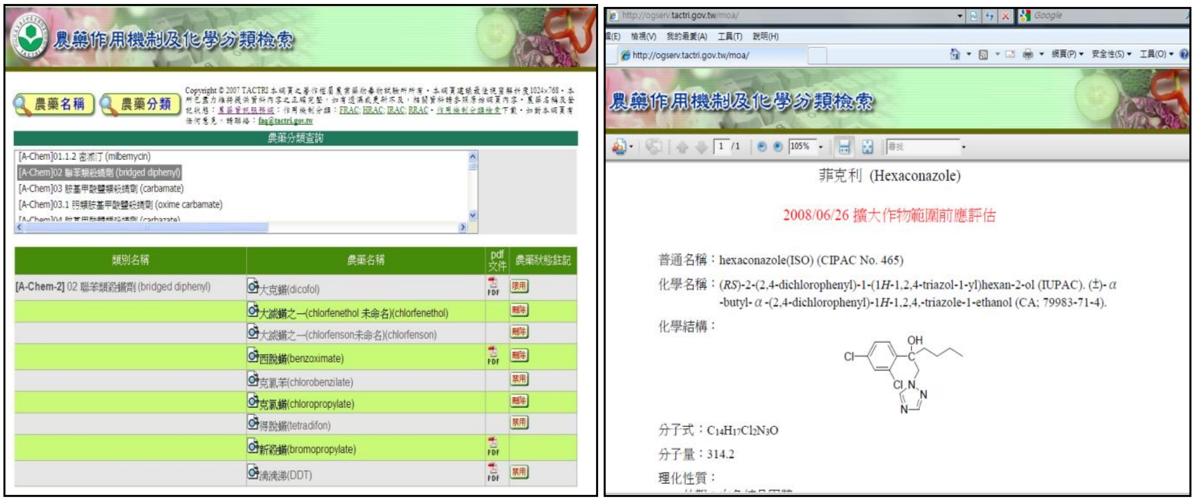

Fig. 4. Pesticide modes of action and chemical classification query system

Pesticide label image query system:

"Pesticide label" is the main channel for pesticide users (farmers, pesticide applicators, or factory workers) to understand the characteristics of pesticide, toxicity, and application scope and method. It is also an important communication channel between government and users. Therefore, pesticide labels shall indicate details in Chinese that includes manufacturer's name, pesticide common name announced by the government, license number, ingredients, contents, formulation, application method, dilution ratio, pest control, precautions, warnings, date of manufacturing, date of expiration, poisoning prevention and detoxification method, and waste container disposal. In addition, color bands are used to indicate the acute toxicity in which "highly hazardous" is labeled in red, "moderately hazardous" is labeled in yellow, "slightly hazardous" is labeled in blue, and "unlikely to present acute hazard" is labeled in green.

When farmers or pesticide applicators apply pesticides, careful reading of pesticide labels and instructions are important to understand general characteristics of the pesticides as well as notice its individual characteristics including pesticide category, eye irritation, toxicity, usage precaution, and understand the toxicity of the pesticides based on the color band. Also, pesticide application should be performed according to the labeled dosage, package inserts, and its directions. In addition, for pesticides with higher toxicity to aquatics, avian, and honeybees, limitations to pesticide application should be followed as labeled for the safety of users, consumers, and the environment.

In order to confirm the labels, online label image query system is offered to users to search for labels of pesticide products that are registered and commercially available (Fig. 5).

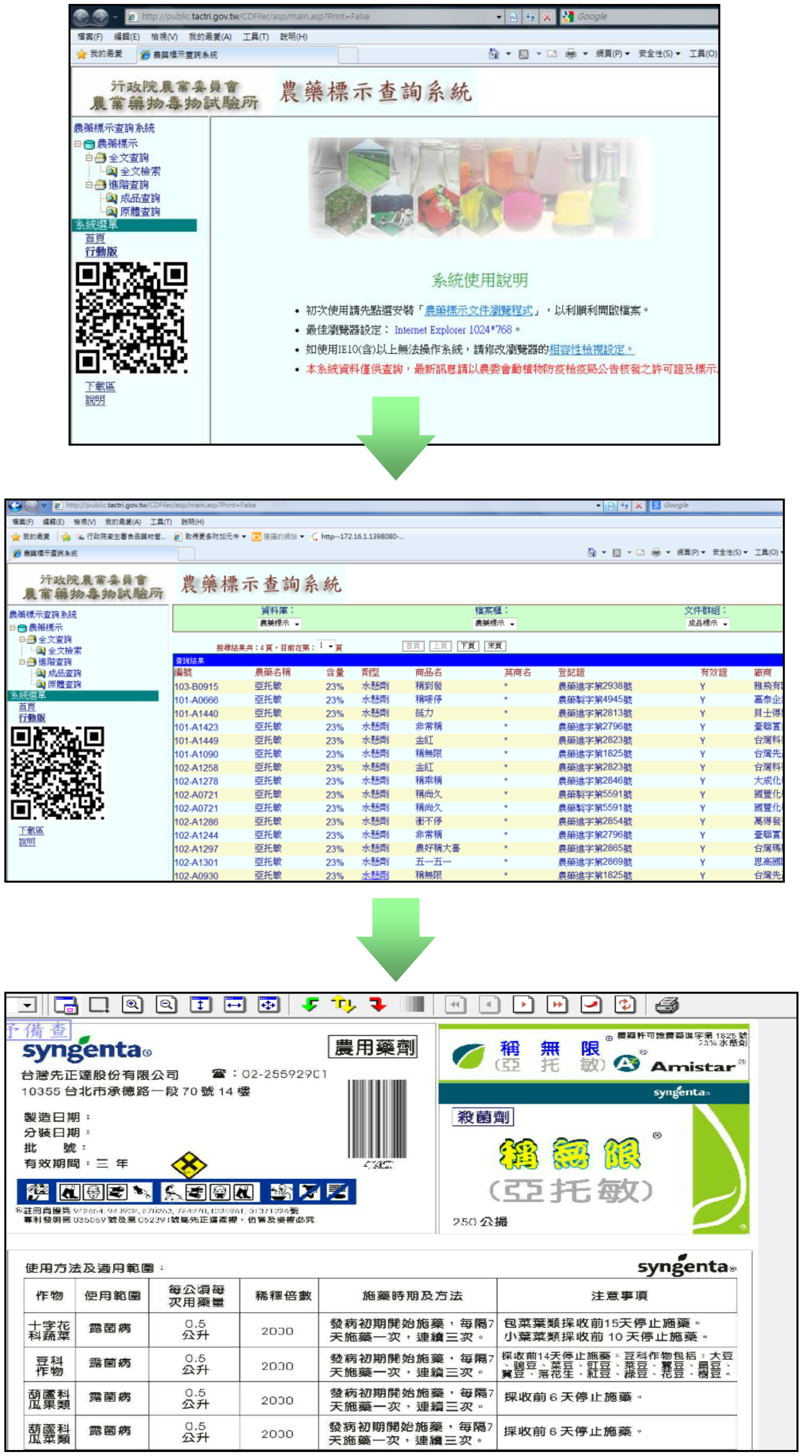

Fig. 5. Web page of pesticide label query system

Also, mobile phone version of the query system is available for users to perform query on site. This system is also convenient for the regulatory authorities to verify counterfeit pesticides.

Pesticide specification and quality inspection information system

Prior to passing the registration review, pesticides should pass the pesticide standard specification inspection required by law. Regarding licensed pesticides approved for sale, regulatory authorities are authorized by the same law to transact supervision, inspection and ban to ensure the pesticide application rights for farmers and the rational usage of pesticides.

Pesticide product specification and quality inspection can be divided into “specification inspection prior to registration” and “random sampling in the market for quality inspection”. Apart from inspecting physicochemical properties such as suspensibility and fineness, and stability characteristics such as thermal and cold stability, important quality inspection includes whether the active ingredients, impurities, and other ingredients comply to the law, consistent to the registered formula, or contain forbidden ingredients. In Taiwan, regulatory authorities perform annual random sampling of approximately 1000 commercial available pesticides for specificity and quality inspection. For pesticide products that fail the inspection, pesticide companies are punished by city/county regulatory authorities according to law and are ordered to retrieve the products from the market. Inspected banned or counterfeit pesticides will be sent to court.

To effectively implement the aforementioned work, the “pesticide specification and quality inspection information system” (Fig. 6) was established to manage the inspection process and allow automatic comparison between the inspection result and the registered formula to determine whether the formula is consistent. The data in the system can be analyzed statistically and the results are served as reference for the regulatory authorities to establish the inspection focus and plan strategy for the coming year.

Fig. 6. Pesticide specification and quality inspection information system
Left: home page; Right: data comparison and report verification

Pesticide sale management and information system

To intensify the management of pesticide sales, the regulatory authorities are soon to stipulate a provision for which “pesticide sale vendors shall regularly report on the sold quantities and its buyers” to enhance the flow control of pesticide sales. Also, regulatory authorities are soon to establish provision of “pesticide sale vendors shall issue pesticide sale certificates" to clarify whether the current issue of agricultural products with unacceptable pesticide residues is due to salesperson recommending illegal use or farmers illegal use of pesticides.

To simplify the conformation of laws and regulations for pesticide vendors in regularly reporting the data of purchase, distribution, and issuing sale certificates, the regulatory authorities have established the "Pesticide Sale Management and Information System" (Fig. 7) and the pesticide procurement card, for which pesticide vendors are encouraged to install. Coupled with the bar coding of pesticides, these measures are able to collect information of sales and farmer procurement that enhances the crop pest management and pesticide use traceability and discourages pesticide abuse due to illegal recommendation, improve the management of pesticide sale business, and ensure the health and safety of agricultural products.

Currently, more than 600 pesticide vendors have installed the system. Each pesticide manufacturing factory and import/export operators have agreed to install and use the system by the end of 2014. Retailers and large pesticide companies have come into agreement to continuously promote the system. For farmers, it is planned to begin with the promotion of Good Agriculture Practices (GAP) production and marketing group for which buyers are encouraged to request for pesticide sale certificate issued by the system. The two-way promotion will facilitate pesticide tracing and management.

Fig.7. Pesticide sale management and information system
Source: website: http://pesticide.baphiq.gov.tw

ESTABLISHMENT OF PESTICIDE MAXIMUM RESIDUE LIMITS (MRLs) AND ITS RELEVANT INFORMATION SYSTEMS

To establish maximum residue limits (MRLs) in agricultural commodities, three basic data are required: (1) Acceptable Daily Intake (ADI): ADI originates from the dosage of which long term feeding to animals would not cause adverse effect (i.e. No-observed-adverse-effect level (NOAEL)). The NOAEL obtained from two-year feeding test is then divided by a safety factor (generally 1/100, of which 1/10 represents the difference between animals and humans, and another 1/10 is the difference between individuals) to obtain ADI value. The unit for ADI is mg/kg body weight /daywhich represent life-long exposure dosage per kg of body weight that would not cause any adverse effects. As animal toxicity tests have standard laboratory practice guidelines, the obtained NOAEL value and ADI value are universal. For example, the ADI values provided by the UN Codex Alimentarius Commission (CAC) and US Environmental Protection Agency (USEPA) are frequently cited by countries. (2) National average intake of each type of crops: as the eating habit and crops are different between countries, each country should establish its own national average intake value while taking into account the imported agricultural products. (3) Actual residue in crops: local data should be used as the pesticide application method and residue decline vary between countries. This data is obtained from the field residue trial performed during pesticide registration in which the trial is conducted through applying pesticides according to the recommended application methods and carrying out sampling at days after last pesticide application to analyze the residues. Residue level close to the preharvest interval is selected for usage. The Maximum Residue Limit (MRL) is established based on the 3 value mentioned above.

To perform effective evaluation for pesticide residues in agricultural commodities, “field residue trials and safety evaluation information system” is established. The system mainly consists of basic information and subsystems of Good Laboratory Practice (GLP) field experiment data, and pesticide safety evaluation and ADI. The Maximum Residue Limit (MRL) and Pre-harvest Interval (PHI) of test crops are estimated through these system data.

Field residue trials query subsystem

The main basis of pesticide safety evaluation is to present the actual residue level in field residue trials. This subsystem includes data reports conducted in the domestic regions as well as preserve foreign data reports submitted by import tolerance applicants. The system includes pesticide information such as applicant information, data source, test crops, and analyzed compounds whereas test results are comprised of details of the sampling date, sessions, the amount of each pesticide application, number of application, crop types, days of sampling, and maximum residue. In addition, the system also collects field trial results provided by international organizations and country regions such as the Joint FAO/WHO Meeting on Pesticide Residues (JMPR), European Union (EU), and Japan. The information in the system is the main reference for the establishment of MRL.

Pesticide safety evaluation query subsystem

The establishment of MRLs includes taking into account the already established MRL of the pesticide, both domestic MRLs and foreign and international MRLs, to pursue international harmonization. This subsystem collects the MRLs of Taiwan, Codex, the United States (US), the European Union (EU), Japan, Australia, and Korea to facilitate the comparison of MRLs. The system contains functions of import, query, and Excel file export.

Pesticide intake risk assessment subsystem

This subsystem (Fig. 8) provides a platform for estimation of total pesticide intake. The estimation is based on national average intake of various agricultural products as well as the crop type, MRL, food intake, estimated intake, and residue. The “estimated total intake” is estimated from the MRL, and the “actual total intake” is estimated from degradation data or monitoring data. The 80% ADI is set as the upper limit to ensure that the intake risk of various pesticides can be regulated effectively.

Fig. 8. Total intake estimation of safety evaluation report

MONITORING AND REGULATION OF PESTICIDE RESIDUES IN AGRICULTURAL COMMODITIES AND THE ESTABLISHMENT OF ITS INFORMATION SYSTEM

The current safety management of agricultural commodities in Taiwan is carried out with the division of work by the Ministry of Health and Welfare (MOHW) and Council of Agriculture (COA). Before agricultural commodities enter the market, the COA is responsible for the safety management of production. After agricultural commodities enter the market, the MOHW will be responsible for food health and safety control. The safety management of production puts emphasis on the promotion and extension of various safe certification systems, monitoring of production, monitoring of major high-risk regions, integration and improvement of safe pesticide application extension for farmers, and management of pesticide sale.

To carry out the monitoring and regulation of pesticide residues in fruit and vegetables from the production end, regulatory authorities annually establish inspection projects, where city/county government perform random sampling in fields, shipping point, and wholesale markets. Samples are then sent to regional inspection centers for inspection. Approximately 13,000 samples of vegetables, fruit, tea, and rice are inspected annually to control agricultural commodities with unacceptable residue levels from entering the market. For those who fail the pesticide residue inspection, regulatory authorities send governmental documents to inform city/county governments to carry out the follow-up control measures such as case tracking, punishment according to the law, and extension education of pesticide application.

The established inspection information platform collects information regarding agricultural commodity inspection and the inspection data for report production, regulatory authority assistance in tracking farmer and crops violation, and statistical analysis of the annual monitoring results (Fig. 9).

Fig. 9. Analysis Report of Pesticide Residue Control

A new edition of inspection information system is currently in progress, for which it adopts new information techniques in integrating sampling, inspection process management, report production and delivery, and statistical analysis into a single operation platform for the purpose of immediate information communication. The new edition inspection information system integrates three core systems: geographic information, laboratory information management, and inspection management operation system (e.g. GAP inspection information platform). The main functions include:

1. Geological information system (GIS)which can provide the spatial information of sampling locations by taking on site photography and inserting the coordinate location;
2. Laboratory inspection management in compliance to ISO17025: all inspection quality assurance and quality control operations required for the certification of ISO17025 adopts E-management;
3. Inspection data preservation and data verification: data verification process adopts E-management, in pursue of gradually reaching paper-free operation. All procedures are recorded in the information system;
4. Report verification and production: The reports can each be prepared according to each inspection unit. Verification and preparation procedures adopt E-operation;
5. Inspection information of regional inspection centers: the regional test centers receive the samples sent by each unit separately and sample information and inspection result can be input into the system. Reports are issued based on each inspection center with the inspection data archived in the same platform;
6. Comparison between inspection results and the MRLs: through calculation programing, the latest MRLs announced by the MOHW can be imported into the system and the inspection results can be compared for the conformity;
7. Comparison between inspection results and pesticide application methods: through the calculation programing, the list of the announced pesticide application methods can be imported to carry out the conformity comparison between inspection results and application methods;
8. Delivery of inspection results: city/county governments can do online query for inspection results with the assigned ID account. Each unit/government is only able to achieve its own inspection result. In the future, the query function using citizen digital certificate will also be introduced; and
9. Statistical analysis of inspection cases: annual statistical analysis can be carried out to produce inspection reports.

CONCLUSION

In the age of consumer awareness, compared to food appearance, price and quality, food safety has become the greatest concern of consumers in advanced countries.

To produce safe and healthy fruit and vegetables, in addition to the monitoring and control of pesticide application from the beginning and pesticide application extension training for farmers, the more important and effective source control means is strict check prior to pesticide registration to exclude poor pesticide products from the market. Coupled with measures such as commercial available pesticides tracing, sale and quality control, cross-ministry check smuggling, and counterfeit pesticides of illegal factories are means for efficient regulation. Adopting the "risk management" concept for agricultural commodities, understanding, and providing extension education of pesticide application habits of farmers and actively promoting various safe agricultural commodity certification systems, inspections are performed before agricultural commodities enter the market to thoroughly implement the source management of safe agricultural commodities. In addition, agricultural commodities that enter the market are randomly sampled for inspection, inspection results provide the regulatory system on whether blind spots were overlooked and further review would be performed for these blind spots to pursue safeness and healthiness of consumers.

To achieve the aforementioned source control measures, the establishment and support of various information systems are necessary. It is of absolute importance that regulatory authorities develop efficient and integral information system through modernized technologies.

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JAPANESE AGRI-FOOD PRIVATE SECTOR'S EFFORTS TO ASSURE FOOD SAFETY

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ABSTRACT

In Japan, efforts on food safety of agricultural products have been carried out using both government policies and private sector-based initiatives. In this review, the efforts on the food safety of agricultural products are introduced under fragmented themes such as traceability, organic farming, and Good Agricultural Practice (GAP).

The establishment of traceability and public information disclosure systems has been urged because of accidents and incidents on food safety that become social problems. For example, the establishment of traceability in beef was triggered by the outbreak of Bovine Spongiform Encephalopathy (BSE) on September in 2001. The establishment of traceability in rice was triggered by illegal reselling of tainted rice on September in 2008, and the food labeling as one of public information disclosure systems was triggered by the beef croquette stuff impersonation incident in 2006.

The amendment of the Agricultural Chemicals Regulation Act (2003) and the Food Hygiene Act (2006) promoted producers to be aware of the drift prevention. After that, Japan's agricultural cooperative association (JA) has been asking all producers to record information about the production of agricultural commodities. Furthermore, producers can easily leverage blogging and internet tools to expose their production information.

In handling operators (distributors) who should confirm safety of their products, the third-party authentication has been proven effective. Especially since organic JAS (Japanese Agricultural Standard) certification has been recognized by consumers all over Japan and its name has gotten so well-known that certified foods win the status of safe foods. However, to conduct the certification entails problems such as cost burden, complexity of recording and lack of support system. Considering the big hurdle for individual producers to get the global GAP straight away and expensive certification fees, it is not realistic to get it individually. Therefore, the hierarchical approach is deemed important. This includes country, local government, J-GAP and the global GAP.

Efforts of Japanese producers on food safety are basically carried out with the production record of agricultural commodities and the introduction of the GAP, and especially now that the Japan Agriculture (JA) has been trying to disseminate these activities to producers all over Japan. However, under current circumstance with many elderly individuals and small-scale producers in Japan, personal information provisions are only recognized as advanced cases and are very rare. In contrast, many business operators get the certification for organic foods certification program compared to other authentications; however, compared to the other countries, the number of obtained certifications is still small.

Keywords**:** Traceability, Organic Farming, Good Agricultural Practice, Japan, Food Safety

INTRODUCTION

In Japan, efforts on food safety of agricultural products have been conducted using both governmental policies and private sector-based initiatives. Although there are no comprehensive aggregated statistics, the efforts on the food safety of agricultural products are introduced under fragmented themes such as traceability, organic farming, and Good Agricultural Practice (GAP) in this review.

CURRENT STATUS OF JAPANESE AGRICULTURE

Briefly the characteristics of Japanese agriculture are described as follows; 70% of the entire land is forest and instead of a large population (120 million people) there is less arable land area (4,550,000 ha: 13% of the land). More than 50% of the arable land is used as paddy fields (2,460,000 ha) and the rest is used as upland fields. Currently agricultural production population is 2,270,000; it was 14,540,000 at the peak in the 1960s, thus now it decreased to be about 1/6. The average age of farmers is 66-years-old, and producers older than 65 years occupy 64% of the total number of farmers.

The average area of farm land per farmer in Japan is about 2.45 ha; a farmer in Hokkaido, located in the northern part of Japan, has 26 ha and other regional average is 1.77 ha (Table 1), indicating that there are many small-scale farmers in Japan.

Table 1. Basic statistics in Japanese agriculture

Total number of farm houses	2,530,000	Cultivated acreage	4,540,000 ha
Selling farm houses	1,410,000	Rice field	2,470,000 ha
Self-sufficient farm houses	900,000	Upland field	2,070,000 ha
Full-time farmer houses	410,000	Management cultivated area per one farm house	
Farmer houses with side job	1,110,000	(National average)	2.45 ha
Population engaged in agriculture	2,270,000	(Hokkaido)	25.99 ha
Female	1,140,000	(National average except for Hokkaido)	1.77 ha
Seniors older than 65 years	64%		
Average age	66.2		

Note 1: Basic statistics on agriculture are quoted from the agriculture, forestry and Fisheries Ministry HP data (In Japanese) http://www.maff.go.jp/j/tokei/sihyo/index.html

Agricultural cooperative organizations support these small-scale farmers and part-time farmers to perform production activities in agriculture. Agricultural cooperatives have given various support to producers, including joint purchases of fertilizers and pesticides, product procurement and sales, and further agricultural guidance. Most of agricultural producers have become members of agricultural cooperatives and received some sort of services from them, but recently, farmers who sell products directly to customers without using them have come out.

A problem of agricultural production in Japan is the serious aging of producers. Many producers quit farming because they are old and often leave their arable land deserted. Although there are some young people who engage in farming, their measly number is not enough to vitalize agriculture.

EXAMPLES OF INCIDENTS RELATED TO FOOD SAFETY AND STRENGTHENING OF TRACEABILITY

Efforts and systems on traceability and information disclosure of foods started because of accidents which relates to food safety being a social problem. Three incidents regarding food traceability and public information systems that had been triggered by the food safety issue are as follows.

Beef traceability

Since the confirmation of BSE outbreak on September, 2001 in Japan, distributors and consumers have been increasingly aware of traceability of beef. Private distributors of beef began to conduct efforts on food safety by announcing in-store use history about beef ahead of governmental initiatives to make beef confidently bought by consumers. In 2003, the beef traceability law was enacted in the country. The law states that cattle raised in Japan are given 10-digit identification numbers to the database registration to be able to trace the cattle transfer history. Once BSE positive cattle are found even after slaughter, it will be possible to find the farm where the cattle were raised and a group of cattle raised with them by using these numbers. These identification numbers are disclosed to the consumers, and the customer can search the database and know the transfer history of the purchased beef. The above mechanism (system) was mandated by law, but further beyond this, as a voluntary certification system, the government published not only the transfer history but also all the feeding and treatment history as "food production information publication JAS certification" in 2003. This provided more detailed information to consumers. Although initiatives on food traceability were focused on beef at the beginning, traceable information about not only meat but also other agricultural and marine products are publicized voluntarily. This is especially evident in the Internet, where producers are actively releasing information regarding conditions of their farms. Food production information JAS system as described above provides certification information release about foods. Aside from beef, there are also information on pork, farmed fish and agricultural products of which traceability consumers are interested in.

Rice traceability

Illegal reselling of tainted rice occurred on September, 2008. Rice tainted with pesticide residue, mycotoxins, and aflatoxins can be used only for industrial application, because it is not edible. In this incident, the agents of rice distribution, who resold tainted rice for industrial application as edible rice, were caught. It was found that the resold rice was used not only for direct eating but also as ingredient in the making of the Japanese-style confection rice flour and shochu which are used (Japanese liquor) as raw materials. Since rice is considered as the Japanese staple food, the impact of this incident was so big that the Minister of Agriculture, Forestry and Fisheries had to resign to take responsibility for this incident. This incident led the obligation of the rice traceability by law. From 2010 all the relevant companies have been mandated to record the production area (the place of origin) of rice and to make sure that the proper coming in and out of rice, are recorded properly and that records are preserved. Also, all the processed foods of which rice is the main raw material are mandated to show their origin on the food packaging.

Display of wholesale foods

In the spring of 2006, meat processors, who used the cheaper meat such as pork to impersonate the raw beef mince as beef croquette stuff, were seized. “Beef croquette” which is made from fake meat and sold as co-op foods, was recovered. Also pork, chicken, and pieces of bread were used to inflate the volume of minced meats, and they were made to look like the authentic 100% ground beef. Although this employer had other sloppy managements in food hygiene, this incident triggered government to strengthen the regulation about impersonation display. So far there have been no obligations to rule the display of raw materials for industrial semi-finished products which are transferred “from processor to processor.” However, government mandates that processors should disclose the same level of information on the materials for the consumers’ information about food products.

Besides these three abovementioned incidents other, incidents of production origin deception often occurred, so from 2009, special penalties for breach of the production origin deception were enhanced.

AMENDMENT OF FOOD SAFETY LEGISLATION

Amendment of the Agricultural Chemicals Regulation Act

Although only registered pesticides can be allowed to be used in Japan, it was found that many unregistered pesticides have been widely used in 2002. The use of unregistered pesticides has become such a disturbing problem for consumers that the Agricultural Chemicals Regulation Act was amended. From 2003, the sale of unregistered pesticides was banned, and farmers using pesticides were required to use the registered pesticides according to usage instructions, and corresponding penalties were applied to the violators.

Introduction of the positive list system for residual pesticides in the Food Hygiene Act

In 2006, amended Food Hygiene Act was implemented, and also a positive list system for agricultural chemicals and food additives started. Residue standards for all pesticides were established pursuant to these regulations, and producers were required not only to use pesticides properly, but also to consider drift risks of pesticides from external factors. For example, even if rice producers properly use the pesticides, when fruit trees adjacent to the rice fields had been sprayed with pesticide in the groves of the trees before the rice harvest, drifting pesticide residues could be found in rice. This situation means that all farmers who use pesticides can become perpetrators or victims. Thus, they are made aware that they do not need to disturb their neighbor farmers.

EFFORTS ON RECORDING OF PRODUCTS BY JA

Since the revision of these series of incidents and laws, there has been a trend among producers who understand that to keep their own farming cultivation history is not only for the purpose of disclosing their products' history but also to protect themselves when they encounter problems.

JA started the traceability recording campaign. Under this campaign JA provided guidance to all of JA farmer members about doing recording of their farm operations, and defined the rules that JA does not accept farm products without records. As many Japanese farmers deliver their harvests to JA in Japan and they are sold through JA, almost all Japanese farmers become involved in this effort.

However, as mentioned above, the average age of Japanese producers is 66-years old. Recording format as an additional task is a burden to old producers because it requires doing records even during daytime farming. Thus, the local JA has developed a recording format which is less burdensome for the producers. For instance, in the case of rice producers, the contents of the labor for farming are almost the same every year, and also farmers of the local JA members are characterized to use JA recommended fertilizers and pesticides. Thus, the contents of operation had been already printed in advance on the form, so it is common that producers add only the date of the operation and amount of fertilizers and pesticides used on the printed form.

PRODUCERS OWN EFFORTS ON TRACEABILITY

Some producers are conducting the efforts to publish information voluntarily on their own products such as rice and beef even without obligation by law.

The easiest way is through publishing the information in a blog form. By efforts on home page (HP) and blog publishing about production activities every day, consumers feel more familiar with products and purchase them in relief. There are also the HPs using a unified catalog format to introduce their own agricultural products. Furthermore, after obtaining production information which the JAS system mentioned above and the third party certification, some producers announce the production history to further increase reliability on their products on HPs. Some producers establish the HP system in which their products are featured. They are allocated a lot number in which consumers can approach a satellite photo of the field where the products were harvested. This is done by entering the lot number on HP using the map software. These producers think that public information is the best means to ensure trust in their products. So the move of producers to take initiative to announce publicly information about their products is done to obtain consumer's confidence by using the Internet has been increasing.

USE OF CERTIFICATION SYSTEM

Whenever incidents and topics concerning food safety and impersonation emerged, entities operators (distributors) should confirm about the safety of their products. This is especially true to those who are interested on whether the origin of the raw materials can be traced. The distribution company sends the quality management department staff to the production area to confirm that their products are indeed safe. However, to visit all the areas is impossible. In this case, if the producers have already gotten a third-party certification, its standards have already been verified so that the trading can be done with confidence.

Distributors and some co-op members who are dealing with specialized organic and additive-free foods are asking that in order for the producers to have traceability, if possible, there should be an organic JAS certification. Also, young people who are newly engaged in farming have to enter the market as new members. In the past, once producers become members of JA, there were channels where products brought to JA could be sold; under these channels, however, producers' personal aspects would be hidden and their obsessions (specialties) can't be appealed. Then, foods such as organic vegetables are often observed to be sold without involvement of agricultural cooperatives. Young people who are newly engaged in farming have the difficulty to cut into sales channel especially those established by veteran producers into trading for many years, and being less experienced means that there have been no business results about the stability of the products. In cases such as these, if new entrants get third-party certification, there is a benefit of having at least safe and reliable foods as base.

(Note) Here, third-party certification refers to certification activities in the following positions.
First-party certification: producers themselves offer assurance of products and ship them.
Second-party certification: the interested parties such as quality management department of distribution company verify their products.
Third-party certification: third-party of disinterested perspectives verifies that production activities are performed according to standards based on published ones.

ORGANIC FOOD CERTIFICATION SYSTEM IN JAPAN

Summary of Japanese organic food certification

Organic certification system is a third-party certification, meaning its standards are published externally and farming method and its name have been globally recognized. In accordance with organic food certification program guidelines adopted by CODEX in 1999, even in Japan, a certification system that complies with CODEX guidelines was enacted in 2000. Organic JAS certification system was incorporated in JAS law which established the standards of the existing foods. Since the start of the system, 15 years have passed.

Characteristics of organic foods in Japan are as follows;

- To display products and foods as organic agricultural products and organic agricultural processed foods, respectively, producers were obliged to obtain the organic JAS certification and attach certification marks (organic JAS) on products and foods by law.
- Even with foreign products, foreign producers and processors have to get the organic JAS certification and export the products with organic JAS mark to be able to show that their products are organic in Japan.
- Although standards were enacted on organic livestock products and processed foods containing organic animal products as raw materials, the certification is optional and not mandatory.
- The target of JAS certification system is foods, and this system does not include alcoholic beverages, textiles and cosmetics.

Current status of organic JAS in Japan;
The number of certified operators is 2,133, and the number of farm houses is 3,812. The organic field area is 9,899 ha and it consists of 0.22 % of the whole arable land area of Japan (Table 2). The Ministry of Agriculture, Forestry and Fisheries also announced that production quantity of organic foods is 0.24%. Main organic foods in Japan market which are produced in Japan or imported from abroad are shown in tables (Table 3: Agricultural products, Table 4: Processed foods).

Table 2. Japanese organic JAS certified farm area and number of certified operators

	Domestic Product	Foreign Product Shipped for Japan
Vegetables	42,467	20,671
Fruit	2,524	11,534
Rice	10,342	199
Wheat	859	712
Soybeans	1,306	9,042
Green tea	2,167	0
Other tea leaves	60	299
Coffee green bean	0	1,837
Nuts	3	2,056
Spice raw materials	17	176

(As of 1st April, 2013)

Table 3. Distribution conditions of the main organic JAS foods in Japan (agricultural products)
Year of 2012 (unit ton)

Total Organic Farm	9,899 ha
Paddy fields	3,098 ha
Up land fields	6,676 ha
Others	115 ha
Japanese cultivated acreage	4,549,000 ha
Organic farm ratio	0.22%
Number of agricultural products certification operators	2,133
Number of farm houses	3,812

The source: Ministry of Agriculture, Forestry and Fisheries HP

Table 4. Distribution conditions of the main organic JAS foods in Japan (processed foods)
Year of 2012 (unit ton)

	Domestic Product	Foreign Product Shipped for Japan
Frozen vegetables	132	2,594
Vegetables bottled and canned	74	1,771
Boiled vegetables	1,039	14,125
Fruit beverages	1,819	2.167
Tea-based beverages	2,728	0
Soybean milk	34,651	1,744
Tofu	18,374	0
Miso	1,979	367
Soy sauce	3,771	23
Processed product of beans	3,968	61 7
Green tea	1,458	6
Sugar	14	4,95 0

The source: Ministry of Agriculture, Forestry and Fisheries HP

It is said that ratio of organic production is about several %~10% in Europe and the United States. Compared to this, there is less organic food production in Japan.

Problems with Japanese organic food certification system

The following three issues could be raised as problems with organic food certification system in Japan.

- Cost: Equal to any countries, certification requires costs. In Japan many small-scale farmers have to ask cheap certification body to get the certification because of large expenses. (Note: In Japan there are 60 organic JAS certification bodies having different organic certification fees)
- Records: keeping records is essential in organic certification, but for producers without habit of recording this, will be a huge hurdle.
- Support: there are no supporting mechanisms to get the certification, so it is required that applicants take seminars held by the accreditation organization and get it by themselves.

Support from a country

There is no support of certification charges from the country. However, the government supports those applicants to obtain certification by publishing a handbook. These are on HP at Ministry of Agriculture, Forestry and Fisheries and anyone can access them freely.

Also, regarding fertilizers there was a list of substances that can be used in the standards. However, the government has been working for several years to have a list of the fertilizers with the actual product trade names. Now, a project on establishing the list is being continued by a third party institute funded by the organic certification bodies.

CURRENT STATUS OF GAP IN JAPAN

In Japan, the government is supporting GAP initiatives. It is not realistic for individual producers to get the global GAP straight away, because to get it would be a huge hurdle and can also be expensive.

Therefore, we have a hierarchical approach for GAP as follows;

1) Fundamental GAP by government;
   With a focus on minimum items the government advocates the GAP standard items. And it was recommended to do self-assessment. There are tools and check tables for the education of GAP on the Ministry of Agriculture, Forestry and Fisheries website. However, there is no country certification system for GAP. On the other hand, JA is also at work in making phased introduction of basic level GAP in addition to recording the production history as mentioned above.
2) Independent GAP by prefectures;
   Refined norms of the fundamental GAP were created at the prefecture level, and they are distributed to producers. Also, in conjunction with processed foods, farm activities on GAP have been recommended as a part of the HACCP (Hazard Analysis and Critical Control Point).
3) J-GAP certification by Japanese GAP association;
   J-GAP certification has the same standards as those of global GAP, and its own certification system. Although J-GAP certification wants to have the equality to global GAP, the exact sameness is not yet accepted.
4) Global GAP certification;
   Global GAP has been widely known in the world and there are currently 2-3 certification bodies in action in Japan. There are not so many producers getting the global GAP certification because of less number of exports for agricultural products. However, some producers who export agricultural products get global GAP certification in Japan.
   Some supermarket companies require producers to introduce global GAP system, and ask them to get global GAP certification. But so far they did not ask certification as mandatory base, but recommend producers to introduce the equivalent level of control on their products as global GAP system.

CONCLUSION

Efforts of Japanese producers on food safety are basically conducted with production records of agricultural commodities and the introduction of the GAP, especially the JA which has been trying to disseminate these activities to producers all over Japan. Some producers have conducted efforts to gain consumers' trust by getting their own third-party certification. However, under current circumstances with many elderly and small-scale producers in Japan, personal information provisions are only recognized as advanced cases and are very rare. In contrast, many organic operators get the certification for organic foods certification program compared to other authentications. However, compared to other countries, the number of obtained certifications is still considered small.

FIELD STUDY

Costales Nature Farms

Brgy. Gagalot, Majayjay, Laguna

(Lifted from http://costalesnaturefarms.com/)

Company Profile

COSTALES NATURE FARMS is a prime agro-tourism destination that conducts ecological and balanced farming techniques which aims to promote a sustainable agriculture, healthy lifestyle, and environmental biodiversity through integrated organic farming.

The farm was adjudged as the Most Outstanding Organic Farm of the Philippines for the year 2012, recognized by Benigno Simeon Aquino III, President of the Republic of the Philippines. We continue to create awareness about the ill-effects of chemical inputs in food production, the importance of organic farming, inspiring small farmers to become better agripreneurs, encouraging students to engage into organic agriculture and patronizing organic produce for a healthy lifestyle.

The five (5)-hectare farm was developed in 2005, initially as a family week-end getaway and a source of healthy and steady supply of organic vegetables and livestock for the family. It went commercial in growing organic produce in 2008 and became the country's biggest single producer of high- value vegetables and culinary herbs.

Mission & Vision

The farm maintains its sustainability by integrating various enterprises like high-value crops and culinary herb production, free range poultry and livestock raising, aqua culture, vermi-culture and orchard enterprise.

The farm is a perfect model of not only certified organic production but also, sustainability, income diversification, business partnership, agro-tourism, extension service, creative fund generation and people management.

The Company answers the call to provide avenues for a chemical-free agriculture, mitigate the effect of climate change and bring farm life experience at its best through dedication, service and excellence in agro-tourism.

The Company envisions to becoming the top-of-mind agro-tourism destination in the Philippines promoting wellness, sustainability, environment-friendly farm practices and customer-centered services that leave a happy experience to every tourist.

Progressively, we have returning clients who are happily at ease with the services we offer. Even bringing their whole family to experience the trusted and worthy expertise we cater to.

Nowadays, the Costales Nature Farms is continuing to grow and suffice the organic community with the help of its growing family. We believe that through each other's helping hand, we can gradually inspire others to live wealthy and healthily.

History

In 2012, Costales Nature Farms opened up its gates for business opportunities in organic agriculture with Overseas Filipino Workers (OFWs) for Joint-Venture (JV) programs on the establishment of greenhouse facilities enabling the Company's aggressive expansion of organic high-value vegetable/culinary herb production for local distribution. Partner OFWs are now enjoying their continuous share of farm revenues while, at the same time, working abroad.

Dizon Farms, the largest fresh produce integrator in the country also ventured with the Costaleses by establishing its own greenhouse facilities managed only by the finest management and technical team of Costales Nature Farms. The organic farm produce in these greenhouse units can be found at the Organic section of Dizon Farms in different supermarkets.

Also at the same year, Costales Nature Farms partnered with top-of-mind organic processed food distributor and number one wellness store in the country, Healthy Options, in the production of organic free-range chickens, eggs and pigs. All the produce are now exclusively sold at Healthy Options outlets. Healthy Options also helped-out in the establishment of top-of-the-line postharvest facilities to ensure highest standard of food hygiene.

Finally, at the 3rd quarter of 2013, the biggest chain of high-end restaurant concepts, Bistro Holdings who owns Italliannis, TGI Fridays, Krazy Garlik, Village Tavern, Tonkatsu and Modern Shanghai, ventured with the Costaleses for the production of high-value vegetables and culinary herbs . These high-value veggies and herbs are served in its finest chain of restaurant concepts with the label "I Love Organic".

Truly, more and more people today are patronizing organically grown produce than those that are raised chemically. Costales Nature Farms will continue to be the catalyst of spreading healthy food, life style and becoming the new hope & inspiration of our true heroes – The Farmers!

Seminars

Costales Nature Farms is an accredited Private Extension Service Provider (ESP) of the Agricultural Training Institute (ATI) of the Department of Agriculture to conduct training on Organic Agriculture all throughout the country. It is one of the three (3) selected few national private ESPs in the Philippines. It is our goal to share, to as many farmers as possible, the technology and the experience that we have earned in the past ten (10) years of doing SUCCESSFUL & SUSTAINABLE organic farming. We believe that with the right technology, marketing skills and business sense, every farmer deserves financial freedom.

Costales Nature Farms has, in its track record, the successful conduct of no less than a hundred batches of trainings and seminars from 2010 to September 2013 to groups of farmers, businessmen, doctors, students in various universities, business schools and cooperatives in relation to the best practices on Integrated Organic Agriculture. This also includes conduct of international trainings on organic agriculture and agritourism in Bali, Sri Lanka, Malaysia, Papua New Guinea and Thailand.

Costales Nature Farms will put up a TESDA-accredited Organic Agriculture Training Center that will cater to out-of-school youths, farmers and high school graduates for the conduct of competency training and assessment on Organic Agriculture (NC2). All graduates that will get the NC2 certificate will have a better chance to work in big organic local farms and abroad. More importantly, graduates will have a better chance to be successful in engaging into organic agriculture as a business.

In the field of marketing, Costales Nature Farms is a recipient of the 2012-2015 Gold Brand Award as one of the "100 Philippines' Most Powerful and Most Admired Brands".