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Technology Reducing Postharvest Losses and Maintaining Quality of Fruits and Vegetables (Philippines)

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Abstract

The Philippines is predominantly agriculture which covers 47% or 30 million hectares. However, the landholdings are small and non-contiguous. Fruits and vegetables grow well with the least inputs except when typhoons and drought hit the country. The bountiful harvest are wasted during the distribution process due to a number of reasons: use of inappropriate containers, poor road conditions, high temperatures, and rough handling. Postharvest losses could be up to 50%. While postharvest technologies are continuously being developed, transferred and adopted by the target sectors, the need for cooperation and coordination among the stakeholders is very critical. Information dissemination on the proper handling of fruits and vegetables through print and broadcast media must be sustained. Postharvest must be strengthened in the different schools as well as the extension manpower all over the country. The support for efficient postharvest facilities and infrastructures for perishable horticultural crops where the small producers would benefit should be prioritized. While the production areas are not increasing, the population is growing very rapidly. To ensure more food becoming available to consumers, a significant reduction in postharvest losses must be achieved.

Introduction

Fruits and vegetables play an important role in our nutrition as sources of vitamins, minerals, protein, and dietary fiber. The changing lifestyles and health conciousness of people is the driving force to demand for safe, quality, and organically grown fruits and vegetables.

The country is predominantly agriculture which covers 47% or 30 million hectares (Andales, 2000). Landholdings are small and non-contiguous. In general, farming is a family affair. Harvested produce are usually collected and combined by traders who transport and sell the produce to the wholesale and retail markets.

The country registered a 4.01 percent growth in Gross National Product (GNP) in 2009. Gross Domestic Product (GDP) expanded by 1.06 percent. Gross Value Added (GVA) in agriculture inched up by 0.03 percent and is 18% of the GDP in 2009. The country's total agricultural export earnings amounted to US$ 3,135.75 million in 2009. This was 19.37% lower than the 2008 record. Fresh banana is included as one of the top earners. On the other hand, agricultural import expenditures reached

US$ 6,079.80 million, 20.88% lower than 2008 (BAS,2010). The gross value of the crops subsector during first three months of 2010 grossed at 170.5 billion pesos.

The consumption of vegetables in the Philippines has remained low, 49 and 51 kg per capita in 1993 and 2003, respectively (Macabasco, 2008). However, changing patterns have been observed like increasing urban households, increasing purchases from supermarkets instead of the wet or traditional markets, and the availability of the fresh-cut fruits and vegetables in the markets. In a study funded by ACIAR in collaboration with UP Mindanao, the different institutional market segments for vegetables in Mindanao were identified: consumers are grouped according to their income. These include (1) the upper income consumers and foreign tourists; (2) upper income and some middle income consumers, budget tourists and conventional markets; (3) the wholesale consolidators which include the upscale institutional market, business market and wet market retailers; and (4) middle and lower income consumers. The lst group having the high income requires quality and food safety certificates. This group requires the widest range and sustainable supply of salad vegetables, temperate and tropical vegetables and herbs and spices. The 2nd group is more price conscious who requires mostly temperate and tropical vegetables. The 3rd group accounts for the largest volume of crops traded on wholesale market and has multiple sources of commodities. They have the capacity to import if their local supplier cannot deliver. The 4th group accounts for 75-80% of retail sales of fresh vegetables in the country. This group consumes mostly tropical fruits and vegetables and their quality requirement is not very strict (Concepcion, 2010).

The Philippines

The Philippines is in Southeastern Asia (longitude: 122°00 E and latitude: 13°00 N) and surrounded by the Philippine Sea, South China Sea and east of Vietnam. The northernmost group of islands in the Philippines is Batanes which is only 190 kilometers from Taiwan, while the southernmost island of Tawi-Tawi, is a mere 60 kilometers away from Borneo (Figure 1).

It is an archipelago with more than 7,100 islands. There are 3 main islands: Luzon, Visayas and Mindanao. Luzon and Visayas are frequented with typhoons while Mindanao is minimally affected. It has a total land area of 298,170 sq km with an estimated population of 97.9 million in 2009.

The country has a tropical rainfall climate characterized by high temperature and high relative atmospheric humidity. It has 2 seasons, the wet and dry. Another peculiarity of the country is the presence of typhoons with a yearly average of 20. Rainfall is from June to November. Lower temperatures (ave 20^{o}C) are during December to February.

It is endowed with fertile soils and tropical climate making it suitable for vegetable and fruit production. Varied horticultural crops are grown but only a few fruits are leading export winners (banana, mango, pineapple, papaya and citrus) to other countries like Japan, Korea, Singapore, Republic of China, and Hong Kong (Serrano, 2006). The vegetables which are considered high value include bitter gourd, asparagus, broccoli, cabbage, carrots, eggplant, garlic, ginger, gourd, habitchuelas,

lettuce, okra, onion, Chinese pechay, native pechay, stringbeans, tomato and white potato (Espino, 2010).

1. The fruit and vegetable industry situation in the Philippines

The production-postproduction-marketing system in the country is disjointed mainly due to the country's archipelagic nature. Huge losses and high costs are incurred because of the inherent nature of these horticultural produce, the tropical setting, lack of postharvest infrastructures and facilities, the way of handling and the multi-layered distribution system. The pattern of postharvest losses varies widely depending on the commodity, the distance of the source to the market, and the handling system practiced in the locality.

Figure 1. Map of the Philippines.

The Philippines, aside from being tropical is also the typhoon path in the Pacific. Challenges beset us not only the presence of natural calamities and its changing patterns (like the typhoon Ondoy in September 2009 which brought about 500 mm or 24 inches of rain water in 24 hours) but also of technical and non technical factors from production, post production and marketing of fresh horticultural crops.

The country is basically agriculture, majority are small producers whose landholdings range from 0.5 to 1 hectare. It is a hand-me-down activity for most producers with the tradition to grow what was grown by one's kins. The small producers need to be organized to have an efficient marketing and distribution system (Nuevo and Lizada, 1999).

Table 1 shows the production (metric tons, mt) of selected fruits and vegetables in the Philippines from 2007 – 2009. Banana (9,013,186 mt) topped the list followed by pineapple (2,198,497 mt) in fruits and eggplant (21,170 mt) production was highest followed by tomato (17,656 mt) in vegetables for the period of 3 years. In terms of area (hectares, ha) planted, banana (446,371 ha) consistently covered the largest area planted followed by mango (188.139 ha) (Table 2).

Table 3 shows the range of percentage of postharvest losses of different fruits (banana, calamansi, mango, and papaya) and vegetables (carrot, cabbage, eggplant, onion, and tomato), the causes of losses and the technology to minimize them. Postharvest losses are generally due to diseases, over ripening, mechanical damage and weight loss. These could occur during harvesting, and all along the handling route up to the consumers' level. In most cases, use of inappropriate packaging materials result in losses. This is aggravated by high transit temperature, rough roads and delays in distribution. Technologies to prevent losses are discussed in section IV.

Table 1. Production in (metric tons) of selected fruits and vegetables in the Philippines from 2007-2009. (Sources: Crop situations in the Philippines. BAS. 2003-2008; & Performance of Philippine Agriculture (Jan-June, 2010).

Commodity	2007	2008	2009
Banana	7,484,073	8,687,624	9,013,186
Calamansi	201, 619	199,675	192,187
Mango	1,023.907	884.011	771,441
Papaya	164.234	182,907	176,656
Pineapple	2,016.462	2,209,336	2,198,497
Cabbage	123,443	128,865	124,712
Eggplant	210,156	199,579	200,942
Onion	146,108	129.923	127.055
Tomato	65,024	68,366	198,948
Carrots	65,024	68,366	68,328

2. Production

Highland vegetables are grown on the terraces of mountain slopes of about 2,000 m above sea level. The heavy load of the produce are manually hauled from the farm to the roads via the rugged and steep terrains of the area. In some areas, the commodities are brought to the roadsides via animal -driven sleds. Another hauling style is securing two (2) baskets or sacks on the hind side of animals of horses or carabao. The produce are piled on the roadsides where traders could pick them up. Hauling containers are quite rough, oversized and mechanical damage easily set in.

Most fruits and vegetables grown by farmers are seasonal and highly dependent on rainfall. Lowland vegetable crops are usually planted after the rice season. Bagging is done in selected crops. Bitter gourds, mango and bananas are bagged. This protects them from insects and wind damage during its growth and development.

In some situations, the farmer cultivates and tends the vegetables with financing from a trader. The seeds and other inputs are provided by the trader and the harvested crops are delivered to the trader's wholesale market. On the other hand, immature fruits still on the tree are already bought while the trader keep watch over it until harvest and distribution to the market.

Table 2. Area planted (hectares) to selected fruits and vegetables in the Philippines from 2007-2009 (Sources: BAS, 2010 Commodity, 2007, 2008, 2009)

Commodity	2007	2008	2009
Banana	436,762	438,593	446,371
Calamansi	20,545	20,956	20,912
Mango	184,173	186,770	188,139
Papaya	9,125	9,175	8,904
pineapple	53,978	58,251	58,823
Cabbage	3,502	8,596	8,483
Eggplant	21,613	21,299	21,170
Onion	15,879	14,579	14,526
Tomato	17,544	17,646	17,656
Carrots	4,898	5,075	5,080

Table 3. Crops with percent losses, causes of losses, and technologies to minimize losses (Loss Assessment Report, 2009; Serrano, 2006).

Crop	% Loss	Cause of loss	Technology
Banana	3-30%	advanced ripening, weight loss, mechanical damage, disease and rotting	use of ethylene adsorbents, careful handling
Calamansi	5-32%	disease, oleocellosis, yellowing	curing, MAP (modified atm packaging)
Mango	2-33%	fruit drop cracking, disease, immaturity	HWT (hot water treatment), careful handling
Papaya	27-44%	disease, mechanical damage	wrapping of fruits, HWT (49–51℃ for 10 minutes)
Carrot	7- 12 %	crack/cut, soft rot/rot diseased, punctures, abrasion, cuts, forking, diseased, damaged top/leaves	use of plastic crates as packaging material; surface drying or air-drying of carrots after washing; use of refrigerated trucks for transport
Cabbage	29%	disease, mechanical damage	use of refrigerated truck; careful handling; passive cooling using block ice or evaporative coolers
Eggplant	10-40%	insect damage, shrivelling	careful handling
Tomato	11-38%	rotting, disease, weight loss	Use of MAP and ethylene adsorbents; careful handling; use of plastic crates
Onion	20-50%	disease, mechanical damage	curing; careful handling; use of cold ctorage

There are a few functioning agricultural cooperatives able to market their produce to Metro Manila and Metro Cebu. Leaders of these cooperatives try their best so the farmer members follow good agricultural practices (GAP) to be able to produce quality fruits and vegetables. The Department of Agriculture and the local government facilitate training of farmer leaders on GAP.

A shift to commercial enterprise in horticulture is now underway. A proliferation of protected farms for vegetables is increasing. The produce are distributed in high end markets like hotels, restaurants, fast food chains, and supermarkets. Leisure farms or agro-farms where vegetables are grown especially for city dwellers are becoming popular. Vegetable gardens are provided where people could plant or just harvest what they want to buy. Professionals who have retired from their 8 to 5 jobs have already ventured into agriculture of high value fruits and vegetables.

3. Postproduction

Handling practices start with *harvesting*; it may vary depending on the location. Simple harvesting tools are sometimes used but manual pulling is common in vegetables. Fruits like mango

from century old trees are harvested using picking pole. The fruits are not allowed to drop on the ground otherwise, these are rejected. Harvesting of banana is done by the 'cutter' who cuts the trunk and a 'backer' who carries the bunch on a pad on his back.

Harvested crops are usually placed in bamboo baskets or plastic sacks which do not protect the produce against mechanical injury. However, the use of plastic crates is now picking up. The harvested produce are *hauled* manually or placed on the hind sides of animals to the preparation area where the produce are sorted as good or rejects. There are noquality and size standards being strictly followed. During *sorting*, commodities are just placed on the ground with or without liners. However, some farms have packing areas with tables and benches where the produce are sorted. *Trimming* is another postharvest operation which adds value to carrots, calamansi, mango, onion bulbs. *Cleaning or washing* is done but not to all harvested produce. For commodities that need to be cleaned or washed, one issue is the frequency of changing the water especially if water is limited in the area. After cleaning, the produce are *packed* in wooden crates, bamboo baskets, polyethylene bags, plastic sacks and in some cases, plastic crates. Packaging materials used depend where the commodity originated. For example, bananas, from the southern part of the country particularly from Davao, are packed in wooden crates lined with banana bracts. This evolved because of the presence of the multi nationals into banana export. However, bananas from Agusan, a province also in Mindanao, are bulk loaded in 10-footer vans and loaded in ships. Bulk loaded bananas are provided with a wooden vertical divider, the original purpose of which is to delineate the produce of the different farmers in one van. However, the vertical divider aided in the dissipation of heat inside the van which is beneficia to the banana fruits.

Commodities are usually *transported* by ship from the southern part where crops are produced and marketed to the northern part where the major domestic market is situated. If there are no delays due to bad weather or technical ship problems, the transit time is about 36 hours. Delay in transport would lead to additonal handling cost, loss of volume and loss of potential profit (Bautista and Maunahan, 2007). When commodities in the metal van are loaded in passenger ships, the vans are placed below the boat where the engine is located. The temperature rises really high due to the engine heat and the heat of the commodities emitted in the process of respiration. Commodities are also shipped using cargo vessels which takes a shorter period of time (24 hrs). However, cargo vessels are more limited than passenger ships.

After the ship has docked, it will still take about 5-6 hours for the fruit van to be released. If fruits are bulk loaded, stripping takes another 16 hours. The bananas will then be transferred in trucks or oversized jeepneys and transported over land. However, the vehicle is always fully loaded and the handlers sit on top of the produce. The people sitting on the bulk loaded fruits add weight especially to the bottom fruits which results in compression damage.

4. Market

The supply chain of the produce is a multi layered system in the country. From the farm, fruits and vegetables are bought by (1) wholesalers from the urban wet market, (2) traders and consolidators, and (3) the processors. From the wholesalers, the produce are sold in the retail wet markets which will be bought by the consumers for their household. The wholesaler, trader, consolidators and processors supply the supermarkets, fast food chains hotels and restaurants. Consumers buy from retailers, supermarkets, and fast food chains (Figure 2).

Harvested crops are transported to the wholesale or retail markets in various kinds of vehicles. Trucks and jeepneys are used for long distance and a "tricycle" (motorcycle with side car) is used for short distancemarket. oading and unloading processes are still manually done where two to 4 bags of produce are carried at the back of the market handlers. In this manner, dropping of the packages is a common sight causing mechanical damage to the commodities. At the retail level, traders re-sort, rearrange, and repack into smaller lots of 5-10 kgs. n all of the traditional or wet markets, vegetables and fruits are displayed at ambient temperature, which is relatively hot (about 30℃). Thus, most fruits and vegetables could only be visually appealing for a day or two. However, in upermarkets where display shelves have temperatures ranging from 10 to 15℃ fruits and vegetables stay fresh for another 3-5 days.

At resent, the distribution system is quite inefficient ue to lack of functional ostharvest facilities, trading centers and packing houses, storage facilities for fresh, poor infrastructure and eak implementation of policies for agriculture. Lately, the government is establishing "Barangay Food Terminals" or village –level food terminals equipped with cold storage equipment for the storage of excess agricultural produce.

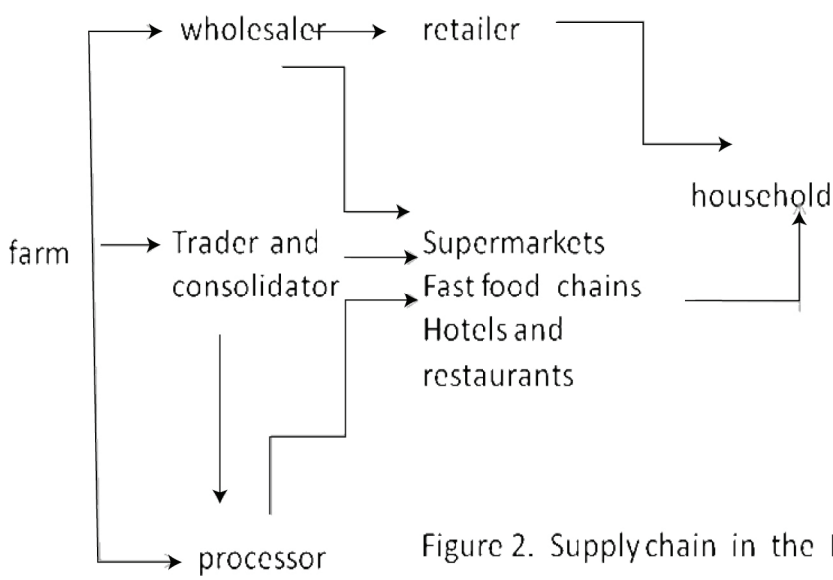

Figure 2. Supply chain in the Philippines

Postharvest Technologies on Rducing Pstharvest Lsses and Mintaining Qality of Fuits and Vgetables

The magnitude of losses could be traced during the pre- and postharvest chain of activities. Through the years, the following postharvest technologies have been developed and adopted by the industry.

1. Pre-harvest (Bagging of 'Cuarenta Dias' Banana)

This 'Cuarenta Dias' banana is grown by small farmers in the Cavite province and sold in bunches to local tourists. Bagging with polyethylene plastic bags as soon as the hands have emerged reduces the occurrence of unsightly scars caused by scarring weevil. Bagging also reduces wind scarring. The plastic wrap when not removed during transit serves also as protection to reduce bruises and latex stain. However, during summer months when temperature is high, bunches must first be wrapped with newsprint before covering with the polyethylene bag to prevent scalding.

2. Hauling (Tramline for mountainous areas)

Huge volume of vegetables especially the semi-temperate vegetables are grown in upland areas that are generally isolated from road networks because of ravines, rivers and dense vegetation. Hauling is generally done manually, or assisted by horses. The slow and long time needed to haul the produce to the nearest road usually result in higher postharvest losses due to bruising. Delayed hauling are experienced during peak harvest period due to lack of labor.

In minimizing the drudgery of manual hauling, the use of tramline system is being promoted by the government. The agricultural tramline system provides fast and reliable means of transportation for the harvested agricultural products and agricultural inputs to and from the mountainous production area to the nearest accessible road thus, reducing the hauling time and cost. It is a hauling facility using cables and pulleys to transport agricultural produce and inputs.

3. Maturity Determination (Flotation Method)

Harvesting the Philippine Carabao mango at the immature stage does not quarantee normal ripening and full aroma and flavor. It is also very susceptible to internal breakdown during high temperatures. A non destructive method of evaluating fruit maturity is dipping the harvested fruits in 1% salt solution. Mature fruits sink due to higher specific gravity while the immature ones float and easily sorted out. This method could be done in the farm as soon as harvesting is over.

4. Disease control (use of alum, hot water treatment [HWT] optimization)

Cabbage grown from the highlands is very susceptible to bacterial soft rot especially during the wet season and temperature is high. The use of alum proved to be very effective in preventing this.

Alum dissolved in warm water is applied by brushing, wiping or spraying to the trimmed butts. It penetrates host tissues and prevents the development of the disease even if the bacteria have set in.

In mango, anthracnose and stem end rot are the common postharvest diseases that cause significant losses. Symptoms appear when the fruit ripens. One effective way of controlling this is the use of hot water treatment at 52-55^{o}C for 10 minutes. In papaya, a lower dipping temperature was optimized. Through time, HWT tanks for disease control are now fabricated for commercial use.

5. Delay Ripening (MAP, wax emulsion for 'Queen' pineapple, ethylene adsorbent,)

MA packaging is an alternative method in extending postharvest life of some commodities (calamansi, tomato, banana). When the produce are placed inside the polyethylene bags, the respiration process slows down due to carbon dioxide accumulation and gradual reduction in the oxygen level. The other benefits include reduced moisture loss, delayed ripening, alleviation of chilling injury and increased shelf life.

Another kind of modified atmosphere in fruits and vegetables is the use of wax emulsion. The technology involves the application of a locally formulated wax emulsion on the fruit surface. This modifies internal fruit gases and subsequent reduction in respiration, extension of shelf life and external quality.

The development of ethylene adsorbent from indigenous waste materials was done as an alternative to imported ethylene adsorbents. Ethylene is a ripening hormone emitted by all commodities that stimulates ripening and deterioration. The role of the adsorbent is to remove the ethylene from the atmosphere surrounding the commodity, thereby retarding senescence and extending shelf life. This is effective when the commodities are in an enclosed condition. This has been done in bulk loaded bananas from Mindanao to Metro Manila.

6. Storage (low cost drip cooler for short term storage of vegetables, use of coconut coir dust)

A drip cooler made of wooden framing and walls made from an absorbing jute sack was fabricated. Evaporative cooling utilizes the cooling effect brought about by the evaporation of water from a wetted surface. The high humidity maintained inside the cooler minimizes moisture loss from the commodity. This technology was used for temporary storage of sweet corn before delivery to the supermarkets.

The use of moist coconut coir dust which is abundant in the country was adopted by farmers especially during peak periods and low market prices of tomato. Green mature and disease-free tomatoes buried in moist saw dust can be extended as long as 3 weeks, with minimal weight loss and full red color development.

7. Transport/Logistics

Generally, fruits and vegetables are transported using open/dry transport system. Transport capacities depends on the volume of produce to be transported and distance of travel ranging from small vehicles such as 'Jeepneys' to 10-wheeler trucks and container vans ranging from 10-footer to 20-footer container vans. Inter-island transport is facilitated using roll-on roll- off system. The produce are usually packed using polyethylene bags (PEB), bamboo or wooden crates piled on top of each other inside the vehicles or vans. Huge losses are observed during transport due to moisture loss, accelerated ripening, and other physical damage like bruising, abrasion and compression.

To address the huge losses during transport, the government introduced the cold chain system in the handling and transport of high value fruits and vegetables. The Cold Chain System is a series of inter-connected handling operations of horticultural produce from the farm to the market with focus on the maintenance of environmental conditions of the the appropriate temperature and humidity at very point (Fig. 3). The chain starts from the farm and ends at the retail market. The components include packinghouse, pre-coolers, refrigerated transport, cold storage and refrigerated product display facilities at the retail market. The use of clean plastic crates is critical under the cold chain system.

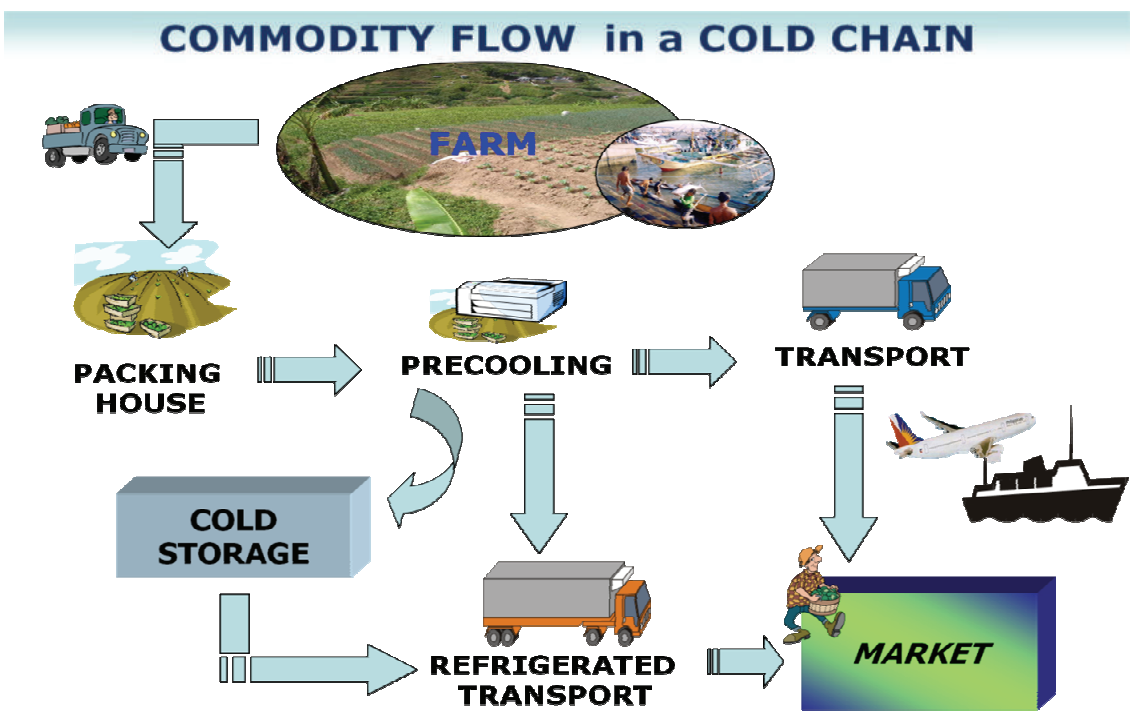

Figure 3. Commodity flow in a cold chain diagram.

Role of academe

Very few schools in the Philippines are teaching postharvest science courses. Compared with the other fields of study in the university, postharvest is a relatively new. Of the more than 200 agricultural schools and colleges of agriculture, less than 10% teach Postharvest Handling of Horticultural Crops as a subject (Bautista and Maunahan, 2007). While the postharvest unit of the university work in coordination with the local government units and the department of agriculture, there are still a lot of researches to be done. However, one drawback is the support for postharvest basic research.

Currently, the university offers postharvest as a major course in the Agriculture curriculum. Aside from the regular semester for agriculture students, a summer short course on postharvest handling is conducted. Attendees to this training include, government and non-government agricultural extension staff, people from the industry like supermarkets, exporters, and entrepreneurs. Invitations and arrangements are also done for the postharvest staff to go to the area and conduct postharvest awareness training workshops in the provinces. Information materials on the proper handling of horticultural crops are also developed and updated.

Role of government and policy makers

Way back in 1998, the Philippine government enacted the Republic Act 8435 Law, also known as the Agriculture and Fiisheries Modernization Act (AFMA) which provided the master plan for development and modernization of agriculture. The AFMA states that agriculture be modern, science and technology-based, more integrated in the national and international markets thus more efficient in terms of productivity. Provided in the AFMA are provisions to reducer postharvest losses in agricultural commodities through:

- Establishment and modernization of postharvest, transport/logistic facilties to ensure efficient flow of commodities, maintain quality and reduce food losses;
- Capacity and capability strengthening and enchancement of agencies such as the Bureau of Postharvest Research and Extension(BPRE) now Philippine Center for Postharvest Development and Mechanization (PHilMech), of the Department of Agriculture and academic institutions such as the Postharvest Horticulture Training and Researchg Center (PHTRC) of the University of the Philippines Los Banos, mandated to address RDE postharvest – related concerns.;
- Establishment of the Bureau of Agriculture and Fisheries Product Standards (BAFPS) to facilitate in the formulation of grade standards and enccourage quality consciousness that would meet both domestic and foreign market requirements; and
- Establishment of a National Marketing Assistance Program (NMAP) that will support marketing and postharvest commerce of agriucltural products.

Conclusion

Production of vegetables and fruits in the country is affected by geographic factors, climate and soil. Crops grow well with the least inputs except when typhoons and drought hit the country. The bountiful harvest are wasted during the distribution process due to the use of inappropriate containers, poor road conditions, rough handling and high temperatures. While postharvest technologies are continuously being developed and adopted, the need for cooperation and coordination among the stakeholders is very critical. There are so many constraints to overcome not only the by farmers but also the traders, service providers, and the market. Information dissemination on the proper handling of fruits and vegetables through print and broadcast media must be sustained. Postharvest must be strengthened in the different schools as well as the extension manpower all over the country. The support for efficient postharvest facilities and infrastructures for perishable horticultural crops where the small producers could benefit must be prioritized.

Quality management systems for horticultual crops like Good Agricultural Practices (GAP), Hazard Analysis and Critical Controls Points (HACCP) and the ISO 9000 series are investments to be able to achieve the our goals and deliver quality produce and services. While the production areas are not increasing, the population is growing very rapidly. To ensure more food becoming available to consumers, a significant reduction in postharvest losses must be achieved.

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