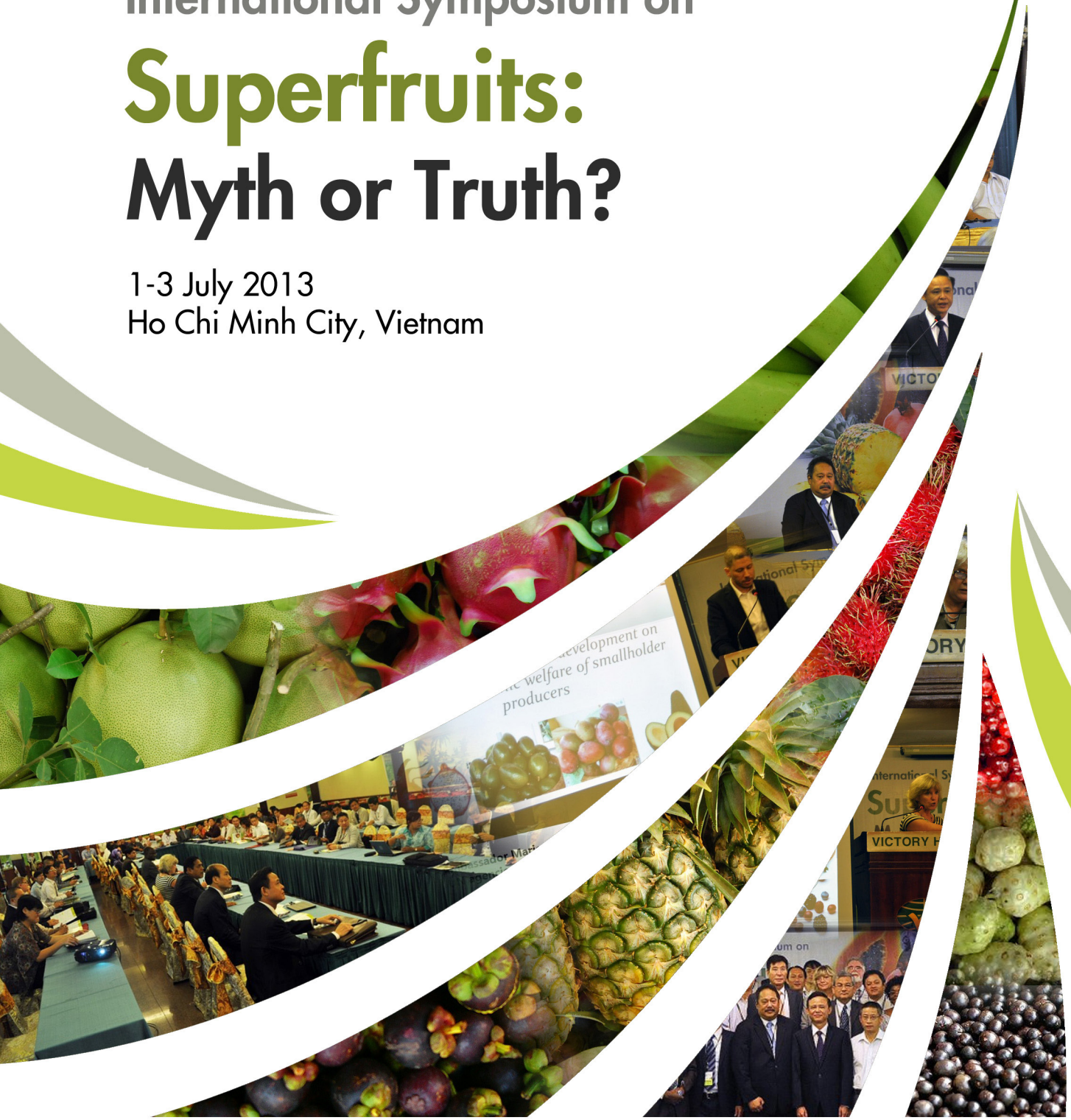
PROCEEDINGS

International Symposium on Superfruits: Myth or Truth?

1-3 July 2013
Ho Chi Minh City, Vietnam



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PREFACE

The steady growth in population and income, and the rising awareness of the positive nutritional value of fruits are generating positive spin offs on world consumption of tropical fruits. Market opportunities are developing rapidly in emerging markets as their economies significantly expand, while demand in Europe and the United States remain strong.

The world fruit market has evolved significantly in the past two decades. Aside from quality, the health benefits of fruit consumption have been promoted extensively, and the term "superfruits" gained significant usage and attention in recent years as a term synonymous with the marketing strategy to promote the health benefits of certain fruits, including pomegranates, cranberries and blueberries. In addition, the biodiversity of fruits, i.e., the individual varieties and cultivars, are attracting attention, as the nutrients and bioactive non-nutrients within species can vary dramatically. Several cooperatives and associations that produce and market these fruits have developed an effective strategy using the content of "antioxidants" in their fruits as an indicator for promoting the health benefits of their fruits.

Scientists and nutritionists have differing points of view on the use of the term. Some claim that there is no scientifically objective assessment of the potential health benefits of fruits in this category. Similarly, there is no definitive list of superfruits and new fruits are regularly put forward as superfruits. In addition to pomegranates, blueberries and cranberries, examples include: acai, avocado, mangosteen, blackberry, raspberry, strawberry, lingonberry, certain banana varieties, and yumberry. However, most fruits are packed with nutrients and yet, some are not perceived as being "super".

Hence, while there is potential to use this term to promote some of the lesser known tropical fruits, this development could also potentially have a negative impact on the consumption of the more established tropical fruits, particularly in an increasingly crowded and competitive international fruit market.

The International Symposium on Superfruits: Myth or Truth? was organized at the behest of the Intergovernmental Group on Bananas and Tropical Fruits to examine the use of the term "superfruit", which has been used successfully particularly by the producers of blueberries and cranberries. The symposium examined latest research findings to determine whether there were nutritional and agronomical evidence to support the claim of a fruit (species and varieties) being a "superfruits" and whether these were adequate to provide a definition.

The symposium also identified threats and opportunities for tropical fruits in the global fruit market, and within the context of enhancing food security through agricultural development, the symposium attempted to identify strategies and models to integrate smallholders in the value chain.

Mention should be made that only papers that were received by the Secretariat have been included in these proceedings. However, all the presentations are available in Appendix 7.

Kaison Chang
Secretary
Intergovernmental Group on Bananas and Tropical Fruits
Trade and Markets Division
Food and Agriculture Organization of the United Nations

REPORT OF THE INTERNATIONAL SYMPOSIUM ON SUPERFRUITS: MYTH OR TRUTH?

I. INTRODUCTION

At its Fifth session in Yaoundé, Cameroon, in May 2011, the Intergovernmental Group on Bananas and Tropical Fruits (IGG/BATF) suggested that the Secretariat organize a Symposium on Superfruits as a concept to promote the consumption of tropical fruits. The symposium was to constitute an essential forum for discussion on the approach, the benefits and gaps to make tropical fruits production and marketing profitable and sustainable over time.

The world fruit market has evolved significantly in the past two decades. Aside from quality, the health benefits of fruit consumption have been used more frequently to promote various fruits. The term "superfruits" has gained significant usage and attention in recent years as a term synonymous with the marketing strategy to promote the health benefits of certain fruits which do not have worldwide popularity, such as pomegranates, cranberries and blueberries. In addition, the biodiversity of fruits, i.e., the individual varieties and cultivars, are attracting attention, as the nutrients and bioactive non-nutrients within species can vary dramatically.

II. RATIONALE OF THE INTERNATIONAL SYMPOSIUM ON SUPERFRUTS: MYTH OR TRUTH?

While there is potential to use the term "superfruit" to promote some of the lesser known tropical fruits, this development could also potentially have a negative impact on the consumption of the more established tropical fruits, particularly in an increasingly crowded and competitive international fruit market.

Therefore, the first objective of the symposium was to determine whether "superfruits" was based on scientific fact or more of a marketing promotion strategy to increase consumption of certain fruits. If there was solid basis for the terminology, then should superfruits be defined?

The second objective was to determine the threats and opportunities for tropical fruits, by first analyzing the market and recommend appropriate marketing strategies. These included:

- An overall assessment of production, consumption, trade and price developments;
- The demand trend of tropical fruit "superfruits" compared to other tropical fruits, both domestically and in export markets;
- The substitution effects of tropical superfruits on traditional tropical fruits;
- The price premiums of tropical superfruits compared to other tropical fruits;
- The markets for "superfruits"; and
- The promotional requirements and returns.

Finally, within the context of enhancing food security through agricultural development, the symposium was to identify strategies and models to integrate smallholders in the value chain. The symposium examined the implementation of effective policies to address the concerns of smallholder producers, which included:

- Access to credit; Institutional building;
- The formation of legal commercial entities, such as cooperatives, to empower small holders;
- Improved transparency through regular dissemination of market information;
- Development of quality standards and grading to meet superfruits requirements, if necessary;
- Development and adoption of appropriate technology to improve productivity and quality to better meet market requirements;
- The necessary structures to meet sanitary and phytosanitary (SPS) and technical barriers to trade (TBT) requirements of import markets; and
- Identifying alternative cost-effective treatments for fruit exports.

III. ACTION PLAN AGREED TO BY THE SYMPOSIUM

Following extensive discussion at the International Symposium on Superfruits: Myth or Truth?, participants agreed on the following action plan and recommended that it be submitted to the Intergovernmental Sub-Group on Tropical Fruits for consideration at its next session.

A. SCIENTIFIC DEFINITION

In regard to the scientific definition of "superfruits", the Symposium concluded that the label "superfruit" is based on two criteria: the nutritive value and the extranutritional benefits. Although antioxidant capacity is the most widely recognized bioactive attribute of a superfruit, most scientists realize that this is only a small part of the overall picture. Bioactive molecules may have potential health benefits independent or additional to their antioxidant effect. Further comprehensive research is needed to fully understand the metabolic pathways and biological role of the bioactive compounds responsible for the benefits observed on health. However, final validation should be obtained with tests *in vivo*.

Outcomes

Although the consensus of the symposium was that superfruits had inherent characteristics that made them uniquely beneficial for human health, the category was not yet well defined scientifically, and was obfuscated by marketing jargon. Hence, one of the most significant contributions to arise out of the symposium would have been to establish a universally recognized definition of the superfruit category that could have been referenced by researchers and commercial market professionals on a global scale.

The symposium agreed that the defining characteristics of the superfruit category included:

a) Nutritional composition (presence of significant vitamin, fibre, micronutrient, and other nutrient content to contribute to daily requirements for optimal human growth and development);
b) Extranutritional composition (presence of pharmacologically relevant levels of health-promoting secondary metabolites like flavonoids (anthocyanins, proanthocyanins, cinnamic acids, etc), carotenoids, betalains, sesquiterpene lactones, and others that contribute to antioxidant, anti-inflammatory, enzyme modulatory, and other functional benefits after ingestion by humans as food;
c) Bioactive properties can be present in the flesh (edible portion) of the fruit, or, in pericarp or other tissues normally discarded as waste materials;
d) Unique flavours/taste/colours/textures that contribute to the appeal of the fruit;
e) Categorization as "exotic" or somehow unusual/not common place;
f) A superfruit need not satisfy all of these criteria, but, should have a significant footprint in at least a), b) and c) of the above criteria.

Another contribution would have been to define the scientific proofs needed to satisfy categorization of a fruit into the superfruits category. Scientific substantiation of unique extranutritional properties of a fruit was based on several levels of proofs, including:

- Historic use of a fruit for health benefits; traditional ecological knowledge regarding use of a fruit for medicinal purposes in a defined geographic area;
- Epidemiological evidence suggesting that populations that consume a certain fruit have lowered incidence of chronic disease(s);
- Lab scale or *in vitro* (cell culture) bioassay results that indicate that a fruit extract was able to positively influence biomarkers relevant to human disease;
- *In vivo* (animal-based) experiments that demonstrate that fruit extracts gavaged, topically-applied or fed to rodent or other animal subjects suppress disease outcomes or improve metabolism; and
- Clinical trials on human subjects (ideally, double-blinded crossover studies).

Financial constraints have precluded complete validation of many purported superfruits using all of the criteria noted above. Indeed, those fruit commodity groups which have deliberately applied funding or provided seed grants to allow experimentation with their fruits (e.g.: pomegranate, blueberry, grape, cranberry) have been best positioned to promote their fruit in the superfruit category. Strategies to channel

government funding into fruit and health research can contribute substantially to the evidence-based categorization of fruits into the superfruit arena.

Science can join hands with marketing to improve the credibility of superfruit terminology

A strategy that can increase the visibility and value of key tropical fruits would be a campaign to deliver science based information and seasonal fruit displays to upscale supermarket chains. Superfruits displayed in premium high visibility locations at selected markets would increase consumption and create a credible premium for the commodities.

Marketing definition of superfruit

Although the term and concept was loosely based on scientific data, the strength of the marketing is the potential health value to consumers, which include their contribution to micronutrient adequacy and richness to diets; beneficial non-nutrient components; and possible contribution to lowering levels of overweight and obesity and decreased risk for non-communicable diseases. It is all about the consumers: Why do they want superfruits? The answer usually has to do with the benefits these fruits can provide, i.e. in terms of the image of the product; pricing policy to support the desirable image; the types of retail outlets; and the appropriate promotional strategy for the targeted market segments. For example, the strategy described in regard to deliver science based information and seasonal fruit displays to increase market outputs.

It is critical to know consumer reactions and preferences. Hence, the possible way forward would be to:

- **Position fruit types accordingly**: Countries should select one or two major fruits and develop the scientific data (ranging from variety, location, agronomic practices, age, etc.); and exchange findings with other countries;
- **Effectively promote selected fruits and by products by**: Using various communication tools; supporting historically established facts (e.g. Chinese and Indian ayurvedic medicine); linking current research results to market promotion; associating with energy drinks;
- **Formulate products with other known branded active ingredients**, such as mixing products that taste good together (e.g. pitaya juice with coconut water);
- **Provide benefits to farming communities**: Expand communities to create economies of scale; and continue improvement of services skills;
- **Conduct market research to determine consumer preferences** and further narrow down new products development;
- **Exploit the commercial uses of underutilized fruits**, e.g. the miracle berry.

Technical and institutional issues and constraints

Items identified in the following sections apply to fruit designated as superfruit as well as those grown already in the region/country.

Education and training

A holistic approach must be adopted in research, education and training for the production and postharvest management of all fruit crops. This would involve revamping course curricula in tertiary education institutes with greater emphasis on high value horticultural crops.

Extension services need to be enhanced to work at the interface between researchers and smallholder farmers. Courses need to be introduced within the curricula on extension technologies for high value horticultural crops.

Fruit production

Fruit types should be grown in the appropriate optimal environmental conditions. Soil and climatic maps are required for all countries so that rational decisions can be made about where to best plant high value horticultural crops, including superfruits.

Cultivars should be selected that provide quality fruit desired by customers in local, regional and export markets. This will involve R&D on plant selection (for underutilized crops from the wild forests) and subsequent breeding using existing selections and cultivars. Major efforts are required to developed integrated sustainable production systems.

Information is available for many innovative technologies but there is an urgent need for these to be introduced, evaluated, demonstrated and implemented to local smallholder farmers. Local technology gaps must be identified and assessed prior to the introduction of policies to enhance production.

Relevant supply chains must be investigated for locally produced products and systems devised to enable the collection of appropriate data that could be used as a basis for local policy determination.

Postharvest requirements

Training of extension personnel required in accepted and well-known postharvest techniques and methodologies.

Encourage R&D on the chemistry and health benefits of super and other tropical and subtropical fruit to ensure that health claims can be made about the nutritional and health benefits of potential superfruit.

Dissemination of market information

Policies should be introduced to facilitate an effective communication system of the market.

Linking smallholders to market and enabling policies

The four papers – from FAO (Intergovernmental Group on Bananas and Tropical Fruit Secretariat), Myanmar (Myanmar Fruit, Flower and Vegetable Producer and Exporter Association), International Tropical Fruits Network CEO and the FAO Committee on Agriculture Chair - enabled an analysis, through various lenses, of factors that can enhance successful participation of smallholders in important value chains – whether fruits or superfruits. The presentations also reviewed the many challenges related to the current exclusion of smallholders from these value chains that policy approaches need to address. The speakers converged in identifying key strategies that can enable poor smallholders to change their lives by increasing the economic returns from their farming activities. During the discussion, issues were explored around the importance of organization of supply chain actors and the power of public/private partnerships in assuring services and facilitating capacity development. In relation to policies and enabling environments for smallholder participation, several proposals were put forward as to what governments (national and local) and development partners can do, and models for different kinds of support initiatives were examined. In addition, specific models and promising approaches for organizing supply chain actors and linking smallholder producers to markets and services were considered.

Clustering of the smallholder tropical fruit producers, e.g. organizing smallholders into producer organizations, such as cooperatives.

APPENDIX 1

PROGRAMME OF THE PLENARY SESSIONS OF THE SYMPOSIUM

1 July 2013

08:30 **Welcome address**
Kaison Chang
Secretary, Intergovernmental Group on Bananas and Tropical Fruits, Food and Agriculture Organization of the United Nations (FAO)

08:45 **Welcome address from co-organiser**
His Excellency Dato' Mohd Hashim Bin Abdullah
Secretary-General, Ministry of Agriculture and Agro-Based Industry, Malaysia
Chairperson, International Tropical Fruits Network
Delivered by:
Yi Ganjun
Vice President, Guangdong Academy of Agricultural Sciences
Vice Chairperson, International Tropical Fruits Network (TFNet)

09:00 **Opening address**
His Excellency Ha Cong Tuan
Vice Minister for Agriculture and Rural Development, Vietnam

09:15 Break

Session 1: Defining superfruits
Chairperson: Kaison Chang
Secretary, Intergovernmental Group on Bananas and Tropical Fruits, FAO

09:30 Introduction by the Chair

09:40 **The impact of superfruit development on the socio-economic welfare of smallholder producers**
Her Excellency Agnes Cishek
Vice Minister for Agriculture Sector Planning, Dominican Republic
Presented by:
His Excellency Mario Arvelo
Chairperson, Committee on Agriculture and Ambassador of the Dominican Republic to FAO

10:00 **Superfruits: a gimmick or scientifically supported? How the science impacts the marketplace or vice versa**
Mary Ann Lila
Director, Plants for Human Health Institute, North Carolina State University

10:20 Discussion

10:35 **Fruits are super vs superfruits**
Barbara Burlingame
Deputy Director, Nutrition Division, FAO

10:55 **Review of the scientific evidence regarding the attributes of "superfruits" and agronomic considerations**
Alison Hodder
Senior Officer, Plant Protection and Protection Division, FAO

11:15 **Therapeutic values of superfruits beyond nutrition and their value addition for commercialization**
DBT Wijeratne
Additional Secretary (Agricultural Technology), Ministry of Agriculture, Sri Lanka

11:35 **Progress on bioactive compounds and pharmacological activities of several major tropical and subtropical fruits in China**
Yi Ganjun
Vice President, Guangdong Academy of Agricultural Science, China

11:55 Plenary discussion to define superfruits in the scientific and marketing contexts

12:20 Morning session wrap up

12:30 Lunch

Session 2: Getting superfruits to market
Chairperson: Yi Ganjun
Vice Chairperson, International Tropical Fruits Network (TFNet)

14:00 Introduction by the Chair

14:10 **Supply and demand trends in the global superfruits market**
Lu Ann Williams
Head of Research, Innova Market Insights, BV, Netherlands

14:30 **Developing the market potential of mangosteen as a superfruit with focus on quality enhancements, promotional requirements and market expansion**
Rhoedhy Poerwanto
Professor, Bogor Agriculture University, Indonesia

14:50 Discussion

15:05 **Demand trends, market, price developments and promotional requirements for dragon fruit**
Luong Ngoc Trung Lap
Southern Fruits Research Institute (SOFRI), Vietnam

15:25 **Market potential of miracle berry in West Africa : production, consumption and trade**
Omolaja Adelaja
Deputy Director, Nigerian Institute of Horticulture, Nigeria

15:45 Break

16:00 **Challenges on production of tropical fruits in the Philippines**
Edna Anit
Assistant Director, Philippine Council for Agriculture, Aquatic and Natural Resources Research and Development (PCAARRD), Philippines

16:20 **Production and expansion of the export market for papaya in Asia and the Pacific**
Miliakere Nawaikula
Director of Research, Ministry of Primary Industries, Fiji

16:40 Discussion and wrap up of the session on superfruit markets

2 July 2013

Session 3: Technical and institutional issues and constraints
Chairperson: Trinh Khac Quang
Vice President, Vietnam Academy of Agricultural Science

08:30 Introduction by the Chair

08:40 **Developing and adopting appropriate technology in superfruits production**
Bob Williams
Director of Plant Industries, Northern Territory Government, Australia

09:00 **Post-harvest requirements: farm to market and is there a case for certifying superfruits?**
Errol Hewitt
Professor Emeritus, Massey University and Chairperson of ISHA Post Harvest Commission

09:20 **Tackling technical and institutional constraints in the development of superfruits in Africa**
Badreldin El Sheik Hassan
Director-General, Horticulture Sector Administration, Ministry of Agriculture, Sudan

09:40 **Improving market access for superfruits through effective dissemination of market information to smallholders**
Sisir Mitra
Chairperson, Tropical Fruits Committee, International Society for Horticultural Science

10:00 Discussion and wrap up

Session 4: Enhancing Food Security for Smallholder Producers
Chaiperson: Alison Hodder
Senior Officer, Plant Protection and Protection Division, FAO

10:35 Introduction by Chair

10:45 **Smallholder participation in the tropical superfruits value chain: ensuring equitable share of the success to enhance their food security**
Kaison Chang and Margarita Brattlof
Secretariat, Intergovernmental Group on Bananas and Tropical Fruits, FAO

11:05 **Improving farmers' integration into the tropical fruit value chain to entrancemarket access in Myanmar**
Than Than Sein
Myanmar Fruit, Flower and Vegetable ProducerAnd Exporter Association, Myanmar

11:25 **Implementing effective policies to enhance market access and improve smallholder integration into tropical superfruit value chains**
Yacob Ahmad
Chief Executive Officer, International Tropical Fruits Network

11:45 **Policy advice to enhance smallholder food security**
Mario Arvelo
Chairperson, Committee on Agriculture and Ambassador of the Dominican Republic to FAO

12:05 Discussion and wrap up

12:25 Lunch

Session 5: The way forward

14:00 **Chairperson's report of the parallel technical session**
Bob Williams
Director of Plant Industries, Northern Territory Government, Australia

14:15 **Summary of the recommended way forward**
Kaison Chang
Secretary, Intergovernmental Group on Bananas and Tropical Fruits, FAO

14:30 Discussion

15:00 Break

15:15 Development of action plan

16:00 Discussion and adoption of action plan

16:30 Closure of Symposium

3 July 2013

Field trip

07:00 Assembly at hotel car park

07:30 Departure to My Tho, Tien Giang Province

09:30 Briefing and station visit: Southern Fruit Research Institute, My Tho

11:00 Visit to sapodilla growing area

12:30 Lunch break

14:00 Visit to dragon fruit growing area in Tien Giang

16:00 Return to Ho Chi Minh City

APPENDIX 2

PROGRAMME OF THE PARALLEL SESSIONS OF THE SYMPOSIUM

1 July 2013

Parallel Session 1: Value Chains and Production Technology of Potential Superfruits
Chairperson: Yacob Ahmad
Chief Executive Officer, International Tropical Fruits Network

16:00 **Aiming on a direct delivery of mangosteen from hill to city**
Juejan Tangtermthong
Agricultural and Food Marketing Association for Asia and the Pacific, Bangkok, Thailand

16:20 **Malaysian carambola from a rising star to a global leader**
Zabedah Mahmood
Director-General, Horticulture Horticulture Research Center, MARDI, Malaysia

16:40 Discussion and wrap up of the session on superfruit markets

2 July 2013

Parallel Session 2: Value Chains and Production Technology of Potential Superfruits
Chairperson: Yi Ganjun
Vice President, Guangdong Academy of Agricultural Science, China

08:30 **Experience in commercialising of *Canarium odontophyllum* Miq.: A potential superfruit of Sarawak**
Pearlycia Brooke
Department of Agriculture Sarawak, Malaysia

08:50 **Tree distance and replacement of citrus greening diseased trees of king mandarin for a superfruit**
Katsuya Ichinose
Resident Officer, Kyushu Okinawa Agricultural Research Centre, Japan

09:10 **Studies on identification of pitaya (*Hylocereus undatus*) yellow cladode-brown spot and the evaluation of some antagonisms, agrochemicals against the pathogens under laboratory conditions**
Nguyen Thanh Hieu
Southern Horticultural Research Institute, Vietnam

09:30 **King mandarin rated as a superfruit in Southern Vietnam by the introduction of tree training and pruning**
Kazuyoshi Yuasa
Project Officer, Japan International Cooperation Agency (JICA), Japan

09:50 Discussion and wrap up

Parallel Session 3: Selection, Postharvest, Pest and Disease Management and Processing of Potential Superfruits

Chairperson: Bob Williams
Director of Plant Industries, Northern Territory Government, Australia

10:15 **Evaluation and selection of early lychee cultivars in Vietnam**
Nguyen Van Dung
Fruit and Vegetable Research Institute, Vietnam

10:35 **Survey on the postharvest quality and management of dragon fruits exported from Vietnam to Holland**
Nguyen Van Phong
Southern Horticultural Research Institute, Vietnam

10:55 *Phytophthora citricola*: **New finding pathogen on durian in Vietnam, control models and preliminary results on varieties screen against** *Phytophthora* **spp.**
Nguyen Van Hoa
Southern Horticultural Research Institute, Vietnam

11:15 **Infestation of pomelo fruit borer *Citripestis Sagittiferella* (Moore) (Lepidoptera: Pyralidae) in Vietnam and the effect of compact fluorescent lamp as a repellent**
Le Quoc Dien
Southern Horticultural Research Institute, Vietnam

11:35 **Total phenolic contents and antioxidant activity of Musa AAA Berangan after UV-C Radiation**
Phebe Ding
Faculty of Agriculture, Universiti Putra Malaysia, Malaysia

11:55 **Commercialization of clarified salak beverage using enzymatic treatment and microfiltration technology**
Wan Izzuddin Sulaiman
Corporate and Technical Director, Team Biovision Sdn Bhd, Malaysia

12:15 **Study of characterization of pectin gel extracted from Malaysian pomelo fruits (*Citrus Maxima* merr.) peels as a noble food ingredient**
Chek Zaini Hassan
Universiti Sains Islam Malaysia, Malaysia

12:35 Discussion and wrap up

12:55 Lunch

APPENDIX 3.A

ABSTRACTS AND PAPERS - PLENARY SESSIONS

SESSION ONE – DEFINING SUPERFRUITS

SUPERFRUITS: A GIMMICK OR SCIENTIFICALLY SUPPORTED? HOW THE SCIENCE IMPACTS THE MARKETPLACE OR VICE VERSA

Mary Ann Lila, Director, mlila@ncsu.edu
Plants for Human Health Institute,
North Carolina State University

ABSTRACT

While "superfruit" is an admittedly nebulous category, and often ensnared in marketing hype, the label is usually awarded based on two criteria: the nutritive value (concentration and assortment of compounds that are required for human growth and metabolism), and the extranutritional benefits (significant presence of bioactive phytochemicals which are purported to counter incidence or symptoms of human chronic disease and/or bolster metabolism). It is the latter attribute that has catalyzed both the marketplace fervor, and the controversies, surrounding the superfruit industry. Why? The biologically-active phytochemical constituents, or phytoactives, are far more difficult to pinpoint than classic nutrients; they can't be validated using high-throughput pharma industry screens. Antioxidant capacity is the most widely recognized bioactive attribute of a superfruit, but, most scientists realize that this is only the 'tip of the iceberg' as regards human health impacts. Putative benefits of phytoactives for human health are typically gauged using a barrage of in vitro and in vivo bioassays, but cost constraints have limited crossover clinical trials for fruits and other produce, which has invited some skepticism in the scientific arena. However, modern consumers who are proactive about maintenance of personal health can be highly motivated by substantive, credible evidence linking fruit consumption to health benefits, as exemplified by recent trajectories of two native North American small fruits (blueberry and cranberry). In these cases, solid, compelling, and persistent health research evidence featuring cranberries (anti-infective) and blueberries (anti-diabetic, cardioprotective, and neuroprotective) steadily accumulated from both academic and government sources. These results were captured and translated in the popular press, which catalyzed escalating, sustainable market demand and industry growth for both berryfruits. Despite heightened demand, growth in the superfruit industries may be limited by seasonal availability and postharvest losses, however, innovative new strategies have now succeeded to capture the fruit bioactive benefits into shelf-stable dry powder matrices.

PAPER

1. Introduction

Superfruit is a term that refers to a subclass of fruits purported to confer exceptional health protective properties to the consumer. Since the category is a food, validation of efficacy is not typically supported by industry or government agencies in the way that pharmaceuticals are supported. There has only seldom been sufficient funding available to support the double-blinded clinical trials to establish proof of efficacy – the gold standard for establishing claims in the pharma industry. Because the standardized recognized validation process hasn't been followed to support superfruit validation, the medical community and the wider scientific arena has sometimes viewed the category with skepticism. Indeed, marketing hype about superfruit introductions may bypass scientific criteria altogether.

However, the impact of superfruits on human health maintenance and prolonged healthspan have been broadly supported in epidemiological evidence, and in in vitro and in vivo scientific research. The compelling and expanding scientific evidence in support of superfruits for human health maintenance is robust, and when clinical trials have been conducted, the health related mechanisms and properties have been substantively confirmed. This brief manuscript will define the superfruit category, detail a few characteristics of the biological activity that have defied evaluation by conventional pharma methods, relate

the science-based evidence in support of health benefits, and illustrate two case studies of North American fruits that spiraled to superfruit status and notoriety based on the scientific evidence in support of human health benefits. Finally, in light of the perishable nature of fruits in general and the seasonal gluts and wastage in many geographic locations for these fruits, some strategies for prolonging shelf stability and capturing the essential phytoactives in alternative products are discussed.

2. Superfruit Category Defined

It is true that the "superfruit"category was originally contrived as a marketing tool, and this appellation has sometimes erroneously been assigned to new or rebranded fruit introductions which really do not meet the criteria. Even so, for those fruits which have earned - through scientifically-validated investigations as well as epidemiological scrutiny – both the label and the recognition, consumption of superfruits can provide immunoprotective benefits against a wide spectrum of chronic human diseases.

What are the criteria that define the superfruit category? The two primary gauges are 1) the levels and types of nutrients present in the fruit, and 2) the extranutritional phytochemical constituents. Nutrients (by classic definition) are those components that a consumer must obtain from an external source (like a fruit) in order to live and grow. Nutritive value of a superfruit is based on the concentrations and assortment of compounds that are required for human growth and metabolism. Examples of nutrients present in edible fruits include vitamins, minerals, and carbohydrates (including sugars). Dietary fibers from fruits can also be categorized as non-essential nutrients. While they are not absorbed in the digestive tract of a human consumer, they do facilitate digestive health.

Non-nutritive bioactive fruit phytochemicals, also known as phytoactives, include extranutritional constituents like polyphenolics (anthocyanin pigments, proanthocyanidins, phenolic acids, other flavonoid compounds), betalains, and carotenoids (including provitamin A). Extranutritional benefits are based on the significant presence of bioactive phytochemicals which are purported to counter incidence or symptoms of human chronic disease and/or bolster metabolism. It is this latter attribute that has catalyzed both the marketplace fervor, and the controversies, surrounding the superfruit industry. The phytoactives are the superfruits' most robust selling point (Facenda, 2007). Health evidence linked to laboratory or (ideally) clinical science is a powerful marketing tool which guides consumer food purchasing decisions (Leatherwood et al. 2007). The phytoactives are linked to prevention or therapy for a series of chronic human disease conditions. Proactive purchasing choices are more likely to occur when consumers are cognizant of the health benefits linked to fruit consumption, rather than just the phytochemical or nutrient content of the food (Wansink et al., 2005). Dietary anthocyanins (the red pigments in berries and apples) have demonstrated ability to lower high blood glucose levels associated with type 2 diabetes mellitus (T2DM), increase insulin sensitivity, depress postprandial glucose responses (Grace et al. 2009; Lila 2011. Roopchand et al. 2013) and elevate satiety. The same class of flavonoids, often interacting with proanthocyanidins and phenolic acides, has demonstrated anti-inflammatory and detoxifying mechanisms of action integral to cancer chemoprevention, cardiovascular diseases, and neuroprotection (Seeram et al. 2004).

The carotenoids are best recognized through both epidemiological evidence and bioassays as cancer chemopreventive phytochemicals (notably in prostate cancer prophylaxis), but also have roles in prevention of macular degeneration and cardiovascular diseases. A range of health-relevant bioactivities have similarly been linked to various other phytochemical classes inherent in the superfruit composition (Lila, 2004).

In addition to the presence of nutritive and extranutritional constitutents, superfruits are also ranked based on organoleptic/sensory characteristics. Fruits that deliver sensory appeal, refreshing and pleasant unfamiliar flavors, textures and colors have frequently climbed quickly in the superfruit category.

In most cases, the rewards of superfruits are best realized by consumption of servings of the whole intact fruit rather than processed product (juices, sweetened dried snacks, etc.) Juices continue to dominate as a means for fruit consumption, although processing diminishes both the nutrient and phytochemical levels in the fruits. Fruit-derived supplements (e.g. fruit extracts encapsulated into daily pill doses) seldom retain the value of the whole fruit.

Finally, it is very often the unknown or exotic fruit introductions that are elevated quickly to superfruit status. The functional foods industry has noted that consumers are intrigued by unusual new fruits that seem to offer more promise than better recognized fruits. The allure of tropical fruits from international locations

has captured public interest, and fruits that were previously unknown, for example, to the U.S.A. population (e.g. mangosteen, papya, mango, acai, pomegranate) are now commanding premium prices at most local grocers. Even domestic fruits can benefit from the mystique of exoticism when they can demonstrate that they contain levels of endogenous health-enhancing phytoactives that match or exceed levels documented for exotic superfruits, that they are indigenous to pristine, undomesticated frontier environments, and that they have a history of traditional use for health protection, as is the case for Alaska Native wild berry introductions (Kellogg et al., 2011).

3. Science Validation of Superfruit Health Benefits

Although the accumulation of research evidence supporting the health-relevant attributes of superfruits has been robust, the categorization and discussion based on bioactive phytochemical constituents continues to provoke some controversy in scientific and regulatory arenas. This is largely because these extranutritional small-to-medium molecular weight compounds are much harder to pinpoint and quantify than nutrtients. A multiplicity of bioactivities can be demonstrated after consumption of a single candidate fruit, which is contrary to the typical activity of a pharmaceutical prescription. Fruit phytochemicals are characterized by classes with potentiating interactions, thus the efficacy of a fruit extract cannot be gauged using high throughput screens typical in the pharma industry (Lila & Raskin 2005; Lila 2007, Seeram et al. 2006).

Another issue that have generated some debate on superfruits is the (apparent) low bioavailability in vivo of fruit-derived constituents that are highly active in cell culture bioassays (Fernandes et al. 2012; Yang et al., 2011). Recent research has revealed a profound influence of the dietary food matrix on phytochemical bioavailability, and the ability of certain food constituents to act as adjuvants or stabilizers to foster bioavailability of phytoactives. Metabolic breakdown metabolites from the original fruit composition have now been identified as the active constituents responsible for health benefits, and bioavailability can now be gauged at much higher levels than previously thought (Czank et al. 2013). Recently, innovative strategies including radiolabeling of parent compounds or metabolites prior to ingestion, or, ex vitro evaluation in artificial gastrointestinal tract systems have provided more insights into the paradox of significant health benefits despite apparent low phytoactive availability (Czank et al. 2013; Lila et al 2012). The inherent complications of assessing health biomarkers in humans coincident with superfruit ingestion have been responsible for much of the reluctance (on the part of scientists and the medical profession).to demonstrate health benefits. In the past 5-10 years alone, however, the emergence of genomics and metabolomics technologies have allowed science to more fully gauge cause-effect relationships on human metabolic pathways.

4. Superfruit Successes: Case Studies

The ability of a strong health science message and compelling evidence to drive market demand for superfruits can be well-illustrated by the recent histories for two indigenous North American fruits – the cranberry and the blueberry. Cranberry fruits originated in New England and Eastern maritime provinces of Canada. Early European explorers circa 1550 recorded the use of these fruits by Native American Indians. With the onset of canning, the cranberries were known to a wider geographic region but until very recently, were relatively unknown to, for example, Asia and Australasia as recently as 25 years ago. Once the anti-adhesin properties associated with cranberry juice (the ability of cranberry consumption to guard against bacterial infections in the urinary tract, as well as the oral cavity), were brought to light within the past two decades (Avorn et al. 1994; Zafriri et al., 1989) the popularity of cranberry juice as a proactive means to combat UTIs skyrocketed, with full shelves in European and Asian grocery stores dedicated to these products. A fruit once purchased only for traditional celebrations of American Thanksgiving and Christmas came into global, year-round demand.

A similar story can be told for the blueberry, but in this case, the health message and the skyrocketing demand was not built around one human condition/pathology, but instead, was created based on the evidence for blueberry efficacy against some cancers, CVD, neurodegeneration and the declines of aging, metabolic syndrome including Type 2 diabetes mellitus, and a few other pathologies (Grace et al. 2009; Lila 2011; Wansink et al. 2005). The wild lowbush blueberry (*Vaccinium angustifolium*) and the huckleberry (V. uliginosum) were the original sources of Native American traditional ecological knowledge about the medicinal attributes of blueberry, but cultivated blueberries (V. corymbosum, V. asheii) share the health-protective benefits and have capitalized on the resounding global demand that escalated once the popular press spread the message borne out of the scientific community. The correlation between the rise in value

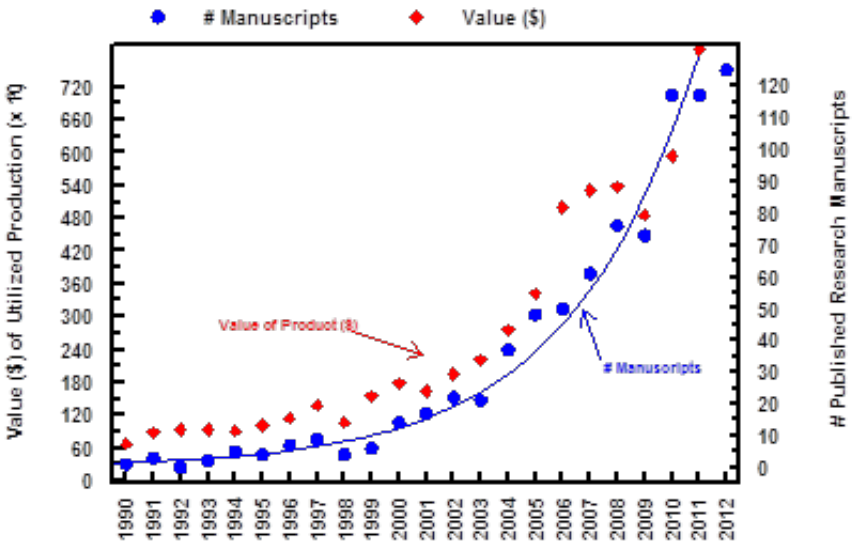
of blueberries as a commodity, and the trajectory of health research advances centered on blueberries, is a clear testimony to the power of the scientific message for a superfruit and human health maintenance (Fig. 1, courtesy of Ron Prior).

5. Conclusions and Recommendations for Preserving Superfruit Phytoactives in the Diet

Although the promise of nutritional and extranutrititional benefits is inherent in the superfruits category, there are multiple reasons why it can be difficult to preserve these benefits in the routine daily diet. For many, the cost and availability of fruits is a limitation. Seasonal availabilities, and high costs outside of local seasons, are other constraints. Whole fruit consumption can be difficult to achieve in various settings (camping, high intensity sports, school lunchboxes) where the bulk and perishability of some fruits is problematic. For these and other reasons, only a very small fraction of the global population actually consumes the recommended daily intake of fruits. Current research aimed at preservation of the ephemeral health-protective phytoactives in superfruits after processing into stable, cost-effective, portable snack products hold promise for extending the considerable benefits associated with superfruit consumption to a wide breadth of the global population (Roopchand et al., 2012).

Figure 1 shows the trajectory of the blueberry market value, plotted against the rising number of manuscripts describing and validating the human health-relevant properties associated with blueberry consumption.

Figure 1: Impact of Science Communications on Product Value (Blueberries)



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THE IMPACT OF SUPERFRUIT DEVELOPMENT ON THE SOCIO-ECONOMIC WELFARE OF SMALLHOLDER PRODUCERS

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ABSTRACT

The trend for consumption of superfruit products has been growing steadily in the last years. Market globalization along with health awareness and a more informed consumer have been drivers for this growing demand. The value of native products only known in small local markets is now appreciated by a growing segment of health conscious international consumers.

There is an evaluation of drivers inducing consumption of superfruit products and case studies on different structures of integration of the smallholder producer to the superfruits value chain as well as the results on

sustainable economic growth and product diversification for rural areas. Many native fruits are little known by consumers in industrialized countries. Small producers depend on international companies for niche market identification and marketing strategies for creating an international demand of tropical superfruits. The dissertation also refers to the advantages of cooperatives and associations as tools to enhance trade capacity and empower smallholder producers on effective management of resources. It takes a glance on how corporate social responsibility is already starting to change business approach of companies serving industrialized markets.

We address the internal and external factors of business dynamics limiting the capacity to grow and ability to compete for small producers, such as: access to credit, compliance with regulatory issued, financial knowledge, production and sales planning, etc. A final segment reviews business models already implemented that have empowered small producers, as well as the role public sector is expected to play with public policies and support programs to improve social development along with entrepreneurial capacity.

FRUITS ARE SUPER VS SUPERFRUITS

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ABSTRACT

Micronutrient malnutrition is a persistent problem, affecting approximately two billion people. As a category of foods, fruits make a substantial contribution to the micronutrient intakes for populations in every country in the world. It is estimated that in some countries, upward of 50 percent of the recommended intake of dietary fibre, pro-vitamin A carotenoids, vitamin C, several B-vitamins, and many trace elements come from fruits in the diet. National food-based dietary guidelines invariably recommend eating two or more servings of fruit every day. FAO/WHO guidelines for prevention of diet-related chronic diseases show convincing evidence that fruit consumption reduces the risk of obesity and heart disease, and there is probable evidence that fruit consumption decreases the risk of diabetes and many cancers. In addition to conventional nutrients, fruits contain thousands of beneficial bioactive non-nutrients, with putative effects ranging from improving intelligence to increasing longevity. The term "superfruits" has gained significant usage in recent years, along with associated terms such as "functional foods", "pharmafoods" and "nutriceuticals", all implying properties that exceed what one should expect from food per se. Some specific species are being promoted as superfruits. However, depending on the component of interest, almost any fruit, or subspecies/variety/cultivar of a fruit, can be singled out as "super" for its composition. Regardless, if fruits are considered super-foods, then what is food? Arguments will be presented to suggest that elevating fruits, and individual bioactive components of fruit, as something exceptional, i.e., over and above normal food, will be detrimental to overall nutrition messages. Regulatory issues also require consideration, as the Codex Alimentarius Commission, and many national food regulatory agencies discourage terminology implying that individual foods or food components will prevent diseases or impart health, independently of the diet as a whole. Fruits should be considered "super" insofar as they are an essential part of a healthy, daily diet. But "superfruits" as a term for a few selected fruits implies more than what is justified for this wonderful category of human foods.

PAPER

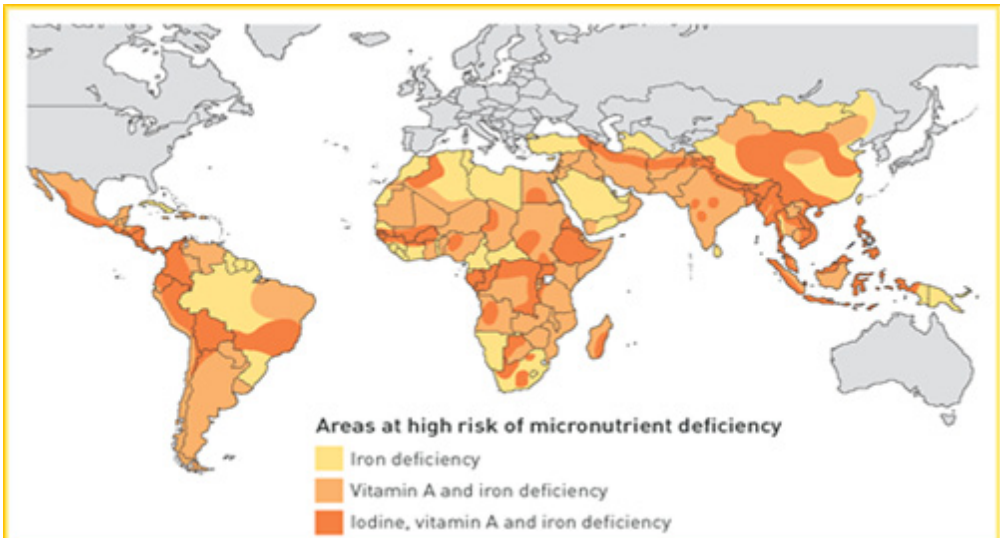
A debate is raging in nutrition circles around the term "superfruit".

"Superfruit" is a marketing term, not a scientific term. It has no endorsement from the FAO/WHO Codex Alimentarius Commission or national food regulatory agencies. Nevertheless, the term and concept is loosely based on scientific data, and the strength of the marketing is the potential health value to consumers.

Before talking about fruit, let's talk about micronutrients, and specifically micronutrient malnutrition. Micronutrient malnutrition is a persistent problem, affecting approximately two billion people. Stunting is can largely be attributed to broad-ranging micronutrient deficiencies. One of the most important international goals related to health and nutrition is to reduce the prevalence of stunting in the world. Some successes have been achieved, with decreases in Asia and Latin America. However, stunting remains a persistent problem in Africa.

This micronutrient map (Figure 1) illustrates areas of the world where specific micronutrient deficiencies have been measured and identified. Illustrated are iron, vitamin A and iodine deficient countries. Vitamin A, iron and iodine deficiencies, which are easily and readily measured, are only markers or indicators for general micronutrient malnutrition.

Figure 1: Prevalence of micronutrient deficiencies in developing countries



Source: USAID.

One continuing failure in nutrition interventions, is dealing with e.g., vitamin A or iron deficiencies by supplementing with vitamin A and/or iron, as if these specific nutrients represent the entire problem. A vitamin A deficiency treated with food-based solutions is much more likely to adequately address the larger issue of dietary quality. As a category of foods, fruits make a substantial contribution to the micronutrient intakes for populations in every country in the world. It is estimated that in some countries, upward of 50% of the recommended intake of dietary fibre, pro-vitamin A carotenoids, vitamin C, several B-vitamins, and many trace elements come from fruits in the diet. National food-based dietary guidelines invariably recommend eating two or more servings of fruit every day. FAO/WHO guidelines for prevention of diet-related chronic diseases show that there is convincing evidence that fruit consumption reduces the risk of obesity and heart disease, and there is probable evidence that fruit consumption decreases the risk of diabetes and many cancers. Supplementing solely with individual nutrients may treat some acute deficiencies but will never adequately address the chronic problems.

"Eat a variety of foods" is the most common recommendation of nutritionists around the world. It features in all national food based dietary guidelines, and has been the foundation of traditional diets for millennia. Diversity includes biodiversity, and biodiversity of the fruit world includes different varieties/cultivars, i.e., the taxonomic level below species, and neglected and underutilized species. There can be many reasons for nutrient content differences in one variety vs another, but the genetic resource itself accounts for most of the beneficial phytochemical differences. For example, should fruits with high beta-carotene varieties regarded as superfruits? No, because in addition to conventional nutrients such as beta-carotene, all fruits contain thousands of beneficial bio-active non-nutrients, with putative effects ranging from improving intelligence to increasing longevity. Depending on the component of interest, almost any fruit, or subspecies/variety/cultivar of a fruit, can be singled out as "super" for its composition.

FAO together with partners including the Centre for Indigenous Peoples Nutrition and Environment (CINE) at McGill University, put together a collection of studies on traditional food systems of indigenous peoples. Twelve case studies are presented, and fruit features in all of them.

One of the studies was in Pohnpei, Federated States of Micronesia, and one of the fruits featured in this study is banana. The banana we all know is the popular Cavendish. It is both a spectacular success and a spectacular failure of modern agriculture. In spite of it popularity and in addition to all its accumulated susceptibilities and vulnerabilities, it contains almost no beta-carotene. But there is a huge, albeit little known, biodiversity of bananas around the world including this one with more than 8 500 micrograms of beta carotene. The difference between a child consuming the Cavendish banana, and the Karat banana, represents the difference between that child having a vitamin A deficiency or adequate vitamin A intake. In FSM, as the traditional varieties of vitamin A rich bananas were neglected in the jungles, children were going blind from vitamin A deficiency. Through the efforts of one particular scientist, the late Lois Englberger, the biodiversity of bananas in FSM is contributing to solving the micronutrient malnutrition problems that have plagued this Pacific Island nation during since the mid-20th century.

Another example is that traditional wisdom long recognised the attributes of apples – an apple a day keeps the doctor away. Yet nowadays, it would not likely be considered a superfruit – it is too common, and its content of conventional nutrients is quite low. The vitamin C content ranges from less than 1 mg to around 8 mg, representing between 0 and 17 percent of the daily vitamin C requirement (Figure 2). However, the contents of many beneficial phytochemicals in apples is more impressive, shown in the last three columns of Figure 2.

Figure 2: Apple, values per 100g fresh weight

	Vitamin C (mg)	Flavonols (mg)	Quercetin (µg)	Catechin (µg)
Apple, Royal Gala, raw	0.4	5.46	120	1090
Apple, Renetta, raw	5.4	3.4	120	3400
Apple, Red Delicious, raw	0.7	5.86	220	2370
Apple, Morgenduft, raw	5.6	5.43	120	1370
Apple, Granny Smith, raw	2.7	4.93	120	2600
Apple, Golden Delicious, raw	7.7	7.14	160	470
Apple, Fuji, raw	2.1	4.77	100	820
Apple, Braeburn, raw	8.1	8.32	190	450

Figure 3 shows some data for different varieties of cactus pears, illustrating both conventional nutrients and bioactive non-nutrients. The green-skinned variety has a relatively low beta carotene content, but a relatively high content of epicatechins, compared to the yellow-skinned variety, with very high beta carotene, and much lower epicatechins. Epicatechin is a member of the chemical family of flavonoids, and functions as an antioxidant.

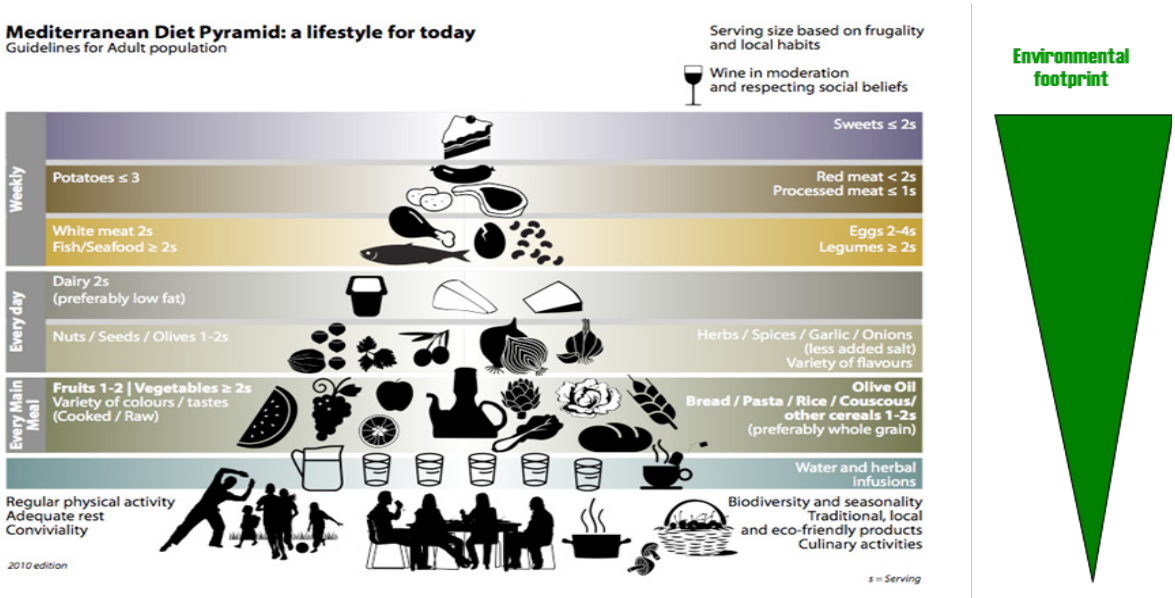
Figure 4 illustrates the new Mediterranean Diet pyramid. Fruit occupies the level where consumption needs to be high and frequent. It specifies 1-2 servings at every main meal. This is seldom achieved, and without claiming causality, progressively lower intakes of fruit correspond with increased prevalence of overweight and obesity, and diet-related chronic diseases.

Figure 3: Cactus, values per 100g fresh weight

Fruit	β-carotene (µg)	Vitamin C (mg)	Epicatechin (µg)	Hesperidin (µg)	Isohamnetin (µg)
Cactus pear, green-skinned, ripe, peeled, raw	290	45.8	6950	2410	220
Cactus pear, yellow-skinned, ripe, peeled, raw	2370	43.7	980	nd	nd
Cactus pear, red-skinned, ripe, peeled, raw	1460	81.5	5480	nd	380
Cactus pear, purple-skinned, ripe, peeled, raw	670	12.1	9350	1900	110

Source: BioFoodComp2.0.

Figure 4: Mediterranean Diet Pyramid



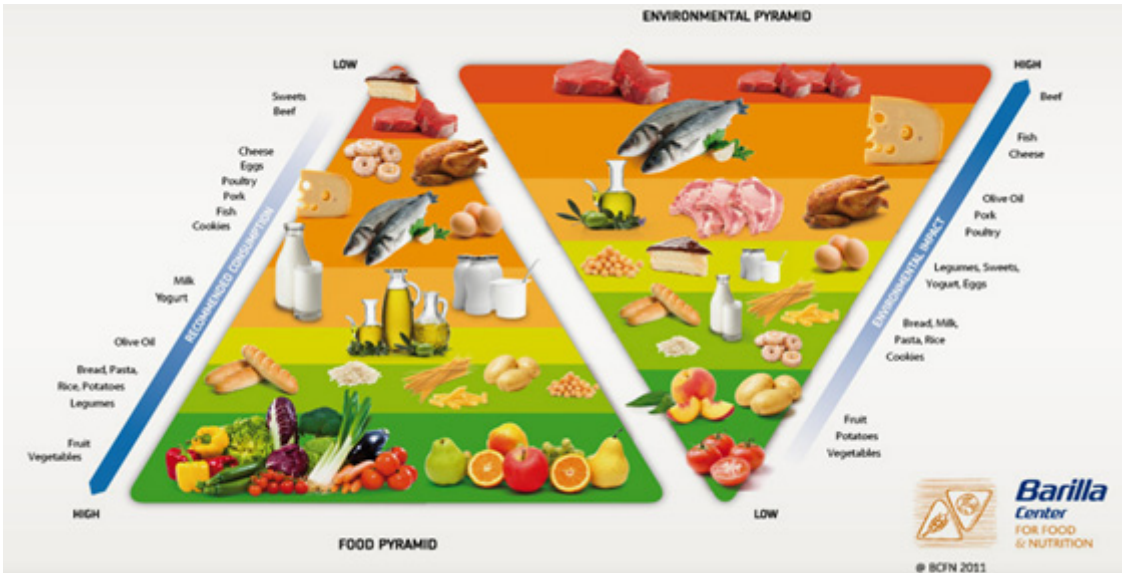
Source: Mediterranean Diet Foundation, 2010.

Double pyramid (Figure 5) which illustrates that the foods low on the food pyramid, i.e., those that should be consumed in the highest amounts, have the lowest environmental footprint. You can see where fruit is.

In terms of footprints, this time water, Figure 6 shows a favourable water footprint compared to many other foods.

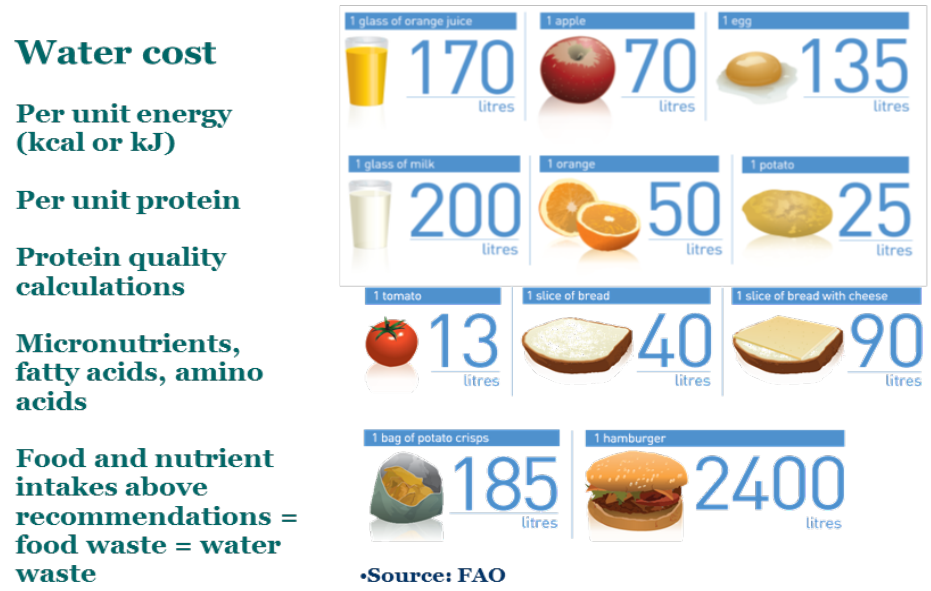
In conclusion, evidence provided would suggest that fruits are super foods, at the very least. But elevating fruits, and individual nutrients and bioactive components of fruit, as something exceptional, i.e., over and above normal food, will be detrimental to overall nutrition messages. Ultra-processed convenience- and snack foods will continue gaining stronger footholds among consumers as normal foods, and fruits will be

Figure 5: Double Pyramid



Source: BCFN 2011.

Figure 6: Water footprints



seen more as a luxury addition or supplement to this normal diet as opposed to forming part of a normal diet.

Other conclusions include:

- Fruit biodiversity is vast and needs to be valued and promoted
- All fruit contributes micronutrient adequacy and richness to diets
- All fruit contains beneficial non-nutrient components
- Fruit consumption is associated with lower levels of overweight and obesity and decreased risk for non-communicable diseases
- Fruits should be considered "super" insofar as they are an essential part of a healthy, daily diet. But "superfruits" as a term for a few selected fruits implies more than what is justified for this wonderful category of human foods.

NUTRITIONAL AND HEALTH BENEFITS FROM THE CONSUMPTION OF FRUITS WITH HIGH CONTENT OF NUTRIENTS AND PHYTOCHEMICALS – WITH REFERENCE TO THE TERM SUPERFRUITS – AND EFFECT OF GENOTYPE AND AGRONOMIC ASPECTS ON THEIR QUALITY

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ABSTRACT

Fruit contain important nutrients and phytochemicals and are an essential component of balanced and healthy diets. They contribute to food security and provide key molecules such as vitamins, minerals, essential micronutrients, fibre, vegetable proteins, carbohydrates and bio-functional components. In particular, their richness in phytochemicals and their benefits on health make them invaluable for physiological functions. They help prevent a number of extremely serious non-communicable chronic diseases (NCD), including cardiovascular diseases, diabetes, cancer, respiratory diseases, and obesity, as well as preventing micronutrient and vitamin deficiencies. The genotype is a major determinant of the quality and composition of ripe fruits. Phytochemicals and nutrients of fruits vary among different varieties and accessions of crops, as well as between wild and cultivated plant species. Environmental conditions also largely affect the composition of fruits, including the geographical area of cultivation, pedology, climatic conditions and the agronomic practices used. A critical review of the literature was conducted in connection with the term Superfruit. In recent years this term - originally used by the food industry to indicate fruit having an exceptional nutrient richness and nutritional qualities, including high concentration of phytochemicals - has been increasingly and generically utilized, mainly for marketing purposes. As time goes by, additional fruits gain the rank of Super and the list of the so-called Superfruits and related products on the market becomes longer. This term has also started to be employed in scientific literature and there is a need for clarity regarding this concept. The capacity to act as antioxidants is considered the major property of molecules with biological significance present in fruit. Nevertheless, results obtained in vitro and in vivo are inconsistent, sometimes contradictory, and overall inconclusive. A better understanding of the metabolic pathways of phytochemicals is being gained, but many key aspects are not yet fully understood. Bioactive molecules may have potential health benefits independent or additional to their anti-oxidant effects. Even the key role of anti-oxidants is questioned and other non-antioxidant mechanisms might be responsible for the biological activity of phytochemicals. Further and comprehensive research is needed to fully understand the metabolic pathways and biological role of the bioactive compounds responsible for the benefits observed on health. Final validation should be obtained with tests in vivo and in particular with epidemiological and clinical studies on humans.

THERAPEUTIC VALUES OF SUPERFRUITS, BEYOND NUTRITION AND THEIR VALUE ADDITION FOR COMMERCIALIZATION

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Abstract

Some of the traditional fruits in the tropical region are not only full of nutritional properties, but also contain bioactive components and could be classified as functional foods. Bale (*Aegle marmelos*) is one such fruit which has been used in indigenous medicine for stomach problems, especially for constipation.

Therapeutically active Marmelosin is present in bale fruit and is responsible for the beneficial effects of the digestive system.

Mangosteen (*Garcinia mangostana*) is another fruit that is popular for its health benefits. The health beneficial properties of the mangosteen are in the fruit pericarp (rind) and are identified as Xanthones, which have demonstrated very high antioxidant properties.

Most of the tropical fruits have a very short life span as fresh fruits, and they need to be processed to extend their shelf life. However, due care needs to be taken during processing in order to not inactivate the biologically active components as most of them are heat sensitive. Also, most tropical fruits are highly acidic (with high astringency and sweetness) and needs to be diluted to be used as a ready-to-drink beverage. The addition of young coconut (Cocos nucifera) water to dilute these fruits is an ideal value addition option as it improves the health benefits due to its very high potassium content and low brix value. Also, aseptic processing coupled with eco-packaging would enhance the value due to minimal heat damage and extended shelf life of the finished products.

PROGRESS ON BIOACTIVE COMPOUNDS AND PHARMACOLOGICAL ACTIVITIES OF SEVERAL MAJOR TROPICAL AND SUBTROPICAL FRUITS IN CHINA

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ABSTRACT

Lychee (*Litchi chinensis* Sonn. and longan (*Dimocarpus longan* Lour.) belong to Sapindaceae family, and they are economically important tropical and subtropical fruits originating from Southern China. China ranked first in the world in terms of the area cultivated to and the production of lychee and longan. During the past few decades, numerous development have been achieved in the Chinese agricultural sector. Consequently, many lychee and longan industries have emerged and produced an enormous amount of fruit that fulfills local consumption demands. As there is a huge amount of fruit that is not consumed locally, there is an urgent need to develop the processing industry. Lychee and longan are very rich in minerals, dietary fibre and phytochemicals, which is why lychee and longan are used as traditional Chinese medicines. Phytochemistry and pharmacologyical sciences prove the health benefit of the lychee and longan. This presentation deals with an overview related to the bioactive compounds – such as antioxidants, anticancer, antivirus and immunomodulatory activities – and their possible contribution to health benefits, which could be a possible natural source of pharmaceuticals and bioactivities.

China is a major producer of citrus fruits and has numerous citrus germplasm resources. In recent years, more attention is being placed on improving the utilization of citrus processing by-products. Pericarpium Citri Reticulatae, mature and dried pericarp of Rutaceae citrus, has high medicinal properities. Here, the latest scientific findings on chemical composition, antioxidant and antimicrobial activity of essential oil and the hypoglycemic activity and mechanism of flavonoids from Pericarpium Citri Reticulatae are presented.

Huazhou pomelo (*Citrus grandis* Tomentosa), also known as Huazhou Juhong, is unique to Huazhou Guangdong Province, China, and is used as a Chinese medicine. The functional role and its active substances to health promoting effects of Huazhou pummel are reported.

SESSION TWO – GETTING SUPERFRUITS TO MARKET

SUPPLY AND DEMAND TRENDS IN THE GLOBAL SUPERFRUITS MARKET

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ABSTRACT

The "supers" are here to stay. The launch of POM Wonderful in the USA ten years ago started the superfruit trend as well as the new categories of superfoods and superspices. Consumer demand for once exotic fruits and vegetables like pomegranate and avocado and ancient grains like quinoa have made them easy to find in supermarkets around the globe.

Health and wellness are key drivers of new product development, globally. Obesity and excess calories are issues on one extreme and lack of nutrients is an issue at the other extreme. Both are driving demand for healthier foods. Consumers are also seeking out new kinds of indulgence, driving demand for new ethnic and exotic flavors and authentic regional products. The health benefits of superfruits have made them successful as ingredients for food companies and as a source of exciting new flavors for consumers. Part of their success is the fact that it is easy for consumers to understand their benefits.

This presentation will provide insights into which fruits are well-established as superfruits, which ones are emerging, how their benefits are marketed to consumers and outline future opportunities.

DEVELOPING THE MARKET POTENTIAL OF MANGOSTEEN AS A SUPERFRUIT WITH FOCUS ON QUALITY ENHANCEMENTS, PROMOTIONAL REQUIREMENTS AND MARKET EXPANSION

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ABSTRACT

Mangosteen is a tropical fruit native to Indonesia which recently became very popular because of the content of xanthones in the pericarp. Xanthones have been demonstrated in numerous scientific studies to hold tremendous health benefits. Our study found that xanthone exhibit strong antioxidant activity, better than tocoferol. Aside from being an antioxidant, xanthones are claimed also to have various health benefits, such as controlling cholesterol, anti-inflammatory, boost immune system, allergy control, nourish the body cells of cancer initiation and tumor growth, eliminating pain in the body and joints, beautify and smooth the skin, smooth bowel movements, restoring body aches and fatigue, good for people with diabetes, treating high blood pressure, heart diseases, uric acid and rheumatism, and to control the growth of bacteria. Because of these properties and becoming the superfruit, many herbs and pharmaceutical companies produce mangosteen fruit peel extract. The form of the product being sold is very diverse, ranging from dry powder of mangosteen peel, whole fruit juices, mangosteen fruit peel extract, until the mixture mangosteen fruit extracted with several of other nutritious plants. The product quality improvement, better formulation, product form, packaging, and labels needed to improve competitiveness of xanthone. Consumers also need information on the phytochemical content in mangosteen and usefulness for improving health. Such

information is needed in marketing this new product. In addition to conventionally marketed, mangosteen peel extract products marketed with direct selling.

DEMAND TRENDS, MARKET, PRICE DEVELOPMENTS AND PROMOTIONAL REQUIREMENTS FOR DRAGON FRUIT

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ABSTRACT

Dragon fruit (*Hylocereus undatus*) is considered one of the specious agricultural produces which is preferred by domestic and international consumers. The area of dragon fruit has rapidly increased in the recent years. It was only 560 ha in 2000, increasing to 26,100 ha in 2012. There are about 30 provinces that produce dragon fruit throughout Viet Nam. Binh Thuan province has the largest area of 20,000 ha (76.6% of total area of dragon fruit), Tien Giang 3000 ha (11.5%) and Long An 2,100 ha (8.0%). There is a high demand for dragon fruit in the world market, especially in Asia, Europe and the America continents. At present, dragon fruit is the leading exported fruit of Viet Nam, which contributed to more than 50% of total fruit export value in the country. The turnover of dragon fruit exports reached USD 10.4 million in 2005, and increased to USD 181 million in 2012. Viet Nam exported dragon fruit to 40 countries and territories around the world, and the main export markets are China, Thailand, Indonesia, Japan, Europe and US. However, dragon fruit was mainly exported to China through border trade, which contributes to price fluctuations and to an unstable market. Consequently, there is a need to develop strategies to promote Vietnamese dragon fruit to the international markets and to expand export markets. In order to penetrate the supermarkets, it is also important to comply with several international regulations, such as GlobalGAP and BRC, HACCP.

MARKET POTENTIAL OF MIRACLE BERRY (*SYNSEPALUM DULFICICUM*, SCHUMACH AND THONN. DANNIELL) IN WEST AFRICA: PRODUCTION, CONSUMPTION AND TRADE

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ABSTRACT

Miracle berry (*Synsepalum dulficum*) is a berry that causes sour foods subsequently consumed to taste sweet when eaten. The plant is a shrub that grows up to 6.1m high in its natural habitat but does not grow higher that 3m in regular cultivation. Its leaves are 5-10cm long, 2-3.7cm wide and glabrous underneath. Its flowers are brown, and the plant carries red 2cm long fruits with each fruit containing one seed. It is rarely grown as a sole crop in West Africa but as intercrop with other cash crops such as cocoa, kolanut, coffee, etc. The plant grows best in soils with pH range (4.5 to 5.8) in an environment free from frost and under partial shade with high humidity. It is tolerant to drought, full sunshine and slopes.

The fruit pulp is used to sweeten palm wine and other sour foods. It is widely used all over the producing area in West Africa as a sweetening agent with high potential as a substitute for sugar for patients suffering from diabetes melitus. Despite the fact that the crop is well known, it is yet to be commercialized. There are no defined marketing channels for trade in miracle berry in West Africa. The need for domestication, genetic improvement and enhanced utilization studies on the crop is proposed and discussed.

CHALLENGES ON PRODUCTION OF TROPICAL FRUITS IN THE PHILIPPINES

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ABSTRACT

The Philippines is blessed with favourable climate for the production of major and minor tropical fruits with high economic importance and potential to boost the fruit industry. These varied fruit species thrive abundantly in the different regions of the country and contribute remarkably to the livelihood of the smallhold farmers. The major tropical fruits such as banana, mango, pineapple, and papaya are the country's export earning fruit crops, while the minor fruit species such as durian, jackfruit, and pummelo, though recognized as banner commodities in their respective regions are not competitive both for local and international markets. The major production constraints, particularly on pre- and post-harvest practices, pest/disease problems as well as marketing inefficiencies, require appropriate science-based interventions that would improve the yield, quality, and marketability of most of these tropical fruits. The presentation shall discuss the various challenges and constraints on the value chain of the most important tropical fruit species in the Philippines. It will include the current initiatives on R&D strategies, promotion and technology transfer modalities as well as capability building activities being implemented to improve/enhance the productivity and marketability of the tropical fruits in the country.

SESSION THREE – TECHNICAL AND INSTITUTIONAL ISSUES AND CONSTRAINTS

TACKLING TECHNICAL AND INSTITUTIONAL CONSTRAINTS IN THE DEVELOPMENT OF SUPERFRUITS IN AFRICA

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ABSTRACT

The importance of superfruits as necessary part of human diet and as cash crop was recognized. Natural growing conditions in Africa are known to be excellent for diverse superfruits. The wide range of climate, rainfall, soils and altitude are considered to give the different regions of Africa a vast potential for growing tropical, subtropical and temperate superfruits. The bright future of superfruits in Africa together with the technical and institutional constraints was discussed. Tackling technical constraints in the development of superfruits were highlighted in terms of cultural practices, postharvest handling, and pest and diseases control. Tackling institutional constraints in the development of superfruits in terms of government attention, partnerships and market access were identified and should be well organized. The monitoring and evaluation to identify information and technology gaps should be addressed by public and private research institutions for tackling constraints in development of superfruits.

PAPER

Introduction:

The superfruits deemed super by nutrition scientists are packed with antioxidants, fiber, vitamins, minerals and other nutrients that improve health condition. Superfruits included tropical, subtropical and temperate fruits such as Acai Berries, Apple, Bananas, Black Berries, Blue Berries, Cantaloupe, Cherries, Lime, Cranberries, and Dragon fruit, Grapes, Grapefruit, Kiwi, Oranges, Plums, Pomegranate, Strawberries, Avocados, Tomatoes, Papayas, Raspberries, Pumpkins, Watermelons, Pineapple and Baobab. The importance of superfruits as a necessary part of the human diet and as cash crops is well recognized.

Natural growing conditions in Africa are excellent for diverse superfruits. The wide range of climate, rainfall, soils and altitude give the different region of Africa a vast potential for growing a wide range of tropical, subtropical and temperate superfruits. Some of the superfruits are grown in thirty two countries across Africa and have been cultivated by rural small farmers with slow progress in some areas and developed in anther.

Avocado, banana, cantaloupe, grapefruit, lime, orange, apple, pomegranate, papaya, pumpkin, watermelon, pineapple and Baobab are considered the most important superfruits in Africa. These fruit crops are often grown by smallholder farmers, and rarely under commercial plantation. Both research and technical services for fruit trees and the general horticultural areas are lacking financial supports. Comparative income economical studies were indicated all the time huge revenue from the superfruits compared to some field crops. All these superfruits in Africa are gradually gaining importance for to be improved in term of varieties, cultural practices, environment, post harvest handling and marketing. For Africa to realize its full potential to produce superfruits, a fully structured and sustainable infrastructure development is needed. Generally, very little efforts have been made by the governments to increase the economic and environmental benefits of growing more superfruits in agricultural managed fields and homesteads.

Therefore, this paper briefly outlines tackling technical and institutional constrains in the development of superfruits in Africa.

Tackling Technical constraints:

Cultural Practices:

Fruit trees in general need to have adequate cultural care from the start so as to avoid any irreversible error may not be easy to be corrected when tree growth advanced. The prevailing cultivars and varieties of the known superfruits, some well adapted, might give inferior yield and/or quality. So cultivar choice will be of crucial importance for good start to the fruit tree establishment. Due to the effect of climate change it's highly needed to conduct research on cultivars that facing this problem. Pruning and plant growth management from nursery stage and fields are very important to gain optimum productivity. Irrigation is vital for tree growth and development and it has to be applied well calculated due to the tree water requirements at different physiological stages for better yield. The response of these kinds of fruits to several levels of fertilizers application needs to be ascertained in order to prepare spectrum of recommendations to match the resources of small, medium and huge plantations.

Pest and diseases control:

Insect pests and diseases are major factors reducing yields of fruit tree crops quantitatively and qualitatively. Insect pests and diseases were surveyed several times at different countries of Africa. These surveys indicated that scale insects, mites, termites, fruit flies, leaf miners, mealy bugs, beetles, in addition to some serious fungal, bacterial and nematodes are major pests and diseases inflicting considerable damage to fruit tree. Despite of this, no serious attempt has been started in many African countries to combat the major pests and diseases properly because control procedures are very expensive. Suggestions to overcome this handicap will be mainly by organizing fruit tree growers in cooperative or unions so that control procedures could easily be secured.

Post Harvest Handling:

Superfruits, except Baobab, are perishable and require the most specialized and careful handling techniques in order to remain fresh, firm and free of marks and bruises. Improper harvest methods and handling, lack of post harvest inputs and treatments, absence of packing houses, Insufficient cold stores, lack of refrigerated trucks for distances transportation and weakness scheduling form harvest to final destinations are all considered as the post harvest constraints. In general poor post harvest techniques will result in high losses percent and inferior quality making investment more restricted. Interventions through successful models of research findings application in the field of post harvest, processing and extension activity will be of crucial importance to overcome all these constraints. On the other hand, processing is recognized as a way of preserving the superfruits. Yet the proportion of fruits to process and the suitability of the different fruits to processing are relatively unknown in Africa, with exception to South Africa.

Tackling Institutional constraints:

Government attention and supportive policies:

Incentives for investment (credit, taxes, tariffs, infrastructures, training and pre-finance), policies to promote engagement in policy initiation and development by public and private sectors institutions, policies to promote and harmonize the quality standards and requirements and policies to integrate and promote entrepreneurship and other technical skills are all identified as major policy gaps requiring urgent government attention. Government should consider strategic use of public resources to promote and develop private sector capacity.

Partnerships, organization structure and coordination:

Partnerships linkages along the superfruits production-consumption chain involving farmers and their organizations, researchers, processors, retailers and whole-sellers on one hand and the service providers (credit banks, transporters, media and information firms) on the other hand, with public sector facilitating the processes with targeted inputs such as capacity building loan guarantees, and other investment incentives all should be well organized and linked together. In this partnership structure, public resources would be focused at strategic intervention inputs such as capacity building, infrastructure development and monitoring and evaluation to identify information and technology gaps that would be addressed by public and private research institutions in the superfruits partnerships chain.

Market Access, structure and function:

Producers are often concentrated in the remote areas which far away from market access. Most of the African countries have always being hindered by poor infrastructure. This situation resulted in lack of services, information and technologies which much needed to develop the whole sector. According to a development research brief, by the African Development Bank in 2009, less than 10% (in 10 countries) and less than 50% (in 33 countries) of roads in Africa are paved, 40% of the continent's population lacks access to safe water; 60% of the population lacks basic sanitation an only 30% of the rural population in Sub-Saharan Africa has access to all-season roads. Therefore, economic efficiency is not harmonized due to these difficulties in accessing Africa's markets. Africa accounts for 12% of the world's population but only contributes 1% of global GDP and only 2% of world trade. The main strategy of market oriented fruit is to start from market feasibility study of each superfruit tree making the market as an entry point to any fruit tree development activity. Build the capacity of individual farmers by commodity will assist in developing marketing cooperatives and private sector partners. Establishment of cold stores, small canning and food processing cottage will help to make use of the available raw material for local and export markets. The national, regional and international markets requirements (quality standards and certifications) have to be carefully identified for each superfruit.

DEVELOPING AND ADOPTING APPROPRIATE TECHNOLOGY IN "SUPERFRUITS" PRODUCTION

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ABSTRACT

Understanding the influences and impacts of abiotic factors on the biotic potential of a superfruit is fundamental to the successful commercial development of such commodities. The track record of horticultural research has traditionally focused down specific scientific disciplines or technology lines. However this approach does not considered the interaction, synergies or detrimental impacts that one intervention to manage a particular problem, has on the total production system. Research strategies that concentrate on specific issues are essential but unless they are then placed in context of the total production system, the outcome is of little value.

This presentation will provide examples where research conducted in isolation of the commercial reality has resulted in meaningless outcomes or missed opportunities that could have been achieved greater impact. The lack of understanding by many plant science disciplines of basic plant phenology and the plants responses to the environmental and commercial management practices, has resulted in science for scientific papers and not for commercial development or poverty elevation. This also leads to identification of deficiencies in many of institutional and industry research strategies, which may be wasting significant resources in times of declining investment into agricultural research. The scientific debate about superfruits maybe stimulating, but will it change the lives of people in need, or influence to economic prosperity of a business.

POST-HARVEST REQUIREMENTS: FARM TO MARKET AND IS THERE A CASE FOR CERTIFYING SUPERFRUIT?

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ABSTRACT

In 2005 the food and beverage industry introduced the term 'superfoods' to describe a range of fruit and vegetables thought to confer significant and essential components to human health and nutrition. These products were purported to have nutritional significance and anticipated health benefits because of their nutrient density, essential vitamins, antioxidant value and other specific biochemical compounds. The term superfruit was refined to describe specific fruit with special nutritional attributes. Such fruit included: pomegranate, mango, mangosteen, berries (including blueberries, black berries, raspberries, boysenberries, goji berries, acai berries), avocado, mango, grapes, dragon fruit, watermelon and others. However the word 'superfruit' was a clever marketing term used very effectively to attract consumers to purchase more fruit because of these supposed health attributes. In fact all fruit have many desirable health attributes, and no food authority has accepted that any fruit has enough specific scientific or proven health effects to be granted official status as a 'superfruit'. Postharvest requirements for these fruit are the same as for other fruit in that they are all very perishable, must be grown properly, be harvested at the correct maturity, maintained at recommended temperatures or atmospheres, packaged appropriately, handled gently to prevent physical damage and reduce losses as well as meeting the quality and phytosanitary requirements of markets. As such there is no need to have specific certification standards for these so-called 'superfruit' other then those that exist for other fruit. Having said that any way that producers and marketers

can use to promote the consumption of a balanced diet containing an appropriate daily intake of fruit and vegetables, such as the '5 plus a day' programme, should be encouraged.

PAPER

Introduction

Introduction of the term 'superfood' by the international food and beverage industry during the mid-2000s was a very clever and successful marketing tactic to encourage consumers to eat more fresh and processed fruit and vegetables. The first use of this term appeared to be in an article in the August number of the journal Nature Nutrition where the following quote by Aaron Ross appeared: "Humans have many options when it comes to fueling their bodies, but the benefits of some options are so nutritious that they might be labeled as superfoods" (Anon. 2013). Superfoods are said to comprise many traditional food products including: fish such as salmon, green or black tea, yoghurt, turkey, grains, fruit, vegetables and nuts. All of these were regarded as nutrient dense, being high in antioxidants including Vitamin C, polyphenols, and other health beneficial phytochemicals. Many attributes for such foods have been claimed including reduction in risk of cancers, heart disease, alleviation of blood pressure, reduced cholesterol and general promotion of wellbeing. Traditional knowledge informs us that vegetables and fruit are key dietary components and our ancestors knew that "an apple a day keeps the doctor away". There is currently much interest in identifying bioactive components from fruit, especially relatively 'new' fruit such as acerola, acai, goji, sapodilla, pomegranate, Surinam cherry, cashew apple as well as more traditional tropical fruit (Da Silva et al. 2014). Widespread reports appear in the literature describing the range of bioactive phytochemicals isolated from fruit and vegetables purported to confer health benefits (Anon 2006; Ruel and Couillard, 2007; Wedick et al. 2012; Felzenswalb et al. 2013; da Silva et al. 2014). A range of metabolic illnesses and diseases are listed as being mitigated by regular consumption for fruit; it has been claimed that anthocyanins are strong antioxidants that inhibit growth of cancerous cells, inhibit inflammation, can be vasoprotectors, and can have anti-obesity effects (McGhie and Walton, 2007). In addition tannic polyphenols are thought to be important because of purported evidence of anticancer properties, antiproliferative properties, antibacterial activity in relation to intestinal pathogens and anti-inflammatory activity (Gasperotti et al. 2013) as well as lowering the risk of cardiovascular diseases (Wallace 2011).

In spite of the increasing literature extolling the presence of an increasing number of beneficial bioactive phytochemicals in a broadening base of traditional and new fruit, there is virtually no direct quantitative information on the uptake and bioavailability to humans of this plethora of compounds. Most studies have been done on cell cultures, or on rodents, with very few human intervention studies. Just because fruit contains a diversity of bioactive components does not mean that the human body absorbs and utilises these chemicals to reduce or mitigate diseases when ingested and digested. For example McGhie and Walcott (2007) stated, with particular reference to berry fruit, that: 'relatively little is known about how anthocyanins and compounds derived from them enter the body, distribute to tissues and exert beneficial health effects'; this statement applies equally to other bioactive compounds from other fruit. Research is progressing rapidly and more human intervention studies are now being undertaken utilising sophisticated monitoring and detection equipment but more such studies will be required before evidence is available to unequivocally quantify the specific health benefits that accrue from consumption of particular phytochemicals from fruit.

Nonetheless until such evidence becomes available the World Health Organisation (WHO) guidelines should be followed; these recommend that each person should eat a minimum of 400 gram of 5 different fruit and vegetables every day (Anon 2004). The international programme "5 Plus a Day" has developed an information brochure that is used for promoting consumption of fruit and vegetables to school children; this has a colour coded presentation that reflects the nutritional and health benefits of the different types of horticultural foods (Anon 2014). Red, black, purple and blue fruit are highly recommended because of the presence of anthocyanins, and yellow and orange fruit because of carotenoids.

However because of the perceived benefits of all fruit it would appear to unnecessary to label any individuals as being 'super'. Doing so may have the unintended consequence of reducing purchases of other fruit that does not have the 'super' connotation yet still provide significant health benefits.

"All fruit are equal but some fruit are more equal than others."
Modified after George Orwell's book Animal Farm.

Currently those marketing fruit are not allowed to promote them as 'superfruit because this term is not accepted by EU, USA or food authorities from some other countries. This will not change until science has demonstrated unequivocally that intake of fruit confers specific and consistent health benefits. However some companies are still using the label 'superfood' in some countries when there are no regulatory constraints applying (Fig 1).

Figure 1. Pawpaw imported to New Zealand and sold with the label 'Superfood for the Skin"

Postharvest management of "superfruit"?

It is suggested here that all fruit have important and essential health benefits. The range of fruit that have been suggested as superfruit varies according to the location and predilections of the individual or organisation making the recommendations. However all fruit are perishable after harvest with those from a tropical or subtropical origin generally being more perishable with shorter shelf lives than those from a temperate origin. All fruit are susceptible to physical, physiological and pathological damage during and after harvest. Therefore the same basic postharvest principles that apply to traditional fruit also apply to any so-called superfruit, whether they are traditional or new.

Key factors for delivering quality fruit to consumers.

The supply (value) chain. There are a number of key factors that must be achieved for obtaining optimum quality for the consumer at the end of the supply chain, and enhance profits for others in the chain including growers. A supply chain perspective should be an automatic part of every activity of all members for the chain from the producer to the retailer. Consumer satisfaction is the key driver; repurchasing ensures continuing demand and profitability. Communication in real time among participants along the entire chain is of paramount importance and successful chains accomplish this using modern IT communication systems. Such communication allows problems and constraints to be identified and remedied quickly.

Preharvest factors affecting postharvest quality. Many aspects of production will affect postharvest quality.

These can include:

- Site selection – different soil types can affect growth, development and quality. Availability of water may be critically important to mitigate the effects of droughts.
- Cultivar selection – cultivars must have fruit with desirable quality attributes including, appearance, size, shape, colour, gloss, juiciness, texture, taste, tolerance (or resistance) to pests and diseases. Plants should be vegetatively propagated to ensure uniformity of vegetative and fruit production and

not planted from open pollinated seedlings. If possible cultivars should have a long shelf life.
- Tree management – optimum productivity will only occur with effective pollination; pruning should be done to allow maximum light penetration to the tree and to maintain a manageable tree height so fruit can be harvested from the ground and reduce the risk of physical damage occurring during harvesting; fruit thinning should be applied where needed to ensure optimal fruit size; where possible integrated pest and disease management strategies should be adopted to minimize spray residues on fruit.
- Nutrition, fertilisers, irrigation, weed pest and disease management. Excess nitrogen and deficiency of calcium in fruit can result in development of postharvest physiological disorders.

Harvest maturity and harvesting. Eventual eating quality is often determined by the maturity at which the fruit is harvested.

- Fruit must be harvested at optimum maturity for specific markets; fruit for local market can be harvested more mature than fruit destined for distant export markets.
- Fruit harvested too immature will not have the dry matter that late harvested fruit have and will not achieve optimum taste and flavour, may be more susceptible to chilling injury than riper fruit. Fruit harvested too mature will senesce rapidly, be susceptible to postharvest pathogens and to handling damage.
- Where appropriate harvest during the cooler, early part of the day.
- Coordinate harvesting with packing, storage and marketing plans
- Avoid physical damage to fruit during harvesting and transport to packhouse.
- Place in shade as soon as possible after harvest.

Temperature management. Rate of postharvest deterioration is a function of temperature: the higher the product temperature the faster the rate of respiration and hence the faster the quality loss.

- Cool product to optimum storage temperature as soon as possible after harvest.
- Different cooling methods are available including passive cooling in coolstore (slow), hydrocooling (fast and useful for some fruit), forced air-cooling (fast and efficient – mobile units are available).
- Most tropical and subtropical fruit are susceptible to chilling injury (CI) that occurs when fruit is exposed to low but NOT freezing temperatures; CI symptoms include pitting, water soaking, internal browning and eventual decay.
- Avoid chilling temperatures during storage and transport (Table 1) that will cause development of physiological damage and ultimate decay.

Table 1. Chill sensitive fruit and lowest safe temperature

Temperature	Product
3	Jujube
4	Avocado (some cultivars), litchi, tamarillo
5	Cactus pear, durian, guava, longan, mandarin, orange, feijoa
7	Avocado (some cultivars), olive, pinapple, pomegranate
10	Carambola, lime mango, papaya, grapefruit, some melons, passion fruit, rambutan, watermelon
13	Banana, breadfruit, cherimoya, mangosteen, jackfruit

Ethylene. Ethylene is a simple naturally occurring ripening gas produced by most fruit that can have serious implications for fruit quality.

- Ethylene has both positive and negative affects on fruit quality.
- Ethylene is essential for ripening of fruit; commercially it is applied from an external source to ripen some fruit including bananas, avocados and kiwifruit.
- Negative affects of ethylene include induction of ripening (softening, colour change), senescence and premature deterioration.
- Physically damaged and rotting fruit produce ethylene.

- Ethylene is produced by internal combustion engines, industrial pollution and decaying fruit and vegetation.

In recent years a chemical has been available commercially that inhibits the action of ethylene. This chemical is 1-methylcyclopropene (1-MCP) and marketed for fruit as SmartFreshSM. It is widely used for apples and pears and has been approved for a number of other fruit including melons, avocado and persimmons in some countries. It is likely to have significant potential for extending shelf life of subtropical and tropical fruit when registered and approved for use. SmartFreshSM is used as a gas and applied within an airtight container, but 1-MCP has also been formulated (HarvistaTM) so that it can be sprayed onto trees before harvest to delay ripening and senescence.

Table 2. Summary of ways to minimize ethylene affects

- Avoid exposure to pollution that contains ethylene;
- Avoid physical, physiological and pathogen damage during harvesting, handling, packing, storage and transport;
- Remove all reject product from packhouses and coolstores;
- Use electric forklifts in packhouses and coolstores;
- Use ethylene scrubbers to reduce ethylene concentrations;
- Run coolstores efficiently; maintain recommended temperatures to minimize ethylene production by products;
- If permitted, treat with SmartFresh SM;
- Use long life cultivars that have reduced production of and susceptibility to ethylene.

Postharvest pathogens and decay. Interestingly most fruit are resistant to most pathogens. However there are several fungi that can cause significant commercial losses including: Rhizopus stolonifera, Botrytis cinerea, Alternaria alternata, Colletochrichum spp. and Fusarium spp. Pathogen losses generally result from physical damage that occurs during harvesting and handling, from storing product too long after harvest, from chilling injury sustained during storing at inappropriate low temperatures and from biotic or abiotic stresses during the growing season. Hygiene in the orchard and the packhouse are of paramount importance in reducing inoculum sources. Products can be washed with cool (>5-7oC) potable water that may include free chlorine (100-200ppm; pH 6.8-7.2) from sodium hypochlorite, calcium hypochlorite or liquid chlorine. Chlorine concentration should be checked daily. Other systems are available for reducing postharvest infections including controlled atmospheres and ozone fumigation. Whatever system is used the process must comply with Good Agricultural Practices (GAP) and market requirements (GlobalGAP).

Packaging. Packaging is critically important for successful marketing. Many wholesale and retail entities will specify the type of package that they require including size, volume, material of package, colour and labeling. There are three main reasons for ensuring that packaging is an integral component of any supply chain (Table 3). Modern trade requires that product traceability is present on all packages; food safety and biosecurity are key drivers for this. Different forms of traceability can be used but electronic product code identification; bar coding and radio frequency identification (RFID) are the prevailing systems today. Several different systems that enable real time monitoring of product temperature and other important factors from packhouse to customer are available commercially. Such technologies are becoming cheaper as track and trace components, including sensors, become cheaper a nd new information transfer systems become available.

Table 3. Packaging – the three Ps

- Protection: protecting products from physical, physiological and pathological damage during handling and transport. This may include clean paper to prevent scuffing and abrasions to more sophisticated polymeric films or polystyrene wraps
- Preservation: polymeric films can be designed to achieve shelf life extension through reducing moisture loss and creating modified atmospheres; C2H4 scrubbing; active packaging (O2 scavenging).
- Presentation: increasingly packages are used for promotion of brands/logos, extensive labeling is now required using bar codes or other identifiers to enable product traceability. Some packages are used for final presentation displays.

GAP and GlobalGAP. Regardless of whether a fruit is 'super' or not, if it is destined for markets in the EU, the USA or other developed markets, there is a requirement from the supermarkets that all fruit products must be safe to eat and must meet GlobalGap standards both production and postharvest parts of the chain. Many developing countries find it difficult to meet the stringent processes required and as an interim step have established national GAP standards (such as VietGAP).

Is certification necessary or possible for "superfruit"?

There are many questions that must be answered before any certification system can be recommended or established for 'superfruit'.

- Are bioactive compounds all effective in humans? It must be proven unequivocally that specific health benefits do occur in humans as a result of one or more particular chemicals affecting one or more disorders. Cranberries are the only fruit known to have achieved this status; it has been shown that intake of cranberries or cranberry products reduce urinary tract infections, presumably because of the presence of anthocyanidin/proanthocyanidin moieties that are potent antiadhesion compounds for fungi and bacteria. However recent evidence suggests that results are not homogeneous, are modest and vary among patients of different ages and backgrounds (Guay 2009; Jepson et al. 2012). Much more in vivo research is needed using humans to determine health benefits of all fruit.
- Do all bioactive compounds have similar or consistent efficacies? All fruit have a plethora of chemicals with potential health benefits. For example there are hundreds of different phenolic compounds identified from red wine (Lachman et al. 2009), but which ones affect human health have not been defined and this applies to many other fruit. Bioavailability and uptake of bioactives varies among specific components such as polyphenols (Manach et al. 2005; Williamson and Manach 2005). Manach et al. (2005) undertook a meta-analysis of 97 intervention studies and concluded that gallic acid and isoflavones were the most well-absorbed polyphenols, followed by catechins, flavanones, and quercetin glucosides, but with different kinetics. The least well-absorbed polyphenols are the proanthocyanidins, the galloylated tea catechins. Uptake and bioavailability of anthocyanins varies among fruit of the same species much more research is needed to establish how specific anthocyanins are absorbed, how the variation in molecular structure consumed in food and the forms generated in vivo, together with the relationships between individual or multiple chemicals generate specific health benefits (McGhie and Walton 2007).
- What are the minimum effective concentrations of bioactives to enable a fruit to be called a "superfruit"? Once the chemical composition of fruit is known, and when the bioactive chemicals have been identified it will be necessary to determine the minimum effective concentration required to provide the specified health benefits. Who will do this?
- Are concentrations of bioactives compounds from a given genera and/or species or cultivar have consistent concentrations and efficacies wherever they are grown? Concentrations of all the bioactives and their effectiveness when ingested, are likely to be significantly influenced by the environment in which the fruit are grown including soil type, mean and fluctuation temperatures, rainfall and other biotic and abiotic stressors. Antioxidant activity in wine grapes varies significantly among grape vine cultivars, growing regions, vineyard location and among winemaking procedures (Lachman et al. 2009). Vitamin C content varies among kiwifruit cultivars and Actinidia species (Ferguson and MacRae 1991; Nishiyama et al. 2004). Phenolic profiles and antioxidant activity in litchi pulp

varied among cultivars (Zhang et al. 2013) and antioxidant properties and polyphenolic composition varied among fruit from different European cranberry genotypes (Kraujalyte et al. 2013). Those fruit that are grown from seed, rather than from vegetative propagation, will vary qualitatively and quantitatively in their tree architecture as well as in bioactive composition.

- Do the bioactives vary with stage of development, ripeness and senescence? In strawberry there are major quantitative and qualitative differences in ellagitannins and ellagic acid conjugates among cultivars, and stage or ripening (Gasperotti et al. 2013). Sterols in grapes decreased as fruit developed into mature stages (Ruggiero et al. 2013).
- Tree management practices can affect concentrations of some bioactive components. Polyphenol content varied according to crop load in apples increasing as crop load reduced although ascorbic acid was not affected (Stopar et al. 2002). Flavonoid and chlorogenic acid concentrations in apple skin vary depending on position in the tree canopies, probably a reflection of light incidence (Awad et al. 2000) influenced by pruning management.
- Who is to be charged with monitoring concentrations and efficacies of bioactive chemicals? Should this be the responsibility of the grower, the exporter, the retailer or should this depend on conservative mandatory limits set and measured by food regulatory authorities?

Given the variation of a range of bioactives that occur within plants, across cultivars, production regions, within orchards, within and between trees, creating an accurate, robust and consistent certification scheme based on minimum concentrations of one or more chemicals will be a major challenge to establish, implement and monitor. It takes a great deal of time, effort and money to obtain certification for relatively simple situations based on geographical criteria such as one of the three EU schemes known as PDO (protected designation of origin), PGI (protected geographical indication) and TSG (traditional specialty guaranteed) that promote and protect names of quality agricultural products and foodstuffs (Anon. 2013a). These are based on the legal framework provided by the EU Regulation No 1151/2012 of the European Parliament and of the Council of 21 November 2012 on quality schemes for agricultural products and foodstuffs. What sort of framework would be necessary to develop for fruit that would be accepted internationally? It would be immensely challenging, if not impossible, to achieve some degree of uniformity in certifying specific fruit that are purported to have 'super' properties, knowing that although they are of a given genotype, that they will have been grown in different countries, varied localities, different microenvironments, with different management conditions for both production and postharvest processes.

The importance of bioactives for human health is well recognised, and a major research effort is being undertaken in many countries to determine the potential health conferring properties of traditional and well known fruit (Cuevas-Roderiguez et al. 2010; Almeida et al. 2011; da Silva et al. 2014; Zhang et al. 2013). More efforts are required to determine the efficacy of uptake in the human system and the quantitative health benefits that accrue from varying concentrations of specific fruit ingested in different forms whether it be fresh, partially processed or fresh-cut, or processed.

Conclusions

It is axiomatic that fruit should be a normal part of everyday human diet. Traditional knowledge knows that a varied intake of fruit is essential for health and wellbeing but there is increasing demand from marketers of food and cosmetic products to be able to highlight benefits that accrue from intake or application of products from certain fruit that may confer more benefits than others. The marketing term 'superfruit' was coined in the mid-2000s, but has not been accepted as a label by food authorities because of the lack of particular and specific information on the health or nutritional benefits that accrue following ingestion. While much research has been, and is being done, more information is required across a wide range of bioactive compounds to determine whether they have any benefits, whether they are absorbed at all, and if so are they in high enough concentrations to be beneficial. It will be very important to determine the minimum amount that needs to be ingested to elicit positive health effects. Much more information is required on the effect that different genotypic and phenotypic variations will have on bioactive concentrations in fruit from different growing regions, environmental influences, different production, postharvest and processing processes.

It does not matter if a fruit is labelled 'super' or not; all fruit are perishable and have a limited postharvest shelf life. Well-accepted and well-known postharvest management practices must be employed for all fruit to maintain quality for as long as possible and practicable. Basic principles mean harvesting at the correct maturity, removing field heat as soon as possible, handling carefully during segregation and

packing, packaging products appropriately for specific markets, minimising pest and disease incidence using integrated management techniques and storing product at optimum temperatures. Supply chain thinking and actions must be an accepted process in fruit production and postharvest handling.

If the term 'superfruit' does eventually become accepted widely, because of the scientific knowledge gained leading to acceptance by food regulatory authorities, it will be very important that this does not lead to a de-emphasis on the health benefits that come from eating other fruit in general confer on human health, even if they do not have a 'superfruit' label.

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IMPROVING MARKET ACCESS FOR SUPERFRUITS THROUGH EFFECTIVE DISSEMINATION OF MARKET INFORMATION TO SMALL HOLDERS

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ABSTRACT

Agricultural markets in developing countries have often failed for smallholders, where both macroeconomics and trade policy tools appear less useful in including market participation by poor smallholders. Some important factors attributed to this include: i) poor access to market information or information asymmetry; ii) lack of access to productive technologies; and iii) poor access to public and private goods. Consequently, the majority of smallholders sell their produce in poorly-paying local markets or at the farmgate rather than travel to distant better-paying markets. Significant national and international assistance have been provided

to assist the establishment of market information systems (MISs) in a range of developing countries. However, experience with state runs MISs, looking to provide current price information to market participants, has not been encouraging. Volatile horticultural markets provide particular challenges for such MISs. Therefore, the emphasis within marketing information provision should be on highlighting market opportunities especially when trading superfruits – not just on gathering and disseminating current market prices.

Various players along the supply chain such as exporter, trader, manufacturers, wholesalers and retailers need to reach out to the farmers by providing a systematic feedback mechanism which will inform the smallholders on the quality and characteristics of the product demand by consumers. This may require a major change in the mentality of participants down the supply chain as most believe that by holding back market information, they are able to take advantage of the marginal farmers. While this may be true in the short run, a mutually beneficial relationship can provide more vibrant business prospects in the longer run. Systems that provide information and communication to the small holders to improve their livelihood strategies must be linked to institutions and external stakeholders that may affect the livelihood of the smallholders. In addition, such systems must be enabled to address the specific needs of the smallholders i.e., be demand-driven. The case studies from different countries (off-season longan marketing in Thailand, pomegranate marketing in India, mangosteens in Indonesia, dragon fruit in Viet Nam) show that MISs markedly improved market access to the farmers.

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Agricultural markets in developing countries have often failed for smallholders, where both macroeconomics and trade policy tools appear less useful in including market participation by poor smallholders. Some important factors attributed to this include: i) poor access to market information or information asymmetry; ii) lack of access to productive technologies; and iii) poor access to public and private goods. Consequently, the majority of smallholders sell their produce in poorly-paying local markets or at the farmgate rather than travel to distant better-paying markets. Significant national and international assistance have been provided

SESSION FOUR – ENHANCING FOOD SECUIRTY FOR SMALLHOLDER PRODUCERS

SMALLHOLDER PARTICIPATION IN THE TROPICAL SUPERFRUITS VALUE CHAIN: ENSURING EQUITABLE SHARE OF THE SUCCESS TO ENHANCE THEIR LIVELIHOOD

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ABSTRACT

The production and trade of tropical fruits generate income, improving the livelihoods and food security of producers, who are almost exclusively smallholders in developing countries. They also contribute positively to meeting daily nutritional requirements, underpinning the importance of these fruits from both a commercial and nutritional perspective. Regardless of whether they are "super" or not, value is added at each step of the value chain – from farm-gate, through intermediaries (wholesale and retail), to the consumer. Significant progress has been made to explore measures to ensure that smallholders gain fairly from value addition along the chain. However, inadequate post harvest and transport infrastructure, resource limitation, institutional support and compliance with market access requirements are some of the reasons that smallholder producers have not been fully integrated. Therefore, forming like-minded players into legal entities, such as cooperatives, would better facilitate their integration through achieving economies of scale and improving their bargaining position. In this report, supporting evidence to some of the arguments put forward will be drawn from successful projects on bananas, tropical fruits and tea which were implemented in the Dominican Republic, Mexico and Indonesia, respectively, and supervised by the RAMHOT Team of the Trade and Markets Division of the Food and Agriculture Organization of the United Nations (FAO).

PAPER

1. Introduction

This document was prepared by the authors to initiate discussion on the role of smallholders in the tropical fruits sub-sector and how their effective participation in the value chain could enhance their food security. The document was written for the International Symposium on Superfruits: Myth or Truth?, which was organized jointly by the Secretariat of the FAO Intergovernmental Group on Bananas and Tropical Fruits, the International Tropical Fruits Network (TFNet) and the Ministry of Agriculture of Viet Nam.

Although reference to smallholders is sometimes made because of the smallness of their farm land, for the purpose of this report, the main reason that this group of producers is classified as "smallholders" is because they lack economies of scale in their operation. In other words, their output is too small to spread fixed cost per unit more efficiently. In addition, their variable cost does not reach an optimum level, as well.

It is a widely accepted concept among development agencies and stakeholders that the strategic involvement of smallholders in rural development programmes would spread the benefits of development to a greater

[1]The RAMHOT Products Team provides economic data and analyses on major agricultural raw materials and horticultural and tropical products. Commodities covered under the Team include: bananas and tropical fruits, citrus fruits, cotton, hard fibres, hides and skins, jute, kenaf and allied fibres, sugar and tea. The Team also undertakes market reviews, outlook appraisals and projections, and provides assistance to developing countries in designing and implementing national policies for those agricultural commodities which enter into international trade.

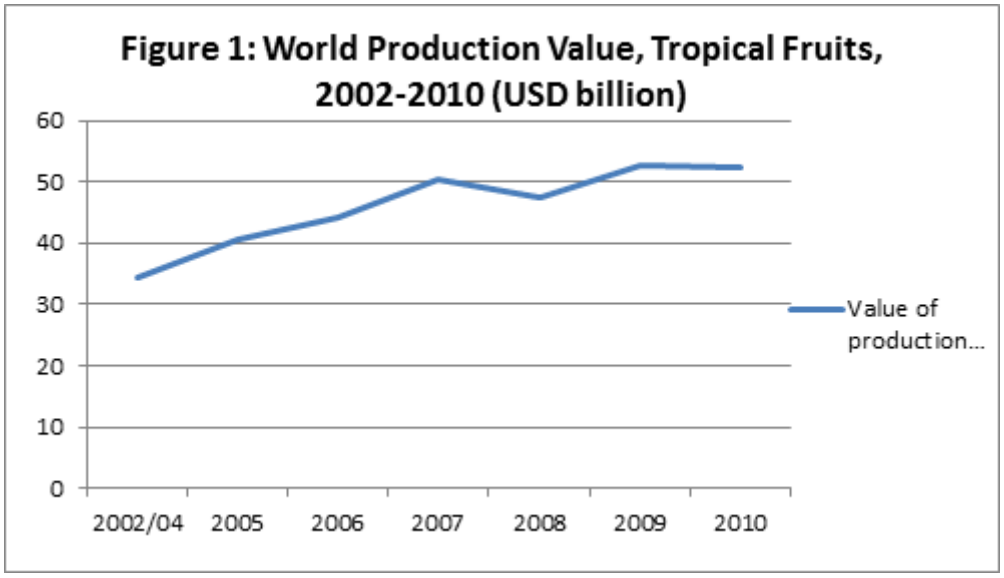
[2]Kaison Chang, Secretary, Intergovernmental Group on Bananas and Tropical Fruits (IGG/BATF); Margarita Brattlof, IGG/BATF Secretariat; and Siranush Ghukasyan, Consultant.

number of people, and in the process enhance their food security. However, a common occurrence often negates such aims: habitually, as value chains become more structured, smallholder participation is reduced. This document identifies some of the reasons smallholders are excluded from the value chain and examines ways to increase their participation to ensure an equitable share of the economic benefits to enhance their food security. In addition, possible strategies are suggested with accompanying enabling policies that could facilitate a more effective participation by smallholders. Finally, a selection of projects implemented or supervised by the Secretariat is summarized as evidence to highlight effective strategies and appropriate policies applied in the field to integrate smallholders in the tropical superfruits value chain.

1.1 Background

Studies conducted by the authors lead to indisputable evidence of the importance of tropical fruits to producing countries from both a nutritional and commercial perspective. These fruits are cultivated widely in the tropics, almost exclusively in developing countries, at commercial and subsistence levels and, until the 1970s, were mostly utilized for domestic consumption.

Contribution to farm/rural household incomes is significant with the value of production of tropical fruits (excluding bananas) estimated at USD 50.8 billion in 2010 (Figure 1).

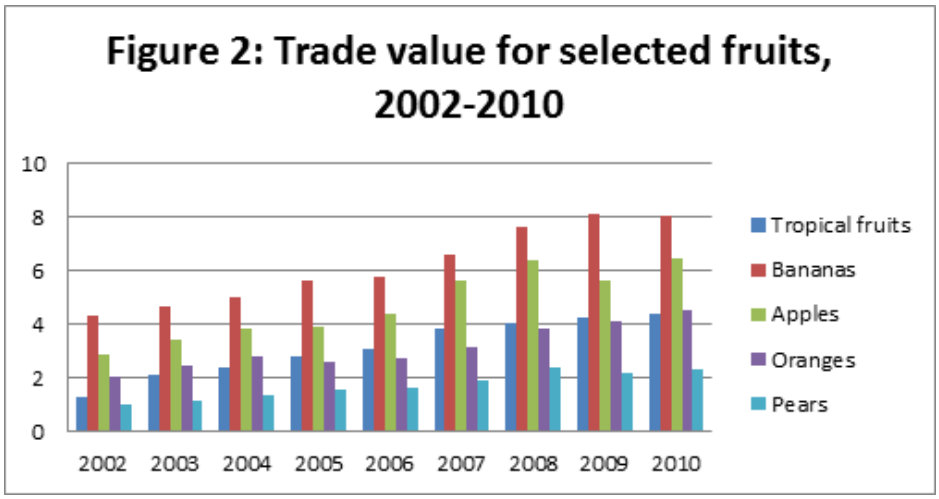


Source: FAOSTAT.

The steady growth in population and income and the rising awareness of the positive nutritional value of fruits are generating positive spin offs on world consumption of tropical fruits. Market opportunities are developing rapidly in China and other emerging markets as their economies continue to significantly expand, while demand in Europe and the United States remains strong for several tropical fruits. Although only ten percent of tropical fruit production is traded internationally, quantities are relatively large compared to other fruits, and earnings from these are significant. In 2010, the value of trade of fresh tropical fruits was USD 12.8 billion (USD 8.1 for bananas and USD 4.7 billion for other tropical fruits), and a further USD 1.5 billion was exported as processed tropical fruits (Figure 2). This compared to USD 6.5 billion for apples, USD 4.5 billion for oranges and USD 2.3 billion for pears (Figure 2).

1.2 Relevant FAO Strategic Objectives

Before proceeding further into the specifics, it would be prudent to understand the development framework that FAO has in place through its Strategic Objectives to improve delivery of its work and meet the main developmental challenges.



Source: FAOSTAT.

FAO has six Strategic Objectives:

- Strategic Objective 1 – Contribute to the eradication of hunger, food insecurity and malnutrition
- Strategic Objective 2 –Increase and improve provision of goods and services from agriculture, forestry and fisheries in a sustainable manner
- Strategic Objective 3 – Reduce poverty
- Strategic Objective 4 –Enable more inclusive and efficient agricultural and food systems at local, national and international levels
- Strategic Objective 5 – Increase the resilience of livelihoods to threats and crises
- Strategic Objective 6 – Technical quality, knowledge and services

Although the Symposium on Superfruits: Myth or Truth? touches on all the strategic objectives, the major thrust centres on Strategic Objective 3 (SO3), which addresses reducing rural poverty, and Strategic Objective 4 (SO4), which focuses on an integrated approach to agriculture.

The outcomes of SO3 are:

i) improving the enabling environment for rural male and female smallholders, family farmers and small rural entrepreneurs to move out of poverty;
ii) improving the enabling environment for agricultural growth to generate increased decent farm and non-farm rural employment opportunities for rural men, women and youth; and
iii) formulating and implementing policies and programmes by governments and their development partners that maximize positive impacts of social protection programmes on rural poverty reduction, food security and sustainable management of natural resources.

The outcomes of SO4 are:

i) enhancing inclusiveness and efficiency of food and agriculture systems through policies, regulatory frameworks and public good;
ii) enhancing public-private collaboration in addressing the challenges and risks faced by smaller and disadvantaged participants in food and agriculture systems; and
iii) promoting inclusive and efficient markets through international agreements and mechanisms.

2. Conceptual framework of the value chain

The concept of value chain which is in vogue today was first described and popularized by Michael Porter in his 1985 best seller: Competitive Advantage: Creating and Sustaining Superior Performance. According to Porter, the "value chain system" suggests that every firm's value chain is composed of two types of

activities: primary and support activities, where primary activities create value, and hence generate margin at each stage.

Other broader definitions of value chain include: *"an economic system which consists of all distribution and supply itineraries used by all producers who aim to sell a similar family of goods competing on the same consumer market"* – Attai and Fourcadet (2003); and *"Value chains describe the full range of activities which are required to bring a product or service from conception, through the different phases of production (involving a combination of physical transformation and the input of various producer services) delivery to final disposal after use"* – Kaplinsky and Morris (2000).

In terms of the methodologies used in analyzing value chains, the most popular ones are:

- *The French Systematic Method* utilizes the concept of the "Filière", which was made popular by French scholars in the 1960s. Although this method is largely descriptive, it is useful in "chain mapping" – Kaplinsky and Morris (2000).
- *The Structure-Conduct-Performance Paradigm* (or SCP model) was developed from industrial economics. The basic concept of this model was first established by Edward S. Mason of Harvard in the 1930s and further developed by other scholars. Scherer and Ross (1990) described the model as *"how productive activities are brought into harmony with the demand for goods and services through some organizing mechanism such as free market and how variations and imperfections in the organizing mechanism affect the success achieved in satisfying an economy's wants."* A major departure in philosophy is that Harvard Business School recommended state intervention to regulate the chain, while the Chicago School endorsed the "laissez-faire" approach.
- *The Neo-Institutional Approach* is defined by Williamson (1996) as *"... the humanly devised constraints that structure political, economic and social interactions. They consist of both informal constraints (sanctions, taboos, customs, traditions and codes of conduct) and formal rules (constitution, laws, property rights)."*
- *The Strategic Approach* is the method made popular by Porter (1980), which is based on competitive strategy and contains the 5 determinants of competition:
  - Rivalry among existing firms;
  - Bargaining power of suppliers;
  - Bargaining power of buyers;
  - Threat of new entrants; and
  - Threat of substitute products or services.
- Finally, the Business Development Cycle method focuses on the whole chain rather than the stages. Hence, the goals are the focus rather than the stages in the chain.

2. 1 Reasons for exclusion of smallholders

Recent developments taking place in food markets around the world are driven by consumer demand and preferences, food safety concerns and the increased bargaining power of modern retail systems. With higher income and changing lifestyles, demand has increased for more variety, higher quality, year-round supply of fresh produce, "healthy" food and convenience. In addition, consumers require safe food, and they have increasing concerns about the social and environmental conditions under which food is produced.

Smallholder participation in the tropical fruits value chain is typically constrained by inadequate farm-level resources, farm-to-market logistical bottlenecks and more general transaction costs in matching and aggregating dispersed supplies to meet buyer and consumer demands. These constraints have been compounded by a new set of challenges associated with compliance with product and process standards set and enforced by governments as well as private supply-chain leaders. Some major weaknesses contributing to the exclusion of smallholders from the tropical fruit value chain include:

- **Lack of economies of scale:** Farm outputs are not large enough to optimise the spread of their fixed costs to reduce unit cost of production, nor is operational efficiency of the scale where variable cost is lowered to an optimum level as well. Therefore, smallholders need to be organized in a way that they do achieve economies of scale, at least at the point where they enter the value chain and thus are able to increase their bargaining position, particularly viz-à-viz the middlemen or wholesalers. In the tropical fruits sub-sector this is commonly achieved collectively through the formation of legal entities, such as cooperatives.

- **Difficulty in complying with market access requirements, poor linkages to market and inadequate market information and dissemination.** This refers less to quantitative and tariff restrictions in the context of international trade but more to the inability to meet market requirements in terms of quantities, quality and regulatory measures such as sanitary and phytosanitary measures (SPS). The remoteness to markets because of the location of smallholder producers and the absence or inadequacy of a market information system, as well as the inability of producers to access the information, even when a system exists, exacerbates their situation.
- **Lack of effective policies.** This is the main constraint to the development of the tropical fruit sub-sector and contributes to most of the exclusion problems associated with tropical fruit production such as:
  - Lack of access to credit. This is a major limitation that could be overcome through enabling policies that would encourage lending institutions, such as development banks, to provide appropriate finance – again, more effectively to the smallholder through a cooperative;
  - Lack of infrastructure. For the smallholder tropical fruit producer, a major constraint to both obtaining inputs as well as transporting fruit to market while maintaining quality is down to the poor roads. To exacerbate matters for the producer, there is also a lack of post harvest infrastructure, particularly an appropriate processing and storage facility;
  - Lack of appropriate quality standards and appropriate compliance mechanism;
  - Lack of harmonization and regulatory mechanisms to rationalize certification issues and cost of compliance;
  - Lack of risk management; and
  - Lack of pre and post harvest technologies.

3. Strategies to integrate smallholders in the tropical superfruits value chain

3.1 Inclusion of smallholders: determinants for inclusion

International trade volumes of tropical fruits have expanded dramatically since the late 1990s, following record price declines of traditional tree crops such as cocoa and coffee. Developing countries diversified from these export crops and developed specialised tropical fruit orchards specifically targeting export markets, which in 2010 earned exporters USD 12.8 billion.

Therefore, given this evidence, it is prudent that smallholders become more involved in the tropical fruit economy as this would contribute significantly to enhancing their food security. The question is how do we promote the participation of smallholders in the value chain? Like most development objectives, this is easier said than done. However, it is commonly agreed that several determinants are critical to the involvement of smallholders in the value chain and these include:

- Geographical location. Their proximity to buyers/processors and adequacy of infrastructure to facilitate efficient logistics;
- Their skills and know how in growing tropical fruits. This usually involves their understanding and ability to carry out recommended good agricultural practices (GAP) as well as post harvest handling skills;
- Representation, which could include membership to a producer organization or cooperative to strengthen the smallholder's bargaining power;
- Access to information, including market information, quality requirements, certification and SPS measures;
- Access to credit; and
- Access to institutional support including extension and technology transfer.

The literature review carried out by the authors concluded that there seem to be several common objectives which are essential for ensuring smallholder participation in the value chain. These include:

- Increasing productivity;
- Improving technology and good agricultural practices;
- Strengthen smallholder linkages to markets, though most commentators conveniently avoid pragmatic advice as to "how" these may be achieved; and
- Policy support. Again the "how" is pretty vague in most literature that has been reviewed. At least the benefit of the doubt could be given in this instance as policy recommendations are usually specific to each case. In other words there is no solution to all problems or "one size fits all".

In relation to supply response of smallholders, there are three factors that influence their propensity to increase production for sale in markets, namely:

- Access to natural resources, labour and capital to satisfy their subsistence needs will determine their ability and willingness to increase production;
- The geographical proximity, knowledge of asymmetries, power relationships, and the cost of commerce; and
- The fundamentals of the markets, such as seasonal price volatility due to supply levels and access to regional and international markets. Volatility can affect risk levels and lack of access to regional and international markets would discourage production and significantly affect participation.

3.2 Appropriate policies

Smallholder participation in markets is constrained by choices available to them. Their participation is usually dependent on the determinants discussed in the previous section, i.e. geographical location, farming knowledge, representation and access to information, credit and institutional support. Therefore, policy support must be targeted at ensuring these determinants are available to smallholders to the best extent possible in order to facilitate their participation in the value chain.

A well functioning market will give smallholders appropriate incentives to participate effectively in the value chain. However, if one of the determinants is missing, they cannot or will not be willing to participate to the same extent.

4. Project evidence

This part of the paper contains a selection of projects that were supervised by the FAO Secretariats responsible for the various intergovernmental groups (IGGs). These projects utilized some of the strategies discussed above to integrate smallholders in the tropical fruits value chain and, in the broader context, the social and economic development in commodity-dependent developing countries by following these criteria:

- Involving policy makers;
- Establishing baseline indicators to measure the project's impact;
- Building alliances with the private sector; and
- Taking into account measures and interventions to ensure smallholder participation.

To improve the livelihood of targeted beneficiaries, emphasis should be put on removing the notion that projects provide free resources and offer free financial support to the beneficiaries. Therefore, the success of a project is its ability to continue to generate income after completion, leaving a legacy of a sustainable source of income which contributes to food security and poverty reduction of the beneficiaries.

4.1 Establishing baseline indicators to measure the project's impact

To assess the success of a project, it is important that baseline indicators be put in place to measure a project's impact. Specific indicators measuring fair and sustainable economic and social benefits to smallholders – including increase in income and building of assets – could be used to demonstrate the level of a project's impact. The following project describes how this could be achieved.

The IGG/Tea Secretariat supervised a project on *Capacity building and re-juvenation of tea smallholdings by adopting eco-friendly management practices and strengthening marketing links for enhanced income generation of poor farming communities in Indonesia and Bangladesh*.

In order to re-vitalize the tea smallholdings, the restraints needed to be assessed through baseline studies. Physical (i.e. soils, landscapes, soil erosion, etc.), biological (i.e. pests, diseases, etc.) and environmental constraints, as well as socio-economic issues needed to be identified as indicators for the baseline. Once the limitations were identified, an integrated agricultural management approach needed to be implemented, through applying good agricultural practices and consolidating the holdings using region-specific cultivars that were resistant to prevailing pests and diseases. Improved nutrient retention capability of soils, control

of pests and diseases with minimal use of pesticides, regular pruning as per location-specific growth cycles and harvesting leaf of high quality needed to be cost-effective.

Following the selection of the project area, baseline surveys were carried at the onset of the project to provide indicators to measure progress made and to assess alleviation of poverty. The baseline surveys were to:

- Verify the existing yield levels and limitations, including soil limitations, existing vacancies, pest and disease incidence, nutrient supplies, frequency of harvesting; and
- Assess the prevailing economic condition and life style of smallholder families in project areas, which would also serve as indicators to assess alleviation of poverty.

The results of the baseline study laid down the foundations for the expected outcome of the project. Regarding tea farm conditions, the survey showed that the selling price of green leaf at the beginning of the project was Rp. 1 200-1 600 (approximately USD 0.10-0.13) per kg. By increasing the quality of the green leaf, building self-help groups among the tea smallholders and establishing partnerships with black and/or green tea processors, the expected outcome of the project was to increase the selling price to Rp. 2 000-2 500 (approximately USD 0.16-0.21) per kg. The survey also found that the income level of 56 percent of tea smallholders was less than Rp. 10 million (USD 820) per year, while 44 percent were earning more than Rp. 10 million per year. By improving tea productivity and quality, tea prices would increase, and the project aimed at decreasing the number of smallholders who earned less than Rp. 10 million per year to 40 percent, and increasing those who earned more than Rp. 10 million per year to 60 percent.

Finally, the baseline survey identified setbacks in business institutions and partnerships. In order to establish partnerships between the tea smallholders and the tea factories and private plantation companies, individual *ad hoc* farmers needed to set up self-help groups, which in turn could organize into cooperatives, with the final aim that the cooperatives became the apex body that is responsible for marketing smallholder tea from Indonesia, namely the Indonesia Tea Inc.

4.2 Building alliances with the private sector

In terms of building alliances with the private sector, the following project illustrates the effectiveness of this strategy. The Secretariat of the IGG on Bananas and Tropical Fruits (IGG/BATF) implemented a project on *The markets for organic and fair trade bananas from the Dominican Republic: recent developments and prospects*. As part of the project's objectives, the IGG/BATF Secretariat recommended mechanisms towards a sustainable market strategy. The lack of trust between producers and exporters was found to weaken the banana industry of the Dominican Republic. Mutual understanding and trust between producer organizations and exporters needed to be built. Providing transparent information in a timely manner could trigger economic benefits and decrease transaction costs and risks. Long lasting partnerships between exporters and importers could increase the willingness for each party to assist one another when emergencies arise.

In order to achieve the objectives of the project, an effective public and private sector partnership was required. Government intervention was necessary to:

- Increase access to credit at reduced rates for producers and producer organizations;
- Improve product quality and reduce the costs of production;
- Introduce "trust funds" based on contributions from the Government, the banks and the producers providing the bank system with an additional guarantee for the reimbursement of the credit provided;
- Promote and invest in agronomic research and development;
- Improve effective agricultural extension services;
- Improve road and rail networks, logistics and telecommunications;
- Promote the producer organizations so that they could provide increasingly effective services to their members; and
- Introduce risk management incentives for producers and producer organizations to use, such as insurance, to ease the economic impacts producers endure due to adverse climatic conditions.

5. Smallholder success story: the case of Chiapas

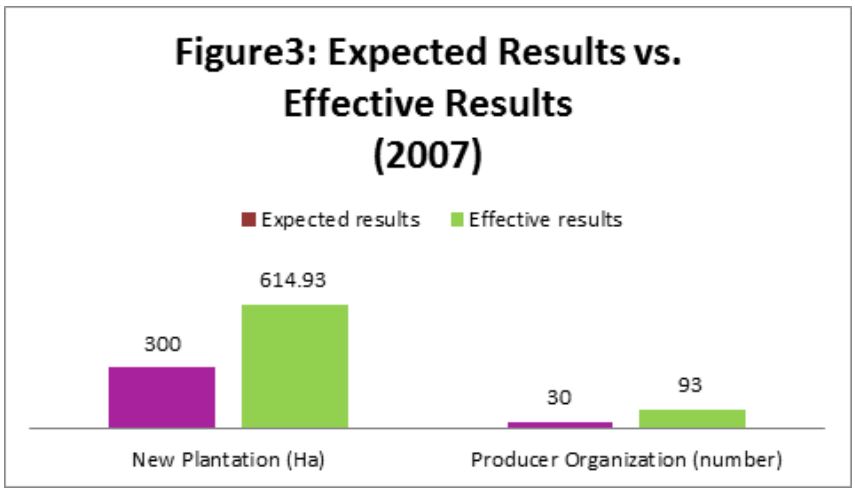
From a pragmatic approach undertaken by the Intergovernmental Sub-Group on Tropical Fruits (SG/TF), the FAO-CFC pilot project *Diversification of Agriculture in Guatemala and Mexico (Chiapas), through the Production and Exports of Fruit* was a successful implementation of converting a smallholder based, traditional cropping system of coffee and maize, to high value horticulture based on tropical fruit and vegetables. The project financed pilot initiatives that improved income and food security of smallholders through diversification from traditional crops to crops that provided higher returns to smallholders, such as limes, avocados and litchis, utilizing new technologies. Smallholders were organized into cooperatives to establish shade houses that would produce high value vegetables to meet the immediate income needs of the smallholder household. In parallel with this development, the cooperatives established tropical fruit orchards that would provide sustainable incomes to their members in the longer term.

The project was designed to contribute towards alleviating rural poverty through a productive re-conversion model, combining a tropical fruit supply chain with intensive vegetable production systems. The model involved establishing technically, environmentally and financially sustainable plantations, nurseries and vegetable greenhouses which would generate sufficient income to growers in six selected communities. The socio-economic conditions in the selected areas were made worse by excessive deforestation, erosion and general environmental deterioration. Therefore, it was necessary that the re-conversion programmes adopted sustainable strategies, not only to alleviate poverty, but to attain income levels that would provide food security and dignity to the rural population.

The project was based on two major principals: to build the capacity of the communities in order to execute the implementation programme effectively and with greater efficacy; and secondly, to add value to the products. It was implemented in the Boca Costa and Peten regions in Guatemala and in Chiapas, Mexico. By and large, the objective was to endow smallholders communities with remunerative and sustainable economic opportunities by integrating them in the value chain, from production to marketing, through the creation of a profitable tropical fruits industry.

Pilot farms were identified and set up and financial and technical support was provided through the project with the aim of showing the indigenous communities the sustainable socio-economic benefits of production and marketing systems. Irrigation systems were built; good agricultural practices were disseminated; and smallholders were trained in capacity building, in improving their marketing competence and in horticultural agriculture systems.

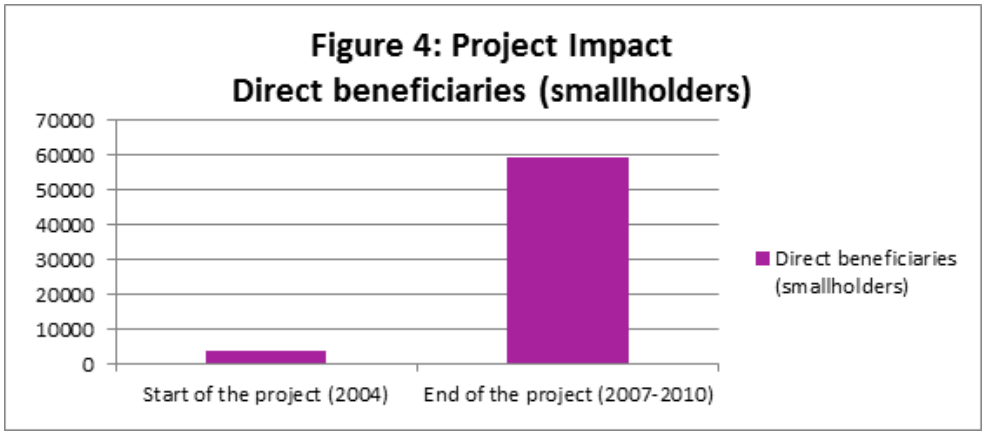
Tropical fruit orchards with domestic and export potential were established in rural communities as pilot units to demonstrate the feasibility of the re-conversion programme to the communities the project touched. These communities were selected in areas with similar characteristics and intensive training programmes were carried out to sensitize the communities to appropriate technologies and good agricultural practices. Nurseries were established and neighbouring communities were encouraged to purchase planting material to implement their own re-conversion programmes.



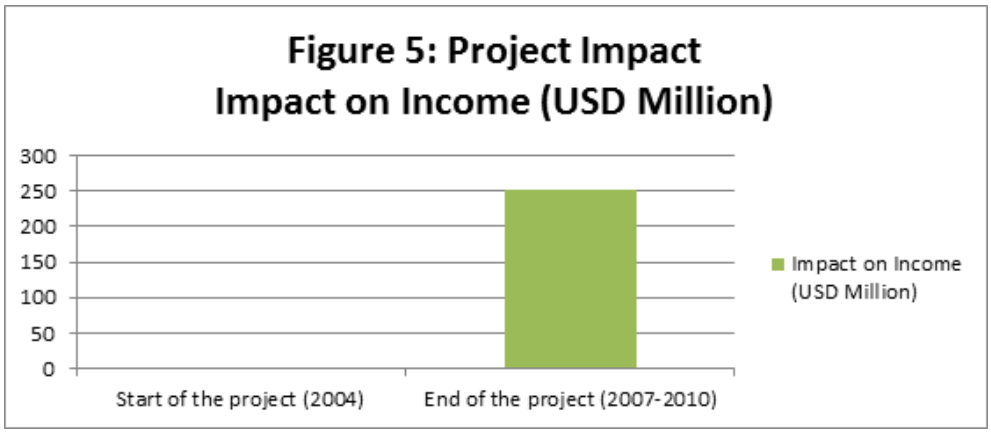
Source: IRBIO (2011).

The project also contributed towards investing in improved planting material and inputs. Employment was generated through the project. Overall, the project improved the livelihood of over 3 500 smallholders who were organized into 75 cooperatives. Over 100 000 fruit plants were supplied to the smallholders. With the significant improvement of the livelihoods of the Chiapas smallholders who participated in the project, the State of the Government of Chiapas further invested USD 60 million to replicate the successful organization and production models developed under the project elsewhere throughout the State. The project executing agency (PEA) was the Instituto para el Desarrollo Regional (IDEAR), while the Instituto para la Reconversión Productiva y Bioenergética (IRBIO) was the entity that spread the model throughout Chiapas after the project's finalization in 2007.

According to IRBIO, a total of 59 572 farmers (Figure 4) were directly linked to the reconversion programme, and almost 33 000 jobs were created, benefiting approximately 240 000 people. In 2007-2010, an estimated Mex$ 1 200 million (approximately USD 91 million) were invested in the reconversion programme, while returns are estimated at Mex$ 3 300 million (approximately USD 251 million), which translates into Mex$ 2 100 million (approximately USD 16 million) net gain for the population who participated in the programme (Figure 5 and Annex Table 1 and Table 2).



Source: IRBIO (2011).



Source: IRBIO (2011)
Note: Before the project implementation there was no income from tropical fruit commercial production and the income from coffee harvesting was minimum due to abundance of coffee plantations and price crisis in coffee market.

6. Concluding remarks

After examining the contribution of the tropical fruit sub-sector in addressing the core mandate of FAO of enhancing food security of the rural poor, it is apparent that some major obstacles need to be overcome to promote the effective participation of smallholders in the value chain. From a strategic point of view,

the effective involvement of smallholders in the production and trade of tropical fruits would amplify the development benefits to a greater number of people and in the process enhance their food security. In addition, evidence supports the fact that the contribution of the tropical fruit sub-sector to generating income and enhancing food security of smallholders underpin their importance to producing countries, 90 percent of which are developing countries and many are food insecure.

Market forecasts carried out by the Secretariat suggest that ample opportunities exist for the commercial development of tropical fruits, as demand for tropical fruits should continue to grow strongly, albeit at a slower rate than the last decade. Major challenges for future market growth appear to be associated with a coordinated approach to managing the field-to-market-supply chain, for both fresh and processed products.

However, a common occurrence in agriculture value chains is that, as the value chains become more structured, smallholder participation is significantly reduced. In the case of tropical fruits, the markets for these fruit have evolved significantly since the 1980s, and with increasing maturity, price premiums based on novelty have virtually disappeared, to be replaced by quality based premiums. The importance of quality in an increasingly crowded international fruit market has led to major initiatives by several multinationals to establish orchards with the necessary post harvest infrastructure to produce and pack fruit for specific export markets.

In spite of the significant progress made to ensure that smallholders gain fairly from value addition along the value chain, restricted market access, the lack of infrastructures, resources and institutional support are some of the reasons that smallholders have not been fully integrated in the value chain.

In spite of the significant progress made to ensure that smallholders gain fairly from value addition along the value chain, restricted market access, the lack of infrastructures, resources and institutional support are some of the reasons that smallholders have not been fully integrated in the value chain.

Hence, strategies need to be put in place with enabling policies to fully integrate smallholders in the value chain. Some examples of these strategies include:

- Organizing smallholders into legal entities such as farmer organizations or cooperatives. These entities would ensure that smallholder members received the necessary technology to produce efficiently, increase their productivity by obtaining inputs collectively and reducing their unit cost of production, improve quality assurance through appropriate extension and grading, achieve economies of scale in the marketing of their produce as well as improve their bargaining power viz. traders along the value chain. Rising production costs has raised concerns over the potential increase of market power in the hand of a small number of players such as multinational producers, supermarkets, and large trading firms. The recent hikes in oil prices and their subsequent effects on inputs and freight rates have eroded profit margins, along the value chain. Some of the costs have been passed on to consumers. However, because of the intense competition in the fruit trade, and the relatively higher price elasticity of tropical fruits in some developed markets, sudden increases in prices could result in tropical fruits being substituted by other fruits;
- Government should also promote policies that encourage smallholder cooperatives, to empower small holders at both the production and processing stages;
- Access to credit. This is a major limitation that could be overcome through enabling policies that would encourage lending institutions, such as development banks, to provide appropriate finance - again, more effectively to the smallholder through a cooperative;
- Infrastructure development to facilitate marketing of quality fruit through appropriate post harvest infrastructure - processing and storage facilities and roads to transport fruit to market;
- Provision of an appropriate regulatory framework and compliance mechanism, including harmonization of the relevant regulations to rationalize certification issues and reduce cost of compliance; and
- Assistance in strengthening risk management.

Table 1 – Productive Reconversion by IRBIO - Advances 2007 -2010

Region	Palm Oil (Has)	Rubber (Has)	Cocoa (Has)	Jatropha (Has)	Fruits (Has)	Green-houses (Has)	Total Area (Has)	Producers	Investment (Mex$) (USD$)	Impact (Mex$) (USD$)
Planicie Costera del Pacífico	24 099		6 544		3 062	7.2	33 712	14 618	318 165 353 23 528 647	856 943 713 63 371 845
Sierra Madre de Chiapas					4 747	2.3	4751	5 259	51 647 335 3 819 373	200 235 730 14 807 633
Depresión Central				10 638	5 374	19.2	16030	9 756	163 892 085 12 119 984	354 569 475 26 220 768
Meseta Central					9 875	36.9	9910	9 147	157 325 625 11 634 388	458 101 493 33 877 064
Montañas del Norte, Oriente y Llanura Costera del Golfo	18 113	10 766	73 030		11 994	23.5	48195	20 792	468 375 145 34 636 811	1 407 301 188 104 071 331
	42 212	10 766	13 847	10 638	35 052	82.0	112597		1 159 405 543 85 739 200	3 277 151 600 242 348 638

Source: IRBIO (2011).

Table 2 – Productive Reconversion by IRBIO – Impacts 2007 – May 2011

Crop	Area (Has)	Projected Area to 2012 (Has)	Annual Income (Mex$) (USD$)	Incorporated Added Value (Mex$) (USD$)	New employment	Beneficiary Producers	Beneficiary Population
Fruits	35 052	60 000	1 086 612 000 80 356 045	1 412 595 600 104 462 858	9 500	28 000	112 000
Palm Oil	42 212	100 000	1 025 751 600 75 855 357	1 641 202 560 121 368 571	8 970	7 187	28 700
Rubber	10 766	20 000	430 640 000 31 846 259	559 832 000 41 400 137	4 350	4 600	18 400
Cocoa	13 847	19 566	276 940 000 20 479 990	360 022 000 26 623 987	5 800	11 000	44 000
Jatropha	10 638	20 000	170 208 000 12 587 052	221 270 400 16 363 168	2 500	3 000	12 000
Greenhouses	82	561	287 000 000 21 223 937	373 100 000 27 591 119	1 700	5 985	23 940
	112 597	220 127	3 277 151 600 242 348 638	4 568 022 560 337 809 837	32 820	59 572	239 040

Source: IRBIO (2011).

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IMPROVING FARMERS INTEGRATION INTO THE TROPICAL FRUIT VALUE CHAIN TO ENTRANCE MARKET ACCESS IN MYANMAR

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ABSTRACT

Myanmar is an agro-based industrialized country and 80% of economies rely on agriculture. Fruits are available year-round in Myanmar because of its tropical and temperate climate. Among them, mango, pomelo and avocado are exported as fresh produce fruits. Fresh tropical fruits are inherently prone to deterioration due to hot and humid climate. Therefore pre-processing and processing steps play an important role in the Myanmar value chain. Therefore, knowledge sharing, training and following-up on interventions and partner linkages contribute to improving the skills and knowledge of the value chain actors and service providers. The Myanmar Fruit, Flower and Vegetable Producer and Exporter Association (MFFVPEA) carried out rapid market assessments which are helpful in identifying potential markets. New market arrangements by the MFFVPEA would need to be developed once the volume of improved fruits increases. Sophisticated post-harvest handling, market arrangement and better actor linkages would be required for Myanmar. Appropriate phyto-sanitary arrangements to avoid the possible spread of plant disease and pests would improve GAP certification for future production. Changing the market oriented policy and foreign investment law in Myanmar, contract farming for fruit production would be encouraged to be developed.

IMPLEMENTING EFFECTIVE POLICIES TO ENHANCE MARKET ACCESS AND IMPROVE SMALLHOLDER INTEGRATION INTO TROPICAL SUPERFRUIT VALUE CHAINS

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ABSTRACT

Most of the tropical fruit growers in developing countries are smallholders who grow them as a mixed tree crop with to other crops or livestock. Common issues associated with smallholders include low productivity due to traditional practices, low quality produce resulting in postharvest losses and low prices, poor infrastructure and logistics and lack of market access. This is compounded by lack of post-harvest facilities, inavailability of credit facilities, lack of market information, traditional market structure and ineffective policies.

Agricultural value chains describe the interaction of the various actors, service providers and enabling environment or regulators along the chain components of production, value-added processes and the market. Value chain analysis is an assessment of the actors, chain structure and efficiency to identify the main constraints that needs to be overcome to improve chain performance. Activities in the value chain from production to value added activities such as post-harvest handling processing and packaging are also based on market requirements.

The chain cannot just function with the actors and activities in a vertical fashion and in isolation, as the horizontal impacts, which are the enabling environment have to be considered in improving chain performance.

Chain performance improvements can be undertaken by mapping the value chain, identifying weaknesses and recommending interventions at the key points along the chain, including the enabling environment which affects it. Through mapping, smallholders can be given more opportunities for a more active role in

the chain, example by progressing up the chain from basic producer to collector or wholesaler. Only with effective integration in the chain can smallholders enjoy its benefits, particularly enhanced access to the market.

Smallholders should also be given new opportunities by improving their knowledge of market demand and pricing, increase access to knowledge, finance, inputs and technology, reducing the transaction cost along the chain and increase share of value added products.

Case studies conducted in Indonesia and Vietnam have shown that the main challenges faced by fruit farmers were lack of infrastructure and logistics including postharvest facilities and access to production areas, lack of information on production technology, pest and disease management problems and lack of credit facilities. These factors are often observed in developing countries where there is mixed or integrated farming, small growing areas and inaccessible production areas.

The case studies suggests that lack of information on production technology affects overall productivity in that fruits were of lower quality and grades and were less marketable. Productivity was also affected by diseases and pest incidences. During the postharvest phase, for smallholders activities from harvesting, handing, sorting and grading are imperative to minimise postharvest losses.

Tropical fruit smallholders are at a disadvantage when it comes to market information, especially with regard to ex-farm prices and seasonal demands. Due to the inaccessibility of market information, they are subject to the offers made by buyers as they have less bargaining power. Another factor which affects price determination at the farm level are the activities at the wholesale / distributor market, where produce are often mishandled and repacked, resulting in price inconsistencies at the farm level.

The lack of credit facilities for smallholders to expand or invest in new technologies is also a major obstacle to increase production and improve quality of produce.

Basically the role of smallholders in the chain needs to be upgraded, to make them more competitive and move into higher value activities. To achieve this, there needs to be a conducive business environment, access to land, lower inputs cost, improved rural infrastructure, encourage production of quality and safe fruits, more access to market information.

To mitigate these common issues, effective and comprehensive policies , together with institutional reform need to be formulated and adopted.

The main areas concerned are having access to:

a. Capacity building in all aspects of production – agronomic, pest and diseases
b. credit facilities for expansion adopting new technologies
c. Market information and pricing
d. Target on quality and safe products for improved market access
e. Logistical and infrastructure development
f. Formation of farmers groups.

Fundamental policy directions that need to be formulated to integrate smallholders into the tropical fruit value chain include;

a. The scaling up of productivity of labour and land, research and development, extension and institutional development
b. The provision of credit facilities
c. Improving capacity building of smallholders in applying modern agricultural technologies for increased production and productivity.
d. Providing accurate marketing information system
e. Providing infrastructural development including road access, collection centers and cold chain
f. Promoting product specialization and diversification, branding and marketing
g. Encourage private sector participation, in training smallholders and assisting them market their products.

With the introduction of tropical 'superfruits', the challenges are similar, however, appropriate policies are required in the promotion, marketing strategy and branding to enhance visibility of the fruits. This should also include clinical trials and research work that demonstrates the effectiveness of these fruits for health and well being.

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POLICY ADVICE TO ENHANCE SMALLHOLDER FOOD SECURITY IN THE TROPICAL SUPERFRUITS SUB-SECTOR

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ABSTRACT

Hunger is the scandal of our time: one-sixth of humanity is food insecure. Most of the hungry and malnourished are farmers and their children. Smallscale agriculture is central to policies for food and nutrition security, sustainable development and environmental conservation. In this context, superfruits are an emerging opportunity. Smallscale agriculture faces challenges ranging from access to capital (high quality seeds, irrigation, fertilizers, pesticides, mechanization, modern technology) and access to markets (information, know-how, ransaction costs, risk management, price volatility, commoditization, narrow value chains). Other challenges include knowledge gaps (capacity building, problem solving, lessons learning), operational inadequacies (post harvest losses, safety standards, farm-to-table strategies, perishability, supply chains), logistical obstacles (storage, packing, processing, labeling, transport, certification, traceability) and the effects of climate change (adaptation, agro-ecology skills, soil degradation, water, biodiversity). The past decade has seen the unprecedented commercial success of superfruits. Projections anticipate wider growth as a cash crop and as a staple local foodstuff. Superfruits offer science-based health benefits (nutrients, antioxidants, taste) and can profit from new marketing tools (branding, fair trade, nature conservation) and constructive approaches (trade liberalization, public/private partnerships, cooperatives, gender streamlining). Governments can deliver an enabling environment through tax incentives, technical support (extension services, research and development, market intelligence, technologies, land rights). Support from international organizations is also crucial, such as FAO's work as a knowledge organization. The policy goals are bridging the gap between policy thinking and practical options for designing and

implementing concrete policies, sustainably increasing smallholder productivity and income and adding value and diversifying income.

PAPER

Background

Hunger is the scandal of our time: UN Food and Agriculture Organization estimates that one-sixth of humanity is food insecure. The vast majority of the hungry and malnourished are farmers and their children. Small-scale agriculture is central to policies for national/regional/global food and nutrition security, sustainable development, and environmental conservation.

Two billion people live in smallholder households in the developing world, mostly in tropical regions, where the challenges of smallholder food security meet an emerging opportunity: superfruits.

Challenges to food security for smallholder producers of superfruits

Small-scale agriculture faces challenges ranging from inadequate access to capital and markets, to the effects of climate change.

Limited finances translate into absence of, or deficiencies in, inputs (availability of high-quality seeds, irrigation, fertilizers, pesticides, mechanization, modern farming technology, etc.), while knowledge gaps inhibit the creation of capacities for problem solving and lessons learning, i.e. for incorporating knowledge-based solutions. These weaknesses lead to operational inadequacies, including post-harvest losses, non-compliance with safety standards, and obstacles to farm-to-table strategies, especially regarding the perishability of tropical fruits.

Imperfect access to physical markets, market know-how, and market information, paired with increased transaction costs, unawareness of risk management (including threats associated with price volatility and shocks), heightened commoditization of products, and narrow value chains (which increase asset specificity) further reduce smallholders' prospects.

Climate change without appropriate agro-ecology skills raises hazards in terms of middle- to long-termplanning, environmental and soil degradation, water availability and absorption, and threats to biodiversity.

Further structural obstacles to productivity are seen in dispersed and inconsistent smallholder supply chains, as well as in competition from economies of scale and related seasonal surpluses. There is ample space for improvement in logistical areas such as in-farm storage, packing, processing, labeling, transport, certifications, traceability, etc.

Opportunities of superfruits for enhancing smallholder food security through adequate policies

The past decade has seen the unprecedented commercial success of superfruits, while projections anticipate wider growth for the short-, medium-, and long-term. Superfruits offer opportunities for both producers and consumers, feeding a virtuous circle of expansion both as a cash crop for exports, and as a staple foodstuff for local consumption.

Marketing of superfruits include ease of intake (presented as a whole "normal" fruit, or in pieces, or desiccated), as juice, as a nutritional supplement, etc. Proven, science-based health benefits facilitate their appeal: outstanding nutrient content, antioxidant abundance, alluring taste, "coolness," etc. Further marketing tools, including branding, fair trade, nature conservancy, etc. should propel superfruits' allure.

Other aspects worth considering include adaptation to, and profit from, trends of trade liberalization; exploring public/private partnerships; expanding aggregate supply through cooperatives (including better use of intensification and flexibility afforded by family labor); and embracing a gender dimension: women's under- utilized productive and economic potential, as well as the positive impact in household health/ nutrition resulting from female -obtained and -managed sources of income.

Governments can deliver an enabling environment through tax incentives, technical support (including extension services, investments in research and development, provision of market intelligence, technology procurement and adoption, etc.), as well as in providing a clear definition and an effective enforcement of land rights.

Support from international organizations is also crucial: FAO promotes knowledge dissemination with an emphasis on specialized training through roundtables, seminars, tutorials, workshops, etc.

Policy goals

Challenges and opportunities should coalesce in bridging the gap between policy thinking and practical options for designing and implementing concrete policies, with a view to increasing smallholder productivity and income in a sustainable manner.

Smallholder food security in the superfruits sub-sector stands to gain from added value and income diversification, including in non-farm activities.

An adequate policy framework should facilitate an increased flow of relevant information, promote capacity- building, incorporate best practices, adopt modern technologies, develop transition strategies, construct managerial competences, and open world-wide markets, including South-South cooperation.

APPENDIX 3.B

ABSTRACTS AND PAPERS - PARALLEL SESSIONS

PARALLEL SESSIONS ONE AND TWO – VALUE CHAINS AND PRODUCTION TECHNOLOGY OF POTENTIAL SUPERFRUITS

AIMING ON A DIRECT DELIVERY OF MANGOSTEEN FROM HILL TO CITY

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ABSTRACT

Mangosteen is a tropical fruit that has been grown commercially in Thailand and many countries in Southeast Asia. It is becoming popular worldwide because of the high antioxidant content. In Thailand is grown widely in the eastern and southern part of Thailand. Mangosteen from groups of farmers in Chantaburi province, eastern region, and Nakhon Sri Thammarat, southern region, were selected to supply to the Green Commerce Community System (GRECOCOS), the project that is initiated by FAO Regional office for Asia and the Pacific in association with AFMA to encourage the chemical-free foods market by direct linking groups of consumers to individual farmers or farmer groups via online system. Mangosteen from these areas are impressive due to their quality (size, taste and appearance) as well as safety (gained GAP certificate) attributes. However, the production from the groups was relatively too small for export. By linking the fruit to community market like Grecocos, package design, handling, and few researches on logistic arrangement was adviced by AFMA. Postharvest management such as fruit handling, packaging and transportation arrangements were then introduced to farmer groups. One group launched their product successfully and the other group was not able to launch. Lessons from the launch of these two mangosteen groups indicate that there was a standing demand for quality mangosteen. However, few challenges contributed to the not-yet sustainability of the linkage. Size of community was a major constraint to create economy of scale in order to sustain benefits for both farmers and consumers. Another crucial factor was service and efficiency of all players. This includes service from AFMA as a project management and coordinator, commitment from farmers on grading and delivering, an organized collecting point and effectiveness on operation through software. GRECOCOS is an alternative market channel for small farmers who produce premium quality agricultural products and consumers who look for safety quality product at reasonable price.

PAPER

Background

Mangosteen

Mangosteen (*Garcinia mangostana*) is tropical fruit native to South East Asia and has one variety throughout the sub-region. It has been grown commercially and mainly for domestic consumption. Thailand is the largest producer and exporter of mangosteen in the world, accounting for more than 50 percent of global output and nearly 90 percent of exports (FAO, 2011). Export market of mangosteen in Thailand has been growing only less than a decade (Figure 1). The export of fresh mangosteen Thailand has been dramatically increased due to the growing economic of import country like China.

Fifty percent of mangosteen from Thailand are exported to China, 30 percent to Vietnam and 20 percent to other ASEAN and European countries. Indonesia also exported mangosteens to China and Singapore, but quantities were less than 5 percent of that exported from Thailand (FAO, 2011).

Harvesting season of mangosteen last for only few months and regularly it can be harvested once a year. Price of mangosteen can fluctuate during some seasons, especially when there is an oversupply of the fruit which causes the price to plunge. However, the early harvested mangosteen can enjoy the higher price.

Price of a seasonal fruit also depends on time of harvesting. Mangosteen from the south of Thailand which is harvested a few months after the one growing in the east sells at a lower price once sold in the market, despite the good quality and no use of chemicals in some growing areas in the hilly area. Usually mangosteen producer in the hill or those who has no relationship with players in the high valued market sells their products at a mix-graded price to collector.

New market channel should be able to open up opportunities for quality mangosteen, produced in a smaller scale with a better and higher price.

The Green Commerce Community System

The Green Commerce Community System (GRECOCOS) is a web-based online market system of chemical-free products servicing to consumers in office buildings or the local community. It is an effort to directly link groups of consumers to individual farmers or farmer groups in order to reduce the overhead cost for several players in a conditional supply chain. It was an initiative of FAO Regional Office for Asia and the Pacific (FAO RAP) in 2010 and later had been managed by AFMA from 2011 to first quarter of 2013.

Players in GRECOCOS were four groups linking each other including Grecocos coordinator, group coordinator, customer (members) and supplier (Figure 2).

GRECOCOS coordinator manages the system and facilitates with both suppliers and customers. The operation needs to have a Group coordinator to act as a payment & collecting point when product was delivered and arrange payment to supplier. Suppliers are selected groups of farmers, company or individual farmers whose products are certified organic or GAP. Customers are anyone who registered themselves to be a member of the community via GRECOCOS website. Therefore, members can log in to see products update at the beginning of the week, place order and pay to receive the products on a designated day of the week. The routine operation happening each week in a Grecocos community is shown in Figure 3.

The four players in pilot operation of Grecocos started in the FAO RAP compound in 2011 included:

1. An FAO officer was a project coordinator
2. An FAO caterer was a community coordinator
3. Swift company was a supplier supplied vegetable, vegetable snacks and mango
4. A group of staffs in FAO RAP as members

Pay and collecting point was at FAO RAP canteen. Order and delivery were opened twice a week. Suppliers and community coordinator had to be trained to use the software. Rules and conditions were guided among colleagues. In this case, authorization of new member was done by FAO officer who overlooked the project.

After finalizing the pilot study, the objective of the operation in 2011-2012 managed by AFMA was to organize more than one supply chain to the system and to expand operation to more than one community. On the other hand, FAO would be responsible on software improvement and backstopping.

AFMA monitored over all services and provided supports of communication and operation between members, group coordinator and supplier. Data and experience from the attempts of organizing supply chain of seasonal mangosteen to Grecocos system will be shared on this paper.

Methodology

AFMA visited the orchard and talked with growers. With the small size of Grecocos members and no trading relationship before, two groups were interested to supply to Grecocos. First group was the default organic mangosteen group called Chengkhao 07 in Nakon Si Thammarat provice, southern of Thailand and the second group was the Chantaburi mangosteen grower group in the east of Thailand. Both group gain GAP certificate.

The Chenkhao 07 group is a default organic orchard that no chemical has been used in the area. It situated in the upper stream of natural water in the mountain area. The other group in Chantaburi was asked to show the profile and certification of the group because AFMA used to visit few of groups members before.

Information on harvesting time, logistic and handling was also collected during the visit. Positioning and package were done after returning from the field visits.

Positioning

Since mangosteen from selected farms received at least a GAP certification and its quality in term of size, taste and appearance were impressive. Their volume of production, however, was small specially the default organic one. Therefore, the Grecocos mangosteen was positioned as a fruit gift package or present.

Products

Fruit should larger than 2 inches in diameter and totally free from yellow gum, cracking or translucent flesh. Each fruit was wrapped using polystyrene net (foam net). Boxes and foam nets were prier given to farmers to pack for Grecocos.

By using the same package size designed by AFMA, mangosteen from Chantaburi province was packed in 1.2 kg-box, while the fruit from Chengkhao07 could put at 2 kg. a box due to different size. A present box of mangosteen shall be fully packed at 11-12 fruits per box.

Information of grade and quality for Grococos, type of packaging and means of transport were affirmed by farmers with AFMA.

Packaging development

Retailed pack of mangosteen in Thailand normally is a box of 5 kg. It is becoming popular but it is too heavy to carry and was not perceived as a value gift.

To design a fruit gift box, an appropriated dimension and function had to be considered. The favorable size and cost efficiency was a box of 1.5 - 2.0 kg. In addition, the designed allowed the box to be used with several kinds of fruits such as rambutan, tangerine, mango and lychee.

Final design of the box is shown in the figure 4 below. Besides, few boxes of different dimensions were brought to ask farmer to ensure if the box suits their handling routines.

Place

Pay and collecting point of Grecocos was changed from FAO RAP caterer to a coffee shop opposite FAO RAP to keep old customer in RAP at the same time, open to the wider community.

Promotion

Website and leaflet was designed to be informative but easy to read.
Green logo was developed to reflect the fresh and healthy products. The logo is also easier to be recognized by customers. Grecocos coordinator (AFMA) helped promote the new products in the system by a short advertisement and sent to all members once. The message also included the origin of orchard and quality. Profile of the producer group was also put up on the website.
Sale or products giveaway had not been used for a promotion because Grecocos would like customer to remember quality, safety and health of the products.

Price

Normally, selling price of all products in Grecocos was set up by producers. Grecocos gives around 20% of retail prices to group coordinator. Farmer would like to quote the price only on the packing day, but AFMA has to announce the price on the system few days before deliver. Hence AFMA fixed price that was high enough to cover the difference in prices on the system.

Generally, prices of the mixed grade mangosteen at the farm gate were varied from US2.0 per kg. (November 2011 to May 2012). But the graded mangosteen for Grecocos cost around US2.5 at the farm gate price. The retailed price of mangosteen in Grecocos was fixed according to the supply chain from farm to consumers as shown in figure 5 and figure 6 below.

Results and discussion

During the conduct of the study, four crops were expected to be marketed. There were 3 crops from the Chengkhao 07 in November 2011, off-season in July 2012 and November 2012 and one crop from Chantaburi mangosteen grower group in May 2012. However, only one crop from Chantaburi was successfully launched. Different reasons made crops from Chengkhao 07 missed the marketing initiative through the system because they were flooding in November 2011, cropped failed in July 2012 and mishandlings in November 2012.

Mangosteen from Chantaburi was supplied to GRECOCOS on 19 April 2012 and continued once a week for a month until the end of harvesting season on 31 May 2012.

The establishment of GRECOCOS promotes direct linkage between farmers and consumers in which at least two fewer intermediaries were reduced, therefore cost of products were reduced. Figure 7 indicates a common supply chain of mangosteen before reduce to four players in Grecocos.

Record of total sales volume in March to May 2012 which cover period of mangosteen supplied to GRECOCOS was shown in the figure 8.

Grecocos has around 130 registered members, 8 percents of total registered members are regular customers. It was clear that mangosteen helped boost up sale volume. The average sale per week rose from USD33 to USD75 per week during the availability of mangosteen in the system. However, this was the supply from Chantaburi mangosteen grower group alone. Several trials were arranged with Chengkhao07 between October to November 2012. But the delivered fruits did not met requirement of Grecocos due to mishandling, loose packaging and inappropriate parcel, causing 25% damaged and thus could not be marketed.

Conclusion

GRECOCOS is an effort to directly link producers to buyers in a community via online ordering system. It is an alternative market channel for small farmers who produce premium quality agricultural products and consumers who look for safe and quality product at lower price than supermarket.

Supply chain developed by FAO/AFMA was a step in bringing mangosteen to market. Experiences with two mangosteen groups from Chantaburi province and Nakhon Si Thammarat province proved that there was a standing demand for quality mangosteen. Nevertheless, sustainability of the linkage was still a great challenge to the operation of GRECOCOS.

- It's advised to expand GRECOCOS community to create economy of scale in order to secure benefits for all players and to attract more suppliers.
- Efficiency of all players in GRECOCOS is an important factor to improve services and build up consumers' trust. Strong commitment from farmers is necessary on fruits' grading, product handling and timely delivery.
- Continouse improvement on its services and software development to the most convenient for all players.
- Though the transportation of mangosteen by post is the most convenient and is an economic choice, it requires farmers to fully understand the important of proper product handling and well management skill.

In first quarter of 2013, products on the list for Grecocos were organic rice from a northeastern province (individual farmer), organic ready-to-eat salad and leave vegetable (group of producers and a company). An apartment has shown interested to use Grecocos system and existing suppliers of Grecocos.

Figures

Figure 1. Amount and value of fresh mangosteen exports from Thailand (from data from the Office of Agricultural Economics, Thailand).

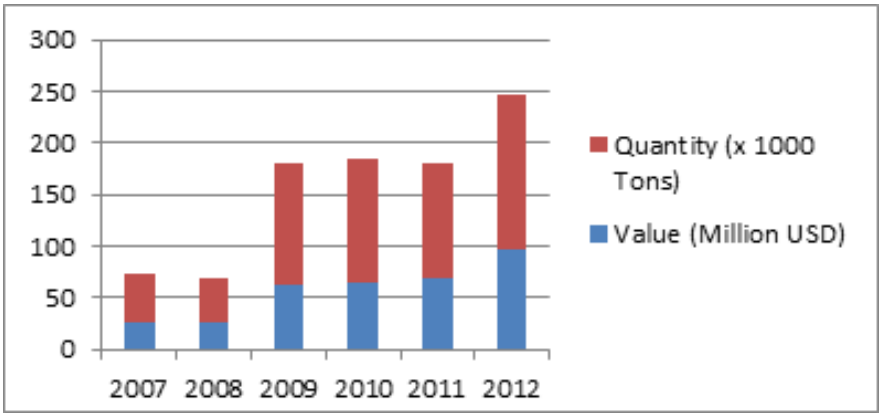


Figure 2. Players in GRECOCOS operation

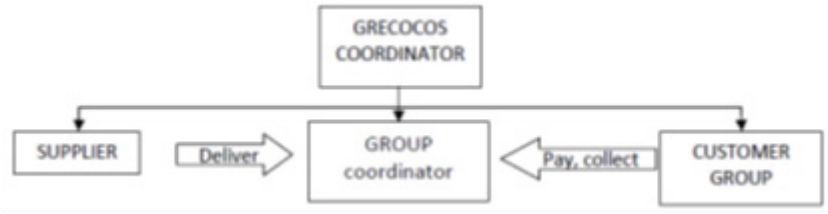


Figure 3. GRECOCOS operation system

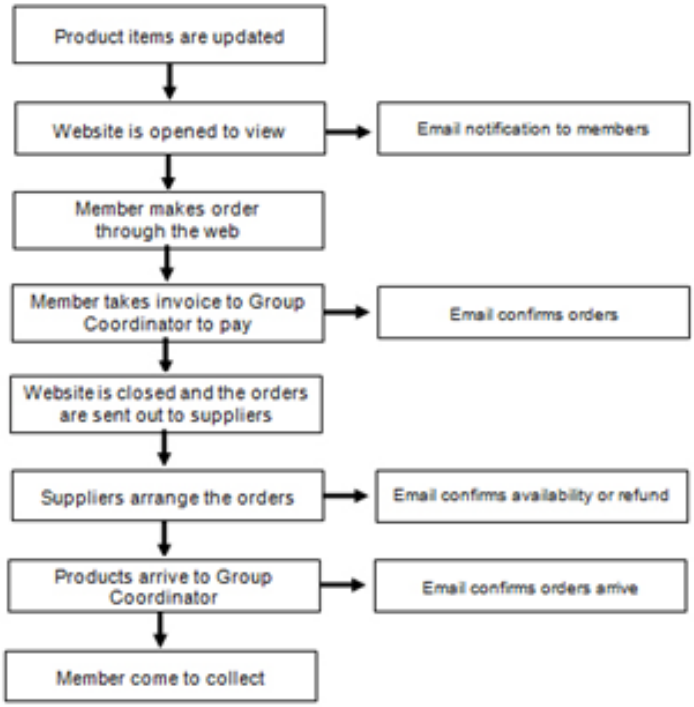


Figure 4. Fruit box is designed to be protective and can be used as a gift box

Figure 5. Supply chain of mangosteen from Nakorn Si Thammarat province to Grecocos consumer (not yet launched)

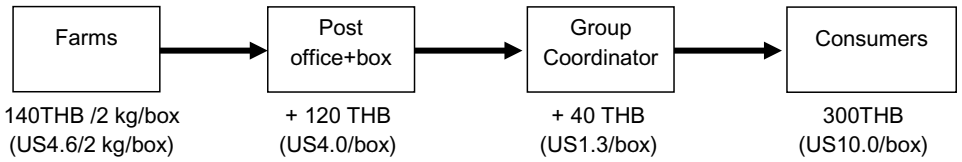


Figure 6. Supply chain of mangosteen from Chantaburi province to Grecocos consumer (launched)

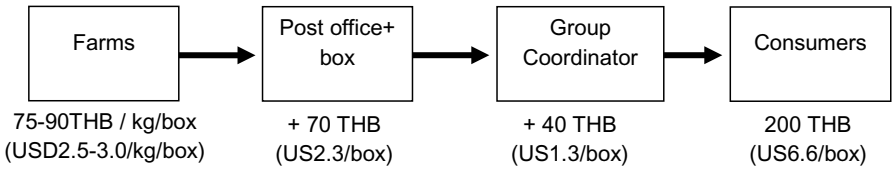


Figure 7. General value chain of mangosteen from provinces

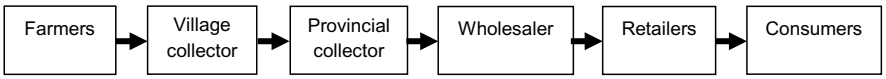
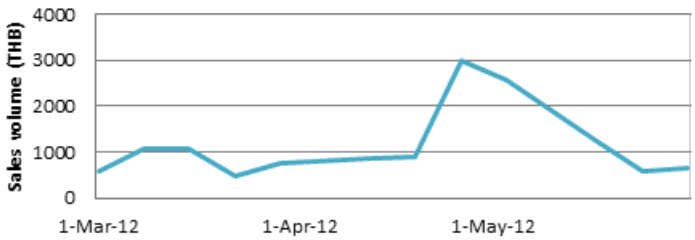


Figure 8. Record of GRECOCOS's sales volume in March to May 2012



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MALAYSIAN CARAMBOLA (A*VERRHOA CARAMBOLA*) FROM RISING STAR TO A GLOBAL LEADER

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ABSTRACT

Malaysian carambola (*Averrhoa carambola*) was commercialised in 1980's. Prior to 1988, carambola trade value was not statistically available as it was then included as 'other tropical fruits'. The export of carambola was initially reported in 1988 when 13,000 tons of carambola worth USD 4.9million was exported to HongKong and Singapore. Realizing the potential of carambola in the local and export market, it was included in the then Fruit Industry Development Programe (1981-2000). To support the rising carambola industry, MARDI initiated research on carambola from 1980's to date. Together with the Australian Centre for International Agricultural Research (ACIAR) MARDI has developed PROMAR protein bait to combat fruit fly menace in the field in 1990. Other recommendation made by MARDI included the planting of pollinator clones for yield enhancement, optimum fertilizer requirement and technology for sea shipment to Europe. In order to overcome the labour issue MARDI embarked studies on the production of carambola under netted structure where yield increased significantly compared to conventional planting, fruits are of high quality with low pesticide residue level. Application of pre harvest calcium was able to improve texture and post harvest storage quality. Study on the phytonutrient content showed that carambola is unique, rich in the polyphenols; apigenins and procyanidins both of which are well known for their health benefiting properties. The annual export value of carambola ranged from USD 7-10 million and Malaysia is recognised as the global leader in carambola production. For the future expansion of the carambola industry several issues need to be addressed, such as its limited use as garnishing in salad and market expansion to fruit fly barrier countries such as United Statess and China. Thus research is being conducted to address the issues as more skilful and technical expertise is required in the production of such high value carambola. This paper reviewed the research and development carried out in the making of carambola into a 'superfruit' by those involved in the Malaysian carambola industry.

PAPER

Background

In 1970's from Malaysian home gardens the carambola started to be grown on commercial scale where the main growing areas were in the state of Selangor (59.7%). However prior to 1988, it was difficult to obtain the value of carambola trade because it was included as 'other tropical fruits' in the statistical data. Demand for Hong Kong and Singapore market was on the increase and in 1988 Malaysia exported 13,000 tonnes of carambola worth USD 4.9 million. Realising the potential of carambola and other tropical fruits in the local and export market the government developed the Fruit Industry Development Program (1986-2000). Some of the strategies in the development of the carambola industry were as follows:

- Expansion of local and export market through a strategic marketing plan
- Intensify research in crop management to reduce labour and production cost
- Coordinate production and export
- Develop a carambola working group in the Malaysian Fruit Council to coordinate the relevant agencies, producer and exporter

Research on carambola is mainly conducted by the Malasian Agriculture Research and Development Institute (MARDI). It was was initiated as in 1980's to support the expanding carambola industry. To date carambola occupies about 0.41% of the total fruit production areas. The production area has decreased from 1,934 ha in 1993 to 1600 ha in 2010. This is mainly due to acute labour shortage especially in wrapping of fruits against fruit fly. The export value of fresh carambola (mainly clone B10) has been quite stable ranging from USD 7-10 million in the past decade. Besides its high labour requirement, the export of green carambola (stage 2.5-3 of the maturity index) to Europe also limits export as the green fruits are only used as garnishing in salads. This paper summarises the research and development in the making of

carambola into a 'superfruit' and Malaysia, a global leader in carambola production.

Research supporting the expanding carambola industry

The floral biology and clonal compatibility

The carambola flower is heterodistylous, meaning the flowers have styles of two different lengths. Pollination is usually by insects such as bees. The fruit set of carambola was found to be rather low, 2.79-2.98%. However, studies showed that for good fruit set, cross pollination between two clones with short styles and long styles are required (Indu et. al 1992). MARDI thus recommended planting of pollinator clones such as B2 or B11 (long styled) in the plot of commercial clones B10 to improve fruit set and increase yield.

Mineral nutrition of carambola

Mineral nutrition studies were undertaken to determine the actual nutrient requirements of carambola. From a field experiment in Serdang, Izham (1994) also found evidence that carambola production is inhibited by high application of nitrogen fertilizer. He concluded that a combination of a low level of N and a high level of K (i.e. 0.8 kg N and 4.8 kg K2O/tree/year) was beneficial for growth and yield of carambola and could be recommended for commercial application. Application of high N and K fertilizers (3.2 kg N and 4.8 kg K2O/tree/year) resulted in decrease of yield. Further investigation showed that application of heavy doses of fertilizer exposed the plants to intermittent shocks which were supported by measurement of the leaf water potential, stomatal conductance and photosynthetic rate.

Management of fruit fly

The fruit fly Bactrocera (Dacus dorsalis complex), is the most important insect pest of carambola and if not properly controlled, can damage all fruits and cause total crop loss (Ithnin et al. 1992). Together with the Australian Centre for International Agricultural Research (ACIAR), MARDI has developed PROMAR, a protein bait to combat fruit fly menace in the field. One part of PROMAR is mixed with two parts of water and insecticide such as Malathion (0.2% active ingredient) . This mixture is spot sprayed (40 ml/tree), on a small portion of the foliage avoiding the fruits and flowers, thus does not pose any danger to the beneficial insects. Using this technique, damage can be reduced to less than 2%, labour and materials minimised.

Post harvest handling

Carambola export started in the 1980's mainly to Hong Kong and Europe. Initially, it was only exported by air freight, but by 1989, they were transported by sea which allowed export of bigger volumes with a lower transport cost. However, fruit handling is very critical to ensure that the fruits arrive in excellent condition. Post harvest studies conducted were mainly on maturity indices, operations in the packing house such as sorting, cleaning, grading and packaging. MARDI developed the maturity index to guide farmers to harvest fruits at the right maturity for the various markets (Lam et al. 1992). Fruits of indices 2 and 3 are for export to Europe, while fruits of indices 3 to 4 can be exported to Hong Kong and Singapore.

Research and development for yield , quality enhancement, breeding and phytonutrient contents for market expansion

Research on production of quality carambola under netted structure

Carambola is known as a labour intensive crop. In order to overcome the labour issue, MARDI embarked on studies related to production of carambola under netted structure. Besides the labour problem, fruits for export must meet the stringent requirements of importing countries such as Europe and farms that produce for export must comply with EUREPGAP requirements. The cultivation of carambola under netted structure also aims at developing ' The Fruit Fly Free Place of Production (FFFPP) Protocol for exporting to fruit fly barrier countries such as China and the United States.

Yield

Zabedah et al. (1999) found that yield obtained under the netted structure was higher compared to the open where fruits were prone to fruit fly attack, the main cause of yield loss. Heavy rain in the months

of October-December hinders fruit set for harvest in January and February as shown in Table 1 which compares the yield obtained under netted structure and in the open during the January-February harvest. The total fruit weight per tree under the netted structure was 75 kg, estimated at 33.7 t/ha. Due to the rainy weather and poor fruit set, only about 6 kg of fruits per tree, yielding 2.7 t/ha was obtained in the open. The exportable fruit was estimated at 23.8 t/ha under the netted structure compared to 2.2 tons/ha in the open (Table1).

Fruit set was good under the netted structure despite the rainy weather in October-December. Thus, production under the netted structure is able to overcome the low production obtained in the months of January-February. This is very important as it is winter in Europe, the demand for carambola is good, fetching a high price.

Fruit quality

Under the netted structure fruits were not individually wrapped as in the open. Zabedah et al. (2003) observed that fruits not protected under the canopy were bleached and lacked lustre and firmness. However, fruits protected under the canopy were of higher quality with the right colour and lustre . Wrapped fruits under the netted structure were also observed to be crunchier with higher cutting force (Table 2). Zabedah et. al (2003) also found that carambola under netted structure had low levels of endosulphan,0.053 mg/kg,cypermethrin, 0.01 mg/kg and low residue of deltamethrin, 0.002 mg/kg and most other pesticides are not detected. Thus the fruit are very safe for consumption.

Preharvest Calcium application

In an experiment on pre harvest foliar application of calcium on developing carambola fruits, Zabedah (2007) observed an increase in fruit calcium concentration on calcium treated fruits (Table 3). This showed that the applied calcium penetrates into the fruit probably through lenticels , hence improved calcium concentration. Similar observation was made by Conway et al., (2002) who concluded that direct application of calcium to the fruit is the most effective method for increasing fruit calcium concentration. Firmness of fresh fruits and fruits stored for four weeks was higher with application of calcium (Table 3). Since carambola exported to Europe takes about 4 weeks to reach supermarket shelves the calcium treated fruits would be of higher quality (in term of firmness) compared to untreated fruits.

This is further confirmed by the result of the DSEM study on tissues of fresh fruits with and without preharvest calcium treatments (Figure 1). The smaller cell size with thicker and dense cell wall of the calcium treated fruit indicated that calcium plays in important role in the formation of rigid cells which resulted in the firmer texture of the fruit. On the other hand the larger cell with thinner cell wall of the fruit without calcium treatment resulted in fruits that are less firm. Besides increase in fruit firmness, the application of calcium also resulted in fruits with thicker wing tips making these fruits less prone to damage and bruising during handlings (Table 3). The fruits with thicker wings would also be less prone to damage during handling. It is thus recommended that fruits for export should be applied with preharvest calcium for better handling and post harvest quality.

Breeding for quality improvement

The breeding programme oncarambola was initiated in the 1990s, to improve the quality of carambola with attractive skin colour and high vitamin C. Two commercial cultivars (B10 and B17) and two pollinator cultivars (B2 and B11) were used as parents in a diallel cross designed to yield hybrid seeds, due to the pollen incompatibility character ofcarambola. Finally, three hybrids (B1711, B1002 and B0217) were selected after sensory evaluation based on their improved quality in terms of high vitamin C content, high total soluble solids and less astringency compared to the commercial cultivars B10 and B17 (Abd.Rahman et al. 2012; Pauziah et al. 2003). These hybrids also have the potential to be exported at maturity ('Golden carambola') for fresh consumption and are currently undergoing location verification trials.

The phytonutrient content of carambola

The carambola is believed to have medicinal properties such as reducing high blood pressure. Studies on its phytonutrient content showed that carambola is rich in the polyphenols; apigenins and procyanidins, both of which are well known for their health benefiting properties. This fruit also contains phenolic acids such

as conjugates of ferulic and sinapic acid. Three types of procynadin were detected in relative abundance in carambola, i.e procynadin dimer, procynadin trimer and a conjugate of procynadin (Fig 2). Procyanidins belong to the class of flavon-3-ols and are characteristically rich in green tea. Procynadins are efficient scavengers of free radicals and due to this property they have been indicated to have chemopreventive properties (Chung et al., 2003). Other studies have indicated its cholesterol lowering ability in vivo especially in the plasma, liver and artery (Bursill et al., 2006)

Apigenin, on the other hand is a type of flavone and its distribution in the plant kingdom is limited. They are found in celery and sweet red pepper and are known also for their chemopreventive properties. Carambola can be considered quite unique in terms of its phytochemical profile as apigenin in the form of its sugar conjugates are relatively abundant in this fruit. The synergistic effects of this complex mixture of these compounds may have additive effects in terms health benefits (Liu, 2004). With the rich source of different phytonutrients, carambola can be considered as a superfruit, with a unique and a good source of natural anti-oxidants , potential to be processed as a functional drink or ingredient.

Conclusion

Malaysian carambola faces very stiff competition from other producers such as Taiwan, Mexico, Brazil and Israel. Although Israel and Brazil are exporting carambola to Europe, to date Malaysia still remains as the bench mark and global leader. A Brazilian supplier Hage' International has recently launched a very attractive carambola branded as 'The Carambola Gold' a sweet, juicy and fresh eating golden variety. Thus for further expansion of the carambola industry especially to Europe it is important for Malaysia to produce a new variety of carambola matching these golden fresh eating varieties in order to remain as benchmark. Meanwhile, before a new variety is released, the 'Golden Carambola', which is variety B10 exported in the golden yellow stage (ripening index 4-4.5) should be promoted. In order to ensure that the 'Golden carambola'- B10 is of premium quality, research needs to be emphasised and production techniques need to be developed to produce fruits with new qualities; attractive colour, shiny sheen, sweet, juicy and improved crunchiness with long storage life for sea shipment to distant markets. Besides 'green for garnishing', it's timely for Malaysian exporters to export 'golden for fresh eating'. Product development from Malaysian carambola such as functional drinks and its use as ingredients in other health products would further enhance the Malaysian carambola industry. This would ensure the Malaysia with its 'super carambola' remains as the benchmark and global leader in carambola production

TABLES

Table 1.Yield of carambola (January-February)

	Under netted structure	In the open
Fruit wt/tree (kg/tree)	75a[y]	6b
Yield (t/ha)	33.7a	2.7b
Fruit no/tree	568a	25b
Exportable fruit (no/tree)	334a	24b
Exportable fruit (t/ha)	23.8a	2.2b

[y]Values followed by different letters in a row are significantly different at $p < 0.05$

Table 2. Fruit quality under netted structure and in the open

Treatments	Hardness (g)	Fruit cosmetic appearance
Under net, protected by canopy	4,391	Lustre present, clean, of right colour, look 'firm'
Under net, exposed fruits	3,763	Lack luster, bleached and look flaccid
Wrapped fruits in the open	3,828	Lustre present, clean, of right colour

Table 3. Effect of pre harvest calcium on fruit Ca concentration, firmness and wing tip thickness of carambola

Treatment		Ca (mg/kg)	Firmness (N)	Firmness at 4 weeeks (N)	Wing tip thickness (mm)
Calcium	+ Ca	287.1 ay	44.0 a	39.0 a	1.66a
	- Ca	228.2 b	35.4 b	30.0 b	1.55 b

FIGURES

Figure 1. Scanning Electron Micrograph (DSEM) of carambola fruit mesocarp tissue, A- Ca treated and B-without pre harvest calcium. The calcium treated fruits have smaller cells with thicker and denser cell walls (CWA) compared to untreated fruits with larger cells and thinner cell walls (CWB). Intercellular space of calcium treated fruits (ISA) is smaller than untreated fruits.

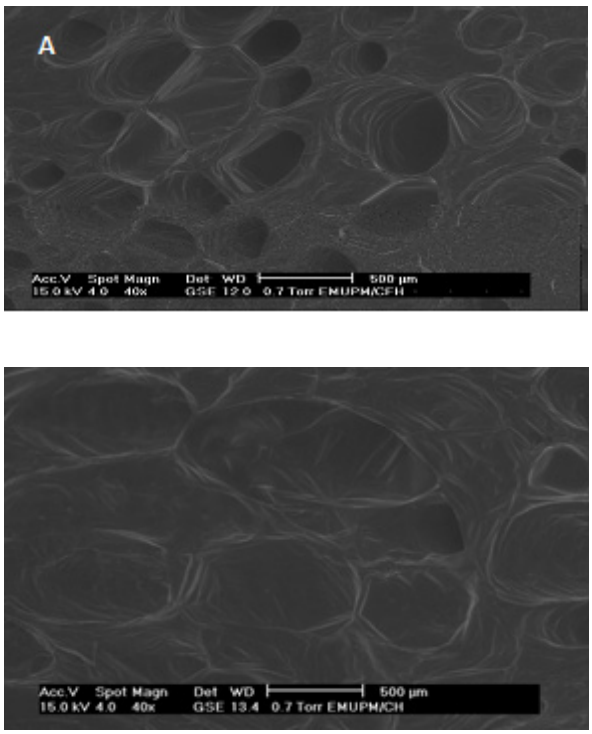
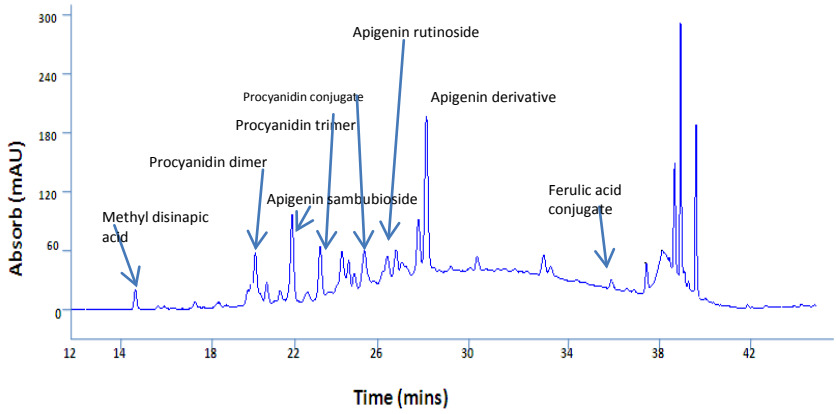


Figure 2. Chemical profile of carambola.



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EXPERIENCE IN COMMERCIALISING *CANARIUM ODONTOPHYLLUM* MIQ.: A POTENTIAL SUPERFRUIT OF SARAWAK

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ABSTRACT

Canarium odontophyllum Miq. or locally known as 'dabai' is an indigenous fruit which is locally consumed by local communities in Sarawak. The fruit was recently assessed as one of six indigenous fruits of Sarawak to have good potential for commercial exploitation. Dabai is considered as a potential superfruit because it is nutritious and contains high antioxidant properties. To ensure sustainable production of quality fruit, smart partnership between the Department of Agriculture (DOA) Sarawak and nursery operators and growers was established. Through this effort, superior clonal planting materials like 'Laja', 'Lulong' and other selected clones were made available for production and establishment of new and productive dabai orchards. Dabai is a highly perishable crop and to overcome this, DOA has embarked on shelf life studies to preserve the fruit by freezing it. This freezing technique allowed the fruit to be stocked up during peak harvest season and marketed later during the off-season. Furthermore, this available supply can be processed into value-added products throughout the year. Arising from this, new dabai products and uses have been developed by DOA and extended to private entrepreneurs to boost commercialisation of the fruit. Through the recent years, several small-scale enterprises have emerged and became front-runners in developing dabai-based products. Therefore, commercialisation activity of this special fruit is expected to increase substantially in the near future. It is hoped that through the concerted efforts by various stakeholders, the local dabai fruit industry will continue to develop and bring economic benefits to parties concerned.

Background

Dabai or scientifically known as Canarium odontophyllum Miq. is of the family Burseracea and is known as 'Sibu Olive'. The genus Canarium contains about 75 species of trees which are mainly found in tropical Asia and the Pacific, and a few species in tropical Africa (Leenhouts, 1956). The tree is resiniferous, 8 to 25 meters tall with a girth of 15 to 60 cm (d.b.h) depending on the age and growing condition. The stem is a straight bole with erect, semi-erect or horizontal branches (Sim and Lau, 2011). The odd-pinate leaf has 7 to 17 leaflets, distinctly acuminate at apex, sparsely to densely hairy below and on the midrib above, with 15-28 pairs of secondary veins which are slightly raised (Lemmens et al., 1995).

The fruit of dabai is ovoid to ellipsoid, slightly triangular in cross-section, 25-35mm (length) × 17-20mm (diameter) and glabrous (Lemmens et al., 1995). The fruit has a yellowish aril with dark purple exocarp. The endocarp is a hard shell and the seed (kernel in testa) inside can also be eaten as a nut. It is a rich source of protein, fat, carbohydrates and minerals like sodium, calcium and iron (Shakirin et al., 2012). The fruit also possesses high antioxidant capacity (Amin et al., 2007). Dabai is sought after because it has a delicious creamy taste and a unique aroma. To prepare for eating, the fruit is normally steeped in warm water of about 60°C for 10 to 15 minutes to soften the flesh. The flesh which turns soft after the treatment, has a smooth texture like an avocado and can be seasoned with salt, sugar or soya sauce to enhance the taste.

According to Ding and Tee (2011), dabai has high respiration production rate which means that it has a short life under non-cold chain handling practices. This is further confirmed by Sim and Lau (2011) which reported that dabai fruit with the pedicel removed can only last for two or three days under ambient temperature. Due to its high perishability, the fruit is much less known outside Sarawak. However, a study by Lau and Fatimah (2007) has proven that frozen dabai, after one year, can still retained acceptable appearance, flavour and taste when prepared by blanching in boiling water for five minutes. This freezing technique helped extend the shelf life of the fruit and allowed it to be stocked up during peak harvest season. It also made year-round processing of dabai products possible and therefore, allowed the fruit to be transported to distant markets; which in the past, could not be accessed with fresh fruit.

As reported by Voon (2003), dabai is one of the six most popular local indigenous fruits in Sarawak that

have good potential for commercialisation. Besides being a fruit with a lot of health benefits, dabai has also been relatively pest and disease free, probably due to its geographical isolation. Therefore, dabai has the 'green marketing' advantage as it can be marketed as organic and can even be produced under the Integrated Fruit Production (IFP) system, designed to produce quality fruit using environmentally responsible production techniques (Lau, 2011).

This paper is written based on the extensive experience of the Department of Agriculture (DOA) Sarawak in commercialising dabai as a specialty fruit of Sarawak. The paper also provides an overview of current knowledge about the nutritional properties of dabai as well as its economic potentials. Information has been derived from review of published and unpublished literature, and from surveys in which dabai commercial nursery operators, growers, processors and marketers were contacted and interviewed.

Production of dabai in Sarawak

In Sarawak, dabai is found naturally along river banks in Sibu, Sarikei, Kapit and Limbang divisions of the State. The main production areas are primarily concentrated in the central region of Sarawak with the exception of Limbang, a division which is located in the northern region (Figure 1). Based on a survey conducted in 2008, the estimated number of good standing trees in the central region is 13, 012 trees (based on 20% sampling size) with estimated average production of 650.6 metric ton per season (C.Y. Lau, personal communication, November 12, 2009). With the increasing interest in dabai, it is possible that the present existing trees exceed the above estimated number and production. The other regions of Sarawak either do not produce dabai, or their production is negligible.

Some of the earliest research on dabai was conducted by Agriculture Research Centre Semongok, an institution which is generally regarded as the pioneer in dabai R&D activities. Since 1985, the institution has performed number of studies on the collection, documentation, conservation and improvement of this fruit (Chai et al., 2008). After years of field evaluation of numerous selections of dabai obtained from different regions in Sarawak, two selected dabai clones were launched by the DOA Sarawak in 2006. These superior clones called 'Laja' and 'Lulong' are highly recommended for commercial planting. Growth of these clones is vigorous and they begin to bear fruits five years after planting. The initial yield is about 10 kg per tree and can gradually increase to 80-100 kg per tree when the tree reaches 10 years and above (Lau and Voon, 2007).

'Laja' and 'Lulong' have excellent eating quality. Both clones have bright yellow flesh and taste creamy with slightly sour tinge. Cross section of the fruit shows that seed of Laja is triangular with concave sides while the seed of 'Laja' is more rounded or convex on its sides. In terms of size, the fruit of 'Laja' is bigger with individual fruit weight of 18.9 g (Table 1). Lau et al. (2008) also reported that these dabai clones are rich in fat (44.3%-'Laja', 33.9%-'Lulong') and also carbohydrate, with 37.2% in 'Laja' and 45.6% in 'Lulong' (Table 2). Besides 'Laja' and 'Lulong', private nursery operators have also come up with other dabai varieties such as 'Song', 'Kapit', 'Intermediate', 'Egg Yolk', 'Tarat', 'Red Dabai' and 'Pulau Keladi' (Brooke and Lau, 2013). In order to select more dabai varieties with better quality, fruit evaluation and tree characterization of these varieties are still on-going.

Dabai is dominated by smallholders, who grow the plant in mixed orchards called 'dusun' which are scattered in villages throughout the State. They managed the orchards on a small-scale ranging from several trees to several hectares. However, recently, entrepreneurs with financial strength have been investing in the dabai industry. Due to the availability of superior clones and usable production technology, larger orchards of several hectares have emerged.

The initial fresh fruit yield of dabai trees is low at 10-20 kilogram/tree/season. However, at maturity, the yield may reach up to 50-200 kilogram/tree. The dabai price varies greatly depending on the season, quality and demand, with higher price ranging from RM 14 to well over RM28 per kilogram observed during the early and towards the end of the season, where availability of dabai is the lowest. During bumper season, the price of dabai could drop to RM 5 or less per kilogram during the peak period. Marketwise, dabai is a highly appreciated crop and can fetch higher price compared to other indigenous fruits.

Dabai is widely, though not advisedly, propagated from seed. Seed propagation is not recommended because the trees may result in fruits with variable traits and would give male trees which do not produce fruit. The fruit can also be propagated by asexual methods such as grafting and budding. For large

scale propagation, patch-budding of hermaphrodite plants is recommended. During the early stage of commercialisation, interested private nursery operators and growers were given technical support especially on the propagation of dabai. Simultaneously, mother plants of selected dabai clones were supplied to them for the establishment of source bush plots. DOA Sarawak regularly monitored the production of grafted dabai and occasionally handed out inputs like rootstocks and budsticks to these nursery operators. As of now, three commercial nursery operators in Sri Aman, Sarikei and Sibu divisions were engaged and promoted as main producers of high quality dabai planting materials in the region. Massive production of superior clonal fruits is also underway, in which three commercial growers in Sarawak were already identified to grow these quality planting materials. This effort has not only generated more income for the dabai producers but also made quality grafted dabai plants available to the masses.

Recognising the economic prospects of this fruit, a field survey on existing productive trees in the central region of the State was conducted in 2008. The study showed that five clusters of 200 trees each could be organised to supply quality fruit for product development, promotion and marketing in new markets (Lau, 2009). As a result, few nucleus dabai growers with selected seedlings in Sarikei and Kanowit divisions were identified. They were around 24 smallholders in these divisions with the estimated average production of 10 metric ton per season (T.H. Tie, personal communication, July 10, 2012). These nucleus growers gave significant contribution to the local dabai industry by providing a resource base for some degree of commercialisation to take place.

Nutritional properties and economic potential of dabai

Nutritional and fatty acid composition

The popularity of dabai as one of the most widely consumed indigenous fruits by the local populace has generated much interest in the nutritional values of the fruit and its potential for product development. Considerable research has been conducted over the years on the health conferring properties of the fruit, kernel and oil. Voon and Kueh (1999), have reported that dabai fruit is highly nutritious and is rich in protein, fat, energy and carbohydrate. It is also high in phenolic compounds and vitamin E such as -tocopherol (Azrina et al., 2010; Shakirin et al., 2010). In recent years, due to the high nutritional quality, the fruit of dabai had been promoted as a specialty fruit by the DOA Sarawak (Leipzig, 1994; Lau, 2009).

The dabai pulp which makes up about 54-60% of the fruit by weight, contains 41.3% of moisture. On a fresh weight basis (per 100g), it contains: 3.8 g protein, 26.2 g fat, 4.3 g crude fiber, 2.3 g ash, 22.1 g carbohydrate and 339 kcal of energy (Wild Fruits & Vegetables in Sarawak, 2010). Although dabai pulp is usually eaten fresh, it is also frequently used as ingredients in cakes, cookies, sandwiches and pizza. Other dabai value-added products have also been developed by DOA, for examples; dabai paste, pitted dabai, dabai crackers, dabai tarts and dabai cakes (Figure 2). Besides using the pulp and kernel for food products, the seeds can also make attractive keychains when polished and painted. The shell, which is usually thrown aside after kernel extraction, can be recycled to produce charcoal.

The pulp oil of dabai has the following composition: 43.42% saturated fatty acid, 42.53% monounsaturated fatty acid and 14.05% polyunsaturated fatty acid. According to Azrina et al. (2010), the fatty acid compositions of dabai pulp oil were comparable to palm oil, as characterized by a near equal percentage of saturated and monounsaturated fatty acids at about 40%, and also polyunsaturated fatty acids at about 12-13%. For this reason, dabai pulp may possess comparable nutrient content as the palm olein, which is consumed and extensively used worldwide as cooking and frying oil. Therefore, the study suggests that dabai pulp oil could be alternative cooking oil in the near future. The high saponification values of dabai pulp and kernel oils (171-181mg KOH/g) also indicated that dabai oils, after hydrogenation, could also be substitutes for some conventional oils that are very useful in the production of soap and shampoo (Azrina et al., 2010).

The kernel of dabai is edible and can be eaten raw, roasted or coated with sugar or honey. It is also being used in cakes, tarts and cookies. The kernel which comprises of 35-40% of the whole fruit by weight, contains (per 100g): 27.05% moisture, 10.75 g protein, 26.20 g fat, 47.24 g carbohydrate, 3.35 g ash, 15.80 g crude fiber and 499.36 kcal of energy (Liew et al., 2011). Fatty acid composition showed that oleic acid (41.9%) was the main constituent of monounsaturated lipids in dabai kernel oil. The polyunsaturated fatty acid was in small amount, with linoleic acid of 14.05%. The major saturated fatty acid present in dabai kernel oil was palmitic acid (40.31%) with small amount of myristic acid, stearic acid and arachidic

acid (Liew et al., 2011). Azrina et al. (2010), reported that dabai kernel oil has high tendency to be solid at room temperature based on its high saturated fatty acid content. The study revealed that the fatty acid composition of the kernel oil was similar to cocoa butter, suggesting the oil as a cocoa butter equivalent (CBE). The study also mentioned the potential of dabai kernel oil as a new source of oil spread in the market. At present, extraction of the oil from the dabai kernel is not being explored owing to inadequate supply of nuts, even for the kernel industry.

Antioxidant properties

In 2007, Amin et. al. carried out a preliminary work where the different parts of dabai fruit, namely skin, flesh, kernel and whole fruits were analysed for antioxidant properties. Based on the -carotene bleaching assay, the highest antioxidant activity was observed in the skin of dabai, with mean antioxidant activity of 89.31% O.I. Antioxidant capacity was classified as high (>70%), intermediate (40–70%) or low (<40%) levels of oxidation inhibition (O.I.) (Hassimotto et al., 2005). The study also showed that the total phenolic content were higher in the skin and whole fruit with 25.07 and 5.43 mg GAE/dried sample respectively, compared to the flesh (3.38 mg GAE/g dried sample) and kernel (2.14 mg GAE/g dried sample). The high antioxidant capacity of dabai could be due to the presence of phenolic compounds in the skin. This is in agreement with the study conducted by Chew et al. (2012), in which appreciable levels of phenolic compounds such as cathechin, epigallocatechin gallate and epicathechin were found in the fruit.

High total anthocyanin contents had also been determined in methanol and water extracts of defatted dabai parts. The defatted pulp was found to be rich in phenolics, while the purplish defatted dabai peel has high amount of anthocyanin (Khoo et al., 2012). From this study, it was proven that dabai is a potential antioxidant source in which the phenolic compounds in the defatted pulp and peel can be exploited as nutraceutical and functional food industry.

The high antioxidant capacity has led to dabai being investigated as a potential cholesterol lowering agent. Shakirin et al. (2012), working with hypercholesterolemic rabbits fed with diet containing different parts of dabai fruit parts, found that rabbits receiving defatted pulp of dabai showed the greatest cholesterol lowering effect as it had reduced plasma LDL-C, TC and thiobarbiturate reactive substance (TBARS) level as well as atherosclerotic plaques. The positive effect of defatted pulp of dabai on hypercholesterolemic rabbits could be due to the 70 mg of polyphenolic compounds and the presence of high dietary fiber (50%) found in the defatted pulp (Khoo et al., 2012).

The aforementioned health conferring properties of dabai suggested that it is a potential superfruit which Sarawak can develop with competitive advantage. Its nutritional properties, antioxidant quality and promising economic potential have made DOA to designate dabai as one of the priority crops in the region. In an effort to make dabai a flagship comodity of the State, the fruit has recently been granted Geographical Indication (GI) protection certification by the Malaysian Intellectual Property Corporation (MyIPO). The certification gives GI such as dabai the recognition necessary to the creation of a high quality product.

Commercial enterprises and local market

Malaysian carambola faces very stiff competition from other producers such as Taiwan, Mexico, Brazil and Israel. Although Israel and Brazil are exporting carambola to Europe, to date Malaysia still remains as the bench mark and global leader. A Brazilian supplier Hage' International has recently launched a very attractive carambola branded as 'The Carambola Gold' a sweet, juicy and fresh eating golden variety. Thus for further expansion of the carambola industry especially to Europe it is important for Malaysia to produce a new variety of carambola matching these golden fresh eating varieties in order to remain as benchmark. Meanwhile, before a new variety is released, the 'Golden Carambola', which is variety B10 exported in the golden yellow stage (ripening index 4-4.5) should be promoted. In order to ensure that the 'Golden carambola'- B10 is of premium quality, research needs to be emphasised and production techniques need to be developed to produce fruits with new qualities; attractive colour, shiny sheen, sweet, juicy and improved crunchiness with long storage life for sea shipment to distant markets. Besides 'green for garnishing', it's timely for Malaysian exporters to export 'golden for fresh eating'. Product development from Malaysian carambola such as functional drinks and its use as ingredients in other health products would further enhance the Malaysian carambola industry. This would ensure the Malaysia with its 'super carambola' remains as the benchmark and global leader in carambola production.

Conclusion

The high nutrient content and antioxidant quality made dabai a potential superfruit for commercialisation. In Sarawak, dabai has the potential to become one of the indigenous fruit species that could contribute to the economic growth of the State. Dabai is highly nutritious and is rich in protein, fat, energy and carbohydrate. It is also high in antioxidant, with the highest antioxidant activity observed in the skin. By and large, a great proportion of dabai grown in the State is consumed fresh. However, quite a substantial amount of the fruit is now available in many forms i.e. food products and non-food products and is well received by the public. It is envisaged that commercialisation activity of this special fruit will increase substantially in the next few years. Therefore, it is hoped that in the near future dabai will be sold into international trade and will be ranked with other commercial fruits in the world market.

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TABLES

Table 1. Physical characteristics of dabai 'Laja' and 'Lulong

Parameter	Dabai Laja	Dabai Lulong
Individual fruit weight (g)	18.9	13.9
Fruit length (cm)	4.5	3.6
Flesh thickness (cm)	0.35	0.31
Seed weight (g)	7.7	5.0
Edible portion (%)	61.5	64.0

Table 2. Nutritional values of dabai 'Laja' and 'Lulong'

Component (% per 100 g)	Dabai Laja	Dabai Lulong
Protein	6.8	5.5
Fat	44.3	33.9
Carbohydrate	37.2	45.6
Fibre	8.1	11.6
Ash	3.8	3.4

FIGURES

Figure 1. Main production areas of dabai namely Sarikei, Sibu, Kapit and Limbang divisions.

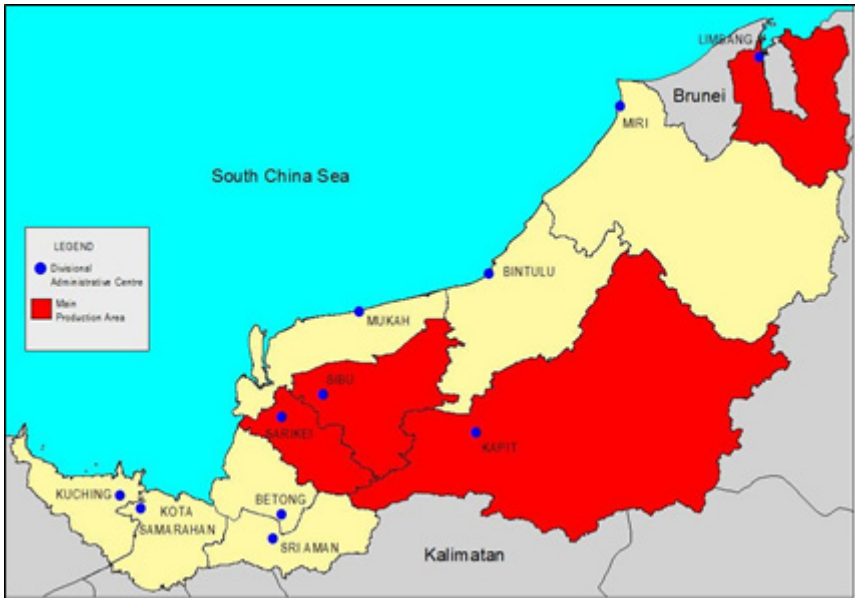

Figure 2. Products made from dabai. A: dabai paste; B: dabai crystal cake; C: dabai cracker and D: pitted dabai.

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TREE DISTANCE AND REPLACEMENT OF CITRUS GREENING DISEASED TREES OF KING MANDARIN FOR A SUPERFRUIT

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ABSTRACT

King Mandarin, Citrus nobilis, has been preferably cultured in southern Vietnam, where trees are traditionally planted at distances < 1.5 m. After the invasion of citrus greening disease, fruit yield has been drastically reduced, and orchards become terminated in eight years. The mean annual yield with this cultivation technique is about 900 kg/m2. The Southern Horticultural Research Institute (SOFRI) has widened the distance between trees to 2.5 m, and recommends farmers to replace diseased trees for new young trees when they are found. JICA has recommended extending the distance even to 4.0m. Farmers are usually conservative in changing tree distances and hesitate to replace diseased trees, especially when they carry fruits. We established models in order to predict the tree distance and the time of diseased-tree removal that would give the highest yield. Diseased trees usually die in < six years after the infestation. Assuming that orchards invaded by the disease would be terminated within eight years, we thus compared yield among managements in which the diseased trees are replaced at the first to fifth years after the infestation. Our models predicted that the highest yield, about 2000kg/1000m2, would be realized when trees are replaced in the disease-detection year, irrespective of the tree distances recommended by either SOFRI or JICA. Cultivation without replacing diseased-trees gave much lower yields, < 800 kg/m2. However, the models also predicted that the keeping of diseased-trees would promise enough yields for the independence of the farm economy provided that orchards were maintained permanently at > 1500 kg/m2. Our models thus showed that continuous maintenance of orchards with replacing diseased trees renders King Mandarin as a superfruit for southern Vietnam in producing a doubled yield even with maintenance of diseased trees at levels that are acceptable to farmers.

PAPER

Citrus production is one of the most important industries in Southern Vietnam, where King is a major crop (Sekino et al. 2011). After its invasion into this region, citrus greening (CG) has been devastating not only this cultivar but also other citrus. This problem has been studied since the late 1990's by Southern Horticultural Research Institute of Vietnam (SOFRI), in corporation with domestic and international organisations. Working with Japan International Research Centre for Agricultural Sciences (JIRCAS) from 2005 to 2011, SOFRI established an IPM with JIRCAS for this disease. Following the results, Japan International Corporation Agency (JICA) started a project with SOFRI to help farmers' economy with cultivation of King, whereas some techniques were modified. For example, SOFRI uses a tree distance of 2.5 m and JICA uses 4.0 m. Both distances are greater than ones that have been traditionally used in this region, < 1.5 m. In the former two cultivations, trees are planted sparsely and much space is left not to be used efficiently. Farmers are likely thus to avoid longer distance for planting trees, especially that by JICA. Their impression is that sparse distribution of trees due to longer planting distances would result in lower yields. The traditional,

SOFRI, and JICA cultivations are designated hereafter as T, S, and J cultivations, respectively.

One of the authors, Tien, made extensive field works in 2004 to 2005 in southern Vietnam, where he asked totally 118 growers of the cultivar King. His study recognised two types in the cultivation according to the practices of insecticide application, especially those recommended by SOFRI, for CG problem (Ichinose et al. 2011). One was periodical, normally bimonthly, application of systemic insecticide for the control of vectors of CG, Diaphorina citri Kuwayama (Tuan & Ichinose 2011). The other was the application of any insecticides facultatively, rarely or even not. As expected, the former achieved much higher yields than the latter, providing farmers to enough income for economic independent of their families.

Not only contributes the intensive insecticide application to higher yields but also does the treatment of tree crowns. In the T cultivation, trees are not trained or pruned to adjust the crown for higher yields. Close position of trees in the traditional cultivation does not allow the trees to extend their crown enough. Techniques for tree training and pruning in southern Vietnam were developed by SOFRI in the course of the international collaborative research with JIRCAS for the problem of CG (Ichinose et al. 2011). Since SOFRI recommends planting trees at a distance of 2.5 m, the space that would be needed for the tree treatments is left. Following the results of the works by SOFRI with JIRCAS, JICA has established their own techniques for cultivation of King with modification of some techniques, especially a wider tree distance of 4.0 m.

As predicted, most or probably all farmers who participate in the project consider that the JICA's distance is too long and the JICA techniques are less productive, although the tree distance is still rather shorter than the one for citrus cultivation in Japan (> 4.0 m) or USA (≈ 8.0 m). Their impression can be understood. If new orchards set for the JICA project are compared with those by T or S cultivation, trees look too sparsely distributed and much space are left useless, especially just after trees are planted. JICA has invested much effort into the orchards of growers who participate in the project. In particular, emphasising the importance of the tree distance and the arrangement of trees to be planted, JICA established more than 130 orchards in southern Vietnam and planted trees in grid at a distance of 4.0 m. Using these orchards as model for the cultivation of King in this region, JICA has attempted to extend their techniques that would facilitate trees to extend the canopy for the utilisation of space most efficiently in the viewpoint of yield augmentation. Because of the sparse distribution of trees in the JICA orchards, however, farmers assume that J cultivation would result in much less yield than the other two. This is one of the most important issues that the JICA project should answer to farmers. Furthermore, sanitation is required for the management of CG: it is recommended to cut and remove CG-infected trees immediately when detected (e.g. Halbert & Manjunath 2004; Gottwald et al. 2007). This is also hardly followed by farmers, since diseased trees may still remain and probably could bear fruits in their crown. If they are replaced for new trees immediately, these and future possible yields should be abandoned, although the yield by diseased trees should be reduced remarkably with time. For answering these issues, we established models that would predict yields under the three cultivation methods and attempted to determine the optimal cultivation under the situation of severe infestation pressure of CG and how infested trees should be treated and when being cut. The results would facilitate farmers to undertake their own decision-making in the cultivation of King.

Methods

The effects of tree distance on the yield were compared between T, S, and J cultivations. Reanalyses of Tien's data (unpublished data) revealed that cultivation of King with sufficient insecticide application gave much higher yields but was obliged to be terminated in eight years after planting irrespective of the mode of insecticide application (Fig. 1). The results indicate that the termination of orchards, probably due to CG as a principal cause, should be inevitable but cultivation of King in one cycle of eight years would guarantee the economic independence of one family. Based on this, the yield in this cycle was considered for the three cultivations.

In this study, CG-diseased trees in orchards by any cultivation were set to die in five years, and two assumptions were introduced: no secondary infestation in the orchard and no difference in invasion risk of CG between cultivations. It is very hard to discriminate the primary and secondary infestations, and also hard is the evaluation of the primary one (Iwanami et al. 2013). Tentative evaluations of annual risk of primary infestation were made from Ichinose et al. (2011) and our personal observations, giving the annual probabilities of infestation as 0.05 (or 5 %) in the first year, 0.1 in the second, 0.2 in the third, and 0.3 in later years. The reduction factor of CG infestation on the yield is also hard to evaluate. For convenience, the following formula was used for this study: $y = 1/(1 + x)$, where x is the age of orchard

and y is the yield of CG-infected trees. Using these assumptions, the annual yields of diseased trees in a cycle of eight years were simulated for the following two situations: no replacement of diseased trees until their death and the immediate replacement of diseased trees for new trees.

For visualisation, an orchard of 30 x 40 m was set, where no water canals were constructed and 494 trees in T, 192 in S, and 80 in J orchard were planted. Using the per capita yields in Fig. 1, annual yields under the conditions described as below were simulated for these cultivations. The mean numbers of trees planted in the T, S, and J orchards are estimated as 153, 100, and 40, respectively. Using these numbers, unit-area yields were calculated with the ratio of 153/494 for T, 100/192 for S and 40/80 for J. Randomized numbers, varying from 0 to 1 with the sixth decimal point, were given to individual trees in the hypothetical orchard every year during the eight year cycle. In each year, the trees tallied with the numbers that exceeded the infestation probability in the corresponding orchard age were assumed to be CG-infested. The total yield in the orchard by individual cultivations was calculated, according to the age and infestation history of trees in the cycle. Finally, yields were simulated for orchards that were either terminated in every eight years or continued for 24 years. Through these simulations, the following questions were attempted to be answered: which cultivation gave the highest yield, when diseased trees should be cut, how long orchards should be maintain.

Results and discussion

Yields were simulated for diseased-trees in a unit area managed by T, S, or J cultivation for two treatments: either not to be cut without any replacement or to be cut and replaced for new trees in the infestation year. Here all trees in the area were assumed to be infected in any given year, when the total yield was considered. The annual per capita production by one tree and the total production in a unit area in the course of an eight year cycle are shown in Fig. 2. The highest per capita yield was attained by the combination of cutting and J cultivation. The difference in the per capita yield between S and J was compensated by that in the number of trees in a unit area, making little difference in the total yield eventually. However, the yields by T were much lower than those by S and J, and it is excluded in the subsequent analyses. The cutting of diseased trees gave higher yields until the fourth year than not-cutting, but lower thereafter. This means that trees diseased until the fourth year should be replaced for new ones immediately but should remained thereafter irrespective of cultivation. Intuitively, cutting of trees that are infected after fifth year would result in lower yields, since replaced trees would produce fewer fruits in the rest years. This was confirmed by further computer simulations (results not shown here). Hence, for the eight-year-cycle cultivation, cutting of newly diseased trees after fifth year was not considered.

The total yield in the hypothetical orchard was simulated for the conditions where trees with different histories of disease infestation existed in the hypothetical orchard. As described previously, tree cutting was executed until the fourth year. Simulation was repeated 10 times for each condition, revealing higher yields with tree-cutting irrespective of cultivation (Fig. 3). Further simulations were done for the elongation of cultivation cycle of 24 years with the same conditions to the eight-year cycle. Since the eight-year-cycle cultivation starts planting newly every eight years, its yield is reset to "0" in the interval of this cycle, 1, 9 and 17 year after planting. In the first cycle, all cultivations except the S and J cultivation with the eight year cycle attained similar yields, whereas orchards of the 24 years cycle produced similar yields thereafter, clearly owing to the continuous presence of trees. Surprisingly, not-cutting treatment in the 24 years cycle achieved similar yields by cutting treatment in this cycle, again irrespective of cultivation, S or J. Thus, there were no apparent differences in the yield between the S and J cultivations, if the orchards were managed with the same tree treatment and the cultivation cycle was same.

The total production in the 24 years cycle was compared between cultivations, revealing the highest production by the cutting treatments of diseased trees by S and J in the eight years cycle, similar but a little less production was attained by S and J with cutting in the 24 years cycle (Fig. 4). Not-cutting of diseased trees in the S and J cultivation in the 24 years cycle provided similar productions to those in the formers. The proportions of CG-infested trees were similar again if the treatment of tree and the cultivation cycle were same irrespective of cultivation (Fig. 4). CG occurrences were least by S and J with replacing diseased trees in the 24 years cycle, whereas they were most in the orchards with no tree-replacement in the eight years cycle.

The results of this study revealed that the economic independence of farmers in southern Vietnam can by realised by cultivation of King, which can be doubled or more than the traditional cultivation by SOFRI or

JICA cultivation. The traditional cultivation would be terminated in eight years due to severe invasion of CG in the orchards. However, S and J cultivations provided similar yields, if the same cultivation cycle and treatment of diseased trees were done. The results suggest that both S and J cultivations utilise the orchard effectively by extending tree canopies and little space is left. The maximum production was attained in the orchards with replacing diseased trees in the eight years cycle. However, the difference from those in the 24 years cycle was conceivably negligible, irrespective of both cultivation and tree treatment. Not-cutting of diseased trees should not be considered for the eight years cycle, but could be for the 24 years cycle. From the viewpoint of labour, not-cutting of diseased trees for the latter could be possible under the conditions of severe CG invasion pressure.

The other unexpected result in our results was the relation between the proportion of CG-infested trees and the total yield. The proportion was constantly lowest in the orchard managed by S or J cultivation for 24 years cycle, and that for eight years cycle varied cyclically in every eight years. CG infection proportions were similar between these cycles with the replacement of diseased trees until fifth year in each cycle, but higher in the eight years cycle thereafter. Despite the tendency of higher CG occurrences, the total yield in this cycle led higher yields. In this point, cultivation of King has some Myths in the viewpoint of the relation between yield and infestation proportion and between yield and cultivation cycle. But it is truth in this cultivar.

The simulations in this study excluded any factors other than CG. In reality, King is subject to various pests and diseases in southern Vietnam. Further, unrealistic assumptions were included in the simulations, e.g. the same risk of CG over cultivations, no secondary infestation, and consistency in CG impact on trees. Ignored were important factors such as differences in cost and labour investment or intercropping. The inclusion of these factors would lead different results. Despite these possibilities, this study would indicate that visual appearance of orchard would not necessarily result in the expected yield. Accepting these deficiencies, we could recommend that diseased trees should be removed from orchards immediately when detected. If desired, orchards may be continued longer. The longer the orchard is continued, the less the necessity of the removal of diseased trees would be reduced. In the sense of the doubled yield by S or J cultivation, King can be "a" superfruit in southern Vietnam.

Acknowledgements

We would like to express our thanks to JICA for giving an opportunity to make simulations in the project orchards and Vietnamese government officers involved in the JICA project for their assistance of us during our study in southern Vietnam. Researchers and employees at SOFRI supported our works. Mr D.V. Bang, Mr L.N. An, Mrs V.T. Nga, Miss V.T.H. Lan and Miss T.T.K. Oanh helped us for a lot of activities involved in this study. Mr R. Koshida, a coordinator of the JICA Project in southern Vietnam, officially supported our works.

FIGURES

Figure 1. Left: Yield (mean ± SEM), in traditionally managed orchards. The dotted line indicates the minimum yield required for income that allows one family to be economically independent. Right: Annual yields of per capita tree (open marks) and those in 1000 m2 (closed) by T, S and J cultivations.

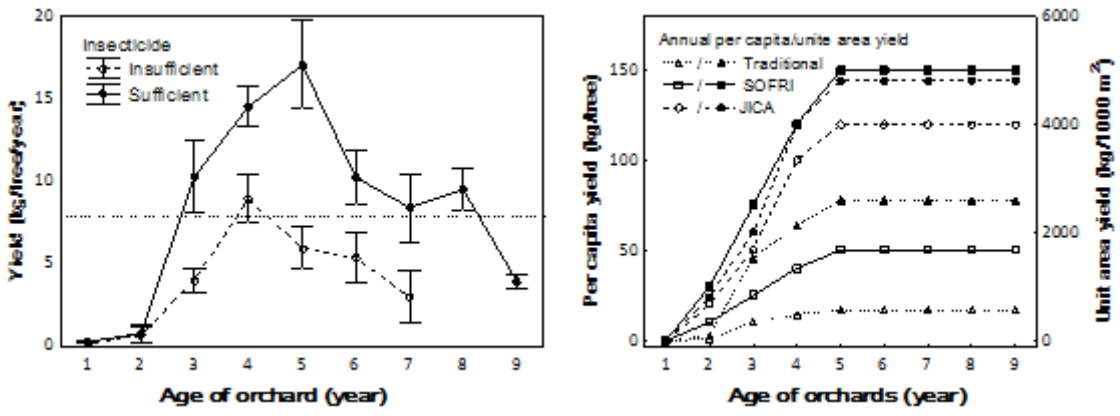


Figure 2. Per capita yield of trees in the eight-year-cycle (left) and the unit-area yield in a unit area (right) managed by traditional (T), SOFRI (S), or JICA (J) cultivation. Trees infested in any given year after planting were treated either not to be cut (Not) or to be cut and replaced for new ones (Cut).

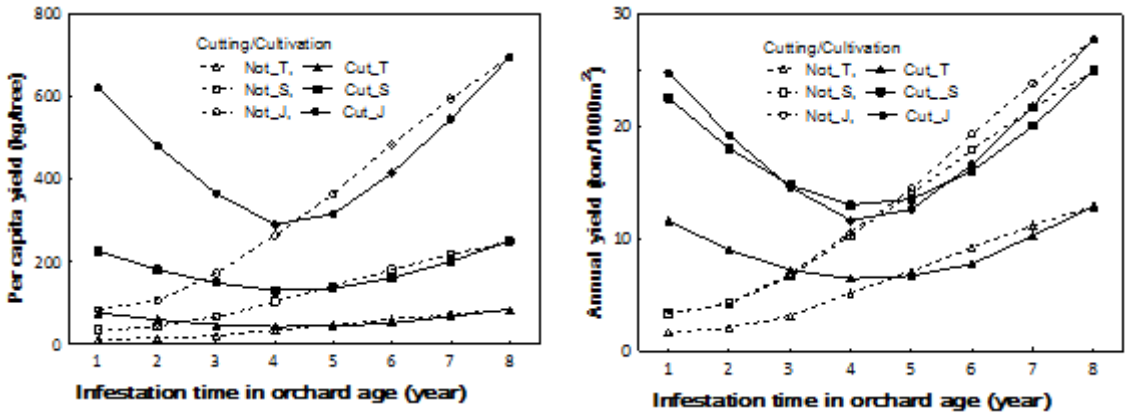


Figure 3. Simulation for the mixture conditions of trees with different disease history in the eight years cycle (left) and those in 24-year cycle (right).

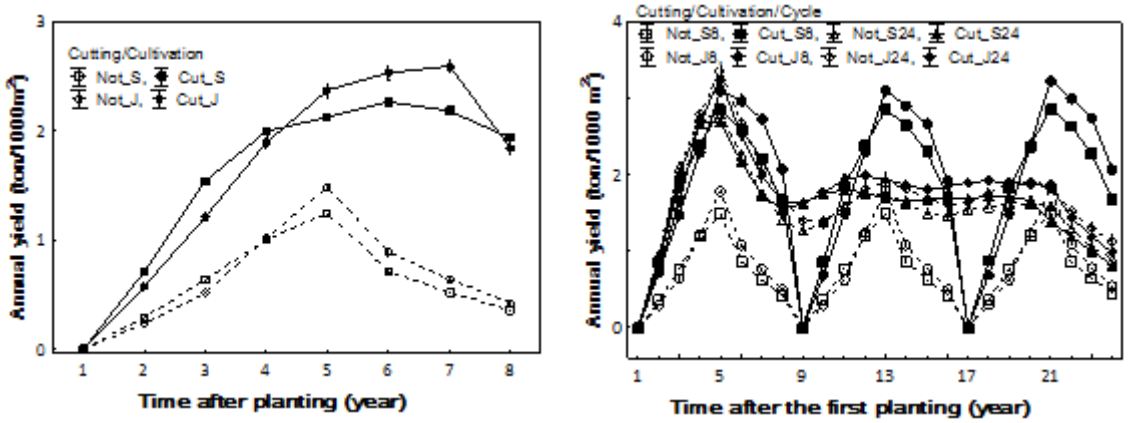
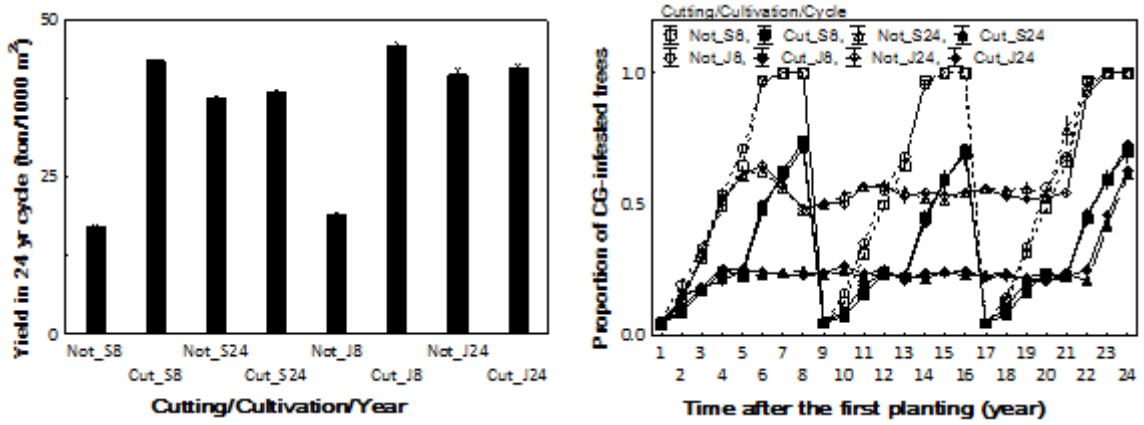


Figure 4. Mean yields (± SEM) in the hypothetical orchard in the 24 years and means of the proportion of diseased trees during the cycle (right).



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STUDIES ON IDENTIFICATION OF PITAYA (*HYLOCEREUS UNDATUS*) YELLOW CLADONE –BROWN SPOT AND THE EVALUATION OF SOME ANTAGONISMS, AGROCHEMICALS AGAINST THE PATHOGENS UNDER LABORATORY CONDITIONS

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ABSTRACT

Dragon fruit (Pitaya) (*Hylocereus undatus*) is one of special fruit crop which occupies more than 22,000ha in Southern of Vietnam at the moment. Unfortunately, yellow cladode -brown spot disease attacked severely at different stages from young tree to old one and caused serious problem in reducing yield. Results of isolation and identification of diseased samples from pitaya stem showed that Bipolaris crustacea and Fusarium equiseti were two main causal organisms which causing pitaya yellow cladode –brown spot.

The efficacy of these antagonistic was evaluaed using an in vitro assay, the obtained results revealed that all the test treatment of *Bacillus subtillis*, *B. megaterium*, *Pseudomonas* sp. and SOFRI- Trichoderma could reduce mycelium growth (40-80% of mycelium growth inhibition) of both *B. crutacea* and *F. equiceti* at seven days after innoculated. Under laboratory conditions, the several of agro-chemicals evaluated for disease checking showed that Mancozeb (Man 80WP) and Iprodione (Viroval 50WP) were the best treatment to completely inhibited mycelium growth of *B. crutacea* as compared to control. Meanwhile, Mancozeb + Metalaxyl (Ridomil 68WP), Fosetyl Aluminium (Aliette 80WP) and Tebuconazole + Trifloxystrobin (Nativo 750WG) showed no fungal growth thereby indicating 100 per cent inhibition of *F. equiceti*.

PAPER

In Vietnam, pitaya (Hylocereus undatus) is considered one of the most important tropical fruits and provides income for producers at Binh Thuan, Tien Giang and Long An. It has been exported to thirty countries:

China, European, Asean, America, Japan, Korea, Chile, etc. At present, the growing area of pitaya is approximately 25,000 ha with the production about 468,300 tons and an average yield 24 to 30 tons/ha. However, due to the expansion of planting area and production, it is also facing many problems, specialy about pests which are causing loss of yeild such as anthracnose, bacteria fruit rot, yellow cladode-brown spot, fruit flies, thrips, etc. One of them which is widespread is the, yellow cladode- brown spot, has affected most of fruit growing regional in the South. It usually occurs in the dry season and mostly appearing on the top of plants, initial symptoms appear on upper stem surfaces as small, pinpoint with reddish-brown in colour. Scabs are usually surrouned by yellow halo and spots expand to cause large yellow areas and finally secondary infection sets in (special stem rot) if in rainy season (Hieu et al., 2012). In the world, there are very few research on this issue and some of them proved that light factor is relative to yellow cladoe phenomenon (Mizrahi and Nerd, 1999; Merten, 2003; Thomson, 2002; Crane and Balerdi, 2005). In Vietnam, the only attempt is to relate it to organisms which causes this brown spot disease and its managements.

Materials and methods

The experiments were carried out in the Plant Pathology Laboratory, Plant Protection Division, Southern Horticultural Research Institute, during March to November 2011. Fungal isolates used in the experiments were sub-cultured on Potato Dextrose Agar (PDA) for further examinations.

Isolation and identification of pathogen

The symptomatic parts of plants were collected at Chau Thanh dist., Long An province and Cho Gao dist., Tien Giang province, brought to laboratory and then isolations were made following by Agrios (2005). Pieces of plant samples taken from the margin of healthy and diseased tissues were briefly disinfected with 70% alcohol and thoroughly washed with three changes of sterile distilled water. These pieces were transferred aseptically into PDA plates. The inoculated plates were incubated in incubator at 25 ± 10C and the single colonies of fungus were then transferred onto fresh petri dishes to obtain pure culture.

Identification of pathogen associated with the disease was done by comparing its different morphological characters like growth behaviour, colour, and shape, etc. following keys in literature of Barnett and Hunter (1998), Nelson et al. (1983).

Sequence of 28S rRNA of Bipolaris sp. and Fusarium sp.

Pure cultures of fungus were sent to NK-BIOTEK Laboratory at HCMC for sequencing using 28S rRNA gene. Using BLAST SEARCH software for comparison of isolated fungus DNA sequence with other relative sequences from gene bank for identification of species.

Pathogencity tests

Pathogencity test was conducted in nethouse following Koch's postulate which was described by Agrios (2005). In nethouse, thirty cuttings of one year old stem were cultured in plastic pots containing sterilized soil which prepared 8 months before. Each seedling was incubated with 3 bits (5mm in diameter) of fresh mycelium of fungus at separate position on stem surface which was injured by the help of sterilized needle, however control pots were not incubated. To maintained moisture for fungus developing by provide frequently sterilized water.

In vitro evaluation of bioagents

Different of antagonistic bacteria viz., *Bacillus subtillis*, *B. megaterium,* Pseudomonas fluorescens and Trichoderma isolated from rhizosphere and fruit surface of different crops were obtained from Plant Protection Division. These antagonistic fungi were screened in in vitro condition for their efficacy in suppressing the growth of fungus by dual culture technique (Dennis and Webster, 1971). Mycelial discs, 5mm in diameter, were taken both from actively growing culture of pathogen and antagonists culture (5 days-old) and placed in Petri plates (Ø=9 mm) containing 20 ml of sterilized PDA. Pathogen was kept at one side of plates and on other side bit of antagonists was placed at equal distance before 24hrs. Control plates without the disc of antagonist i.e., inoculated only with pathogen was kept for comparison. Each treatment had four replications and was maintained along with control. Inoculated plates were incubated

in incubator at 25 ± 10C. Observations on radial growth of the pathogen both in treatment as well as in control plates were recorded after every 24hrs. of inoculation till control plates were fully covered by pathogen. The per cent inhibition of mycelial growth of fungus over control was calculated by using formula given by Vincent (1927)

Screening of fungicides in vitro

Poinsoned Food Technique (Grover and Moore, 1962) was employed to screen the fungicides against fungus. For Bipolaris crutacea, an experiment was conducted in Plant Pathology Laboratory to study the effect of various agro-chemicals on fungi under in vitro conditions. The experiment was laid out in Completely Random Design (CRD) and replicated thrice. Six fungicides (treatments) were tested at producer recommend concentrations viz. Man 80WP (Mancozeb), Coc 85WP (Copper oxychloride), Norshield 58WP (Cuprous oxide), Viroval 50WP (Iprodione), Daconil 75WP (Chlorothalonil), Biogreen (Oligo-chitosan) along with control treatment. Similarly, for Fusarium equiseti, eight fungicides viz. Nativo 750WG (Tebuconazole + Trifloxystrobin), Phytocide 50WP (Dimethomorph), Amistar Top (Azoxystrobin + Difenoconazole), Aliette 80WP (Fosetyl Aluminium), Amistar 250SC (Azoxystrobin), Ridomil 68WP (Mancozeb + Metalaxyl), Score 250EC (Difenoconazole), Funomyl 50WP (Benomyl) and control (no treated) were tested for disease control.

Statistical analysis of data

Data were subjected to statistical analysis after proper transformation wherever required as described by Gomez and Gomez (1984).

Results and discussion

Isolation and identification of pathogen

Among 40 samples collected and isolated from infested cladode at Tiengiang and Longan provinces, there were three different fungi species associated with disease: Bipolaris sp., Fusarium sp. and Alternaria sp. However, out of them, the two of Bipolaris sp. and Fusarium sp. appeared with high proportion in PDA culture, whereas Alternaria sp. was only negligible appearance (Table 1).

Morphology identification

These isolates were confirmed as Bipolaris crustacea Shoemaker and Fusarium equiseti based on the morphological and cultural characteristics of the anamorph (Table 1). The morphological characteristics of Bipolaris crustacea examined were very similar to those reported by previous workers (Luttrell, 1963; Alcorn, 1983; Sivanesan, 1987; Alcorn, 1990; Barnett and Hunter, 1998; Nelson et al., 1983).

Pathogencity test

All of the two isolates tested were virulent on dragon fruit (Hylocereus undatus) both nethouse and in the field. Characteristic spots were noticed on the cladode inoculated with mycelium 5 days after treatment. Scabs were brown spot symptom with yellow halo which were induced on cladode surface of the plants after inoculation with the isolates were similar to those observed in the field (Table 3).

Sequence of 28S rRNA gene of Bipolaris sp. and Fusarium sp.

The sequences of 28S rRNA gene of Bipolaris sp. and Fusarium sp. revealed 188bp and 179bp rDNA sequence, respectively and when we made BLAST SEARCH from the gen bank on NCBI, the results revealed that Bipolaris sp. and Fusarium sp. rDNA was identified as Bipolaris crustacea and Fusarium equiseti with up to 99% and 100% respectively.

The identities with Bipolaris crustacea started bp of 409 to bp of 596 and only one bp different at bp number 503 (disappear). However, the identities with Fusarium equiseti started bp of 1030 to bp of 852. (Fig. 1)

Evaluation of effective of antagonisms again pathogens

The result from Table 4 showed that among the antagonisms, at 7 day after incubated (D.A.I) Trichoderma sp. recorded maximum inhibition of mycelium growth of *B. crustacea* (80.27%) which differed significantly with the other antagonisms followed by B. subtillis (45.63%). The antagonistic of Trichoderma was increased and most powerful in among biological agents in experimental at all observation periods. However, B. subtillis recorded as moderate antagonist in reducing mycelium growth of *B. crustacea* (Soleimani et al., 2005, Gomathinayagam et al., 2010).

At two days after incubation, there were no significantly influenced in inhibited mycelium growth of *F. equiseti*, except in case of B. subtillis (15.25%). However, up to 3 to 6D.A.I, Trichoderma was determined as the best treatment in checking mycelium growth of *F. equiseti* (75.33% at 6D.A.I). Similarly, B. subtillis was at par and higher significantly inhibited than other bacterial isolates (Table 5).

Evaluation of effective of fungicides against pathogens

Data presented in Table 6 revealed that all the fungicides tested in laboratory showed the fungicidal activity against *B. crustacea*, except in case of Biogreen. Nevertheless, Man and Viroval proved highly toxic and showed no fungal growth thereby indicating 100 per cent inhibition at all observation periods. Norshield, Super Cook and Daconil were determined as next best fungicides with 95.03, 82.17 and 68.12 per cent mycelial growth inhibition at 7D.A.I, respectively. This present findings are in accordance with many earlier research works (Percich and Huot, 1989; Moletti et al., 1993).

Similary, the significant differences and maximum in inhibition of *F. equiseti* mycelium growth were recorded with Nativo, Aliette and Ridomil (100%) as compared to others at all observation periods. It was followed by Score (94.74%) which was at par with Amistar top (87.63%), Phytocide (70.44%) and Funomyl (70.30%) at 6 day after incubation (Table 7). The results are more similar in agreement with many earlier research papers (Cromey et al., 2002; Kopacki and Wagner, 2006; Chandel and Deepika, 2010).

Conclusion

Isolations of yellow cladode – brown spot were identified and that *B. crustacea* and *F. equiseti* which were the main organisms related with the disease. All tests of biological agents inhibited mycelium growth of the fungus *B. crustacea* and *F. equiseti* in the laboratory, specialy the SOFRI-Trichoderma gave highest ability of inhibition against both of *B. crustacea* and *F. equiseti* under in vitro conditions. Treatments of Man 80WP and Viroval 50WP completely inhibited *B. crustacea*, whereas Ridomil 68WP, Aliette 80WP and Nativo 750WG proved highly effective (100%) to *F. equiseti*, followed by Score 250EC. For further research should be confirm these results to fields as well as make the problems clear with the studies on abiotic factors (light, temperature, radiation) which are effectively stimulating develop of pathogen or not.

TABLES

Table 1. Fungi isolated from diseased samples

Collection areas	Fungus appearance frequencies (%)		
	Bipolaris sp.	Fusarium sp.	Alternaria sp.
Tiengiang (Chogao dist.)	62,0	68,0	5.0
Longan (Chauthanh dist.)	45.0	50.0	10.0

Table 2. Morphology characteristics of isolated fungus

Isolates	Conidia			
	Morphology	Color	Dimension (µm)	Septation
Bipolaris sp.	Elliptical, straight or curved,	Yellow brown, yellow	19.56 4.97 x 9.3 1.46	1-4 septates (commonly 2-3 septate)
Fusarium sp.	Oval to comma-shaped	White/PDA, tan to brown	17.5 6.06 x 4.58 2.68	1-4 septates (commonly 2-4 septate)

Table 3. Proportion of scab formation after artificial incubated

Isolated fungus	Scab formation (%)	
	Nethouse	Field
Bipolaris sp.	56.25	62.50
Fusarium sp.	52.08	60.42

Table 4. Effective of antagonist against *B. crustacean*

Treatments	Percent inhibition (%)					
	2D.A.I	3 D.A.I	4 D.A.I	5 D.A.I	6 D.A.I	7 D.A.I
B. subtillis	6.19c	24.50b	37.66b	36.60b	35.41b	45.63b
B. megaterium	3.09d	8.17d	17.49d	26.04c	29.17c	32.67d
P. flourescent 8	15.47b	13.60c	29.57c	38.11b	33.76b	40.83c
SOFRI-Trichoderma	24.75a	35.37a	68.58a	73.55a	77.01a	80.27a
CV (%)	1.13	2.08	2.84	2.89	1.95	1.87
LSD (0,01)	0.45	1.13	2.23	2.04	1.67	1.70

D.A.I: Day after innoculated.Values in the same column followed by the same letter were not statistically significant. Ogrinal data were converted to arcsin before analysis.

Table 5. Effective of antagonist against *F. equiseti*

Treatments	Percent inhibition (%)					
	1 D.A.I	2 D.A.I	3 D.A.I	4 D.A.I	5 D.A.I	6 D.A.I
B. subtillis	15.16a	15.25a	19.77b	30.79b	37.44b	53.00b
B. megaterium	18.24a	12.20b	16.20c	38.15d	30.95c	48.50c
P. flourescent 8	15.16a	12.20b	15.82c	25.33e	26.23d	44.67d
SOFRI-Trichoderma	7.58b	12.20b	42.29a	59.67a	66.82a	75.33a
CV (%)	8.42	1.47	1.5	1.04	1.23	0.82
LSD (0,01)	2.66	0.44	0.61	0.57	0.69	0.57

D.A.I: Day after innoculated.Values in the same column followed by the same letter were not statistically significant. Ogrinal data were converted to arcsin before analysis.

Table 6. Effect of some fungicides against *B. crustacean*

Sr.no	Treatments	Percent inhibition (%)						
		1D.A.I	2D.A.I	3D.A.I	4D.A.I	5D.A.I	6D.A.I	7D.A.I
1	Man	100a	100a	100a	100a	100a	100a	100a
2	Super Cook	89.74b	84.90c	84.62c	80.25c	81.88c	81.34c	82.17b
3	Norshield	89.74b	93.04b	93.68b	94.08b	94.70b	94.77b	95.03a
4	Viroval	100a	100a	100a	100a	100a	100a	100a
5	Daconil	100a	87.44c	84.82c	77.20c	76.25d	73.80d	68.12b
6	Biogreen	0.0c	0.0d	0.0d	0.0d	1.33e	1.89e	9.35c
	CV (%)	3.68	3.89	2.67	4.20	2.81	3.11	7.21
	LSD0,01	5.24	5.29	3.60	5.55	3.74	4.13	9.68

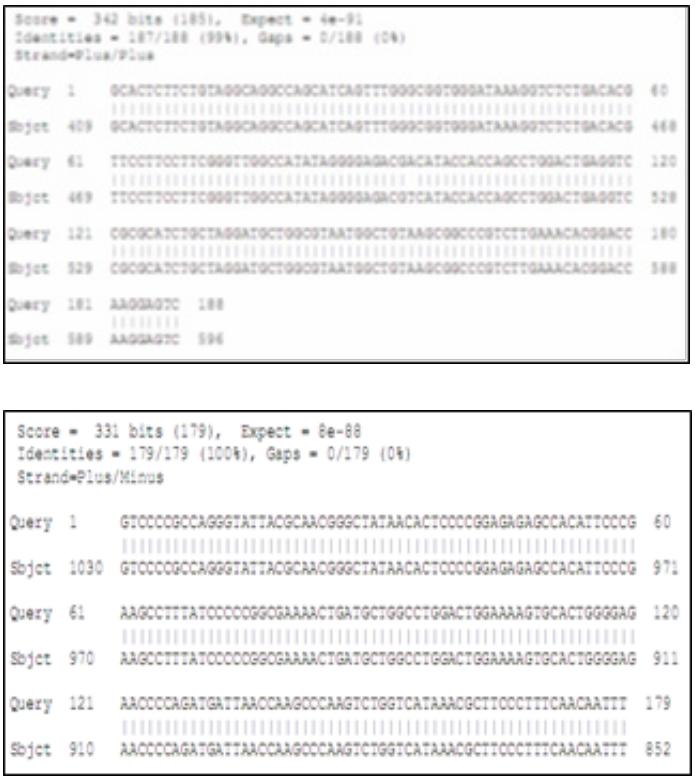
D.A.I: Day after innoculated.Values in the same column followed by the same letter were not statistically significant. Ogrinal data were converted to arcsin before analysis.

Table 7. Effect of some fungicides against *F. equiseti*

Sr.no	Treatments	Percent inhibition (%)					
		1D.A.I	2D.A.I	3D.A.I	4D.A.I	5 D.A.I	6D.A.I
1	Nativo	100a	100a	100a	100a	100a	100a
2	Phytocide	45.80c	51.99e	61.90e	73.82d	73.83e	70.44d
3	Amistar Top	95.59a	84.87c	89.25c	90.49c	87.76c	87.63c
4	Aliette	100a	100a	100a	100a	100a	100a
5	Amistar	71.08b	47.20e	62.54e	61.62e	63.04f	64.96e
6	Ridomil	100a	100a	100a	100a	100a	100a
7	Score	100a	87.55b	92.10b	92.05b	93.37b	94.74b
8	Funomyl	94.61a	62.40d	71.25d	76.12d	77.19d	70.30d
	CV (%)	10.67	5.21	2.46	2.10	1.63	1.28
	LSD0,01	9.14	3.92	1.93	1.67	1.29	1.20

FIGURE

Figure 1. Sequence of 28S rRNA gene of *Bipolaris sp.* and *Fusarium sp.*



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KING MANDARIN RATED AS A SUPERFRUIT IN SOUTHERN VIETNAM BY THE INTRODUCTION OF TREE TRAINING AND PRUNING

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ABSTRACT

King mandarin (*Citrus nobilis*) is one of the most popular fruits in southern Vietnam, where trees are planted in 1.0 to 1.5 m from each other (ca. 5000 per 1 ha). This planting condition does not allow the tree canopy to expand horizontally, resulting in broom-shaped crowns that intersect. The touching of crowns renders the vector of huanglongbing, *Diaphorina citri,* to move between trees easily, in turn leading the disease to sweep the orchard in a short time. The JICA-SOFRI project in this region introduced the following techniques that may reduce the frequency of vector moving, mitigate the severity of the disease effects and render participant growers to be economically independent from producing fruits of the cultivar: 1) trees are planted in a distance of 4.0 m; 2) vegetative branches are bent at about 45 degrees perpendicularly to gravity. In one case, the average tree growth reached 1.7 m wide and 1.3 m high in the first year, and 3.5 m and 2.0 m in the second year. The first harvest was attained 26 months after the planting, reaching 15 to 20 kg per tree. The techniques evidently mitigated the severity of the disease effects and rendered the growers to be economically independent from the income of fruits of the cultivar. This yield is almost equivalent to the highest harvest using traditional cultivation. The project further introduces interplanting guava (*Psidium guajava*), with expectations of both the reducible effects of the guava tree on the vector invasion and extra income from guavas. Thus, king mandarin can be superfruit in southern Vietnam from the viewpoint of the yield increased by the techniques.

PAPER

Introduction

Mandarin and orange production in Vietnam is soaring annuall, reaching 740 thousand tons in 2010 (General Statistics Office, 2011). King mandarin is one of the most important citrus cultivar in southern Vietnam, where trees were planted in 1.0 to 1.5m traditionally, rendering about 5000 trees per 1 ha. Due to the crowded conditions in the planting of trees, traditional cultivation does not allow citrus trees to expand their branches horizontally, and their canopies touch and cross each other. Consequently, the tree is likely to become broom-shaped. Such tree growth would often result in low quality of fruits. For the avoidance of the exacerbation of tree growth, planting distance and regulation of tree growth by pruning and training have been optimised through the long history of citrus cultivation in Japan, since the import of citrus from China around 1500 years ago (Nesumi 2002). These techniques are still being developed. Representative techniques, particularly tree training in the early stage, often significantly influence the future yield. The fruit yield in Satsuma mandarin is correlated to the extent of the canopy enlargement by training during the young stage of tree (Yahata et al. 2005). This means expanding of the canopy on non-bearing stage is important in the planning of the productivity in later stages of the tree. Furukawa et al. (2011) attempted to optimise the yield on 4 years old tree by the tree-training of new branches of young trees of Satsuma mandarin when they were younger.

From the viewpoint of transmissible disease by insect vectors, such high densities that tree canopies are crossed with each other may facilitate vectors to move between hosts more frequently and would result in more rapid expansion of the disease in the orchard. This seems to be the case of citrus greening or Huanglongbing (HLB) that is transmitted by the Asian citrus psyllid, Diaphorina citri. HLB is the most destructive disease of the citrus industry (Bové, 2006) and no decisive controls of this disease have not been established yet (Halbert & Manjunath 2004; Gottwald 2010). The current managements for HLB

consists of 1) the sanitation of the planting location by the elimination of HLB inoculum (e.g. vectors and HLB reservoirs such as Murraya paniculata) both in and around the place before the planting of new trees that are produced under both vector- and HLB-free conditions in nursery and the periodical use of pesticides thereafter for the effective reduction in the risk of disease invasion via the control of the vector (Belasque Jr et al. 2010; Halbert & Manjunath 2004; Iwanami et al. 2013).

In Vietnam, HLB was spread widely since 1995 (Bové et al., 1996), and the disease has threatened the citrus industry of this country. Southern Horticultural Research Institute (SOFRI) and Japan International Research Centre for Agricultural Sciences (JIRCAS) carried out collaborative research for the establishment of HLB management for king mandarin in southern Vietnam (Chau et al., 2011). The results in the project contributed to the establishment of new techniques that were incorporated into the management of HLB as an integrated pest management, IPM (JIRCAS, 2011). Following the IPM, in October 2009 the Japan International Cooperation Agency (JICA) launched a project in which the establishment of the extension system for transferring of appropriate cultivation techniques of king mandarin to citrus farmers is attempted in five provinces of southern Vietnam. In this paper, we report the efficacy of pruning and tree-training techniques for the increase in the yield of King mandarin under severe HLB conditions.

Materials and methods

Farm location

King mandarin trees were planted in farms in Tam Binh in Vinh Long province (farm A and B), Mo Cai Bac in Ben Tre (farm C, D and E) and Ke Sach in Soc Trang (farm F). All of these farms were located in southern Vietnam. In each farm, ledges of 8 to 9 m width were constructed, which were divided by irrigation channels of 2 m width. Two planting lines were set at a 4 to 5 m distance on each ledge, where planting mounds were made every 4 m. Every farm has different HLB inoculum conditions on their surroundings. Farm A was bordered with king mandarin orchards on the sides of north, east and west, and farm B located in paddy field area on the edges of or near which a few lime (C. aurantifolia) or pomelo (C. maxima) trees existed. Farm C was surrounded by coconut trees (Cocos nucifece), and king mandarin trees infected by HLB were cultivated on the west side. In Farm D, coconut trees were planted as windbreak vegetation, and its east side was shared with a citrus farm in which HLB management was carried out. Farm E surrounded by coconut palm had pomelo trees that had been cut off six months after its preparation. On the margins of Farm F, Nippa palm (Nypa fruticans) trees were planted as windbreak.

Plant preparation

Trees used for the JICA project all were produced either at SOFRI or the nursery centre of Vinh Long, using Volkamer lemon (C. volkameriana) for rootstock. No HLB-infested trees were detected from all King mandarin trees by DNA polymerase chain reaction (PCR) analysis, which was performed before planting. Each tree was subjected to the application of 0.2g imidacloprid (Admire 050EC; Bayer CropScience, Leverkusen, Germany) around its trunk on the soil surface on the pot by soil-drenching method 10 days before the planting.

Planting of trees

Trees, mostly about 70 cm high, were planted on soil mounds in farm A and B on 18th February 2010 and in the rest farms on 25th November to 26th December 2010. Each tree was tied on a stick at its rootstock with rope to be resistant against swinging, especially by blowing. The tree was then bent at or cut back to 30 cm above the joint between the scion and rootstock. These procedures were finished on the planting day. Two months later, bimonthly application of 0.2g imidacloprid around the trunk on the ground surface was started, and this application was continued for one year thereafter. Then, the application mode was changed for monthly application of Admire 050EC (0.2 g/tree) by foliar spray. Monthly application of 30g synthetic fertilizer (20N-20P-16K+TE) per tree was carried out for one year, and the dose was increased to 90g in the second year and 150g from later on. Every six months from the planting year, 10kg organic fertilizer, 0.5kg phosphate and 0.3kg magnesia-lime were given to each tree.

Tree form managements

When the first flush of shoots appeared on young trees, usually a month after planting, all but three shoots

were removed from each tree. This treatment was done to make the tree canopy open-centre-form. The remained three shoots were reared to grow into the main branches. When these branches reached about 60cm length, they were bent at the base on the main trunk down about 45 degree with vinyl rope. Mostly it was about six months after the planting. Likewise, other vegetative shoots were bent down when needed. The first three branches would be finally grown as primary scaffold branches and other branches bent later would become second scaffold branches.

HLB examination

Five matured leaf samples were collected randomly from each tree every six months. Any leaves on which any suspected symptoms of HLB were found were selectively collected. These leaves were tested for the detection of the HLB pathogen by PCR (Kawabe et al. 2006).

Data collection

In each farm, about 30% trees were randomly selected and the following observations were made: tree height (H) and the major and minor axes (Mj and Mi, respectively) of the canopy were measured every three to four months; and trunk diameter was measured 5cm above the grafted joint. The vegetative volume of the measured trees (V) was calculated by the formula (Institute of Fruit Tree Science, 1987):

$V = 0.7 \times H \times Mj \times Mi$

Fruit yield was estimated from questionnaires to participant growers.

Results and discussion

The means of tree height ranged from 139.2cm to 141.7cm and its widths were 171.3cm to 210.6cm in the first year. In the second year, these values increased and 180.5cm to 203.7cm and 247.7cm to 348.0cm (Fig.1). Tree volumes reached 2.0m3 to 6.3 m3 and 3.7m3 to 16.2 m3 in the second year (Fig.2). Canopy width, tree volume and trunk diameter in traditional orchard were smaller than those in the project farms (Data not shown).

The mean proportion of HLB-infested trees was less than 2.0 % in the first year in each farm (Fig.3). The proportion was increasing gradually with time after the second year. In one farm, the proportion reached more than 20% in two years, but was still less than 10% in the other farms. The proportions in two years after planting were much lower than those in farms managed by the traditional cultivation which often led the HLB-infestation proportion to reach 20 to 50 % in two years (pers. observ.). The proportions of infested trees in three years were 55.7% in one farm and 13.2% in another. In farms with the traditional managements, the proportion usually reached 100 % in three years. Compared with these observations, the HLB-infestation was still smaller in the project farm. The differences in these proportions between farms are still unknown. Analyses of the observations would contribute to further improve the techniques used for this project.

The purpose of pruning and tree-training techniques is to provide high and stable fruit yield and improvement of work efficiency in orchard (Iwahori & Kadoya 1999). Iwagaki (1981) mentioned the attributes of selective hand pruning that is practiced in most mandarin orchards in Japan: 1) the small size of farms afford growers to pay careful attention for individual trees, 2) a beautiful fruit appearance and large fruit size as well as high internal fruit quality can be expected, and 3) a simple and strong branch framework is necessary not only to maintain the vegetative strength of the mandarin trees but also to facilitate the cultural practices are conducted in or on the tree canopy. Open centre form with using hand pruning and training is the most popular for the citrus in Japan. Daito et al. (1981) obtained that yield and trunk growth on open centre form are better than hedgerow form in Satsuma mandarin.

In southern Vietnam, king mandarin has been traditionally preferably cultivated with such high tree densities that farmers expect to gain earlier yield from them. The tree is rarely bent, resulting in higher trees the top of which foliar spray would not be reached within three years after the planting. This is likely to provide insecticide-free space on the tree for pests, including citrus psyllids, the vector of HLB. This condition in turn eases the spread of HLB both within the orchard and between it and surrounding ones. In contrast, king mandarin trees in our project farms have lower and wider tree size than those on traditional farms. The

management seems to lead both higher yield and lower HLB infestation. For example one grower attained 17.3kg fruit yield per tree for the first harvest in second year, when the HLB-infested proportion was seemingly 20% or less by visual inspection. In another, the first harvest was 14.7kg and < 10% infestation proportion. These results of our project suggest a long-lasting life of King mandarin tree under the severe HLB conditions, as well as the implementation of yield by tree-training. Thus, King mandarin can be one of a superfruit in southern Vietnam.

Acknowledgements

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FIGURES

Fig.1. Means (minimum - maximum) of height (left) and major axis (right) of canopy of trees of King mandarin in the farms that participated in the JICA project in southern Vietnam.

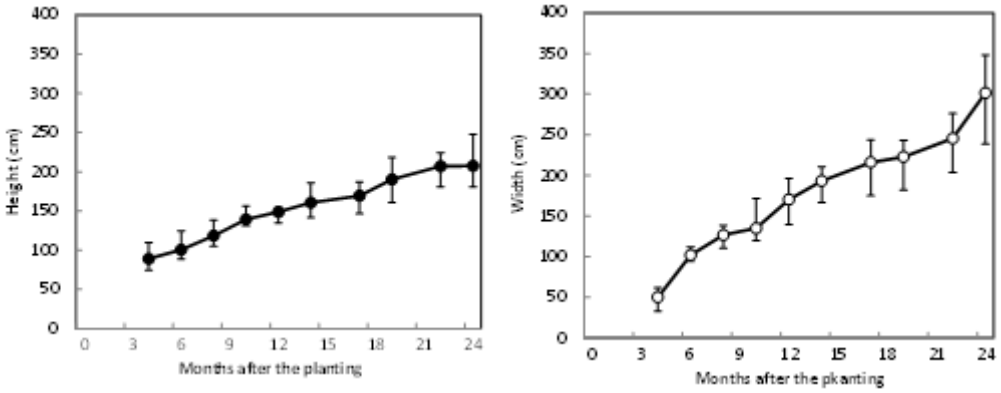


Fig.2.The volume of the tree was calculated by the formula (1), shown in the lower left.The diameter of tree trunk is shown in lower right.Vertical bar represent maximum and minimum.

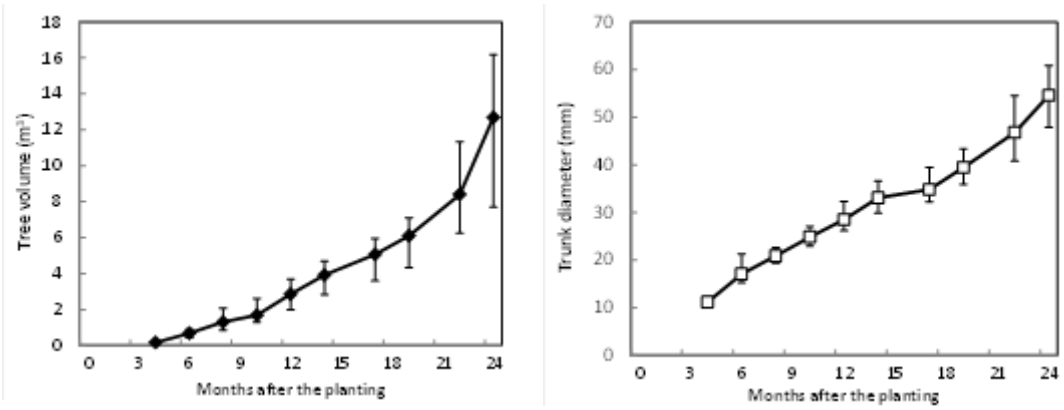
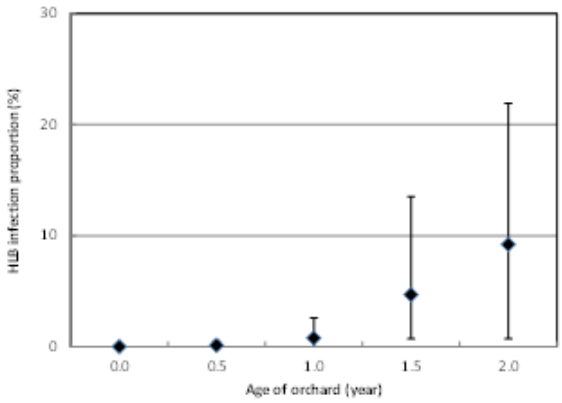


Fig. 3. The mean (minimum to maximum) of the proportion of infested trees in the project farms.



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PARALLEL SESSION THREE – SELECTION, POSTHARVEST, PEST AND DISEASE MANAGEMENT AND PROCESSING OF POTENTIAL SUPERFRUITS

EVALUATION AND SELECTION OF EARLY LYCHEE CULTIVARS IN VIETNAM

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ABSTRACT

Lychee (*Litchi chinensis* Sonn.) is sub-tropical fruit that has high nutritional and economic value. In Vietnam, lychee is mainly cultivated in the northern part with total production area of 88,900 ha in 2012, producing 428,900 tons of fresh fruit. Most plants ripen concurrently for about 30 days in June. Large quantities of production in a short period caused difficulties in harvesting, storage and consumption, leading to significant postharvest damage, low market price and poor economic efficiency.

To extend harvesting time to 45-60 days to facilitate farmers in harvesting, storage, consumption and enhance economic efficiency, the Fruit and Vegetable Research Institute conducted a survey and implemented selections of early cultivars in 2005-2012. The result showed that in 28 lychee cultivars in the north of Vietnam, there are four cultivars that ripen 15-30 days earlier such as Hung Long, Binh Khe, Yen Hung and Yen Phu. Fruit quality is good, weighing 23.4-33.5 g per fruit, with a flesh percentage of 71.5-73.1%, and yield of 84.8-92.8 kg per tree.

These early cultivars have been recommended to large scale production, with 5.7% of the total in 2008 to 15.0% in 2012 and generating high economic profit to grower.

PAPER

Introduction

Litchi (*Litchi chinensis* Sonn.) is an important subtropical fruit crop in the world with high nutritional and economic value and is regarded as a sedative to treat headaches and insomnia.

In Vietnam, litchi is mainly grown in the Northern provinces with an area of 88,900 ha in 2012, producing 428,900 tons. However, 90% of the fruit grow varieties that ripen at a concentrated harvesting time of 30 days every June. Harvest, storage and distribution (including exports and domestic consumption) face difficulties, high postharvest losses and low price, leading to its low economic efficiency.

In 2005-2012, the Fruit and Vegetable Research Institute has focused on the investigation and selection of early litchi varieties with targets of high yield, early maturity and good quality. Through the evaluation of morphological characteristics, growth potential and adaptability of early litchi varieties in different ecological areas, Hung Long, Binh Khe, Hung Yen, Yen Phu early litchi varieties have been selected.

The cultivation area of the early litchi varieties increased by 5.7% in 2008 and 15.0% in 2012, prolonging harvesting time, facilitating harvesting, processing, distribution and improving economic efficiency for producers.

Materials and methods

Materials

Materials include litchi collections grown in local areas and the Fruit and Vegetable Research Institute.

Methods

Early litchi varieties were selected from 8 major litchi producing provinces of Northern Vietnam as Ha Tay, Ha Nam, Hai Duong, Phu Tho, Quang Ninh, Hoa Binh, Bac Giang and Hung Yen. After 3 years of evaluation in the selected areas and selection of elite trees, propagation from these trees was carried with experiments on evaluation and variety comparison.

Experiments on evaluation of growth characteristics, yield, and quality was designed sequentially on the available experimental orchards with the 8-year-old trees, propagated by grafting, and arranged in the experiments in the same conditions.

Results and discussion

Evaluation of current situation of litchi cultivation in Vietnam

Area under litchi cultivation in Vietnam reached 88,900 hectares in 2011 with production of 428,900 tons (accounting for 32.9% and 24.8% of the respective fruit area and production in the North of Vietnam). The concentrated litchi production area includes Bac Giang, Quang Ninh, Hai Duong, Thai Nguyen. Particularly, Bac Giang province is the largest litchi province with an area of 39,835 ha and production 228,558 tons accounting for 44.8% and 53.3%, of the whole country, respectively. These are the main litchi production regions due to favorable soil and climate conditions forlitchi growth and development. (Table 1)

Although Vietnam has a large area for litchi cultivation and production in the world, the cultivated varieties are the main commercial ones, while early varieties account for only small area (5.7% in 2008 and 15% in 2012) and yield (3.7% in 2008 and 12.5% in 2012). The increased area of early litchi varieties is resulted from the variety evaluation and selection, contributing to solving problems of too concentrated harvesting time, pressing on labor, distribution, high post-harvest losses and low economic efficiency (Table 2).

Results of survey, evaluation of early litchi varieties

Results of early litchi variety survey

Survey results in period of 2005-2008 had identified 30 litchi varieties planted in 8 main Northern provinces including Ha Tay: 15 varieties, Ha Nam: 5 varieties, Hai Duong, Bac Giang, Quang Ninh and Hoa Binh provinces: 2 varieties each, Phu Tho, Hung Yen: 1 variety each (Table 3).

Of the surveyed varieties in the North of Vietnam, there were only 2 main litchi varieties (Thieu Thanh Ha and Thieu Luc Ngan) and 28 early varieties. This is the specious material source for breeding litchi varieties towards prolonging harvesting time.

Results of elite tree evaluation of early litchi varieties

In the 2nd year evaluation of early litchi varieties at growing locations, based on the ability of the growth, yield, quality and resistance to pests and diseases, 14 varieties were selected out of 28. Growth, yield and quality of each variety are presented in Table 4.

In the 3rd year evaluation of elite trees, the 7 of the 14 elite trees that were selected are Binh Khe (VBK.25) ; Duong Phen (VHT.05); Hung Long (VPH.10); Thach Binh (VPH.31); Yen Hung (VQN.09); Yen Phu (VHY.15); Phuc Hoa (VPH.40), characterized by large fruit weight (from 23.08 to 33.5 g / fruit), edible rate of 65.35 to 74.5%; brix of 16.5 to 18.6%, and moderate to high yield depending on the age of the tree height (Table 5).

Evaluation results of agronomic characteristics

To have the accurate evaluation of the characteristics of the varieties for breeding purposes, experiments on evaluation of growth, development of the varieties were designed on trees propagated by grafting (propagated from the elite trees above), with the same age, the same soil conditions and climate.

The variety with good growth in terms of tree height is Yen Hung (219.3 cm), while Binh Khe variety had the highest canopy diameter (309.5 cm). The remaining varieties: Duong Phen, Thach Binh, Phu Yen, Phuc Hoa had tree height of 234.8cm-264.2cm, canopy diameter of 224cm-277cm. In general, early litchi varieties had much better growth than Thieu Thanh Ha variety (main commercial variety) for both tree height and canopy diameter (Table 6).

The selected early litchi varieties had the higher total flowers/cluster than Thieu Thanh Ha one. Binh Khe variety produced the biggest number of flowers at 3,758.4 flowers/cluster.

The remaining varieties had the 2 - 3 times higher flowers than Thieu Thanh Ha.

Observation of the number of female flowers and hermaphrodite flowers showed that of the early litchi varieties, Binh Khe variety had the highest number of female and hermaphrodite flowers (503.1 flowers/ clusters), followed by Hung Yen variety (337.7 flowers/ clusters). This figure for Phuc Hoa, Phu Yen varieties ranged from 226.9 to 319.6 flowers/ clusters similar to Hung Long variety at 238.7 flowers/cluster. The varieties with low proportion of female and hermaphrodite flowers included Duong Phen, Thach Binh which is only slightly higher than Thieu Thanh Ha variety (Table 7).

Fruit setting rate of early litchi varieties ranged from 0.17- 0.49%. The highest fruit setting percentage was given by Yen Phu variety (0.49%) and the lowest was given by Binh Khe variety (0.17%). The remaining varieties had higher fruit setting percentage than Thieu Thanh Ha (Table 8).

Results showed that both theoretial yield and actual yield of Binh Khe variety were the highest (34.86 and 25.91 kg / tree, respectively), followed by Hung Yen and Yen Phu varieties at 27.48 kg / tree and 24.40 kg / tree, respectively (for Hung Yen one) and 29.50 kg/tree and 22.32 kg/tree (for Phu Yen one). Tthe remaining varieties had lower yield but higher than Thieu Thanh Ha one (Table 9).

In general, total sugars, total acidity, vitamin C, and dry matter were similar to or slightly lower than Thieu Thanh Ha, which is considered a good quality variety in Vietnam (Table 10).

The early litchi varieties gave high economic efficiency (the net return of from 16,869,000 to 61,763,000 VND/ha), higher than Thieu Thanh Ha variety (9,182,000 VND/ha). Of the selected varieties in the same selection, 4 varieties with the highest economic efficiency are Binh Khe variety: 61,763,000 VND/ ha, followed by Phu Yen variety: 56,459,000 VND / ha; Yen Hung variety: 39,265,000 VND/ha, and Hung Long variety: 24,319,000VND/ha (Table 11).

Hence, of 7 selected elite early litchi varieties, 4 varieties have good growth and high economic efficiency as Binh Khe, Hung Yen, Phu Yen and Hung Long. These varieties have been inlcuded in the production, increasing the proportion of area under early litchi culltivation varieties by 5.7% in 2008 and 15.0% in 2012. Annually, it brings high economic efficiency to producers through profits made from 24.3 to 61.7 million VND/ha.

Conclusion

Litchi area and production in Vietnam is relatively high compared to other litchi growing countries in the world, with area under cultivation of 88,900 ha in 2012, production of 428, 900 tons, but largely from main commercial litchi varieties. It is aimed at selecting early litchi varieties to prolong harvesting time, increasing area under early litchi cultivation by 15% in 2012

Early litchi variety collection in Northern Vietnam is very abundant and highy diverse. The investigation has collected 28 early litchi varieties in key litchi growing areas of Vietnam. This is an important material source for storage, evaluation and breeding activities.

Four early litchi varieties including Binh Khe, Hung Yen, Phu Yen and Hung Long were evaluated and selected to introduce to production. These varieties have good growth potential, high yield, good quality and harvested at 15-30 days earlier than the main varieties, bringing high economic benefits to growers.

TABLES

Table 1. Situation of litchi cultivation in some major provinces in 2011

IV. Region	Area (ha)	Percentage (%)	Harvested area (ha)	Yield (Quintal/ha)	Production (ton)
Bac Giang	39,835	44.81	39,238	58 .2	228,558
Hai Duong	14,219	8.41	12,634	37.7	47,632
Lang Son	7,473	7.72	5,501	23.1	12,684
Thai Nguyen	6,861	7.51	4,692	36.7	17,219
Quang Ninh	6,700	15.57	4,981	45.1	22,465
Other provinces	13,812	15.99	12,410	41.3	100,342
V. Whole Country	88,900	100.00	77,500	55.3	428,900

Source: GSO – 2011

Table 2. Area and production of litchi cultivation in Vietnam by years

Varieties	2008		2012	
	Area (ha)	Production (tons)	Area (ha)	Production (tons)
Early	386.7	11,438.3	13,330.0	53,612.5
Main	67,844.0	309,153.0	88,900.0	428,900.0
Rate of early/main (%)	5.7	3.7	15.0	12.5

Table 3. List of early litchi varieties in Vietnam

TT	Survey location (Province)	Number of surveyed trees	Number of collected varieites	Name of variety
1	Hà Tây	1,050	15	Bánh Trôi, Đường Phèn, Dừa, Lục, Vàng Anh, Cánh Trả, Lọng Vàng, Hoàng Bào, Lai Đồng Quang, Ớt, Bầu Đất, Mít Dai, Ông Thiệu, Sung, Nhọ Nồi.
2	Hà Nam	5,489	5	Do Lễ, Bộp, Chín Trắng, Nghệ, Thạch Bình.
3	Hải Dương	6,500	1	Lai Thanh Hà.
4	Phú Thọ	4,200	1	Hùng Long.
5	Quảng Ninh	32,600	2	Yên Hưng, Bình Khê
6	Hòa Bình	315	2	Lai Lương Sơn, Lai Liên Sơn
7	Bắc Giang	10,300	1	Phúc Hòa.
8	Hưng Yên	350	1	Yên Phú.
	Total	60,804	28	

Table 4. Characteristics of elite trees of selected varieties

No	Varieties	Tree code	Tree height (Year)	Everage yield of 3 years (kg/ tree)	Fruit weight (g)	Pulp rate (%)	Brix (%)	Harvesting time
1	Lai Lương Sơn	VLS.11	45	37.5	24.74	62.16	15.2	15/5-20/5
2	Lai Liên Sơn	VLS.16	40	65.5	17.38	56.38	14.6	15/5-20/5
3	Bánh Trôi	VHT.06	95	98.5	21.40	42.84	13.7	20/4-1/5
4	Đường Phèn	VNT.05	105	104.3	23.61	65.35	15.8	20/4-1/5
5	Lục	VHT.07	95	95.5	21.28	38.90	14.5	20/4-1/5
6	Vàng Anh	VHT.08	95	86.4	22.67	46.20	14.2	20/4-1/5
7	Do Lễ	VHN.12	95	90.5	24.53	43.90	14.7	30/4-5/5
8	Thạch Bình	VPH.31	28	82.3	24.50	70.50	16.5	15/5-20/5
9	Hùng Long	VPH.10	28	99.7	23.47	73.01	17.4	15/5-20/5
10	Lai Thanh Hà	VLTH.17	14	54.7	24.15	70.43	17.2	15/5-20/5
11	Yên Phú	VYP.15	45	85.6	27.20	74.50	18.6	10/5-15/5
12	Phúc Hoà	VPH.40	50	89.8	23.08	71.88	17.5	15/5-20/5
13	Yên Hưng	VQN.09	19	62.1	30.10	73.20	17.8	15/5-20/5
14	Bình Khê	VBK.25	32	94.2	33.50	71.50	17.5	5 /5-10/5

Table 5. List of selected elite trees

No	Varieties	Tree code	Tree age (Year)	Everage yield of 3 years (kg/tree)	Fruit weight (g)	Pulp rate(%)	Brix (%)	Harvesting time
1	Đường Phèn	VHT.05	105	104.3	23.61	65.35	15.8	20/4-1/5
2	Thạch Bình	VPH.31	28	82.3	24.50	70.50	16.5	15/5-20/5
3	Hùng Long	VPH.10	28	99.7	23.47	73.01	17.4	15/5-20/5
4	Yên Phú	VYP.15	45	85.6	27.20	74.50	18.6	10/5-15/5
5	Phúc Hoà	VPH.40	50	89.8	23.08	71.88	17.5	15/5-20/5
6	Yên Hưng	VQN.09	19	62.1	30.10	73.20	17.8	15/5-20/5
7	Bình Khê	VBK.25	32	94.2	33.50	71.50	17.5	5 /5-10/5

Table 6. Growth of early litchi varieties

No	Varieties	Tree height (cm)	Plant diameter (cm)
1	Bình Khê	205.8	309.5
2	Đường Phèn	183.3	234.8
3	Thạch Bình	201.2	242.4
4	Yên Hưng	219.3	276.2
5	Yên Phú	201.4	224.1
6	Phúc Hoà	212.1	264.2
7	Hùng Long	209.3	277.2
8	Thiều Thanh Hà	161.5	172.4

Table 7. Flowering of early litchi varieties

No	Varieties	Total number of flowers / cluster	Male flowers		Female and hermaphrodite flowers	
			No of flowers	Percentage (%)	No of flowers	Percentage (%)
1	Bình Khê	3,758.4	3,255.3	86.61	503.1	13.39
2	Đ. Phèn	2,196.4	2,026.8	92.28	169.6	7.72
3	Thạch Bình	2,186.4	2,044.1	93.50	142.3	6.50
4	Yên Hưng	2,719.0	2,381.3	87.58	337.7	12.42
5	Yên Phú	1,688.7	1,369.1	81.10	319.6	18.90
6	Phúc Hoà	2,025.6	1,798.7	89.00	226.9	11.20
7	Hùng Long	2,832.5	2,593.8	91.57	238.7	8.43
8	T.T. Hà	1,057.5	940.60	82.23	116.9	11.10

Table 8. Fruit setting percentage of early litchi varieties

No	Varieties	Total number of flowers (flowers/cluster)	Number of set fruit (fruits/clusters)	Fruit setting percentage (%)
1	Bình Khê	3,758.4	6.3	0.17
2	Đường Phèn	2,196.4	5.8	0.26
3	Thạch Bình	2,186.4	5.2	0.24
4	Yên Hưng	2,719.0	7.2	0.26
5	Yên Phú	1,688.7	8.4	0.49
6	Phúc Hoà	2,025.6	6.3	0.31
7	Hùng Long	2,832.5	6.2	0.2l
8	Thiều Thanh Hà	1,057.5	5.2	0.50

Table 9. Yield and yield components of early litchi varieties

No	Variety	No of clusters/ tree	No of fruits/ cluster	Fruit weight (g)	Theoretial yield (kg/ tree)	Actual yield (kg/ tree)	Harvesting time
1	Bình Khê	165.4c	6.3a	33.50d	34.86c	25.91b	5/5-10/5
2	Đường Phèn	144.7b	5.8a	23.61a	19.81a	16.20a	20/4-5/5
3	Thạch Bình	138.5a	5.2a	24.50a	17.64a	14.33a	15/5-20/5
4	Yên Hưng	126.0a	7.2b	30.10c	27.31b	24.40b	15/5-20/5
5	Yên Phú	129.1a	8.4c	27.20b	29.50bc	22.32b	10/5-15/5
6	Phúc Hoà	141.2b	6.3a	23.08a	20.53a	17.60a	15/5-20/5
7	Hùng Long	135.6a	6.2a	23.47a	19.73a	17.23a	15/5-20/5
8	T. Thanh Hà	127.2a	5.3a	20.70a	13.95a	11.50a	5/6-20/6
	CV(%)	5.7	11.3	6.1	13.8	11.7	

Table 10. Some criteria in fruit quality of early litchi varieties

No	Name of variety	TSS (%)	Total acidity (%)	Vitamin C (mg%)	Dry matter (%)
1	Bình Khê	16.5	0.31	26.3	17.3
2	Đường Phèn	12.3	0.38	29.8	14.9
3	Thạch Bình	13.1	0.26	18.4	15.8
4	Yên Hưng	15.2	0.37	21.3	16.7
5	Yên Phú	16.7	0.28	29.7	17.2
6	Phúc Hoà	13.8	0.22	15.8	16.1
7	Hùng Long	13.2	0.30	17.2	16.8
8	Thiều Thanh Hà	16.9	0.26	27.1	18.5

Table 11. Economic efficiency of some litchi varieties

Varieties	Tree age	Yield (kg/ tree)	Unit price (1.000d/kg)	Amount (1000d/ha)	Total expenditure (1.000 /ha)	Net return (1.000d/ha)
Bình Khê	5	23.91	12	79,763	18,000	61,763
Đường Phèn	5	16.20	8	36,028	15,000	21,028
Thạch Bình	5	14.33	8	31,869	15,000	16,869
Yên Hưng	5	24.40	8	54,265	15,000	39,265
Yên Phú	5	22.32	12	74,459	18,000	56,459
Phúc Hoà	5	17.60	8	39,142	15,000	23,142
Hùng Long	5	17.23	8	38,319	15,000	24,319
Thiều Thanh Hà	5	11.50	6	19,182	10,000	9,182

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SURVEY ON THE POSTHARVEST QUALITY AND MANAGEMENT OF DRAGON FRUITS EXPORTED FROM VIETNAM TO HOLLAND

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ABSTRACT

In order to improve the postharvest management of dragon fruit exported from Vietnam to Holland, a survey was conducted on the quality and temperature of dragon fruits from two trial containers. Commercially packed dragon fruit in 5 kg boxes were pre-cooled by placing in a commercial coldstore under a high air-flow cooled at about 14oC, approx 18 hours before loading while another was not pre-cooled. Both containers exported from a commercial packhouse at Binh Thuan, Vietnam to a packhouse at Rotterdam, Holland by sea. Temperature was set at 5°C, and the voyage took 25 days. Along with fruit and temperature observations, interviews with the managers for the exporting and importers companies were carried out.

Temperatures for the containers showed that boxes of dragon fruit pre-cooled before loading resulted in better quality in terms of freshly green color of bracts and a lower incidence of rots compared to the non-precooled fruit. Temperature of fruit recorded by dataloggers set at various locations in the non-precooled container indicated that temperature did not achieve the set temperature (5°C) and only reached 7°C after 5-7 days of loading, while in the precooled container, the temperature of fruit achieved 6°C in only 1-2 days of loading.

Result of the interviews showed that the present postharvest management practices (no precooling) would be acceptable in the dry season (mid November-beginning May), however, it would result in problems due to high rot incidence in the wet season when precooling is recommended.

PAPER

Introduction

Dragon fruit (*Hylocereus undatus*) is a key export fruit with a significant strategic importance of Vietnam. In recent years, the development of many dragon fruit production models that satisfied successfully the GAP standards has made the consumption market of Vietnam dragon fruits to have a considerably extension. From the two main markets i.e. China and Southeast Asian countries, Vietnam dragon fruit has penetrated to other markets such as the U.S. and European countries, where Holland has been considered as the main focal consumption in the European markets. Although the annual fruit export is relatively good growth, however, the competitiveness of Vietnam dragon fruit is poor due to a relatively high price and unstable quality at the consumption places. Therefore, to improve this problem, a survey on quality and postharvest management of fruit for each supply chain is essential.

Dragon fruit quality is basically based on the quality criteria described by Woolf et al., (2006). However, the fruit quality requirement may be different in various consumption markets, usually determined for each particular supply chain. Rejections of fruit at the market are partly due to improper postharvest management practices, in which, improper fruit temperature management is considered as a main cause of rot incidence that quickly deteriorates fruit quality. Temperature management is related to many factors like variety, season, optimum temperature and storage conditions etc. However, strict maintenance of the cold chain and the time-temperature relationships are the most important factors determining fruit quality (Vorster et al., 1990).

For the white flesh dragon fruit cultivar, Do Minh Hien and Nguyen Thanh Tung (2003) had reported that the optimal storage temperature of fruit was 5°C and under this storage temperature, the dragon fruit quality could be maintained up to 4 weeks of storage. However, under a condition of using low temperature conditionings prior to storage at 3oC, Nguyen Van Phong et al., (2010) showed that the fruit quality could be maintained upto 6-8 weeks after harvest. This indicate that the efficiency of temperature management has extremely important significance, the good temperature management regime the longer postharvest life with a low rot incidence of dragon fruit may be obtained. However, for a supply chain, the management efficacy of fruit quality, in general, and fruit temperature, in particular, only bring good results to through a realistic assessment survey on a practical supply chain. The objectives of this survey were to evaluate the quality and temperature of dragon fruit in two trial containers (non-precooled and precooled containers) and the issues related to postharvest management of fresh dragon fruits exported from Vietnam to Holland.

Materials and Methods

Survey locations

The packhouse of Queen Dragon Fruit company, Binh Thuan province, Vietnam was used for the survey on quality and postharvest handlings of fruit at the beginning of the supply chain.

The packhouse of TFC company, Rotterdam, Holland, was selected as the coming place of fruit, where had been considered as a main distribution node to consumers in Holland.

Survey on issues related quality management of fresh dragon fruit exported from Vietnam to Holland

This activity was done via observations and interviews at two survey places: the packhouse of Queen dragon fruit company, Binh Thuan province, Vietnam, where fruit was exported and the packhouse of TFC company, Rotterdam, Holland, where fruit was imported.

Observations included records/measurements of temperature and quality of fruit at main points from the two packhouses and the postharvest handling practices of fruits during packing, storage and transportation.

Based on the prepared questionnaire list, direct interviews with managers for both exporting and importers companies were carried out during the survey.

Survey on quality and temperature of dragon fruits in a transportation by sea from Vietnam to Holland

For this activity, two containers of dragon fruit were used for the survey.

For precooled containers, dragon fruits were commercially packed in 5kg boxes and stacked into pallets and placed in a commercial coldstore under a high air flow for 1.5-2 days before loading into a container.

For noncooled container, commercially packed dragon fruit in 5 kg boxes were stacked into pallets and placed in the commercial coolstore at a high air flow just for a few hours before loading into a container.

Fruit temperature was monitored by using dataloggers, set at pallets of dragon fruits during holding in a commercial coolstore and at various places in the containers exported by sea.

The containers departed from the packhouse, Binh Thuan, Vietnam and arrived to the packhouse, TFC Company, Rotterdam, Holland. Cursory evaluation was made at arrival. Fruits were then placed at ~20 °C for 4 days and external quality assessed.

Results and Discussions

Postharvest management of dragon fruit at the packhouse in Binh Thuan, Vietnam

Quality requirements of dragon fruits for export to Holland/Europe

Fruit must be collected from dragon orchards that obtained the certificate of GlobalGAP standard. Fruit quality has medium size with a fruit weigh of 400±50g, no defects, have firm green bracts and stems and the fruit skin is bright red color.

Postharvest handlings

Dragon fruits are harvested by hand and placed in 40kg plastic crates and transported to the packhouse by truck. In the packhouse, fruit is cut stem, trimmed and cleaned the blossoms, washed in clean water, soaked in Umikai solution and dried by fan before being packed in a perforated PE bag. Dragon fruits are packed in carton box (1 layer) (9 fruits / box), then temporarily stored in a coolstore at 2-10°C before loading into refrigerated container for export.

Temperature management

Temperature management is mostly not concerned by the packhouse. They only use the setting temperature on coolstore or container to control temperature of fruit during storage or transportation. Temperature and cooling rate at various places inside coolstore/container are not monitored. In addition, temporary storage time of fruit in the coolstore is mostly not determined and thus fruit temperature before loading into refrigerated container is not monitored.

Result of temperature monitoring of fruit in the commercial coolstore (capacity. 300 m3) of the packhouse, Binh Thuan

Monitoring fruit temperature was done by measuring temperature and cooling rate of fruit at three various sites as high air flow, medium air flow and low air flow. The results showed that temperature and cooling rate at different places in the coolstore are very different. Under these conditions, the fruit would neede long periods of storage to reach the setting temperature (Fig.1). From these results, the most practical solution to cool fruit after packing prior to shipping was simply to hold the boxes in a coolstore with high air flow near the evaporator fans for 2-3 days. Faster cooling (e.g. overnight) would require use of a forced-air or "precooling" system

TFC company and quality management activities on dragon fruits imported from Vietnam

Overview of situation from the Manager of the TFC company

TFC has developed a major market of dragon fruit in Holland supermarkets. During a "promotion week," they will use 24,000 boxes (small) at 4000 boxes per container. In total, there will be so 6 containers in a promotion week and one container in a non-promotion week. Most of the year, consignments encounter no problems, with a rejection rate of 1-10%. The key problem is fruit quality in the wet season (June – End Oct) that increases rejection rates from 35% up to 100%, at an average of 66%. Appearance upon receival is critical since even a pinprick sized rot will develop rapidly. Diseases have symptoms such as white spots on the fruit surface.

Fruit handling and quality management activities at the packhouse, TFC company

TFC importer is 15 km from port and the container arrives within a few hours of unloading from the ship. Fruits are taken out of container and palced into the main handling area with a temperature of 8-10°C. Fruits are unloaded by hand (about 5 people/container) by stacking onto pallets (by size) as boxes are not palletised in Vietnam. This takes at least 1.5 hours and results in box handling, and most likely, fruit damage. Quality control will carry out a quick fruit assessment to determine whether it will need re-packing or not. Pallets are put into a racked 3-layer coolstore, generally within an hour. Coolstore set at 2°C and have ethylene scrubbers.

Assessment of quality and temperature of dragon fruits from two trial containers (one precooled and another non-precooled)

Container temperature was set at 5±1°C. The voyage of the containers during shipping from Cat Lai port, Ho Chi Minh city to Rotterdam port, Holland lasted for 23 days. However, the voyage of fruit (from the harvest time to the arrival at TFC Company) was 25 days for dragon fruits in the non-precooled container and 27 days for dragon fruits in the precooled container.

Temperature of dragon fruits in containers was recorded by using dataloggers and expressed as shown in Fig.2. Results showed that the temperature of dragon fruits in non-precooled containers did not reached the set temperature (5°C), only reaching 7°C after 5-7 days of loading. In the precooled containers, the temperature of fruit reached 6°C in 1-2 days of loading. Therefore, precooling fruit may be one of the effective approaches to improve the control of fruit temperature inside the container.

Although fruit temperature between two containers was different, surprisingly, their external quality characteristics were not found to be considerably different, although this may have been due to grower effects (different growers / pack-lines in each container). Dramatic differences observed were in rot incidence and bract color. Fruit in the precooled container maintained the better green color of bract and had a low rotting rate (2.22%) as compared fruit in the non-precooled container, the bracts were yellowish and had higher rotting rate (4.44%) (Table 1). This result indicated that the proper temperature management can maintain the good quality of fruits but the postharvest life of precooled dragon fruits at the observation time was recorded longer (27 days) than non-prcooled fruit (25 days).

A key factor was that this survey was carried out when rot pressure was at a low level (less 5% for both cases showed in the table 1). That is to say, the wet season in Vietnam is the time when very poor fruit quality is observed in Holland. Thus, further trials are planned to be carried out in this period, which should yield significant differences in terms of rot incidence and out-turn quality.

Out of important information mentioned above, the survey recorded four main postharvest damages that occurr in the supply chain: yellowing of bract, typical rot symptoms, condensation on bag that lead to rotten tissue at stem end and browning burn of bract. Agents/causes of these symptoms were addressed in the table 2 and most of them were related to temperature management. Appearance of these symptoms showed that the current postharvest management practices of dragon fruit for this supply were not proper and it needs to be improved.

Conclusions

The present postharvest management practices would be acceptable in the dry season (mid November-beginning May). However, it would result in problems due to high rot incidence in the wet season.

Dragon fruit precooled before being loaded into the container would be better in controlling the temperature of fruit during shipping. The better temperature control helped the dragon fruits to keep the green color of bract and had a low rotting rate.

The air temperature in the container is always higher than 5°C, so the temperature of container should be set at 4°C. Dragon fruits should be precooled or held in a coldstore at least two days before loading into the container. It is necessary to conduct further investigations to develop novel postharvest management systems for dragon fruit in the wet season.

TABLES

Table 1: Rotting rate and bract color of dragon fruits from the two containers exported to Holland from Vietnam

Non-precooled container

Sampling position in container	Number of rotten fruit (fruits/box/9 fruits)					Rotting rate (%)	Color of bracts
	Box 1	Box 2	Box 3	Box 4	Box 5		
Top	0	0	1	0	0	2.22	green, yellowish green
Middle	1	1	0	0	1	6.67	green, yellowish green
Bottom	0	1	0	1	0	4.44	green, yellowish green
					Average	4.44	

Precooled container

Sampling position in container	Number of rotten fruit (fruits/box/9 fruits)					Rotting rate (%)	Color of bracts
	Box 1	Box 2	Box 3	Box 4	Box 5		
Top	0	0	0	0	0	0.00	green
Middle	1	0	0	1	0	4.44	green
Bottom	0	0	0	0	1	2.22	green
					Average	2.22	

Table 2: Symptoms on dragon fruits collected from two trial containers

Symptoms	Photos	Agents/Causes
Yellowing of bracts		The temperature of dragon fruits in this position was not controlled as expected
Condensation on bag and rotten tissue at stem end		Sudden rise in temperature when dragon fruit was transferred from coldstore to container.
Browning burn of bracts		Direct contact with high cold air flow (very low temperature and high speed)
Typical rot symptoms (white spot)		Fungal pathogen development

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PHYTOPHTHORA CITRICOLA: NEW FINDING PATHOGEN ON DURIAN IN VIETNAM, CONTROL MODELS AND PRELIMINARY RESULTS ON VARIETIES SCREEN AGAINST *PHYTOPHTHORA* SPP.

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ABSTRACT

In Vietnam, durian is mainly grown in the South. In 2004, Dang Vu Thi Thanh et al reported that *Phytophthora palmivora* caused a wide range of diseases in durian with the symptoms of gummosis and trunk patch canker. Recently, in many durian orchards in the Mekong Delta region and Lam Dong province, a new disease has manifested that cause quick decline of the trees. The symptoms appeared as dried rot on parts of the trunk base while the bark of the trunk was still normal or a little brighter than that of the healthy tree. When the bark was removed, xylem tissues were brown with many black stripes and the trees died suddenly. In this study, we found and proved with Koch's postulates that *Phytophthora citricola* is the causal organism of this disease at Tiengiang, Vinhlong and Lam Dong provinces. The fungus could grow well at temperature of 25 to 35°C. In another study, results show that the two varieties La Queo Vang and Chanee were tolerant of *P. palmivora* while Sua Hat Lep Chin Hoa and Chuong Bo provided better tolerant to *P. citricola*.

PAPER

Introduction

Lim (1990) studied and identified soil-borne fungi from durian grown in Malaysia, including *Phytophthora*, Pythium, Sclerotium. *Phytophthora* was the most common and deemed the most devastating disease to this crop. Lim and Sangchote (2003) said that root rot and gumosic on durian were caused by *Phytophthora palmivora*. Tsao (1983) has studied and listed many factors on isolation and *Phytophthora* from soil in durian orchards. In Vietnam, Dang et al (2004) reported that *Phytophthora palmivora* caused a wide range of diseases in durian. The integrated management of *Phytophthora* diseases of durian has been reported by Guest et al (2004).The bioassay method was used on durian to evaluate the susceptibility of different durian varieties to *Phytophthora* (Verma and Anwar, 2000). This method has been used and confirmed by Thanh and Binh (2001a), Tri and Binh (2003) and Emer O'Gara et al (2004).

Recently, in many durian orchards in the Mekong Delta region, Vietnam, a new disease has manifested that caused quick decline of the tree, even the fruit bearing trees. The symptoms appeared as dried rot on parts of the trunk base while the bark of the trunk was still normal or a little lighter in color than that of the healthy tree. When the bark was removed, xylem tissues were brown with many black stripes and the trees died suddenly. So we carried out the experiments to identify the causal organism, provide control measures under field conditions and search for tolerant rootstock.

Methodology

Survey on current situation of quick decline disease on durian at Tiengiang, Vinhlong and Lam Dong provinces

Survey was conducted on 3-year-old orchards with an area of more than 1000 m2, following the methods of McMaugh (2005), Thanh and Trung (1999). Screening of diseased tolerance followed methods of Dang Vu Thi Thanh, Ha Minh Trung (1997) and Burgess et al. (2008).

Diseased samples collection

Diseased samples were collected from symptomless areas, and areas showing symptoms of diseased. Three to 4 samples per tree were collected and labelled and brought to the laboratory for isolation.

Observation for spores color and morphology

The isolated spores and mycelia were observed under the light microscope based on the method written by Nguyen Van Tuat (1997) and classification by Donalt and Olaf (2005) for *Phytophthora* and Pythium.

Koch's postulates for confirmation of the pathogen

The experiment was conducted by complete random design on Monthong variety with 8 treatments: (I) Fusarium + Xyleborus sp.; (II) *Phytophthora* sp. + Xyleborus sp; (III) *Phytophthora* sp. + Fusarium sp. + Xyleborus sp; (IV) *Phytophthora* sp.+ Fusarium sp; (V) Only Xyleborus sp; (VI) Only *Phytophthora* sp.; (VII) *Phytophthora* sp. + *Phytophthora palmivora* and (IIX) control, five replicates were used per treatment per tree.

The inoculum was cultured 6-7 days in advance. Inoculated trees were wounded by a sharp knife, a piece of agar containing fungal mycelium placed on that wound and covered with absorbent cotton. The case used Xyleborus sp. to transmit the fungus, wherein twenty beetles were quickly soaked in suspensions of the fungal culture at 106 spores/ml before being released to the wounded trees in cages.

The data collected are severity level (%) and the diameter of diseased portion at 7 and 10 days after inoculation.

Sequence of 28S rRNA of Phytophthora sp.

Cultures of *Phytophthora* sp. were sent to NK-BIOTEK lab, at Ho Chi Minh City for sequencing using 28S rRNA gene.

BLAST N software was used for comparison of *Phytophthora* sp DNA sequence to other relative sequences from gene bank for identification of species.

Determination of temperature range for development of P. citricola

A complete random design experiment was conducted with 8 treatments and 7 different levels of temperature such as 15, 20, 25, 26, 28, 30, 32, 35 oC and control at ambient temperature. The agar medium containing mycelium of *P. citricola* was put in the centre of the fresh medium and then the plates were incubated at the appropriate temperature for 6 days.

The data collected were the diameter of mycelium growth at different times after inoculation (every day up to 6 days).

Screening for tolerant rootstock to Phytophthora spp.

Six selected varieties of durian were chosen for this test: Sua hat lep Chin hoa, La queo vang, Chuong bo, D6, Ri6 and Chanee. Seeds of these cultivars were sown for testing and followed the method described by O'Gara et al (2004).

The experiment was completely random designed with 6 treatments of six cultivars, four replicates each and three seedlings per replicate.

Inoculum preparation: cultures of *Phytophthora citricola* and *Phytophthora palmivora* were prepared on PCA medium at 7 days in advance for inoculation.

4-month-old seedlings were inoculated by spraying each separately on the seedling canopy at 106 spores/ml and then kept in a screen house for the symptoms to develop.

Data collection at 3 weeks after inoculation for disease severity (%), diameter of the lesion (cm), and all the data were analyzed by SPSS software (version 13.0).

Results and Discussions

Survey on current situation of quick decline on durian at Tiengiang, Vinhlong and Lam Dong provinces

In this investigation, there were 7 fungi present on durian grown in the surveyed provinces (Table 1). The most common disease was caused by *Phytophthora palmivora*, followed by *Phytophthora* sp. and Pythium sp. One new finding in this survey was that the sudden death or quick decline of the trees occurring in many orchards was associated with new species of *Phytophthora*.

In Lam Dong, the survey in 2012 shown that the ratio of patch canker and quick decline infection were high respectively (21.8, 81.14 %). Many farmers still have not known how to control it, at 40-77% number of interviewed growers from different locations. The others used Agrifos 400, Aliette, Coc 85 and Ridomyl for controlling of the disease, but were not effective.

Farmer recognition the quick decline disease and their management

The susceptible varieties are Khoquaxanh, Chuongbo, Monthong, Sua Hat Lep. Results from the investigation showed that most of the farmers at Nguhiep village, Cai Lay district, Tien Giang could recognize the diseased tree through symptom expression. However, they did not know the causal agent, so they treated the tree with chemicals that can not control the disease, causing the trees to die gradually (Table 2). Farmers also detected one kind of beetle associated with this disease. Many other farmers cut diseased trees but did not collect the plant debris and then replanted with new seedlings without any treatment.

At Tam Binh and Long Ho districts, Vinhlong Province, most of farmers did not know about the disease, suddenly the fruit bearing trees wilted and died.

Field observation

Orchard observations show that durian trees in orchards at Tiengiang province had an infection rate of 32.7-73.3 %, with disease severity range of 30.4-80.3%. In Vinhlong province, number of tree per orchard had an infection range of 65.2-67.7% and a severity ranged of 55.4-63.2% (Table 3). Kho qua xanh was the most susceptible variety, followed by Monthong and then Sua Hat Lep and Chuong Bo.

Amongst 158 samples collected and isolated from diseased trees at Tiengiang, Vinhlong and Lamdong provinces, there were three different fungi species associated with this disease: *Phytophthora palmivora*, *Phytophthora* sp. and Fusarium sp. The two *Phytophthora* species seem to be common and dominant, especially the new species of *Phytophthora* present with high proportion (48.60-66.00% of samples). Result from isolation shown that beetle Xyleborus sp. was associated with the disease.

Koch's postulates

Results from Koch's postulation showed that, the lesions of the patch canker on treatment of *Phytophthora* sp. alone and Xyleborus sp. were long dark brown and dried patch, brown strips on the xylem vessels, leaves turned yellow and fallen down. These symptoms were the same as those expressed in the original trees.

Characteristics of Phytophthora sp.

The mycelium developed directly on the medium at the centre of the disk where it was inoculated. There were ellipsoid to pear shape sporangia with unclear or without papilla, at a ratio of long and wide of sporangium at 2:1. They had round and smooth zoospores.

The sporangial morphology of *Phytophthora* sp. was the same as what described by Donalt and Olaf (2005) for *Phytophthora citricola* such as ellipsoid to pear like sporangium, unclear papilla and mycelium like cotton on medium.

Sequence of 28S rRNA gene of Phytophthora sp.

The sequences of 28S rRNA gene of *Phytophthora* sp. revealed 184 bp rDNA sequences and when BLAST SEARCH was done from the gen bank on NCBI, the result revealed the *Phytophthora* sp. rDNA was identical with *Phytophthora citricola* up to 99%. The identities with *P. citricola* started bp of 640 to bp of 824 and only one bp different at bp number 816 (Table 7).

Therefore, the results from sporangial morphology, Koch's postulates and rDNA sequence of 28S rRNA gene of *Phytophthora* sp. has confirmed that the quick decline of durian in Tiengiang, Vinhlong and Lamdong provinces was caused by *Phytophthora citricola*. This is an important pathogen on citrus trees at many different regions of the world, including Vietnam (Dang Vu Thi Thanh and Ngo Vinh Vien, 2004). Jung and Burgess (2009) reported that this fungus developed and caused much damage at temperature of 25oC, with a wide host range of 39 woody trees such as coffee and cacao. Our result showed that *P. citricola* has a new host that is durian.

Optimum temperature for development of P. citricola

Results in Table 8 show that the fungus could grow in a range of temperature from 15-40oC.

At 24, 48 and 72 hours after inoculation, fungus grew fastest at 35oC, but at 96, 120 and 144 hours after inoculation, it grew fastest at 25-26oC.

Therefore, the suitable temperature for this fungus development was from 25 to 35oC. These results are similar with the report by Jung and Burgess (2009) that the fungus develops well at 25oC.

Screening for tolerance against Phytopthora spp. in durian varieties

Results from Table 9 revealed that when inoculated with *P. palmivora*, the two varieties La queo vang and Chanee had the lowest disease severity and this was significantly different to the other treatments. This result is similar to those reported by Mai Van Tri and Nguyen Thi Thuy Binh, 2003; Huynh Van Thanh and Le Ngoc Binh, 2001a that La queo variety was tolerant to *P. palmivora*.

When they were inoculated with *P. citricola*, the two Sua Hat Lep Chin Hoa and Chuong Bo varieties had the lowest diseased severity (44.59 and 44.74%) and smaller lesion diameter (1.44 and 2.47 cm) while La Queo Vang and Chanee had significantly higher disease severity (61.24 và 71.83%). This result confirmed the survey results earlier, that the varieties Sua Hat Lep and Chuong Bo are more tolerant to *Phytophthora citricola* than other varieties under investigation.

Conclusions

In this study, seven fungi diseases were found in durian orchards at Tiengiang, Vinhlong and Lamdong provinces, of them, the quick decline was caused by the new disease that occurred.

Most of interviewed farmers said that durian trees died due to disease attacked on the trunk base, but they did not know causal agent or any control measures and only removed infected trees and that were replaced with new seedlings.

Varieties Kho Qua Xanh, Chuong Bo, Monthong and Sua Hat Lep were infected by the disease, with Chuong Bo and Sua Hat Lep being less susceptible to the causal agent.

Results from isolation showed that the three fungi *Phytophthora palmivora* and *Phytophthora* sp. associated with the disease.

Result from Koch's postulates revealed that *Phytophthora* sp. was the causal agent that had sporangia sometimes arranged in chains, the sporangium with the papilla was not clear and sometimes no papilla. The rDNA sequence of 28S rRNA gene indicated that this was *Phytophthora citricola*. This fungus could grow well in the range of temperature from 25-35oC.

Results from evaluation, the two variteis La Queo Vang and Chanee were tolerant to *P. palmivora* while Sua Hat Lep and Chuong Bo were tolerant to *P. citricola*.

TABLES

Table 1. Main diseases on durian in Tiengiang and Vinhlong provinces (2009)

Stt	Disease and pathogen	Infected part	Severity
1	Gummosis (*Phytophthora palmivora*)	Trunk base, branch, fruit	+++
2	Quick decline (*Phytophthora* sp.)	Trunk base, branch	+++
3	Root rot (*Pythium* sp.)	Root	++
4	Pink disease (*Corticium salmonicolor*)	Branch and twigs	+
5	Anthracnose (*C. Gloeosporioides*)	Leaf, young shoot	+
6	Sooty mold (*Capnodium* sp.)	Leaf, fruit, twig	++
7	Algae (*Cephaleuros virescens*)	Leaf	++

Note: +: <10% trees per orchard; ++: 11-25% trees per orchard; +++: 26-50% trees per orchard

Table 2: Results on quick decline survey at CaiLay – TienGiang and Tam Binh, LongHo – Vinh Long (base on Farmer knowledge)

Location	Surveyed area (m^2)	Variety	Knowledge on disease (%)	Diseased orchards/ surveyed Orchards (%)	Related to beetle	Treatment
Ngu Hiep - Cailay	25,000	Kho Qua Xanh	- Yes: 54.5 - No: 45.5	38.2	Beetle appear	Cut off the tree
	10,000	Chuong bo	- Yes: 12.4 - No: 87.6	16.0	Yes	Cut off the tree, plant new tree
TamBinh - Cailay – TienGiang	22,000	Mon thong	- Yes: 10.3 - No: 89.7	28.6	No	Remove diseased part & paste with chemical
	6,000	Sua hat lep Chin Hoa	- No: 100.0	16.0	No	Remove diseased part & paste with chemical
Tam Binh-Vinh Long	30,000	Kho Qua Xanh	- Yes: 25.0 - No: 75.0	32.4	Yes	Cut off the tree
Long Ho – Vinh Long	20,000	Kho qua Xanh	- Yes: 13.3 - No: 86.7	22.6	No	Remove diseased part & paste with chemical

Table 3: Result on field surveyed orchards

Location	Surveyed area (m^2)	Variety	Diseased tree/ surveyed trees (%)	Disease severity (%)
Ngu Hiep - Cailay	25,000	Kho Qua Xanh	73.3	80.3
	10,000	Chuong bo	32.7	30.4
TamBinh-Cailay -TienGiang	22,000	Mon thong	49.1	40.1
	6,000	Sua hat lep Chin Hoa	36.3	29.7
Tam Binh-Vinh Long	30,000	Kho qua Xanh	67.7	63.2
Long Ho – Vinh Long	20,000	Kho qua Xanh	65.2	55.4

Table 4. Fungi isolated from diseased parts of durian trees (%)

Collected location		*Phytophthora sp.*	*Phytophthora palmivora*	*Fusarium sp.*
Tiengiang (Cai lay district)	Ngu Hiep	51.43	62.34	33.17
	Tam Binh	48.60	43.59	38.76
Vinh Long	Tam Binh	55.25	49.78	57.41
Lam Dong	Dahuoai	66.00	83.00	76.00

Table 5: Frequently appearance of fungi isolated from beetle Xyleborus sp. (%)(2012)

Location	*Fusarium sp.*	*Phytophthora palmivora*	*P. sp.*	Other
Dạ Huoai	66.40	53.30	64.04	33.6
Di Linh	78.20	65.00	56.20	45.8
Bao Lam	40.50	30.00	42.50	19.3

Table 6: Koch's postulations of different fungi on Monthong variety under net house conditions

Treament	Dis. severity (%)		Length of lesion (cm)		Symptoms expression
	7 DAI	14 DAI	7 DAI	14 DAI	
Fus + Xyl	32.0c	38.7cd	1.8bc	4.637d	Dry black lesion, leaves started with yellow and dropped off at 7 days after inoculation, holes due to Xyleborus presented.
Phyt + Xyl	59.7ab	89.7a	3.4ab	10.7a	Long dry dark brown lesion with brown trips along the stem, leaves fall, holes due to Xyleborus presented.
Phyt+ Fus+ Xyl	33.3b	69.7b	1.9bc	8.4ab	Long dry dark brown lesion with brown trips along the stem, leaves fall, holes due to Xyleborus presented.
Phyt + Fus	79.7a	43.7cd	4.5a	4.9cd	Long dry dark brown lesion with brown trips along the stem, leaves fall, water soaking on the lesion in the morning.
Only Xyl	37.7b	22.7d	1.3c	2.7d	Only holes due to Xyleborus
Only Phyt	90.3a	63.0bc	5.1a	7.5bc	Long dry dark brown lesion with brown trips along the stem, leaves fall.
Phyt + Phy –pal	40.0b	38.3cd	2.3bc	4.6d	Dry dark brown to black lesion,with brown trips along the stem, leaves fall.
Control	-	-	-	-	Wound dry and started to heal after 7 days
CV (%)			57,26	51,77	

conditions (SOFRI, 2012)

Note:

Fus + Xyl :Fusarium sp. + Xyleboruss sp.

Phyt + Xly: Phytophthora sp +Xyleborus sp.

Phyt + Fus+ Xyl:Phytophthora sp +Xyleborussp.+ Xyleborus sp

Phyt + Fus : Phytophthora sp. + Fusarium sp.

Phyt + Phy –pal: Phytophthora sp + Phytophthora palmivora

Table 7: Sequence of 28S rRNA gene of Phytophthora sp.

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Query  1    GGTTGGGACTGAGGTGCCTACAACGTGCTTTTGAGTGGGTTTGTGTCTCCGTGTGCGCCG  60
            ||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||
Sbjct  640  GGTTGGGACTGAGGTGCCTACAACGTGCTTTTGAGTGGGTTTGTGTCTCCGTGTGCGCCG  699
Query  61   TGTGCGGATAGCTTGCTATGCGTGTGTGGTTGTGTGTGGATGGATGCGGGCCTTAACTTG  120
            ||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||
Sbjct  700  TGTGCGGATAGCTTGCTATGCGTGTGTGGTTGTGTGTGGATGGATGCGGGCCTTAACTTG  759
Query  121  TCGCCGTTCGGGACGTTGACGAAATGGAGCGATCCGACCCGTCTTGAAACACGGAC-AAG  179
            ||||||||||||||||||||||||||||||||||||||||||||||||||||||||| |||
Sbjct  760  TCGCCGTTCGGGACGTTGACGAAATGGAGCGATCCGACCCGTCTTGAAACACGGACCAAG  819
Query  180  GAGTC
            |||||
Sbjct  820  GAGTC
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Table 8: Development of P. citricola at different temperature range

Temp. (°C)	Mycelium diameter of P. citricola after inoculation (cm)					
	24 h	48 h	72 h	96 h	120 h	144 h
15	0.82 d	2.07 d	2.46 d	4.07 c	5.26 d	6.25 c
20	1.01 d	2.22 cd	.2.70 d	4.68 bc	6.17 d	7.33 ab
25	1.33 c	2.54 bcd	3.04 cd	5.62 ab	8.02 a	8.50 a
26	1.41 c	2.84 bc	3.45 bc	6.13 a	7.34 abc	8.50 a
28	1.60 bc	2.92 b	3.40 c	5.12 b	6.61 bc	8.50 a
30	1.86 ab	3.55 a	4.05 ab	5.46 ab	7.42 abc	7.97 a
35	2.08 a	4.08 a	4.58 a	5.61 ab	7.84 ab	8.34 a
40	1.36 c	2.34 bcd	2.84 cd	3.16 d	3.92 e	4,30d
CV(%)	20.38	22.94	19.73	18.54	19.52	17.59

Note:- In one column, those numbers have the same character is not significant different under Duncan test.

Table 9: Response of some durian varieties against *Phytophthora spp.* under screenhouse conditions

Varieties	*P. citricola*		*P. palmivora*	
	Disease severity (%)	Lesion Diameter (cm)	Disease severity (%)	Lesion Diameter (cm)
Sua hat lep Chin Hoa	44.59 c	1.44 c	57.10 ab	1.12
La queo vang	61.24 b	2.07 b	37.58 c	1.31
Chuong bo	44.74 c	2.47 b	50.15 b	1.40
D 6	83.64 a	3.19 a	66.01 a	1.46
Ri 6	59.97 bc	2.65 ab	59.97 ab	1.65
Chanee	71.83 ab	2.59 ab	29.74 c	1.43
Significant different	*	*	*	Ns
CV%	16.74	17.08	15.67	22.61

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INFESTATION OF POMELO FRUIT BORER *CITRIPESTIS SAGITTIFERELLA* (MOORE) (LEPIDOPTERA: PYRALIDAE) IN VIETNAM AND THE EFFECT OF COMPACT FLUORESCENT LAMP AS A REPELLENT

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ABSTRACT

In Vietnam, pomelo has the biggest growth area among Citrus group with a total growth area of 8.170 ha, and annual production of approximately 50.000 tons. Although pomelo is planted almost everywhere in Vietnam, its biggest growth area is in Mekong delta, specially in Hau Giang, Soc Trang, Vinh Long, Ben Tre, Tra Vinh, Ti n Giang province and Can Tho city. Since November 2011, pomelo fruit borer *Citripestis sagittiferella* (Moore) has started spreading and causing severe damage across all planted areas in Mekong delta, specially on Green skin and Nam roi pomelo variety. The percentage of fruit infected varies from 17.4% to 80.1%.

In the conditions of ToC= 26 ± 1; H% = 60 ± 10, the life cycle of *C. sagittiferella* is 28.15 ± 3.64 days. Field tests conducted on 6 pomelo orchards from October 2012- Jun 2013 in Ben Tre province recorded that on three orchards illuminated with compact fluorescent lamps (200 lamps/hectare from 17: 30 PM to 6:00 AM), no infestation from pomelo fruit borer was found while on the other three without compact fluorescent lamps, the average percentage of fruits infected can go up to 32,5%. The result shows the use of compact fluorescent lamps can prevent *C. sagittiferella* from coming to the orchards and laying eggs on the surface of pomelo fruit. The effect of compact fluorescent lamp as a repellent against pomelo fruit borer is at high interest and being experimented on bigger pomelo growth areas in Mekong delta of Vietnam.

PAPER

Introduction

Pomelo culture has significantly played a key role in the Mekong Delta economy, since it represents a main revenue of over milions of dollars annually, translating into hard currency for the country. The Mekong Delta accounted for about 85% of the Viet Nam citrus production (MARD, 2010).

Since November 2011, pomelo fruit borer Citripestis sagittiferella (Moore) has started spreading and causing severe damage across all planted areas in Mekong delta as Ben Tre, Tien Giang, Soc Trang, Vinh Long, Bac Lieu, Can Th city and spacial và specially on Hau Giang (PPD, 2013). This specices also has started spreading to Indonesia, Philippines, Thai Land and Malaysia.

It was reported that an insect parasite, *Rhoptromeris* sp. (Hymenoptera: Eucoilidae) plays an important role in the control of Citripestis sagittiferrella on lemon at University Pertanian Malaysia (now University Putra Malaysia) orchard. At 24% larval parasitism was estimated from larvae collected in the field. Field studies to evaluate the effectiveness of malathion 50 EC emulsifiable concentrate sprayed to trees at 0.1% a.i. active ingredient show that the percentage of fruits attacked was nuch more higher in the sprayed block than that of the unsprayed block (Hussein and Rahman (1981).

Insect visual systems have the abililty to detect objects, colours, movement, prey or other specifics using the properties of light, which provides an incredible spatial advantage as critical information is collected and, responded to from an extended scene. Visual systems of insects have adapted to operate in a wide range of intensities and spectrally diverse visual conditions, such as diurnal and nocturnal periods, dense forests or aquatic enviroments (Briscoe and Chittka, 2001). Many of these adaptation have likely evolved from the basic compound eye and photoreceptor design to take advantage of specific environmental information contained in the available light soures.

The objective of this work is to describe the steps that were developed to rationnalize Citripestis sagittiferella control by using compact fluorescent lamp as a repellent, from the basics up to a final product that is currently sold to pomelo producers.

Methodology

The year round survey of pomelo in Chau Thanh district, Ben Tre province was carried out by interview approach directly with pre-composed questionnaires from March to June, 2012, 2013. The interviewees were growers possessing more than 2,000 square meter area of pomelo in five villages in the largest pomelo areas.

The number of interviewed growers was 410 in total. Demonstrations of pomelo year-round production were conducted on "Da xanh" pomelo aging from 6 to 8 years.

Field experiment: 6 orchards set compact fluorescent lamps tube treatment and non compact fluorescent lamps treatment sites relied on conventional fungicides without pesticides application, but were routinely sprayed with growth regulator. N-P-K fertilizers with animal matures to supplement nutrient were applied in both the treatment and non treatment sites. In addition to 6 orchards set compact fluorescent lamps tube treatment, a range of set time 17:30 PM to 6:00 AM was used in the treatment site for the prevent adults to lay eggs, one compact fluorescent lamps tube was placed one tree, tubes put in canopy center, as in the other sites. For each site, coordinate data were recorded by using a handheld logger device. Experiments were observed at monthly intervals in the same location.

Location of experiment

Nhan Thanh villeage, Chau Thanh Dist, Ben Tre Province and Long An villeage, Chau Thanh Dist, Tien Giang province.

Data analysis: Student t- test were performed to assess prevent fruit borer between compact fluorescent lamps treatment and non compact fluorescent lamps treatment. T- test was undertaken using using the SAS version 8.0 (SAS, 1999).

Levels of infestations

100 fruits were selected, labelled and recorded for fruit borer infestation.

Results and Discussions

Survey

<u>The period of pomelo fruit season and yield in Mekong Delta</u>

Generally the weather conditions of the Mekong delta, is suitable for natural year long production of pomelo fruit, with distinct peak seasons.

Due to the cool seasons (Tuan and Tien,2007) flowering can be inconstent. Recently, with flowering treatments, growers can initiate flowering periods per year round which could be divided to four primary periods, i.e. in-season (Sep–Dec), late-season (Jan-Mar), off-season (Mar-Jun) and early-season (Jun-Sep).

In-season flowering treatment is not frequently applied because of low price whereas the price of pomelo is higher in the off–season. However, dry season and low flowering rate together with high expenditures of pesticide are considered as significant reasons of lower practice rate in comparison with early and late–seasons. Average yield is under dry season is made up about 30% of total yield per year. The fluctuations of average yield are significant difference and depend on the efficiency of flowering technique and pest management. There could be losses or unsold fruits due to fruit borer.

The period of pomelo fruit season and yield in Mekong Delta

There are many kinds of insect pests in pomelo orchards in Chau Thanh dist, Ben Tre province; including thrips (Thrips sp.), mite, and fruit borer Citripestis sagittiferella cause highest damage to pomelo orchards. In addition to that insects usually cause much more higher serious damages in the dry season. In order to be able to prevent insect infestation, the majority of growers use permitted insecticides. Cypermethrins are seen as the most favorite substance because of lower toxicity and low residual effect in the environment in comparison with other ones.

The pomelo fruit borer is a relatively new insect pest in the Mekong zone. With its very fast population build up, many growers have been affected with serious fruit loss. (Table 1).

Control fruit borer by growers in Chau Thanh, Ben Tre province

Since April, 2012, 48.8 % of growers using pesticide sprays to protect pomelo were recorded (table 2). Due to the cost of pesticide and labor, fruit borer still affects the pomelo zone seriously. In April, 2013 the survey was repeated on 410 orchards, 72,68 % of growers bagged their fruits, regardless of the cost of bags and labor. The most favorite kind of bag is from Hoa Mai company, one bag per fruit. According to experience of growers, bags can be used for one year with care and utilization of microbe removing reagents after harvesting. Fruit bagging starts 30 day after fruit setting. Frequently, bagging is also done at the 45th day after fruit set because, at this period, physiological immature fruit drops have ceased, thus fruit number is more stable than at the early stages when abscission still occurs.

Taxonomic identification

The first step (as the studies began) consisted of the correct identification of the pest. The pomelo fruit borer, until then known as *Nephopteryx sagittiferella* Moore (1891), was correctly identified as *Citripestis sagittiferella* (Anderson, 2012).

Basic biology studies in laboratory

Samples of pomelo fruit were collected in different province of Mekong Delta during the period of 2012 and 2013, and then exposed to adult fruit borer so that they were infested with eggs, larva, pupal and adult. Plant protection section of SOFRI, the laboratory stock colonies of Citripestis sagittiferella were then maintained for more than 10 generations. The rearing test environmental room lab was maintained at constantly temperature of 26 ± 10C and H% (60± 10).

Eggs had oval, dirty white, translucent with fine raised irregular networking, layed singly and in small irregular patches on the lower side of the fruit. Duration of the egg stage was from 5.3 ± 1,00 days. Larvae had reddish yellow and turn dark green upon pupation. Initially, larvae are gregarious but then separate and burrow into the pulp and pith of fruit. As larvae increase in size they eat their way through the fruit and create holes used for ejecting waste; larvae are very active. The mature larva drops to the ground by silken threads and burrows into the soil at a depth of approximately 1-2 cm. It then constructs cells of agglutinated earth lined with white silk measuring 0.7 inch in length, 0.4 inch in breadth and 0.3 inch in depth. Duration of the larval stage was from 15-16 days.

Pupal stage is in the soil for development to the adult phase. Duration of pupa development was 10,2±1,1days.

Adult had ground colour of forewing yellowish-brown, veins black scaled, median band hardly marked at all; hindwing somewhat transparent, pale yellowish-grey to grey-brown; head brown; thorax grey-brown, tegulae yellowish-brown (Moore (1891), Kalshoven (1981) & Chong et al (1991). The duration from adult emergence until female laid eggs was 28.15 ± 3.64.

Field studies

Factors affect the fruit borer in field: Observation on laid egg time of of Citripestis sagittiferella

The main finding of this study was the relationship of temperature and RH(%) on March 2013 becomes an important role in egg laying time. At 31 0C and 35% RH observation at 19:00 pm were recorded as suitable time for the insect to lay eggs (Figure 5). Temperature and RH (%) were well-known to be a key factor in the determination of the developmental of laid eggs and as a whole, and the result from this study are consistent with earlier research.

The Result in figure 5 showed that at the time of 19:00 pm fruit borer was highly active and laid eggs as well. This period helps growers to prevent adults laid egg in orchard by compact fluorescent lamps as repellent.

Compact fluorescent lamps prevent fruit borer laid egg in pomelo orchard

The major aim of this research was to investigate the impact on new control using compact fluorescent lamps as repellent on the communities of fruit borer in pomelo orchards in Mekong delta, Viet Nam.

The rates of fruit borer infestation differed singnificantly in both treatment and non treatment sites (P<0.0001) (Table 4). Every month (from october to December, 2012), from six samples of 600 pomelos collected in the treatment sites, no fruit was infested and no fruit borer was found. In contrast, in the untreated site, mean 12.13; 23.30 and 31.63 fruits infestation were found. Infestation was found in October, November, December, equivalent to 12.13%; 23.30% and 31.63% respectively.

In table 5, the experiment was repeated and treated following the same method of table 4. The rates of fruit borer infestation differed singnificantly in both treatment and non treatment sites (P<0.0001) (Table 5). Results recorded every month (from January to March, 2013), with six samples of 600 pomelos collected in the treatment sites, no fruit was infested and no fruit borer emerged. which confirms the non-infestation rate. In contrast, in the untreated site, mean 7.83; 12.13 and 16.52 showed fruits infestion in January, Febuary, March, equivalent to 7.83 %; 12.13% and 16.52% damage by fruit borer respectively.

Although the positve effects on compact fluorescent lamps treatment have been widely recognized and documented through many field trails, the development and non application of compact fluorescent lamps in Viet Nam have not progressed as well as it should have to reflect its potential (PPD, 2013).

Since pomelo growers in Mekong delta are familiar with the conventional insecticide cover sprays, an effective way is to persuade farmers to use compact fluorescent lamps treatment in order to demonstrate the economic efficiency of this alternative method. As a result, SOFRI (2013) has reported that farmers used compact fluorescent lamps treatment would gain a much more higher net profit of 406.410.000 VND per hectare.

Despite a number of inherent advantages, the benefit of compact fluorescent lamps treatment use has been argued to outweigh the disadvantages. Compact fluorescent lamps treatment are known to be more safe to the environment. with the lower cost involved in compact tubes, labour and the technology are easier for farmers to transfer, thus having a great deal of potential ability to be introduced as un alternative procedure to conventional insecticide usage. This finding was also in similar with previous studies (Theobald et al. 2007).

Conclusions

The study had identified that the conditions of T0C= 26 ± 1; H% = 60 ± 10, the life cycle of C. sagittiferella is 28.15 ± 3.64 days. Field tests conducted on 6 pomelo orchards from Dec 2011- Jun 2012 in Ben Tre province recorded that three orchards illuminated with compact fluorescent lamps (200 lamps/hectare

from 17: 30 PM to 6:00 AM), showed no infestation from pomelo fruit borer, while the other three ones were used without compact fluorescent lamps, the average percentage of fruits were infected, reaching to 32,50%. The result shows the usage of compact fluorescent lamps can prevent C. sagittiferella from laying eggs on the surface of pomelo fruit. The effect on compact fluorescent lamp as a repellent against pomelo fruit borer is at high interest and being experimented on bigger pomelo growth areas in Mekong delta of Vietnam.

The use of compact fluorescent lamps should be considered in orchards, especially in rainy season which lead to reduce serious damages of fruit borer to lemon, orange fruit in Mekong Delta. There is a need to conduct studies on economic efficiency of compact fluorescent lamps at different periods after lemon fruit setting so as to determine the most effective ones.

TABLES

Table 1: Percentage (%) of surveyed orchards damaged pomelo fruit borer in different provinces of Mekong Delta

Provinces	Areas of pomelo (ha)	Areas infested (ha)	% infested fruit
Ben Tre	4.132	717,9	17.4
Tien Giang	5.900	2.120	30.9
Vĩnh Long	7.517	3.739	49.7
Can Tho	566	368	65
Hau Giang	3.037	2.450	80.1
Soc Trang	6.911	1.678	24.3
Tra Vinh	1.400	1.120	80.0
Total	29.463	12.192,9	-

Source: Plant protection Department (PPD), 2013

Table 2: Fruit borer management by growers in Chau Thanh dist., Ben Tre province

Control method	Year 2012		Year 2013	
	Number orchard	Percentage (%)	Number orchard	Percentage (%)
Pesticide spray	200	48.8	50	14.63
Bag fruit	86	21.0	298	72.68
Green ant	0	0.0	15	3.66
Camphor repellent	3	7.0	25	6.10
Not practice	121	29.5	12	2.93
Total	410	100	10	100

Source: Survey orchards in Chau Thanh, Ben Tre province , 2012 to 2013

Table 3: The cycle of Citripestis sagittiferella (T0C= 26 ± 1; H% = 60 ± 10)

Stage	Life cycle	
	Fluctuation of duration (day)	Duration (day)
Egg	5-6	5.3 1,00
Larva 1	2-3	2,5 1,29
Larva 2	2-3	2,2 1,00
Larva 3	3-4	4,4 1,58
Larva 4	4-6	5,0 1,28
Pupa	9-11	10,2 1,1
Life cycle		28.15 ± 3.64
Male: Female	-	1:1

Table 4: Comparison of percentage (%) number fruit infested recorded monthly per 100 fruit in 6 six orchards in Chau Thanh, Ben Tre province from (oct, 2012 to December, 2012)

Months set Compact fluorescent lamps	Number fruit observation	Compact fluorescent lamps treatment (%)	No compact fluorescent lamps treatment (%)	P	T "test"
October, 2012	100	0.0	12.13	0,0001*	10.66
November, 2012	100	0.0	23.30	<0,0001*	11.55
December, 2012	100	0.0	32.50	<0,0001*	23.29

Table 5: Comparison of percentage (%) number fruit infested recorded monthly per 100 fruit in 6 six orchards in Chau Thanh, Ben Tre province from (Jan, 2012 to March, 2012)

Months set Compact fluorescent lamps	Number fruit observation	Compact fluorescent lamps treatment (%)	No compact fluorescent lamps treatment (%)	P	T "test"
January 2013	100	0.0	9,13	<0,0001*	7.83
Febuary 2013	100	0.0	20.30	<0,0001*	12.13
March 2013	100	0.0	23.13	<0,0001*	16.52

Table 6: Comparision of cost and benefit per hectare of pomelo production between compact fluorescent lamps treatment and non treatment one

Description	Compact fluorescent lamps treatment			Non treatment		
	Quantity	Unit price (VND)	Amount (VND)	Quantity	Unit price (VND)	Amount (VND)
Chemical fertilizer (kg)	3.750	10.000	37.500.000	3.750	10.000	37.500.000
Organic fertilizer (kg)	3.500	3.000	10.500.000	3.500	3.000	10.500.000
Insecticides and fungicide (litre)	4	500.000	2.000.000	10	500.000	5.000.000
Labor (days)	300	120.000	36.000.000	450	120.000	54.000.000
Compact fluorescent lamps (tubes)	200	43.750	8.750.000	0	0	0
Electrical wiring	400	8.600	3.440.000	0	0	0
Fruit production (kg)	14.000	55.000	770.000.000	10.640	35.000	372.400.000
Net profit			671.810.000			265.400.000

FIGURES

Figure 1: Period pomelo yield in Mekong Delta (Source: MARD, 2010)

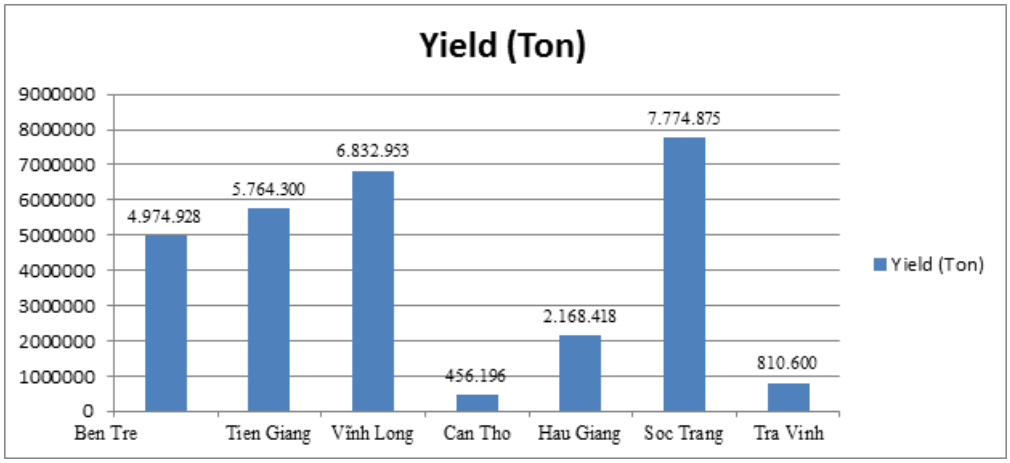
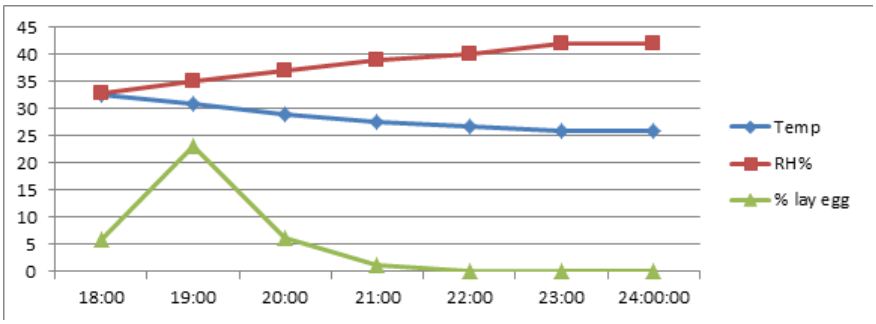


Figure 2. Adult (left) and eggs (right)

Figure 3. Larva (left: Larva 1; right: Larva 5)

Figure 4. Pupa (left) and pupa in soil (right)

Figure 5: Mean time temperature and relative humidity (RH%) in six orchards in Ben Tre Province on 1 - 30 March 2013. Temperature and relative humidity (RH%) were recorded using data loggers set at every one hour.



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TOTAL PHENOLIC CONTENTS AND ANTIOXIDANT ACTIVITY OF *MUSA* AAA BERANGAN AFTER UV-C RADIATION

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ABSTRACT

Ultra-violet (UV) has been well established for water treatment, air disinfection and surface decontamination. Recently UV has been recognized in fresh-cut industry as effective germicidal treatment. The application of UV especially UV-C as postharvest treatment for intact horticultural produce has not gained much attention as compared to fresh-cut industry. Thus, a study to determine the effect of UV-C radiation on total phenolic contents and antioxidant activity of Musa AAA Berangan was carried out. The mature green fruits were exposed to UV-C doses of 0, 0.01, 0.02, 0.03 and 0.04 kJ/m2 and allowed to ripen at 26oC for 5 days after ripening initiation. The antioxidant activity of the fruit was evaluated with ferric-reducing antioxidant power (FRAP), 1,1-diphenyl-2-picrylhydrazyl (DPPH) free radical-scavenging and 2,2'-azinobis-(3-ethyl-benzothiazoline-6-sulfonic acid (ABTS) assays at ripening day 0, 1, 3 and 5. There was significant interaction between UV-C radiation x day after ripening on total phenolic contents of Berangan banana. However, no significant interaction was found in antioxidant activity of Berangan banana as evaluated using FRAP, DPPH and ABTS assays. Fruit irradiated with UV-C showed significant higher of total phenolic contents at ripening day 3 and 5 as compared to control. There were significant difference in FRAP, ABTS and DPPH values of Berangan banana fruit when exposed to different doses of UV-C. Antioxidant activities measured with the three assays in the present study showed significant decrease as ripening day progressed. The result of this study revealed that 0.01 kJ/m2 UV-C radiation is sufficient to increase Berangan banana fruit total phenolic contents and antioxidant activity. Hence, apart from the application of UV for microbial safety at industrial levels, this novel technology can also be exploited to enhance health promoting compounds for benefit of consumers.

PAPER

Introduction

Banana is one of the most important fruit as the staple food source worldwide with estimated annual world banana production around 70.6 million tons in 2004. In Malaysia, banana is the second largest cultivated fruit crop after durian. This tropical fruit is widely grown in all states and available throughout the year. The popular cultivars are 'Mas' (AA), 'Embun' (AAA), 'Rastali' (AAB), and 'Berangan' (AAA). Among these four cultivars, Berangan is a major cultivated banana for local consumption, occupies 50% of total banana cultivated area.

Ultraviolet (UV) light has long been used as germicidal to treat water. Recent findings reported that UV-C radiation can induce the antioxidant system of strawberry (Erkan et al., 2008), blueberries (Perkins-Veazie et al., 2008) and pear (Li et al., 2010). Besides enhancing antioxidant activity, UV light also induces both defense mechanisms and biological stress of plant tissues including cell wall modification, raise in the activity of defense enzymes and accumulation of antimicrobial compounds (phytoalexin) (Maharaj and Mohammed, 2012). Thus, reduce the decay and finally extend the shelf life of fruits and vegetables. As a result, UV light especially UV-C (200-280 nm) has attracted great attention of researchers lately.

From our knowledge, study on the effect of UV-C treatment on the antioxidant activity Berangan banana has not been reported yet. Therefore, the objective of this study was to determine the effect of UV-C radiation on antioxidant activity of Berangan banana.

Methodology

Mature green Musa AAA Berangan was purchased from a wholesale market. The fruit were carefully selected in terms of size, color and free from defect. The fruit of the banana hands were separated into clusters of three fingers. Then, the clusters were placed in a chamber equipped with fluorescent germicidal lamp (VER bright T8 207, 30 W) with a peak emission at 254 nm. The fruit were then irradiated with UV-C light of 0, 0.01, 0.02, 0.03 and 0.04 kJ/m^2, respectively.

After irradiation, the fruit were initiated to ripening using ethylene. After 24 h of ripening initiation, the fruit were allowed to ripen at 26oC with 75-80% relative humidity. Fruit at day 0 (before ripening initiation), 1, 3 and 5 after ripening initiation were used for extraction.

Determination of total phenolic contents and antioxidant activity

One gram of freeze-dried ground sample was extracted using 50 ml 80% methanol. After centrifuge, the supernatant was used to determine total phenolic contents and antioxidant activity.

Total phenolic contents (TPC) of the extract were determined by using Folin–Ciocalteu assay method as described by Alothman et al. (2009) with some modifications. The absorbance was measured at 765 nm using a spectrophotometer (S1200, Cambridge, England) in triplicates. A calibration curve was prepared using a standard solution of gallic acid and results were expressed as mg gallic acid equivalents (GAE)/g banana dry weight.

The antioxidant activity of the fruit extracts were evaluated using ferric-reducing antioxidant power (FRAP), 1,1-diphenyl-2-picrylhydrazyl (DPPH) free radical-scavenging and 2,2'-azinobis-(3-ethyl-benzothiazoline-6-sulfonic acid (ABTS). The assay of FRAP and DPPH was adopted from Alothman et al. (2009) with some modifications while assay of ABTS was modified from Shan et al. (2005). A calibration curved was prepared using a standard solution of trolox (6-hydroxy-2,5,7,8-tetrametychroman-2-carboxylic acid) and results were expressed in µmol trolox/g banana dry weight.

Statistical analysis

The experimental design was RCBD and replicate for three times. Data was analyzed by using ANOVA. When F values showing significance ($P \leq 0.05$), differences within each factor was separated by least significant difference (LSD).

Results and Discussion

There was significant interaction between UV-C radiation x day after ripening on total phenolic contents of Berangan banana (Table 1). However, no significant interaction was found in antioxidant activity of Berangan banana as evaluated using FRAP, DPPH and ABTS assays. Fruit irradiated with UV-C showed significant higher of total phenolic contents at ripening day 3 and 5 as compared to control (Fig. 1). This indicated UV-C radiation has increased the total phenolic contents of Berangan banana. Strawberry irradiated with 2.15 kJ/m2 UV-C had the highest total phenolic contents followed by 0.43 and 4.30 kJ/m2 UV-C radiation and control fruit has the lowest total phenolic contents (Erkan et al., 2008). Irrespective of UV-C dose, total phenolic contents of strawberry increased during 15 days storage period. However, the increase was relatively lower in control fruit when compared to UV-C irradiated fruit. Phenolic compounds in fruits may produce the beneficial effects by scavenging free radicals (Chun et al., 2003). Thus, phenolic compounds may help protect cells against the oxidative damage caused by free radicals (Wada and Ou, 2002). In the present study, total phenolic contents of Berangan banana decreased as ripening day progressed (Fig. 1) indicating the antioxidative properties of Berangan banana reduced when ripening took place.

There were significant difference in FRAP, ABTS and DPPH values of Berangan banana fruit when exposed to different doses of UV-C (Table 1). FRAP values of rruit irradiated with 0.01 kJ/m2 showed significant higher of antioxidant activity than control and 0.04 kJ/m2 UV-C irradiated fruit. Antioxidant activity as expressed in DPPH and ABTS values indicated Berangan fruit irradiated with 0.01 kJ/m2 UV-C was

higher than those irradiated with 0.04 kJ/m2. This showed high dose of UV-C radiation did not enhance antioxidant activity in Berangan banana. Similar findings was also reported in strawberry where fruit irradiated with 2.15 kJ/m2 UV-C and stored for 15 days had the highest antioxidant activity, followed by 0.43 and 43 kJ/m2 UV-C radiation (Erkan et al., 2008). Control fruit had the lowest antioxidant activity. As ripening day progressed, antioxidant activities of Berangan banana measured with the three assays showed significant decrease. Again, this reflects antioxidative properties of Berangan banana decreased once ripening started.

Conclusions

The result of this study revealed that 0.01 kJ/m2 UV-C radiation is sufficient to increase Berangan banana fruit total phenolic contents and antioxidant activity. Hence, apart from the application of UV for microbial safety at industrial levels, this novel technology can also be exploited to enhance health promoting compounds for benefit of consumers.

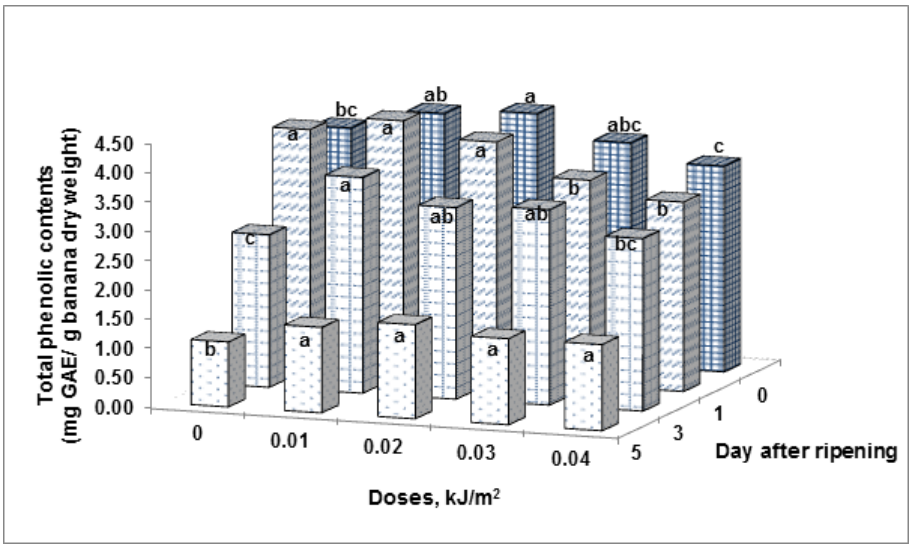
TABLE

Table 1. Effect of UV-C radiation and day after ripening on total phenolic contents and antioxidant activity (FRAP, DPPH and ABTS) of Berangan banana

Factors	Total phenolic contents (mg GAE/g fruit DW)	FRAP (mol trolox/g fruit DW)	DPPH (mol trolox/g fruit DW)	ABTS (mol trolox/g fruit DW)
UV-C radiation dose (U), kJ/m2				
0	2.88 bcz	35.75 bc	28.31a	20.50 ab
0.01	3.39 a	39.93 a	31.79 a	22.47 a
0.02	3.14 ab	38.94 ab	28.12 b	21.96 a
0.03	3.16 ab	38.32 ab	29.13 ab	21.54 a
0.04	2.79 c	33.90 c	25.62 b	19.23 b
Day after ripening (D)				
0 (Before ripening)	3.88 a	46.34 a	36.48 a	27.41 a
1	3.83 a	45.69 a	35.22 a	27.00 a
3	3.16 b	35.33 b	23.17 b	20.12 b
5	1.42 c	22.12 c	19.51 c	10.02 c
Interaction				
U x D	*	NS	NS	NS

FIGURES

Fig. 1. Effects of UV-C radiation x ripening day on total phenolic contents of Berangan banana. Means separations pertaining to each ripening day followed by the same letters are not significantly different by LSD at (P< 0.05).



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STUDY OF CHARACTERIZATION OF PECTIN JELLY EXTRACTED FROM POMELO FRUIT (*CITRUS MAXIMA* MERR.) PEELS AS FOOD INGREDIENTS

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ABSTRACT

Pectin was extracted from pomelo fruit (*Citrus maxima* Merr.) peels by traditional method. Pomelo is a native citrus fruit of Asia, belonging to the citrus family that has thick but soft peels that can be used as a source of pectin. This study focused on determining the ratio of albedo to water. The water used for extraction of pectin affect the gelling properties of pectin jelly. The ratio of the pomelo peel juice, sugar and citric acid ass were also determined. The ratio of albedo to water was 1:1 and the ratio for pomelo peel juice, sugar and citric acid was 3:2:1. Gelling properties was determined in terms of sag percentage (tenderness) at Formulation 1: 14.30%; Formulation 2: 8.33%; Formulation 3: 25.00%; Formulation 4: 14.67%; Formulation 5: 3.03%. Proximate analysis was performed on pectin jelly. Pectin jelly contained 32.01% moisture content, 13.33% ash content, 0.46% fiber content, 0.41% protein content, 0.12% fat content, and 67.46% carbohydrate content. The determination of effect of sugar on pectin jelly showed significant difference in terms of gel strength. This study produced pectin jelly from pomelo peels that can be implemented for large scale industrial production.

PAPER

Introduction

Pomelo (*Citrus maxima* Merr.) is widely grown in the states of Perak, Kedah, Kelantan, and Johor, Malaysia. Dry citrus peels commonly contain 20-50% pectin. The flesh of pomelo is either eaten fresh or processed into juice while the middle and outer layer are disposed. The albedo, which is the white middle layer of peel, is reported to contain pectin (Ittimongkol, et. al. 2004; Madhav, et. al. 2002; Norziah et. al. 2000; Spencer, et. al. 1930; Sriamornsak, 2003). Pectin is safe for human consumption and has been successfully used in food and pharmaceutical industries for many years.

Conventionally, pectin has been used as thickener, emulsifying agent, suspending agent, film former and binder (Sriamornsak 2003). Using alcohol to extract and characterize pectin from pomelo fruit peels has been studied (Norziah et. al. 2000). The extraction of the pectin from albedo of was used to develop gel for industrial applications as food ingredientssuch as jam, jellies, marmalades, preserves, and thickening agent for ketchup, sauces, and flavored syrup (Madhav, et.al. 2002). It is also useful as texturising agent in fruit-flavored milk desserts. In this work, the natural uniqueness of albedo from Malaysian pomelos that has gelling capability is expected to promote the production of a good gelling substance and food thickeners. Pectin is also used in traditional and modern medicine (Holloway, 1983).

Materials and Methods

Pomelo fruit (*Citrus Maxima* merr.) was purchased from local market in Shah Alam Selangor, Malaysia. Pomelo peels were separated from the flesh and the outer layer of pomelo peel; the green part called flavedo was removed using sharp knife. Pectin was prepared from the white part of pomelo that is albedo peel, used for this work. The albedo was cut into small size cubes, weighed, heated with water at temperature of 100oC for 20 minutes and reduced to simmering temperature for 5-10 minutes. The extracted juice was filtered through muslin cloth. The yield of the juice was measured using graduated cylinder, poured into a saucepan and boiled with sugar, citric acid until sugar dissolved and the thermometer indicated 4.4oC above boiling point. Jelly was poured into clean jelly glasses. The glass was sealed with a layer of paraffin and was cooled and setting time of jelly was measured (McWilliams, 2005). This study focused on characteristics of pectin jelly extracted from pomelo peels added with water, sugar and citric acid. The materials used have its own function to determine the characteristics of the pectin jelly. This study was done

to observe the effect of sugar, the tenderness, the color, the time and temperature for the pectin jelly to set, the spreadibility and the yield of the pectin jelly.

The ratios of water and albedo for extraction of pectin were formulated using 1:0.88, 1:0.70, 1:0.54, 1:2, and 1:1. The ratios of pectin, sugar and citric acid for making the jelly were formulated using 10:5:1, 10:20:1, 6.3:4.4:1, 33.3:20:1 and 3:2:1. For development of a strong jelly, ratio of albedo and water was recorded at 1:1 and the ratio of pectin, sugar and water was recorded at 3:2:1.

Proximate values; Moisture, protein, fat, ash, and fiber of the jelly were determined according to the AOAC method 2. Fat was measured by petroleum ether method and fiber was determined according to the procedure of AACC, 2000 1. All samples were analyzed in triplicate. The physical characteristics of the jelly were measurement of the tenderness, determined by percentage sag, yield of the jellies were determined by the height of the jelly before and after the jelly was unmolded 9. Spreadibility was determined by Line Spread Test and the Color was measured using Colorimeter and the texture analysis using analyzer.

A 10 point Quantitative descriptive Analysis method (with scale of 0=lowest intensity and 10= highest intensity) and a 7 point Hedonic scale rating (1=dislikes extremely and 9=like extremely) were used in evaluating the sensory attributes of the jelly. The attributes that have been evaluated were color, aroma, texture, elasticity, taste, bitterness and overall acceptability. Data were analyzed with MINITAB program using one way Analyses of variance (ANNOVA). Significant differences were tested using Duncan Multiple Range Test. Three replications were used for chemical and physical measurements and two replications for sensory evaluation.

Results and Discussions

Figure 1 showed the trend of line tenderness versus time was consistent. The analysis of variance (ANOVA) was carried out, the p-value is 0.00 was less than -value, 0.05, and it was concluded that there were no significant difference between all variations. These results showed that the amounts of sugar in pectin influenced the tenderness of the jelly.

Five formulations were done to determine the ratio of albedo and water for extraction. Table 1 showed the different proportions of albedo and water used to extract pomelo peel juice that was reported to contain pectin. Formulation 5, 1:1 (water and albedo) showed the best result, compared to (McWilliams, 2005), the best ratio for making pectin jelly from apples was 1.92:1. When extracting pomelo peel juice, enough water should be added, as a large quantity of water only dilutes the pectin, and then boiling is required to concentrate it (Tarr, 1926). The greater the acidity of the juice the lower the amount of sugar is required and juices with high acid will produce firmer jellies compared to juices that contain less in acid (Singh, 1922). The increasing rigidity of jellies with acid increased when the pectin and sugar concentrations are constant (Spencer, 1930).

Table 2 showed that the percentage sag test was done to measure the gel strength. The higher the percentage score value indicated that the gel is soft. The Fifth formulation showed that the lowest the percentage sag the stronger the jelly. The lowest the percentage of sag the stronger the jelly (McWilliams, 2005).

Table 3 showed that the proximate analysis for protein, fat, fiber, moisture, and ash has been done according to AOAC method. Protein content of pectin jelly is low that is 0.41% compared to banana peel jelly that contain 10g banana peel powder (Lee et. al., 2010), the protein content is 0.62%. The percentage of fat is so small; 0.12% compared to banana peel jelly which is 0.22%. The percentage of fiber content in pectin jelly is 0.46% when compared to banana peel jelly that has high fiber which is 4.64%. The highest composition in pectin jelly is moisture that is 32.01%. However, when compared to banana peel jelly that has 42.92% moisture content, pomelo pectin jelly has rather low moisture content. Ash content analysis resulted in high value which is 1.33%. It is higher compared to banana peel jelly that has 1.04% ash content. The carbohydrate contains in pectin jelly is 67.46% higher than banana jelly which has total carbohydrate of 54.25%.

Table 4 showed that there were significant differences between samples for the sensory attributes of color, aroma, tenderness, sweetness and bitterness. It was concluded that the amount of sugar affect the physical

characteristics of pectin jelly. Sample 3 has the highest value of aroma and color intensity due to Maillard. Increase in sugar level accelerate the setting of the jelly, probably due to increased dehydration, although rate of setting is also modified by others factors (Holloway, 1983). Sample 4 showed the highest results for tenderness because it contains high sugar and the jelly becomes weak and tenderer. Sample 1 showed the highest value of bitterness due to less sugar content.

Table 5 showed the hedonic test of pectin jelly variation. Hedonic test is also known as liking test is used to measure the level of liking for a product. A 9-point Hedonic scale ranging from dislike extremely (1) to like extremely (9) was used in evaluating the sensory attributes. According to table 4.9, Sample 2 has the highest score of 6.2±2.35 for hedonic test. Therefore, the most likeable pectin jelly is Sample 2. It means that the panelists have chosen Sample 2 because they like all the attributes from the sample.

Figure 2 showed the color of the jelly measured using Colorimeter. Color values were recorded as "L" (0, black; 100, white), "a" (-a, greenness; +a, redness), and "b" (-b, blueness; +b, yellowness). The "L" values observed in this study were possibly due to maillard reaction and caramelization, which were influenced by the distribution of water and the reaction between reducing sugars and amino acids (Siddiq, 2009). The "L" values observed in this study ranged from 30.96 to 44.57. Sample 4 was darker in color, as depicted by lower "L" value than other samples. Statistical test showed that there was significant difference between "L" color of the samples because p-value is less than -value, 0.0.5. The "a" values ranged from -2.07 to -0.66. The "b" values ranged from 11.29 to 19.28. Sample 4 shows that there were significant different among the samples for "a" and "b" values. Sample 4 got the lowest "b" value which indicates the jelly color is more bent to blueness.

Conclusions

This study focused on characteristics of pectin extracted from albedo added with water and boiled at boiling point 100oC. The amount of sugar, citric acid were formulated. The effect of sugar, tenderness, color, time, temperature for the jelly to set and the yield of the jelly were tested and analyzed.

From the results of the study, the recommended ratio of albedo and water was 1:1 and the recommended ratio of pomelo peel juice, sugar, water for making pectin jelly was 3:2:1. It is concluded that the pectin jelly from pomelo extracts has the potential to be used as a food ingredient in the food industry.

TABLES

Table 1. Formulation of pectin jelly

Formulation	1	2	3	4	5
Albedo (g)	40	152	260	500	500
Water	35	100	140	1000	500
Ratio	1:0.88	1:0.70	1:0.54	1:2.00	1:1.00
Juice Extracted (mL)	40	60	100	500	150
Sugar (g)	20	120	70	300	100
Citric Acid (mL)	4	6	16	15	50
Ratio	10:5:1	10:20:1	6.3:4.4:1	33.3:20:1	3:2:1

Table 2. Characteristics of pectin jelly

Characteristics	Formulation				
	1	2	3	4	5
% Sag	14.30±0.00%	8.33±0.00%	25.00±0.00%	14.67±2.31%	3.03±0.00%

Table 3. Proximate analysis of pectin jelly

Proximate Analysis	Pomelo Peel Pectin Jelly (%)
Protein	0.41±0.08
Fat	0.12±0.02
Fiber	0.46±0.47
Moisture	32.01±1.01
Ash	1.33±1.15
Carbohydrate	67.46±0.41

Table 4. Attributes scores for pectin jelly variation

	Sample 1	Sample 2	Sample 3	Sample 4
Colour	4.9±1.91a	6.6±1.65b	7.7±1.06b	7.2±1.62b
Aroma	4.8±1.40a	5.7±1.06a	6.8±1.14a	6.5±1.58a
Tenderness	3.4±1.35a	5.2±0.92b	7.3±0.82c	8.7±0.82d
Sweetness	3.9±1.60a	4.9±1.52a	7.9±0.74b	8.6±0.70ac
Bitterness	8.6±1.07a	8.2±0.92a	4.8±0.63b	4.3±1.06ac

Table 5. Hedonic scores of pectin jelly variation

Sample	Hedonic score
1	2.5±0.97a
2	6.2±2.35b
3	5.9±1.20c
4	4.9±1.10c

Values are mean ± standard deviation.
Means sharing the same letters in columns are not significantly different from each other (Tukey's test, $p > 0.05$

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APPENDIX 4

WELCOME ADDRESSES

Opening address

Kaison Chang
Secretary, Intergovernmental Group on Bananas and Tropical Fruits, Food and Agriculture Organization of the United Nations (FAO)

It gives me great pleasure in welcoming all participants to the International Symposium on Superfruits : Truth or Myth?

On behalf of the Organizing Committee, I would like to express sincere appreciation to the Government of Viet Nam for hosting this event and for extending their warm hospitality to all of us.

To feed a growing population that is expected to reach 9 billion in 2050, the world needs to increase agricultural production by at least 60 percent in the next decade, but this would not be enough to overcome food insecurity. We need to ensure that those who suffer from hunger, the vast majority of whom live in rural areas, have the means to access the food they need to live a healthy and productive life. In this regard, the tropical fruit sector has an important role for millions of rural households across the globe as a source for employment, income generation, and economic growth, apart from the direct nutritional benefits derived from tropical fruits consumption.

During discussion at its Fifth Session in Cameroon, in 2011, the FAO Intergovernmental Group (IGG) on Bananas and Tropical Fruits acknowledged the importance of tropical fruits from both a nutritional and soci-economic perspective. They are cultivated widely in the tropics, almost exclusively in developing countries, at commercial and subsistence levels and until the 1970s, were mostly utilized for domestic consumption. Contribution to farm/rural household incomes is significant with the value of production of tropical fruits estimated at USD 50.8 billion in 2010. Although only 10 percent of tropical fruit production is traded internationally, quantities are relatively large compared to other fruits, and earnings from these are significant. In 2010, the value of trade of fresh tropical fruits was USD 4.7 billion, USD12.8 billion if bananas are included, compared with USD 6.5 billion for apples, USD 4.5 billion for oranges, and USD 2.3 billion for pears. A further USD 1.5 billion was exported as processed tropical fruits.

Of the estimated 90 percent that remain in the producing countries, up to 40 percent are lost through inadequate post-harvest handling and wastage through seasonal gluts and substitution from imported temperate fruits.

During discussions at the Session the IGG suggested that the Secretariat examine opportunities for promoting the consumption of tropical fruits. Hence, this Symposium constitutes an essential forum to firstly derive a definition of "superfruits", then examine the nutritional and economic benefits of these fruits, and develop an Action Plan to ensure that the production and trade of tropical fruits are profitable and sustainable over time. Hence, the participants of the symposium are not only from tropical fruits producing and consuming countries around the world but also practitioners from public, private and civil society organizations, policy makers, the research and development community, academia, traders, financial institutions and the media. From a nutritional perspective, micronutrient malnutrition is a persistent problem, affecting approximately two billion people, according to FAO estimates. As a category of food, fruits make a substantial contribution to the micronutrient intakes for populations in every country in the world. It is estimated that in some countries, upward of 50 percent of the recommended intake of dietary fibre, pro-vitamin A carotenoids, vitamin C, several B-vitamins and many trace elements come from fruits in the diet. National food-based dietary guidelines invariably recommend eating two or more servings of fruit every day. FAO/WHO guidelines for prevention of diet-related chronic diseases are based on these convincing evidence that fruit consumption reduces the risk of obesity and heart disease, and there is probable evidence that fruit consumption decreases the risk of diabetes and many cancers. In addition to conventional nutrients, fruits contain thousands of beneficial bio-active non-nutrients, with putative effects ranging from improving intelligence to increasing longevity.

I take this opportunity to thank the members of the organizing committee, the International Tropical Fruits Network (TFNet) and the Ministry of Agriculture and Rural Development (MARD) of Viet Nam for supporting the FAO Secretariat of the Intergovernmental Sub-Group on Tropical Fruits in organizing this event.

I wish you a very constructive and fruitful discussion.

Welcome address from co-organizer

His Excellency Dato' Mohd Hashim Abdullah
Secretary-General, Ministry of Agriculture and Agro-Based Industry, Malaysia Chairperson, International Tropical Fruits Network (TFNet)

Delivered by

Yi Ganjun
Vice President, Guangdong Academy of Agricultural Sciences, People's Republic of China

His Excellency Dr. Ha Chong Tuan, Vice Minister of the Ministry of Agriculture and Rural Development,

Mr. Kaison Chang, Chairman of the Organising Committee and Secretary of the Intergovernmental Group on Banana and Tropical Fruits, Food and Agriculture Organisation of the UN,

Distinguished guests,

Ladies and Gentlemen,

As Chairperson of International Tropical Fruits Network (TFNet), it gives me great pleasure to warmly welcome you to the 'International Symposium on Superfruits: Myth or Truth'. TFNet is honored to be part of this joint collaboration with FAO and the Ministry of Agriculture and Rural Development, Vietnam.

First of all, I would like to express my gratitude to the Vice Minister of the Ministry of Agriculture and Rural Development, Vietnam, Her Excellency Nguyen Thi Xuan Thu for kindly accepting this invitation to grace and officially open this symposium.

I am also happy that TFNet will be having their Board of Trustees meeting and a workshop on smallholder integration into tropical fruits value chain after this symposium, beginning on 4 July.

For the benefit of those who are unfamiliar, TFNet or International Tropical Fruits Network, has been established since 2000 under the auspices of FAO's Intergovernmental Group for bananas and tropical fruits. TFNet's operations are defined by members needs on the various challenges faced in developing tropical fruits. Currently TFNet has 150 members, 13 of which are country members. The main activities of TFNet are to conduct consultancies, studies and projects, capacity building activities and information dissemination.

TFNet is hosted by the Malaysian Government, which, as a key member and contributor has been supportive of TFNet's role and activities in developing tropical fruits.

However, there is still room for TFNet to expand its activities and visibility, especially in member countries. In relation to this I would like to urge member countries, whose representatives are present today, to engage more with the organisation in order to fully benefit from the various activities organised by TFNet.
Ladies and Gentlemen,

This symposium is an example of the commitment of TFNet to explore the concept of superfruits for tropical fruits.

In recent years, the current market scenario on horticultural crops, especially with fruits have been very crowded and competitive. Fruit producers, distributors and retailers have been very responsive with the

introduction of new varieties, technologies and marketing strategies, to feed the growing demand for safe, good quality and nutritious food.

The marketing of 'superfruits' has achieved some success in developed countries with the identification of certain fruit types and the health benefits it provides to consumers. selected fruit types believed to contain phytochemicals beneficial to human health. Currently the definition of 'superfruits' is debatable, which is why this symposium is very important, especially considering that some tropical fruits can be included in this category.

Besides the question of definition, I am happy that this symposium also looks at the other aspects, such as production technologies, breeding, post- harvest management, pest and disease control and value chain development of potential tropical 'superfruits'.

I also like to extend my appreciation to our colleagues from FAO, the Ministry of Agriculture and Rural Development, Vietnam, all presenters and all participants for their contribution in making this symposium a success.

I sincerely hope the inputs provided by all presenters and resulting deliberations will bear fruit.

Thank you.

Welcome address

His Excellency Dr. Ha Cong Tuan
Vice Minister for Agriculture and Rural Development, Vietnam

His Excellency the Secretary General of the Ministry of Agriculture and Agro-based Industry Malaysia and Chairperson of International Tropical Fruits Network, Dato' Hashim Abdullah,

Chairman of the Symposium Organising Committee from the Food and Agriculture Organisation, Mr. Kaison Chang

Distinguished Guests

Ladies and Gentlemen

On behalf of the Government of Vietnam, I warmly welcome you to the International Symposium on Superfruits: Myth or Truth in this lovely city of Ho Chi Minh.

It is my pleasure to join you today to preside over the official opening of this very important symposium.

We are indeed honoured to be host of this symposium and two other events following the symposium, which is the TFNet Board of Trustees Meeting and a workshop on smallholders integration into the tropical fruit value chain andI would like to express my appreciation to Food and Agriculture Organisation (FAO) and International Tropical Fruits Network (TFNet) for selecting Vietnam for these events.

I am also happy that there are more than 100 participants from more than 18 countries attending the symposium.

Ladies and Gentlemen,

Agriculture is a main activity in Vietnam with about 29 percent of total land area developed for agriculture. Of this total area estimated of 3.8 million hectares is cultivated with rice. Besides rice which is the main exported crop, there are some other crops used for export such as: coffee, cashew nuts, pepper, rubber, tea, etc.… With its range of tropical and subtropical fruits, the total land area for fruits in Vietnam is estimated at 780,000 ha, which makes it a major fruit producer in Asia. The main fruits grown in Vietnam are citrus,

banana, pineapple, mango, litchi, longan, pitaya, guava, avocado, rambutan, durian, mangosteen and sapote.

The Mekong River Delta which is a major rice producing area is also known to produce tropical fruits with a cultivated area of about 360,000 ha. Most of the fruits produced are for the domestic market, and the rest is for export. The Government through the Ministry of Agriculture and Rural Development (MARD) is now looking at avenues to increase exports of tropical fruits, through programmes including improving quality and post-harvest management. Currently we are exporting pitaya, rambutan and pummelo to the European and US markets.

The MARD has given much emphasis to develop tropical fruits in Vietnam through our research institutions and effective capacity development programs with the focus of producing high yielding, marketable good quality fruits. The Vietnam standards for Good Agricultural Practices (VietGAP) for fruits, has been established and currently is being implemented in the fruit growing areas.

Besides this, the private sector too has played a major role in improving quality, including storage and processing of the fruits. In other words, Vietnam is set to become a major producer and exporter of tropical fruits in the region. This initiative by Vietnam is in line with the recent move by more developed markets for quality and safe food. In recent years, there has been an increase in consumer awareness and demand, for nutritious food for health, wellbeing and those with anti-aging/anti-oxidant properties.This is very much related to the theme of this symposium on superfruits.

Ladies and Gentlemen,

In general, the term 'Superfruits' is a marketing approach to promote fruits used as raw or processed products that has health enhancing properties and promotes human well-being. Can the major tropical fruits produced in Vietnam or other countries also be called superfruits?

In this regard, the organisation of this symposium is well-timed, considering the objective of defining what superfruits are, and which tropical fruit types fit in this category.

The participation of experts in the various field, I am sure will provide valuable inputs for deliberations, and eventually to an acceptable definition and expansion of the term, superfruits.

I would like to urge for all participants to fully indulge in the discussion.

It is expected that by the end of this symposium,

- there will be an agreement among participation and endorsement from FAO on the various characteristics of fruits that can be labelled as superfruits
- a list of tropical fruits that has the potential to be called superfruits
- sharing of knowledge and exchange of information on superfruits which can be later disseminated by participants in their respective countries
- the establishment of networking ties between all participants for future collaboration.

I would like to thank FAO, TFNet, all presenters, participants, sponsors and all staff from Fruit and Vegetable Research Institute, Southern Fruit Research Institute and the International Cooperation Department of Ministry of Agriculture and Rural Development for their contribution in making this symposium a success.

On behalf of the Ministry of Agriculture and Rural Development of Vietnam, I would like to wish all participants a productive and engaging symposium.

To our foreign participants, have a pleasant and enjoyable stay in Vietnam.

Ladies and Gentlemen,

I officially open this Symposium on Superfruits: Myth or Truth.

Thank you

APPENDIX 5

THE ORGANIZING COMMITTEE

Chairperson:
Kaison Chang - Secretary, Intergovermental Group on Bananas and Tropical Fruits, Food and Agriculture Organization (FAO), Rome

Co-Chairperson:
Yacob Ahmad - International Tropical Fruits Network - TFNet

Members:
Margarita Brattlof - Trade and Markets Division, Food and Agriculture Organization of the United Nations (FAO), Rome
Trinh Khac Quang - Fruit and Vegetable Research Institute (FAVRI), Vietnam
Nguyen Minh Chau - Southern Fruit Research Institute (SOFRI), Vietnam
Nguyen Thi Tuyet Hoa - Ministry of Agriculture and Rural Development (MARD), Vietnam
Nguyen Van Son - Southern Fruit Research Institute (SOFRI), Vietnam
Le Thi Ha - Fruit and Vegetable Research Institute (FAVRI), Vietnam
Ho Thi Minh Chau - International Cooperation Department, Ministry of Agriculture and Rural Development (MARD), Vietnam
Yi Ganjun - Guangdong Academy of Agricultural Sciences, China
Errol Hewett - Massey University, New Zealand
Sisir Mitra Kumar - Bidhan Chandra Krishi Viswavidyalaya, India
Nguyen Quoc Hung - Fruit and Vegetable Research Institute (FAVRI), Vietnam
Nguyen Van Hoa - Southern Fruit Research Institute (SOFRI), Vietnam
Luong Trung Lap - Southern Fruit Research Institute (SOFRI), Vietnam
K. Palasubermaniam - International Tropical Fruits Network - TFNet
Hariyatul Asni Abd. Rani - International Tropical Fruits Network - TFNet
Christian Cangao - International Tropical Fruits Network - TFNet
Mohd Khairul Najmi - International Tropical Fruits Network - TFNet
Noor Said - International Tropical Fruits Network - TFNet

APPENDIX 6

LIST OF PARTICIPANTS

No.	Name	Designation	Organization / Institution / Company
1	A.K. Misra	Project Coordinator	Central Institute for Subtropical Horticulture (CISH) India
2	Adenike Olusolape Olufolaji	Executive Director	National Horticultural Research Institute (NIHORT), Nigeria
3	Ahmad Widodo Heru	Deputy General	Department of Horticulture, Indonesia
4	Alison Hodder	Senior Officer	Food and Agriculture Organization of the United Nations (FAO)
5	Azman Aris	Marketing Officer	Federal Agricultural and Marketing Authority (FAMA), Malaysia
6	Babasola Ayodele Adelaja	Director	Fruit/Spices Division, National Horticultural Research Institute (NIHORT), Nigeria
7	Badreldin Elsheikh Mohamed Elhassan	Director General	Horticultural Sector Administration, Ministry of Agriculture & Forests, Republic of Sudan
8	Bin Zheng	-	Lianping County Dafulin Agriculture Co. Ltd. P.R. of China
9	Cecep Effendi	Director General	Center on Intergrated Rural Development for Asia and the Pacific (CIRDAP), Bangladesh
10	Chek Zaini Hassan	Researcher/ Lecturer	Universiti Sains Islam Malaysia, Negeri Sembilan, Malaysia
11	Christian Anthony Cangao	Information Officer	International Tropical Fruits Network (TFNet)
12	Danilo T. Dannug	Senior Agriculturist	Buerau of Plant Industry Depart of Agriculture, Philippines
13	DBT Wijeratne	Additional Secretary	Ministry of Agriculture, Sri Lanka
14	Duan Dongyang	Researcher	Fruit Tree Research Institute, PR China
15	Edna A. Anit	Supervising Science Research Specialist	Philippine Council for Agricultural Aquatic and Natural Resources Research and Development (PCAARRD)
16	Errol W. Hewett	Professor	Massey University, New Zealand
17	Hariyatul Asni Abdul Rani	Administrative Officer	International Tropical Fruits Network (TFNet)
18	Juejan Tangtermthong	Executive Director	Agricultural and Food Marketing Association for Asia and the Pacific (AFMA), Thailand
19	Kaison Chang	Senior Economist/ Secretary	IGG on Bananas and Tropical Fruits, Food and Agriculture Organization of the United Nations (FAO)
20	Kamarulnizam Kamarudin	Entrepreneur	Federal Agricultural and Marketing Authority (FAMA) Enterpreneur, Malaysia
21	Katsuya Ichinose	Researcher	Kyusu Okinawa Agricultural Research Center, Kkinawa-ken Japan
22	Kazuyoshi Yuasa	Researcher	(Japan International Cooperation Agency) JICA Project Office
23	Kwek Mei Jiun	Scientific Assistant	Crops For The Future (CROFU), Malaysia

24	Lu Ann Williams	Head of Research	Innova Marketing Insights, US
25	Margarita Brattlof	Officer	Intergovernmental Group on Bananas and Tropical Fruits, FAO
26	Mario Arvelo	Chair/Ambassador	United Nations Council of Agriculture/ Dominican Republic Embassy, Rome
27	Mary Ann Lila	Food Science Director	Plants for Human Health Institute, North Carolina, USA
28	Miliakere R. Nawaikula	Principal Research Officer	Ministry of Agriculture and Primary Industries, Fiji
29	Mohamad Bin Harun	Marketing Officer	Federal Agricultural and Marketing Authority (FAMA), Malaysia
30	Mohd. Azraie Ramli	Marketing Officer	Federal Agricultural and Marketing Authority (FAMA), Malaysia
31	Mohd. Firdaus Ab. Aziz	Marketing Officer	Federal Agricultural and Marketing Authority (FAMA), Malaysia
32	Mohd. Khairul Najmi Abdullah	Information Technology Officer	International Tropical Fruits Network (TFNet)
33	Mohd. Ridzuan Sirun	Marketing Officer	Federal Agricultural and Marketing Authority (FAMA), Malaysia
34	Mohd. Shamsuddin Saberi	Marketing Officer	Federal Agricultural and Marketing Authority (FAMA), Malaysia
35	Mohd. Zainuddin Mat Hassan	Marketing Officer	Federal Agricultural and Marketing Authority (FAMA), Malaysia
36	Muez Abd. Aziz	Director	Ministry of Agriculture (MOA), Malaysia
37	Naoko Kozai	Researcher	Japan International Research Center for Agricultural Sciences (JIRCAS)
38	Ninlawan Leeungculsatien	Research Officer	Horticultural Research Insitute, Dept of Agriculture, Thailand
39	Noor Ba'ah Abdol Said	Personal Assistant	International Tropical Fruits Network (TFNet)
40	Ong Chong Guan	Entrepreneur	BAS Speciality Fertilizers Sdn. Bhd., Malaysia
41	Palasuberniam Kaliannan	Technical Officer	International Tropical Fruits Network (TFNet)
42	Pearlycia Brooke	Agricultural Officer	Department of Agriculture Sarawak, Malaysia
43	Phebe Ding	Researcher	Faculty of Agriculture, Universiti Putra Malaysia
44	Qingming Sun	Researcher	Guangdong Academy of Agricultural Sciences, P.R of China
45	Robert C Williams	Director	Northern Territory, Government of Australia
46	Roedhy Poerwanto	Researcher	Bogor Agricultural University, Indonesia
47	Sisir Kumar Mitra	Chair	International Society for Horticulture Science (ISHS), West Bengal, India
48	Takefumi Hayashi	Researcher	Faculty of Informatics, Kansai University
49	Tatsushi Ogata	Researcher	Japan International Research Center for Agricultural Sciences (JIRCAS)
50	Tengku Malik Tengku Maamun, YM Hj.	Director	Malaysian Agricultural Research and Development Institute (MARDI), Malaysia
51	Than Than Sein	Consultant	Myanmar Fruit Flower and Vegetable Association
52	Then Kek Hoe	Senior Agronomist	Felda Agricultural Services Sdn. Bhd., Malaysia

53	Wan Izzudin Sulaiman	Interim Chief Executive Officer	Team Biovision Sdn. Bhd. Malaysia
54	Yacob Ahmad	Chief Executive Officer	International Tropical Fruits Network (TFNet)
55	Yi Ganjun	Vice President	Guangdong Academy of Agricultural Sciences, P.R of China
56	Zabedah Mahmood	Deputy Director	Horticulture Research Center, MARDI, Malaysia
57	Zhong Guangyan	Director	Fruit Tree Research Institute, PR China
58	Robert Nissen	Managing Director	AG-Hort International Pty. Ltd.
59	Bui Quang Dang	Officer	Fruit and Vegetable Research Institute (FAVRI)
60	Bui Thi Ngoc lan	Officer	Southern Horticultural Research Institute (SOFRI)
61	Bui Xuan Khoi	-	-
62	Dang Thi Thu Truy	-	-
63	Dao Quang Nghi?	Officer	Fruit and Vegetable Research Institute (FAVRI)
64	Dao Thanh Van	Officer	Fruit and Vegetable Research Institute (FAVRI)
65	Do Dinh Ha	Officer	Fruit and Vegetable Research Institute (FAVRI)
66	Kim Ki Taek	Officer	Fruit and Vegetable Research Institute (FAVRI)
67	Kim Myeong Seong	Officer	Fruit and Vegetable Research Institute (FAVRI)
68	Le Quoc Dien	Officer	Southern Horticultural Research Institute (SOFRI)
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70	Luong Ngoc Trung Lap	Officer	Southern Horticultural Research Institute (SOFRI)
71	Ly Thanh Thao	-	-
72	Mai Van Tri	Officer	Southern Horticultural Research Institute (SOFRI)
73	Nguyen Duy Hung	Officer	Fruit and Vegetable Research Institute (FAVRI)
74	Nguyen Khac Anh	Officer	Fruit and Vegetable Research Institute (FAVRI)
75	Nguyen Minh Chau, Dr.	Deputy Director	Southern Horticultural Research Institute (SOFRI)
76	Nguyen Quoc Hieu	Officer	Fruit and Vegetable Research Institute (FAVRI)
77	Nguyen Quoc Hung	Officer	Fruit and Vegetable Research Institute (FAVRI)
78	Nguyen Thanh Hieu	Officer	Southern Horticultural Research Institute (SOFRI)
79	Nguyen The Huan	Officer	Fruit and Vegetable Research Institute (FAVRI)
80	Nguyen Thi Dao	-	-
81	Nguyen Thi Ngoc Truc	Officer	Southern Horticultural Research Institute (SOFRI)
82	Nguyen Trinh Nhat Hang	Officer	Southern Horticultural Research Institute (SOFRI)
83	Nguyen Van Dung	Officer	Southern Horticultural Research Institute (SOFRI)
84	Nguyen Van Hoa	Officer	Southern Horticultural Research Institute (SOFRI)
85	Nguyen Van Phong	Officer	Southern Horticultural Research Institute (SOFRI)
86	Nguyen Van Son	Officer	Southern Horticultural Research Institute (SOFRI)
87	Pham Dinh Dung	-	-
88	Pham Van Hung	Officer	Southern Horticultural Research Institute (SOFRI)
89	Selby Xavier	Executive	Royaland, Vietnam
90	Tran Thi My Thanh	Officer	Southern Horticultural Research Institute (SOFRI)
91	Tran Thi Oanh Yen	Officer	Southern Horticultural Research Institute (SOFRI)
92	Trinh Khac Quang	Director	Fruit and Vegetable Research Institute (FAVRI)
93	Truong T. Ngoc Diem	Officer	Southern Horticultural Research Institute (SOFRI)

94	Vo Huu Thoai	Officer	Southern Horticultural Research Institute (SOFRI)
95	Vo Mai	Adviser	Vacvinas, Vietnam
96	Vu Manh Hai	Officer	Fruit and Vegetable Research Institute (FAVRI)
97	Vu Viet Hung	Officer	Fruit and Vegetable Research Institute (FAVRI)
98	Yim Jihye	Officer	Fruit and Vegetable Research Institute (FAVRI)

LINKS TO PRESENTATIONS

Session 1

Session 2

Session 3

Session 4

Session 5

Parallel Session 1

Parallel Session 2

Parallel Session 3