Enhancing Export Competitiveness of **Asian Fruits**

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United Nations Asian and Pacific Centre for Agricultural Engineering and Machinery

ENHANCING EXPORT COMPETITIVENESS OF ASIAN FRUITS

APCAEM

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FOREWORD

ESCAP is mandated to contribute to poverty reduction in the region corresponding to the Millennium Development Goals (MDGs) of the United Nations, which was adopted in 2000 by the leaders in accordance with governments of more than 150 member countries of the United Nations. The action plans of the MDGs, among others, specifically call for reducing poverty through increased food availability, affordability and safety by applying postharvest and food processing technology and through food trade. One of the action plans recommends efficient marketing and distribution channels by promoting linkages among farmers, agro-enterprises, R&D institutions, and government entities along the food chain.

The market demand for fresh horticultural produce has been growing steadily since the 1980s. International trade in fruits and vegetables has expanded rapidly over the past two decades compared to trade in other agricultural commodities. International trade and investment liberalization, globalization and accelerated urbanization provide opportunities and challenges for agricultural development. The consumer demand for high quality and safe agro-products and food, along with fair trade practices, is an opportunity that can tap Asian exporting countries as providers of fresh fruits and vegetables, enabling Asian fruits to access global consumers. The export of fruits should lead to increase in farming income and create employment opportunities among young and female workers, as well as to promote economic growth of rural areas in the Asia-Pacific region.

Asia takes around 44% of the world's acreage of fruit production, but the export of fruits from Asia lags behind those from other major fruit-producing regions such as Central America, which takes 33% share of global exports, and South America with 37% share. Several reasons related to domestic conditions as well as impediments to trade development and requirements/standards set by the importing developed countries of the world have been attributed to this imbalance in the production and export of Asian fruits. Substandard and inadequate postharvest technology and management system is a major bottleneck to the expansion of trade of Asian fruits from the region. The current situation calls for policy-makers' heightened attention to improving postharvest technology and major issues related to storage and processing, as well as marketing and distribution in the context of integrated supply chain management system. The quality and the cost of the fruits commensurate with the requirements of the importing countries need to be approached through a whole range of infrastructural, socio-economic, technology, financial and policy measures.

To discuss the issues and derive the strategies and action plans in strengthening postharvest management and export of fruits, the Asian and Pacific Centre for Agricultural Engineering and Machinery (APCAEM) organized the “International Seminar on Enhancing Export Competitiveness of Asian Fruits” in Bangkok, Thailand on 18-19 May 2006. The seminar covered with issues involved in fresh fruit exports, current status of and prospects for advanced postharvest technology and food supply chain management, and the discussion on best practices in maintaining fruit quality and food safety assurance as a means for improving export competitiveness of Asian fruits.

The Seminar shared the latest postharvest technology among the ESCAP member countries. It identified the best practices in fruit supply chain management and adaptation of the postharvest technology suitable to the conditions in the Asian-Pacific region. Adoption and application of the most appropriate and efficient food (inter alia, fruits and fresh vegetables) chain management would lead to increased food production both in terms of quantity and quality and increase the potential for exports of these horticultural produce from the region. The resultant higher income and employment of the rural population will contribute to rural poverty reduction, one of the major goals of the MDGs of the United Nations (UN).

The recommendations emerging from the Seminar deliberations need to be placed in the proper context in different countries and implemented by the member country Governments with appropriate strategies and action plans. The knowledge value chain thus gained must be brought to the linkages within the UN system and outside to help relevant programmes.

ABBREVIATIONS

APCAEM	Asian and Pacific Centre for Agricultural Engineering
ASEAN	Association of Southeast Asian Nations
CA	Controlled Atmosphere
CETROFS	Center for Tropical Fruit Studies
DCS	Dynamic Control System
ESCAP	Economic and Social Commission for Asia and the Pacific
EU	European Union
FAO	Food and Agriculture Organization of the United Nations
GAP	Good Agriculture Practice
GMP	Good Manufacturing Practice
HACCP	Hazard Analysis and Critical Control Point
ICM	Integrated Crop Management
INM	Integrated Nutrient Management
IPM	Integrated Pest Management
ISO	International Standardization Organization
MA	Modified Atmosphere
MDGs	Millennium Development Goals
MRD	Mekong River Delta
MMT	Million Metric Tons
MT	Metric Tons
NAFTA	North American Free Trade Agreement
NIR	Near Infra-Red (wavelength of 780-2500nm)
NTB	Non-Tariff Barriers
QACCP	Quality Analysis of Critical Control Points
QMS	Quality Management System
SCM	Supply Chain Management
SPS	Sanitary and Phyto-Sanitary

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1. INTRODUCTION

Human life (physical, mental and spiritual) is immensely influenced by the quantity and quality of food consumed. As the saying goes, “a man is what he eats.” Several studies have linked the physical and behavioral traits of the people of specific geographical locations to the composition of food and water available to them.

Obviously, one of the most important requirements for ensuring healthy population on this planet is to provide quality food in sufficient quantity. Not only should food meet the gross energy requirements of human body, there should be a proper balance of major, micro and trace nutrients to ensure complete human development. Poor nutrition contributes to 1 out of 2 deaths (53%) associated with infectious diseases among children aged under five in developing countries. Iron deficiency with its attendant anemia is the most prevalent micronutrient disorder on a worldwide basis. All forms of malnutrition's broad spectrum are associated with significant morbidity, mortality, and economic costs, particularly in countries where both under- and over nutrition co-exist as seen in developing countries undergoing rapid transition in nutrition and life-style. In today’s world, food must be wholesome and safe for human consumption. Wholesome food availability obviates a large number of ailments and disorders leading to better quality of life and reduced expenditure on health care. It is not surprising, therefore, that food safety and quality concerns are increasingly evident today among producers, processors, marketers, regulators and consumers alike.

Fruits are an integral part of food needed to meet the mineral requirements of human body and to strengthen body defence mechanisms against various biotic and abiotic stresses. On average, fruits have been contributing to about 4% to human nutrition. Fruits consumed as fresh or in processed form have shown specific health benefits. Increased awareness about the health-related benefits of fruits consumption is leading to increased trade in fruits, especially, driven by the consumers of developed countries. There was a double-digit growth in the export of mangos and avocados during 1989-2001, while the overall fruit exports grew at 4.2% during the same period. While several southern hemisphere and banana exporting countries have been quick to take advantage of the growing fruit trade, the same does not hold good for the countries of Asia. In fact, among the top thirty exporters of fruits in the world, only three (Thailand, China and the Philippines) stand out from Asia.

Asia is the cradle of human civilization and domestication of crops and animals, which began first on this continent. It is, therefore, expected that the whole range of temperate and tropical fruits are grown in Asia. Asian tropical fruits such as durian, mango, pomegranate, guava and starfruit have their unique traits in the world of fruits. Asia takes some 44% of the total fruit producing area in the world and contributes about 42% to the

total world fruit production, with the largest and the second largest fruit producers located on this continent. Table 1.1 presents a summary of the production data of the major fruits from Asian countries. A brief description of the major Asian fruits is included in Annex to provide the reader a flavor of these unique creations of Mother Nature.

Table 1.1. Major fruits and fruit producing countries in the Asia-Pacific region
(Unit: thousand tons)

Fruit / Country	Citrus	Mango	Pears	Grape	Banana	Papaya	Pineapple	Persimmon	Total
Bangladesh	44	187	–	–	700	–	–	–	1,476
China	12,545	3,413	10,642	5,435	6,246	155	1,404	1,656	72,203
India	4,580	10,500	200	1,200	16,820	700	1,300	–	45,911
Indonesia	–	950	–	–	4,874	733	710	–	9,012
Korea Rep	667	–	452	–	–	–	–	273	2,749
Japan	1,455	–	352	–	–	–	1	286	3,782
Malaysia	30	20	–	–	530	72	30	–	1,155
Pakistan	1,995	1,036	31	49	148	8	–	–	5,459
Philippines	181	890	–	–	5,631	132	1,759	–	11,804
Sri Lanka	–	–	–	–	–	–	–	–	854
Thailand	1,116	1,750		43	2,000	125	1,997	–	7,521
Viet Nam	512	305	–	–	1,221	–	–	–	5,096
World	103,821	25,564	16,000	67,200	69,286	6,504	13,889	2,335	480,250

Source: FAOSTAT (2004).

In spite of the natural advantages that the Asian fruits have in terms of variety, production scale and nutrition, the export volume of the fruit is rather low. Therefore, while there appears to be an ample scope for increasing the intra-Asia and inter-continental trade in Asian fruits, it is important to understand the constraints in tapping the trade potential. This trade will not only provide more income for farmers in the Asian and Pacific countries, but also offer greater variety and associated health benefits to the world consumers.

With the objective of promoting international trade and investment for Asian fruits, an International Seminar on Enhancing Export Competitiveness of Asian Fruits was held in Bangkok from 18-19 May 2006, coinciding with ThaiFex 2006. The event was jointly sponsored by the United Nations Asian and Pacific Centre for Agricultural Engineering and Machinery (APCAEM), a subsidiary body of the United Nations Economic and Social Commission for Asia and the Pacific (ESCAP) and the Department of Agriculture of the Ministry of Agriculture and Cooperatives of the Royal Thai Government. The Seminar was attended by Government officials, agribusiness entrepreneurs, marketers and producers to discuss the current status, problems and solutions for enhancing export competitiveness of Asian fruits.

The Seminar's goal was to formulate an action plan for increasing investment and assistance from national, bilateral and multilateral development agencies so as to contribute to rural poverty reduction and development. The action plan would lead to the application of postharvest technology and management for reduction of postharvest losses, establishment of agro-enterprises, and generation of employment opportunities in rural areas. It also served as a venue for exchanging information and networking at the national and regional levels.

2. CURRENT STATUS AND SITUATION ANALYSIS

The Asia-Pacific region during 1986-1988 commanded a significant share in the world production of important fruits (Table 2.1). The region produced more than 68% of the share of the minor fruits in the world market, which included litchi and longan.

Table 2.1. Annual production of some major fruits in Asia-Pacific and the world during 1986-1988
(Unit: thousand tons)

Fruit	Asia Pacific* (A)	World (B)	Ratio (A/B, %)	Major producing countries
Banana	16,425	40,087	41.0	India, Philippines, Indonesia, Thailand, PNG, Viet Nam
Citrus	12,609	63,295	19.9	China, Japan, India, Pakistan, Australia
Mango	11,381	14,563	78.2	India, Pakistan, Indonesia, Thailand, Philippines
Pineapple	6,380	10,354	61.6	Philippines, Thailand, India, Viet Nam, Indonesia
Minor fruits**	11,350	16,679	68.1	
Total	**83,996**	**326,886**	**25.7**	

Source: Adapted from Singh (1993).
*Comprises 30 countries.
**Minor fruits include durian, mangosteen, litchi, longan, langsat, rambutan, sugar apple, guava, and starfruit.

The terms major, minor and rare fruits are relative in their meaning depending on whether one is talking about their market availability, production, planted acreage or even other economic considerations. In the international fruit markets, most tropical fruits are considered minor and exotic compared to the temperate fruits, except for a few such as banana and pineapple. Durian, for example, is a major fruit in Malaysia and Thailand, and is also popular in a number of other countries in Southeast Asia; but durian is still unheard of in many parts of the world. In the context of this report, the major and minor fruits are loosely defined as those that are planted with production in mind, but differing in their relative abundance. Rare fruits however are usually not deliberately planted, and many are only found in the forests. Few, if any, find their way into the market. Most of the rare fruits are indigenous and endemic to the region.

A number of major and minor fruits have been introduced into the region; for instance papaya, pineapple, guava, sapodilla and soursop from South America. Presently, the fruits produced in the region are a well-varied mix of indigenous and introduced fruits. Some fruit types, such as citrus, durian, jackfruit and annona are categorized under both major and minor fruits depending on their relative importance in a particular country, and total area under cultivation. However, several fruits, such as papaya, durian, rambutan, jackfruit, mangosteen and lansium are cultivated in a majority of the countries. The major and minor fruits of importance in Asia-Pacific can be summarized as below in Table 2.2.

Table 2.2. Major and minor fruits of Asia

Major fruits	Minor fruits	
Banana	Annona*	Lansium
Citrus	Atis	Litchi
Mango	Avocado	Longan
Pineapple	Caimito	Mangosteen
Durian	Chico	Marang
Rambutan	Citrus*	Papaya
Jackfruit	Durian*	Pili
Annona	Guava	Pummelo
Champedak	Guayabano	Salak
	(soursop)	Sapodilla
	Jackfruit*	Starfruit
		Tiesa

Source: Osman and et al. (1994).
*Also occurs as a major fruit in some countries.

More than 500 species of fruits are estimated to be found in the region. Due to the varying agro-ecologies and socio-economic influences, even the introduced fruit species, such as guava and papaya, have accumulated considerable diversity (Singh, 1993).

Southeast Asia has always been recognized as the centre of origin for a number of cultivated tropical fruit trees. The region possesses a variety of tropical fruits, and is unrivalled in terms of the variety of fruit genetic resources. In many countries of this region, fruits are considered as a source of food and income. Although a wealth of indigenous genetic resources are available, most are still grown in wild or semi-cultivated state. For many, their economic potential has not been fully realized. Unfortunately, systematic efforts to tap their potential have been lacking or not given high priority. Although a few indigenous tropical fruit types are becoming relatively important, on the whole, many tropical fruits are still underexploited.

2.1 Fruit production and export from Asian countries

In this section of the report, fruit production in a few major countries of the region and the export of fresh fruits from these countries are reviewed and discussed. Overall status of the fruit production in Asia will be summarized at the end of this section.

Bangladesh

Bangladesh is blessed with a large variety of fruits. Among the fruit species: banana, mango, pineapple, jackfruit, papaya, guava, lemon, lime, pummelo, litchi, coconut and jujube are the major fruits, while anola, starfruit, bullock's heart, custard apple, Indian olive, pomegranate, bael, hogplum, jamun, wax apple, wood apple, palmyra palm, sapota and rose apple are important minor fruit species. The annual production of fruits in 2000 was about 1.6 million tons from an area of about 0.2 million hectare. The area under fruits cultivation is only 2.1% of the net cropped area. While fruits are mainly grown in the homestead, there are a few commercial orchards of mango, pineapple, banana, papaya and guava in some localized areas of Bangladesh. The average production of fruits both in homesteads and commercial orchards is about 8.4 tons per hectare, which is very low compared to that of other tropical and sub-tropical countries of the world.

China

Fruit is one kind of cash crop for farmers in China and plays an important role in generating income for peasants. China has been the top producer of fruits in the world since the 1990s. Fruit production in China comprised 15.2% of the world total production in 2003; apple and pear accounted for 35.5% and 53.1%, respectively. Citrus growing acreage and production has recently been increasing. China produced more than 16 million tons of citrus fruits, equaling 16% of the world's market for citrus fruits, and became the second largest producer of citrus in the world, after Brazil in 2005.

According to the Chinese Ministry of Agriculture (MOA, 2005), in 2004, the total fruit acreage covered 9.8 million hectares with 83.941 million metric tons (MMT) of production (Table 2.3). Among all the fruits, apple ranked the first with 23.675 MMT, followed by citrus at 14.958 MMT and pear at 10.642 MMT; these three fruits accounted for 58.7% of the total production (Figure 2.1). During the past 4 years, the total fruit production increased by 9.7% annually, but the acreage only increased by 1.5%. It can be seen from Figure 2.1 that the increase during the period of 1980 to 1992 was a slow incline, but increased at a faster pace after 1992. Export of fresh fruits in China has been increasing since 1990s, and reached 1.75 MMT in 2004. The export volume kept at a low level during 1980-1992; however, it registered a sharp increase after 2001(Figure 2.2). The fruits China produced were mainly for domestic consumption. The net balance of trade for China in 2005 was positive with about 2.5 MMT net export of fruits and fruit products, with US$ 1.38 billon trade surplus.

Table 2.4 gives a detailed list of the import and export of fresh and processed fruits for 2005. As compared to 2004, an increase of 15.7% in exports was recorded. On volume basis, apple accounted for 40.5% of the total, followed by citrus (22.8%) and pear (18.1%). China expected 58.1% of the fresh fruit and products were exported to Asia, 23.2% to Europe, and 16.1% to Northern America. Exports to ASEAN accounted for 28.8% (Table 2.5). In 2005, China exported about 0.3 MMT of canned citrus, which accounted for about 60% of the total canned fruit export. The main market was NAFTA (47.1%), followed by the EU (18.6%). Apple juice exported in 2005 amounted to a total of 0.65 MMT; 39.1% of which destined for NAFTA, and 30.3% for EU.

China imported about 0.984 MMT of fresh fruit during 2005, an increase of 8.3% over the previous year. Out of all fruits, bananas from Southeast Asia (mainly from Philippines), longans from Thailand and kiwi fruit from New Zealand were the top three. In October 2003, an agreement between China and Thailand on the removal of non-tariff barriers (NTB) for vegetables and fruits was in effect. This agreement has enhanced the optimization of resources on both sides (Zhang & Tao, 2005). Thailand has the upper hand at producing longans and other tropical fruits, and China stands out with excellent apples and pears. Although there are still some issues that need to be resolved in this agreement, it has facilitated the fruits trade between the two countries. In 2004, China signed NTB agreements for fruits and vegetables with 5 other countries including Singapore, Malaysia, Indonesia, Philippines and Brunei; and in 2005, the cooperation expanded to more ASEAN countries. In 2005, China imported 0.253 MMT fruits from Thailand, and exported 0.125 MMT. For the Philippines, import and export volumes were 0.307 MMT and 0.117 MMT, respectively.

Table 2.3. Fruits production during 2001-2004 in China
(Production in thousand tons; area in thousand hectares)

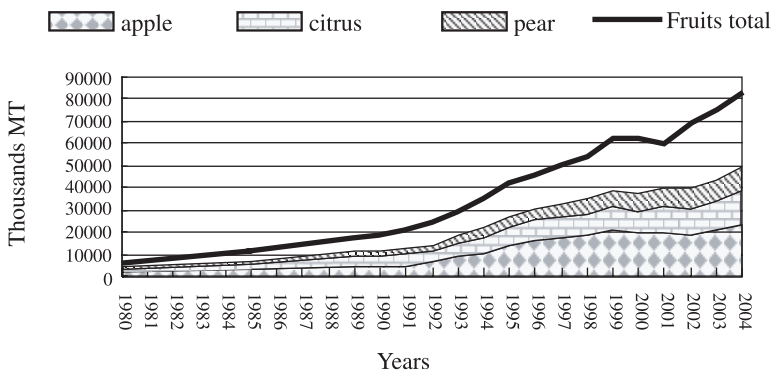
Years	2001		2002		2003		2004	
Items	Production	Area	Production	Area	Production	Area	Production	Area
Apple	20,015	2,066	19,241	1,938	21,102	1,901	23,675	1,877
Citrus	11,607	1,324	11,990	1,405	13,454	1,506	14,958	1,627
Pear	8,796	1,062	9,309	1,042	9,798	1,062	10,642	1,079
Peach	4,562	452	5,230	547	6,148	607	7,011	663
Banana	5,272	245	5,557	248	5,903	256	6,056	265
Grape	3,680	334	4,479	392	5,176	421	5,675	414
Lychee	954	558	1,523	555	1,124	559	1,556	586
Pineapple	869	61	827	56	822	53	808	51
Kiwi fruit	242	48	283	50	330	52	409	53
Total	**60,453**	**9,200**	**69,520**	**9,098**	**75,515**	**9,437**	**83,941**	**9,769**

Source: MOA (2005).

ASEAN became the significant supplier of fresh fruits to China with 72.2% of the total import in 2005. It is also the important export destination, with 28.8% of the total exports from China.

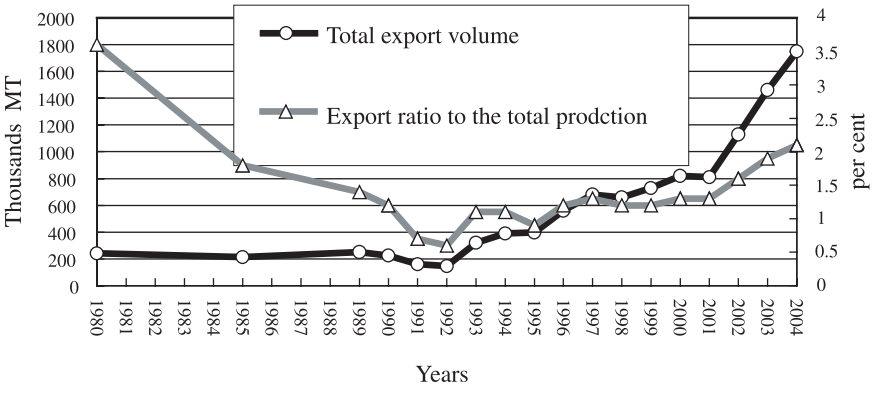
In conclusion, fruits production in China has increased rapidly since 1992, with the total production in 2004 recorded at 84 MMT. In 2005, more than 3.6 MMT of fresh fruits and fruit products were exported to other countries/regions including Asia (58.1%) and Europe (23.2%), with export revenues amounting to US$ 2 billions. Apple, citrus and pear ranked the top three in the production and export volume.

Figure 2.1. Growth of China's fruit production



Source: Compiled from MOA (2005).

Figure 2.2. China's export of fresh fruits,1980-2004



Source: Compiled from MOA (2005).

Table 2.4. Export categories of fresh and processed fruits in China

Categories	Export volume (MT)	Change to previous year (%)	Export value (1,000 US$)	Import volume (MT)	Change to previous year (%)	Import value (1,000 US$)
Fresh Fruits subtotal	**2,037,014**	**15.7**	**752,204**	**984,158**	**8.3**	**512,615**
Banana	23,550	0.5	7,492	355,508	-6.6	100,031
Other fruits	307,332	28.1	153,114	393,419	44	205,916
Pineapple	5,395	-6.3	1,278	663	367.3	335
Citrus	465,622	29.1	143,287	61,550	-8	44,629
Grape	21,257	19.4	9,970	57,490	- 2.5	82,353
Kiwi fruit	4,487	-12.3	3,586	82,101	-9.5	53,606
Apple	823,988	6.5	306,256	33,204	-10.9	25,411
Pear	368,333	15.8	122,177	81	-83.8	52
Peach	17,050	9.2	5,043	141	2.5	281
Canned fruits subtotal	**505,929**	**5.5**	**331,855**	**5,193**	**-24.3**	**3,994**
Pineapple	72,084	-6.3	37,002	2,833	74.5	1,781
Citrus	299,479	5.9	198,739	246	108.5	468
Pear	34,511	15.8	18,701	4	-89.1	4
Peach	76,784	9.4	61,839	2,111	-58.5	1,740
Other fruits	23,072	18.4	15,575	0	0	0
Fruit Juice subtotal	**703,629**	**33.2**	**518,600**	**68,853**	**18.8**	**73,179**
Citrus	4,055	22.7	4,209	61,483	27.4	63,149
Pineapple	4,960	-34.6	5,161	305	37.6	266
Grape	803	74.2	1,018	2,541	-1.2	3,851
Apple	650,608	33.6	459,709	465	-65.4	418
Other fruits	43,203	45.0	48,503	4,059	26.9	5,496
Other processed fruits	**401,462**	**12.4**	**433,264**	**86,847**	**-0.6**	**69,185**
Total	**3,648,034**	**16.8**	**2,035,923**	**1,145,051**	**8.0**	**658,973**

Source: CY2005, China Custom.

Table 2.5. China's export of fruits

Areas/organizations	Volume (MT)	Ratio (%)	Value (1,000 US $)	Ratio (%)
Asia	2,120,514	58.1	1,067,039	52.4
Europe	845,991	23.2	471,614	23.2
Oceania	64,966	1.8	48,119	2.4
South America	10,873	0.3	7,454	0.4
Africa	19,650	0.5	12,905	0.6
North America	586,039	16.1	428,792	21.1
ASEAN	1,049,572	28.8	391,880	19.2
EU	478,037	13.1	310,207	15.2
NAFTA	588,018	16.1	430,292	21.1
Others	1,532,407	42.0	903,545	44.4
Total	**3,648,034**	**100.0**	**2,035,923**	**100.0**

Source: CY2005, China Custom.

India

India is the second largest producer of fruits in the world, because its diverse agro-climatic conditions allow a wide range of tropical, sub-tropical and temperate fruits to be produced. The production in 2004 was estimated to be 49.2 MMT, accounting for about 10% of the world's fruit production; the shares ranging from 4% of citrus fruits to 43% of mango. Table 2.6 gives the data on production of major fruits in India and the corresponding figures in the world. Fruit production in India covers an area of 4.96 million hectares. However, India's fruit production only contributes 1% to the export earnings from agricultural products. Indian fruit production, yields and exports are more than the average for the world: production at 5.3% compared to 2.2%; yields at 2.1% compared to 0.9%; and exports at 8.2% compared to nearly 2%. India's share in the global exports of fruits is less than 5%. Table 2.7 indicates the major destinations for the fresh fruits from India.

Global imports are forecasted to reach 4.3 MMT by 2010, with 87% (3.8 MMT) destined from developed country markets. The EU is expected to remain the world's largest import market, followed by the United States, together accounting for 70% of import demand. Europe is expected to remain the main market outlet for tropical fruits, with France as a major importer and the Netherlands the major European transshipment point for imported fruits.

The export market for fresh fruits is highly competitive among the top exporters. Gaining access to foreign markets is critical to countries that export much of their production if they wish to stay in competition. Free trade agreements is one method used to provide increased market access and to encourage increased exports. In addition to negotiating trade agreements, top exporters use various export promotion and marketing techniques to increase their share in foreign markets.

Table 2.6. Production of major fruits in India vis-à-vis World for 2004

Fruit	Production (MMT)	
	India	World
Banana	16.22	72.42
Grapes	1.55	67.07
Mango	11.60	27.04
Papaya	2.57	6.79
Pineapple	1.23	15.70
Others	16.06	332.02
Total	**49.23**	**511.04**

Source: National Horticulture Database, 2005. National Horticulture Board, Ministry of Agriculture, Government of India.

Table 2.7. India's export of fresh fruits in terms of quantity and value, 2004–2005

Country	Mango		Grapes		Others		Total	
	Quantity (1,000MT)	Value (Million INR*)	Quantity (1,000MT)	Value (Million INR*)	Quantity (1,000MT)	Value (Million INR*)	Quantity (1,000MT)	Value (Million INR*)
Bangladesh	32.5	297.10	14.7	83.04	58.0	631.50	105.2	1011.64
Germany	–	–	1.1	43.71	0.7	17.43	1.8	61.14
Netherlands	0.5	21.27	6.8	359.50	–	–	7.3	380.77
Nepal	3.4	26.96	1.5	12.20	30.0	242.14	34.9	281.30
Saudi Arabia	–	–	–	–	3.9	84.16	3.9	84.16
South Africa	2.3	74.80	–	–	–	–	2.3	74.80
United Arab Emirates	9.5	270.00	4.3	218.70	2.5	329.00	16.3	817.70
United Kingdom	1.2	71.81	5.2	290.00	2.0	74.50	8.4	436.31
Others	3.0	107.61	2.4	99.59	33.4	261.27	38.8	468.47
Total	**52.4**	**869.55**	**36.0**	**1106.74**	**131.5**	**1640.00**	**219.9**	**3616.29**

Source : Ministry of Commerce and Industries Data Sheet, 2005, Government of India.
(One US$ is equivalent to about 46 INR.)
* INR means Idian Rupee.

Indonesia

The total harvested land of fruits in Indonesia is less than 1 million hectares, much lower than the harvested land of paddy, the single largest commodity of food crops, which amounts to nearly 12 million hectares. The decreasing harvested land of fruits attributed to the decreasing growing land of durian, rambutan, mangosteen, and other local-traditional fruits cultivated under small-scale and even back-yard practices. The harvested land of mangos is growing at the highest rate (80.2% per year), and the lowest growth rate was found on bananas. The total production of fruits in Indonesia has been continually increasing from 8. 41 MMT in 2000, reaching 14.35 MMT in 2004 (Table 2.8).

Indonesian exports of fresh fruits has been fluctuating in the past seven years in both the total volume and the total value of major fresh fruit exports (Table 2.9), while the fruit production has remained relatively stable (Table 2.8). Major fresh fruit exports are mangosteen, pineapple, mango, banana, and papaya. The total export value of Indonesian fresh fruits reached US$ 15.95 million in 2002 and decreased to US$ 9.89 million in 2004. The fresh fruit exports accounted for only about 10 % of the total fruit production in Indonesia. Major importing countries of Indonesian fresh fruits were the neighboring Asian countries: Hong Kong for mangosteen and Malaysia for pineapple. More recently, the Middle East countries have started importing mango and banana (Figure 2.3).

Table 2.8. Harvested land and fruit production in Indonesia

Commodity	Year					Growth 04-03 (%)	Average growth (%)
	2000	2001	2002	2003	2004		
Harvested land (thousand ha)							
Mango	44.18	44.21	184.66	158.90	185.77	16.92	80.18
Orange	37.12	35.37	47.82	69.14	72.31	4.58	19.91
Banana	73.54	76.92	74.75	85.69	95.43	11.37	6.95
Durian	23.02	49.81	41.03	53.77	48.28	-10.21	29.89
Mangosteen	5.19	4.61	8.05	9.35	8.47	-9.42	17.56
Other fruits*	223.22	272.03	294.27	345.12	296.86	-13.98	8.33
TOTAL	**406.27**	**482.94**	**650.59**	**721.96**	**707.12**	**-2.06**	**15.62**
Fruits production (MMT)							
Mango	0.87	0.92	1.40	1.53	1.44	-5.82	15.08
Orange	0.64	0.69	0.97	1.53	2.07	35.38	35.19
Banana	3.75	4.30	4.38	4.18	4.87	16.69	7.17
Durian	0.24	0.35	0.53	0.74	0.67	-8.89	32.56
Mangosteen	0.03	0.03	0.06	0.08	0.06	-21.44	36.04
Other fruits*	2.88	3.67	4.32	5.50	5.23	-4.91	276.55
TOTAL	**8.41**	**9.96**	**11.66**	**13.55**	**14.35**	**5.88**	**14.39**

Source: CBS and DG of Horticulture Production 2005.

* Other fruits include pineapples, rambutans, salok and etc.

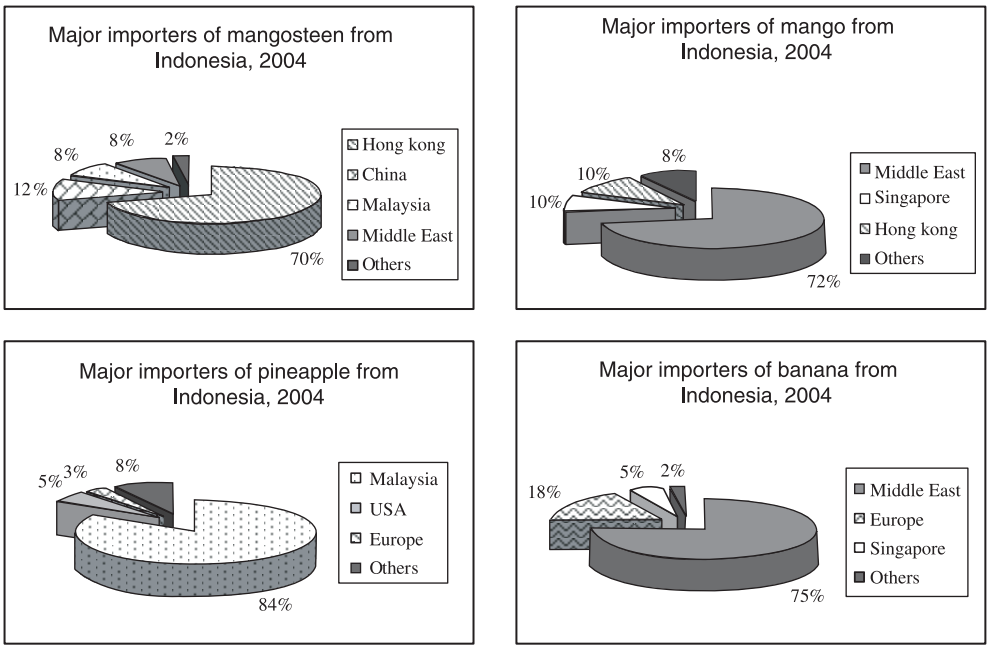
Table 2.9. Export volume of fruits during 1999-2005 in Indonesia

(Unit: thousand tons)

Commodity	Year							Average growth (%)
	1999	2000	2001	2002	2003	2004	2005	
Pineapple	163.76	154.76	158.76	181.10	148.05	169.76	231.99	7.37
Fresh	1.13	2.98	2.02	3.73	2.28	2.43	0.64	18.37
Processed	162.63	151.78	156.74	177.36	145.77	167.32	231.35	7.50
Banana	76.14	2.22	0.29	0.58	0.24	1.19	3.65	76.65
Tamarin	6.22	7.33	5.69	7.02	8.67	20.97	15.80	26.59
Mangosteen	4.74	7.18	4.87	6.51	9.30	3.05	8.47	34.39
Mango	0.64	0.49	0.45	1.57	0.58	1.88	0.94	54.73
Citrus	0.61	0.74	1.04	0.89	0.86	0.27	0.57	14.43
Orange	0.59	0.40	0.84	0.60	0.38	1.30	0.77	35.65
Fresh	0.28	0.31	0.67	0.48	0.15	0.64	0.52	56.54
Processed	0.31	0.09	0.16	0.12	0.23	0.66	0.25	33.05
Grapes	0.42	0.41	0.43	0.07	0.25	0.19	0.04	12.16
Rambutan	0.23	0.23	0.20	0.37	0.60	0.13	0	-7.37
Other fruits	5.08	5.18	4.96	16.80	7.22	5.21	7.34	32.08
Other juice fruits	5.15	5.08	7.55	4.69	4.67	3.09	0	-20.81
Total	**264.95**	**187.34**	**188.04**	**225.37**	**189.65**	**210.18**	**270.66**	**2.45**

Source: Central Bureau of Statics (BPS) - Indonesia (2005).

Figure 2.3. Major importers of Indonesian fresh fruits, 2004



Source: Compiled from BPS (2005).

Philippines

The Philippines is a world leader in fruit and vegetable production, particularly pineapples, mangos, and coconuts. The Philippines has more than 300 edible fruits and nut species but only a few are commercially cultivated. In terms of volume of production, banana, pineapple and mango are the major fruits grown, followed by citrus, papaya, jackfruit and durian. The fruit industry contributes significantly to the country's economy in terms of employment, income, and foreign exchange generated from sales of both fresh and processed fruits. The fruit sector occupies almost 600 thousand hectares, including at least 20 different fruit crops. It is estimated that about 10 million people are dependent on the fruit industry alone. During the period 1999 - 2003, horticultural exports from the Philippines comprised only 1.69% of total exports on average, and majority of it was fruits, which was 1.60% of total exports. The value of the exports of fruits, vegetables, ornamental plants, and cut flowers increased 7.53% year-on-year on average during the same period.

Republic of Korea

Total production of fruits has increased gradually over the past decades. Particularly, the production of citrus, oriental pears, persimmons, and peaches has increased, but apples and grapes remain unchanged or decreased slightly (Table 2.10).

Table 2.10. Fruit production in Republic of Korea

(Unit: thousand tons)

Fruit	1998	2000	2002	2004
Citrus	511	563	642	584
Pear	259	324	386	452
Grape	397	475	422	368
Apple	459	488	433	357
Persimmon	260	287	281	299
Peach	151	170	187	200
Plum	39	51	57	72
Etc.	73	66	71	78
Total	**2,153**	**2,428**	**2,500**	**2,410**

Source: Ministry of Agriculture and Forestry, Republic of Korea, Statistical Yearbook of the Agriculture and Forestry (2005).

The Republic of Korea (ROK) produced 2.41 MMT of fruits in 2004 from 157 thousand hectares. Citrus and oriental pears have become the major fruits grown in 2004, followed by grapes, apples, persimmons, peaches and plums. The total fruit production per capita in 2004 was 50.6 kg, which is well behind the world average of 64.6 kg per capita. Individual shares of fruit production per capita were 12.3 kg of citrus, 9.5 kg of oriental pears, 7.7 kg of grapes, and 7.5 kg of apples.

International trade in fruit has grown rapidly since the mid-1980s, with the annual rate of growth of international exports averaging 10% during 1985-95, although with a slight fall to 7.7% during the period 1990-95.

The ROK exports small volumes of horticultural crops mainly to the United States, Japan, Canada, Taiwan, Hong Kong, and a few countries in the South-East Asia. The export value of horticultural products has been stable over the last five years. In 2004, the export value (Table 2.11) of vegetable crops was US$ 230 million (3% of total vegetable production); that of fruits was US$ 86 million (3% of total fruit production).

Table 2.11. Export value of horticultural crops from Republic of Korea

(Unit: million US$)

Commodity	2000	2001	2002	2003	2004
Vegetables	187	190	169	194	230
Fruits	45	56	82	71	86
Flowers	30	32	32	45	49
Total	**262**	**278**	**283**	**210**	**355**

Source: Ministry of Agriculture and Forestry, Republic of Korea, Statistical Yearbook of the Agriculture and Forestry (2005).

Four major fruits including oriental pear, apple, citrus, and persimmon are exported to the countries mentioned above. The export volume of oriental pear has been increasing for the last five years, whereas the other three fruits remained more or less stable. In 2005, the total export values (Table 2.12) of oriental pear, apple, persimmon, and citrus accounted for US$ 56.1, 7.8, 5.6, and 3.4 million, respectively. The export value of these fruits is only 3% of the total fruit production in Korea. Quality competitiveness of the ROK fruits is relatively high, but they have low competitiveness in price because of high production cost. Labor cost and land price are relatively higher than those in many other countries. Furthermore, consumers' awareness of the brands for Korean fruits has not only been well-established in international markets, but also in domestic markets.

Table 2.12. Export value of fruits from Republic of Korea

(Unit: million US$)

Fruit	2001	2002	2003	2004	2005
Pear	19.6	34.1	30.1	35.2	56.1
Apple	3.0	14.2	7.7	5.2	7.8
Citrus	4.9	5.7	4.3	5.6	3.4
Persimmon	4.4	4.6	2.3	3.6	5.6

Source: Ministry of Agriculture and Forestry, Republic of Korea, Statistical Yearbook of the Agriculture and Forestry (2005).

Thailand

Fruit production is one of the most important businesses in Thailand; it contributes to a great share of the country's national income. The country is known for fresh tropical fruits, such as rambutan, mangosteen, mango, guava, durian, coconut and pineapple. Most of these fruits are seasonal with the exception of mangosteen, longan, mango and pineapple, which are available throughout the year. As a result of agricultural diversity, Thailand is never in short supply of fresh fruits. The total tropical and subtropical fruit production in the year 2000 amounted to an average figure of 10.5 MMT. Thailand has the capacity to export fresh fruits globally all year round. The country is currently exporting more than thirty types of fresh, dry and frozen fruits to every corner of the world, including the United States, Europe, the Middle East, and Asia-Pacific. In 2002, the country exported 1.2 MMT (US$ 600 million) of fruits.

Viet Nam

The area of fruit plantation in Viet Nam has grown rapidly in the 1990s at 6.5% per year. The area has also increased between 2000-2005 but at slower rate. In 2005, fruit trees accounted for 766 thousand hectares, an increase of 2.6 from 2004 due to improvements

on orchards and increase of highly commercially valued fruit trees. In spite of this growth, fruit only accounts for about 5% of the total crop area. Growth rates vary widely across commodities, with the fastest growing commodities including litchis (litchi, longan, and rambuttan), citrus and dragon fruits. However, bananas are stagnant and pineapples have fallen in the last 10 years. While fruit production is more widespread in the North, the degree of commercialization is the greatest in the Mekong River Delta (MRD). The MRD is not only the nation's richest rice producer, but also the largest fruit planters. The MRD has an average per capita of more than 0.23 hectares of natural land area. It is also very fertile and creates favorable conditions to growing rice, fruit trees and commercial-oriented plants. According to preliminary estimates, the area of fruit in the MRD has reached more than 300 thousand hectares. About 12% of the whole output is exported and the remainder is locally consumed (Table 2.13). Major exported fruit includes pineapples, longans, litchis, blue dragons, bananas, mangos, and more.

Table 2.13 Vietnamese fruit export turnover during last 5 years

Year	Export Value (million US$)
2000	213.1
2001	344.3
2002	221.2
2003	151.5
2004	178.8
2005	235.0

Source: Viet Nam Ministry of Agriculture and Rural Development (2006).

The Vietnamese have had much experience in plantation and intensive cultivation of fruit, especially commercial fruit trees. In many provinces, local people consider horticulture as an occupation and fruit production as a poverty reduction method. According to the latest survey and calculation, socio-economic efficiency of fruit trees is relatively high, particularly in the MRD with a value that is 4-5 times higher than rice cultivation. The economic value of a horticulture-specialized area can be 10 times higher than that of rice cultivation.

Most of the growers have been growing fruits since 1990, reflecting the rapid growth in fruit production and the expansion in the number of growers since the economic reforms were launched. The management system for fruit production is not particularly advanced. The majority of producers rely on mechanical canal irrigation where possible, with the usage of tube and drip irrigation becoming less used. The vast majority of producers use pesticides to control insect attacks, with biological control and integrated pest management being rare. In general, producers rely on other farmers to provide seeds and organic manure, and on private traders to provide virtually everything else. Some specialty items, such as cuttings and seedlings for fruit production, are purchased from state enterprises and government institutions, particularly in the South.

Almost all fruit output is sold fresh. Less than 2% of the output is kept for home consumption or reserved for further processing. Produce sold on the fresh market does, however, undergo postharvest activities such as grading and washing. The majority of produce is sold to assemblers and wholesalers, with very little sold to processors, exporters, or retailers. About 80 % of the fruits and vegetables produced are sold to wholesalers and assemblers. Processors, exporters, and state-enterprises play small roles in farm-level marketing.

Fruits are diverse in terms of size and legal status. Small traders tend to be unregistered private enterprises, while medium and larger ones are often registered private. Among the large traders are provincial and central state-owned enterprises. The use of cold storage is quite rare, although a large majority of traders have storage facilities. Only 3-4% use cold storage. This percentage is slightly higher among larger traders and exporters. Traders purchase most of their produce from farmers in spot-market transactions and one-third is purchased by other traders and processing industry. Traders are reluctant to contract with growers because of uncertainty regarding the market price. While domestic traders sold mostly to processors, exporters sold directly to foreign customers.

Furthermore, export to China and Japan reduced sharply, while the export to Russia increased remarkably. According to FAO (2004), in the next few years, demand for fruit in the global market will increase at the rate of 3.6%, while fruit production will only increase at 2.8%. This will provide Viet Nam an opportunity to introduce its fruit into new markets.

Vietnamese fruit is still a regional fruit compared to other countries, especially, Thailand. The results from a recent survey of the Viet Nam Fruit Producers Association (Vinafruit) in border provinces show that Vietnamese fruit had scored very low. Vietnamese fruit scores low because of damage (from harvesting, packaging, transportation), infestation, fast perishability, non-uniformity, poor appearance, poor packaging, high SO_2 content, etc. This makes Vietnamese fruit only enter China in limited amounts.

Summary

The Asia-Pacific region contributed about 42% to the world's total fruit production during 2004, which stood at 511 million metric tons. Together, China and India shared 26 % of the total production. Table 2.14 provides a summary of fruit production data for the majority of Asian countries, with Indonesia, Iran, Japan, Malaysia, Pakistan, Philippines, Sri Lanka, Thailand and Viet Nam contributing significantly to the total fruit basket of the Asia-pacific region. Other important fruit producing countries include Bangladesh, Nepal, Republic of Korea and Myanmar. The region is a major producer of some of important tropical fruits, such as bananas, mangos, pineapples and citrus, which accounted for about 56% of the total fruit production in the region. The major producing countries for several of these fruits are China, India, Thailand, Indonesia, Philippines, Pakistan and Viet Nam. Also, the region can be considered as the most important producer of minor fruits, such as durian, mangosteen, langsat and rambutan.

Table 2.14. Fruit (excluding melon) production in Asia

(Unit: thousand tons)

Country	1993	2000	2001	2002	2003	Annual Growth Rate 1993 - 2003 (%)
DEVELOPING COUNTRIES						
SOUTHEAST ASIA						
1. Cambodia	260.2	321.7	322.2	322.2	322.7	2.2
2. Indonesia	7 325.0	8 275.3	9 192.4	10 320.6	9 012.6	1.2
3. Lao PDR	144.9	191.4	198.8	209.3	209.5	4.6
4. Malaysia	1,165.0	1,182.0	1,180.0	1,155.0	1,155.0	0.0
5. Myanmar	1,012.7	1,416.0	1,562.0	1,550.0	1,570.0	4.7
6. Philippines	8,591.5	10,657.5	11,119.5	11,516.5	11,804.2	3.1
7. Thailand	7,276.4	7,844.9	7,769.8	7,547.0	7,521.1	0.8
8. Timor-Leste	8.4	5.4	6.4	7.4	7.4	7.5
9. Viet Nam	3,593.1	4,342.2	4,447.8	4,772.9	5,096.2	3.1
SOUTH ASIA						
10. Bangladesh	1,355.2	1,361.0	1,406.9	1,467.0	1,467.0	0.6
11. Bhutan	65.3	65.0	65.0	36.6	46.3	-3.6
12. India	33,885.2	44,316.9	45,041.3	45,951.3	45,911.3	3.3
13. Maldives	11.7	15.8	12.1	12.5 F	12.5	0.6
14. Nepal	519.5	549.4	590.3	585.7	589.0	2.0
15. Pakistan	4,746.4	5,320.1	5,436.7	5,459.1	5,459.1	1.0
16. Sri Lanka	780.3	832.1	842.2	850.3	854.8	0.6
CENTRAL ASIA						
17. Kazakhstan	125.1	263.3	214.4	212.0	190.3	5.6
18. Tajikistan	236.7	280.2	262.1	226.8	177.8	-1.5
19. Uzbekistan	945.3	1,395.2	1,352.2	1,326.2	1,287.1	3.1
OTHER ASIA						
20. Afghanistan	-	-	-	-	-	-
21. China	1,265.0	1,350.0	1,385.0	1,396.5	1,401.5	0.8
22. DPR Korea	9,239.0	12,287.0	12,671.6	12,863.7	12,712.0	3.2
23. Mongolia	.2	.1	.1	.1	.1	-0.5
24. Rep. of Korea	2,072.5	2,625.4	2,706.7	2,725.6	2,749.1	2.6
PACIFIC ISLANDS						
25. CookIslands	5.65	4.59	4.55	2.95	2.18	-5.2
26. Fiji Islands	11.54	21.41	22.82	22.82	22.82	6.2
27. Kiribati	5.30	5.70	5.85	6.10	6.10	1.0
28. Marshall Islands	-	-	-	-	-	-
29. Micronesia, Fed States of	-	-	-	-	-	-
30. Nauru	0.28	0.28	0.28	0.28	0.28	0.0
31. Niue	0.58	0.58	0.58	0.58	0.58	0.0
32. Palau	-	-	-	-	-	-
33. Papua New Guinea	1399.50	1666.30	1710.00	1762.00	1782.20	2.5
34. Samoa	21.40	42.25	42.55	44.35	44.35	6.7
35. Solomon Islands	14.25	16.89	18.30	19.33	19.33	3.4
36. Tonga	15.45	9.46	9.80	9.80	9.80	-2.3
37. Tuvalu	0.52	0.65	0.65	0.65	0.65	2.5
38. Vanuatu	18.40	20.35	20.40	20.90 F	20.90	1.2
SUB-TOTAL	118,618.9	171,177.1	178,542.3	184,405.8	183,668.4	4.5
DEVELOPED COUNTRIES						
39. Japan	4,408.3	3,794.1	4,060.9	3,860.2	3,782.1	-1.2
ASIA & PACIFIC	126,468.7	179,134.9	186,929.5	192,759.7	191,822.1	4.3
REST OF WORLD	264,944.2	292,560.6	285,312.1	285,136.7	288,427.4	1.0
WORLD	**391,412.9**	**471,695.5**	**472,241.6**	**477,896.4**	**480,249.5**	**2.2**

Source: FAOSTAT (2004).

China has an impressive growth rate of 8.2% during 1993-2003 for its fruit production sector. The Asia and Pacific region on the whole registered 4.3% growth rate as compared to the world average of 2.2% over the same period.

2.2 World fresh fruit trade

The EU is the leading destination as well as source of supply in the global fruit and vegetable trade. During 1999-2001, the EU countries accounted for nearly half of the world's imports and over 40 percent of the exports. Though the EU is importing almost one-third of its fresh fruit imports from the banana-exporting and Southern Hemisphere countries, the imports from Asia is low: 0.5% of the fresh fruits, 3.3% of the fruit and vegetable juices (Huang, 2004). The European agro-food industry itself is a leading global exporter and it affords significant added value and offers scope for growth within new EU Member States, development of regional economies and exploitation of cultural diversity and tradition.

International trade is dominated by temperate varieties of fruit, that are most heavily consumed in the large markets such as Europe and the United States, even if bananas show the fastest growth in consumption during the 1990s (11% per year), and peaches the lowest (2% per year). World production of such fruit is around 261 million tons per year, with China, Brazil, the United States and Italy being the principal producers accounting for about 37% of world production.

During the 1990s, growth averaged 3% per year, with China achieving outstanding annual growth rates that averaged 20% per year, and that have transformed it from the fourth largest producer at the start of the decade into the world's largest producer of fruit. Another country that has achieved extremely high rates of production growth is Ecuador (12% per year), with this figure represented principally by growth in banana production.

For production of fruits, apples and pears showed the greatest increase, with average annual growth rates of 7% and 6% respectively. Among apple producing countries, the fastest growth rates were achieved by China (26%), Egypt (50%) and Poland (9%), while notable among pear producing countries were China (14%), Chile (12%) and Egypt (11%).

Less than 10% of production is sold internationally in the form of fresh fruit, even if there is no precise data on consumption in the domestic markets of the principal producer countries. This is due to the fact that data reflect import volumes, but does not identify the use of fruit, which after having been imported, may be used in pulp, fresh juices, ice creams, confectionery or other processed products.

The largest exporters of fresh fruit are Spain, the United States, Italy, the Netherland, France and Ecuador, which together account for 54% of sales by value. the Netherland / Belgium/ Luxembourg and France act as distribution centers for Europe, which accounts

for 47% of exports, while the United States has a 36% share. With regard to imports, Germany, the United States, Britain and France absorb 42% of international trade in fresh fruits, with Germany as the largest importer (16%), followed by the United States (11%).

The leading example of specialization is Spain, which supplies the world orange market, a specific niche, since most orange production is processed into juice (Brazil is a typical case). Spain, responsible for 49% of world orange supply, is the world's largest exporter of fresh fruits. Despite the fact that its production has been declining at an annual rate of 2%, exports have risen by an average of 5% per year over the last decade. Another case of specialization is Ecuador, the world's third largest producer of bananas, whose contribution to world trade is limited to this product, even if it has a 17% share of the market for supplying this, the most widely sold variety of fresh fruit. As a result of its banana production, Ecuador is the fourth largest international exporter of fresh fruits, with production having increased at a rate of 2% per year, and exports by as much as 12% year.

The United States is the leading example of diversification, with a significant share of all the markets analyzed: import, export and production (with the exception of banana production). Most notable is the reversion of the US position in the orange market, having boosted production at a rate of 7% per year, while imports have fallen (by 13% per year), and exports risen (by 11% per year), in a market that has grown at 5% per year.

The Netherland is active in the fresh fruit market, as it is in several others, as a commercial distribution center. Although it is absent from trade in oranges, peaches and grapes, all markets dominated by other European countries and by the United States, it has increased the value of its exports at a rate of 39% per year in those commodities where it is present. France also acts as a European distribution center for pineapples and bananas. In the case of pineapples, it has a clear strategy of increasing imports for re-export, while in the case of bananas, its increased share of international trade seems to have been determined by the reduction in domestic consumption, since imports have remained stable.

Another notable example is China, which has significantly increased its production of the most widely sold varieties of fruit at international level, namely: bananas (growth of 13% per year), oranges (7% per year), apples (26% per year), pears (14% per year) and peaches (15% per year). While the country has increased its imports of peaches (29% per year), and has a net deficit in apples, the overall increase in production (18% per year), and its share of world supply (12% per year), suggests that it has adopted a strategy of supplying the world market, most notably with temperate fruits (apples and pears) as well as with table oranges.

The principal varieties of fruit sold and consumed throughout the world are oranges, apples, grapes, bananas, peaches, pears and pineapples. Of these, bananas, pears and pineapples are predominantly consumed in their natural state, oranges and apples as juice, while

most grape production is transformed into wine or juice, and peaches into nectar or canned fruit in syrup. This explains why the largest producers are not the main exporters of these products in their natural state (with the exception of Italy, which is the leading producer of grapes and also the largest exporter).

Despite the preference for varieties of fruits traditionally consumed in Europe and the United States, there has been an increase in recent years of imports of so-called exotic fruit, typically from tropical climates, such as guavas, mangos, papayas and kiwifruit. According to the FAO (Agra Europe, 1998), international consumption of tropical fruits should increase by around 40% between 1995 and 2005, equivalent to an annual growth rate of 3.5%. This growth should be accompanied by an increase in supply, although prices may decline due to intense competition between exporters. Most of the 56 million tons of production (1997 data) is directed towards domestic consumption by producer countries. Mangos (40%), pineapples (23%), papayas (9%) and avocados (4%) are the principal products. International trade accounted for only 1.8 million tons in 1996, representing some 3% of production.

Demand for fresh fruits is concentrated in Europe and the United States, which absorb around 60% and 11% respectively of international imports. The European and US markets are extremely dynamic, and are notable as major producers and exporters of fresh fruits. Some of the larger players in this market achieve annual revenues in excess of US$ 1 billion, notably the two US groups, Dole Foods (US$ 4 billion) and Chiquita (US$ 2.4 billion in 1997). According to Rabobank International (1997), four trading companies control 80% of world trade in fruits.

International trade has grown more than total production (by 7.7% per year against 3% per year during the 1990s), leading to an increased supply of products and a consequent downward pressure on prices that has tended to profit margins. Mangos are a good example, with prices in Europe falling 30% since 1988 (Agra Europe, 1998), in conjunction with a 66% increase in import volumes.

World fruit production is 511 million tons (FAO statistics, 2004). About 60% of this is consumed fresh in the country of production, 30% is processed and 10% is exported as fresh fruit. The value of world fruit exports was US$ 21 billion in 2001.The main fruits were citrus (21%), bananas (19%), grapes and apples. The value of trade in tropical fruits (mangos, papayas, pineapples and others) was slightly under US$1 billion (5%).

Developing countries account for virtually all exports of bananas and tropical fruits, and about half the trade in citrus. The value of exports such as avocados, melons, and pears is higher in developing than in developed countries with a concentration of exports from a few countries. Developing countries have been less successful at adding value to their fruit and vegetables and have a lower share in the exports of processed products: 36 percent in 2001.

2.3 Market opportunities

Major trends

The major drivers for innovation in food products are health (16%) and well-being (12%) (CIAA, 2004). Other important drivers are easy-to-use and price. In the evaluation of the top-20 of the most successful food introductions in the Netherlands over the last 4 years show that health is gaining importance, along with well-being. Ethical values/conscience and “on-the-go” are believed to be two drivers that are gaining importance. There is an increasing societal awareness of the opportunities to improve the quality of life through healthy eating and sustainable production, which can lead to the improvement of the overall environment (ETP, 2005). The trend that people tend to get heavier in developed countries (obesity) supports the healthy choice. Product introductions that score on a combination of the major drivers have a better chance of being successful.

Effects on fruit consumption

Low fruit and vegetable intake is currently among the top 10 selected risk factors for global mortality (WHO, 2002). Nevertheless, fruit and vegetable consumption in many European countries is below the recommended daily intake. A recent elaborate survey in the Netherlands on eating habits showed that fruit and vegetables intake even decreased by 15 to 20 % during the last 10 years and it is expected that this trend will continue over the coming years (RIVM, 2004). Similar trends are apparent in other EU countries. In recent years, the issue of sustainability has been given much attention and increased amounts of products from organic or sustainable production systems have entered the market. This development has, however, not led to an overall increase in fruit consumption.

The different consumption patterns in Europe and the different behaviour of consumer subgroups may partly be explained by the different availability of high quality products and the socio-economic status. However, other cultural, behavioural and psychological factors of which we know almost nothing about may play an equally important role. This data are of major value for relating dietary habits with health, underscoring the importance of fruits and vegetables without giving clear directions on possible strategies to increase consumption (Woltering, 2005).

The turnovers in both organic and fair-trade products have grown significantly in fruit products in the last ten years. Specifically the sales of organic tropical fruits are expanding rapidly, especially organic bananas which are popular with consumers seeking organic and fair-trade products. There are large differences in the sales of organic food in different EU countries; the average sales of organic fruits comprise only a small percent of the total sales (Organic Monitor, 2005). In non-organic produce there is a growing demand for

residue-free products, in accordance with the trend for more sustainable production methods.

The first fair trade label was established on coffee by Max Havelaar in the Netherlands in 1988. Now there are 14 European countries, plus the United States, Canada and Japan that sell fair trade labelled products. The “Fair-trade” and “Max Havelaar” labels guarantee consumers that certain standards were met in the production and trade of the products where the labels appear. Fair trade certification guarantees not only fair prices, but also the principles of ethical purchasing. These principles include adherence to the ILO agreements such as those banning child and slave labour, guaranteeing a safe workplace and the right to unionize, adherence to the United Nations charter of human rights, a fair price that covers the cost of production and facilitates social development, and protection and conservation of the environment. The fair trade certification system also promotes long-term business relationships between buyers and sellers, and greater transparency throughout the supply chain.

Many food producers have taken the initiative to introduce new products over the past years, trying to be successful with the translation of the consumer trends into product innovations. There has been a large growth in the fresh cut vegetable segment (healthy and convenient). Packed fresh cut fruit products have been introduced, but are not as diversified and voluminous yet. Ready to eat fruits (mango, avocado and pear) have been introduced, and are sold at a premium price. In some niche areas, large percentage growth is perceived. For example, the sales of blueberries in the Netherlands have grown with over 850% in a 3 year period. Sales of raspberries have increased over 250%. Both products fit in the healthy trend (vitamins, antioxidants) and are convenient to eat.

The most successful fruit innovations come from the processing industry. Two of the most successful product introductions in the Dutch consumer product market in the last few years are the “Breaker” and “Fruit2day”. Both products contain (processed) fruit. The “Breaker” is a combination of yoghurt and fruits in a flexible bag. The “Fruit2day” is a bottle with printed fruits design that contains the same ingredients as two pieces of fruits. It runs the slogan: “two ounces of veggies and 2 pieces of fruit a day keeps the doctor away”. The reasons for their success are the combination of multiple consumer requirements: “healthy” , “easy to use” and “on the go” . As a result of their success, the two most successful product introduction in 2005 are another combination of dairy and fruit, for example, a small bottle containing processed fruits and vegetables. A strong marketing effort to promote their products is an important reason for success.

2.4 Opportunities and challenges for Asian fruits

Greater consumer awareness as outlined above indicates that there are reasons to be optimistic about the opportunities to increase fruit consumption. The new consumer

consciousness on health is driving the fruit consumption. It is generally agreed that increased consumption of fruits greatly contributes to a healthier lifestyle. Easy to use and convenient is something that needs to be kept in mind when developing or introducing new fruit products. Consuming fresh products needs to become more attractive and trendy. The growth in sustainable and fair trade products is also an opportunity that could still be further exploited. Creating added-value products and marketing will be important. Added-value can also be based on the different levels of the food pyramid: consistent high quality, chain quality and ethical values.

Food tastes are local even though production capabilities are global. It is important to learn how to build global type production economies, yet to be able to market into countries where food tastes are local. One issue, for example, is simply packaging. Labeling requirements are different from country to country, so what people expect to see on packages also differs (Bell, 2006). Local products, that are to some extend unknown to the European consumer, could be an opportunity. Since many people travel to other countries to feel the local culture and try the local food, this could lead to buying these products at home. Marketing and organizing the supply chain to ensure good quality products are crucial aspects. One of the results of the growing interest in sustainability can be the preference with specific consumer groups for products that have used less energy in transport. If in the product labeling the “food miles” will be introduced, this could lead to change in buying behavior. Since Asian fruits can only be imported, it is more a matter of using the right transportation method, such as reefer transport.

3. CURRENT ISSUES AND CONSTRAINTS IN POSTHARVEST HANDLING AND EXPORT

The previous chapter has clearly indicated the potential that exists for Asian countries to export fruits. There are, however, several technological, financial and trade policy-related issues that have been limiting exports. While fruits have been found to be rich with minerals, vitamins, and health promoting and disease preventing compounds, they are perishable. This demands that extra caution in growing, harvesting, handling, storing, processing and transporting is necessary. While traditional and conventional practices have adequately met the requirements of local consumers, the same does not hold true with exports. It is not simply enough to ensure the quality of the fruits at the delivery point. A genuine assurance of quality through the established trade protocols is essential to command a sustainable market presence. Asian countries need to take cognizance of the existing trade frame-work and strive to position their products strategically through the intervention of appropriate technology, human resource development programs, policies and marketing strategies. The conference participants deliberated on the related issues, and the outcome related to issues and constraints is given in the following sections.

3.1 Infrastructure aspects

Infrastructural aspects relate to such inputs as soft infrastructure in the form of research and development institutions and hard infrastructure in the form of roads, railways, transport vehicles, storage structures and handling systems. Governments should primarily focus on the soft infrastructures of research and institutional development, rather than production targets and hard infrastructures like storage facilities and processing plants in order for the export of fruits to grow. Storage facilities and processing plants are commercial investments that the private sector will undertake under the right circumstances. If the public invests in this type of infrastructure, the outcome will often lead to excess capacity and implicit subsidies for state-owned enterprises. The government should focus instead on agronomic research to improve fruit productivity and raise the quality of fruits, research to satisfy the sanitary and phyto-sanitary requirements of importing countries, towards a more effective extension service, develop farmer associations and business associations, and create institutions to provide market information to growers and traders.

Knowledge empowerment

Farmers represent the beginning of the fruits value chain. Lack of adequate knowledge about the modern methods of production, as well as post production management of the

produce at the farmers' level, has been a serious constraint keeping the growth of the value chain at a low level. Public investment in putting a human resource development infrastructure for farmers and rural workers/entrepreneurs would yield favorable results earlier than expected. A network of Agricultural Technology Institutes (ATI) with adequate live demonstrations and appropriate training programs should be able to empower the stake holders in a predetermined time frame.

Public research institutions should focus on the following issues in order to increase the technical support for enterprises that export fruit:

- Developing and transferring technology of production of disease-free and good quality planting materials for fruit trees;
- Developing and transferring technology of postharvest handling.

The infrastructure may relate to either domestic "Supply Chain" of food products or "Market Access" which comprises of various parameters and factors driven by the requirements of the target countries.

Approach on fruit seed and planting materials

In an effort to implement Good Agricultural Practices (GAP) and post-harvest handling, the Centre for Tropical Fruits Studies (CETROFS) was founded in 1997 by Indonesia. The centre's network covers universities, government bodies, and private sectors. It ranges from breeding, production, postharvest handling and distribution. Currently, the centre focuses on mangosteen, pineapple, banana and papaya. The center at IPB, Bogor (ipbfruit@indo.net.id, http://www.rusnasbuah.or.id) is funded by the Ministry of Research and Technology.

CETROFS has improved the agricultural practices of mangosteen small-scale growers effectively which has resulted in the portion of fruit produced for export quality to increase from 5% to 40%. New hybrid varieties have been developed and released by CETROFS, including arum Bogor and prima Bogor papaya, wanayasa and kiarapedes mangosteen, mahkota Bogor (crown of Bogor) and delika Subang (delicate of Subang) pineapple. CETROFS has also collected germplasms of 61 pineapple genotypes, 75 papaya genotypes and 230 banana genotypes. Genetic markers for some fruit varieties have also been determined and the method to achieve high multiplication rate of fruits by tissue culture is currently being worked on. Sobir and Sujiprihati (2005) already obtained DNA markers to identify sex expression in papaya, utilizing five SCAR (Sequence Characterized Amplified Region) markers of 20-21 mers. International cooperations have also been obtained to help small-scale growers of mango in implementing GAP on the lines similar to the project of Integrated Horticultural Development in Upland Area at five provinces West Java, Bali, West Nusa Tenggara, and South Sulawesi supported by Japan International Cooperation Agency (JICA).

The government needs to excel with their policies, seedling production network and distribution system. The supporting policy needs to reach farmers so that they do not need to be required to purchase poor seedlings at a higher price. The technical approaches on fruit plant breeding are as follows:

- Identify good domestic fruit varieties to develop and conserve;
- Import new good varieties from other countries;
- Industrializing in seedling production (Application of biotechnology, utilization of machinery for nursery operations);
- Seedling and cuttings production using the tissue culture and greenhouse;
- Establishing network of seedling production units with support from government and scientific institution.

Supply chain and cold chain distribution system

On marketing front, the Indian, Indonesian and other governments are now making efforts to establish Terminal and Sub Terminal Agribusinesses for both domestic and international marketing purposes. Terminal agribusiness will be developed in central places like cities, while sub terminal will be established in production catchments. It is expected that farmers will sell their products directly to collection centers or the sub terminal agribusiness, and subsequently, the sub terminal agribusiness will sell the products directly either to Terminal Agribusiness or other markets such as traditional, super- and hyper markets. This way, farmers are expected to have better bargaining power and increase their incomes. Terminal agribusiness is then expected to sell the products not only in domestic markets, but also foreign ones.

In the supply chain management, the regional governments and private sectors should set up packing houses at the production centers and sub-terminal agribusinesses in urban areas with cold storage. In Indonesia in the last five years, a lot of improvement has taken place in implementing the cold chain distribution system from the growers to the exporters. Many manufacturers of refrigerated truck and containers have opened their businesses with sales doing well since the awareness of using cooling equipment and systems to obtain the prime quality of fruits is increasing. However, simple techniques to provide cooling of fruits on farms right after harvesting are not common. Training and demonstrations are still required to encourage growers to adopt even the simple pre-cooling method of soaking the fruits in a water-ice mixture.

Indonesia is an archipelago consisting of more than 13,000 islands. The collection of fresh fruits from the growers sometimes has to be done from the outer islands of Java and Sumatera, making sea-freight essential, and both more efficient and cheaper than air-freight. Sea-freight for export is also the only means of transportation besides air-freight since Indonesia does not have access to land transportation for export as other countries may have. Thus, the use of refrigerated containers is a must to support a lengthy transportation time. The exporters meet to accurately calculate the required time to reach the destination port in order to maintain the prime quality of their produce.

Appropriate technology such as the automatic control of atmosphere (CA) and the active modified atmosphere storage (MAS) inside the fruit container has been considered, so that the ripening process could be extended during the transportation to achieve the pre-determined quality when the fruits arrive at the destination ports.

3.2 Socio-economic aspects

Land holdings

Holding small amounts of land per household is the foremost problem. Income from farming is not enough to make a living. Small-scale farmers (land < 0.5 ha per household) have limited capital and formal education. Having a small land size in many cases is not suitable for a capital intensive system. It creates the problem of implementing modern practices of production. It is not possible for an average farmer to own machines and facilities for mechanized farming, nor for farm holdings to permit independent postharvest management. Therefore, provisions for custom-hired services in production and postharvest management activities need to exist. Alternatively farmers may form cooperatives to arrange for the mechanization and efficient postharvest management activities. The empowerment of farmers is essential if a cost-effective production of quality fruits and postharvest management is to become a reality.

Funds availability

Farmers and entrepreneurs in Asian countries do not have access to disposable funds to invest in technology and inputs. The lack of available funds has been a serious restraint in upgrading fruit production and postharvest management. The traditional credit facilities available from the local money lenders have generally been highly unproductive. Reforms in credit availability and delivery mechanisms are needed in order for this sector to grow.

Scale of operation

Most exports from Asia lack scale of operation - for example the largest fresh produce exporter in India records annual sales of about Rs. 500 million (US$ 11 million approx.). The low volume translates into lack of economics in operation and makes exports uncompetitive. Hence, exporters are not able to establish themselves as long-term players in the export market, and rely heavily on opportunistic businesses. These factors cumulatively translate into low investments in upgrading skill sets, product innovation, quality improvement and brand building.

Multiple safety standards

The emergence of private food safety and quality standards in developed countries is now a must. These standards operate alongside regulatory systems, but in terms of market access, including to the shelves of the leading supermarkets in the rich countries, it has

become nearly mandatory. With these standards becoming a global phenomenon, countries in the developing world face increasing constraints in exporting their food products to markets in developed countries. An additional dimension of this hypothesis is whether current fruit quality and safety standards are truly based on consumer needs, or whether these standards are determined in isolation by retailers without taking the actual needs of consumers into account. The primary policy issue is therefore that food safety and quality standards should be fair and transparent in their purpose.

3.3 Technology aspects

The major technology-related constraints contributing to low productivity of horticultural crops and inferior quality of produce include:

- Large tracts of low and unproductive plantations needing replacement / rejuvenation;
- Low productivity of crops due to inferior genetic stocks and poor management;
- Inadequate supply of quality planting materials of improved varieties;
- High incidence of pests and diseases;
- Heavy postharvest losses and low utilization in processing sector.

As a result, the productivity per unit area is low, resulting in a high cost of production. Also, the quality of produce in many cases is far from satisfactory and postharvest losses continue to be high. The potential has yet to be tppedaken advantage of from several frontier areas including biotechnology, protected cultivation, computer aided management of inputs, integrated nutrient management (INM), leaf nutrient standards, bio-fertilizers, and integrated pest management (IPM). There is also a need for change both in the content and approach of research which can be taken up in partnership with private sector on aspects like production of hybrids, green house production of fruits, biotechnology, value addition and export. The future growth of horticulture industry will largely depend on new and globally competitive technologies. In the area of postharvest technology, progress needs to be made in extending the storability and shelf life of perishable products by improved and innovative technologies.

Postharvest handling

The main approaches and activities in the field of postharvest handling are suggested as follows.

- Researchers should give the guidance on key indicators of fruit quality to the farmers, traders and buyers. Harvesting maturity: the stage of maturity when fruits have become fully physiological mature (size, firmness, taste, flavor, color). In order to ensure the effective handling and high produce quality, it is essential to define the proper harvest maturity. The main indicators of harvest maturity of some fruits have to be defined. Work needs to be continued to find a way to apply

this knowledge in the production process. Farmers have to follow proper techniques during the pre-harvest period (irrigation; fertilization; pruning; thinning; insect, pest and disease control) to ensure a minimal theproduce quality.

- Harvesting is an important step of the postharvest handling chain to maintain quality produce before reaching the final consumers. Harvesting methods depend on the habits and experience of the local people. Research needs to develop and introduce proper harvest methods and tools or equipment to the farmers (for example, lychee fruits must be harvested early in the morning, when it is not raining).

- Sorting and pre-treatment are the most important steps. Handling will not be effective if the quality of input of the raw materials does not meet the market requirements. Efforts are needed to find the appropriate methods (washing, grading, packaging, preservation and storage) and define the investment scales installing packinghouse for specific fruits.

- Packaging technique effects fruits and vegetables during transport and storage. A lack of knowledge of an effective packaging technique can lead to considerable losses. Farmers, traders and exporters need to be provided the proper packaging technique for specific fruits.

- Transportation facilities and equipments play an important role in ensuring the effectiveness of postharvest handling. Refrigerated trucks are considered to be essential facilities for fresh fruit and vegetable transportation. Different transportation systems, with and with out cooling machines need to be developed. This will help to reduce loss and maintain good quality fruit to be exported and consumed domestically.

Long-term storage of fresh products

The dynamic control system (DCS) is an interactive, patented storage concept, which can be regarded as the successor of the traditional controlled atmosphere (CA) storage for some commodities. Instead of using static, fixed set-points for gas conditions like in CA, the oxygen concentration in the DCS storage facility is controlled upon product response. When applying DCS, the oxygen concentration is slowly lowered until the product emits a stress signal. More specially, DCS uses an ethanol sensor to detect low level ethanol concentrations, the product of fermentation. DCS was initially applied for apples (variety Elstar). Experiments with Elstar show that apples are firmer after DCS storage and have a better color retention compared with traditional CA. Furthermore, apples tend to develop less skin spots under DCS (Veltman, 2003). Based on these results, the DCS control systems has been installed on several Elstar storage locations in the Netherlands. Research and experiments with other products like ox-heart cabbage and soft fruits have shown good storage results. For example, a reduction of fungal growth in red currants has been seen after a storage period of 8 months.

A technique used in the last five years is Smartfresh as an additive to improve postharvest quality during storage. The active component of Smartfresh is 1-MCP, which blocks the sensitivity of the product for ethylene and inhibits production of ethylene. Smartfresh is applied in the damp phase in the storage room where it only needs a single application treatment. Worldwide experiments and commercialization have started on several products, like apples (Europe and the United States), avocado (South Africa), banana (the United States and Europe), kiwi (Chile) and also vegetable products. In general Smartfresh gives many products a better quality, less spoilage, longer storability and improved consumer preference. However, extensive registration procedures limit its use worldwide.

Another new area that has potential to change the possible storability of fresh produce is ultra fast cooling and freezing. For example, the company Supachill developed a new patented method to freeze vacuum packed products almost ten times as fast as with blast freezing methods. Cell walls and tissue are not broken down and the texture, taste and color of the produce is maintained (more info: www.supachillusa.com). After defrost, the quality of the product is good. In fact, many products consumer panels cannot identify any differences between the fresh and freeze-fresh products. Unfortunately, for soft fruit, like strawberries, some tissue-degradation is visible. What is most promising is how this method is applied to products with added value, like prepared fresh meals and expensive meat. This development could have a global impact for semi-fresh products.

Packaging technology

Packaging is important, and serves multiple functions: guide for usage and handling, marketing display and the information carrier for chain actors and consumers. Especially for fresh product, the package protects the product against physical, chemical and biological decay. Longer shelf life can be achieved with optimal packaging. Still, a lot of fruit products are on display in supermarkets with no packaging on the items. Products that have a limited shelf life, like pre-cut fruit, definitely benefit from individual packaging during the whole chain and until the moment of consumption moment. In traditional packaging a plastic film is used to create a gas barrier, so optimal CO_2, O_2 and H_2O levels can be achieved at the equilibrium stage. The gas diffusion characteristics of the film are specified by the product. In the last decade the concept of Modified Atmosphere (MA) packaging has been applied for several products. The process begins by actively creating the initial gas atmosphere, where air is replaced by a new mixture of proactive gas. This gas mixture prevents on oxidation and microbial decay, keeping the quality of the production in tact for a longer period of time.

A new research area to improve the MA concept is Active Packaging. The basic idea is that, when required, an active element is released in the packaging, which influences product quality by absorbing undesirable components or releasing desirable components. Application areas are:

- Controlling moisture and gas composition in the packaging;
- Release of anti-microbial components;
- Absorbance of ethylene (delaying ripening);

- Absorbance of ‘off-flavors’;
- Release of flavors.

The market for packaging materials is very competitive, making the price of the material a key factor. Specially, research on barrier films is done by producers. Current developments are seen in micro-perforated packages, where small micro-pores are made in the packaging films. The amount and size of the micro perforations is determined by the type of product and should be optimized for the actual respiration rate of the product. This will result in cheaper specific barrier films. The speed and flexibility of packaging equipment will also become better in time.

Lately the use of biodegradable packaging materials have been used more to package fresh products. The performance of the materials has greatly improved in the last few years (e.g. PLA based materials). The price performance ratio for barrier films is still far lower than plastic films and the increased costs of oil-based resources for plastic films production helps to push the product. Sustainable development is the main reason why biodegradable packaging materials are used. It is believed that a major collective effort is needed from governments, producers and consumers to achieve significant use.

Cold chain management

In postharvest handling it is generally known that maintaining a low temperature, optimal for the commodity, is essential to maintain a good storability and shelf life for the product. Not as much is known about the necessity and advantages of pre-cooling and the effects of short intervals at higher temperatures. Because of the trend for flexible and high-speed logistics the configuration of the chain needs to be optimized based on specific needs. In 2002 Wageningen-UR has executed a three year project called “Keepability and Cooling of food horticultural crops”. The Product Board for Horticulture financed the project with chain partners participating in the research activities. The case products were crops such as strawberry, peppers, tomato, chicory and lettuce. The main research questions were:

- Is speed of logistics more effective than cooling?
- Where is the break-even point?
- What is the effect of slow cooling?
- What is the effect of temperature change and condensation?

The results of the project are in some cases different from current practice in the pre-cooling processes. Cooling is always needed, but there was no effect of fast pre-cooling of these products, as long as within 48 hours after harvesting the optimal temperature has been achieved. Also, condensation has no effect on the quality. Temperature changes can be tolerated, as long as it falls within certain limits. However, the unavailability of cooling facilities in supermarkets has a disadvantageous effect on quality. These conclusions are only valid for produce with an acceptable initial quality. All products with low initial quality showed several product specific artifacts. The conclusion of the research project is that the initial postharvest quality is the most important factor. With poor products, no amount of

treatment has any positive effects, and usually results in spoilage (van den Boogaard, 2004). An essential tool for analyzing the cold chain is the ability to record and analyze the time-temperature profile during transport (info: www.e-faqts.com).

Energy efficient reefer transport

Long distance transport of perishable products with a reefer container has resulted in using less energy per kg of product by a factor of 100 in comparison to air cargo. Since increasingly large world-wide volumes of fresh agro-products are transported the total energy use is huge. About 30 million tons of agro-food products were transported in sea containers in 2000. Energy consumption used for climate conditioning of sea containers is often higher than that needed for the quality control of the product. The project Quest started in 2000 and aimed at the development of a new agro-container concept with reduced energy use and optimization of product quality. One of the products developed in the project is the "Quest Regular" control system, developed to reduce power consumption of reefer containers. The Quest Regular concept was tested in a real-life shipment of mangos from Brazil to the Netherlands in December 2005. The test results were positive and demonstrated that the power consumption of mangos shipped in reefer containers can be reduced to a high extent without any negative effect on the quality of the product.

A second part of this project was to develop a "ripening on board" concept for climacteric products. One of the deliverables is a computer model that can be used to control the ripening of avocado, the case product used in this research project. Fruit ripening of avocado is strongly related to ethylene. The main control mechanism available to influence the ripening and prevent ethylene production is storage temperature. The ultimate control of the storage environment can be used to ripen avocados during transport, in such a way that a desired ripening stage is reached at the desired time. The research showed that theoretically and technically the concept of "ripening on board" is possible. Some practical issues need to be solved and are subject to further research. A low-budget and easy-to-operate ethylene measurement system is under construction and being evaluated. Another aspect is the influence of the variability in the batch on the ripening process. It is expected that the product is already in the climacteric phase will affect others. However, the use of temperatures higher than optimal to initiate ripening will enhance the variance (Tijskens et al., 2003).

Quality measurement

Initial postharvest quality of a product batch and the biological variation in the batch are considered to be the most important factors in the market potential of a crop. Determining the quality status of the product is extremely important in order to be able to take the right decisions. The quality of fresh produce is in general being measured with the help of biochemical, physiological, instrumental optical, electrochemical or mechanical equipment and human visual inspection methods. With these methods, several intrinsic or extrinsic quality parameters can be measured. Some methods are invasive techniques and require the destruction of the product. Others, like human perception, are less objective. There

has been extensive research for methods that can determine the initial quality that also can be used to predict postharvest behavior. Molecular diagnostics, based on genomics, is a potential candidate that can fulfill this requirement. Gene expression is related to the basic physiological processes. It expresses the actual status of a product, giving its genetic profile and any environmental history. In the medical diagnostic research area this process has been applied with the first successes now being reported.

For assessment of initial quality of plant based products the “proof of concept” has been delivered for a few crops. For crops like carnation, iris, roses, apple and potato, research has been done at Wageningen-UR to identify gene expression profiles that are indicative for a specific quality aspect. For carnation and iris the development stage of flowering has been selected as quality aspect. For apples the research focus was the optimal harvesting moment, and for potato the storability in relation to the sweetening processes. As an intermediate step cDNA micro array plots have been made to monitor the expressions of thousands of candidate genes. Using pattern recognition techniques from the bio-informatics area, a subset of genes has been selected with the highest prediction scores for that specific quality aspect for each product. A real-time PCR method has been used as platform for the diagnostic predictive tests. The results are very promising, where for all crops a subset of genes could be found that could predict within an acceptable accuracy level the quality aspects. Further research and development will be done in the coming years to validate these findings and design an easy to use protocol and test method for practical applications.

3.4 Policy aspects

Government-support policies

Investment policies should be considered for modifying and amending based on the issued regulations so that they match the current situation of production. In order to eliminate or at least minimize any weakness in the fruit production sector, readjustment in investments and credit policies in production, marketing, import-export need to be made, and farmers, factories and enterprises should be encouraged to upgrade with direct investments and new technology and equipment. The government should also implement and amend incentive policies in agricultural extension and technology transfer for farmers, householders and enterprises in order to connect research institutions and production catchments. The tax structure should be such that it maintains an enabling environment as far as the production and trade of fruits is concerned.

Planning for fruit-specialized areas

A case in point is the comparison between Vietnamese and Thai fruit sectors. The Vietnamese fruit sector is not an industry; its fruits are still non-uniform in sharp, size, quality, taste, and maturity. This explains why Thailand with 260,000 hectares, has a considerable

export market presence, where as Viet Nam with three times higher area has negligible exports. The national governments could designate specific agro-climatic areas for specific fruits along all the related knowledge, technology and other inputs to enable the production and post production management for trade.

Aiming to enter into the world fruit market, Viet Nam is planning to adjust its agricultural and rural structure, gradually planning for a fruit-specialized area and to locate processing zones in order to exploit strengths of separate areas. By then the entire country would have had 27 fruit-centered areas with a total area of 242,000 hectares, inclusive of 100,000 hectares of fruits for export, mainly in the MRD.

Market reforms

Market reforms have the potential to reduce poverty, expand fruit production and exports, and contributed to greater diversity in fruit consumption. State-owned and private enterprises should continue to play a large role in agricultural markets, including seed production, fertilizer distribution, fruit processing, and exports.

Import liberalization, including the reduction of tariffs and quotas on fresh and processed fruits, would generate net benefits for a country in the long run. Although such imports will undoubtedly put competitive pressure on domestic fruit growers, they would yield three types of benefits for the country. The first is consumers would gain from greater choice and lower prices, Secondly, fruit exporters would gain from reciprocal trade liberalization by trading partners. Finally, although painful in the short run, imported fruits impose a useful discipline on domestic growers, forcing them to improve efficiency, respond to consumer demand, and provide the packaging and quality that consumers respond to.

Institutional development

Market information is increasingly important in fruit marketing. As fruit marketing extends over a longer distance, the need for timely and accurate information about prices and market conditions increases. Because fruits are highly perishable, storage is less able to moderate prices, and market information is particularly valuable when prices are volatile. Market information services must focus on key products and markets to avoid over-extension. Furthermore, they must incorporate regular feedback from users to ensure that they remain useful and relevant. The size of litchi and longan exports to China, as well as the volatility of the market, suggests that market information in this area would be valuable to producers and traders.

By facilitating the creation of professional associations, the government would make fruit markets more efficient. Producer and trader associations would make it easier to cooperate on matters of common interest, including the creation of a system for collecting and disseminating marketing information, the establishment of grades and standards, the provision of feedback to agricultural researchers regarding producer priorities, support for extension services for members, and the exchange of views on policy with the government.

The Viet Nam Fruit Association (Vinafruit) established in March 2001, for example, is a non-governmental organization uniting enterprises operating in the fruit industry. Vinafruit mobilizes and enhances cooperation among fruit enterprises to develop the fruit industry, in response to the increasing demands of the international and domestic markets, and to help integrate the Vietnamese fruit industry to international agricultural markets. Vinafruit promotes domestic business and serves as a bridge between Vietnamese exporters and foreign importers. The association provides research, training, information dissemination and technical assistance to support membres in the areas of quality improvement and price reduction. Vinafruit also promotes cooperation among all stakeholders in the industry to further these goals. However the government needs to strongly support Vinafuit in order for it to carry out its activities. Similar associations in Indian fruit sector, such as Mahagrape, have been very successful. At this moment, it is necessary to establish a number of associations and cooperatives for fruit production and export.

Establishment and development of a brand

In the current process of international integration, promotion on brand name establishment and protection registration for agro-products is very important so that rights and legal interests of agricultural specialties are protected legally, benefiting farmers who produce these products. Promotion on establishment and protection registration for names of origin is necessary and important in the current process of international integration. This will help farmers produce special products that are more competitive in the market.

Fruit quality control: sanitary and phytosanitary issues

The government should devote more attention and resources to sanitary and phytosanitary (SPS) issues in fresh fruit exports. SPS issues are perhaps the greatest obstacle to fruit exports to middle- and high-income countries. As FTA and WTO agreements reduce the ability of countries to protect their domestic agricultural producers from imports with tariffs and quotas, sanitary and phyto-sanitary issues will probably be used for protectionist purposes. Even without the protectionist motive, consumers in high-income countries are becoming increasingly concerned with pesticide residues, bacterial contamination, and other food safety issues.

The governments need to prepare a strategy for controlling the use of pesticides in fruit and vegetable production. This strategy should include four components: supply (import) control, research on the agronomic and economic aspects of pesticide use, farmer education campaigns, and more systematic testing of fruits and vegetables in the market place. This strategy should improve both the safety of the domestic food supply and the marketability of exported fruits and vegetables. As part of this strategy, there needs to be more systematic testing of pesticide residues in fruits and vegetables.

4. TRENDS, DEVELOPMENTS AND TECHNICAL INNOVATIONS

Globalized agricultural and food trade has given rise to new paradigms in food science and technology research. Local production of food and its processing before consumption did not invite any undue anxiety on the part of the consumers. However, one would like to be reasonably sure about the quality and safety of the food arriving from alien lands. Accordingly, efforts have been directed towards ensuring that the food is produced, handled, stored, processed, packaged and delivered with total quality and safety assurance. Besides, there is increasing awareness and demand for diversified, novel and functional foods. These contemporary developments have triggered R&D efforts in such areas as quality and safety assurance, designer foods, food biotechnology and nano technology. A few relevant trends, developments and innovations discussed during the conference are presented in this chapter.

4.1 Good agriculture practice (GAP)

The code of practices are designed for use by growers, trainers, facilitators, auditors and customers to achieve greater certainty and consistency in the development, implementation and auditing of on-farm food safety program.

Quality Management System (QMS) for agricultural goods is based upon the concept of Good Manufacturing Practices (GMP), GAP, Hazard Analysis and Critical Control Point (HACCP), Sanitary and Phyto-Sanitary (SPS), Quality Assurance (QA) and ISO method. QMS is designed to give guidance applicable for any Certification Body (CB) to certify on-farm production process of individual growers or of produce marketing firms. The system is associated with management to prevent, eliminate or minimize physical, chemical and biological hazards, to produce pest-free and marketable quality fresh fruits and vegetables from farm through distribution for markets and processing. It is also the set of applicable practices for growers to ensure safety and quality of fresh produce for customers. The on-farm management system places emphasis on Integrated Pest Management (IPM) and Integrated Crop Management (ICM).

Core concept of the system

The core concept or requirements of the system is grouped into 8 items. The details of those items appeared in operation procedures in the document. The following 8 key items can serve as quality objectives of the system (Table 4.1).

Table 4.1 Core concept of quality management system: good agricultural practice for on-farm quality and safety for fresh produce

Quality and safety items	Quality objectives
1. Water	Physical, chemical and biological safety
2. Field and land history	
3. Pesticide issues	
4. On-farm stocking and transporting of produce	
5. Crop protection	Free of pests
6. Production process	Quality to meet customer satisfaction
7. Post harvest handling	
8. Records	Trace back

Source: Salakpetch (2005).

Components of the system

The following are the components of QMS for on-farm production: quality policy, quality objectives, quality plan, operation procedures and work instruction, and forms and checklist. The document of the system has to be produced for individual crops with details on each component, particularly, quality plan.

Quality policy

It is the policy or vision of growers in the system. Normally, growers present their policy as "We strive to produce *fresh fruits and vegetables* for fresh markets and processing and offer the best customer satisfaction". If they are durian growers, their quality policy will be "We strive to produce *quality durian* for fresh markets and processing and offer the best customer satisfaction".

Quality objectives

Quality objectives are developed based on customer requirements and used as a guideline to establish a quality plan. The concept of quality objectives is to produce fresh fruits and vegetables that meet customer satisfaction, physical, chemical and biological safety and free of pests. Durian growers show their quality objectives as:

- To produce mature durian with no symptom of hard flesh, wet core and mummy flesh;
- To produce chemically safe durian;

- To produce durian that is free of pests.

While mangosteen growers present their quality objectives as:

- To produce mangosteen with no symptom of translucent flesh and interior gummosis and fruit weight not less than 70g;
- To produce chemically safe mangosteen;
- To produce mangosteen that are free of pests.

The difference of the quality objectives between those two crops is the eating quality of each crop that meets customer satisfaction.

Quality plan

The working group modified HACCP and ISO method to develop the quality plan that was used as a practical framework to get quality produce in accordance with quality objectives. The concept of HACCP enables them to identify potential product quality hazards and the practices needed to prevent, eliminate or minimize the hazards. This means that the agro-techniques for the whole process of production cycle must be well prepared and developed. A quality plan describes on-farm practices required to provide quality fresh produce that meets the customer satisfaction. The 8-column-table quality plan (Table 4.2) offers interest and value to growers and other suppliers, auditors and customers. Growers must follow practices in the quality plan in order to provide fresh produce in accordance with quality objectives. Auditors can use a plan to implement and audit on-farm food safety program. Customers can make sure that quality and safe fresh produce will be provided.

Table 4.2. Example of 8-column-table quality plan

Process step	Hazards	Control measures	CP/CCP	Operating limits	Monitoring	Corrective actions	Records

Process step	Stage of plant growth and development affected quality objectives.
Hazards	Problems or hazards related to quality objective(descriptive information).
Control measures	The control measures of problems and hazards.
CP/CCP	Do practices in a particular stage of plant growth and development need (control point, CP) or must need(critical control point, CCP) be followed to get produce in accordance with quality objectives.
Operating limits	In dicators to control or monitor hazards or CCP.
Monitoring	What, how to and frequency of monitoring.

Corrective actions	Corrective actions when problems or hazards exceed operating limits.
Records	All corrective actions must be recorded.

Examples of generic and durian quality plan are showed in Table 4.3.

Operation procedures and work instruction

Operation procedures describe all procedures required in the system and details of core concept that need to be achieved. The work instruction is a set of on-farm techniques to ensure that growers produce high quality, as well as safe fresh fruits and vegetables.

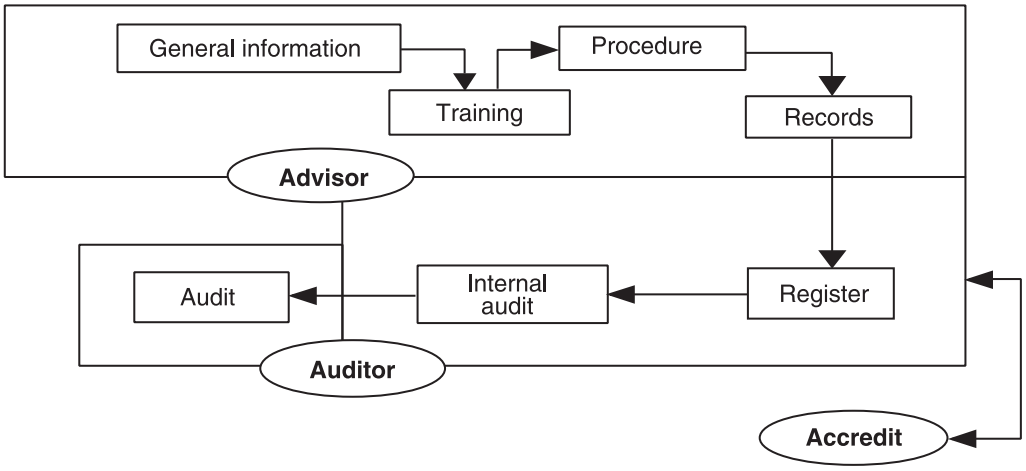
Forms and checklist

All practices indicated as critical control points (CCP) in the quality plan must be recorded in the provided forms for the purpose of trace back. The checklist can be used to supplement existing and auditing checklists used by certification bodies or for internal audits carried out by group of growers, grower cluster and individual business.

Organizations involved in the system in Thailand

The Ministry of Agriculture and Cooperatives, which is in charge of food safety policy of the country has assigned the Department of Agriculture and Extension to act as an advisory body (AvB), Department of Agriculture takes a role of a certification body (CB) and National Bureau of Agricultural Commodity and Food Standard acts as an accreditation body (AB). Government agencies play a role of CB during an early stage of QMS launching, and then auditing will be empowered to private institutions in near future. The implementation of the system in Thailand is shown in Figure 4.1.

Figure 4.1. Implementation of quality management system: GAP for on-farm production in Thailand



Source: Salakpetch (2005).

Status of quality management system (QMS) in Thailand

Food safety based upon QMS is the country policy. Documents regarding the system, particularly about quality objectives, quality plan, work instruction and forms of 28 crops have been published since the 2003 fiscal year by the Department of Agriculture. The twenty-eight crops include 14 fruit crops, rice and 8 kinds of tropical vegetables. Vegetables in the cruciferae, leguminosae, capsicum and eggplant, melons and herbs family are also documented. The certification in the system is divided into 3 levels; Level 1- safety level, Level 2- safety and free of pests level and Level 3 -safety, free of pests and quality level.

Since Thailand is an agricultural country, about 60% of total population is in agricultural sector and farm certification is a big task. Business clusters of growers and between growers and traders are emphasized to certify in groups and to strengthen fruit trade of the country. Information technology for food safety and trace back has been developed to visualize and control the outbreak of avian influenza disease since 2003. Information management of fruit supply chain includes: a case study in durian and mangosteen began at the end of 2006 to help manage the logistics of fresh produce and to support the development of trace back system. Periodical revision of the systems and implementation plans is needed to remain up-to-date.

Table 4.3. Example of details to be filled in a quality plan to provide fresh produce in accordance with quality objectives

No.	Process step	Hazards	Control measures	CP/ CCP	Operating limits	Monitoring	Corrective actions	Records
1.	Seed or propagation material preparation	Produce is not true to type Non-marketable quality Non-acceptance to quality objectives	Seed or propagation material must come from reliable sources	CCP	True to type and in accordance with marketable quality	Seed or propagation material pedigree including source of origin or source of purchasing must be investigated	Variety required by market is needed Seed or propagation material must meet its standard and come from the reliable sources	Variety name Source of origin or of purchasing Date and amount of purchasing
2.	Crop protection during growth and development of leaf, flower and fruit (depending upon which plant parts are consumed)	Non-marketable quality Non-accepta nce to quality objectives	Diseases and insects affecting the produce during its growth and development until harvest will be examined and compared to key pest economic threshold level (ETL) of a particular crop	CCP	Key pest economic threshold level of a particular crop	Need to examine pests during a certain stage of plant growth and development at 5 to 7-day-intervals and compare to their ETL	Integrated pest management (IPM) techniques of a particular crop is fully applied Sorted out is needed to provide produce that is free of pests and any damage from pests	Choice and rate of chemical applied Records of application

4.2 Nondestructive quality evaluation

Fresh fruits and vegetables have such a characteristic that their size, color, shape, chemical composition are different from each other even though they are of the same variety and were harvested at the same place and time. Accordingly, sorting the fruits should be done one by one on individual basis to ensure the quality of commodity. To do so it takes a lot of manpower and time.

With consumers' desire for the better quality commodities and rapid expansion of international trade of agricultural products, a marketing policy to ensure the quality of agricultural products is emphasized in advanced countries to promote the consumption of domestic products as well as to protect the domestic products from the imported ones. New technology to evaluate the internal qualities of fresh products nondestructively has been developed and commercialized in Republic of Korea, Japan, Eu and the United States. The nondestructive methods could be divided into two types, off-line and on-line. In other words, the former is a method free from the time limit in measurement of fruit quality and the latter is the one limited by time. To inspect all fruits one by one, an on-line method having high sorting speed of 2 to 5 fruits per second needs to be developed. Recently, image processing technology using CCD camera has been developed for evaluating appearance quality factors such as the size, color and shape; and non-destructive technologies using VIS/NIR spectroscopy, sonic/ultra sonic, x-ray and MRI have been developed for internal quality factors such as sugar content, acid content, internal breakdown and cavity.

Quality component

Quality of fresh fruits and vegetables could be defined differently depending on a consumer's preference and final utility, but a standardization to identify the degrees of quality in a commodity is necessary for marketing fresh products. The major quality factors of fruits and vegetables are their appearance, texture, flavor, nutritional value and safety as shown in Table 4.4.

Table 4.4. Components of quality factors of fruits and vegetables

External quality factors	Size	Weight, Volume, Dimension
	Shape	Diameter/Depth ratio
	Color	Uniformity, Intensity
	Defect	Bruise, Stab, Spot
Internal quality factors	Flavor	Sweetness, Sourness, Astringency, Aroma
	Texture	Firmness, Crispness, Juiciness
	Nutrition	Carbohydrates, Proteins, Vitamins, Functional property
	Defect	Internal cavity, Water core, Frost damage, Rotten

Source: Noh and et al. (2001).

The relative importance of each quality factor or component depends upon the commodity and its intended use. Appearance factors have been the most important quality attributes for the fresh products before nondestructive assessment technology of internal quality was developed. Grade standards of commodities are established by country or region to provide valuable tools in marketing produce. Table 4.5 shows an example of quality components, which are included in the grading standard of apples adopted in Republic of Korea, Japan and the United States.

Table 4.5. Quality components involved in grade standards of apple by country

Country	Quality components	
	External	Internal
Republic of Korea	Color, Shape, Weight, Scab,Sunburn, Disease and insect damage,Scars, Pesticide damage, Stem	Sugar content , Maturity, Internal breakdown, Internal browning
Japan	Color, Shape, Weight, Scab, Sunburn, Scar, Disease damage, Insect damage, Stem	Maturity, Internal breakdown, Internal browning
the United States	Color, Shape, Size, Decay, Scald, Scab, Jonathan spot, Insect damage, Scars Freezing injury, Russeting	Maturity, Firmness, Bitter pit, Internal breakdown, Water core, Internal browning, Bruises

Source: Noh and et al. (2001).

Necessity of sorting / grading

Quality is attributed to the several factors such as level of cultivation techniques, climatic conditions and soil condition. Therefore, there is a wide difference in quality among products even if they were grown and harvested from the same area. In 1999, Chungdo Peach Experiment Station in the Republic of Korea harvested all peaches (Miback variety) from three trees selected from three different locations, and measured their weight and sugar content. Table 4.6 shows distributions of weight and sugar content of those peaches. The weight ranged from 140g to 450g, and its sugar content was 5.2% Brix to 15.7% Brix indicating a large variation of 2.6 to 7.5% Brix within each weight class.

Table 4.6. Weight and sugar content distribution of Miback peaches harvested from three trees selected

Weight		Substandard	Small	Medium	Large	Extra large
		less than 180g	180-210g	210-250g	250-300g	more than 300g
Size distribution (per cent)		3.1	7.7	25.3	40.5	23.4
Sugar content (Brix)	Min.	5.2	5.5	5.9	6.9	8.2
	Max.	7.8	10.1	11.2	12.7	15.7
	Average	6.6	7.7	8.5	9.4	10.8

Source: Rearranged from Annual Report of Chungdo Peach Experiment Station of Republic of Kore (1999).

Chungdo Peach Experiment Station also purchased 5 boxes of peaches in each price range from a wholesale market and measured weight and sugar content of those peaches. Table 4.7 shows weight and sugar content distributions of peaches in each price range. It is also noted that there is large difference in sugar content among peaches in the same priced box, ranging from 5.7% Brix to 9.3% Brix. Table 4.8 is the result of a survey to track the consumers' preference in purchasing peaches. Sweetness (47.3%), freshness (28.6%) and price (15.1%) are the most important factors, with the preference in sweetness increasing a lot, showing a decrease in price preference, as compared with the survey result conducted 5 years ago. The fruits having high sugar contents are more desired in the market, and consumers are willing to put more weight on the quality over the price.

Table 4.7. Weight and sugar content distribution of peaches purchased from a wholesale market

Price (Korean Won*/10kg)	Number of boxes/peaches	Weight (g)			Sugar content (Brix)		
		Min.	Max.	Average	Min.	Max.	Average
Less than 20,000	5/194	205	310	251	4.5	13.8	9.0
20,000 - 25,000	5/152	265	400	324	7.1	12.8	9.4
25,000 - 30,000	5/138	300	440	352	7.1	13.3	10.0
More than 30,000	5/125	321	475	395	7.4	13.6	10.6

Source: Annual Report of Chungdo Peach Experimental Station of Korea (1999).
*Won means Korean Won currency.

Table 4.8. Consumers' preference in purchasing fruits

Year	Flavor	Freshness	Price	Safety	Place of origin	Size	Color	Shape	Nutrition
1998	29.0	27.2	26.5	10.0	—	2.4	1.2	0.3	3.5
2003	47.3	28.6	15.1	2.6	1.8	1.6	1.5	0.9	0.5

Source: Agricultural Outlook 2003. Korean Rural Economic Institute.

Since large-scale world-famous discount stores have entered the Korean domestic market from the middle of 1990s, scales of domestic stores have been enlarged, consequently, this trend has brought about a great progress and changes in post-harvest system. To meet the markets' demand of high quality fresh fruits and vegetables, many modernized packinghouses, which are called Agricultural products Processing Centre (APC) in Republic of Korea, have been introduced to rural area. As the market becomes globalized and technology advancement is made, consumers' behavior in purchasing farm products is being switched from quantity to quality with their increase in per capita income. In this frame, it is indispensable to develop and transfer quality evaluation technology to provide consumers with high quality and safe fruits and vegetables.

Non-destructive techniques for measuring quality components

Many kinds of nondestructive techniques were developed to measure quality components

of biological products including fruits and vegetables, and can be classified into optical, electromagnetic and dynamic methods according to their measurement principals. Table 4.9 is a summary of those techniques and quality components that could be measured with the corresponding technique. It is noted that most of the quality components listed could be measured at off-line state but not at on-line state at the spot.

Specific examples of practical uses include (1) near infrared (NIR) reflectance and/ transmittance technique to measure soluble solid content of peaches, pears, apples, citrus, melon, and watermelon, (2) the acoustic response technique to evaluate the maturity and internal defects of melon and watermelon, and (3) the electrical capacitance technique to estimate soluble solid content of watermelon.

Table 4.9. Non-destructive techniques to ensure quality factors of horticultural products

Principle	Technique being used	Components
Optics	Image analysis	Size, Shape, Colour, External defects
	Reflectance, transmittance and absorbance spectroscopy	Colour, Chemical constituents, Internal defects
	Laser spectroscopy	Firmness, Visco-elasticity, Defects, Shape
Dynamics	Vibrated excitation	Firmness, Visco-elasticity, Ripeness
	Sonic	Firmness, Visco-elasticity, Internal cavity, Density
	Ultrasonic	Internal cavity and structure, Firmness, Tenderness
	X-ray image and CT	Internal cavity and structure, Ripeness
Electro-magnetic	Impedance	Moisture contents, Density, Sugar content, Density, Internal cavity
	MR/MRI	Sugar content, Oil, Moisture content, Internal defect and structure

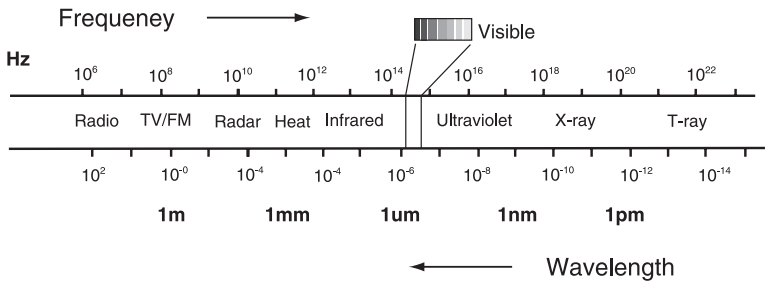
Source: Lee and Choi (2001).

On the other hand the magnetic resonance (MR) has been studied to measure the moisture and oil content of agricultural materials. The magnetic resonance imaging (MRI) was proved to be an extremely valuable method to evaluate ripening, core breakdown, bruises, worm damage, chilling and freezing. Currently, MR and MRI are not practically used for routine quality testing, because the equipment is too expensive and difficult to operate. However, MR and MRI methods have great potential for evaluating the internal quality of fruits and vegetables. Among the above advancements, NIR spectroscopic method has contributed to development and wide use of sorting and grading technology during the last 15 years.

Principle of NIR spectroscopy

The electromagnetic radiation covers a wide range of photon energies, and is generally divided into the following bands from the longest to the shortest wavelengths (radio wave, microwave, infrared, near infrared, visible, ultraviolet, X-ray and gamma-ray) (Figure 4.2).

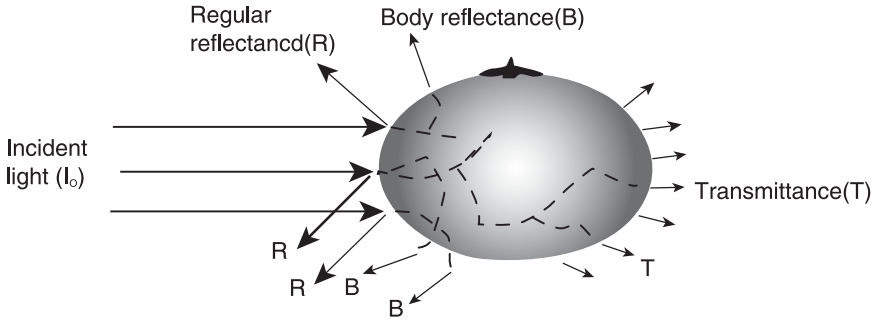
Figure 4.2. Electromagnetic spectrum of radiation



Source: Berger (1965).

Optical properties are concerned with response of a matter to UV (ultraviolet:180-380 nm), VIS (visible: 380-700nm) and NIR (near infrared: 780-2500 nm) light, which are characterized by reflectance, transmittance, absorbance, or scattering. When a light beam falls on a biological object, part of the incident beam (about 4 %) is reflected by the surface, which is called regular reflectance or specular reflectance. Most of the incident radiation is(I_o) transmitted into the cellular structure of the object. Of this portion, part is absorbed by the object, part is reflected back to the surface, which is called the body reflectance or diffusive reflectance, and part is transmitted through the object. The absorbed radiation is transformed to other forms of energy instantaneously (such as heat and chemical changes) or other forms of radiation (such as fluorescence and phosphorescence) (Figure 4.3). VIS/NIR spectroscopic method is attributed to the absorption phenomena of certain wavelengths by certain molecules.

Figure 4.3. Distribution of incident light on an object

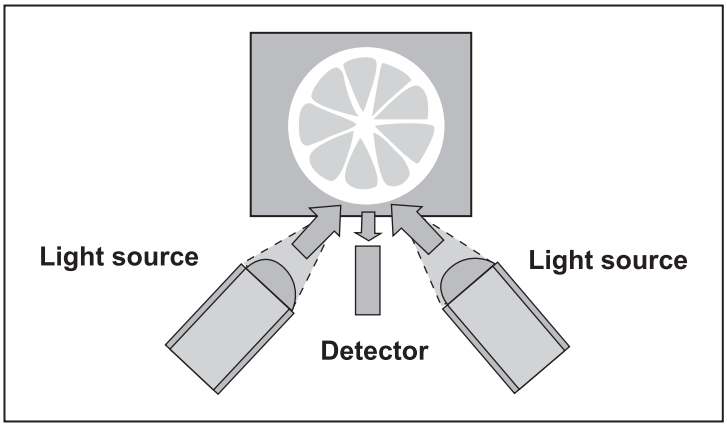


Source: Chen (1976).

Measurements of reflectance or transmittance spectrum data

Optical devices to measure spectrum data are classified into reflectance and transmittance modes depending on the relative arrangement of light source, detector and object. In the reflectance method, light source and detector are located at the same side as shown in Figure 4.4. When lamps illuminate an object, the diffusive reflected radiation is measured on a wavelength scale by a diode array sensor. A calibration equation to measure the target component is developed with those spectrum data sets, and validity of the equation is

Figure 4.4. Measurement of reflectance



Source: Choi and et al. (1998).

proved with the spectrum data sets of unknown samples. In developing the calibration equation, the row of spectrum data sets are pre-processed for reduction of noise and scattering effect. which are caused by the difference in size and other physical properties of the given samples. The development of a robust calibration equation is an essential part of the non-destructive technique to measure the quality component.

The reflectance method can be used to measure the chemical constituents of the fruits and vegetables having relatively thin peel such as peaches, apples, and tomatoes, but this method is not useful for them having thick peel such as citrus, melon, and watermelon since penetration depth of the reflected light is limited to about 5 mm.

In summery, the reflectance method has the following advantages and disadvantages compared to the transmittance method.

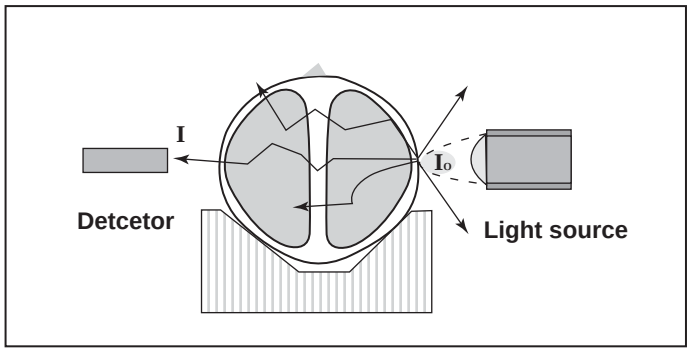
- Strong spectrum can be obtained at a wider wavelength range;
- Internal defects such as browning or rot can not be detected since the light is not penetrated throughout the whole fruit;
- The measured value does not represent an average of the target component because the light only illuminates the local part of the sample only.

The transmittance method is to measure the light transmitted through the object. Configuration of this method is classified into half transmittance and full transmittance depending on the arrangement of the sample, detector and light sources as shown in Figure 4.5 and Figure 4.6. Full transmittance is usually applied to relatively small fruits and soft tissue such as citrus and tomato. A half transmittance arrangement however is widely used for many types of fruits and vegetables such as apple, pear, melon and watermelon, because an high intensity of radiation can be made by placing several lamps around the sample.

The most important considerations in implementing a transmittance type is to select a

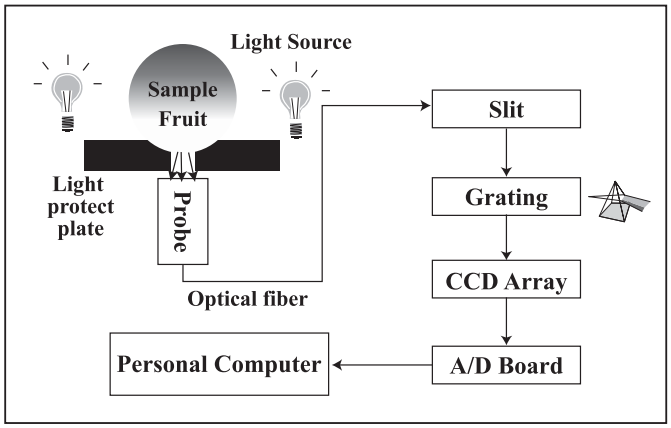
detector unit that is highly sensitive, collect and deliver the diffusive transmitted light to the detector as much as possible, and block the stray lights from the light source so they are not able reach the detector. The slit size and number of grooves in a grating are related to the intensity and resolution of the spectrum. Usually, slits that are greater than 100 um and gratings less than 600 lines/mm are adoptable for transmittance measurement. The light protect plate in Figure 4.6 is designed to block the leakage of stray light between the contact surface of the fruit sample and the tray. Concentric stairs are grooved inside the tray and ring-shape silicon pads are put on them to block the leakage of the stray light.

Figure 4.5. Measurement of full transmittance



Source: Lee and et al. (2004).

Figure 4.6. Measurement of half transmittance



Source: Hwang (1999).

In summery, the transmittance type has the following merits and demerits:

- Internal defects such as browning and breakdown can be detected;
- The measured value can represent the average of the target component;
- S/N ratio of the spectrum data is relatively low;
- Leakage of stray light must be blocked.

On-line applications of VIS/NIR spectroscopy

Regarding to the on-line prediction of sugar contents of intact fruits, Kawano (2001) described that in 1989 Mitsui Mining and Smelting Co., Ltd. in Japan developed and introduced an on-line sugar-sorting machine for peaches based on the NIR reflectance method. The geometry of the optical part was composed of two focused tungsten halogen lamps for illumination, a lens for collecting the reflected light from the sample and a spectroscope having a diode array detector. The sorting rate was 3 fruits per second and the sugar content of each peach was predicted from the reflected NIR radiation by using the calibration equation.

The optical part of the machine developed by FANTEC Co. was constructed with ten tungsten halogen lamps set up around the equator of the fruit sample which was placed and moved on a free tray. The light transmitted through the sample was measured with a fiber optic sensor unit which was placed underneath the free tray (Figure 4.6). While each sample is lined up and moving on a conveyor, the equator part of the sample was illuminated by a focused tungsten halogen lamp and the light transmitted to the other side of the sample was detected by a sensor unit.

In Republic of Korea, Choi et al.(1998) developed an on-line sugar grading machine using reflectance spectrum data of Fuji apples which was obtained with a commercial real time spectrometer covering a wavelength range of 500 nm to 1050 nm. The standard error of prediction (SEP) of the developed system was 0.78% Brix at a sorting speed of 2 fruits per second. Hwang (1999) developed a transmittance type sugar-sorting machine which was constructed with free trays and an automatic free-tray feeder. Each sample placed on a free tray was fed onto the carrier by the feeder and was illuminated by two line-shape tungsten halogen lamps that were installed at both sides of the fruit sample. The transmitted light through the sample was collected by the optical fiber probe which was set up underneath the free tray carrier. The spectrum range was from 500 nm to 1050 nm. SEP was reported to be 0.5 to 0.6% Brix at sorting rate of 2 to 3 apples per second.

In the middle of the 1990's, a few large-scale color and sugar sorting machines were imported from the United Staes and Japan. For the past decades sugar content graders using transmittance spectrums were domestically developed and supplied to packinghouses with government financial aid. As of the end of 2005 the non-destructive sugar sorting systems were operated at 98 packinghouses in total (73 for apple, pear and peach, 10 for watermelon, 8 for mandarin, 6 for Korean watermelon and 1 for tomato). The sorting speed of these systems is 1-4 fruits per second and SEP is known as 0.5 to 0.8% Brix. Table 4. 10 presents current sorting technologies available for major fruits and vegetables in Republic of Korea

Table 4.10. Current status of sorting technologies for fruits and vegetables in Republic of Korea

Fruits Quality Factor	Apple	Pear	Peach	Persi-mmon	Orange	Melon	Tomato	Korean melon	Water-melon
Weight	○	○	○	○	○	○	○	○	○△
Size	–	–	–	–	○	–	–	–	–
Color	○	○△	○△	x	○	–	○	x	x
Sugar content	○	○	○	x	○	△	△	○	△
Acid content	△	△	△	–	△	–	x	–	–
Maturity	x	x	x	x	△	x	△	x	△
Internal breakdown	○	○	x	x	x	x	x	○	△
Water core	○	–	–	–	–	–	–	–	–
Sponge disorder	–	○	–	–	–	–	–	–	–

Source: Noh and et al. (2001).
Note: ○ :Using at packing house
△ : Technology is available but has not reached packing house
△ : Under study for improving accuracy
x : Has not been studied
– : Not regarded as quality factor

Peach grading system

Korean peaches have such a characteristic that the intact flesh is relatively soft and the sugar content within in the fruit is different by 2 to 3% Brix depending on the locations (such as stem side, blossom side, equator part, etc.). To minimize the damage which may occur during the sorting process, a free tray-type sorting system was developed, and the optical devices were designed so that reflectance spectrums could be measured from both sides of a peach at one time when it passes through the illumination chamber on the tray. All grading results of each producer's products are saved in database and provided to producers so that the data can be used for producing better quality peaches.

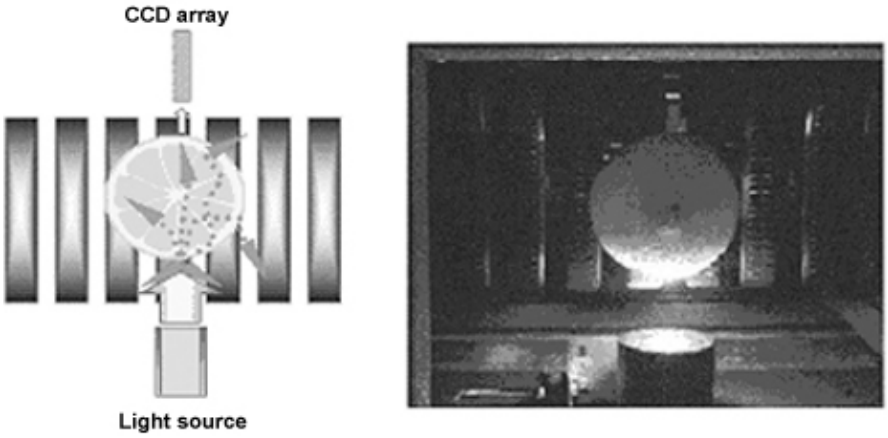
The multiple linear regression (MLR) model was adopted in developing the calibration equation to predict sugar content. Performance of the system showed determination coefficient (R^2) of 0.69, standard error of prediction (SEP) of 0.49% Brix and sorting capacity of 7,200 peaches per hour. It was also noticed that the accuracy of the sugar content measurement was much improved by using two reflectance probes as compared with the grading system of using one (Lee and et. al., 2001).

Citrus grading system

Conventional citrus sorters have been used for sorting citrus fruits based on size by using a series of rotating drums having holes of different sizes. With the requirement of internal quality evaluation of Satsuma mandarin produced in Republic of Korea, the National Institute

of Agricultural Engineering, Rural Development Administration (NIAE/RDA) developed an on-line citrus sorting system which is composed of an automatic feeder, grader and an automatic discharging unit. The grading unit was designed so that the NIR spectrums of full transmittance could be measured from the citruses which were fed one by one into the illumination chamber by an automatic feeder (Figure 4.7). Using the spectrum, it was observed that the data is affected by the posture of the Satsuma mandarin which passing through the illumination chamber. To reduce such a variation in spectrum data, the automatic feeder should be designed so that those fruits are always placed flat on the conveyer belt.

Figure 4.7. Arragement of light and detector for sugar sorting of Satsuma mandarin



Source: Lee and et al. (2004).

The spectrum data were measured in a range of wavelengths from 650 to 955 nm with a real time spectrometer having CCD array sensor of 2048 pixels. A 300 W halogen lamp and a lens assembly were used for strong illumination. For collecting and collimating the transmitted light, a probe was made with lens assembly and optical fibres. The calibration equations to estimate sugar content and acid content of mandarin oranges were developed by using the Partial Least Square Regression (PLSR) model. The sugar content measurement model has a standard error of calibration (SEC) of 0.55% Brix and a standard error of prediction (SEP) of 0.42% Brix. The sorting capacity was 10,800 citruses per an hour (Lee and et al., 2004)

Detection of internal defects

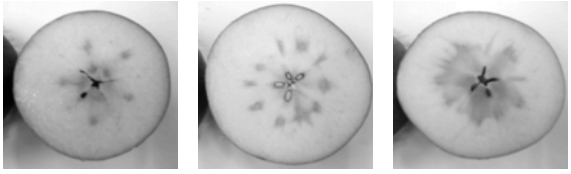
Non-destructive methods to detect internal rot (Figure 4.8) and water-core (Figure 4.9) in Fuji apples, by means of VIS/NIR transmittance spectroscopy, have been developed at Seoul National University in Korea.

To acquire the transmitted energy spectra of an apple, a proto-type spectroscopic sensing

unit was made with a sample holder, light sources and a real time spectrometer as shown in Figure 4.6. All spectra of the Fuji apple samples showed three peaks near 640 nm, 710 nm and 800 nm and the transmitted energy levels of the water-core apples were generally higher than the sound. Those of the internally rotted samples were the lowest. With such a normalization, classification analysis and an algorithm, Correct Classification Ratios (CCRs) of the sound, the water-core and the internally rotted samples were expected to be 100%, 91.4% and 97.6%, respectively (Hwang, 1999).

Figure 4.8. Internal browning

Figure 4.9. Water-core of Fuji apples



minor mild severe

Watermelon grading system

The quality components of the watermelon include maturity, sugar content, inside cavity, yellow belt and blood flesh, but the quality grading is practically being done by inspector's sensibility or experience. A non-destructive watermelon sorting system which can grade the watermelon by weight, sugar content and internal defect was developed by NIAE/RDA in Republic of Korea (Lee and et. al., 2004). The grading system adopts NIR half transmittance and an acoustic method to evaluate sugar content and internal defects. To get the transmittance spectrum from a watermelon, a strong light source of 2.4 kW tungsten halogen lamps was used. Sugar contents could be estimated with the developed system in SEP of 0.8% Brix. The internal defect, mainly maturity and cavity, was detected by hammering the watermelon to generate the acoustic sound. The acoustic signals were measured from three points of the watermelon sample in the noisy packinghouse, which were then processed for removal of noise and detection of the internal breakdown. The performance of this sorting system has a sorting capacity of 1,500 watermelons per hour, a sugar content measurement error of ±0.8% Brix and 90.1% accuracy of internal defects.

Applications of other nondestructive techniques

Lately, research has been conducted on exported fruit to try and establish a grading system based on quality. With this focus, methods for non-destructive quality evaluation have been developed using image processing, visible light, NIR spectroscopy and ultrasonic. While

some tests have provided good results, the implementation of the new techniques is in the hands of commercial parties.

Image processing has been applied to detect and monitor the development of bruise for salak stored at room temperature (26°C) and 10°C (Ahmad et al., 2001). Grading of lanzone using the visible light has been developed to separate the seeded and seedless fruits (Hendri et al., 2001). An evaluation system using image processing for the color of mango has been successfully applied, along with using NIR for the taste evaluation of the fruits, grading the mango into four different groups: sweet-sour, sweet, sour and tasteless (Saputra et al., 1995, and Susanto et al., 2000). Ultrasonic is used to evaluate the maturity and ripeness of durian and mangosteen (Budiastra et al., 1999; Haryanto et al., 2001; and Nasution et al., 2005).

4.3 Agricultural supply chain management (SCM)

In setting up an efficient and robust supply chain, the use of the latest technology, knowledge and protocols in postharvest management are important. In the area of research and development in postharvest technology several new concepts and innovative ideas are being examined. Long time storage, packaging concepts, cold chain management, controlled ripening and quality measurement are a few projects being pursued these days. These innovations lead to opportunities for better quality products, lower energy consumption, lower transportation costs, and flexibility in using transportation modalities. An integral supply chain management approach is necessary if flourishing solutions are to develop. Simulation tools using quality decay models and knowledge management systems are powerful exploration and scenario analysis tools. Certification systems and the use of protocols are important for operational management of the production and supply chain. New certification systems are being developed, like Quality Analysis of Critical Control Points (QACCP), to ensure quality attributes throughout the entire chain.

There have been major changes in the supply chain of agro & food products over the last decades. Nowadays the complex is addressed as “the global food system”. A more liberalized international trade system, globalization and the transition towards a consumer driven market have empowered this development. International trade in fruits and vegetables has expanded at a higher rate over the past 25 years than trade in other agricultural commodities (Huang, 2004). This global food system means opportunities for further growth of the import of Asian fruits in Europe. This will not be an easy challenge; world wide competition in supplying fruit is quite high. Understanding the market and its consumers and building up business relations are necessary steps in order to grow. Only those who meet the high demands for quality and safe products can profit. Furthermore in specific consumer segments other added-value concepts are needed, like healthy convenient products produced in a sustainable manner. Since chain performance is important in order

to be competitive, the supply chain needs to be organized in an effective and efficient manner. The use of the state of the art postharvest technology and supply chain management concepts contribute to “making the difference”.

One of the major developments in worldwide transport is the increase of the volume in reefer container transport of perishable products. For fruits like apple, citrus, banana, avocado, mango and melon, overseas shipment is the standard way of shipping long distance. Because of technological innovations in combination with the integral development approach, several products have been added to the list of those that can be transported by ship instead of airplane. Other reasons to shift toward container transport include the higher costs for air trade because of high energy prices, the consolidation in logistics and more contract based deliveries. Who would have thought ten years ago that flowers like tulips and even cut roses could be transported transatlantic with a reefer container?

For example, the Netherlands has a long history in the agro & food business. Its stronger points lie in breeding, processing and trading. For some products the Netherlands has a leading position in the global trade: 84 % of all flowers and 83 % of all flower bulbs are traded via this country. The main ports, Rotterdam harbour and Schiphol airport, serve as excellent bases for orchestrating roles in trade and logistics. They serve as a transit port for imported fresh produce from all over the world. The Netherlands also has a strong background in education, business training and research in the agro & food area.

The growing power of the retail trade segment in present times has an effect on the total supply chain. Retail is forcing requirements backwards to every single link in the chain. In Europe today only 90 large retail organizations are responsible for supplying most of the food that European consumers can buy in the supermarket. They will further control the quality management of the total chain and keep on putting pressure on achieving more efficiency in the chain. The amount of private labeled products has increased recently; the consumer is not willing to pay a high premium price for A-brand products. In Europe today, 40% of packaged foods have supermarket names rather than manufacturer labels (Bell, 2006). To be able to guarantee quality and safety of products several procedures have been installed, like HACCP, EurepGAP, GMP and recently the General Food Law (traceability). This has led to the overall perception, by consumers, government agencies and chain actors, that our food has never been as safe as it is today. The first signs are visible that attention from the governmental agencies is shifting from safety only to also food quality aspects. Some retail and purchase organizations, also in the discount segment, are setting higher standards than required to be distinctive towards consumers.

One of the undesirable side effects of the transition towards a consumer driven food chain is the inefficiency in the supply chain resulting in huge product losses. Rough estimates are that in developed countries 45-50% of the total fresh product volume ends up in the waste stream, mainly because of quality deterioration. Estimates are that in retail and food service 5-6% of the total volume of fresh products is subject to spoilage. For some of the

recent fresh product, like fresh-cut vegetables and fruit salads spoilage percentages can be as high as 15%. Quite alarming are the spoilage figures for the consumer segment. In the Netherlands an average household spoils 10-15% of the fresh food, about 165kg a year. The spoiled products are consisting of unused products (27%), leftovers of opened products (48%) and rest of prepared meals (25%) (Milieu Central, 2001).

Further vertical integration of the food chain is needed to get closer to the customer and become more responsive to their needs. Retailers will be more integrated with their suppliers, and suppliers must become more integrated with the farmers. The time between identifying a consumer demand and being able to grow, process, and put it on the shelf needs to be much shorter. This means that chain actors will work more as partners than competitors. And because of the more integral approach, the increased transparency and trust between actors, efficiency can also be improved. Also issues like spoilage in the chain up to the consumer can be better controlled and reduced dramatically with an integral approach. In the Netherlands currently a consortium of retailers, food service companies, suppliers, producers and enabling technology suppliers is working on reduction of spoilage in a project called “Fresh on Demand”. Global success will be driven by the capacity to establish seamless partnerships that serve customers (Bell, 2006). The real challenge for the future is the transition from transaction to trust.

Integral approach

Several definitions for supply chain management (SCM) can be given. Here SCM is defined as the integrated planning, coordination, and control of all logistic business processes and activities in the supply chain to deliver superior consumer value at a lower cost to the supply chain as a whole while satisfying requirements of other stakeholders in the supply chain (e.g., the government or NGOs). SCM should result in the choice of a supply chain scenario (i.e., an internally consistent view on how a supply chain should look like in terms of production and distribution processes and their coordination). An essential product attribute in food chains is product quality. The way in which product quality is controlled and guaranteed in the supply chain, is considered of vital importance for supply chain performance. Apart from being a performance measure of its own, product quality is directly related to other food attributes like integrity and safety. Furthermore, product quality is tightly coupled to logistical decisions since the use of specific resources at specific environmental conditions in processing and distributing steps influences product quality. One of the keys to food SCM is an integrative view on logistics and product quality (van der Vorst, 2005).

Role of modeling and simulation tools

Simulation tools are often used to support decision-making on supply chain (re)design, building on their inherent modeling flexibility. However, food supply chains set some specific

requirements to simulation models. To address these demands a new discrete event simulation environment called ALADIN (Agro-Logistics Analysis and Design Instrument) has been developed. It is based on a generic modeling framework that offers the analyst guidance in modeling, and provides model transparency to problem owners. An essential feature of the new tool concerns the integration of reusable process building blocks and quality decay models (van der Vorst, 2005).

The models describing quality aspects in relation to its process and distribution chain are so-called Quality Decay Models (QDM). These models incorporate all variation that can occur (i.e., variation in initial quality due to seasonal variations, variation in process conditions). The developed models must be able to incorporate these sources. An example is the ability of the model to predict the shelf-life of fresh-cut vegetables. With this model, insight can be gained into the role of condensation and micro-perforations in quality decay of minimally processed vegetables (Top, 2005).

Certification systems and protocols

Certification systems and the use of protocols are important for operational management of the production and supply chain. QACCP is - at this moment still theoretical - a system approach to visualize the effects of chain processes on the quality of products and make it useful for decision making. With the help of concrete tools and instruments, in which practical knowledge and scientific models are combined, critical decision points are made visual, the band width set at a specific point, and the effects of possible corrective actions determined. Based on a QACCP analysis decisions can be taken to optimize a chain process, redesign a configuration or reallocate different product streams in the chain. The idea of QACCP is not yet formalized into rules like HACCP is; it is still under investigation. Its purpose is to show quantitatively, via Quality Decay Models, which factors have an effect on food quality attributes for each element in the food chain (van Boekel, 2005).

Integral project cases

Fruitful is an example of an integral international supply chain project with multiple goals. The objective of Fruitful was to study the possibilities for investments in an integrative supply chain information system. With the assumption that enhancement of information exchange improves logistic performance and fruit quality. Partners in the project came from South Africa and the Netherlands with participation from industry (Capespan, FTK, Hage, Seabrex, Seatreade, e.o.), knowledge institutes (Wageningen-UR, TNO, CSIR), and other stakeholders (Klict, Ministry of Agriculture, e.o). The project started in August 2001 and continued until October 2002. The project's aim was to identify promising opportunities for improvement of the supply chain for fruit from South Africa to the Netherlands using a participative approach, in a setting where all the key actors in the chain are represented. Pilot consortia were set up for grapes, citrus, avocados and mangos. Some

results and conclusions from the project were:

- Pilot partners agree on importance of the usage of standard codes;
- Codes must be maintained by an authorized third party;
- Electronic booking gives advantages;
- Better understanding of the functions of others within the chain;
- First steps have been made towards more integrated information exchange.

A project that has just started in 2006 is the ISAFRUIT project. ISAFRUIT is an integrated research project funded by the EU under the Framework 6 program. The total activity amounts to more than 21 million Euro. Both research institutes and private companies also fund part of the activities. 40 universities and research institutes and 20 companies are partners in the integrated project. The partners come from 17 countries, including two research institutes from developing countries, and 21 SMEs.

The idea of ISAFRUIT is to fulfill the consumer needs and expectations and increase fruit consumption through consumer satisfaction. Awareness of the health effects of fruit may be a driving force for the consumer, making consumer-linked sciences the starting point of ISAFRUIT giving input to the other RTD activities. Research on human health and fruit consumption is part of the project and activities on quality and health effects of fresh and processed fruit shall stimulate consumer interest in a wider range of healthy products. Sustainable chain management and production methods including organic production are addressed by a number of work packages dealing with the post harvest and pre harvest quality of the fruit in the supply chain. The goal is to stimulate the availability of a wider range of fruit and fruit products from sustainable production on the market (www.isafruit.org).

5. STRATEGY AND ACTION PLAN

5.1 Role of the government sector

Governments envisage the needs of the society and find ways to meet these needs. They catalyze the relevant research and development activities, create the nec essary policy environment, find various actors to implement the action plan, help in putting the appropriate infrastructure in place and then administer the programs.

Trade agreements

National Governments could enter into bilateral or multilateral trade agreements with other National Governments to facilitate the trade activities. In 2003, an agreement between China and Thailand for trade liberalization in the vegetables/fruits sector was signed. This agreement has enhanced the optimization of the resources of both sides (Zhang & Tao, 2005). While Thailand's advantage lies longans and other tropical fruits, China's lies in temperate fruits such as apples and pears. Although there are still some issues that need to be modified in this agreement, it has promoted the fruits trade between these two countries. In 2004, China signed non-tariffs agreements for fruits/vegetables with 5 other countries including Singapore, Malaysia, Indonesia, Philippines and Brunei; and in 2005, the cooperation expanded to more ASEAN countries. These agreements have facilitated the fresh fruit trade.

Targeted products

It may be useful to focus on a few products/markets in the initial phase. The product categories may be diversified on the basis of one or more of the following parameters:

- Country's production advantage (in aggregate terms or for specific varieties). In fact, production strategy should shift to demand driven rather than supply driven;
- Current and likely trade volumes in the category, based on underlying demand trends;
- Potential for differentiation;
- Comparative cost advantage.

Improvement of market access

Two key steps for improving market access of fruits in overseas market is to institutionalize the market intelligence network for exporters, harmonize with international standards and develop associated infrastructure for certification and testing.

Market intelligence

In order to focus on some key products and markets it is critical to develop a strong database to enable current and potential exporters to make rational decisions. The key information needed by exporters includes:

- Major importing markets;
- Country's competitiveness compared to key competitor;
- Existing tariff structure and non-tariff barriers, and likely changes in the context of WTO requirements;
- Current status of quality standards and food regulations in target markets for imports of defined products.

Harmonization with international standards/practices, certification and testing

One of the major challenges for any country following the dismantling of quantitative restrictions on imports is to raise the level of quality standards to become globally competitive. There are variations in standards and regulations adopted by different importing countries which may lead to trade conflicts and disputes. The specific steps in this direction are:

- Substitute post arrival testing of products in the importing country with pre-shipment inspection reports by recognized international agencies;
- Encourage importing countries (the United States, EU, Japan) to set up offices in the exporting country for certification of export consignments;
- Encourage national food testing laboratories to obtain accreditation from international agencies though high cost of international accreditation and laboratory incentives by partly funding these costs;
- Introduce certification zoning systems like pesticide free zones, organic production zones, and disease free zones to facilitate high value exports from exporting countries;
- Promote certification of organic farming for different crops.

Supply chain alignment with international requirements

The supply chain needs to be aligned with the requirements of importing countries which require control and monitoring of quality standards of the raw materials and processed products. The specific action steps to facilitate this include:

- Enable direct farmer-importer linkages;
- Set up independent world class food testing and inspection infrastructures, particularly in clusters with a large presence of exporters;
- Devise an alternate system of processing grade products specifications based on internationally accepted norms, de-linked from fair average quality of table grade products;

- Encourage investment in infrastructure to improve product quality;
- Support the private sector initiatives for investing in specialized transport infrastructure such as refrigerated vans.

Integration of government schemes

The Governments, through various ministries and allied agencies, offer support to exporters through various schemes to partially finance specific investment requirements. It is essential to align the various offerings of the Government to avoid duplicating efforts by exporters trying to meet the requirements.

The issues of market access, supply chain and Governmental policies have been found to be connected in both time and space coordinates. As a result, there is a growing realization that a comprehensive solution to these issues could be envisioned. As a matter of fact, the conceptualization of modern terminal markets stems from this realization. National and State Governments need to conceptualize the creation of such terminal markets

Modern Terminal Markets have been conceptualized with the objective of fulfilling the above goals. The United States of America House Committee on Agriculture (Anonymous, 2006b) defined terminal market as a central site, often in a metropolitan area, that serves as an assembly and trading place for agricultural commodities. Terminal markets are usually at or near major transportation hubs. Here produce is either finally disposed off to the consumers or processors, or assembled for export.

Terminal Markets (TM) would endeavor to integrate farm production with buyers by offering multiple choices to farmers for sale of produce such as electronic auctioning and facility for direct sale to exporters, processor and retail chain network under a single roof (Anonymous, 2006a). In addition, the market would provide storage infrastructure thus offering the choice to trade at a future date to the participants. It is envisaged to offer a one-stop-solution that provides logistic support, including transport services, cool chain support and facility for storage (including warehouse, cold storage, ripening chamber, storage shed), facility for cleaning, grading, sorting, packaging and palletisation of produce, and extension support to advise farmers. Each of these services would be provided in lieu of a user charge. The TM would be built, owned and operated by a Corporate/ Private/ Co-operative entity (hereinafter called as Private Enterprise) either by itself or through adoption of an outsourcing model. The enterprise could be a consortium of entrepreneurs from agri-business, cold chain, logistics, warehousing, agri-infrastructure and related background.

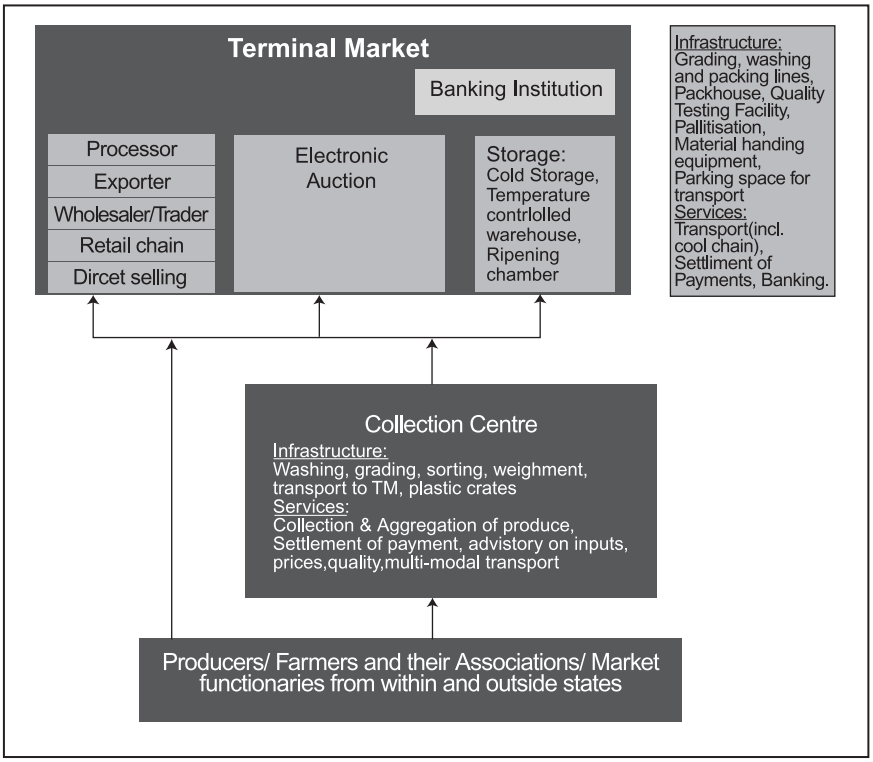
Implementation and successful operation of this initiative would necessitate State Government support. Thus, the creation of a conducive regulatory and legal framework for entry and operation of the project and provision of a level playing field to the private enterprise would be integral to the realization of this vision. The National Government will need to support the initiative by financing the project.

Terminal market (TM) operation

It is envisioned (Anonymous, 2006a) that a TM would operate on a Hub-and-Spoke Format wherein the Terminal Market (the hub) would be linked to a number of Collection Centers (the spokes). The spokes would be conveniently located at key production centers to allow easy farmer access. The catchment area of each spoke would be based on meeting the needs of farmers, operational efficiency and effective capital utilization of the investment. The commodities to be covered by the markets include fruits, vegetables, flowers, aromatics, herbs, meat and poultry. Producers, farmers and their associations and other market functionaries from any part of the country may use the infrastructures and facilities of the TM directly or through the collection centers. The TM can source the commodities from the entire State where the project is located and may extend its operations to the whole country, depending on the commodities handled there.

The infrastructure and services that are to be provided to farmers, traders, consumers and other stakeholders at the TM and the Collection Centers (CCs) are presented in Figure 5.1 below. The infrastructure and services to be provided by the TM and CCs should be in conformity with recognized national/ international standards and can also be outsourced.

Figure 5.1. Structure of a typical terminal market



Source: Anonymous (2006 a).

Role of the national government

The national government may support the project through participation in its equity capital through venture capital fund. The terms for participation would be as follows:

- National government would provide equity assistance;
- State participating in equity capital will retain option to allocate on redemption, its equity in favor of farmers organizations feeding business to the market complex;
- National government would assist the state governments in fixation of throughput per day and yearly handling capacity of the terminal market complex.

Role of the state government

The state government would play a pro-active role and constitute a committee for terminal market complexes. The responsibility of the committee would include:

- Approval of the number and location of the terminal market complexes;
- Approval of the bidding process and implementation modalities of the project;
- Technical appraisal and approval of the detailed project report (DPR) of the complex;
- Regulatory clearances, issue of licenses and granting of permission for facilitating establishment and operation of market complexes and the collection centers;
- Identification of land and, if necessary, provision of government land for TM and CCs;
- Convergence with other development programs for infrastructure support to TM and CCs such as road connectivity, power and water supply;
- Participation on the equity of the project either through direct funding, land/ infrastructure support and/ or transfer of existing market assets;
- Selection of the private enterprise through an open, transparent competitive bidding process;
- Make recommendations to central agencies for the release of central equity and for its redemption and allocation to farmers' associations doing business with the TM complex;
- Set up institutional mechanism for resolution of disputes, if any, arising out of the implementation of the terminal market complex.

5.2 Role of research institutions

Research institutions have the essential responsibility to acquire, develop and invent appropriate knowledge and systems to help the society function efficiently. In the case of the exports of fruits, research institutions need to find solutions to the export related issues such as extending the shelf life of the fruits, maintaining quality of the produce, storage & packaging systems, transport and handling equipment in a way that all

stakeholders along the fruit value chain are benefited. Research institutions have to keep functional linkages with all stake-holders to ensure that their constraints are addressed adequately in a timely manner. The mission of such research institutions may be summarized as follows:

- Maintain an up-to-date global perspective of the innovations, consumer demands, trade and policies;
- Act as a think tank for developing future scenarios in terms of the societal structure and its requirements;
- Undertake appropriate R&D activities in consultation with the stake holders;
- Maintain expertise, research infrastructure and relevance to be able to meet the contemporary and future challenges;
- Maintain and nurture enabling environment for stake holder interactions, knowledge dissemination and sustainability.

5.3 Role of the private sector

The private sector needs to take the initiative to create and efficiently manage the infra-structure required for the trade. The government and research institutions find the workable solutions and these solutions in turn are multiplied to meet the overall requirements. The huge investments required in creating such infrastructure may not be available from the governments. The Private Enterprise would have the following rights and obligations in relation to the establishment and operation of efficient marketing systems:

- The enterprise would have to provide the infrastructure facilities and services as stated in Figure 5.1 at the TM and CCs complex in the 'Hub-and-Spoke' Format;
- The TM (the hub) would be linked to a number of CCs (the spokes). The CCs would be located at key production centers to establish backward linkage with growers and to allow easy access to farmers for the marketing of their produce;
- The enterprise would have the option to provide additional facilities to render complimentary services such as input supply, processing, agro machinery and equipments, and durables;
- The enterprise would have the option to deal with non-perishable commodities at the terminal market complex in order to attain volumes and economic viability of the project;
- The enterprise would have the freedom to buy the commodities from the farmer directly or through the TM/ CCs;
- The enterprise would facilitate the farmers in making a direct supply to processing units, retail chain and exports, at their choice;
- The enterprise would provide advisory services to farmers on inputs, prices, quality, multi-model transport and exports;

- Farmers would be free to sell their produce either through the TM/ CCs or the TM directly or to any other marketing channel not related with the project;
- The enterprise would promote Farmers' Associations and progressively involve them in the operation and management of the CCs;
- The enterprise would be responsible for the acquisition of land for setting up of the TM and the CCs and obtain necessary licenses, clearances and approvals for the establishment and operation of the market;
- The enterprise would be free to collect user charges (determined by commercial considerations) from market participants and producers, for the infrastructure and services provided by it. The charges for providing the basic services of aggregation at collection centers and auction at the Terminal Market should, however, not exceed a reasonable limit, say 2% of the value of the produce;
- The Private Enterprise would be free to collect taxes, duties and fees (including market fees) from the market users.

5.4 Role of cooperatives and farmers' organizations

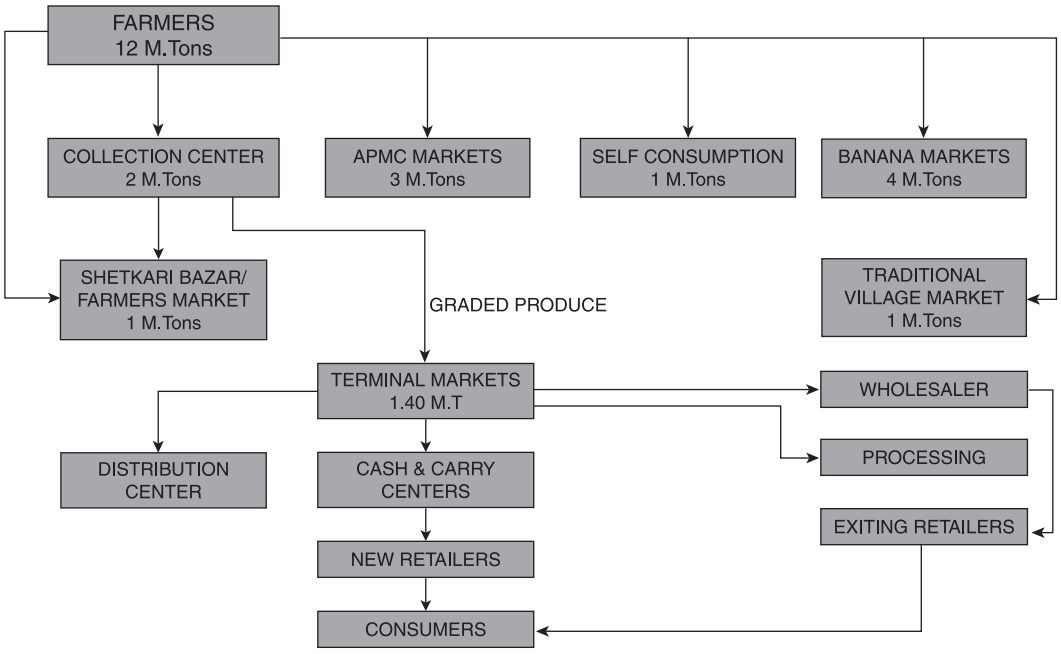
The farmer organizations will help the individual farmers to improve the quality and reduce the product cost. Package and postharvest treatment in production catchments are the bottleneck for the fruit export. China's fruits growers are generally small with about one acre for a family. Currently the government is considering how to organize them and use the same protocol to produce fruits. In the past few years, the farmer organization that unites separate farmers together like a board to unify the culture practices and the market issue has increased, and is also promoted by the governments. This work will benefit the improvement of quality and reduce the cost. There is an increasing trend that this kind of organization coordinates technique training, and cooperatively invests packinghouse. They invite professors to give lectures, establish websites and send messages with mobile phones, and publish newsletters. In south part of Jiangxi, Fujian and Zhejiang, this kind of organization is replacing the traditional extension system, and has played an important role in transferring technology.

5.5 Case 1: Mumbai's terminal market for fruits and vegetables

It is designed to cater to around 30% fruits and vegetable needs of Mumbai city (Anonymous, 2006c). The terminal market project proposes backward integration (all the way to farmers and production centers) and forward integration (all the way to distribution centers and retail outlets). Key features include modern postharvest management and marketing infrastructure, including cold chain, processing unit, electronic auction center and marketing

facility (Figure 5.2). The total cost of the project is estimated at Rs. 250 crores (US$ 55 million). Of this the State's contribution will be limited to providing the required land with remaining funds expected to come from private entrepreneurs and farmer's cooperatives. The following are the essential components of theterminal market.

Figure 5.2. Flow diagram of Mumbai terminal market



Source: Anonymous (2006 a).

Auction facility

The primary source of supply of produce to the terminal market will be collection centers owned and professionally managed by the farmers associations. Graded produce is auctioned at a single time with all buyers competing for lots of each grade. The terminal market would be professionally managed, self-financed with income generated by service charges levied on growers/ buyers and rentals/ fees for use of facilities. Volume and price information will be rapidly and widely disseminated backward to the farmers' associations, as well as forwarded to retailers and consumers. Key facilities include: auction hall, traders shops, distribution halls, cash & carry counter, administration and support buildings.

Cold storage

A commercial cold storage with 10,000 MT capacity for a variety of fruits and vegetables (i.e., a multi chamber/multi product storage facility) was set up within the Terminal Market for use by the traders, the management/ the operating company and other interested

parties. Attached to the cold storage would be a facility to handle, grade and pack fruits and vegetables.

Processing unit

The terminal market would also have a processing unit to handle 50,000 MT of fruits and vegetables annually. Available rejects and low grade fruits and vegetables not considered suitable for fresh sale, and quality material that is available at competitive rates during peak harvest season is processed. The processing unit would be flexible enough to process a variety of produce. Transportation for logistic support systems, in terms of refrigerated trucks/insulated trucks or other means would be made available for efficient and speedy delivery in and out of the market as required.

Volumes

The terminal market would handle around 350,000-700,000 MT annually of pre-sorted, graded, quality horticultural produce from a number of collection centers spread across key production areas.

Backward and Forward Linkages

The terminal market is planned with both backward linkages, for supply of produce, and forward linkages for marketing. The key backward linkage includes collection centers and the key forward linkage includes the wholesalers distribution centers, cash and carry counters and retail store network. The backward and forward linkages would be owned and operated jointly by private entrepreneurs, farmers' associations, farmer co-operatives or private individuals.

Infrastructure at collection centers would be set up by farmers/ producers from respective areas, with or without financial involvement from traders, management of terminal market and the government. Similarly, cash and carry counter, distribution center and retail stores will be set up by private entrepreneurs and or farmers associations or the public sector. All sorted, graded and packed, quality horticulture produce received at the terminal market, would be available for sale mainly in the domestic market, with a small portion of high quality produce sourced and exported by trader-exporters.

Government support

Besides providing required land for the terminal market, as its equity contribution, the government may also provide additional equity and act as a facilitator. The government will bring about necessary changes in existing agricultural produce marketing rules and regulations, with the exemption of levy or cess of the proposed terminal market from local laws and regulations.

Benefits

With no service charges, fewer intermediates, less handling, better and modern infrastructure for handling and processing of perishable horticultural produce, the Terminal Market will ensure better produce quality, better storability and efficient marketing thus benefiting farmers and consumers. The farmers can expect better price realization for their produce through value addition, significant reductions in spoilage, reduced quality losses and processing activities. In addition the terminal market will act as a competition and extract better service and efficiency from traditional markets which will contribute to the overall improvement in marketing activities in the State.

5.6 Case 2: Japan's wholesale sector being modernized

The Japanese wholesale market is being modernized to make way for new technology, as well as a new reality, such as increased supply from overseas sources. Wholesale products are gathered in terminal markets, which totaled 86 central markets and 1,351 local markets in 2002. Wholesalers operating in these markets sell to retailers and intermediate wholesalers, the latter by auction. The Wholesale Market Law was amended in June 2004 to revitalize the wholesale sector through measures such as allowing third-party and direct sales. In third-party sales, wholesalers sell goods directly to retailers without the involvement of intermediate wholesalers. Under the direct procurement system, intermediate wholesalers can purchase perishable goods directly from producers without the involvement of wholesalers, thereby saving time while preserving product quality.

It is also possible to carry out sales through auction, bidding or separately between the seller and individual buyers. These types of transactions are only permitted, however, up to a certain limit, namely, a percentage of the quantity expected to be handled by a market. The local government overseeing the market makes such determinations, generally on a product-by-product basis.

Under the reforms, conventional market functions have generally been preserved to ensure the stability of supplies and prices. However, the revised law has paved the way for electronic wholesaling of certain kinds of items, such as relatively standardized products that do not necessarily need to be brought to market. This is in contrast to the past when the law required the physical presence of goods to be sold.

Another change is the deregulation of wholesale commissions, which will take place in April 2009. For example, producers traditionally pay wholesalers a fixed percentage of sales to intermediate wholesalers. Nationally unified commissions vary by category, such as 8.5% for vegetables, 7.0% for fruit, 5.5% for fisheries products, 9.5% for flowering plants

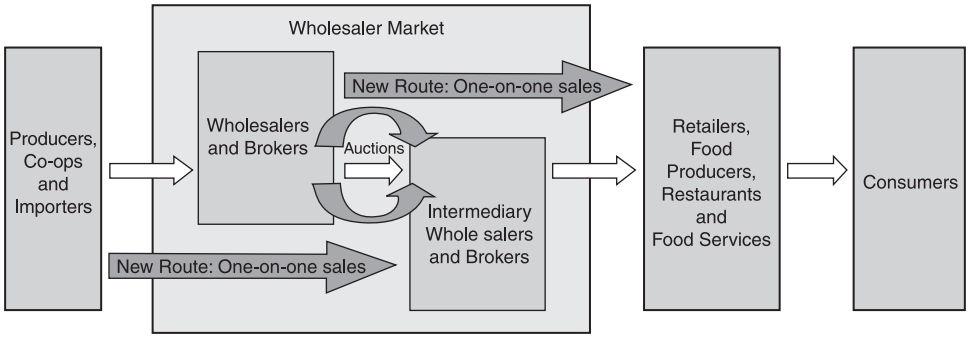
and 3.5% for meat excluding chicken. This system will be lifted to allow commission rates to be set in accordance with the specific functions and services of wholesalers in particular fields. Intermediate wholesalers will continue to be able to sell purchased products at discretionary prices.

The dividing line between wholesalers and intermediate wholesalers will effectively vanish once third-party sales and direct procurement become common practice and commissions are liberalized. This will inevitably intensify competition. Companies that are not on solid footing may be driven out of business, causing the industry will further get reorganized.

Deregulation of the wholesale sector

As indicated above, the reforms will eventually lead to the deregulation of the wholesale sector and the producers and consumers will have minimum connecting links. Figure 5.3 below shows the new pathways as against the conventional marketing channels.

Figure 5.3. Conventional and new path ways in Japanese marketing system



Source: Anonymous (2006 c).

Linking producers and consumers

Distribution in Japan involves more layers than in Europe or the United States. This is particularly noticeable in the fisheries sector, where wholesale markets play a major role in the distribution process. The amendment to the Wholesale Market Law will stimulate competition and reform among primary and intermediate wholesalers without inhibiting the crucial function of the free-market auction. It will also streamline the circulation of domestic and imported fresh foods. Moreover, it will enable consumers and producers to make direct contact, which should facilitate the development of products that are closely aligned with consumer tastes and demands.

6. CONCLUSIONS AND RECOMMENDATIONS

Export markets offer plenty of opportunities for Asian fruits. It must, however, be kept in mind that these are competitive markets with requirements of high product safety and quality. The current consumer preference for a healthy lifestyle should lead to a continued growth in fruit consumption and its trade worldwide. The growth in sustainable and fair trade products is an opportunity that could be further harnessed. The real challenge is to build up partnerships with importing companies to innovate and create value-added products and concepts: convenient, easy-to-use products. To be distinctive, other attributes such as sustainability, efficiency, pricing, flexibility, diversity, consistency, marketing and branding are also important. The key to success will, however, be driven by the capacity to establish seamless partnerships that serve customers.

In setting up an efficient and robust supply chain, the application of the latest technology, knowledge and protocols in postharvest are important. Long-term storage, packaging concepts, cold chain management, rapid and accurate on-line quality assessment and controlled ripening are some of the relevant researchable issues. Simulation tools using quality decay models and knowledge management systems are powerful exploration and scenario analysis tools. An integral supply chain management approach is essential to develop robust solutions.

Certification systems and the use of protocols are important for operational management of the production and supply chain. New certification systems are being developed, such as Quality Analysis of Critical Control points (QACCP), to ensure quality throughout the entire chain. Entrepreneurship and finding a business strategy are crucial aspects in being successful in setting up an export chain. Selecting the right partners in the chain and building up a network of relevant stakeholders are important factors as well.

On the basis of the presentations and deliberations during the International Seminar, the following general conclusions emerged.

- All stakeholders in the fruit production to consumption value chain must be duly benefited for sustainable growth in this sector. While producers need to produce what consumers want, the producers must have their due share in the benefits of value addition and exports. Likewise, all other stakeholders must have their due share of added value and earnings;
- Fruit producers need to be enabled, empowered and incentivised for cost competitive production of high quality fruits and make them available for trade or further value addition with minimum losses;
- Basic and continuing training of fruit growers about Good Agricultural Practices

(GAP), postharvest management and marketing will go a long way in enhancing the competitiveness on a sustainable basis;

- Infrastructure for storage, transport, communication and power needs to be created to facilitate the production and maintenance of quality material in the production catchments and throughout the supply chain;
- Networks of accredited food safety and quality testing laboratories need to be created, and the value chain stakeholders need to be encouraged to use the network of testing facilities to monitor and ensure food safety and quality throughout the value chain;
- Food quality and safety standards need to be harmonized at different levels to avoid confusion and logistics for compliance with the standards needs to be worked out;
- Appropriate technological packages for all stakeholders in the value chain need to be made available;
- Fruit producers need to cooperate among themselves in their activities to achieve economic scales of operation. Mechanisms for such cooperations need to be put in place with transparency, equity and amicable dispute resolution.

The following recommendations are intended for National Governments.

- Promote knowledge empowerment of fruits producers and others in the supply chain requiring adequate infrastructure and qualified human resources;
- Support a responsive research and development infrastructure to provide technological upgrade for sustainable and growth of export market share;
- Integrate all schemes offered for export promotion through various Ministries and allied agencies;
- Strengthen food processing infrastructure in identified Agri-Export Zones;
- Encourage food testing laboratories to get accreditation from national/ international agencies;
- Set up independent world class food testing and inspection infrastructure, particularly in clusters with significant presence of exporters;
- Promote aggregation of exports to meet the minimum order requirement of importers;
- Develop a strong market intelligence system to aid exporters to take rational decisions;
- Introduce certification zoning systems like pesticide free zones, organic production zones, disease free zones to facilitate high value;
- Promote certification of organic farming for different crops;
- Undertake marketing reforms and setup appropriate infrastructure such as collection centres, storage structures and terminal markets in tune with the globally compatible technologies and policies so as to minimize the losses in the value chain and to benefit the stakeholders.

The following recommendations relate to specific areas of collaboration among National Governments.

- Build global brands in collaboration with other national Governments or regional trading blocks;
- Enter into complementary collaboration in food quality and safety issues between countries in the Asia and Pacific region;
- Stengthen collaboration with infrastructure and human resource development for sustainable agricultural progress in the region;
- Establish grade standards to identify quality of agricultural products;
- Strengthen the cooperation related to sharing of market intelligence and risk analysis;
- Promote common food market in the region where intra- and inter-regional trade could take place. This arrangement could be on the lines of EU market with common facilities and regulations.

The following recommendations relate to the role that APCAEM might play in catalyzing the enhancement of export of Asian fruits.

- Assist the member countries in capacity building and catalyzing the policy framework;
- Facilitate research and development cooperation through APCAEM network, based on mutual interests and sponsored by potential donor countries;
- Provide a pro-active role in regional agricultural reforms;
- Facilitate the development of certification system for standard export quality and food safety in each APCAEM member country, supported by the state-of-the art laboratory;
- Launch a website concerning updated market information and consumer preferences facilitate networking of fruit growers and exporters among APCAEM member countries.

ANNEX

Brief Descriptions of the Major Asian Fruits

Brief Descriptions of the Major Asian Fruits

Brief descriptions of the important Asian fruits are being included in the annex just to provide the reader a flavor of these unique creations of Mother Nature. Indigenous tropical fruit species and their geographical distribution of these fruits are also summarized in the annex for a quick reference.

Banana

The word “banana” is a generic term covering a number of species or hybrids in the genus Musa of the family Musaceae. Different cultures have religious and medical attributes to banana tree and fruits. Edible banana was originated in the Indo-Malaysian region extending to northern Australia. The ovaries contained in the first (female) flowers grow rapidly, developing parthenocarpically (without pollination) into clusters of fruits, called hands. The number of hands varies with the species and variety. The fruit (technically a berry) turns from deep green to yellow or red, and may range from 6 cm to 30 cm in length and 2 cm to 5 cm in width. The flesh, ivory-white to yellow or salmon-yellow, may be firm, astringent, even gummy with latex when unripe; turning tender and slippery, or soft and mellow or rather dry and mealy or starchy when ripe. The flavor may be mild and sweet or sub-acid with a distinct apple tone. The common cultivated types are generally seedless with just vestiges of ovules visible as brown specks. Occasionally, cross-pollination with wild types will result in a number of seeds in a normally seedless variety.

Durian

The family Bombacaceae is best known for showy flowers and woody or thin-shelled pods filled with small seeds and silky or cotton-like fiber. The durian, Durio zibethinus L., is one member that differs radically in having large seeds surrounded by fleshy arils. The durian is believed to be native to Borneo and Sumatra. It is found wild or semi-wild in South Tenasserim, Lower Burma, and around villages in peninsular Malaya, and is commonly cultivated along roads or in orchards from southeastern India and Ceylon to New Guinea.

Durian is the most important native fruit of southeastern Asia and neighboring islands. Botanically speaking, the durian fruit is actually a capsule, and the edible sections are technically called arils. The fruits are ovoid or ovoid-oblong to nearly round, 15 to 30 cm long, 12-15 cm wide, and up to 8 kg in weight. The yellow or yellowish-green

rind is thick, tough, semi-woody, and densely set with stout, sharply pointed spines, 3- to 7-sided at the base. Handling without gloves can be painful. Inside there are 5 compartments containing the creamy-white, yellowish, pinkish or orange-colored flesh and 1 to 7 chestnut-like seeds, 2-6 cm long with glossy, red-brown seed coat. Most seeds inside the durian are abortive.

Guava

Guava, Psidium guajava L., of the myrtle family (Myrtaceae), is almost universally known by its common English name or its equivalent in other languages. In Malaysia, it is generally known either as guava or jambu batu, but has also numerous dialectal names. Its place of origin is uncertain, but it is believed to be an area extending from southern Mexico into or through Central America. It is common throughout all warm areas of tropical America and in the West Indies, the Bahamas, Bermuda and southern Florida. Early Spanish and Portuguese colonizers were quick to carry it from the New World to the East Indies and Guam. It was soon adopted as a crop in Asia and in warmer parts of Africa.

The fruit is round, ovoid or pear- shaped berry, 5 cm or more in diameter and 4 - 12cm long. It has a thin greenish-yellow skin and a flesh of varying thickness which may be white, yellow-pink or red. The outer layer of flesh is a finely granular pulp; the inside is softer pulp with many small hard seeds. Some varieties are seedless. The flavor is variable and is distinguished by a characteristic and penetrating musky aroma of varying intensity. The flesh may be white, pink, yellow, or red. The quality of the fruit of guavas grown in cooler areas is often not as good as those grown in warmer areas.

Jackfruit

Jackfruit, Artocarpus heterophyllus Lam of the family Moraceae, is also called jak-fruit, jak, jaca, and, in Malaysia and the Philippines, nangka; in Thailand, khanun; in Cambodia, khnor; in Laos, mak mi or may mi; in Viet Nam, mit. It is an excellent example of a fruit prized in some areas of the world and allowed to go to waste in others.

Jackfruit is believed to be indigenous to the rain forests of the Western Ghats of India. It spread early on to other parts of India, southeast Asia, the East Indies and ultimately the Philippines. It is often planted in central and eastern Africa and is fairly popular in Brazil and Surinam. Jackfruit is the largest tree-borne fruit in the world, reaching 40 kg in weight and up to 90 cm long and 50 cm in diameter. The exterior of the compound fruit is green or yellow when ripe. The interior consists of large edible bulbs of yellow, banana-flavored flesh that encloses a smooth, oval,

light-brown seed. The seed is 2-3.5 cm long and 1-2 cm thick and is white and crisp within. There may be 100 or up to 500 seeds in a single fruit, which are viable for no more than three or four days. When fully ripe, the unopened jackfruit emits a strong disagreeable odor, resembling that of decayed onions, while the pulp of the opened fruit smells of pineapple and banana.

There are two main varieties. In one, the fruits have small, fibrous, soft, mushy, but very sweet carpels with a texture somewhat akin to a raw oyster. The other variety is crisp and almost crunchy though not quite as sweet. The latter variety is the more important commercially and is more palatable to western tastes.

Jujube

Jujube or the Chinese date thrives best in warm, dry climates; it can also withstand the winter temperatures down to -30°C. The jujube originated in China where they have been cultivated for more than 4,000 years and where there are over 400 cultivars. The plants traveled beyond Asia centuries ago and today are grown to some extent in Russia, northern Africa, southern Europe, the Middle East and the southwestern United States.

The fruit is generally dark brown when ripe, oval to pyriform in shape, 2.5-5.0 cm in diameter, with a single stone. It will dry if left on the tree, similar to figs. The skin is smooth and thin until the drying of the fruit occurs, then it becomes wrinkled. The pulp is dryer than in most fruits. The immature fruit is green in color, but as it ripens as goes through a yellow-green stage with mahogany-colored spots appearing on the skin, as the fruit ripens further. The fully mature fruit is entirely red. Shortly after becoming fully red, the fruit begins to soften and wrinkle. The fruit can be eaten after it becomes wrinkled, but most people prefer them during the interval between the yellow-green stage and the full red stage. At this stage the flesh is crisp and sweet, akin to an apple. Under dry conditions jujubes lose moisture, shrivel and become spongy inside. Tests in Russia indicate that the fruit has a high vitamin C content. The fruit has been used for medicine purpose for millennia by many cultures. One of the fruit’s most popular uses is to process it as a tea for sore throat treatment.

Longan

Closely allied to the glamorous lychee, in the family Sapindaceae, the longan, or lungan, also known as dragon's eye, and as mamoncillo chino in Cuba, has been referred to as the "little brother of the lychee", or li-chihnu, "slave of the lychee". Botanically, it is placed in a separate genus, and is currently designated Dimocarpus longan Lour. The longan is native to southern China, in the provinces of Guangdong, Guangxi, Sichuan and Fujian, between elevations of 150-450 m. It is commonly

grown in Thailand, Cambodia, Laos and Viet Nam and in the Taiwan Province of China. The tree grows but does not fruit in Malaysia and the Philippines.

Longan is less important to the Chinese as an edible fruit, but more widely used in oriental medicine. The drupaceous fruits are spherical to ovoid, 22-36 mm in diameter and 6-19 g in weight. The peel is tan or light brown, thin, leathery and smoother than that of the lychee. The pulp is whitish and translucent; thin in large seeded fruits and medium thick to thick in others. Each fruit has 1 seed; globular and shiny, brown to dark brown. The pulp does not adhere to the seed and is flavorful and sweet with 12-21% soluble solids.

Lychee (Litchi)

The lychee is the most renowned group of edible fruits of the soapberry family, Sapindaceae. It is botanically designated Litchi Chinensis Sonn and widely known as litchi and regionally as lichi, lichee, laichi, leechee or lychee. The lychee is native to low elevations of the provinces of Guandong and Fujian in southern China. Cultivation spread over the years through neighboring areas of southeastern Asia and offshore islands.

Showy fruits, in loose, pendent clusters of 2 to 30 are usually strawberry-red, sometimes rose, pinkish or amber, and some types tinged with green. Most are aromatic, oval, heart-shaped or nearly round, about 2.5 cm wide and 4 cm long; have a thin, leathery, rough or minutely warty skin, flexible and easily peeled when fresh. Immediately beneath the skin of some varieties is a small amount of clear, delicious juice. The glossy, succulent, thick, translucent-white to grayish or pinkish fleshy aril which usually separates readily from the seed, suggests a large, luscious grape. The flavor of the flesh is subacid and distinctive.

Related to longans, lychees are sometimes on a dessert menu of Chinese restaurants. Once stripped of their nubbly reddish-brown shells, these lychees look like large white grapes, each with a single large, glossy seed within its pale flesh. They have a sweet, flowery fragrance and flavor. Lychees are rich in vitamin C: ten pieces of fruit supply more than 100% of the Daily Value.

Mango

The luscious mango, one of the most celebrated of tropical fruits, is a member of the Anacardiaceae family. The mango is the apple (or peach) of the tropics, and one of the most commonly eaten fruits in tropical countries around the world. Native to southern Asia, especially eastern India, Burma, and the Andaman Islands, the mango has been cultivated, praised and even revered in its homeland since Ancient times.

Buddhist monks are believed to have taken the mango on voyages to Malayasia and eastern Asia in the 4th and 5th centuries B.C.

There is a great variation in the form, size, color and quality of the fruit. They may be nearly round, oval, ovoid-oblong, or somewhat kidney-shaped, often with a break at the apex, and are usually more or less lop-sided. They range from 6.25-25 cm in length and from a few grams to 1.8-2.2 kg. The skin is leathery, waxy, smooth, fairly thick, aromatic and ranges from light-or dark-green to clear yellow, yellow-orange, yellow and reddish-pink, or more or less blushed with bright-or dark-red or purple-red, with fine yellow, greenish or reddish dots, and thin or thick whitish, gray or purplish bloom, when fully ripe. Some have a "turpentine" odor and flavor, while others are rich and pleasantly fragrant. The flesh ranges from pale-yellow to deep-orange. It is essentially peach-like but much more fibrous and extremely juicy, with a taste ranging from very sweet to sub-acid or tart.

Papaya

The papaya is a member of the small Caricaceae family, allied to the Passifloraceae. The papaya is believed to be native to southern Mexico and neighboring Central America. It is now present in every tropical and subtropical country.

There are two types of papayas, Hawaiian and Mexican. These pear-shaped fruit generally weigh about 1 pound and have yellow skin when ripe. The flesh is bright orange or pinkish, depending on variety, with small black seeds clustered in the center. Hawaiian papayas are easier to harvest because the fruit seldom grows taller than 2.5 m. Mexican papayas are much larger than the Hawaiian types and may weigh up to 4.5 kg and be more than 40 cm long. The flesh may be yellow, orange or pink. The flavor is less intense than that the Hawaiian papaya but it is still delicious and tasty. They are slightly easier to grow than Hawaiian papayas. A properly ripened papaya is juicy, sweetish and somewhat like a cantaloupe in flavor, although musky in some types. The fruit (and leaves) contain papain which helps digestion and is used to tenderize meat. The edible seeds have a spicy flavor somewhat reminiscent of black pepper.

Persimmon

Persimmons, Diospyros kaki, are a yellow to orange fruit (sometimes called the “Apple of the Orient”). The fruit can be eaten fresh or it can be dried, canned or crystallized. It is also used for making jams and dessert toppings. The oriental persimmon is native to China, where it has been cultivated for centuries and more than two thousand different cultivars exist. It spread to Republic of Korea and Japan many years ago where additional cultivars were developed.

There are two types of persimmons - the astringent varieties which tend to be the older ones and the newer non-astringent varieties. Astringent ones taste rather unpleasant, which makes your mouth pucker up; for these astringent types it was vital to harvest and eat the fruit at the right time. The development of the non-astringent varieties has been a real boon to the industry and, in recent years, it has developed into an exportable quality. A non astringent persimmon can be eaten when it is crisp as an apple. These cultivars need hot summers, and the fruit might retain some astringency when grown in cooler regions.

Pineapple

Pineapple, a member of the Bromeliaceae plant family, is believed to have originated in north-northwest South America. It was cultivated there, probably for thousands of years, by Amerindians, and essentially all cultivated types are virtually unchanged from the time they were first discovered by Spanish explorers. Commercial varieties are seedless and are usually propagated by suckers which develop near the base or terminal of the fruiting stalk. The fruit is composed of the thickened rachis or stalk, in which the numerous fleshy fruitlets, botanically berries, are imbedded. The fleshy, persistent bracts make the surface of the composite fruit much roughened and tough.

The fruit is a terminal, cylindrical, compound structure at the apex of the stem and is formed by the fusion of the berrylike fruitlets that develop from the flowers. At its apex, the fruit bears a compressed, leafy shoot called a crown. The typically yellow fruit flesh is best eaten when sweet and moderately acidic, it may contain from 10 to 18% sugar and from 0.5 to 1.6% titratable acidity. This fruit is large, weighing 1 - 3 kg or more.

Pomegranate

The pomegranate, belongs to the Punicaceae family. The pomegranate is a native fruit from Iran and the Himalayas in northern India and was cultivated and naturalized over the whole Mediterranean region since ancient times. It is widely cultivated throughout India and the drier parts of southeast Asia, Malaya, the East Indies and tropical Africa.

Nearly round, but crowned at the base by the prominent calyx, the fruit, 6.3-12.5 cm wide, has a tough, leathery skin or rind, basically yellow more or less overlaid with light or deep pink or rich red. The interior is separated by membranous walls and white spongy tissue (rag) into compartments packed with transparent sacs filled with tart, flavorful, fleshy, juicy, red, pink or whitish pulp (technically the aril). In each sac, there is one white or red, angular, soft or hard seed. The seeds represent about 52% of the weight of the whole fruit.

Rambutan

Though a close relative of the lychee and an equally desirable fruit, this member of the Sapindaceae family is not nearly as well-known. Botanically, it is Nephelium lappaceum L. and native to Malaysia and Indonesia. Rambutan is grown in Southeast Asia, Australia, South America, and Africa, but only exported from Malaysia and Thailand.

The fruit is ovoid, or ellipsoid, pinkish-red, bright-or deep-red, orange-red, maroon or dark-purple, yellowish-red, or all yellow or orange-yellow; 3.5-8 cm long. Its thin, leathery rind is covered with tubercles from each of which extends a soft, fleshy, red, pinkish, or yellow spine 0.5-2 cm long, the tips deciduous in some types. The somewhat hairlike covering is responsible for the common name of the fruit, which is based on the Malaysian word “rambut”, meaning “hair”. Inside the fruit the white or rose-tinted, translucent, juicy, acid, sub-acid or sweet flesh, 0.4-0.8 cm thick, adhering more or less to the ovoid or oblong, somewhat flattened seed, which is 2. 5-3.5 cm long and 1-1.5 cm wide. There may be 1 or 2 small undeveloped fruits nestled close to the stem of a mature fruit.

Sapodilla

The sapodilla, a member of the Sapotaceae family, is now known botanically as Manilkara zapota van Royen. The sapodilla is believed to be native to Yucatan and possibly other nearby parts of southern Mexico, as well as northern Belize and northeastern Guatemala. It was introduced long ago throughout tropical America and the West Indies and the southern part of the state of Florida.

The fruit may be nearly round, oblate, oval, ellipsoidal, or conical; varies from 5-10 cm in width. When immature, it is hard, gummy and very astringent. Though smooth-skinned, it is coated with a sandy brown scurf until fully ripe. The flesh ranges in color from yellowish to light- or dark-brown or sometimes reddish-brown; may be coarse and somewhat grainy or smooth; becomes soft and very juicy, with a sweet flavor resembling that of a pear. Some fruits are seedless, but normally there may be from 3 to 12 seeds which are easily removed as they are loosely held in a whorl of slots in the center of the fruit. Immature sapodillas are rich in tannin (proanthocyanadins) and very astringent. Ripening eliminates the tannin except for a low level remaining in the skin.

Starfruit (Carambola)

A fruit of the Oxalidaceae family is believed to have originated in Sri Lanka and the

Moluccas, but it has been cultivated in south-east Asia and Malaysia for many centuries. The showy, oblong, longitudinally 5- to 6-angled fruits, 6.5-15 cm long and up to 9 cm wide, have thin, waxy, orange-yellow skin and juicy, crisp, yellow flesh when fully ripe. Slices cut in cross-section have the form of a star. The fruit has a more or less pronounced oxalic acid odor and the flavor ranges from very sour to mildly sweetish. The so-called "sweet" types rarely contain more than 4% sugar. There may be up to 12 flat, thin, brown seeds 6-12 mm long or none at all.

Tamarind

Of all the fruit trees of the tropics, none is more widely distributed nor more appreciated as an ornamental than the tamarind of the family Leguminosae. Native to tropical Africa, the tree grows wild throughout Sudan and was so long ago introduced into and adopted in India that it has often been reported as indigenous there also, and it was apparently from this Asiatic country that it reached the Persians and the Arabs who called it “tamar hindi” (Indian date, from the date-like appearance of the dried pulp), giving rise to both its common and generic names.

The fruits, flattish, beanlike, irregularly curved and bulged pods, are borne in great abundance along the new branches and usually vary from 5-18 cm long and from 2-3 cm in diameter. Exceptionally large tamarinds have been found on individual trees. The pods may be cinnamon-brown or grayish-brown externally and, at first, are tender-skinned with green, highly acid flesh and soft, whitish, under-developed seeds. As they mature, the pods fill out somewhat and the juicy, acidulous pulp turns brown or reddish-brown. Thereafter, the skin becomes a brittle, easily-cracked shell and the pulp dehydrates naturally to a sticky paste enclosed by a few coarse strands of fiber extending lengthwise from the stalk.

Wax Jambu Apple

Native to the Malay and Southeast Asian region, it grows quite well in the subtropical climate. The waxy fruit, usually light-red, sometimes greenish-white or cream-colored, is pear-shaped, narrow at the base, very broad, flattened, indented and adorned with the 4 fleshy calyx lobes at the apex; 3.5-5 cm) long, 4.5-5.5 cm wide. The skin is very thin, flesh white, spongy, dry to juicy, sub-acid and very bland in flavor. There may be 1 or 2 somewhat rounded seeds, 0.5-0.8 cm wide or none.

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