Country Papers
Technology on Reducing Post-harvest Losses and Maintaining Quality of Fruits and Vegetables in Bangladesh

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Abstract

The post-harvest handlings of fruits and vegetables scenario is quiet unsatisfactory and mostly comprise of traditional techniques practiced by the growers, traders and processors, owing to which considerable deterioration in physical and nutritional qualities of the harvested produced in Bangladesh. It is estimated that the post-harvest loss of fruits and vegetables in the country is about 25-35% (Mia and et-al, 2008). Therefore, improvement of these indigenous practices and development of low cost new technologies through precise research efforts has now become essential to prevent the huge post-harvest losses of fruits and vegetables in view of ever increasing, demand for food and nutrition. In the development plans, considered post-production phenomenon merely as a support programme and the allocated resources for this sub-sector was only negligible amount of the total investment in agriculture sector. Under such situation, reduction of post-harvest losses has become the prime issue to increase the availability of fruits and vegetables at household level. However, the existing status of post-harvest handles including packaging, transportation, storage, processing and preservation of our harvested fruits and vegetables and to identify the loss reduction interventions. The experience in developed countries shows that the post-harvest losses of fruits and vegetables produce could be reduced by using the technology together with appropriate selection, preservation, transportation, packaging, processing and marketing. However, the developing country like Bangladesh suffer much of the post-harvest losses due to a number of factors such as lack of adequate knowledge and information, the unavailability of appropriate technology under funded research and development. However, many countries in this region possess their own indigenous, inherited knowledge in the field of post-harvest technology which perhaps has been neglected in the hurry to modernize. It is high time that the scientists and policy makers come together, discuss the issue of post-harvest technology and developed knowledge to facilitate the exchange of available technology and information between them.
Introduction

Agriculture is the predominant sector of the economy of Bangladesh. The agriculture sector creates not only large number of employment opportunities but it also provides a source of livelihood to the majority of the people of Bangladesh. The classical domain of investment on agriculture sector has undermined the role of post-harvest technology. Most of the fruits and vegetables are good sources of vitamins and minerals. So, emphasis should be given on availability and of consumption of various quality fruits and vegetables. The low consumption of fresh fruits and vegetables during off-season should be considered as a major concern from the standpoint of nutritional status of a country.

In Bangladesh, the production of vegetables is 2.7 million ton, potato 6.6 million ton and fruit is about 5.5 million ton (BBS, 2008). The present productions can hardly fulfill 50% requirements of the nation. Besides a significant portion of fruits and vegetables (25-35%) is lost due to improper post-harvest handling and processing resulting huge shortage of fruit and vegetable in the country. That is, consumption of the fruit and vegetable is almost half than the recommended doses. Consequently, vast majority of the peoples are suffering from various nutritional deficiency diseases.

Different Operations of Fruits and Vegetables after Harvesting

Harvesting of fruits and vegetables, are done manually. During harvesting maturity indices are not yet followed by farmers. To catch the high prices, farmers are generally harvest their fruits and vegetables very early when the nutritional quality is poor. Proper grading, sorting, packaging even pre-cooling is not generally done. Resulting, deterioration has been starting just after harvesting. However, the losses at the different stages of storage, grading, sorting, packaging, transport and finally marketing as a fresh produce is account for 25-35 percent. Such an enormous loss has proved a great handicap in exploiting the full potential of the increasing production of these crops and thereby improves the rural income, employment and nutrition of the population. The production and marketing of these commodities suffer from the uncertainty and instability of the market conditions and since these are grown by small and marginal farmers and handled at the retail level by poor sections, the effect is very frustrating. The infra-structural support available for the handling of about 15 million tonnes of fruits and vegetable, including potato produced annually, is too inadequate in the country. The practices currently in use in post-harvest handling and standards of material or facilities being used for storage, packing and transport are indigenous and outdated, contributing directly to the above loss.

1. Fruits

Maturity indices for mango cultivars namely Gopalbhog, Khirshapat, Langra, Fazli, Bombai and Aswina have been standardized. The optimum maturity time for harvesting;
• Gopalbogh, Khirshapat, Langra, Fazli, Bombay and Aswina were 87-91, 87-95, 97-105,112-120, 97-105 and 139-146 days respectively. The indicators applied were color, specific gravity and sinking and floating behavior of mangoes in salt solutions of different concentration. The mangoes harvested at above age were found to have 9-10 days shelf life at ambient temperature with good eating quality. All the methods are easily adoptable by the growers.

• Mangoes treated with hot water and transported through paper carton or plastic creates performed better in reducing transport losses.

• An evaporative cooler without use of refrigeration was designed and fabrication for short-term preservation of fruits and vegetables during dry season for use at farmer’s level with maintaining relative humidity 90-99% and lowering temperature to an extent of 13°C was attained. This cooler has excellent potentiality for village level storage of harvested fruits and vegetables for a short period.

• Physical injury of banana was minimum when transported in plastic crates.

• For local marketing, litchi having bunches in perforated polyethylene bags which were put in plastic crates for transporting to distant place can be maintained the shelf life for 3 to 4 days.

2. Vegetables

Leafy vegetables viz. spinach, red amaranth and Indian spinach packed in perforated packages give longer shelf life.

Processing and Preservation Technologies of Fruits and Vegetables

1. Preservation of Fruits by Steeping

Preservation by steeping in brine solution has been in practice from time immemorial. Sodium chloride acts as a preserving; conditioning, flavour enhancing and taste-improving agent in the processed and preserved foods. The vegetables preserved by steeping can be used for pickling or home cooking after leaching out the salt and acid. The fruits like green mango, olive, golden apple, satkora etc and vegetables like tomatoes, carrot, cauliflower , cabbage, bitter gourd, peas, mushroom and animal foods (meat, fish and poultry) could be preserved in an acidified sulphited brine solution (Ranote et al., 1991; Pruthi et al., 1990)

Preservation of green mango by steeping

Fresh, sound green mangoes are selected, washed and removed the stalk and cut into slices by hand cutter. After removing the seed and foreign particle again they are washed with clean water, blanched for 2 min at 90°C and cooled immediately. The blanched slices were soaked in the
solution containing 8% salt, 0.6% acetic acid, 0.02% turmeric powder and 1000 ppm SO_2 in a clean plastic drum and closed airtight and stored in dry, clean and cool place at room temperature. The self-life of the mango slices in the brine solution is 8 months. PRAN group also steeps the mango slices using the same procedure.

Preservation of olive by steeping

Fresh, mature sound green olives are selected, removed the stalk and foreign particles, washed with clean water and blanched for 3 min at 90°C and cooled immediately. The blanched olives are soaked in the solution containing 8% salt, 0.6% acetic acid, 0.02% turmeric powder and 1000 ppm SO_2 in a clean plastic drum and closed airtight and stored in dry, clean and cool place at room temperature. The self-life of the olives in the brine solution is 8 months.

Preservation of golden apple by steeping

Fresh, mature, sound, green golden apple are selected, removing the stalk and foreign particle washed with clean water and blanched for 3 min at 90°C and cooled immediately. The blanched golden apple are soaked in the solution containing 8% salt, 0.6% acetic acid, 0.02% turmeric powder and 1000 ppm SO_2 in a clean plastic drum and closed airtight and stored in dry, clean and cool place at room temperature. The self-life of the golden apples in the brine solution is 8 months.

2. Preservation of Fruitpulp

Preservation of mango pulp at ambient temperature

Mango is an important fruit crop in the country with a production of about 0.77 million ton (BBS, 2007). The approximate harvesting period of mango is June-August. Like most other fruit crops, mango is a highly seasonal crop. Mangoes are highly perishable in fresh form and shelf life is extremely limited to about a week only. Preservation of pulp extracted from fresh mangoes in production season can be an alternative way to make it available during the off-season. The semi-processed pulp may be used for processing into products like jam, drinks, squash, nectar etc. This type of processing may be adopted at home level and at community level. The technology is inexpensive and do not need sophisticated equipment and machinery. The small entrepreneur may come forward to adopt the technology especially in the production areas since the technologies are inexpensive and do not need sophisticated equipment and machineries.

Preservation by semi-processing consists of alternation of the biological activity in mango pulp. This is achieved through inactivation of the enzymes responsible for larger number of biochemical reactions that characterize fresh mangoes. In addition to enzyme inactivation, processing eliminates many microorganisms on or within the commodity that might cause rotting or decay so as to prolong the storage life of the product much longer than storage in fresh form.
Mango pulp after extraction should be strained in mosquito net/bamboo made sieves to remove the fibers and other coarse fractions. Heating of pulp should be done to attain temperature of 85-90°C with addition of 100 ml water per kg pulp followed by 10 minutes heating at this temperature and maintained the acidity at 0.9% with the addition of citric acid. Sodium benzoate (1000 ppm) or KMS (1000 ppm) should be added to the pulp before 2 minutes of completion of heating. After completion of heating, the pulp filled hot into sterilized bottles followed by further processing of the filled bottles for 20 minutes in boiling water. The processed bottles are scaled and kept inverted for 5 minutes. When cool, the mouth of the filled bottles is dipped in molten wax and then the bottles are stored in a dry, clean and cool place. The size of the bottles may vary but the steps of sterilization, hot filling, inverting, waxing, cooling etc. should be rigidly followed for any size of bottle, PRAN group also preserves these pulps by mechanized process and follows the HACCP requirements.

Preservation of tomato pulp at ambient temperature

Tomato is one of the most important vegetables in our country. It is extremely perishable and can not be preserved in fresh stage. Huge post harvest losses of the harvested tomatoes may occur due to inadequacies in transportation and storage facilities which brings substantial loss to the growers and hence to the national economy. Preservation of tomatoes as semi-processing system not only takes care of the marketable surplus but also ensures the supply of raw materials for finished products like sauce, ketchup, drink etc, (Rodrigez et al., 1975; Nickerson and Ronsivalli, 1976). A simple technology of concentrating tomato pulp kept in locally available containers might be a solution to the problem of huge tomato loss during harvesting period.

Tomato pulp after extraction and strained through mosquito net/bamboo made sieves to remove the seeds and other coarse fractions. The pulp is concentrated in open cooker as per method outlined by Bhatia (1982). The pulp is concentrated to 10°B from the initial TSS 4°B and then citric acid0.2% and sodium benzoate (1000 ppm) are added. The pulp is filled hot into sterilized bottles followed by further processing of the filled bottles for 20 minutes in boiling water. The processed bottles were sealed, kept inverted for 5 minutes. When cool, the mouth of the filled bottles is dipped in molten wax and then stored in a dry, clean and cool place. PRAN group also preserve these pulps by mechanized process and follows the HACCP requirements.

3. Preservation of Fruit Slices in Sugar Syrups

Select firm-rip fruits (mango, pineapple, jackfruit etc.) and wash, peel and slice. Sterilize clean neutral glass containers by dipping them in boiling water for at least half an hour. Place the fruit slices in the container and then put 30-40°B (30-40% sugar in water w/w basis with 0.05% citric acid) sugar syrup into the filled container up to the brim. Exhaust the bottle in boiling water for 7 minutes. Seal the bottle loosely and process in boiling water for half an hour. Remove the container and place it inverts position. After cooling store it preserves at room temperature.
Transportation of Fruits and Vegetables

In the rural areas, from field to hat/bazaar, the farmers are generally used shoulder slings for transportation of fruits and vegetables. However, for short distance vans (manual) and auto pickup are used. For long distance, fruits and vegetables are transported through truck. Besides roads, fruits and vegetables are also transported by boat or launch. It is very unfortunate that there is no cool chain system in transporting fruits and vegetables. Moreover, the produces are loaded in ways which promotes major problems such as inadequate transport containers, inappropriate staking, inadequate packages, very rough loading method, poor and non existence of air circulation, heating and mechanical injury to the produce. Consequence, a significant portion of fruits and vegetables is lost/ damaged during transportation.

Packing of Fruits and Vegetables

The major portion of the fruits and vegetables are sent directly to the major markets for disposal. The rest of the produced is packed loosely in bamboo baskets, gunny bags, wooden boxes. But banana and pineapple are directly transported by Truck. These consignments are exposed to the sunlight and other weather abbreviations, causing huge losses in their quality as well as total weight. However, mango fruits are packed with bamboo basket with rice straw for internal markets. Report quotes the following factors responsible for the damages of fruits after harvest:

i. Packing either too tightly or too loosely;
ii. Packing fruits of different maturity;
iii. Poor quality packing material and packing cases;
iv. Expose to sun and rain;
v. Delay in disposed, and
vi. Frequent transshipment, loading and unloading and all involving rough handlings.

The shortage of fruit boxes and its high cost has posed another problem for the marketing and distant shipment of fruits. Packing and packaging systems are important of the post-harvest chain of fruits and vegetables. Packages are made of different sizes, shapes and materials depending on the type of the fruits and vegetables and their uses. Generally low cost packages materials are used for transporting or marketing of fruits and vegetables. The materials are used as followed:

i. Bamboo baskets,
ii. Gunney bags and socks,
iii. Plastic creates,
iv. Hardboard, etc.

Standardization of package is not yet established in Bangladesh. However, it varies from 10 kg to 80 kg depending on type of fruits and vegetables as well as distance. For carrying wholesale market the trader’s prepared big bag and its size up to 500 kg capacity.
Processing Fruits and Vegetables into Pickles

Mango, jackfruit, aonla, brinjal, ber (jujube), taikar, Indian olive, and golden apple are under utilised but popular fruits and vegetables were processed into pickles with the ingredients of chilli powder, garlic, ginger, turmeric powder, mustard powder, green chilli, sugar, fenugreek powder, salt, cumin powder, mustard oil and acetic acid.

1. Olive Pickle

Ingredients

<table>
<thead>
<tr>
<th>Item</th>
<th>Quantity</th>
<th>Item</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Olive</td>
<td>1 kg</td>
<td>Mustard powder</td>
<td>20 gm</td>
</tr>
<tr>
<td>Sugar</td>
<td>100 gm</td>
<td>Cumin powder</td>
<td>2.5 gm</td>
</tr>
<tr>
<td>Garlic</td>
<td>30 gm</td>
<td>Fenugreek powder</td>
<td>5 gm</td>
</tr>
<tr>
<td>Ginger</td>
<td>60 gm</td>
<td>Salt</td>
<td>50 gm</td>
</tr>
<tr>
<td>Chili powder</td>
<td>20 gm</td>
<td>Mustard oil</td>
<td>400 ml</td>
</tr>
<tr>
<td>Turmeric powder</td>
<td>10 gm</td>
<td>Acetic acid</td>
<td>15 ml</td>
</tr>
</tbody>
</table>

Methods of preparation

Select sound, tender and mature green olive, wash and cut the slices of the fruits. Blanch the slices for 10 minutes with 0.05% turmeric powder and then drain out the water. Fry the slices in mustard oil and then remove from the pan. Prepare ginger and garlic paste with addition of 1% acetic acid; add chili powder and turmeric powder with paste. Fry the mixture paste in left over mustard oil of the pan. Add fried olive slices, sugar, cumin power, fenugreek powder and mustard powder gradually. At last, add salt and acetic acid and cook up to complete removal of water. Fill the pickles in sterilized glass container keeping the oil layer on the top. Seal the cap airtight and store them at ambient temperature.

2. Mango Pickle

Ingredients

<table>
<thead>
<tr>
<th>Item</th>
<th>Quantity</th>
<th>Item</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Green mango</td>
<td>1 kg</td>
<td>Turmeric powder</td>
<td>10 gm</td>
</tr>
<tr>
<td>Ginger</td>
<td>60 gm</td>
<td>Salt</td>
<td>50 gm</td>
</tr>
<tr>
<td>Garlic</td>
<td>30 gm</td>
<td>Fenugreek</td>
<td>5 gm</td>
</tr>
<tr>
<td>Sugar</td>
<td>100 gm</td>
<td>Cumin</td>
<td>5 gm</td>
</tr>
<tr>
<td>Chili powder</td>
<td>30 gm</td>
<td>Mustard oil</td>
<td>400 ml</td>
</tr>
<tr>
<td>Mustard powder</td>
<td>20 gm</td>
<td>Acetic acid</td>
<td>15 ml</td>
</tr>
</tbody>
</table>
Methods of preparation

Select sounds, tender and immature green mango, wash and cut longitudinally in to 4 pieces and remove seeds of the fruits. Soak the pieces into 2% salt solution with 0.05% turmeric powder. After removal from the salt solution, blanch the pieces for 5 minutes at 100°C and drain out the water. Fry the pieces in mustard oil and remove from the pan. Ginger and garlic are made into paste with addition of 1% acetic acid; add chili powder and turmeric powder with paste. Slightly fry the mixture paste in the left over oil of the pan. Add fried mango pieces, sugar, cumin powder fenugreek powder, and mustard powder gradually. At last add salt and acetic acid and cook up to complete removal of water. Fill the pickles in sterilized glass container and sealed airtight and store them in dry, clean and cool place at ambient temperature.

3. Brinjal Pickle

<table>
<thead>
<tr>
<th>Item</th>
<th>Quantity</th>
<th>Item</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brinjal</td>
<td>1 kg</td>
<td>Green chili</td>
<td>30 gm</td>
</tr>
<tr>
<td>Dry chili powder</td>
<td>30 gm</td>
<td>Fenugreek powder</td>
<td>5 gm</td>
</tr>
<tr>
<td>Garlic</td>
<td>30 gm</td>
<td>Cumin powder</td>
<td>2.5 gm</td>
</tr>
<tr>
<td>Ginger</td>
<td>60 gm</td>
<td>Salt</td>
<td>50 gm</td>
</tr>
<tr>
<td>Sugar</td>
<td>200 gm</td>
<td>Mustard oil</td>
<td>400 ml</td>
</tr>
<tr>
<td>Turmeric powder</td>
<td>10 gm</td>
<td>Acetic acid</td>
<td>15 ml</td>
</tr>
<tr>
<td>Mustard powder</td>
<td>20 gm</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Methods of preparation

Select sound long type brinjal, wash and cut into 5 cm pieces and halves them longitudinally. Fry the pieces in mustard oil and then remove from the pan. Green chillies are soaked in 4% acetic acid. Ginger and garlic are made into paste with addition of 1% acetic acid. Add chilli powder and turmeric powder with the past. Fry the mixture paste in the left over mustard oil. Add fried brinjal, green chilli, sugar, cumin powder, fenugreek powder and mustard powder gradually. At last add salt and acetic acid and cook up to complete removal of water. Fill the pickles in sterilized glass container and sealed airtight and store them in dry, clean and cool place at ambient temperature.
4. Garlic Pickle

**Ingredients**

<table>
<thead>
<tr>
<th>Item</th>
<th>Quantity</th>
<th>Item</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Garlic bulb</td>
<td>1 kg</td>
<td>Mustard powder</td>
<td>10 gm</td>
</tr>
<tr>
<td>Sound bulb</td>
<td>30 gm</td>
<td>Cumin powder</td>
<td>5 gm</td>
</tr>
<tr>
<td>Ginger</td>
<td>60 gm</td>
<td>Fenugreek powder</td>
<td>5 gm</td>
</tr>
<tr>
<td>Sugar</td>
<td>100 gm</td>
<td>Salt</td>
<td>50 gm</td>
</tr>
<tr>
<td>Dry chilli powder</td>
<td>30 gm</td>
<td>Mustard oil</td>
<td>400 ml</td>
</tr>
<tr>
<td>Turmeric powder</td>
<td>10 gm</td>
<td>Acetic acid</td>
<td>15 ml</td>
</tr>
</tbody>
</table>

**Methods of preparation**

Select sound garlic, peels the thin skin and wash with clean water. Fry the garlic in mustard oil and the remove from the pan. Ginger and garlic are made into paste with addition of 1% acetic acid and the mix chilli powder and turmeric powder with the paste. Fry the mixture paste in the left over mustard oil. Then add fried garlic, sugar, salt, cumin powder, fenugreek powder and mustard powder gradually to the mixture paste. At last add salt and acetic acid and cook up to complete removal of water. The pickles are then filled in sterilized glass container and sealed airtight and store them in dry, clean and cool place at ambient temperature.

5. Ber and Tamarind Mixed Chutney

**Ingredients**

<table>
<thead>
<tr>
<th>Item</th>
<th>Quantity</th>
<th>Item</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dry and clean ber</td>
<td>1 kg</td>
<td>Black pepper powder</td>
<td>1 gm</td>
</tr>
<tr>
<td>Tamarind</td>
<td>250 gm</td>
<td>Cloves powder</td>
<td>0.5 gm</td>
</tr>
<tr>
<td>Sugar</td>
<td>1.25 kg</td>
<td>Cinnamon powder</td>
<td>1 gm</td>
</tr>
<tr>
<td>Salt</td>
<td>32 gm</td>
<td>Joyfál</td>
<td>1 gm</td>
</tr>
<tr>
<td>Salt (Bit laban)</td>
<td>5 gm</td>
<td>Joyatri</td>
<td>0.5 gm</td>
</tr>
<tr>
<td>Dry chilli powder</td>
<td>6 gm</td>
<td>Salt</td>
<td>59 gm</td>
</tr>
<tr>
<td>Fenugreek powder</td>
<td>5 gm</td>
<td>Mustard oil</td>
<td>100 ml</td>
</tr>
<tr>
<td>Mustard powder</td>
<td>12 gm</td>
<td>Acetic acid</td>
<td>6 ml</td>
</tr>
<tr>
<td>Cumin powder</td>
<td>2.5 gm</td>
<td>Sodium Benzoate</td>
<td>0.75 gm</td>
</tr>
<tr>
<td>Kawlanji</td>
<td>8 gm</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Methods of preparation

Select ripe and dry ber, wash and then immersed in water for whole nigh. On the following day boil the ber until becomes soft. Remove the pan from the burner and after cooling separate the pulp by pressing with hand. Soak required amount of tamarind pulp in water and remove the pulp and filter by using a bamboo sieve. Mix the ber pulp with the tamarind pulp and add required amount of sugar and the heat the mixture. Add oil, salt and spices one by one and continue the heating. When the mixture becomes concentrated and acetic acid and cook until the Brix rises to 62° B and the add sodium benzoate. Remove the pan from the burner and transferred the chutney into sterile glass jar.

Conclusion

Reduction of post-harvest losses has become the prime issue to increase the availability of fruits and vegetables. A significant portion of the produce is lost but it can be overcome by processing into different products. The processing methods are simple. If practical training and demonstration are provided to the rural people and if they adopt the technology, it will play a vital role in reducing the post-harvest losses of fruits and vegetables. The policy should encourage the gender groups for improving adoption of technology and reducing losses. It can also create job opportunities for disadvantages section of population.

Recommendation and Suggestion

Bangladesh has excellent environmental resources for the production of fruits and vegetables. To meet the challenges on global safety requirements Bangladesh should gradually takes necessary measures throughout the food chain from farm to table for the maintaining international quality and safety of fruits and vegetables. For this, the following recommendation and suggestion may be followed:

- Human resource development (HRD) on post-harvest technologies;
- Infrastructure development for R&D, education, extension, training, input supply, marketing, processing, storage, etc.;
- Development of supply chain for horticultural produces;
- Cooperative basis marketing should be explore;
- To make available like equipments, chemical, glassware for small scale cottage industry;
- The fiscal policy of the government should be conducive for post-harvest development;
- Interest free bank loan should be provided to post-harvest and processed sectors for sustain development;
- Priority should be given towards development and expansion of processing technologies and facilities suitable for export of processed food products;
- Excumption/ withdraw excise duty, VAT and other taxes, etc. may encourage processed fruits and vegetables; and
- Develop industries for diversified use of agricultural products.
References


Vegetable Marketing Channels, Post-harvest and Adjustment in Taiwan

Yi-Tan Fang
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Abstract

The vegetable production in Taiwan has been unstable in rainy spring, summer and winter seasons. To maintain the balance between production and consumption demand, planned production based on the amounts of domestic production/consumption and imports trade is important, especially when the production and price is fluctuated. Those sensitive for production and marketing vegetables include garlic, onion, cabbage, Chinese cabbage, and Welsh onion. Most vegetables especially leafy vegetables are highly perishable. Cold chain system for vegetable storage is an advanced operation compared to other traditional operations in postharvest handling and marketing channels, which can reduce postharvest loss and maintain quality. To establish a high efficiency agricultural marketing system of vegetables, cold chain system is necessary for sustainable practices.

Introduction

Taiwan is located in the subtropical zone. It has high temperature and heavy rainfall in summer, but warm and dry in winter, with about 822,364 hectares cultivated land for crops production. The output of agricultural and food produces valued at 179.1 billion NT dollars which accounted for 43% of the total agricultural production value in Taiwan in 2008. Among the output of agricultural produce value, fruit crops contributed 38% of the total value, followed by vegetables (27%), rice (17%), flower crops (7%), special crops (5%), upland crops (4%), and other crops (2%).

In Taiwan, the average temperature is over 22°C, so that the temperature keeps high for more than half year. However, climate influences the vegetable production extremely. The rainfalls concentrate in summer, and plum rain, cloudburst, typhoon also happen frequently. With such a condition, it induces serious natural diseases problems for growing vegetables from May to October, so called “summer vegetable problem”. For this reason, the vegetable production is not enough for consumption. In contrast, vegetable grows fast in the winter season after paddy rice. During this period, vegetable is always over-supplied and the price decreases even lower than the production cost.
Vegetable Industry in Taiwan

More than 100 vegetable crops are cultivated on 153,964 hectares of land in Taiwan. The total production exceeded 2.64 million tons valued at 48.5 billion NT dollars in 2008. Table 1 indicated that the cash vegetable was about 65% of production area and 73% of total vegetable production, which mostly are short-time cultural crops, such as leafy vegetables and flowers. Those are high value per unit area and make most income for farmer. The major production area locates in central part of Taiwan, particularly like Yunlin and Changhua County. Yearlong vegetable, including bamboo shoot, taro and yam, etc., was mostly produced in south Taiwan which is about 19% of production area and 12% of production volume. Melons include watermelon, cantaloupe, and strawberry.

In Table 2, the data indicated that vegetable production was an important industry in Taiwan. The vegetable crops to total crops increased form 21.74% in 1992 to 27.09% in 2008. According to the statistics, the vegetable consumption increased from 40 kg per year in 1950 to 120 kg in 2000.

Table 1. The vegetable production in Taiwan from 1995-2008.

<table>
<thead>
<tr>
<th>Year</th>
<th>Total Planted area (ha)</th>
<th>Total Production (M.T.)</th>
<th>Cash vegetables Planted area (ha)</th>
<th>Cash vegetables Production (M.T.)</th>
<th>Yearlong vegetables Planted area (ha)</th>
<th>Yearlong vegetables Production (M.T.)</th>
<th>Melons Planted area (ha)</th>
<th>Melons Production (M.T.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1995</td>
<td>174,749</td>
<td>2,887,017</td>
<td>111,222</td>
<td>2,011,715</td>
<td>33,820</td>
<td>410,348</td>
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<tr>
<td>1996</td>
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<td>113,024</td>
<td>2,229,869</td>
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<td>1997</td>
<td>182,393</td>
<td>3,056,290</td>
<td>115,628</td>
<td>2,188,904</td>
<td>33,588</td>
<td>394,921</td>
<td>33,177</td>
<td>472,465</td>
</tr>
<tr>
<td>1998</td>
<td>180,072</td>
<td>2,911,734</td>
<td>113,987</td>
<td>2,064,417</td>
<td>33,998</td>
<td>385,311</td>
<td>32,087</td>
<td>462,006</td>
</tr>
<tr>
<td>1999</td>
<td>183,600</td>
<td>3,513,788</td>
<td>118,439</td>
<td>2,563,797</td>
<td>34,477</td>
<td>411,550</td>
<td>30,684</td>
<td>543,476</td>
</tr>
<tr>
<td>2000</td>
<td>177,074</td>
<td>3,045,605</td>
<td>115,569</td>
<td>2,279,210</td>
<td>33,374</td>
<td>388,094</td>
<td>28,131</td>
<td>494,890</td>
</tr>
<tr>
<td>2001</td>
<td>173,672</td>
<td>3,045,605</td>
<td>113,637</td>
<td>2,222,768</td>
<td>32,907</td>
<td>365,845</td>
<td>27,128</td>
<td>456,993</td>
</tr>
<tr>
<td>2002</td>
<td>179,473</td>
<td>3,461,803</td>
<td>116,945</td>
<td>2,485,830</td>
<td>33,093</td>
<td>386,942</td>
<td>29,435</td>
<td>589,031</td>
</tr>
<tr>
<td>2006</td>
<td>157,184</td>
<td>2,877,991</td>
<td>106,017</td>
<td>2,162,465</td>
<td>30,699</td>
<td>357,977</td>
<td>20,468</td>
<td>357,549</td>
</tr>
<tr>
<td>2007</td>
<td>154,112</td>
<td>2,595,162</td>
<td>101,776</td>
<td>1,959,713</td>
<td>30,567</td>
<td>326,397</td>
<td>21,769</td>
<td>309,052</td>
</tr>
<tr>
<td>2008</td>
<td>153,964</td>
<td>2,640,700</td>
<td>104,979</td>
<td>2,070,571</td>
<td>29,854</td>
<td>288,267</td>
<td>19,131</td>
<td>281,862</td>
</tr>
</tbody>
</table>

| Average % | 100% | 100% | 65% | 73% | 19% | 12% | 16% | 15% |

The data is collected from Agricultural Statistics and Yearbook, Council of Agricultural, Executive Yuan, R.O.C., 2008.
Table 2. The variation of crop production in period of 1992-2008.

<table>
<thead>
<tr>
<th>Year</th>
<th>Total Production (ha)</th>
<th>Ratio (%) Vegetable</th>
</tr>
</thead>
<tbody>
<tr>
<td>1992</td>
<td>142,312,811</td>
<td>21.74</td>
</tr>
<tr>
<td>1993</td>
<td>157,523,597</td>
<td>19.82</td>
</tr>
<tr>
<td>1994</td>
<td>160,263,443</td>
<td>18.35</td>
</tr>
<tr>
<td>1995</td>
<td>168,517,511</td>
<td>20.35</td>
</tr>
<tr>
<td>1996</td>
<td>172,781,410</td>
<td>21.17</td>
</tr>
<tr>
<td>1997</td>
<td>173,744,104</td>
<td>20.89</td>
</tr>
<tr>
<td>1998</td>
<td>163,618,674</td>
<td>21.75</td>
</tr>
<tr>
<td>1999</td>
<td>170,523,785</td>
<td>23.43</td>
</tr>
<tr>
<td>2000</td>
<td>165,214,487</td>
<td>23.34</td>
</tr>
<tr>
<td>2001</td>
<td>160,758,570</td>
<td>22.87</td>
</tr>
<tr>
<td>2002</td>
<td>151,853,269</td>
<td>23.26</td>
</tr>
<tr>
<td>2003</td>
<td>147,274,670</td>
<td>23.52</td>
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<tr>
<td>2004</td>
<td>162,300,578</td>
<td>25.09</td>
</tr>
<tr>
<td>2005</td>
<td>162,630,935</td>
<td>26.21</td>
</tr>
<tr>
<td>2006</td>
<td>172,691,533</td>
<td>25.49</td>
</tr>
<tr>
<td>2007</td>
<td>168,368,459</td>
<td>27.90</td>
</tr>
<tr>
<td>2008</td>
<td>179,108,569</td>
<td>27.09</td>
</tr>
</tbody>
</table>

The data is collected from Agricultural Statistics and Yearbook, Council of Agricultural, Executive Yuan, R.O.C., 2008.

The production and marketing of vegetables are monitored continuously by the Council of Agriculture (COA)/Agricultural and Food Agency (AFA) for the purpose of regulating market supply and price, especially in the conditions of abnormal fluctuations in prices and supply in rainy spring and typhoon season. Vegetable soybean, spinach, head lettuce, short-term leafy vegetables, melons and mushrooms are vegetables in high daily demand by the consumers. The government promotes vegetable protective cultivation of green-house structure and the technique of the integrated pest management to ensure the stable supply in quality and safety produce. The application of grading system, with improved packaging and post-harvest techniques, facilitates the export of vegetables, such as lettuce, carrot and cabbage, to neighboring countries.
Regarding to vegetable trade, the import quantity and value of vegetable products were increasing by year, from 1992 to 2008 the quantity increased from 171.8 thousand tons to 417.7 thousand tons and the value increasing three times, from 96 million US dollars to 264.3 million US dollars. But the export quantity decreased from 204 thousand tons to 66 thousand tons and the value decreased from 299.6 million US dollars to 112.7 million US dollars, from 1992 to 2008 (Table 3).

Table 3. The statistics data of trade on vegetable products in the period of 1992-2008.

<table>
<thead>
<tr>
<th>Year</th>
<th>Import Weight (ton)</th>
<th>Import Value (1,000 USD)</th>
<th>Export Weight (ton)</th>
<th>Export Value (1,000 USD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1992</td>
<td>171,857.07</td>
<td>96,106.64</td>
<td>204,556.66</td>
<td>299,636.10</td>
</tr>
<tr>
<td>1993</td>
<td>197,366.18</td>
<td>100,255.56</td>
<td>169,720.74</td>
<td>263,652.80</td>
</tr>
<tr>
<td>1994</td>
<td>235,563.30</td>
<td>111,117.41</td>
<td>152,789.66</td>
<td>222,918.09</td>
</tr>
<tr>
<td>1996</td>
<td>231,261.88</td>
<td>139,309.10</td>
<td>152,662.87</td>
<td>184,483.60</td>
</tr>
<tr>
<td>1997</td>
<td>260,818.27</td>
<td>158,742.60</td>
<td>115,533.05</td>
<td>151,636.00</td>
</tr>
<tr>
<td>1998</td>
<td>302,413.73</td>
<td>163,948.90</td>
<td>91,053.81</td>
<td>128,071.80</td>
</tr>
<tr>
<td>1999</td>
<td>297,235.06</td>
<td>169,418.80</td>
<td>112,406.40</td>
<td>134,146.80</td>
</tr>
<tr>
<td>2000</td>
<td>303,333.52</td>
<td>170,468.00</td>
<td>105,592.34</td>
<td>131,191.80</td>
</tr>
<tr>
<td>2001</td>
<td>336,461.53</td>
<td>166,907.20</td>
<td>85,464.37</td>
<td>109,116.40</td>
</tr>
<tr>
<td>2002</td>
<td>321,596.47</td>
<td>172,911.10</td>
<td>81,029.67</td>
<td>98,194.50</td>
</tr>
<tr>
<td>2003</td>
<td>239,012.96</td>
<td>170,876.50</td>
<td>80,405.07</td>
<td>104,389.80</td>
</tr>
<tr>
<td>2004</td>
<td>340,039.84</td>
<td>184,107.20</td>
<td>88,153.75</td>
<td>113,311.50</td>
</tr>
<tr>
<td>2005</td>
<td>466,210.19</td>
<td>236,487.60</td>
<td>76,950.78</td>
<td>97,587.30</td>
</tr>
<tr>
<td>2006</td>
<td>421,950.99</td>
<td>217,801.80</td>
<td>66,500.38</td>
<td>94,016.60</td>
</tr>
<tr>
<td>2007</td>
<td>473,245.01</td>
<td>239,654.50</td>
<td>59,674.98</td>
<td>87,734.90</td>
</tr>
<tr>
<td>2008</td>
<td>417,723.25</td>
<td>264,284.70</td>
<td>78,470.41</td>
<td>112,753.70</td>
</tr>
</tbody>
</table>

The data is collected from General Bureau of Tariff, Ministry of Finance, R.O.C.
The Supply System and Cold Chain of Vegetables Marketing

Agriculture is vital and multi-functional. It serves all facts of human life and is an integral part of environmental conservation and culture. However, agriculture is facing a series of global challenge today. According to statistics and other scientific evidence, global temperature and sea level will raise, and frequency of extreme weather conditions will also increase. These global changes will bring in great impacts on agriculture production and threaten food security.

Climate of Taiwan has both subtropical and tropical types, and the meteorological phenomena are unstable. The natural disaster includes monsoon, typhoon, cloudburst, high temperature, high humidity and cold current, which often attack this island. Due to the climatic characteristics, the agricultural disasters often happen, and high temperature becomes the main restricting factor for cultivating vegetable crops.

In Taiwan, vegetable production is unstable in rainy spring and summer seasons and is over supply in winter time. Developing cold chain system provides high quality, safety, convenience and stable vegetable supply. There are two major pathways of vegetable marketing. Traditionally, vegetables are transported from growers at growing area to wholesale markets, and auction markets are nearby the consuming city, and then transported to retailers (Fig.1). For the purpose to keep product quality, it is necessary to shorten the transport time. To ensure the products arriving convention retail market in early morning and reaching to consumer’s refrigerator in 24 hours, vegetable is always transported in the midnight for auction.

About 45% of vegetables are sold through the traditional channels. Because of the distance from southern to northern Taiwan is short, most vegetables can be kept well due to these prompt transportation. The quality of vegetables is maintained by such a good short time and direct transportation.

![Fig. 1. The vegetables supply system of Taiwan. The solid line means the supply by cold chain.](image-url)

Another way is to supply for supermarket and hypermarket. In this system, cold chain vegetable is widely accepted, and vegetables are also sold to big group, like military, companies, and schools, etc. Cold chain management for vegetables can reduce post-harvest loss and keep better quality, especially for highly perishable vegetables such as leafy vegetables. Theoretically cold chain system for vegetables should be widely applied. At present, only about 30-40% of vegetables are sold through this system.

Various kinds of practices are used in cold chain operation, especially for horticultural crops. Different practices are adopted for different situations, depending on vegetable properties, available facilities, and consumer’s demands. Post-harvest handling is a very important step for most horticultural products prior to shipping and marketing. Among them, the use of “pre-cooling” technique has greatly improved vegetable quality. Pre-cooling is a very important step in cold chain operation. The facilities and techniques include hydrocooling, room cooling, forced air cooling and vacuum cooling.

Low-temperature storage is well-used in cold chain management. The use of “controlled atmosphere” storage (CA storage) provides a chance to prolong the storage life of cabbage and other vegetables. In this system, the suppliers, such as supermarkets, can keep vegetable quality stable in quantity. However, the supply and price of vegetables from growers or wholesale market are often fluctuate when climate change unexpectedly. Short term storage of leafy vegetables is commonly used by farmers’ associations. Long term storage for certain seasonal vegetables, such as onion and cabbage, is more professional

**Newly Supply Choice – “Fresh-cut” Vegetables**

Fresh-cut vegetables are easy to become spoiled. The procedure for producing fresh-cut vegetables is very complicated to keep the product fresh and away from microorganism contamination. Among the products, fresh-cut vegetables need the most precise control in all steps of operations. Shredding and slicing cause damage to vegetables tissues.

In addition to keep fresh-cut vegetables fresh, safety control in microorganisms’ contamination is also important. Processing operations such as cutting cause damage to vegetable tissues and lead to leakage of nutrients and cellular fluids providing opportunities for microorganisms’ contaminations. The microorganisms may result in a public health problems caused by food borne disease, especially for the fresh-cut vegetables like salad which are consumed without cooking.

The other choice is frozen vegetable, which has been developed for 30 years in this place and not only supply for domestic market but also for export to Japan. According to the modern consumption habit, consumers need more fast and safety food, and frozen vegetable now becomes more popular in the supermarket, especially when the vegetable price arises.
**Vegetable Adjustment Measures in Taiwan**

For improving marketing efficiency, the Agency of Food and Agriculture (AFA) helped wholesale market to enrich trade facilities, increase service quality and develop shared software. Government assists farmers’ associations establishing cold-chain for domestic agricultural production, enhancing their supermarket operations, increasing its cooperation with direct sale channels, such as supermarkets, hypermarkets or consumers who booking large orders.

For vegetable shortage problems caused by natural disasters such as typhoons and extremely rainfall in summer, the AFA assists farmers’ associations to establish large scale refrigeration facilities for storing long-term vegetable like cabbage and Chinese cabbage. The storage product will be released to Taipei Wholesale Market when local markets are shortage of supply and/or when market price has abnormal fluctuation. The market-regulate measures implemented by government are listed as followings:

A. **Storage facilities improvement**

   Carefully select the qualified farmer groups, and help them to improve their refrigeration facilities and the marketing ability.

B. **Restore measures**

   Disaster relief and vegetable restore are implemented shortly after the occurrence of natural disasters. Technical and financial assistance for shortening period of leaf vegetable replanting are offered to meet market vegetable demand as early as possible. The replant vegetable can compensate market shortage until it restores to the original quantity in 15 days.

C. **Emergency measures**

   The government will release storage vegetables to compensate for the shortage caused by natural disaster. The government collect weather forecast information continuously and take measures to prevent disasters. The government also monitors crops damage condition and fluctuations in vegetable prices during the period of natural disasters.

   AFA will inform the agricultural groups who are taking part in the storage program to release vegetable, when there is AFA showing abnormal fluctuations in prices and supply of vegetable.

**Conclusion**

Abnormal climate and extreme weather cause the shortage of vegetable in Taiwan. Cold chain system for vegetables is an advanced post-handling system compared to the traditional marketing channels, which helps to expand the vegetable preservation life. However, many factors may restrict the application of cold chain system. These factors include increased cost, complicate
facilities and treatment techniques, high investment and management, and competition from other marketing channels. The main competitions are low cost, easy to handle and high quality channel which is achieved by prompt and short time transportation.

In addition, high quality cold chain system provides products with more stable supply, high convenience and safety than other marketing system. For sustainable operation of cold chain system, farmers’ associations build large refrigerators and establish a more efficiency supply system. An integrated management is needed for better control in supply, treatment of products, operation in packing house, and stable outlet. Government will continue efforts on collecting supply and market information, improve techniques and facilities for vegetable production and handling, and develop new products.

Acknowledgements

The author would like to thank Dr. Doung-Liang Lin, the researcher of Tainan District Agricultural Research and Extension Station, and Mr. Hsiang-Yi Huang, the researcher of Kaohsiung District Agricultural Research and Extension Station, for their providing information for this country report.

References


The Agricultural Survey and Postharvest Handling Research of Avocado In Taiwan

Min-Chi Hsu
Taiwan Agricultural Research Institute (TARI), Taiwan, ROC

Abstract

The technology for improving postharvest handling from growing field to consumers has been the major subject of detailed research for over a century. The cost for harvest and postharvest up to 30% to 60% of all production and marketing system during horticultural produce, and significant quality loss due to improper processing. Technologies involved in handling, packaging, precooling, transportation, which would minimize losses, maintain high quality, and enhance value-added for horticultural crops that had been extensively applied in Taiwan. For example, precooling is the most common practice, and forced air cooling and vacuum cooling are widely adapted. In this article, information of current postharvest technology in Taiwan, including value, production, and planted area of fruits and vegetables, will be discussed. Avocado is a developing fruit in Taiwan. Postharvest methods of avocado have been tested, including storage temperature, storage period, the effect of ethylene absorbent and the effect of ethylene inhibitor. By some of these methods, avocado can be maintained in good appearance and quality.

Introduction of Taiwan’s Agriculture and Postharvest Handling of Fruits and Vegetables

The total population of Taiwan is about 23.1 million people in 2009. The agricultural employed population is 543 thousands, with male population of 70.02% and female of 29.98% in 2009. The gross domestic production (GDP) is 383,343 million USD in 2007 and 402,616 million USD in 2009. The gross national production (GNP) per capita is 17,252 USD in 2007 and 17,651 USD in 2009, according to the statistic table from Directorate-General of Budget. Taiwan’s GNP is predicted increasing to 18,565US$ in 2010. The gross domestic product based on purchasing-power-parity (PPP) per capita GDP from 1980 to 2009 is from 4,000US$ to 29,000US$ (Fig. 1).

The industrial origin of gross domestic product is 417,089 million USD in 2009 and agricultural industry shares almost 1.55%. The composition of crop products in agricultural production is 5960.6 million USD, about 43.9% of total agricultural products, in 2009. Horticultural crops contributed 70.20% of total value of all crops products in 2009 (Table 1 and Fig. 2). Fruit crops and vegetable crops are the most important, 26.59% and 36.75%, respectively, of all crops. In Taiwan, consumers usually buy fresh fruits and vegetables in the markets.
Table 1. The composition of crop products in agricultural production from 2006 to 2009

<table>
<thead>
<tr>
<th>Item</th>
<th>Value</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2006</td>
<td>2007</td>
</tr>
<tr>
<td>Crop production</td>
<td>5756384.4</td>
<td>5612282.0</td>
</tr>
<tr>
<td>Rice</td>
<td>979330.7</td>
<td>869711.4</td>
</tr>
<tr>
<td>Coarse grain</td>
<td>266627.7</td>
<td>209165.1</td>
</tr>
<tr>
<td>Special crops</td>
<td>270584.8</td>
<td>262651.7</td>
</tr>
<tr>
<td>Vegetables</td>
<td>1467589.5</td>
<td>1565726.4</td>
</tr>
<tr>
<td>Mildew</td>
<td>99361.4</td>
<td>106380.3</td>
</tr>
<tr>
<td>Fruits</td>
<td>2255521.5</td>
<td>2186511.6</td>
</tr>
<tr>
<td>Flowers</td>
<td>417368.8</td>
<td>412135.5</td>
</tr>
</tbody>
</table>

Note: the production unit is ton.

Taiwan has a mild climate, allowing the production of fresh fruit and vegetables throughout the year. More than 100 different kinds of vegetables are grown as well as various kinds of fruits are planted and cultivated. The major vegetables and fruits species are listed in Table 2 and Table 3. At the same time, owing to climate tends to be warm and humid, it has taken great efforts to reduce postharvest losses to their present level of 10% for both vegetables and fruits (FAO/ Food Balance Sheet). In order to maintaining high quality of fresh produce, cold chain system has been applied since 1960 in Taiwan. At present lots of vegetables and fruits are sold through this system.
Fig. 2. Fruits crops and vegetable crops are 26.59% and 36.75%, respectively, of all crops.

Table 2. The value, production and planted area of major fruits in Taiwan in 2009

<table>
<thead>
<tr>
<th>Species</th>
<th>Value (1000US$)</th>
<th>Production (MT)</th>
<th>Planted area (ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Citrus</td>
<td>6853533</td>
<td>458813</td>
<td>24062</td>
</tr>
<tr>
<td>Pineapple</td>
<td>6238070</td>
<td>434769</td>
<td>11236</td>
</tr>
<tr>
<td>Mango</td>
<td>5064466</td>
<td>140290</td>
<td>17130</td>
</tr>
<tr>
<td>Pear</td>
<td>5079179</td>
<td>153450</td>
<td>8132</td>
</tr>
<tr>
<td>Grape</td>
<td>4311093</td>
<td>98091</td>
<td>3225</td>
</tr>
<tr>
<td>Banana</td>
<td>4400020</td>
<td>172550</td>
<td>12349</td>
</tr>
<tr>
<td>Longan</td>
<td>2663917</td>
<td>82602</td>
<td>11790</td>
</tr>
<tr>
<td>Sugar apple</td>
<td>2885177</td>
<td>70370</td>
<td>5987</td>
</tr>
<tr>
<td>Lychee</td>
<td>3113723</td>
<td>95440</td>
<td>12015</td>
</tr>
<tr>
<td>Guava</td>
<td>2739882</td>
<td>135303</td>
<td>7225</td>
</tr>
</tbody>
</table>
Table 3. The value, production and planted area of major vegetables in Taiwan in 2009

<table>
<thead>
<tr>
<th>Species</th>
<th>Value (1000US$)</th>
<th>Production (MT)</th>
<th>Planted area (ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bamboo shoot</td>
<td>230154.7</td>
<td>251994</td>
<td>27045</td>
</tr>
<tr>
<td>Other leafy vegetables</td>
<td>126681.4</td>
<td>242723</td>
<td>17556</td>
</tr>
<tr>
<td>Cabbage</td>
<td>109660.8</td>
<td>346297</td>
<td>8371</td>
</tr>
<tr>
<td>Scallion</td>
<td>96500.4</td>
<td>111347</td>
<td>5368</td>
</tr>
<tr>
<td>Watermelon</td>
<td>81244.6</td>
<td>217619</td>
<td>11925</td>
</tr>
<tr>
<td>Garlic bulbs</td>
<td>74399.9</td>
<td>49600</td>
<td>5477</td>
</tr>
<tr>
<td>Tomato</td>
<td>67985.4</td>
<td>99491</td>
<td>4104</td>
</tr>
<tr>
<td>Water bamboo</td>
<td>60789.4</td>
<td>46169</td>
<td>2057</td>
</tr>
<tr>
<td>Cauliflower</td>
<td>46068.8</td>
<td>76569</td>
<td>2976</td>
</tr>
<tr>
<td>Muskmelon</td>
<td>24840.0</td>
<td>26147</td>
<td>2099</td>
</tr>
</tbody>
</table>

However, extended cold storage always result in physiological disorders and abnormal fruit ripening, reducing consumer acceptance. In many commodities the severity of chilling injury (CI) increases when the fruit is refrigerated for prolonged periods at close to 0°C, but above fruit freezing point. These symptoms are important to commercial business since shipping of fruits to distant markets and storage before selling. In the past report of Taiwan, the guava symptoms of chilling injury appeared when fruits were stored at 1°C to 5°C for a period of 7 to 12 days and then placed at 20 to 25°C for 3 days. Guava fruit shows that abnormal ripening, pulp browning and water-soaking core, and the data suggest that 5°C to 10°C is the appropriate temperature for storage. For this reason, several physiological and physical researches of fruits and vegetables preventing chilling injury and other storage methods are developed. Furthermore, extension storage life and export horticultural products to markets in other country are always the continuously pursue goal of the industry.

**Postharvest Handling of Avocado in Taiwan**

**Introduction**

Avocado (*Persea Americana* Mill.), which has been referred as the most nutritious of all fruits, has worldwide recognition and significant volume in international trade. The unique fruit has been appreciated and utilized for at least 9,000 years in and near its center of origin in Meso-America. It is a polymorphic tree species that apparently originated in a broad geographical area stretching from the eastern and central highlands of Mexico through Guatemala to the Pacific region of Central America. Avocado produced a green-skinned, pear-shaped fruit that ripens after
harvesting, and is partially self-pollinating and often is propagated through grafting to maintain a predictable quality and quantity of the fruit.

**Ecological races and adaptations**

There were three distinct ecological species of avocado: The Mexico, Guatemalan and West Indian races. The Mexico species is grown at high elevated (1400-2500m) and cooler (14–19.8°C) areas, with rainfall from 600 to 1600mm and a half year dry season from winter to spring. The Guatemalan species is grown in the less extreme conditions. They are common in tropical highlands with all year-round cool conditions. The West-Indian avocado species is grown in lowland and in hot and humid Central American forests with a short dry season.

**World production and fruit composition**

Total world avocado production increased approximately 3.3-fold over 35-year period, from 697,869 tons reported from 76,770 ha in 1961 to 2,303,389 tons harvested from 339,141 ha in 1996. According to FAOSTAT Database, Mexico is the country that producing the most avocados around the world, Indonesia is the second, and the United States of America is the third (Table 4).

**The data is collected from FAO statistic database**

The avocado fruit is a traditional staple in Guatemala and nearby countries, the daily food of the labouring individual. It is also an ingredient of widely consumed for traditional foods. In some countries the fruit is eaten with sugar, in ice cream or mixing with milk. Avocados are high in valuable fats and appear to have a beneficial effect on blood serum levels. Avocados also have 60% more potassium than bananas, and rich in vitamins B (Table 5).

Table 4. The avocado production countries

<table>
<thead>
<tr>
<th>Rank</th>
<th>Country</th>
<th>Production Value (US 1,000)</th>
<th>Production (MT)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Mexico</td>
<td>668,586</td>
<td>1,040,390</td>
</tr>
<tr>
<td>2</td>
<td>Indonesia</td>
<td>169,381</td>
<td>263,575</td>
</tr>
<tr>
<td>3</td>
<td>United States of America</td>
<td>137,523</td>
<td>214,000</td>
</tr>
<tr>
<td>4</td>
<td>Colombia</td>
<td>119,408</td>
<td>185,811</td>
</tr>
<tr>
<td>5</td>
<td>Brazil</td>
<td>112,460</td>
<td>175,000</td>
</tr>
<tr>
<td>6</td>
<td>Chile</td>
<td>104,749</td>
<td>163,000</td>
</tr>
<tr>
<td>7</td>
<td>Dominican Republic</td>
<td>89,968</td>
<td>140,000</td>
</tr>
<tr>
<td>8</td>
<td>Peru</td>
<td>65,548</td>
<td>102,000</td>
</tr>
<tr>
<td>9</td>
<td>China</td>
<td>54,624</td>
<td>85,000</td>
</tr>
<tr>
<td>10</td>
<td>Ethiopia</td>
<td>52,374</td>
<td>81,500</td>
</tr>
<tr>
<td>Item</td>
<td>Avocado, raw (edible parts)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>----------------------</td>
<td>-----------------------------</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nutritional value per 100 g (3.5 oz)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Energy</td>
<td>670 kJ (160 kcal)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Carbohydrates</td>
<td>8.53 g</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sugars</td>
<td>0.66 g</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dietary fiber</td>
<td>6.7 g</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fat</td>
<td>14.66 g</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Protein</td>
<td>2 g</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Thiamine (Vit. B₁)</td>
<td>0.067 mg (5%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Riboflavin (Vit. B₂)</td>
<td>0.130 mg (9%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Niacin (Vit. B₃)</td>
<td>1.738 mg (12%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pantothenic acid (B₅)</td>
<td>1.389 mg (28%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Folate (Vit. B₉)</td>
<td>81 μg (20%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vitamin C</td>
<td>10 mg (17%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Magnesium</td>
<td>29 mg (8%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Phosphorus</td>
<td>52 mg (7%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Potassium</td>
<td>485 mg (10%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Zinc</td>
<td>0.64 mg (6%)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Percentages are relative to US recommendations for adults. (Source: USDA Nutrient database).

**Research of postharvest handling of avocado in Taiwan.**

In Taiwan, there are about 875 ha planted with avocado trees, and is considered as a new growing fruit industry. Avocados was imported first time in 1930. The avocado fields are spreaded in Chiayi and Tainan counties. The objectives of the research were to search for the most suitable storage conditions of the 'CASE3' avocado fruits, which is a popular variety in Taiwan and bred by TARI. The shape of 'CASE3' fruit is like pear and seed is middle size. The fresh weight, seed weight, dry matter content and crude fat content of 'CASE3' avocado fruits increased with the delaying of harvest date. Its major harvest season is from August to October.

**The effect of different storage temperature and storage period to the fruit quality**

The ripening quality of 'CASE3' avocado fruits are influenced by storage temperature and time. High temperature will induce rotten while low temperature will induce chilling injury. In order to know the effect of storage temperature and storage period of 'CASE3' fruit quality, fruit were stored at different temperatures at 1, 3, 6, 9, 12, 15°C for 2, 4, 6, and 8 weeks, respectively.
After storage, fruits were treated with Ethrel (diluted 1000X) for 12 hours and stored at 25°C, 85% RH to observe the change of their quality of fruit. The result (Fig. 3, Table 6) shows that 'CASE3' avocado fruits stored at 1°C and 3°C after two weeks would exhibit chilling injury (CI) symptom, as peel color change abnormally and pulp could not soften normally. Fruit pulp stored at 6°C after 8 weeks might soften, but fruit pulp mostly become brown. The fruit produced fetid odor and lost the edible value. Fruit pulp which stored at 9°C after 4 and 6 weeks could soften normally, and the color of pulp was in normal yellow. The fruits stored at 12°C after 4 weeks would be soften rottenly, similar result at 15°C after 2 weeks storage. These results indicate that optimal storage temperature for 'CASE3' avocado fruits is 9°C and the fruit could ripen normally without pulp browning after storage for 6 weeks.

Fig. 3. The fruits of “CASE3” avocado stored at 1, 3, 6, 9, 12, and 15°C for 2, 4, 6, and 8 weeks, respectively. (Source: Dr. Ching-Chang Shiesh)
The influence of ethylene absorbent on avocado fruit

The avocado (*Persea americana* Mill.) is a climacteric fruit that is characterized by a surge in ethylene production at the onset of ripening. This climacteric increase in ethylene production is associated with hastened ripening. Avocado is one of the most rapidly ripening fruits. It often ripen completely within 5 to 7 days after harvest.

To know the influence of ethylene absorbent on avocado fruit, ethylene absorbent was put in the PE bag with fruits stored at 9°C for 2 months. After the fruits were treated with Ethrel (diluted 1000X) for 12 hours and stored at 25°C, RH:85% to observe the quality of fruits, color of pulp and peel turn brown and pulp became soft after four days of treatment. The fruits treated with ethylene absorbent maintained normally in peel color and pulp firmness.

![Fig. 4. The effect of ethylene absorbent on avocado fruits 4 days after storage at 9°C for 2 months and Ethrel treatment. (Source: Dr. Ching-Chang Shiesh)](image-url)
Table 6. The pulp firmness of “CASE3” avocado fruit stored at 1, 3, 6, 9, 12, 15°C for 2, 4, 6, and 8 weeks, respectively

<table>
<thead>
<tr>
<th>Storage temperature</th>
<th>Pulp firmness (N)</th>
<th>Storage time</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2 weeks</td>
<td>4 weeks</td>
</tr>
<tr>
<td>H</td>
<td>26.6 b</td>
<td>26.6 b</td>
</tr>
<tr>
<td>1°C</td>
<td>3.9 b</td>
<td>131.0 a</td>
</tr>
<tr>
<td>3°C</td>
<td>3.1 b</td>
<td>115.6 a</td>
</tr>
<tr>
<td>6°C</td>
<td>0.3 b</td>
<td>12.1 b</td>
</tr>
<tr>
<td>9°C</td>
<td>0.0 b</td>
<td>3.4 b</td>
</tr>
<tr>
<td>12°C</td>
<td>0.0 b</td>
<td>0.0 b</td>
</tr>
<tr>
<td>15°C</td>
<td>0.0 b</td>
<td>--</td>
</tr>
</tbody>
</table>

* Means with same letters within a column are not significantly different by Duncan’s Multiple Range Test at 5% level.

y H=evaluated after ripening at 25°C for 4 days, no stored.

Table 7. The influence of ethylene absorbent on pulp color and pulp firmness

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Pulp color</th>
<th>Pulp firmness (N)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>L</td>
<td>a*</td>
</tr>
<tr>
<td>CK</td>
<td>35.4 b</td>
<td>9.1 a</td>
</tr>
<tr>
<td>Ethylene absorbent</td>
<td>67.7 a</td>
<td>2.6 b</td>
</tr>
</tbody>
</table>

* Means with same letters within a column are not significantly different by Duncan’s Multiple Range Test at 5% level.

The influence of ethylene inhibitor (1-MCP) on avocado fruit

1-MCP (1-methylcyclopropene) has been shown to delay ripening and improve storage quality of climacteric fruits including avocado. 1-MCP and fruit was both put in a 0.03 mm thickness PE bag. In control the fruit was put in PE bag without 1-MCP. Then they were stored at 9°C for 4 to 6 weeks. After storage, they were treated with Ethrel (diluted 1000X) for 12 hours and kept at 25°C, 85% RH for 4 days to observe the quality of fruits. In Table 8, the peer color of fruit treated with 1-MCP has higher L, a*, C and H value. The a* value is -8.2 compared to the control with a value of 7.5. The peer color without 1-MCP turn red while the peer color of 1-MCP treatment maintained normal green. The pulp color of fruit of 1-MCP treatment is better than control. Both of them have high firmness. On the other hand the respiration rate and ethylene production rate of fruits treated with 1-MCP are higher than control after have treated with Ethrel (Table 9).
Table 8. The effect of 1-MCP treatment on the peel color and pulp color of avocado fruits.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>L</th>
<th>a*</th>
<th>b*</th>
<th>C</th>
<th>H</th>
</tr>
</thead>
<tbody>
<tr>
<td>Peel color</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CK</td>
<td>32.7</td>
<td>7.5</td>
<td>17.7</td>
<td>20.1</td>
<td>63.7</td>
</tr>
<tr>
<td>1-MCP</td>
<td>47.3</td>
<td>-8.2</td>
<td>35.6</td>
<td>36.5</td>
<td>102.7</td>
</tr>
<tr>
<td>Pulp color</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CK</td>
<td>66.9</td>
<td>-0.6</td>
<td>42.4</td>
<td>42.6</td>
<td>90.5</td>
</tr>
<tr>
<td>1-MCP</td>
<td>71.5</td>
<td>-2.2</td>
<td>46.3</td>
<td>46.4</td>
<td>92.4</td>
</tr>
</tbody>
</table>

Table 9. The respiration rate, ethylene production, and firmness of avocado fruits after treated with 1-MCP.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Respiration rate (mlCO₂/kg-hr)</th>
<th>Ethylene production rate (µl C₂H₄/kg-hr)</th>
<th>Firmness (N)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CK</td>
<td>115.0</td>
<td>1.6</td>
<td>8.4</td>
</tr>
<tr>
<td>1-MCP</td>
<td>122.7</td>
<td>90.5</td>
<td>110.7</td>
</tr>
</tbody>
</table>

**Conclusion**

Many countries wish to export their products to other countries. Difficulty exists in passing the quarantine requirements imposed by importing countries. The development of more advanced technologies on this purpose should be emphasized and proceeded continuously. Until now, high quality, safety, and good appearance become more important at present and future. Recent progress has been based on good cooperation between postharvest scientists and government coordinators. It helps in improving the quality of fresh produce at the markets. Farmers can get the benefits from reduced postharvest losses and increased value-added products.

**Acknowledgements**

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**References**


Technology on Reducing Post-harvest Losses and Maintaining Quality of Fruits and Vegetables in India

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Abstract

Fruits and vegetables are highly perishable in nature. A considerable amount of these commodities produced in India is lost due to improper postharvest operations; as a result there is considerable gap between gross production and net availability. Post harvest loss reduction is essential to make available more food from the existing level of production. The losses can be minimized by following simple management practices, such as, sorting and grading, pre-cooling, suitable packaging, proper handling, storage and supply chain management. Therefore, to achieve the target of feeding the growing population as well as meeting the requirements of the processing industry and export trade, only increasing the production and productivity will not be enough. A lot more emphasis needs to be given to post harvest management and maintaining quality of these highly perishable crops.

Introduction

India being a home of wide variety of fruits and vegetables holds a unique position in production among other countries. The diverse agro climatic conditions in the country make it possible to grow almost all varieties of fruits and vegetables. Recent economic growth and changes in dietary patterns have made both the production and consumption of fruit and vegetables increasingly important. The fruit and vegetable sector has a vital role in farm income enhancement, poverty alleviation, food security, and sustainable agriculture. This sector plays a significant role in Indian agriculture. The contribution of horticultural crops towards agricultural output and export earning of total agricultural produce is very high considering the percent area covered by these crops. The horticulture sector contributes around 28% of the GDP from about 13.08 % of the area and 37% of the total exports of agricultural commodities in the country. Although India is a major producer of horticultural crops, many Indians are unable to obtain their daily requirement of fruits and vegetables, a considerable amount of fruits and vegetables produced lost due to improper post harvest operations; as a result there is a considerable gap between the gross production and net availability. Furthermore, only a small fraction of fruits and vegetables is utilized for processing compared to other countries.
India with its current production of around 62.8 million MT, accounts for about 11% of the world’s fruit production. The area under fruit crops in India is 5.81 million ha with a production of 62.86 million tons. Among the horticulture crops, at present fruits crops recorded a two folds increase in area and production as compared to 1991-92. India occupies first place in the production of mango, banana, papaya, pomegranate, sapota, aonla and acid lime. About 39% of the world mango and 23% banana are produced in the country. Major fruit producing areas are distributed in subtropical and tropical parts of the country and a limited area has been harnessed in the temperate region. It is a matter of great concern that approximately 25 to 30% of fruits are lost during transit and storage, highest being about 40% in banana followed by mango. As a result the net quantity reaching the consumers is about 90 g of per capita availability daily as against a recommended consumption of 120 g per capita/ day. One of the factors aggravating post harvest losses of fruits which are seasonal and perishable is the utilization of very meager quantities for processing. Less than two percent of total fruits are processed for various products.

India has emerged as the second largest producer of vegetables with a total estimated production of 122.26 million tons from an area of 6.15 million ha with productivity level of 15.82 ton per hectare. In the last one and half decade, country’s vegetable production has almost doubled and gross vegetable productivity of the country by one and half times. Presently, India’s share is 11% of total world production of vegetables. But less than 2% of the total vegetable production in the country is commercially processed as compared to 70-80% in developed countries. Major contribution to vegetables comes from potato, tomato, brinjal, okra, beans and cucurbits. India is the first in cauliflower production, second in onion production and third in cabbage production in the world. Still, per capita availability of vegetables is 190 grams against the requirement of 280 grams.

**Present Status of Post Harvest Technology in India**

India has a strong in horticulture production base. However, among other things, the lack of a modern supply chain including cold chains has prevented this strength from being fully leveraged either for exports or for processing. As a result India has a little over 1% share of global fruit and vegetable exports despite having over 10% of the world’s production of fruits and vegetables. At the same time, considerable postharvest losses occur in fruits and vegetables, owing to the lack of suitable harvesting equipment, collection centers in major producing areas, suitable packing containers, commercial storage facilities, a cold chain and proper transportation systems. Losses in fruits and vegetables are estimated about 30% due to mismanagement, valued at nearly Rs. 13600 core in fruits and Rs. 14100 core in vegetables annually depending upon the fruit variety and the postharvest handling system. Spoilage of fresh produce is also accelerated by the hot and humid climate of the region.

The small farmers lack resources and are unable to market their produce and implement suitable postharvest handling practices. Therefore, to achieve the target of feeding the growing
population as well as meeting the requirements of the processing industry and export trade, only increasing the production and productivity will not be enough. A lot more emphasis needs to be given to post harvest management and maintaining quality of these highly perishable crops. The only way to cope with the present situation is to give a massive thrust to post harvest loss reduction in order to make available more food from the existing level of production. To achieve the target we shall have to adopt advanced technology in our post-production system of horticultural produce. The detailed analysis of current status of post harvest technology in India is as under:

**New Initiatives for Development of the Sector**

In past few years, considerable emphasis has been given to the production of horticultural crops in India. There is sharp increase in budgetary allocation in horticulture sector from IV to X plan i.e. 1700 times for research and 5800 times in respect of development programmes. At present the programmes related to horticulture crops form approximately 30 percent of the total outlay of agriculture development of the Department of Agriculture & cooperation. Five new development programmes launched during the X plan namely; Technology Mission for Integrated Horticulture Development in North-East region & Himalayan States, National Horticulture Mission, National Mission on Medicinal Plants, National Bamboo Mission and Micro Irrigation Mission to achieve the transformation of horticulture utilizing the technology. These programmes have been invested Rs. 2400 crore during X plan and continuing during XI plan with budgetary support of Rs. 14134 crore for overall development of Horticulture sector with end to end approach.

The efforts in the investment have been rewarding and the area under horticultural crops has been increasing. The increase in area which was 2.3% and 2.43 %during the VIII and IX plan significantly went up to 6.6% in the X plan. Accordingly, the area under fruits from 3.8 million hectares in 1999 has increased up to 5.81 million hectares in 2008 with an increased production of about 20 million tons. The area under vegetable cultivation also showed a similar increase of 1.85 million ha from 1999 to 2008 with an increased production of 34.67 million tons.

The new schemes are having provision of financial assistance for establishment of post harvest infrastructure to increase marketability of horticulture produce, adding value to produce, increasing profitability and reducing losses. Different post harvest activities like establishment of pack houses, pre-cooling units, mobile pre-cooling units, cold storage units, controlled (CA) storage,/ modified atmosphere (MA) storage, refrigerated vans/ containers/ mobile processing units, ripening chambers, evaporative/ low energy cool chambers, preservation units, onion storage units and zero energy cool chambers etc. being supported under the schemes. To induce investment from private sector in marketing related activities provision of assistance for wholesale markets, rural markets/ apni mandi and retail markets, static mobile vending cart platform with cool chamber etc. have also been made under National Horticulture Mission.
Infrastructure for Technology Development

Horticulture research in India received a boost with the establishment of Indian Institute of Horticulture Research Institute, Bangalore in 4th five year plan (1969 to 74). Rapid expansion of horticulture research infrastructure took place in 7th and 8th plans. Today India has dedicated research infrastructure by way of 10 central Institutes with 27 regional stations, two full fledge State Universities on Horticulture (each in Himachal and Andhra Pradesh), 28 State Agricultural Universities and 15 central/general/deemed to be universities with Horticulture discipline.

Postharvest research is currently conducted mainly by the CFTRI, Mysore, CIPHET, Ludhiana, RRL, Jammu and BARC, Mumbai, CSIR laboratory, Palampur and the DFRL, Mysore. Relatively little emphasis was given to research and postharvest technology in the ICAR system until the late seventies. An All India Coordinated Research Project on Postharvest Technology (AICRP) of horticultural crops was started by the ICAR in August 1978 and four centers in the country (IARI, New Delhi; CMRS, Lucknow; IIHR, Bangalore and YSPUHF, Solan). During the 6th plan the AICRP (PHT) was continued by the ICAR and was strengthened by adding four new centers, i.e., TNAU, Periyakalam, KKV, Dapoli, HAU, Hisar and ICAR-RC, Shillong during 7th and 8th plans, four more centers were added, i.e., BCKVV, Kalyani; MPKVV, Rahuri and RAU, Pusa, Bihar, bringing the total to 11 centers under the project.

Packing Stations

Pack houses have sorting, washing, grading, packaging and labeling facilities in addition to pre-cooling. In most of the growing areas, there is lack of the concept of establishing packing stations in India. Fruits and vegetables are generally packed in the field without any pretreatment. In absence of packing station concept, large volumes of the inedible parts of fruits and vegetables are transported to the markets from the field. This increase the cost of transportation and inedible parts ultimately cause sanitation problems.

Recently, several modern pack houses have been established with washing/ cleaning, sorting, grading, waxing, and packaging facilities for fruits and vegetables in the country. National Horticulture Mission, National Horticulture Board and APEDA supported pack house activities by providing financial assistance for establishing these facilities for fruits and vegetables. In modern pack houses most of these operations are done automatically under a cooled house. Belt conveyor conveys the materials form reception to a jet washer. Jet washer removes the dirt and cleans the surface under forced jet of water. After this the produce is graded into three to four grades based on size by power operated size grader. In some cases surface of fruits/ vegetables waxed with edible waxes to have good appearances and enhances shelf life.

Primary Processing

The minimal processing of fruits and vegetables is an area which offers considerable potential for development of the fruit and vegetable sector. Consumers in metro cities are increasingly
demanding ready to eat fruits and vegetables, with a fresh like quality containing only natural ingredients. This has been mainly due to changing life styles. These changing trends have led to increased demand for fresh cut or ready to eat fruits and vegetables. In addition to convenience, consumers perceive fresh-cut produce to be good value of its freshness, cent percent edible food of high quality nutrition.

Today, minimally processing of vegetables such as cauliflower, peas, leafy vegetables, etc has started at some packing stations immediately after harvesting, through the removal of inedible parts and being marketed in metro city markets in unit packs. Consumer friendly products like frozen green peas, ready to use salad mixes, vegetable sprouts, ready-to-cook fresh cut vegetables are major primary processed retail items. Minimally processed produce, however, deteriorates at a much faster rate than does intact fruits and vegetables. Stringent quality management systems such as Good Manufacturing Practices (GMP) and Hazard Analysis and Critical Control Point (HACCP) as well as proper packaging and temperature management are, therefore, required to assure its safety and freshness.

Packaging and Transportation

Packaging is an integral element in the marketing of fresh horticultural produce and it is link between the producer and consumer. It requires at both the stages i.e. from field to market and processor to consumer. From field to market traditional forms of packaging such as bamboo baskets, wooden boxes and gunny sacks are still widely used but plastic crates are gaining more popularity as a packaging material for transport of fruits and vegetables. Considerable work has been done by different agencies in introducing alternative types of packaging. The ventilated CFB box which contains ventilated partitions is found ideal for the packaging and transportation of fruits, owing to the comparably minimal level of bruising observed in these boxes.

Packaging provides handling facilities for loading, transport & storage for both the processor and consumer. Modern technology and changes in consumer demand for convenience and packaged foods, have given both for the development of new packaging material, packaging techniques, machinery, graphics, computer design etc. There is an increasing demand for the new specific and innovative packaging techniques for processed foods. India is a fast emerging market for canned fruits and vegetables. Potatoes, cauliflower, tomato are canned in dry either in natural form or curried type using spices.

Cold Storage

Exposure to the high temperature is the biggest factor in the post harvest losses of fruits and vegetables. The ideal condition for storage of fresh fruits and vegetables is the lowest temperature which does not cause chilling injury. This can be maintained by different type of cooling systems. Cold storages have existed in India from decades for storing perishables. India has more than 5000 cold stores with about 22 million metric tons capacity out which 80% are almost dedicated for
potatoes only and about 17% fall under multi commodity category. Surprisingly only 2-3% of its capacity is utilized for storage of other fruits and vegetables. Most of these units do not have facilities to store a wide range of products across varied temperature ranges. Mainly cold stores are designed for storage of potatoes and in similar conditions fruits and vegetables are stored. In addition to this, different types of fruits and vegetables, which are not compatible to each other, are stored together and causes post harvest losses in different form even in the cold store. The technology in use for cold storage has also largely based on the principle of evaporative cooling with the use of diffusers and bunker coils. The last few years have seen replacement of ammonia with Freon.

The major constraints in the development of cold storage industry in India are high capital cost, high electricity tariffs causing increased operational cost, non-adoption of energy efficient technology and non-professional management. Uninterrupted power supply is essential for cold storage facility which is not always available readily. If refrigeration plant is failed even for a small period and temperature of cold stores increased, induce thermal shock to the produce and causes accelerated loss during storage. Cooling operation is generally for quality; however temperature control is also useful to inhibit the growth of pathogenic bacteria. Therefore, stakeholders at both the ends of value chain farmers and consumers must be aware about the benefits of it.

Cold storage activities in India are limited mostly to tuber crops, onion and Cole crops. Spices like chillies and tamarind are stored largely in cold storages. Apple has been chosen as one to build infrastructure around it as it lends itself to longer duration storage of 8 to 10 months when stored under controlled climatic conditions which is limited to a few weeks under ambient storage conditions. Banana and Mango constitute over 50 percent of the total fruits produced in the country. Litchi, grapes, pomegranate, potato, onion, Chillies are another ideally suited crops for cold chain.

**Control Atmosphere/Modified Atmosphere Storage**

Modified atmosphere (MA) essentially means any deviation from the normal atmospheric gas composition. If this deviation is strictly controlled with certain specific gaseous concentrations of \( N_2 \), \( CO_2 \) and \( O_2 \) then it is termed as "Controlled Atmosphere" (CA). Usually modification of atmospheres during storage of fruits and vegetables involve reduction in oxygen (\( O_2 \)) and/or elevation of carbon dioxide (\( CO_2 \)) concentrations. The use of CA/MA should be considered as a supplementary practice to proper temperature and relative humidity management.

The beneficial effects of CA/MA treatments are retardation of ripening, senescence and physiological changes. In addition it helps in reducing the physiological disorders, e.g. chilling injury of various commodities. Modified atmosphere can have a useful tool for control of certain insects. However, there are certain limitations such as irregular ripening, development of off
flavors and stimulation of sprouting etc. if not properly carried out. The design and construction of controlled atmosphere stores require precision control of the system. The controlled atmosphere store has to be relatively gas tight, and fitted with reliable refrigeration system with a means of measuring and controlling the concentrations of both carbon dioxide and oxygen. Now establishment of CA/MA storages have been started in India after having provision of financial assistance under National Horticulture Mission and National Horticulture Board schemes.

**Cold/Cool Chain**

While India’s strength in the horticultural sector has led to a large production base of fruits and vegetables, the enormous amount of wastages (estimated to the extent of 30%) due to inefficient supply chain has prevented the farmers and processors from reaping the benefits. Eliminating field heat immediately after harvest is very important for extending the shelf life and quality of fresh fruits and vegetables. For this, maintenance of cold chain from grower to the consumer is of crucial relevance for maintaining quality of the product. Cold chain refers to a complete set of supply chain involving the production, storage and distribution of perishable products that require temperature control in order to keep the products characteristics, freshness and nutritive values retained for longer duration. This requires control over various factors such as fluctuations in temperature and humidity and impact from incorrect handling across the supply chain.

The cold chain industry in India consists of a dozen large players such as snowman, Frick India, Voltas Ltd, Blue Star etc. that provide services ranging from refrigeration equipments and storage services to integrated logistics. The services being presently provided rarely cover the entire country leading to breakage in cold chain and consequent produce wastages. Cold chain activities in India are fragmented and mostly confined to retail markets and cold storages. The key issues in the agri-logistics related to the development of the cold chain industry are of non-standard pricing, lack of scientific handling of produce and consequent high prices and limited choices for the consumers. The cold chain operators also do not have knowledge about what treatment and handling to accord to which produce and what sort of cold chain configuration is required for which produce. In addition to the above factors, the perishable nature of the commodity class and the fact that the requirement for cold chain varies across each commodity even within the same class makes the task very complicated.

Despite fairly widespread awareness on the need for a strong cold chain network, adoption in India is continues to be low. Although, the recent development of direct retailing in domestic segment has demonstrated the success and utility of captive end-to-end cold chain in India including that of refer transportation. Desai fruits and vegetables in Gujarat, Namdhari fresh in Karnataka, Adani Agrifresh in Himachal Pradesh are some of the few models in private sector in direct retailing with established cold chain to ensure quality of produce. The cold chain not only
helps in enhancing the shelf life but more importantly the ripening chambers help overcome the
health issues associated with common ripening systems using carbide. India’s rapid economic
growth and ongoing consumer boom have contributed greatly to the growth of retail sector. The
maintenance of low temperatures at different stages of handling by maintaining cold chain helps in
reducing losses and retaining the quality of fruits and vegetables...

The requirements for cold chain extend right across the product value chain and can be very
complicated depending upon the nature of the produce and the ultimate customer preference. The
possible routes of fruits and vegetables in the country may be as under:

I. Harvest- Primary Market Transport- Secondary Market Transport- Processor- Consumer
II. Harvest- Pre-cooling- Packaging- Reefer Transport- Perishable Center Handover- Doc
Unloading- Dispatch- Tarmac- Aircraft

Processing

Presently, less than 2% of fruits and vegetables are processed in India. The prominent items
processed in fruit and vegetable processing sector are fruit pulps and juices, fruit based ready to
serve beverages, canned fruits, and vegetables, jams, squashes, preserve, ketchups, sauces, pickles,
chutneys and dehydrated vegetables. The industry has also taken up the processing of frozen pulp
and vegetables, freeze-dried fruits and vegetables, fruit juice concentrates, preserved garlic, ginger
and onion pastes etc. Development of new products like juice punches, banana chips and fingers,
mango nectar and fruit kernel essential oil from citrus, fruit wines, dehydrated products from
grapes, pomegranate, mango and coconut etc. are getting popularity day by day.

The number of processing units based on fruits and vegetables and their installed capacity are
increasing at a compound growth rate (CGR) of 3.68 percent and 10.04 percent per annum
respectively. However, the actual capacity utilization is about 47 percent. Among the components
of processed fruit and vegetable products basket, dried and preserved vegetables accounts for the
highest at 60% followed by mango pulp (15%), pickles and chutney (11%) and other processed
fruit and vegetables (13%).

The fruit and vegetable processing industry has been faced with the problems of quality raw
material, capacity utilization, transfer of technology being difficult due to majority of the units
being in cottage and home scale sector. The recent innovations, if properly utilized, would help
overcome the problems of marketing.

Marketing

Due to presence of too many intermediaries and concentration of trade in few hands resulting
in exploitation of the growers – sellers, the producer’s share in consumer rupee is low. However, in
view of the increased production of fruits and vegetables and also to sustain the interest of the
cultivators and also to motivate them to produce more, it is imperative that they get a reasonably
high price for their produce. It is also essential to identify the best channel of marketing which ensures this.

Pre-harvest contractors (PHC) are found to be predominant in marketing of fruits as about 75% of fruits has been marketed through PHC. Thus, pre-dominance of PHC in fruit marketing is still continuing despite the fact that it is not desirable practice. The studies on vegetables have shown the pre-dominance of commission agents in their marketing and commission charges is one of the major components of marketing costs.

Transformation is taking place in marketing of high value commodities like fruits and vegetables due to globalization and liberalization. Accordingly procurement and distribution system for fruit and vegetables is also witnessing changes in the form of contract farming, growers associations, cooperative marketing and also integration of production and marketing through processing. Of late super markets (Retail supply chain) are entering the fruit and vegetable marketing in a big way.

**Quality and Safety**

The quality of fruits and vegetables can be defined on the basis of external, internal and hidden attributes. External attributes are size, shape, color, firmness, defects etc. The internal attributes may be aroma, taste etc. Combination of external and internal attributes generally determines the acceptability of fruits and vegetables. Hidden attributes may be wholesomeness, nutritional value (vitamins, minerals, fiber etc.), and safety aspects (natural occurring toxicants, chemicals residues, heavy metals etc.).

Fresh fruits and vegetables are living tissues which are subject to continuous change after harvest. While some of the changes are desirable, most are not desirable from consumer’s standpoint. Grade standards identify the degree of quality in a given commodity that provides the basis for its usability and value. Due to globalization of trade, 32 important fruits and vegetables grade standards have been harmonized with international standards viz; Codex, EC etc. and notified. Grade standards of another 7 fruits and vegetables are at various stages of finalization and notification. This provides recommendations for proper packaging and transport of fresh fruits and vegetables in order to maintain produce quality during transportation and marketing.

In response to consumer concerns, many retailers in various countries require growers to have independent third party inspections of farms to ensure that fruits and vegetables are being grown, harvested and packed using Good Agricultural Practices (GAPs), Good Hygienic Practices (GHPs), Good Manufacturing Practices (GMPs) etc. These programmes have developed rapidly over the past decade and many growing packing operations are being inspected by the agencies approved by the retailers. EUREPGAP/ GLOBAL GAP, Hazard Analysis and Critical Control Point (HACCP), British Retail Consortium (BRC), ISO- 22000 standards, etc. are worth mentioning in this regard.
In India, the farmers generally bring fruits and vegetables to the market without grading and packing. There is need to encourage grading, packing and labeling at farmers level to ensure uniformity and traceability. The cold chain needs to be developed to reduce post harvest wastages and ensure quality and safety of fresh fruits and vegetables. GAPs, GHPs, GMPs and other Food Safety Management Systems need to be promoted amongst farmers and other stakeholders in supply chain to ensure safety of fresh fruits and vegetables.

**Modern Processing Techniques**

Several new R&D innovations have been made in the field of value addition of fruits and vegetables from different organizations. Some of the new technologies replacing conventional processes are as under:

a. High pressure processing  
b. Ohmic heating  
c. Microwave heat processing  
d. Irradiation  
e. Extrusion Processing

The future thrust areas may be oriented towards popularizing these new technologies giving safe packaged large amounts of fruits and vegetables.

**Conclusion**

The perishable fruits and vegetables need very careful handling at every stage starting from pre-harvest to harvest, sorting, grading, packaging, marketing and storage. For preventing the post harvest losses proper storage, cold preservation, packaging and transport methods with Hazard analysis Critical Control Point (HACCP) norms have to be given more thrust. The cold chain system is effective in reducing postharvest losses in fruits and vegetables. For this infrastructure at proper place and proper time is a key element for post harvest management and value addition of fruits and vegetables. Development of cold chain in rural areas presents the biggest challenge due to lack of existing infrastructure, poor financial strength of the farmers. This can, however, be circumvented through the adoption of an integrated cluster approach involving aggregation of villages in the form of clusters. This can be done in an effective manner wherein infrastructural facilities (pre-cooling and pack houses) can be provided in a pooled manner to the farmers as it would enable risk sharing, improved marketing and market power among producers besides going long way in assuring quality control and economies of scale. Pooling refers to the combination of production from many producers under the marketing skills of a specialized staff.

Most of the fruits and vegetables flow to the primary markets from where they change multiple hands before reaching the ultimate consumer. Lack of facilities along the transportation
route increase the wastage and deteriorate the quality. Hence an effective cold chain network at these places is need of the hour. Diversification of the processed product base, including the production of low alcoholic fermented beverages to make use of surplus quantities of fruit, could be one of the several approaches to reduce the postharvest losses in the country. The quality and safety issues of fruit and vegetable products (freedom from microbial toxin & pesticide residues) is also need to be given greater attention in view of its significant implications for human health.

Based on the information given above the following efforts are needed to accelerate the pace of development of post-harvest infrastructure in the country.

1. Intensify the use of proper harvesting tools and gadget.
2. Popularize low cost sorting, grading equipment at farm level.
3. Popularize mobile sorting, grading, waxing and packaging concept on farm.
4. Develop marketing concept for minimally processed foods at production catchment.
5. Develop clusters of modern food factories in production catchment with good market links.
6. Develop facilities for hands on training in modern food factories.
7. Develop novel value added products from ethnic fruits & vegetable for niche market and export as health foods.
8. Encourage the corporate sector to undertake contract farming of crops to keep away multiple intermediaries between grower and processor.
9. Introduce private and corporate entrepreneurs in sharing investment in the establishment of efficient marketing systems.

References

2. Indian Horticultural congress, 2004. held at New Delhi during 6–9 November 2004 organized by Horticultural Society of India.
3. Agriculture Summit, 2006. Held at Nee Delhi, October 18, 2006, organized by Federation of Indian Chambers of Commerce and Industry.
An Overview on Postharvest Sector in Jordan

Mohammad awaidah
Jordan

Introduction

Jordan has a very significant comparative advantage in the production and export of high value horticultural commodities during the off-season period, due to its location, unique climatic conditions, and proximity to traditional markets (Arab Gulf-States, Syria, Lebanon and Iraq) and EU eastern and western markets as compared to many other countries. Western Europe is the world’s largest importing region for fresh fruit and vegetables, and Jordan initiated research to define market opportunities in Europe since 1991.

Jordan produces a wide range of horticultural crops almost year round. The Jordan valley which consider as a natural big green house make Jordan a good fresh fruit producer in winter season that could be exported to Europe. Jordan also produces horticultural crops in summer time at the high land areas to be exported to the Gulf-States where it’s almost impossible to produce there under a very hot weather. Jordan is more than self-sufficient in most vegetables crops and self-sufficient in a few fruit crops.

Although Jordan have witnessed a tremendous change horizontally and vertically on fresh fruit and vegetables production during the last four decades, the post harvest sector has remained relatively unchanged, with high post harvest losses percentage, inefficient marketing systems, weak research and development capacity, and improper policies, infrastructure and information exchange. Such constraints within the post harvest sector have drawn the attention of the concerned agencies dealing with horticultural crops either from the public sector or from the private sector.

Post Harvest Losses

The range of post harvest losses in fruit and vegetables is estimated to be 5-20% in developed countries, and 20-50% in developed countries depending on the commodity. To reduce these losses percentages we must understand the biological and environmental factors involved in fruits deterioration, then use the post harvest technology procedures which will maintain quality and delay deterioration.

In Jordan, the post harvest sector is highly influenced by the marketing system. The marketing system of fresh horticultural crops suffers from different problems or constrains that limit the development of this sector. These problems and constrains affect either directly or indirectly the post harvest losses of horticultural commodities. Marketing problems and constrains can be divided in to subgroup in Jordan as follows:
Post harvest losses in Jordan are within the range of losses of many developing countries. Several studies had been conducted to estimate the losses for some important crops. The results revealed that the losses are high. The post harvest percentage losses were (19, 22, 23, and 18%) for tomatoes, squash, sweet pepper and eggplant, respectively. More investigation is required to determine the size of the problem in Jordan.

The post harvest losses causes in Jordan

1- Improper harvesting stage of maturity (immature, over ripe)
2- Improper postharvest handling practices in the marketing chain (field, wholesale markets, packing house of export firms, cold storages, transportation means, retailers and consumers).
3 - Improper packing (overfilling and over staking).
4- Improper package (poor material and design).
5- Absence of pre-cooling.
6 - Improper loading and unloading.
7- Absence of sorting any fruit not marketable from the field.
8- Water loss.
9- Poor temperature and relative humidity management.
10- Losses due to physiological, mechanical and pathological disorder.
11- Exposing the product to an appropriate conditions (light, temperature, relative humidity, rain, winds, ethylene).
12- In adequate transport means.

Infrastructures required for healthy marketing sector in Jordan

1- Efficient wholesale markets.
2- Packing house with grading machines
3- Efficient exporting firms.
4- Cold storages.
5- Apropraiate ripening rooms.
6- Transportation means.
7- Pre-cooling units.
8- Package factories.
9- Marketing services

Export firms

There are two kinds of export firms in Jordan, depending on the targeted market. First kind is the export firms for the traditional markets (Arab Gulf-States, Syria, Lebanon and Iraq), and the second kind is the export firms to eastern and western Europe countries.
Traditional export firms

There are 40 export firms to the traditional markets. All of them are owned by private sector.

Export firms to Europe

There are 18 export firms to Europe.

Cold storage facilities

There are 60 cold storage facilities distributed in Jordan, with a storage capacity of 85,000 ton.

Ripening rooms

There are 73 ripening room facilities, 58 of them in Amman while the rest distributed in the cities of Jordan.

Transportation means

In Jordan, Mini-trucks, trucks, refrigerated trucks and airplanes are used to move fresh horticultural crops from shipping point to the destination markets. The major portion of exported crops is transported by refrigerated trucks mainly to the Arab Gulf-States, Syria, Lebanon, Iraq and Eastern Europe countries.

Pre-cooling facilities

Pre-cooling is removal of field heat from the fruits as soon as possible after harvest. This technology leads to a reduction in plant or plant part the following:

1- Respiration rate.
2- Water loss.
3- Ethylene production.
4- Pathogen infection.
5- Delaying ripening and senescence.

In Jordan, the pre-cooling concept is still limited for small-scale growers and unknown for many shippers (mainly shippers of traditional markets).

Packing and packages factories

Polystyrene. Plastic, carton and wooden boxes are used in Jordan for both local and export markets. Eight polystyrene factories located at different locations producing packages with several dimensions with a processing capacity to manufacture between 50,000 to 500,000 boxes a day. There are four factories producing more than 7 million of plastic boxes of different sizes annually. Four factories processing carton boxes. There are 20 manufacturing workshops for wooden boxes with different sizes and styles are operating in Jordan.
Vision for an active and an efficient marketing system for Jordan

1- An independent governmental umbrella involved only with marketing of fresh horticultural crops, and strongly cooperate with private sector.
2- Qualified staff for both private and public sectors in the methods of production and marketing to insure high quality product.
3- Orientation the production in accordance with market demand.
4- Adequate infrastructure and marketing services.
5- Database and market information intelligence.
6- Budget financing agency for pre and postharvest technology required.
7- Strict and efficient legislations.
8- Inefficient exporting firms.
9- An active quality control system
10- Straight forward training programs for growers on production (cultural practices) techniques and proper postharvest handling practices.

Post-harvest Losses of Tomatoes and Eggplants
Produced for Local Market in Jordan

Introduction

Jordan produces a wide variety of horticultural crops around the year. Such an advantage is created by the combination of climate, soil, and topography of growing areas, namely the Jordan valley and the Uplands.

Tomato and eggplant are considered as fleshy fruit vegetables, although differ in their physiological characteristics from postharvest point of view. Tomato fruit, harvested mature, is a typical climacteric fruit, undergoes different metabolic changes associated with ripening in coordination with a climacteric rise in respiration, which marks the transition stage in the fruit development between maturation and senescence [2]. When harvested at the mature green stage, the fruit continues to develop and ripen similar to having been left on the plant [3, p 24]. On the other hand, eggplant, harvested immature, is a non-climacteric fruit that does not undergo the metabolic changes exhibited by tomatoes.

The objectives of this study were: to assess postharvest losses in tomatoes and eggplants grown in open fields in the Jordan Valley and the Uplands; to identify causes of these losses; and to propose means for reduction of postharvest losses.
Materials and Methods

Plant Materials: Tomato (Solanum lycopersicum L. cv. “GS12”) and eggplant (Solanum melongena cv. “Black Beauty”) fruits grown in the open field in the Jordan Valley (North and mid-valley) and in the Uplands (Al-Mafraq area) were subjected to this postharvest loss study. This study was carried out during October to July in the Jordan Valley (the minimum and maximum air temperatures were between 12.1 and 36.3°C), and during March to December in the Uplands (the minimum and maximum air temperatures were between 2.6 and 34.4°C) in 1999. Fruit samples of tomatoes and eggplants packed in polystyrene (Styrofoam) boxes (46 x 26 x 12 cm, holding 7-9 kg) were examined for postharvest losses at different levels (farm, transport, wholesale and retail markets) of the marketing chain. Fruits were handled traditionally as described below under postharvest practices for tomatoes and eggplants in Jordan.

Determination of postharvest losses: For each sample, ten boxes were taken at random at the study site. After weighing the contents of each box, unmarketable fruit (diseased, injured, immature green, very soft over mature, bruised, crushed, blemished etc.) were isolated, weighed (and returned into their box), and their percentage was calculated from the total weight of the box. The fact that postharvest losses are cumulative (i.e. increasing with the progression of postharvest handling) was taken into consideration in order to come up with the actual loss percentage at a given level. At the farm level, the percentage reported was the actual percentage of loss, since no preceding levels exist. Each of the reported percentages thereafter, was the result of subtracting the preceding percentage(s) from the newly obtained loss value for a given level. For example: the obtained loss at the transportation level was 11.6 – 6.0 (loss at the farm level) = 5.6 (actual loss at the transport level reported in Table 1).

Table 1. Percentages of postharvest losses of tomatoes and eggplants at four levels of postharvest handling in both growing areas

<table>
<thead>
<tr>
<th>Postharvest handling</th>
<th>Average loss</th>
<th>Uplands</th>
<th>Jordan valley</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Eggplant</td>
<td>Tomato</td>
<td>Eggplant</td>
</tr>
<tr>
<td>Farms</td>
<td>7.2</td>
<td>5.6</td>
<td>7.8</td>
</tr>
<tr>
<td>Transport</td>
<td>4.6</td>
<td>4.1</td>
<td>6.2</td>
</tr>
<tr>
<td>Wholesale market</td>
<td>1.8</td>
<td>1.1</td>
<td>2.1</td>
</tr>
<tr>
<td>Retail stores</td>
<td>5.4</td>
<td>6.3</td>
<td>1.9</td>
</tr>
<tr>
<td>Total loss</td>
<td>19.4</td>
<td>18.0</td>
<td>16.2</td>
</tr>
</tbody>
</table>

1. Represents the average of 90 boxes.
2. Means within the column followed by the same letter are not significantly different at P<0.05 levels by the LSD method.
Table 2. Color variation of harvested tomato fruit at the farm level.

<table>
<thead>
<tr>
<th>Farm</th>
<th>Color stage1 (%)</th>
<th>G</th>
<th>B</th>
<th>T</th>
<th>P</th>
<th>LR</th>
<th>R</th>
<th>DR</th>
</tr>
</thead>
<tbody>
<tr>
<td>J. V. 1</td>
<td>1st</td>
<td>4.3</td>
<td>2.1</td>
<td>1.5</td>
<td>24.9</td>
<td>12.4</td>
<td>50.1</td>
<td>3.1</td>
</tr>
<tr>
<td></td>
<td>2nd</td>
<td>3.5</td>
<td>43.2</td>
<td>33.0</td>
<td>13.4</td>
<td>2.5</td>
<td>3.0</td>
<td>1.6</td>
</tr>
<tr>
<td></td>
<td>3rd</td>
<td>4.5</td>
<td>40.1</td>
<td>23.8</td>
<td>18.5</td>
<td>3.0</td>
<td>2.8</td>
<td>7.1</td>
</tr>
<tr>
<td>Up. 1</td>
<td>1st</td>
<td>2.1</td>
<td>40.1</td>
<td>28.1</td>
<td>21.1</td>
<td>1.4</td>
<td>3.2</td>
<td>3.3</td>
</tr>
<tr>
<td></td>
<td>2nd</td>
<td>3.7</td>
<td>4.1</td>
<td>2.8</td>
<td>10.4</td>
<td>27.1</td>
<td>41.7</td>
<td>1.7</td>
</tr>
<tr>
<td></td>
<td>3rd</td>
<td>3.2</td>
<td>2.9</td>
<td>5.1</td>
<td>21.4</td>
<td>18.8</td>
<td>45</td>
<td>3.9</td>
</tr>
</tbody>
</table>

1. G (green), B (breaker), T (turning), P (pink), LR (light red), R (red), DR (dark red).
2. J.V. (Jordan Valley) and Up. (Uplands).
3. Each value represents the average of 90 boxes.

Table 3. Decay and defect percentages of tomato fruit at the farm level.

<table>
<thead>
<tr>
<th>Farm</th>
<th>Decay %</th>
<th>Defect %</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1st</td>
<td>2nd</td>
</tr>
<tr>
<td>J. V. 1</td>
<td>3.6</td>
<td>5.9</td>
</tr>
<tr>
<td>Up. 1</td>
<td>30.3</td>
<td>27.3</td>
</tr>
</tbody>
</table>

1. J.V. (Jordan Valley) and Up. (Uplands).
2. Each value represents the average of 90 boxes.

Table 4. Proportions of the different causes of postharvest losses of tomatoes and eggplants from the total loss at four levels of postharvest handling tested for both growing areas.

<table>
<thead>
<tr>
<th>Growing area</th>
<th>Direct causes of postharvest loss (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Diseases</td>
</tr>
<tr>
<td>Jordan Valley</td>
<td>Tomato</td>
</tr>
<tr>
<td></td>
<td>Eggplant</td>
</tr>
<tr>
<td>Uplands</td>
<td>Tomato</td>
</tr>
<tr>
<td></td>
<td>Eggplant</td>
</tr>
</tbody>
</table>

1. Each value represents the average of 360 boxes.

**Introduction**

The environment and conditions exist in Jordan to produce large volume of high quality crops. All impedances to proper postharvest handling techniques are managerial and not physiological in nature due to lack of resources or infrastructure.

Generally, postharvest handling systems of tomatoes and grapes in Jordan can be summarized as follows:

**Tomatoes for the local market:**
- Harvest in buckets, wooden or Polystyrene boxes
- Sorting & Packing
- Loading & Transport
- Wholesale markets

**Tomatoes for export to the Gulf States:**
- Harvest in buckets, wooden or Polystyrene boxes
- Packing in Polystyrene boxes
- Loading & Transport
- Exporters warehouse
- Repacking
- Loading in refrigerated trucks
- Shipping to destination markets

**Grapes Handling System**
- Harvest in field boxes
- Trimming and Primary Sorting
- Packing
- Transport
- Cold Storage
- Packing House
- Sorting, Grading & Re-packing
- Precooling
- Shipping to destination markets
Objectives

The objective of the current study was to evaluate five common postharvest steps in the handling of tomatoes and grapes in order to estimate the postharvest losses and determine the causes of these losses.

Results and Discussion

1. Tomatoes

Color:

![Figure 1: Color (C1, C2, C3) of tomato fruits following testing at the HP, PP, RP, and CRP in all five harvests.](image)

Firmness:

![Figure 2: Firmness (F1, F2, F3) of tomato fruits following testing at the HP, PP, RP, CP, and CRP treatments in all five harvests.](image)
### Calyx Freshness

Table 3. Calyx Freshness 1,2 of tomato fruits following testing at the Harvest Point (HP), Packing Point (PP), Room temperature Point (RP), Cold storage Point (CP), and Cold storage + Room temperature Point (CRP), in all five harvests.

<table>
<thead>
<tr>
<th>Harv.</th>
<th>Treat.</th>
<th>1st H</th>
<th>2nd H</th>
<th>3rd H</th>
<th>4th H</th>
<th>5th H</th>
</tr>
</thead>
<tbody>
<tr>
<td>HP</td>
<td></td>
<td>85.87&lt;sup&gt;a&lt;/sup&gt;</td>
<td>88.3a</td>
<td>72.0a</td>
<td>82.0a</td>
<td>76.3a</td>
</tr>
<tr>
<td>PP</td>
<td>83.66a</td>
<td>82.7a</td>
<td>76.3a</td>
<td>83.0a</td>
<td>81.7b</td>
<td></td>
</tr>
<tr>
<td>RP</td>
<td>47.0b</td>
<td>57.0b</td>
<td>50.7b</td>
<td>56.7b</td>
<td>34.0c</td>
<td></td>
</tr>
<tr>
<td>CP</td>
<td>61.3c</td>
<td>69.4c</td>
<td>63.0c</td>
<td>69.7c</td>
<td>66.3d</td>
<td></td>
</tr>
<tr>
<td>CRP</td>
<td>42.3b</td>
<td>30.6b</td>
<td>39.3c</td>
<td>37.0d</td>
<td>33.6c</td>
<td></td>
</tr>
</tbody>
</table>

1. Calyx freshness was rated as (1 = dry & brown), 2 = Partially green), and (3 = Green & fresh), the average of the three values was taken out of 3 which then were converted to percentages (3 considered as 100%).
2. Means are the average of ten separate samples (10 boxes of fruits).
3. Higher values represent fresher calyx.
4. Values within columns followed by the same letter are not significantly different at the 0.05 level by the LSD method.

### Decay

Table 4. Decay1, 2 incidence in tomato fruits following testing at the Harvest Point (HP), Packing Point (PP), Room temperature Point (RP), Cold storage Point (CP), and Cold storage + Room temperature Point (CRP) in all five harvests.

<table>
<thead>
<tr>
<th>Harv.</th>
<th>Treat.</th>
<th>1st H</th>
<th>2nd H</th>
<th>3rd H</th>
<th>4th H</th>
<th>5th H</th>
</tr>
</thead>
<tbody>
<tr>
<td>HP</td>
<td></td>
<td>3.8&lt;sup&gt;a&lt;/sup&gt;</td>
<td>3.8a</td>
<td>5.6a,b</td>
<td>3.6a</td>
<td>8.5a,b</td>
</tr>
<tr>
<td>PP</td>
<td>2.9a</td>
<td>3.8a</td>
<td>3.9a</td>
<td>4.7a</td>
<td>6.8a</td>
<td></td>
</tr>
<tr>
<td>RP</td>
<td>6.6a</td>
<td>9.3b</td>
<td>9.5b,c</td>
<td>11.0b</td>
<td>13.3b</td>
<td></td>
</tr>
<tr>
<td>CP</td>
<td>7.8a</td>
<td>10.8b</td>
<td>12.5c</td>
<td>10.2b</td>
<td>11a,b</td>
<td></td>
</tr>
<tr>
<td>CRP</td>
<td>29.1b</td>
<td>23.7c</td>
<td>28.9d</td>
<td>37.4c</td>
<td>26.0c</td>
<td></td>
</tr>
</tbody>
</table>

1. Decay was determined by the number of decayed fruits, converted to percentages from the total number of the fruits in each box (considered as 100%).
2. Means are the average of ten separate samples (10 boxes of fruits).
3. Higher values represent more decayed fruits.
4. Values within columns followed by the same letter are not significantly different at the 0.05 level by the LSD method.
Defects

Table 5. Defects1, 2 occurrence in tomato fruits following testing at the Harvest Point (HP), Packing Point (PP), Room temperature Point (RP), Cold storage Point (CP), and Cold storage + Room temperature Point (CRP) in all five harvests.

<table>
<thead>
<tr>
<th>Treat. ▼</th>
<th>1st H</th>
<th>2nd H</th>
<th>3rd H</th>
<th>4th H</th>
<th>5th H</th>
</tr>
</thead>
<tbody>
<tr>
<td>HP</td>
<td>47.7a</td>
<td>61.7a,b</td>
<td>51.9a</td>
<td>53.2a</td>
<td>53.3a</td>
</tr>
<tr>
<td>PP</td>
<td>42.5a</td>
<td>51.5a</td>
<td>50.0a</td>
<td>59.5a,b</td>
<td>67.8a,b</td>
</tr>
<tr>
<td>RP</td>
<td>69.0b</td>
<td>69.4b,c</td>
<td>66.2b</td>
<td>67.8b</td>
<td>67.8b</td>
</tr>
<tr>
<td>CP</td>
<td>59.5b,c</td>
<td>62.3a,b</td>
<td>66.2b</td>
<td>62.9b,c</td>
<td>62.9b,c</td>
</tr>
<tr>
<td>CRP</td>
<td>72.5b</td>
<td>81.2c</td>
<td>85.9c</td>
<td>81.5c</td>
<td>80.5c</td>
</tr>
</tbody>
</table>

1. Defects were determined by the number of defected fruits, converted to percentages from the total number of the fruits in each box (considered as 100%).
2. Means are the average of ten separate samples (10 boxes of fruits).
3. Higher values represent more defected fruits.
4. Values within columns followed by the same letter are not significantly different at the 0.05 level by the LSD method.

Cleanliness

Table 6. Cleanliness1, 2 of tomato fruits following testing at the Harvest Point (HP), Packing Point (PP), Room temperature Point (RP), Cold storage Point (CP), and Cold storage + Room temperature Point (CRP) in all five harvests.

<table>
<thead>
<tr>
<th>Treat. ▼</th>
<th>1st H</th>
<th>2nd H</th>
<th>3rd H</th>
<th>4th H</th>
<th>5th H</th>
</tr>
</thead>
<tbody>
<tr>
<td>HP</td>
<td>71.3a</td>
<td>64.0a</td>
<td>67.3a</td>
<td>67.0a</td>
<td>63.6a</td>
</tr>
<tr>
<td>PP</td>
<td>72.0a</td>
<td>72.0a</td>
<td>71.0a</td>
<td>51.0a</td>
<td>65.3a</td>
</tr>
<tr>
<td>RP</td>
<td>56.7b</td>
<td>73.3a</td>
<td>72.0a</td>
<td>69.3a</td>
<td>71.7a</td>
</tr>
<tr>
<td>CP</td>
<td>72.0a</td>
<td>76.3</td>
<td>73.7a</td>
<td>71.7a</td>
<td>78.3b</td>
</tr>
<tr>
<td>CRP</td>
<td>69.7a</td>
<td>78.3a</td>
<td>73.7a</td>
<td>64.0a</td>
<td>66.4a</td>
</tr>
</tbody>
</table>

1. Cleanliness was determined using a scale of 1= dirty, 2= skin clean but calyx is dirty, and 3=completely clean.
2. Means are the average of ten separate samples (10 boxes of fruits).
3. Higher values represent more clean.
4. Values within columns followed by the same letter are not significantly different at the 0.05 level by the LSD method.
## General Appearance (GA)

Table 7. General Appearance1, 2 of tomato fruits following testing at the Harvest Point (HP), Packing Point (PP), Room temperature Point (RP), Cold storage Point (CP), and Cold storage + Room temperature Point (CRP) in the five harvests.

<table>
<thead>
<tr>
<th>Harv.</th>
<th>1&lt;sup&gt;st&lt;/sup&gt; H</th>
<th>2&lt;sup&gt;nd&lt;/sup&gt; H</th>
<th>3&lt;sup&gt;rd&lt;/sup&gt; H</th>
<th>4&lt;sup&gt;th&lt;/sup&gt; H</th>
<th>5&lt;sup&gt;th&lt;/sup&gt; H</th>
</tr>
</thead>
<tbody>
<tr>
<td>HP</td>
<td>76.3&lt;sup&gt;a,b&lt;/sup&gt;</td>
<td>76.7&lt;sup&gt;a&lt;/sup&gt;</td>
<td>77.0&lt;sup&gt;a&lt;/sup&gt;</td>
<td>75.7&lt;sup&gt;a,c&lt;/sup&gt;</td>
<td>72.7&lt;sup&gt;a,c&lt;/sup&gt;</td>
</tr>
<tr>
<td>PP</td>
<td>81.0&lt;sup&gt;b&lt;/sup&gt;</td>
<td>74.3&lt;sup&gt;a,b&lt;/sup&gt;</td>
<td>79.0&lt;sup&gt;a&lt;/sup&gt;</td>
<td>77.3&lt;sup&gt;a&lt;/sup&gt;</td>
<td>76.0&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>RP</td>
<td>73.3&lt;sup&gt;a,b&lt;/sup&gt;</td>
<td>68.7&lt;sup&gt;b&lt;/sup&gt;</td>
<td>73.0&lt;sup&gt;a&lt;/sup&gt;</td>
<td>68.4&lt;sup&gt;b&lt;/sup&gt;</td>
<td>68.3&lt;sup&gt;b,c&lt;/sup&gt;</td>
</tr>
<tr>
<td>CP</td>
<td>69.7&lt;sup&gt;a&lt;/sup&gt;</td>
<td>70.7&lt;sup&gt;a,b&lt;/sup&gt;</td>
<td>72.0&lt;sup&gt;a&lt;/sup&gt;</td>
<td>70.0&lt;sup&gt;c&lt;/sup&gt;</td>
<td>69.3&lt;sup&gt;c&lt;/sup&gt;</td>
</tr>
<tr>
<td>CRP</td>
<td>60.7&lt;sup&gt;c&lt;/sup&gt;</td>
<td>61.0&lt;sup&gt;c&lt;/sup&gt;</td>
<td>59.0&lt;sup&gt;b&lt;/sup&gt;</td>
<td>55.7&lt;sup&gt;d&lt;/sup&gt;</td>
<td>63.0&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

1. General appearance was determined by 1= poor, 2= good, and 3= excellent.
2. Means are the average of ten separate samples (10 boxes of fruits).
3. Higher values represent better general appearance.
4. Values within columns followed by the same letter are not significantly different at the 0.05 level by the LSD method.

## 2. Grapes

Table 8. Total Soluble Solids (TSS) 1,2 of grapes following testing at the Harvest Point (HP), Packing Point (PP), Room temperature Point (RP), Cold storage Point (CP), and Cold storage + Room temperature Point (CRP) in the five harvests.

<table>
<thead>
<tr>
<th>Harv.</th>
<th>1&lt;sup&gt;st&lt;/sup&gt; H</th>
<th>2&lt;sup&gt;nd&lt;/sup&gt; H</th>
<th>3&lt;sup&gt;rd&lt;/sup&gt; H</th>
<th>4&lt;sup&gt;th&lt;/sup&gt; H</th>
<th>5&lt;sup&gt;th&lt;/sup&gt; H</th>
</tr>
</thead>
<tbody>
<tr>
<td>HP</td>
<td>15.2&lt;sup&gt;a&lt;/sup&gt;</td>
<td>15.7&lt;sup&gt;a&lt;/sup&gt;</td>
<td>16.0&lt;sup&gt;a&lt;/sup&gt;</td>
<td>16.3&lt;sup&gt;a&lt;/sup&gt;</td>
<td>16.6&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>PP</td>
<td>15.1&lt;sup&gt;a&lt;/sup&gt;</td>
<td>15.5&lt;sup&gt;a&lt;/sup&gt;</td>
<td>16.0&lt;sup&gt;a&lt;/sup&gt;</td>
<td>16.8&lt;sup&gt;a&lt;/sup&gt;</td>
<td>16.7&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>RP</td>
<td>15.5&lt;sup&gt;a&lt;/sup&gt;</td>
<td>16.2&lt;sup&gt;a&lt;/sup&gt;</td>
<td>16.8&lt;sup&gt;a&lt;/sup&gt;</td>
<td>16.9&lt;sup&gt;a&lt;/sup&gt;</td>
<td>17.3&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>CP</td>
<td>15.2&lt;sup&gt;a&lt;/sup&gt;</td>
<td>15.8&lt;sup&gt;a&lt;/sup&gt;</td>
<td>16.3&lt;sup&gt;a&lt;/sup&gt;</td>
<td>16.5&lt;sup&gt;a&lt;/sup&gt;</td>
<td>16.6&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>CRP</td>
<td>15.5&lt;sup&gt;a&lt;/sup&gt;</td>
<td>16.0&lt;sup&gt;a&lt;/sup&gt;</td>
<td>16.2&lt;sup&gt;a&lt;/sup&gt;</td>
<td>16.4&lt;sup&gt;a&lt;/sup&gt;</td>
<td>16.6&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

1. TSS was determined for each cluster by refractometer.
2. Means are the average of ten separate samples (10 boxes of fruits).
3. Higher values represent more TSS content.
4. Values within columns followed by the same letter are not significantly different at the 0.05 level by the LSD method.
Abscission (shattering)

Table 9. Abscission (Shattering) of grape berries1,2 following testing at the Harvest Point (HP), Packing Point (PP), Room temperature Point (RP), Cold storage Point (CP), and Cold storage + Room temperature Point (CRP) in the five harvests.

<table>
<thead>
<tr>
<th>Harv.</th>
<th>1st H</th>
<th>2nd H</th>
<th>3rd H</th>
<th>4th H</th>
<th>5th H</th>
</tr>
</thead>
<tbody>
<tr>
<td>HP</td>
<td>10.83a4</td>
<td>10.2a</td>
<td>11.5a</td>
<td>15.3a.b</td>
<td>13.9a</td>
</tr>
<tr>
<td>PP</td>
<td>9.3a</td>
<td>9.7a</td>
<td>14.7a</td>
<td>11.7a</td>
<td>12.2a</td>
</tr>
<tr>
<td>RP</td>
<td>16.6b</td>
<td>15.2b</td>
<td>23.3b.c</td>
<td>15.2a.b</td>
<td>17.4a</td>
</tr>
<tr>
<td>CP</td>
<td>16.4b</td>
<td>12.8a.b</td>
<td>18.5a.b.c</td>
<td>17.6b.c</td>
<td>12.4a</td>
</tr>
<tr>
<td>CRP</td>
<td>18.4b</td>
<td>15.2b</td>
<td>25.8c</td>
<td>20.9c</td>
<td>16.9a</td>
</tr>
</tbody>
</table>

1. Shattering was determined by the number of missing berries from each cluster.
2. Means are the average of ten separate samples (10 boxes of fruits).
3. Higher values represent more shattering percentages.
4. Values within columns followed by the same letter are not significantly different at the 0.05 level by the LSD method.

Firmness

Table 10. Firmness1, 2 determination in grapes following testing at the Harvest Point (HP), Packing Point (PP), Room temperature Point (RP), Cold storage Point (CP), and Cold storage + Room temperature Point (CRP) in the five harvests.

<table>
<thead>
<tr>
<th>Harv.</th>
<th>1st H</th>
<th>2nd H</th>
<th>3rd H</th>
<th>4th H</th>
<th>5th H</th>
</tr>
</thead>
<tbody>
<tr>
<td>HP</td>
<td>93.33a4</td>
<td>96.0a</td>
<td>98.7a</td>
<td>96.0a</td>
<td>95.7a</td>
</tr>
<tr>
<td>PP</td>
<td>96.0b</td>
<td>96.3b</td>
<td>99.3b</td>
<td>97.7b</td>
<td>98.0b</td>
</tr>
<tr>
<td>RP</td>
<td>63.7c</td>
<td>61.3c</td>
<td>62.9c</td>
<td>55.0c</td>
<td>60.3c</td>
</tr>
<tr>
<td>CP</td>
<td>69.7d</td>
<td>76.7d</td>
<td>69.7d</td>
<td>65.d</td>
<td>68.6d</td>
</tr>
<tr>
<td>CRP</td>
<td>58.3e</td>
<td>49.7e</td>
<td>46.7e</td>
<td>51.7e</td>
<td>45.7e</td>
</tr>
</tbody>
</table>

1. Firmness was determined for each cluster using a scale of 1=soft, 2=firm, and 3= very firm.
2. Means are the average of ten separate samples (10 boxes of fruits).
3. Higher values represent firmer berries.
4. Values within columns followed by the same letter are not significantly different at the 0.05 level by the LSD method.
## Stem Freshness

Table 11. Stem Freshness of grapes following testing at the Harvest Point (HP), Packing Point (PP), Room temperature Point (RP), Cold storage Point (CP), and Cold storage + Room temperature Point (CRP) in the five harvests.

<table>
<thead>
<tr>
<th>Harv.</th>
<th>Treat.</th>
<th>1st H</th>
<th>2nd H</th>
<th>3rd H</th>
<th>4th H</th>
<th>5th H</th>
</tr>
</thead>
<tbody>
<tr>
<td>HP</td>
<td>94(^1)(^a4)</td>
<td>97.0a</td>
<td>99.3a</td>
<td>98.3a</td>
<td>99.7a</td>
<td></td>
</tr>
<tr>
<td>PP</td>
<td>98.7b</td>
<td>93.3b</td>
<td>99.3a</td>
<td>98.3a</td>
<td>100b</td>
<td></td>
</tr>
<tr>
<td>RP</td>
<td>52.3c</td>
<td>47.0c</td>
<td>45.3b</td>
<td>38.9b</td>
<td>49.0c</td>
<td></td>
</tr>
<tr>
<td>CP</td>
<td>72.0d</td>
<td>77.4d</td>
<td>80.7c</td>
<td>73.0c</td>
<td>80.3d</td>
<td></td>
</tr>
<tr>
<td>CRP</td>
<td>50.3e</td>
<td>39.0c</td>
<td>39.0d</td>
<td>41.0d</td>
<td>42.0c</td>
<td></td>
</tr>
</tbody>
</table>

1. Stem freshness was determined for each cluster using a rating scale of 1 = dry, 2 = partially dry, and 3 = fresh and green.
2. Means are the average of ten separate samples (10 boxes of fruits).
3. Higher values represent better stem freshness.
4. Values within columns followed by the same letter are not significantly different at the 0.05 level by the LSD method.

## Decay

Table 12. Decay incidence in grapes following testing at the Harvest Point (HP), Packing Point (PP), Room temperature Point (RP), Cold storage Point (CP), and Cold storage + Room temperature Point (CRP) in the five harvests.

<table>
<thead>
<tr>
<th>Harv.</th>
<th>Treat.</th>
<th>1st H</th>
<th>2nd H</th>
<th>3rd H</th>
<th>4th H</th>
<th>5th H</th>
</tr>
</thead>
<tbody>
<tr>
<td>HP</td>
<td>2.0(^1)(^a,b4)</td>
<td>1.8a.b</td>
<td>1.5a</td>
<td>1.8a</td>
<td>1.4a</td>
<td></td>
</tr>
<tr>
<td>PP</td>
<td>1.3a</td>
<td>1.0a</td>
<td>1.9a</td>
<td>1.8a</td>
<td>1.5a.b</td>
<td></td>
</tr>
<tr>
<td>RP</td>
<td>3.0b.c</td>
<td>1.7a.b</td>
<td>2.6a</td>
<td>2.0a</td>
<td>2.8b</td>
<td></td>
</tr>
<tr>
<td>CP</td>
<td>3.3b.c</td>
<td>1.8a.b</td>
<td>2.8a</td>
<td>2.3a</td>
<td>2.0a.b</td>
<td></td>
</tr>
<tr>
<td>CRP</td>
<td>3.7c</td>
<td>2.2b</td>
<td>5.0b</td>
<td>3.8b</td>
<td>2.8b</td>
<td></td>
</tr>
</tbody>
</table>

1. Decay occurrence was determined by the number of decayed berries.
2. Means are the average of ten separate samples (10 boxes of fruits).
3. Higher values represent more decayed berries.
4. Values within columns followed by the same letter are not significantly different at the 0.05 level by the LSD method.
**Defects**

Table 13. Defect occurrence1, 2 in grapes following testing at the Harvest Point (HP), Packing Point (PP), Room temperature Point (RP), Cold storage Point (CP), and Cold storage + Room temperature Point (CRP) in the five harvests in the five harvests.

<table>
<thead>
<tr>
<th>Harv.</th>
<th>1&lt;sup&gt;st&lt;/sup&gt; H</th>
<th>2&lt;sup&gt;nd&lt;/sup&gt; H</th>
<th>3&lt;sup&gt;rd&lt;/sup&gt; H</th>
<th>4&lt;sup&gt;th&lt;/sup&gt; H</th>
<th>5&lt;sup&gt;th&lt;/sup&gt; H</th>
</tr>
</thead>
<tbody>
<tr>
<td>HP</td>
<td>45.4&lt;sup&gt;a&lt;/sup&gt;</td>
<td>34.4a</td>
<td>35.7a.b</td>
<td>39.7a.b</td>
<td>34.9a</td>
</tr>
<tr>
<td>PP</td>
<td>31.8a.b</td>
<td>20.3c</td>
<td>21.2b</td>
<td>21.2b</td>
<td>19.2b</td>
</tr>
<tr>
<td>RP</td>
<td>28.5b</td>
<td>30.4a.b</td>
<td>36.8a.b</td>
<td>36.8a.b</td>
<td>30.7a.b</td>
</tr>
<tr>
<td>CP</td>
<td>34.3a.b</td>
<td>23.2b.c</td>
<td>38.3a.b</td>
<td>38.3a.b</td>
<td>29.0a.b</td>
</tr>
<tr>
<td>CRP</td>
<td>37.4a.b</td>
<td>27a.b.c</td>
<td>45.6a</td>
<td>45.6a</td>
<td>38.4a</td>
</tr>
</tbody>
</table>

1. Defects were determined by the number of defected berries.
2. Means are the average of ten separate samples (10 boxes of fruits).
3. Higher values represent more defected fruits.
4. Values within columns followed by the same letter are not significantly different at the 0.05 level by the LSD method.

**Cleanliness**

Table 14. Cleanliness1,2 of grapes following testing at the Harvest Point (HP), Packing Point (PP), Room temperature Point (RP), Cold storage Point (CP), and Cold storage + Room temperature Point (CRP) in the five harvests.

<table>
<thead>
<tr>
<th>Harv.</th>
<th>1&lt;sup&gt;st&lt;/sup&gt; H</th>
<th>2&lt;sup&gt;nd&lt;/sup&gt; H</th>
<th>3&lt;sup&gt;rd&lt;/sup&gt; H</th>
<th>4&lt;sup&gt;th&lt;/sup&gt; H</th>
<th>5&lt;sup&gt;th&lt;/sup&gt; H</th>
</tr>
</thead>
<tbody>
<tr>
<td>HP</td>
<td>79.0&lt;sup&gt;a&lt;/sup&gt;</td>
<td>84.7a</td>
<td>78.3b</td>
<td>82.0a.b</td>
<td>87.3a</td>
</tr>
<tr>
<td>PP</td>
<td>86.0a</td>
<td>81.7a.b</td>
<td>87.5a</td>
<td>85.3a</td>
<td>89.7a</td>
</tr>
<tr>
<td>RP</td>
<td>69.4c</td>
<td>69.4c</td>
<td>78.4b</td>
<td>71.2c</td>
<td>71.0b</td>
</tr>
<tr>
<td>CP</td>
<td>75.3b.c</td>
<td>79.0a.b.c</td>
<td>81.0a.b</td>
<td>74b.c</td>
<td>84.3a</td>
</tr>
<tr>
<td>CRP</td>
<td>68.3c</td>
<td>73.7b.c</td>
<td>62.3c</td>
<td>65.4c</td>
<td>59.2c</td>
</tr>
</tbody>
</table>

1. Cleanliness was determined using a scale of 1= dirty, 2= skin clean, but stem dirty, and 3= complete clean.
2. Means are the average of ten separate samples (10 boxes of fruits).
3. Higher values represent more clean clusters.
4. Values within columns followed by the same letter are not significantly different at the 0.05 level by the LSD method.
General Appearance

Table 15. General Appearance1,2 of grapes following testing at the Harvest Point (HP), Packing Point (PP), Room temperature Point (RP), Cold storage Point (CP), and Cold storage + Room temperature Point (CRP) in the five harvests.

<table>
<thead>
<tr>
<th>Treat.</th>
<th>1st H</th>
<th>2nd H</th>
<th>3rd H</th>
<th>4th H</th>
<th>5th H</th>
</tr>
</thead>
<tbody>
<tr>
<td>HP</td>
<td>57.3a</td>
<td>70b</td>
<td>67a.b</td>
<td>68.7a</td>
<td>71.3a</td>
</tr>
<tr>
<td>PP</td>
<td>58.7a</td>
<td>77.3a</td>
<td>68.3a</td>
<td>71.7a</td>
<td>74.7a</td>
</tr>
<tr>
<td>RP</td>
<td>50a</td>
<td>54c</td>
<td>58.3b.c</td>
<td>51c</td>
<td>54.7b</td>
</tr>
<tr>
<td>CP</td>
<td>58.7a</td>
<td>68.7b</td>
<td>68.7a</td>
<td>59.3b</td>
<td>68.7a</td>
</tr>
<tr>
<td>CRP</td>
<td>53.7a</td>
<td>56.3c</td>
<td>52b.c</td>
<td>51c</td>
<td>49.3b</td>
</tr>
</tbody>
</table>

1. General appearance was determined using a scale of 1= poor, 2= good, and 3= excellent.
2. Means are the average of ten separate samples (10 boxes of fruits).
3. Higher values represent more fruits with better general appearance.
4. Values within columns followed by the same letter are not significantly different at the 0.05 level by the LSD method.

Postharvest Losses

Estimation of postharvest losses for tomatoes and grapes

Table 16. Estimated postharvest losses in tomatoes and grapes in the five treatments.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>% Losses in tomatoes</th>
<th>% Losses in grapes</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>The Assumed Lower Range</td>
<td>The Maximum Possible Range</td>
</tr>
<tr>
<td>HP</td>
<td>14.0</td>
<td>24.4</td>
</tr>
<tr>
<td>PP</td>
<td>13.1</td>
<td>22.5</td>
</tr>
<tr>
<td>RP</td>
<td>16.7</td>
<td>29.7</td>
</tr>
<tr>
<td>CP</td>
<td>15.7</td>
<td>29.8</td>
</tr>
<tr>
<td>CRP</td>
<td>25.0</td>
<td>40.2</td>
</tr>
<tr>
<td>Average loss</td>
<td>16.9</td>
<td>29.3</td>
</tr>
</tbody>
</table>
References


Technology on Reducing Post Harvest Losses and Maintaining Quality of Fruits and Vegetables in Kenya

Severino Kinge Manene
Ministry of Agriculture, Kenya

Introduction

Horticultural sub-sector is the fastest growing industry in the agricultural sector in Kenya. It employs directly and indirectly about 4 million people. Small scale holder farmers contribute over 60% of the total production. The sub-sector generates over US$ 300 Million in foreign exchange earnings. Total horticultural production is close to 3 million tones, making Kenya one of the major producers and exporters of horticultural products in the world. The emerging issues such as maximum residue levels (MRLs) and social environmental accountability in the dynamic fresh produce markets and increased drought incidences makes it necessary for the industry to reposition itself so as to provide relevant, adequate, globally oriented products that are competitive and meet customer requirements.

Current Status of Fruits and Vegetables Practices

Crop loss through pests/diseases

1. Pests and diseases management has been a major challenge especially for small scale farmers.

2. Apart from being expensive, chemical control is not always effective against some of the major pests, including scales and mites and diseases such as anthracnose.

3. It has been estimated that approximately 35% of all crop is lost through attack by pests and diseases.

Post- harvest handling

1. Losses are common with agricultural produce marketing, even if nothing is actually thrown away.

2. Post harvest losses account for approximately 10% of the total horticulture produce. Poor harvesting techniques and poor on-farm handling (bruises, exposure to sun) damage the produce before they are sold to consumer.

3. Post harvest handling is as important as growing for delivering an attractive product to the consumer.
4. Harvesting of most fruits and vegetables is mainly done by hand before packaging. Fresh tomatoes for instance, are highly perishable, and unless proper post harvest handling procedures are followed, their quality declines rapidly due to bruises.

**Lack of trainings/enforcement of regulations**

The EU directives on traceability are currently of concern to Kenyan farmers and exporters of fresh produce to Europe. The regulations covers all food produced for consumption in the EU, both locally and imported. This poses major challenges, both financial and technical, to comply by many small scale farmers, hence leading to crop losses.

**Transportation**

1. Poor off farm handling of fruits and vegetables causes considerable loss to produce. Delays in delivery of horticultural products to markets destinations have monumental costs in some products such as tomatoes-caused mainly by poor infrastructure (bad roads) and inefficient organizations.

2. Reliability of air connections is as critical as its costs.

**Preservation/cold storage facilities**

1. Cooling and storage facilities not available in most rural areas and even where they are available, farmers not adequately utilizing the facilities adequately owing to high storage costs/charges.

2. Facilities mainly utilized by large scale farmers and exporters.

3. Some horticultural crops such as tomatoes require forced air cooling to avoid excessive water loss, and provide high humidity cooling air.

4. Mechanical refrigeration also provides efficient systems for preservation of harvested products.

5. However, most rural areas where horticulture production is practiced have no electrical power, hence farmers not able to use these technologies.
Lack of organised markets/contract farming

Smallholder farmer are currently not well organized into production and marketing groups to take advantage of contract farming, thereby improving producer–buyer linkages and thereby reduce losses

Local utilization to products

1. The Ministry of Agric, promotes local utilization and consumption of horticultural products.

2. Utilization targets reduction of surplus production and or market rejects, and minimizes wastes.

3. This strategy reduces over-reliance on export market and encourages local consumption and value addition of horticultural products.

Processing/value addition

1. Processing is a common way of adding value to products.

2. Unfortunately, as farming becomes more commercial, such processing tends to be more in control of commercial firms, making it more difficult for small scale farmers to do such value addition for themselves.

3. A number of processors of horticultural crops are in operation in Kenya: Sunny Processors in central Kenya and Premier Foods in the coast have established plants for Passion fruit processing.

Valley Orchard has a processing plant for passion, and Del Monte processing plant for pineapple and mangoes.

1. These investments in production and processing have the potential to make Kenya a market leader in tropical fruit juice.

2. Most small scale farmers, however do not benefit from the presence of the above processing plants because of low production volumes, and low quality.

3. Hence most of their raw materials are imported from Egypt and South Africa.
Technical and advisory services

1. Educating and continuous training horticultural growers on production, record keeping, harvesting and post harvest handling, especially for small holders being done.

2. Improving productivity through demonstrations on new technologies and introducing new crop varieties
Post-Harvest Profile in Sultanate of Oman

Rashid AL-Shukili
Agricultural and Livestock Research, Oman

Abstract

To control the fruit and vegetables crops quality, knowledge and understanding of fruit and vegetables crops postharvest behavior and characteristics are necessary. Sultanate of Oman give considerable attention to the cultivation and development of fruit and vegetables crops. Ministry of Agriculture developing different research programs that aiming to improve productivity and quality of fruit and vegetable crops. The ministry of Agriculture also aimed to reach sustainable production of some important crops like date palm, banana and tomato. In addition, it contribute to the farmers by providing information knowledge of modern agriculture techniques and introducing high yielding varieties.

Introduction

The Sultanate of Oman occupies the southeastern part of the Arabian Peninsula and shares borders with the United Arab Emirates, Saudi Arabia, and the Republic of Yemen. It extends along the Gulf of Oman and the Arabian Sea. The country has a coastal line of almost 1,700 km, from the Strait of Hormuz in the north to the borders of the Republic of Yemen in the south-west, overlooking three seas: the Persian Gulf, the Gulf of Oman and the Arabian Sea. The Sultanate occupies about 309,500 sq. km equivalent to approximately 31 million hectares. The cultivable area has been estimated at 2.2 million ha, which is 7% of the total area of the country.

With the exception of Dhofar region, which has a strong monsoon climate and receives warm winds from the Indian Ocean, the climate of Oman is extremely hot and dry most of the year.

Summer begins in mid-April and lasts until October. The highest temperatures are registered in the interior, where readings of more than 53 °C (127.4 °F) in the shade are common. On the Al Batinah plain, summer temperatures seldom exceed 47 °C (116.6 °F), but, because of the low elevation, the humidity may be as high as 90 percent. The mean summer temperature in Muscat is 33 °C (91.4 °F), but the gharbi (literally, western), a strong wind that blows from the Rub al Khali desert, can raise temperatures from the towns on the Gulf of Oman by 6 °C (10.8 °F) to 10 °C (18 °F). Winter temperatures are mild and pleasant, ranging between 18 and 26 °C (64.4 and 78.8 °F).

Because the plateau of Al Jabal al Akhdar is porous limestone, rainfall seeps quickly through it, and the vegetation, which might be expected to be more lush, is meager. However, a huge
reservoir under the plateau provides springs for low-lying areas. In addition, an enormous wadi channels water to these valleys, making the area agriculturally productive in years of good rainfall.

Dhofar, benefiting from a southwest monsoon between June and September, receives heavier rainfall and has constantly running streams, which make the region Oman's most fertile area.

**Agro-Climatic Conditions**

Agro-climatic conditions in the Sultanate are classified as arid to extremely arid. Two main agro-climatic zones are recognized in the Sultanate based on the parameters which influence crop water requirements and efficient use of water, land and water resources potential and cropping patterns:

- Northern Oman including Batinah Coastal plain, Interior Oman and Dahira plains, Jebel Akhdar and Sharqiya plains.

- Southern Province, (Dhofar) including Salalah plain, Dhofar Jebel and Najd.

1. **Production and Cultivation Areas**

A wide range of crops are cultivated in the Sultanate. The permanent tree crops particularly Dates, lime and mango occupy the largest part of the cultivated land followed by fodder crops such as alfalfa and Rhodes grass, followed by vegetables and other seasonal crops (Table 1).

The cultivated area was 64314.7 ha in 2008, of which 28598.7 ha consisted of annual crops and 35716 ha consisted of permanent crops. Both fruit and vegetable production represent together almost 64.1% of the volume of total agricultural production in Oman. Over half the agricultural area is located in the Batinah Plain in the north, which has a total area representing about 3% of the area of the country (MA, 2008).

The aim of the Ministry is to achieve self-sufficiency in the main commodities of fruits, vegetables and field crops through the agricultural research strategy in crop pattern, which is based on selected crops to have the priority for research.

<table>
<thead>
<tr>
<th>Crop</th>
<th>Area (ha)</th>
<th>Area (%)</th>
<th>Production (Tons)</th>
<th>Production (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fruits</td>
<td>35716.0</td>
<td>55.5</td>
<td>327625</td>
<td>28.3</td>
</tr>
<tr>
<td>Fodders</td>
<td>16276.0</td>
<td>25.3</td>
<td>662539</td>
<td>57.3</td>
</tr>
<tr>
<td>Vegetables</td>
<td>5732.0</td>
<td>8.91</td>
<td>141095</td>
<td>12.2</td>
</tr>
<tr>
<td>Field crops</td>
<td>6590.7</td>
<td>10.29</td>
<td>24567</td>
<td>2.2</td>
</tr>
<tr>
<td>Total</td>
<td>64314.7</td>
<td></td>
<td>1155826</td>
<td></td>
</tr>
</tbody>
</table>
2. Priority of Crops.

Crop Priority is set according to the agricultural importance and agriculture policies. Agricultural importance takes in consideration the followings: the main region of production, total yield, yield per unit area, price/ton, net income/feddan, water use efficiency, imported and exported quantities of a crop or commodity.

The agricultural selected crop priority is as following:

**Fruit:** Date palm, lime and other citrus species, mango, banana, coconut, papaya, grapes, deciduous crops in mountain areas.

**Vegetables:** Tomato, onion, garlic, potato, watermelon, cucumber, sweet melon, squash, carrots, hot pepper.

**Field crops:** Wheat, barley, maize and legumes.

**Forages:** Alfalfa and Rhodes grass.

3. Imported and Exported Products

The main distribution of fruit and vegetables in country is at Mawaleh market which located at Muscat capital where all fruits and vegetables from different region are marketed. Storage of all fruits and vegetables are in main storage place at Mawaleh markets and then are distributaed to different counties. While the export of fruit and vegetables of the regions are marketed to different counties for example UAE, Soudi Arabia, Kuwait, also some of fruits and vegetable are export to Europe and Japan. Import of fruits and vegetable are from different regions around the word for stance, Holland France, UAE, Soudi Arabia ect.

**Quality Management Systems**

Quality standards and specifications for some fresh products are available and updated frequently by the Directorate General for Specifications and Measurements (DGSM), Ministry of Commerce and Industry. There are 38 Omani specifications of fruits, vegetables and nuts available.

1. Current Status of the Post-Harvest Sector

**General Overview of the Post-Harvest Chain**

The available information suggests that more than 90% of Agricultural production in Oman is practiced on small farms, which are less than 4 ha (DAS, 2002). Thus producers are responsible for all activities related to growing, harvest, handling and marketing of their produces. However, there are relatively a very few number of specialized farms that have their own facilities in order to practice some sort of post-harvest techniques such as grading, treatment of fruits and packaging as requested by destined market.
Markets are mostly local or close by (less than 500 km), in which care is taken to determine the stage of ripening at which harvest takes place in order to minimize losses, which growers are aware of. Those losses, which might occur during and after harvest or those due to delay in marketing.

There are two central markets in the Capital (Muscat), which are mainly specialized for fresh fruits and vegetables. Grain and dry seeds are traded through local markets. This market receives all local and imported products.

Apart from farm initial grading, depending on the distance to markets, and packaging there are no other post-harvest techniques that are adopted. Packaging is normally done using carton or wooden boxes. Crates are also common for tubers and large leafy products. In some cases net bags are used.

2. Post-Harvest Units and Centers

Market and wholesale facilities are available in the Sultanate. As well as long-term cooled stores are available in certain areas particularly in the capital (Muscat). In addition, to the presence of few large scale commercial farms, which adopt post-harvest steps. There are some specialized centers for certain crops such as Dates and Banana.

Dates Handling in the Sultanate

Date palm trees numbers in the Sultanate is about 6,486,628. The total Dates production is about 219,771.80 tons and the average production of Dates per Date palm tree is about 33.9 kg (MA, 2008). The table 2 shows area cultivated under date palms indifferent regions of Oman.

<table>
<thead>
<tr>
<th>Location</th>
<th>Date palm Numbers (%)</th>
<th>Production (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Al-Batinah</td>
<td>43.4</td>
<td>44.1</td>
</tr>
<tr>
<td>Al-Sharqiya</td>
<td>21.5</td>
<td>18.8</td>
</tr>
<tr>
<td>Oman Interior</td>
<td>14.7</td>
<td>18.0</td>
</tr>
<tr>
<td>Al-Dhahira</td>
<td>12.7</td>
<td>12.9</td>
</tr>
<tr>
<td>Muscat</td>
<td>5.2</td>
<td>4.6</td>
</tr>
<tr>
<td>Musandam</td>
<td>2.2</td>
<td>1.7</td>
</tr>
<tr>
<td>Dhofar</td>
<td>0.33</td>
<td>0.06</td>
</tr>
</tbody>
</table>
There are more than 200 cultivars of Date palm in the Sultanate but the commercial varieties are perhaps not more than 20 cultivars. The Omani cultivars are generally divided into three groups depending on time of fruit ripening. However, the difference is not distinct and is sometimes affected by climatic factors in various regions of the Sultanate.

Dates Pre and Post Handling

Dates take special attention by the Ministry of Agriculture, which has a strategy for Date palm development. The Ministry has launched an ambitious project in which, machines to process and pack Dates are distributed (subsidized by 50%) to farmers and small packers to establish small Date packing houses in an effort to introduce new techniques and ideas of the current pattern of consumption which requires modern attractive packages to fulfill consumers demands.

Private Companies Working in Dates Industry

There are about 8 companies investing in Dates in the Sultanate. These are:

- Tomoor Oman.
- Oman Modern Farm.
- Angara Trading.
- Billah Supply & Crops.
- Omani Dates Flake Factory.
- Muscat Overseas Agriculture.
- Muscat Food Industries.

Banana Handling in the Sultanate

Banana cultivated area in the Sultanate is 2642 ha (6.3% among fruits) and producing about 28,890 tons (10.3%) (MS, 2009). The most common cultivar is ‘Cavendish’ and have been studied and described for vegetative and bunch characteristics. Banana is highly developed and regulated through the strategy of the Ministry of Agriculture.

Banana Units

There are specialized Banana ripening and packing house in the Southern governate (Salalah) of the Sultanate and cold storage facilities in the central markets. In addition, to a receiving unit at Suwaiq on the Batinah Coast. Some farmers have initiated their own ripening rooms and chambers at their fields.

Banana Post-Harvest Practices

Bananas are a very high risk and demanding crop that requires constant attention to production, personnel and marketing management. Harvesting bananas is a big task and involves carrying heavy bunches, weighing more than 50 kg to the trailers. Particular care and training is
needed to avoid injuries to workers and damage to fruits.

Since, bananas deteriorate rapidly in hot sun, thus reducing their shelf life; farmers adopt the following steps to prevent this deterioration:

**Pre-Harvest stage**
- Plants are checked regularly and all rubbing leaves are removed or turned aside.
- The bunches are covered by plastic bags opened from both sides after complete development of the inflorescence (bagging) to prevent the fruits to be damaged by sunburn, spray residues, insects and birds.
- Incomplete hands are removed after bloom to increase the weight of the other hands.
- The bunches are not left ripened on the tree.

**Harvest stage**
- Bunches are harvested at light green stage.
- Banana is harvested with complete hands and when the fingers are fully developed.
- Bunches are collected in a shade area to be ready for packing.
- Padding is used to protect bunches during transport in the trailers or during storage.
- Washing.
- Banana are washed in water tanks and disinfected by using antifungal solutions in packing houses.
- Storing and Ripening.
- Farmers store banana bunches in well closed rooms at 15-19°C and relative humidity 85-95% for 24 hours in the first stage. Ethylene gas is used for ripening.
- Packing and Transport.
  
  Banana after ripening process are transported directly to the markets. Some refrigerated trucks are used to transport produce from collection centers to marketing outlets. Farmers also use their trailers to transport their commodity to the market but they use padding to prevent damages to the fruits.

**Tomato Handling in the Sultanate.**

Tomato is considered one of the main vegetables grown in the Sultanate. The area cultivated under tomatoes is 974 ha constituting about 14.3% from the total cultivated vegetables. The total tomato production is about 41925 tons (25.7% of total vegetable production).
Tomato Post-Harvest Practices

The bulk of the fresh market tomatoes are mature green stage because they tolerate rough handling better than the riper stages and hold the longest in storage, shipping, and on the supermarket shelf. In the industry, this is referred to as having a low shrinkage rate.

Steps of Tomato Harvesting

- **Picking.**
  Tomatoes are picked at 2 stages depending on the ripening. These stages are:
  1. Mature green: a white to yellow ‘star’ on the blossom end.
  2. Breaker, pink, and red: The breaker stage occurs within 24 hours of the mature green stage and is easily distinguished because the blossom end is pink.

  Farmers collect the fruits when completely developed or when it has reached the suitable degree of ripening. The fruits are picked without making any mechanical injury, while the damaged fruits are discarded.

- **Sorting and Grading.**
  The preliminary sorting take place at the field. The fruits with symptoms of infection of disease or infestation of insects as well as sun burn are discarded. As well as the up-normal fruits. This process is necessary to remove culled tomatoes and to separate the fruits into lots of uniform ripeness, consistency, size and appearance.

- **Storing.**
  Farmers traditionally don’t store tomatoes. They directly take the fruits to the market after harvest. However, some new advanced farms store tomatoes depending on the ripening stage.
  1. Green ripened tomatoes: Stored at temperature range between 12-14°C, which will reach the fully ripening stage after 20-25 days. Relative humidity at 85-95%.
  2. Partial ripened tomatoes: Stored at 10-12°C, which will reach the complete ripening after 15 days.
  3. Hard red tomatoes: Stored between 8-10°C for one week.

- **Packing.**
  Tomatoes are packed in different sizes, materials, and shapes and then transported to markets.

Private Companies Working in Tomato Industry.

There are about 2 companies to our knowledge investing in tomatoes industry in the Sultanate. They are Ali and Abdul-Karim Company for food stuff and Al-Khabora. Both companies produce ketchups. However, most of their tomato concentrate were imported from outside the country.
Problems in the Post-harvest

Specific Problems
• Rough handling
• Inadequate cooling
• Temperature maintenance.
• Lack of sorting to eliminate defects before storage.
• Use of inadequate packaging materials.

General Problems
• Lack of specialized and advanced research in the post-harvest technologies.
• Shortage of Post-harvest facilities.
• Non-existence of educational courses at and at underground level in universities.
• Lack of training to producers and workers on Post-harvest sectors technologies.
• Non awareness of consumers and public.
• Lack of private sector investment in post-harvest.

Conclusions and Recommendations

Conclusions
At present post-harvest technology in the Sultanate is mainly concerned with harvesting, collecting and preparing cereals, fruits and vegetables for trading, storing or processing. Post-harvest process is an integral function rather than separate entity. Therefore, efforts to preserve food should be adopted aiming in minimizing the factors that lead to deterioration by this integral function. These processes include drying, salting, sugaring, smoking, fermentation, even in refrigeration, packaging, freezing and storage. Prevention or decreasing post-harvest losses allows consumer to have access to more food product. The post-harvest activities are an integral part of the food production system. Most often post-harvest losses are considered symptoms rather than problems. Detection of the cause is therefore, essential for deciding measures to prevent that cause. Such measures may be taken by small farmers (producers), private traders, cooperative organizations, marketing procedures and handling and transportation undertakers.

Recommendations
• Improved markets. It can be either through private or cooperative, agricultural companies.
• Improved communications. Including feeder roads to make easy movement of produce possible
• Study the pre-harvest treatments to get good quality of fruits
• Studies to identify special standards mechanism of gathering or harvesting the fruits of different crops.
• Encourage farmers to use primary cooling for storage of agricultural products.
• The identification of crop species which will bring about the highest prices at home and abroad.
• Intensification of research for the protection of crops and the harvested produce from losses due to pests, diseases and weeds at pre and post-harvest stages.
• The preservation techniques of crops to maintain quality from the field to consumer, including package and storage.
• Development of proper infra-structures for most commodities such as cold storage facilities, packaging agencies and appropriate handling procedures.
• Identification of the correct stages of fruit harvest for each crop.
• Conducting training and educational programs to farmers and small producers.

References

5. Saaidi, M. 1992. Report on Date-Palm protection and training activities. Ministry of Agriculture and Fisheries (Sultanate of Oman) and FAO.
6. Estimates of cropped area and production for Sultanate by crop (M S 2009)
Technology Reducing Postharvest Losses and Maintaining Quality of Fruits and Vegetables (Philippines)

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\textsuperscript{2} Philippine Center for Postharvest Development and Mechanization

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 consciousness 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 1st 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°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.
(Source: Crop situations in the Philippines. BAS. 2003-2008; & Performance of Philippine Agriculture (Jan-June, 2010).

<table>
<thead>
<tr>
<th>Commodity</th>
<th>2007</th>
<th>2008</th>
<th>2009</th>
</tr>
</thead>
<tbody>
<tr>
<td>Banana</td>
<td>7,484,073</td>
<td>8,687,624</td>
<td>9,013,186</td>
</tr>
<tr>
<td>Calamansi</td>
<td>201,619</td>
<td>199,675</td>
<td>192,187</td>
</tr>
<tr>
<td>Mango</td>
<td>1,023,907</td>
<td>884,011</td>
<td>771,441</td>
</tr>
<tr>
<td>Papaya</td>
<td>164,234</td>
<td>182,907</td>
<td>176,656</td>
</tr>
<tr>
<td>Pineapple</td>
<td>2,016,462</td>
<td>2,209,336</td>
<td>2,198,497</td>
</tr>
<tr>
<td>Cabbage</td>
<td>123,443</td>
<td>128,865</td>
<td>124,712</td>
</tr>
<tr>
<td>Eggplant</td>
<td>210,156</td>
<td>199,579</td>
<td>200,942</td>
</tr>
<tr>
<td>Onion</td>
<td>146,108</td>
<td>129,923</td>
<td>127,055</td>
</tr>
<tr>
<td>Tomato</td>
<td>65,024</td>
<td>68,366</td>
<td>198,948</td>
</tr>
<tr>
<td>Carrots</td>
<td>65,024</td>
<td>68,366</td>
<td>68,328</td>
</tr>
</tbody>
</table>
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

<table>
<thead>
<tr>
<th>Commodity</th>
<th>2007</th>
<th>2008</th>
<th>2009</th>
</tr>
</thead>
<tbody>
<tr>
<td>Banana</td>
<td>436,762</td>
<td>438,593</td>
<td>446,371</td>
</tr>
<tr>
<td>Calamansi</td>
<td>20,545</td>
<td>20,956</td>
<td>20,912</td>
</tr>
<tr>
<td>Mango</td>
<td>184,173</td>
<td>186,770</td>
<td>188,139</td>
</tr>
<tr>
<td>Papaya</td>
<td>9,125</td>
<td>9,175</td>
<td>8,904</td>
</tr>
<tr>
<td>pineapple</td>
<td>53,978</td>
<td>58,251</td>
<td>58,823</td>
</tr>
<tr>
<td>Cabbage</td>
<td>3,502</td>
<td>8,596</td>
<td>8,483</td>
</tr>
<tr>
<td>Eggplant</td>
<td>21,613</td>
<td>21,299</td>
<td>21,170</td>
</tr>
<tr>
<td>Onion</td>
<td>15,879</td>
<td>14,579</td>
<td>14,526</td>
</tr>
<tr>
<td>Tomato</td>
<td>17,544</td>
<td>17,646</td>
<td>17,656</td>
</tr>
<tr>
<td>Carrots</td>
<td>4,898</td>
<td>5,075</td>
<td>5,080</td>
</tr>
</tbody>
</table>
Table 3. Crops with percent losses, causes of losses, and technologies to minimize losses (Loss Assessment Report, 2009; Serrano, 2006).

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

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
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 no quality 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 benefici 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 jeepsneys 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 distance. Loading 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. In all of the traditional or wet markets, vegetables and fruits are displayed at ambient temperature, which is relatively hot (about 30°C). Thus, most fruits and vegetables could only be visually appealing for a day or two. However, in supermarkets where display shelves have temperatures ranging from 10 to 15°C, fruits and vegetables stay fresh for another 3-5 days.

At present, the distribution system is quite inefficient due to lack of functional postharvest 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.
Postharvest Technologies on Reducing Postharvest Losses and Maintaining Quality of Fruits and Vegetables

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 guarantee 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°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 depend 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.](image-url)
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 Fisheries 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 reduce postharvest losses in agricultural commodities through:

- Establishment and modernization of postharvest, transport/logistic facilities to ensure efficient flow of commodities, maintain quality and reduce food losses;

- Capacity and capability strengthening and enhancement 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 Research 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 encourage 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 agricultural 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 horticultural 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.

References


Status Report on Fruits and Vegetables Production and Processing Industry in Sudan

Hind A. Elbashir\textsuperscript{1} and Mohamed A. Imam\textsuperscript{2}

Ministry of Agriculture, Sudan

Abstract

Sudan has a great potential to produce good quality fruits and vegetables. This is because of its large areas of fertile soil, abundant amount of water from rivers, rains and underground water, suitable wide range of climate which allow variability of crops. Studies showed high losses (30→40\%) of fruits and vegetables during harvesting, transport and handling. These losses add to the cost of production and have negative impact on marketing and hence national economy. Therefore adoption of proper post-harvest techniques, investment in the infrastructure and post-harvest technology should be established.

Introduction

Sudan is one of the largest countries in Africa (250 million hectares), strategically located in the center of Africa making it a melting pot between Arabs and sub-Saharan peoples. The country shares extensive boarders with nine countries in the northern, central eastern and western Africa.

It lies within the latitudes 4-23 degrees north and longitudes 23-28 east. It has a wide climatic variation with several distinct ecological zones including high altitudes or mountainous regions in the west (Jabel Marra) and east (Red Sea Hills) that have Mediterranean climate.

Considerable water resources are available which include the White Nile, the Blue Nile and the River Nile and their tributaries, seasonal streams and rains with an annual amount of 109 billion m\(^3\) of water in addition to the underground water i.e. the Nubian Sand-Stone Aquifer which is one of the largest water reservoirs in the world with an estimated rechargeable potential of 29 billion m\(^3\) of water (HS, 2003).

Sudan has 80 million hectares of fertile soil but only 20 million hectares are cultivated. Agriculture remains the leading sector in the Sudanese economy with an estimated contribution of 45\% to the GDP. The agricultural sector provides employment for about two thirds of the industrial sector (CBOS, 2008).
1. Status of Fruits and Vegetables Production Compared to Total Agricultural Production

Many types and cultivars of fruits and vegetables can be produced almost all the year round due to the climatic variations plus available land and water. This large potential could supply both local and export markets. However, horticultural crops represent about 12% of the national agricultural income, compared to 17% for cotton and 29.6% for cereals and oil seeds. Hence the economic impact of fruits and vegetables is still very limited compared to their actual production potential in the country. This is due to less attention paid to them compared with the cash crops e.g. cotton, gum Arabic and the staple food grains. Even reliable data on the area and production of fruits and vegetables are still difficult to obtain.

Various vegetables are grown in both irrigated and rain-fed plots, in a total area of about 273,000 ha i.e. about 3% of the total cultivated area producing on average about 3.4 million tons of vegetables. The most important vegetables are onions and tomatoes followed by potatoes, okra, eggplant, water melons, cucumbers, pumpkins and a number of leafy vegetables. Vegetables are grown in small plots with pumped water including the national corporations such as Gezira Scheme where about 30,000 ha are devoted to vegetables. Table 1 shows area and production of some major vegetables during the period 2005 to 2009.

Fruit production in Sudan needs very little agro-chemicals thus the fruits are relatively free of chemical residues which if certified could give a comparative edge and a competitive advantage in international markets. The variations in climate and topography created conditions for the production of various types of fruits including date palms, citruses, mangoes, guava, pine apples and banana. In the high areas of Jabal Marra temperate fruits such as apples, grapes, strawberries and sweet oranges grow well. However, commercial production is hampered by the lack of investments and poor transportation facilities. The estimated total fruit production in Sudan is about 1.9 million tons in a cultivated area of about 186,000 ha. The area and production of some major fruits grown in Sudan during the period 2006-2009 are shown in Table 2.

Table 1. The area (’000 feddan) and production (’000 tons) of common cultivated vegetables crops in Sudan.

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<tr>
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<th></th>
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</tr>
</thead>
<tbody>
<tr>
<td>Onion</td>
<td>110</td>
<td>688</td>
<td>113</td>
<td>900.8</td>
<td>115</td>
<td>920</td>
<td>117.3</td>
<td>938.4</td>
<td>128</td>
<td>1024</td>
</tr>
<tr>
<td>Tomato</td>
<td>66</td>
<td>396</td>
<td>68.3</td>
<td>409.8</td>
<td>72</td>
<td>432</td>
<td>76.3</td>
<td>453</td>
<td>80</td>
<td>480</td>
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<tr>
<td>Okra</td>
<td>42</td>
<td>210</td>
<td>45</td>
<td>220</td>
<td>48</td>
<td>235</td>
<td>48.4</td>
<td>249</td>
<td>48.9</td>
<td>252</td>
</tr>
<tr>
<td>Egg-plant</td>
<td>8.2</td>
<td>65.6</td>
<td>8.8</td>
<td>70.4</td>
<td>9</td>
<td>72</td>
<td>9.2</td>
<td>75.6</td>
<td>9.4</td>
<td>75.2</td>
</tr>
<tr>
<td>Potato</td>
<td>36</td>
<td>252</td>
<td>37.7</td>
<td>263.9</td>
<td>39</td>
<td>273</td>
<td>41</td>
<td>284</td>
<td>43</td>
<td>301</td>
</tr>
<tr>
<td>Cucurbits</td>
<td>72</td>
<td>504</td>
<td>78</td>
<td>546</td>
<td>81</td>
<td>567</td>
<td>84.2</td>
<td>589</td>
<td>88</td>
<td>616</td>
</tr>
<tr>
<td>Leafy -Vegetables</td>
<td>10.8</td>
<td>54</td>
<td>11</td>
<td>55</td>
<td>13</td>
<td>65</td>
<td>15</td>
<td>66.3</td>
<td>17.2</td>
<td>68.8</td>
</tr>
<tr>
<td>Sweet potato</td>
<td>16</td>
<td>112</td>
<td>17</td>
<td>119</td>
<td>19</td>
<td>133</td>
<td>21</td>
<td>147</td>
<td>32</td>
<td>216</td>
</tr>
</tbody>
</table>

One hectare = 2.38 feddan. (HS, 2009).
Table 2. The area ('000 feddans) and production ('000 tons) of the major fruits grow in Sudan.

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Mango</td>
<td>67.8</td>
<td>611</td>
<td>68</td>
<td>632</td>
<td>68.2</td>
<td>651</td>
<td>68.5</td>
<td>616.5</td>
</tr>
<tr>
<td>Banana</td>
<td>43</td>
<td>516</td>
<td>45.2</td>
<td>540</td>
<td>47.2</td>
<td>561.6</td>
<td>52</td>
<td>624</td>
</tr>
<tr>
<td>Lime</td>
<td>30</td>
<td>210</td>
<td>32</td>
<td>224</td>
<td>34</td>
<td>233</td>
<td>36</td>
<td>236</td>
</tr>
<tr>
<td>Grape fruit</td>
<td>24.5</td>
<td>147</td>
<td>26</td>
<td>156</td>
<td>27.5</td>
<td>165</td>
<td>29</td>
<td>174</td>
</tr>
<tr>
<td>Orange</td>
<td>23</td>
<td>115</td>
<td>24</td>
<td>120</td>
<td>24.9</td>
<td>124.8</td>
<td>25</td>
<td>124</td>
</tr>
<tr>
<td>Dates</td>
<td>83</td>
<td>332</td>
<td>84</td>
<td>336</td>
<td>84.8</td>
<td>339.3</td>
<td>85.5</td>
<td>422</td>
</tr>
<tr>
<td>Guava</td>
<td>16.5</td>
<td>115.5</td>
<td>17</td>
<td>119</td>
<td>17.5</td>
<td>122.5</td>
<td>18</td>
<td>126</td>
</tr>
</tbody>
</table>

One hectare = 2.38 feddan. (HS, 2009).

Mango tree is the number one fruit tree in terms of production, followed by banana, date palm and lime. Sudan produces about 5.7% of the total Arab world production.

Mango is the main fruit produced in the northern states e.g. Western Darfur, Southern Kordofan, Northern and Khartoum states. Kassala State is the main area for banana production (ca. 35%), followed by Blue Nile (ca. 25%), Gezira, Sennar and Khartoum states. Grapefruit and oranges are mainly produced in the Northern State (ca. 60% & 40% respectively). Oranges are also produced in River Nile and Western Darfur states. Both dry (75%) and semi-soft (25%) dates are produced by small farmers in the Northern and River Nile states (PAB, 2003).

2. Major Constrains in Fruits and Vegetables production:

1. Lack of sufficient improved management technologies.
2. Inadequate financial and credits facilities.
3. Land fragmentation.
4. Poor vegetables seed production.
5. Limited application of agricultural research findings due to inadequate extension services.
6. Low productivity due to poor and traditional cultural practices.
7. High cost and improper local transportation.
8. Weeds, pests and diseases.

3. Main Distribution and Production of Fruits and Vegetables

Most of the horticultural production in Sudan is under irrigated farming system, along valleys and streams in the western states and the areas of high rainfall in the south. Most of southern Sudan and the fertile locations in South Kordofan, Southern Darfur, Southern Sennar and Blue Nile states are considered main potential areas for horticultural production (HS, 2009).

The most important vegetables are mentioned in Table 1. Other vegetables like carrot, cabbage,
red beet and cauliflower are grown at the outskirts of large cities. These vegetables are grown in different areas and marketed in the same or other areas. Vegetables acreage increased tremendously in the last few years due to the increased urbanization, awareness of their nutritive value and high returns per unit area. Both production and consumption of fresh vegetables and fruits are increasing due to relatively high demand locally and externally. The rate of consumption from fresh vegetables and fruits per annum is about 43 kg and 32 kg/person respectively (PFS, 2005). The increase in vegetable production is rather horizontal, productivity remains low and lags far behind international yields indicating high potential for improvement through better cultural practices, improved varieties and protection against pests and diseases. At present horticultural production is a flourishing enterprise in the country. The national strategy (2002-2027) emphasized the importance and role of the horticultural sector in development plans and on the national income (Abdelkareem, 2003).

4. Post-harvest Handling and Processing

Generally, huge losses occur in the horticultural crops due to poor post-harvest practices. Losses range between 30% - 40% (HS, 2003). These have a negative impact on the national economy.

5. Storage

Refrigeration of fruits and vegetables started in the early seventies (FRC, 1998) with the compelling need for potato storage. Later, many cold stores were established to about 10,000 tons capacity with extra storage in the Northern State.

Exhibition of fruits and vegetables at the local markets is very poor because the markets are not properly equipped for their exhibition. Numerous packing materials mainly for bulk packing are used that do not satisfy the consumer taste, for example:

- 15 kg tin packs for tomatoes.
- Different sizes of local containers made of palm trees leaves.
- Onions jute bags 50 kg.
- Potato jute bags 50 kg.
- Fertilizers sacks which are used for eggplant and okra.

All these containers are available at the local markets and are the main reason for post-harvest losses for retailers (FRC, 2008). These containers are against the requirements of ISO 9000 and Environment ISO 14000 (Elyas, 2008).

The horticultural crop supply chain

The chain involves:


Handling and preparation: Cleaning, sorting and grading all carried out manually.
Packaging: Manual e.g. tomatoes packed in 4-gallons tins, mangoes and grapefruits in locally made baskets and imported jute sacks for dates/lime or oranges.

Transport: Most of the crops are transported by animals or lorries to local consumption villages or urban cities' central markets.

Marketing: The products are sold at road sides, village household stalls, urban cities street markets and some supermarkets. Some producers sell their products directly at different markets i.e. to an assemblers or itinerant wholesalers. No real markets exist in this case. The products are being transferred directly from the centre of supply to the centre of consumption.

The following practices are specific causes of post-harvest losses

(1) Banana

Bananas are grown in the Blue Nile and Kassala states about 600 km from Khartoum markets. They are transported in 5-6 tones trucks where banana bunches are stacked to the maximum permissible load. Most of the bruises which appear later after ripening are due to the harvest and transport methods. Post-harvest losses of bananas are about 35%.

Dwarf Cavendish is the predominant cultivar which in spite of its locally preferred taste and flavor, it has short fingers and is a poor keeper and shipper, a major reason for its unacceptability in the world markets. Fortunately, new banana cultivars have been released recently from the Sudan National Variety Release Committee targeting the export markets such as Granien and William.

(2) Mango, Guava and Citruses

Mango, guava and citruses (lemon, oranges, mandarin and grape fruits) are harvested mainly by using a hook and stick. This method increases losses during handling and storage due to the fall and contact with the ground that causes fruit deterioration. International cultivars of mangoes and grape fruits were recently introduced such as Kit, Kent, Tomyattkins, Sensasion and Haden for mangoes and Ray Robby, Rio ruby, Chamber, Froset march for grape fruits to secure the export market.

(3) Melon

Export of Gallia cultivar induced the producers to use improved methods of harvesting and packing but the main problems are time of harvest and packaging. Post-harvest losses of melons are about 15-20%.

(4) Dates

Dates are harvested manually by cutting the bunch and dropping it to the ground. causing losses of up to 50%.

(5) Leafy vegetables

Leafy vegetables like Jews mallow, garden rocket, dill, purslane and parsley are produced for the
local markets. These vegetables are packed in local straw containers and exhibited covered with jute sacks soaked in water. They are totally lost after 24 hours from harvest.

(6) Potatoes

Potatoes are harvested manually when the vines turn yellow. Tubers are cured for 10 days in the field in shallow pits called 'Boata' covered with potato vines. The tubers are then packed in jute sacks and placed in the same field under the direct sun rays (30-37°C) for 2-3 days waiting for loading to the cold store. This method leads to poor potato quality and about 30% losses.

6. Post-harvest Research

Research in the field of post-harvest technology is mainly conducted at the Post-harvest Physiology and Storage Department, Food Research Centre. It was established in 1969 to improve post-harvest techniques by minimizing the losses, improving the storability and maintaining the quality of the horticultural crops. A number of researches were carried out on the:

- Improvement of local harvesting methods (maturation and maturity indices, best local tools for harvest and suitable containers for harvest, handling and export).
- Preparation of fruits and vegetables for export (sorting, grading, waxing and packing).
- Ripening of climacteric fruits (banana, mango and guava).
- Degreening of citrus.
- Suitable storage temperatures for export fruits and vegetables.
- Improvement of local methods of onion storage.
- Introduction of cold storage techniques for fruits and vegetables such as, potato, mango and citrus.
- Publishing booklets on the standard metrology indices for Sudanese fresh fruits and vegetables for local market.
- Extension of shelf life of vegetables and fruits using gamma irradiation (potato, guava, mango, banana and onion).
- Evaluation of fruits and vegetables for processing and export markets.

Studies on post-harvest technology including canning (jams, tomato paste etc), drying (okra, potato) are conducted in the dehydration and canning sections, Food Research Center.

However, the research findings are poorly applied hence their low contribution to the national economy. This is due to inadequate extension services and limited investment in the food industry. Post-harvest technology research can contribute more to the national economy since Sudan can add to the world markets' supply of mango, grapefruit, lime, guava, pineapple and papaya whether fresh or concentrates.

7. Post-harvest Research Constraints

- Limited number of well trained technical staff.
• Weak linkage between research and the industrial sector.
• Limited training opportunities for research scientists and technical staff abroad.
• Weak linkage with the international information and research centers.

8. Fruits and Vegetables Markets

There are no marketing institutions dealing with fruits and vegetables. Farmers and producers deal as individuals directly with local traders and exporters. The trade lacks exhibition sheds, loading and unloading platforms, cold stores and trucks loading equipments. Therefore the producers sell their products early in the morning at very low prices especially perishable vegetables, i.e. tomatoes. The central markets are administrated by local authorities who collect fees for services (waste disposal) and rents for selling stalls and shops. Farmers and traders associations exist in Kassala, Gedarif, River Nile and Northern states.

The main local markets are in Khartoum, Khartoum North, Omdurman, Wad Madani and Port Sudan (Abdalazeez, 2005). The trends in domestic, regional and international markets are shown in the following diagram:

The performance of the horticultural crops marketing system is irregular in terms of prices, profits and cost of production and is unsustainable hence it is a traditional and ineffective system. Table 3
shows the cost of production of some horticultural crops in Kassala State.

Table 3. Average cost of production and financial profit margin for main vegetables and fruits in Kassala State.

<table>
<thead>
<tr>
<th>Crops</th>
<th>Cost of production (SDG/ton)</th>
<th>Selling price (SDG/ton)</th>
<th>Profit (SDG/ton)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>During season</td>
<td>Off season</td>
<td>During season</td>
</tr>
<tr>
<td>Onions</td>
<td>150</td>
<td>200</td>
<td>1200</td>
</tr>
<tr>
<td>Tomatoes</td>
<td>500</td>
<td>1000</td>
<td>10000</td>
</tr>
<tr>
<td>Mangoes</td>
<td>535</td>
<td>1162</td>
<td>4980</td>
</tr>
<tr>
<td>Grapefruit</td>
<td>325</td>
<td>600</td>
<td>2000</td>
</tr>
</tbody>
</table>


The selling price fluctuates greatly at the beginning of the season and during the season. For example, tomatoes will be sold at a low price at the start of the winter season and for two months but in summer the price will increase to up to 10000 SDG/ton (for two months).

Industry

There are many factors dealing with fruits and vegetables processing in Sudan but most of these factories are out of functioning because the grown variety is unsuitable for processing characteristic, financial storage and lack of technical experiences.

9. Import of fruits and vegetables

Import of fruits started in the mid nineties from Egypt, China, Quarter and Lebanon. These are grapes, strawberries, apples, cherries, kiwis and pears.

10. Export of Fruits and Vegetables

In spite of the high potential and diversification of horticultural products, the export of fruits and vegetables is very limited as it contributes around 2% of the total exported food commodities (HS, 2009).

The export business started in the early seventies and the amounts exported are still low (Idris, 2006). Most of the Sudanese vegetables are produced in winter (November-March) which is the best time to fill the seasonal gap demand in European markets for onions, eggplant, sweet pepper, snap-bean, Gallia melon, hot pepper, squash and okra. Fruits with high export potential are mango, banana, grapefruit, dates and lime. Export links with European and Gulf countries is being established e.g. Holland, England, Italy, France, Greece, Saudi Arabia, Qatar, Kuwait, Jordan, Bahrain and United Arab Emirates (Elyas, 2008). Gezira State is the most important state in the export of fruits and vegetables, followed by River Nile and Northern states. Average amounts exported are shown in
Table 4. Average amounts of yearly exported fruits and vegetables.

<table>
<thead>
<tr>
<th>Crop</th>
<th>Amount (ton)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Onion</td>
<td>185</td>
</tr>
<tr>
<td>Tomato</td>
<td>27</td>
</tr>
<tr>
<td>Snap-bean</td>
<td>73</td>
</tr>
<tr>
<td>Lime</td>
<td>57.1</td>
</tr>
<tr>
<td>Mango</td>
<td>305.8</td>
</tr>
<tr>
<td>Banana</td>
<td>271.2</td>
</tr>
<tr>
<td>Grape fruits</td>
<td>26.4</td>
</tr>
<tr>
<td>Melons</td>
<td>727</td>
</tr>
</tbody>
</table>

Source: Sudanese Standardization and Metrology Organization, Ministry of Ministries.

10.1. Factors affecting programs and plans for fruits and vegetables export

1. Small holding fields for export crops and poor cultural practices.
2. The absence of suitable export varieties to compete in international markets.
3. Lack of suitable and well defined technologies for growing fruits and vegetables for export.

10.2. Major Constrains facing the export of fruits and vegetables

(1) Post-harvest practices
- Poor infra-structure and logistics which include inadequate transport system, absence of refrigerated transport, insufficient cold storage, grading and packing facilities.
- Lack of proper knowledge in post-harvest practices by both producers and exporters.
- Complicated custom services.
- Poor airport handling i.e. pallets handling.

(2) Air-freight
Horticultural crops are mainly exported by air. Problems faced are:
- High cost of air-fright 1000-1200 US$ per one ton to Europe.
- Frequent delays in flight schedules.
- Charter flights contracted are not equipped with noise isolation system which is necessary to land in European countries.
- High cost of rented planes.
- High competition with other exporting countries.

(3) Marketing

Technical barriers
• Poor quality of produce as far as post-harvest treatments is concerned.
• Lack of sustainability.
• Poor internal transportation system and processing facilities.
• Poor production and the lack of specialized varieties for export.
• Absence of sanitary certificates required at the other end.
• Unreliable feedback and absence of market information.
• Limited technical marketing expertise.
• Limited marketing organization with resources capable of gathering and disseminating market information.

Financial barriers
• Lack of agricultural finance.
• High production and export risks which limits banks credit and finance.
• High cost of service fees and taxations.
• High cost of the agricultural inputs.
• Poor marketing extension in Sudan.

Constraints and potentialities of the horticulture sector
- Low productivity due to disease and pest problems, lack of certified seeds and availability and high post-harvest losses (50%).
- Irregular production, consumption and prices.
- High temperatures lead to irregular flowering e.g. optimum flowering for mango is 8-15°C at night. It also increases the rate of ripening and hence relatively short shelf-life.
- High cost of agricultural inputs.
- Availability of proper packaging materials.
- Inadequate cold chain. Preservation of quality requires an unbroken chain from the field to the consumers. No cold stores facilities are available at the centers of production, central markets and airports.
- Weak entrepreneurial skills.
- Inadequate market knowledge and weak marketing channels and mechanisms. No effective market linkages are established.
- Weak management skills in the fields of production planning, production practices and organization of harvesting at the correct maturity for fresh consumption, processing and export.
- Lack of extension services and weak technology dissemination mechanism for the application of proper post-harvest operations developed by Food Research Center (FRC) and the Agricultural Research Corporation (ARC).
- Availability and access to credit and finance.

Potentialities
- Horticultural crops are products of high demand locally and in overseas markets.
- There are great potentialities to expand production areas e.g. in Kassala, Northern and Gedarif states.
- There is a winter window of opportunity in export markets (during December – March) due to a long growing season (winter and summer seasons) e.g. in Kassala State.
- The value added through processing is high and hence its impact on GDP will be appreciable.
- Availability of experienced laborers and accessibility to cheap water and irrigation infrastructure.
- Availability of an extensive range of institutions and skills in the public sector e.g. Ministry of Agriculture and Forestry, ARC, FRC and universities.

**Conclusion**

In conclusion, there are slight increases in fruits and vegetables production and limited amounts exported. Thus there is an urgent need for a total revision of Sudan's horticultural policies with the objective of increased production and better qualities of produce. Agricultural scheme should be adopted and financed, taxation policies should be revised to make the sector competitive in international markets.

**Recommendations**

- Investment in infrastructure and post-harvest technologies. The government of Sudan adopted a series of macro economic policies to promote the investment environment in the field of agriculture. These policies insures no discrimination between the invested fund by reason of being local or foreign, or by reason of its being a public, private, co-operative or joint sector. Investment act gives privileges such as:
  1. Exemption from the business profit tax, for a period not exceeding five years.
  2. Exemption may not exceed 70% of the custom duties and any other taxes.
  3. Production and consumption duties.
  4. Allotment of necessary land at an encouraging price for the project to competent bodies.
- Improvement of productivity per feddan through the introduction of new high quality breeds and by development of the local hybrid seed production.
- Development of integrated horticulture supply chain.
- Promoting an enabling environment through:
  1. Increasing awareness and market information.
  2. Making credit more affordable.
  3. Improving technology dissemination and extension services.
  4. Creation of an effective market linkage.
- Establishment of a regional training centre run by public and private sectors e.g. in Kassala State in order to link R & D's, extension departments and farmers.
- Supporting R & D institutions financially and technically.
• Application of proper post-harvest operations developing by FRC to reduce losses, increase productivity and up-grade qualities.
• Economical utilization of existing vegetables and fruit factories' capacities i.e. Kassala Canning and Onion Dehydration factories to increase the revenue from the added value. The objective should be exporting processed products instead of raw materials. International companies and firms are encouraged to invest in this sector.

References
5. FRC, 1998. Annual report of Food Research Center, Ministry of Science and technology.
Some Horticultural Post Harvest Aspects in Sudan with Special Focus to Banana

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Introduction

Sudan is one of the largest countries in Africa. It lies in the hart of Africa content between long. 21-38 E and lat. 4-22 N. Sudan enjoys wide variety of climates ranging from desert in the north, tropical and subtropical in the middle and equatorial in the south. It has been blessed with abundant water resources from rivers, rain, and underground water beside huge areas of fertile soil.

The country has got reasonable infra-structure including railways, paved roads connecting the regional capitals and the main production areas with the federal capital and the national seaport at. Also there are international airports, well established network of telecommunication.

In Sudan there is about 84 millions hectares available for cultivation of which about 17 million are actually cultivated.

The vegetables cultivated areas is about 273154.14 hectares with total production of 3.4 M tons with average productivity of 12.5 ton/ ha. The fruit cultivated area is about 158864.85 ha with total production of 1.9 m tons with average productivity of 14.4 ton/ ha. Sudan has the capability of producing fruits and vegetables, ornamental plants, spices, and medicinal plants all over the year. Production for export is highly specialized for being trace naturally and free of chemical residues.

Problems Facing Fruits and Vegetables Export:
1. High cost of agricultural inputs.
2. Cultural practices still need a lot of extension, training, and applied research.
3. Improper harvest time and process.
4. Lack of precooling.
5. Bad access roads conditions leads to great losses and reduces the quality of the produce.
6. Insufficient centers for grading sizing and backing.
8. High cost of air transportation. For example, A ton of produce to Europe will cost more than one thousand $, also the trips are not regular.
9. Marketing problems which include:
   (a) No strict adherence to market specifications
   (b) Lack of regulatory and sustainability of export produces
(c) Non sufficient market information
(d) Weak government finance.
(e) Weak processing for surplus.

Solutions
1. Production cost must be reduced by reducing cost of inputs, charges, and irrigation cost.
2. Provision of necessary finance.
3. Improvement of production quantity and quality by:
   a. Training of farmers to improve their work in the field and post-harvest practices and create awareness.
   b. Strengthening and support of research and extension services.
   c. Implementation of suitable technical packages.
   d. Weed and pest control.
   e. Delegation of information to exporters.
   f. Improvement of nursery services.
4. Strengthening and support of necessary infrastructures for export.
5. Provision of market information.
6. Encourage investment in agricultural industry.
7. Diversification of exportable crops and creation of new markets through efficient market survey and study and recognition of market size.
8. Regulation and organization of air transport.
9. Introduction of sea transport which is cheaper.

Exportable and promising horticultural crops include mango, lime, grapefruit, banana, papaya, melon, onion, green beans, sweet and hot pepper, okra, potato, medicinal and aromatic plants.

Banana

The area cultivated with banana in Sudan is estimated at 41340 feddans with a total production of 400000-500000 tons per year. About 87% of total production comes from three states, namely Sinnar, Blue Nile, and Kassala. Within the three states, Sinnar state comes on the top (in fact the top of the country) as 73% of total production of banana in the country comes from this state. Then come Blue Nile state with 8%, and Kassala state with 6% of the total production.

In Sudan, there are a lot of factors in favour the production of banana. These factors include availability of fertile soil, suitable climate, experienced farmers, adequate technically qualified personnel in addition to that Sudan is near Gulf market. Almost only dwarf Cavendish variety of banana is produced in the Sudan. More than 95% if not 100% of banana produced in Sinnar and Blue Nile states is transferred to Khartoum state where it ripened and sold in the local market.

The situation of banana can be discussed with regard to:

A. local market
Although the bananas are generally clean in appearance in the field, the quality presented in the market is poor and a lot of post harvest losses occur which are estimated at 30-40%. The reasons for that are:

1) Condition in the field:
   The various cultural practices are not well paid attention, fertilisation is done occasionally. Although the temperature in the production areas (Sinnar, Blue Nile) range from 30-42 Celsius, it did not affect plant growth and development because of the irrigation by flooding which also add to the fertility of the soil. No serious pests and diseases are observed.

2) Harvest:
   The farmer has good experience with regard to harvest time but the harvest process is not done properly. The bunches are cut and put over each other in a front of a pile in a place in most cases not shady waiting for truck which in most cases do not come in proper time. There is no any post harvest treatments.

3) Loading and transport:
   Worker are not fully aware of right way of loading of trucks which are usually overloaded in addition people normally travel together with the banana on the same track with their luggage kept on the top of the load. The distance between the production areas and Khartoum is about 700-900 km. the truck at first has to pass through the bad access roads from the farm before reaching the paved road. Although the main road connecting the production area with Khartoum is paved but it is not in a good condition in many part of it where holes and cracks exist. A long the road there is a lot of tax points where the driver has to stop and pay for traffic taxes or to check his documents. Also drivers are not aware of the load they carry and they take a lot of time resting at service areas. Due to all these fact, the trucks take more than 16 hours before they reach the ripening rooms in Khartoum. During the rainy season the story is different. The truck can not move any more in access roads to farm so the truck wait beside the main paved road. The banana is lifted from the farm by a tractor-trailer to the place of the truck and then the load is transferred to the truck. Several tractor trips are needed for one truckload, which means more handling, more cost and more delay to the produce.

4) Unloading and ripening conditions:
   On arrival at the ripening rooms, the handling of the bunches is rough. The bunches are thrown from the truck to a man waiting beside and he in turn throw it to the ground. The common practice in most ripening rooms is to dip the bunches one after another in a barrel of water which is usually not changed even if it becomes dirty. By doing so the fungal spores from banana will accumulate in the water which becomes a source of fungal infection. After unloading the bunches are then weighed and piled on the floor of the room almost up to the roof in this way air circulation will be severely hampered. The ripening rooms are seldom washed or cleaned and when washed on soap or disinfectants are used. As a result the rooms are conducive to growth of micro organisms. Most
B. Banana export

In spite of an area of 31340 feddans cultivated with an average production of 400000-500000 tons, only small trail shipments found their way to the export markets. To study the situation of banana export a comparative study was conducted (Imam, 2001) where banana production and export for five years (1993-1997) was compared with the production and export of other three horticultural crops namely mango, Lime and grapefruit for the same period.

By referring to table (1) banana production comes in the second level after mango with a percentage of 25.6%. table (2) shows that banana export comes at the bottom and the amount exported is very low and non-sustainable. Form the table ,the total amount exported during the five years equals only 19.5 tones, which represents only 0.06% of the total amount export of all fruits in the study, which equals 32315.19 tones. If we take the total amount of banana exported during the five years (19.5tones)as percentage of the amount of banana produced during the same years it constitutes only 0.0009% (table 3). from the three table (1, 2 and 3) , it is clear that the problem of banana export is not is not related to production . also the problem is not a lack of market because sudan is next door to gulf area where the market capacity is very large. Table 4 shows that a total amount of 688000 tones of banana is imported in gulf area in one year . total amount of banana exported from sudan in five years (19.5tones) constitute only 0.016% of the amount imported by Saudi Arabia in one year which is equal 125000 tons .

Table 1. Banana production for the period 1993-1997 as compared with other crops.

<table>
<thead>
<tr>
<th>Year</th>
<th>Mango (1000 tons)</th>
<th>Banana (1000 tons)</th>
<th>Lime (1000 tons)</th>
<th>Grapefruit (1000 tons)</th>
<th>Total (1000 tons)</th>
<th>Mango (%)</th>
<th>Banana (%)</th>
<th>Lime (%)</th>
<th>Grapefruit (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1993</td>
<td>793.2</td>
<td>405</td>
<td>228</td>
<td>121</td>
<td>1493.2</td>
<td>49.5</td>
<td>27.1</td>
<td>15.3</td>
<td>8.1</td>
</tr>
<tr>
<td>1994</td>
<td>776</td>
<td>414</td>
<td>234</td>
<td>217</td>
<td>1641</td>
<td>47.3</td>
<td>25.2</td>
<td>14.3</td>
<td>13.2</td>
</tr>
<tr>
<td>1995</td>
<td>821.6</td>
<td>436.5</td>
<td>237</td>
<td>224</td>
<td>1719.1</td>
<td>47.8</td>
<td>25.4</td>
<td>13.8</td>
<td>13</td>
</tr>
<tr>
<td>1996</td>
<td>870.4</td>
<td>459</td>
<td>240</td>
<td>238</td>
<td>1807.4</td>
<td>48.2</td>
<td>25.4</td>
<td>13.3</td>
<td>13.2</td>
</tr>
<tr>
<td>1997</td>
<td>960</td>
<td>486</td>
<td>252</td>
<td>254</td>
<td>1952</td>
<td>49.2</td>
<td>24.9</td>
<td>12.9</td>
<td>13</td>
</tr>
<tr>
<td>Total</td>
<td>4167.2</td>
<td>2200.5</td>
<td>1191</td>
<td>1054</td>
<td>8612.7</td>
<td>49.5</td>
<td>27.1</td>
<td>15.3</td>
<td>8.1</td>
</tr>
</tbody>
</table>

Source: Horticulture Sector Administration.
Table 2. Banana export for the period 1993-1997 as compared with other crops.

<table>
<thead>
<tr>
<th>Year</th>
<th>Mango</th>
<th>Lime</th>
<th>Grapefruit</th>
<th>Banana</th>
<th>Total</th>
<th>Mango</th>
<th>Lime</th>
<th>Grapefruit</th>
<th>Banana</th>
<th>Percentage (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1993</td>
<td>5829.9</td>
<td>768.1</td>
<td>37.1</td>
<td>9.5</td>
<td>6644.6</td>
<td>11.6</td>
<td>0.6</td>
<td>0.1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1994</td>
<td>6528.2</td>
<td>200.3</td>
<td>13.9</td>
<td>10</td>
<td>6752.4</td>
<td>2.9</td>
<td>0.2</td>
<td>0.1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1995</td>
<td>5458</td>
<td>866</td>
<td>101</td>
<td>0.0</td>
<td>6425</td>
<td>13.5</td>
<td>1.6</td>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1996</td>
<td>5095</td>
<td>114.1</td>
<td>110</td>
<td>0</td>
<td>5319.1</td>
<td>2.1</td>
<td>2.1</td>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1997</td>
<td>5194</td>
<td>137.7</td>
<td>603</td>
<td>0</td>
<td>5934.7</td>
<td>2.3</td>
<td>10.16</td>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>28105.1</td>
<td>2086.2</td>
<td>865</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>19.5</td>
</tr>
</tbody>
</table>

Source: Sudan Airport quarantine office

Table 3. Banana export as percentage of production.

<table>
<thead>
<tr>
<th>Year</th>
<th>Banana production (1000 tons)</th>
<th>Banana export (tons)</th>
<th>Export percentage (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1993</td>
<td>405</td>
<td>9.5</td>
<td>0.002</td>
</tr>
<tr>
<td>1994</td>
<td>414</td>
<td>10</td>
<td>0.002</td>
</tr>
<tr>
<td>1995</td>
<td>436.5</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>1996</td>
<td>459</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>1997</td>
<td>486</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td></td>
<td>2200.5</td>
<td>19.5</td>
<td>0.0009</td>
</tr>
</tbody>
</table>

Table 4. Annual import of banana in Gulf area

<table>
<thead>
<tr>
<th>Import country</th>
<th>Total amount imported (1000 tons)</th>
<th>Value (million dollars)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Saudi Arabia</td>
<td>125</td>
<td>78</td>
</tr>
<tr>
<td>Iran</td>
<td>145</td>
<td>60</td>
</tr>
<tr>
<td>kuwait</td>
<td>24</td>
<td>15</td>
</tr>
<tr>
<td>Lebanon</td>
<td>26</td>
<td>13</td>
</tr>
<tr>
<td>Libya</td>
<td>35</td>
<td>18.75</td>
</tr>
<tr>
<td>Syria</td>
<td>53</td>
<td>23.85</td>
</tr>
<tr>
<td>Turkey</td>
<td>165</td>
<td>82.5</td>
</tr>
<tr>
<td>UAE</td>
<td>60</td>
<td>36</td>
</tr>
<tr>
<td>Rest of Gulf</td>
<td>55</td>
<td>33</td>
</tr>
<tr>
<td>Total</td>
<td>688</td>
<td>359.5</td>
</tr>
</tbody>
</table>

The problems of banana export are
1. improper harvest methods and bad handling
2. absence of backing houses
3. lack of refrigerated trucks
4. improper mode of transportation
5. insufficient scheduling
6. lack of post-harvest treatment
7. other problems shared with other horticultural corps

Solutions
1. Roads must be improved specially access roads
2. Backing houses must be established
3. Training of farmers for suitable cultural practise
4. Farmers must be trained how to harvest and conduct post harvest handling for such delicate crop
5. Creation of awareness among workers and drivers about the need of care and gentle handling for banana
6. Loading operation must be organized in advance to avoid delays
7. Farmers must be trained to use traveler boxes instead of transporting banana as bunches
8. If the boxes are not affordable by they should but a layer of wood at the middle of the truck so that the load of bunches is separated into two parts to reduce damage of the fruit
9. Other solutions shared with other crops

Efforts to improve banana handling

An improved method of harvest and handling of banana was conducted [imam,2001] and compared with the traditional methods of handling. The improved methods involves careful cutting by two persons, dehanding under water treated with chlorine 100 ppm then dipping in fungicide (TBZ 300 ppm) as a separate treatment. The hands are then backed in traveller boxes (69 x 30 x 25 cm). The boxes are then loaded in the truck and transferred to Khartoum for ripening. The result of the study showed that there is a significant difference in the percentage of losses and the grade of fruit. The total losses decreased from 41% to 12.3% and the quality percent raised from 6.6% to 58.1%. This method of dehanding, washing, backing is demonstrated several times in the field in front of the farmers for training purpose.

References
2. FAO Year Book 1998.
Technology on Reducing Post – harvest losses and Maintaining Quality

Abdul Hamid Al Imam
Syria

Abstract

The Syrian working paper includes three chapters. The first Chapter contains general information about the Syrian Arab Republic (where the site - the border - the most important cities – population). It also includes the agriculture in Syria (where importance - the distribution of land use - agricultural settlement zones – the important agricultural products, value of agricultural commodities for commercial exchange). The second chapter contains a presentation of post-harvest techniques (Harvest - Pre cooling - Quality Control in the field – Packaging – Transport) and the best practices to be followed to reduce the loss and maintain the quality of fruits and vegetables.

The third Chapter contains the recommendations for marketing chain and post-harvest techniques, these recommendations are at the macro level, at the farm level and the retailer level.

Worksheet also includes many forms and important illustrations in point.

Introduction

1. General Informations about Syrian Arab Republic

Syrian Arab Republic is republic in southwestern Asia continent, bounded on the north by Turkey, on the east by Iraq, on the south by Jordan and on the west by Lebanon and the Mediterranean Sea. Syria is divided into fourteen governorates, these governorates are divided into a total of sixty districts.

The capital Damascus is the largest city in Syria, it is One of the oldest cities in the world, where many of the landmarks and cultural. The most important cities in Syria are:

- Aleppo in northern Syria, the second largest city, it is also a major industrial and cultural center.
- Latakia along with Tartus are Syria's main ports on the Mediterranean sea.
- Homs in central of Syria and Deir -Zor on the Euphrates river in eastern Syria.
The total population of S.A.R. inside the country at the end of 2008 is (19880000).

Fig. 1. Shows the location of Syria in the world.

Fig. 1. Syria's position in the world.

And Fig. 1. Shows the map of Syria and its borders.

Fig. 2. Map of Syria and its borders.
2. The Agriculture In Syria

A special situation is going to the agricultural sector in Syria within the other economic sectors which compose the national economy, and that is visible because the food is given to citizen regularity, the raw material is available to the industry normally, the commercial balance is raised and the foreign coinage is available to finance the requirements of others economic sectors. During the past years the Syrian government adopted many structural Adjustment programs; this reflects the increasing growth rate of agricultural export due to increase in agricultural production, specially for the products that have Relative Advantage. The area of Syria is (18517971) ha distributed as in table 1:

<table>
<thead>
<tr>
<th>Total Area</th>
<th>Cultivable Land</th>
<th>Uncultivable Land</th>
<th>Steppe and Pastures</th>
<th>Forestes</th>
</tr>
</thead>
<tbody>
<tr>
<td>18517971</td>
<td>6023792</td>
<td>3683404</td>
<td>8231974</td>
<td>578801</td>
</tr>
</tbody>
</table>

Fig. 3 shows the land use in Syria for 2008.

Syria is divided into five agricultural settlement zones according to the amount annual rainfall as follows :

**First settlement Zone**
A zone with annual rainfall over 350 mm, It is divided into two areas:
- The area of annual rainfall rate over 600 mm, Where rain field crops could be successfully planted.
- The area of annual rainfall rate between 350 - 600 mm, and not less than 300 mm, during the 2/3 of the relevant year, it is possible to get two seasons every three years and its main crops are: Wheat, Legumes and Summer Crops. The area of this zone is 2701000 ha, that forms 14.6 % of the country area.

**Second settlement Zone**

A zone with annual rainfall 250 - 350 mm, and not less than 250 mm during 2/3 of the relevant year, i.e., it is possible to get two barley seasons each three years, and could be planted beside barley, wheat, legumes and summer crops, the area of this zone is 2475000 ha, that forms 13.3 % of the country area.

**Third settlement Zone**

A zone with annual rainfall 250 mm, and not less than this figure during the half of the relevant years i.e. it is possible to get one to two Seasons each three years. Its main crops is barley, legumes could be planted, the area of this zone is 1303000 ha, that forms 7.1% the country area.

**Fourth settlement Zone (Marginal)**

A zone with annual rainfall rate between 200 - 250 mm, not less that 200 mm during the half of the relevant years. It is good just for barley or for permanent grazing crops, the area of this Zone is 1830000 ha, that forms 9.9% of the country area.

**Fifth settlement Zone (Desert and steppe)**

This area covers the rest of the country land and it is not suitable for rain field planting, the area of this zone is 10,209,000 ha, that forms 55.1% of the country area.

Fig. 4. Shows distribution of agricultural settlement zones in Syria.
Despite climatic handicaps Syria produces a wide variety of crops, some in sufficient quantity for export. The major crops are cereals, primarily wheat and barley; cotton, grapes, olives, citrus, other fruits such as (Apples, pears, apricots, cherries, peaches, plums, figs, pomegranates, pistachios .. ) and vegetables (Potatoes, tomatoes, cucumbers, cabbage, lettuce … ) .

The agricultural production value for 2008 by fixed prices amounted / 351511 / million s.p. including / 217068 / million s.p. for plant production value & / 134442 / million s.p. for animal production value. The total value of agricultural commodities for commercial exchange and their percentage to the total exchange of the country in 2007 and 2008 are as in table 2.

<table>
<thead>
<tr>
<th>Year</th>
<th>Commercial Exchange</th>
<th>Value/Million s.p</th>
<th>Percentage</th>
<th>Value/Million s.p</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Import</td>
<td>57442</td>
<td>8.4%</td>
<td>93781</td>
<td>11%</td>
</tr>
<tr>
<td></td>
<td>Export</td>
<td>110048</td>
<td>19%</td>
<td>113163</td>
<td>16%</td>
</tr>
</tbody>
</table>

Post - harvest Techniques in Syria and the Mechanism of Improvement

Agricultural sector suffers from many problems that are an obstacle to growth and development, Foremost of these difficulties the problem of agricultural marketing and post – harvest techniques, In addition to technical operations in the field and packing centers and wholesale markets, These Operations include farming practices that must be carried out on farm in order to obtain a good harvest to ensure its ability to compete against a similar product in foreign markets and thus achieve the best profits, These practices begin to determine the appropriate time for harvest and ending with transfer of products to target places, whether the wholesale markets, or sorting and packing centers, or factories, therefore We must know the most important Post - harvest techniques that contribute to maintaining quality of fruit and vegetables.

1. Determine the harvest date

Harvest date subjects to many factors including: the specific and clear signs of growth in addition to desires of consumers (size, color and degree of maturity), method of harvest manually or automatically, and nature and type of crop and peak breathing.

In principle, it is recommended usually harvest in the early hours of day to minimize of temperature field and reduce the costs of cooling units, and should maintain the agricultural products in the shade until they are transferred, It is also recommended to transfer the product as soon as possible.

Photo No. 1 shows stages of maturation in the lemon:
In all cases, harvest date varies by type of fruit. Some farmers pick when the fruitage reach physiological maturity, such as apples, pears and peaches.

Also some crops are picking after their arrival at the final stage of ripening such as strawberries, grapes, cherries, tomatoes, and others.
2. Pre – cooling (Rapid cooling )

Refrigeration is the most important technology to maintain quality of agricultural products, the high temperature is the main reason for deterioration of these products and increase loss. The most important features of rapid cooling and disposal of temperature field are:

- Reduce of fruit respiration and thus reduce the damage.
- Reduce of transpiration, thus reducing water loss and wilt.
- Reduce of production of ethylene gas and thus delay the maturity and variegated and deterioration of fruit quality.

Note that need for rapid cooling vary from one product to another example:

Grapes - lettuce - strawberries - the flowers should be cooled within a period not more than 3 hours after picking, but Products that are less sensitive to damage such as apples – tomatoes – apricots should be refrigerated within 24 hours.

There are several ways for rapid cooling:
1. Forced air cooling.
2. Hydro cooling.
3. Vacuum cooling.
4. Ice cooling.

3. Quality Control in the field

We must start with application of quality standards for agricultural products in a series of treatments post-harvest and immediately after start with the harvest to reduce mechanical damage or injuries or bruises which are caused by workers, and should also be applied during the collection and mobilization in field. In addition to exclusion of infected fruits and try to initial sort according to color and size, which reduces the effort required in packing centers and reduces costs.

The farmers must use portfolio quality field contains: testing device and measuring the sugar (Refractometer) - device for measuring fruit diameter - Plates for measuring the degree of coloration - A measure of soil acidity - A measure of moisture.

In addition to that the process of mobilization is a very important in series of post-harvest and marketing of vegetables and fruits. It aims to mobilize fruits in boxes of various designs based on crop type, target market.

There are many products that must be mobilized in field because of its sensitivity and to minimize damage during the process of handling, such as grapes and strawberries.
I will show some pictures of mobilization in field and types of boxes:
4. Packaging

The process of packing is the most important stage in series of post-harvest for handling of vegetables and fruits, as the aim of it is contain the fresh product to achieve intact easy unification handling during transport, storage and marketing, in addition to that the correct packing protect the fresh product from mechanical damages which could affect them during handling, such as bruises resulting from the pressure, collision, friction due to vibration.

The packaging system is very effective in promoting and advertising of agricultural products, The systematic boxes that contain slots for ventilation facilitate cooling process of agricultural products.

It is necessary to put labeling on packages include: type, weight or number and country of origin and brand, and in some cases name of farm and exporter. I will show some pictures of packages:
5. Transport of fresh agricultural products:

Markets of agricultural products and consumption areas are often far from production areas, as well as export markets. This justifies the importance of transport and infrastructure in a series of post-harvest and marketing of agricultural products.

And we must be sure of past practices during transport in terms of packing compaction and temperature control during transport, as well as the movement of air circulation and ventilation. It should be noted that selection of the optimum means for transport depends on important factors including: value and importance of crop, susceptible to damage, the distance.

There are many methods for transport:
1. Ground transportation in refrigerated trucks.
2. Rail transport.
3. Air transport.

Whatever means of transport we must take into account the following:
1. Protect the product from heat and wind and loss of water content and mechanical damages.
2. Completion of loading and unloading quickly and carefully.
3. Ensure adequate space for ventilation and air circulation.

Recommendations

1. At the macro level:
   1. Training farmers for applying post-harvest techniques, and how to comply with the specifications approved in foreign markets.
   2. Establishment of companies and associations which are specialized in marketing.
   3. Study of foreign markets and target the most important of them.

2. At the farm level:
   1. Reap the fruits of high quality in appropriate maturity stages, and get rid of unwanted fruits.
2. Cut through cold hours of day to avoid excess heat.
3. Harvest with technically correct way to reduce mechanical damage.
4. Mobilization products in a shady spot in field and put the harvested fruits under the shade of trees.
5. Avoid the excess packaging in boxes in order for ventilation.
6. Transport products to market by appropriate chilled means of transport.

3. At the retailer level:

1. Put products in packages of different weights to satisfy desires of consumers.
2. Isolate infected and rotten fruits and get rid of them.

The following painting shows losses and benefits to all dealers in fresh agricultural products, from the producer (farm) passing by sorting, packaging, refrigeration and transport and finally the consumer:
Post-harvest Losses of Fruits and Vegetables in Zambia

Adrian Phiri
Mulungushi University, Zambia

Abstract

In Zambia, fruits and vegetables play a major role in the diets of most low income households. They are also a good source of essential vitamins and minerals and indeed the source of livelihood. The production and processing of fruits are labour intensive and affected by the challenge of lack of adequate water supply. A lot of people are involved in the marketing and trading of fruits to earn income. Fruits, especially indigenous species are well adapted and can ensure household food security during periods of natural disasters such as droughts. However, the challenge is the high post-harvest losses incurred due to climatic conditions and handling of the produce before consumption. This paper gives an overview of the fruit and vegetables production situation in Zambia. It will also analyse challenges faced in avoiding post-harvest losses and maintaining quality.

Introduction

The post-harvest sector includes all points in the value chain from production in the field to the food being placed on a plate for consumption. Postharvest activities include; harvesting, handling, storage, processing, packaging, transportation and marketing of the produce are a major problem in the post-harvest chain. They can be caused by a wide variety of factors, ranging from growing conditions to handling at retail level. Not only are losses clearly a waste of food, but they also represent a similar waste of human effort, farm inputs, livelihoods, investments and scarce resources such as water. Post-harvest losses for horticultural produce are, however, difficult to measure. In some cases everything harvested by a farmer may end up being sold to consumers. In others, losses or waste may be considerable. Occasionally, losses may be 100%, for example when there is a price collapse and it would cost the farmer more to harvest and market the produce than to plough it back into the ground. Use of average loss figures is thus often misleading. There can be losses in quality, as measured both by the price obtained and the nutritional value, as well as in quantity.

Quality of Vegetables and Fruits

In maintaining quality of vegetables and fruits, attention has to be given to:

- Market demand for the products to be grown; he must know the market and the buyers
- Cultivation
- Harvesting and field handling
- Packing or packaging
- Transport
- Market handling; possibly storage or refrigeration
- Sales to consumers, wholesalers or agents
- Perishability of the produce.

**Vegetable and Fruit Production in Zambia**

The smallholder horticulture sector in Zambia is relatively underdeveloped with few farmers specialising in fruit or vegetable production. Horticultural production is usually a secondary activity producing food for home consumption with surplus for sale usually locally or in nearby towns. The main vegetable crops produced by smallholders are tomatoes, onions, water melons and brassicas (cabbage, rape), Chinese cabbage, amaranth, carrots, cleome, corchorus, cucumber, egg plants, French beans, edible gourds, lettuce, okra, onions, peas, hot pepper (paprika and green pepper), pumpkins. On the other hand, common fruits grown include, mango in the Western and Eastern provinces respectively, pineapples are grown in large quantities in North-western province, oranges, lemons and guavas grown on a small scale country wide.

The fruit and vegetable production in Zambia is mainly of exortic or foreign origin. However, in most rural areas, indigenous or wild fruits are harvested for local consumption and sale in the nearby urban centres. Most farmers regard horticultural production as a secondary activity coming towards the end of the rain season and producing crops for home consumption with a surplus for sale. They usually have limited access to credit for inputs and have major problems getting their produce to markets because of limited transport and poor roads. They rely mostly on family labour and use simple implements like hoes and animal drawn ploughs.

Production of fresh vegetables and fruits for export has increased in recent years. Medium scale and large commercial (both corporate and individual) farmers have invested in all-year round irrigated production of horticultural products as well as fresh flowers. There has been a marked increase in the export of horticultural products, especially with the expansion in number of out-grower schemes. Specialty vegetables include baby corn, mangetout, fine beans, sugar snaps, baby carrots, chillies, patti pans, okra and green asparagus (ZEGA, 2002).

**The Role of Women in Post Harvest Losses**

In Africa south of the Sahara, the labour of women is more important in all parts of the food production than the labour of men (Fresco, 1986). They must provide the agricultural labour needed in every phase of the food cycle to guarantee the family’s nutrition. At the same time, they cannot neglect their other tasks of food preparation, child care, fetching water and fuelwood, washing, housecleaning and looking after the small animals (Presvelou, 1986). Besides these tasks
women also generate income, which is often more than half of the total Household income (Due, 1985; and Fresco, 1986). Thus in many ways women play an important role in the food supply of Households: through their productive labour, their decisions on production, consumption and division of food and through their income, this can contribute to buy food.

The Times newspaper, 2005 reported that, farmers could easily embark on successful banana plantations if they were to follow the techniques concerning the production of the fruit. In fact the demand for banana consumption in Zambia is so high such that producers have not satisfied. Therefore, this calls for more farmers to participate in the production of the fruit in order to satisfy the demand and also earn an income. Like for many other fruits, the main challenge faced is the short life of bananas. Technology is limited to having them harvested before they are ready and within a short period before reaching to the market. Further, open air and road side trading of the commodity makes the weather favourable for quick ripening beyond which they lose the quality and flavour, reducing the market value.

The Importance of Post-harvest losses in Zambia

Time and money are required to cultivate food products, and unless the farmer is providing food only for his own household, he automatically becomes part of the market economy: he must sell his produce, he must recover his costs, and he must make a profit. Estimates of the post-harvest losses of food grains in the developing world from mishandling, spoilage and pest infestation are put at 25 percent; this means that one-quarter of what is produced never reaches the consumer for whom it was grown, and the effort and money required to produce it are lost-forever. Fruit, vegetables and root crops are much less hardy and are mostly quickly perishable, and if care is not taken in their harvesting, handling and transport, they will soon decay and become unfit for human consumption. Estimates of production losses in developing countries are hard to judge, but some authorities put losses of sweet potatoes, plantain, tomatoes, bananas and citrus fruit sometimes as high as 50 percent, or half of what is grown. Reduction in this wastage, particularly if it can economically be avoided, would be of great significance to growers and consumers alike.

Potential of Zambian Fruit and Vegetable Production

Zambian fruits have a high potential to be processed into juices, jams and other assorted drink types if only appropriate technology could be adopted. Though many of these products have some commercial value in their unprocessed forms and usually find their way into urban markets, their potential as industrial raw products is largely unexploited. Little work has been done towards their improvement, domestication or conservation. Some of the fruit species may be endangered making their conservation a matter of urgency. Small-scale horticulturists in Masaiti District on the Copperbelt Province of Zambia appealed to the Government and business companies to partner with the farmers to market their produce locally and abroad. Lack of market usually increases cases of post-harvest losses of the produce. Zambia had a potential of yielding up to 31,700 to
61,200 kilogrammes per hectare under intensive commercial growing conditions. The production output of banana yields of 6,800 to 15,900kg/ha and 22,700 to 34,000kg/ha could be considered good. However, in Zambia, the average yield of bananas for most of small-scale farmers is 12,000kg/ha and this yield may be as a result of disease attacks.

**Challenges in Fruit and Vegetable Production**

Fruits and vegetables are living parts of plant and contain 65 to 95 percent water. When food and water reserves are exhausted, produce dies and decays. Anything that increases the rate at which a product’s food and water reserves are used up increases the likelihood of losses. Increases in normal physiological changes can be caused by high temperature, low atmospheric humidity and physical injury. Such injury often results from careless handling, causing internal bruising, splitting and skin breaks, thus rapidly increasing water loss.

**Transport**

Transportation is a big and often the most important factor in the marketing of fresh produce in Zambia. Ideally, transport would take produce from the grower directly to the consumer, as in many developing countries. In more complex marketing systems (those serving towns, cities or distant countries) the cost of transport contributes significantly to the price paid by the consumer, and sometimes exceeds the value of the raw product. Losses directly attributed to transport conditions can be high. Further, the road system is poor and becomes impassable especially during the rainy season from most of the rural areas to urban centres. This is a big challenge and increases post-harvest losses. The goal of every person concerned with transport should be that the produce be kept in the best possible condition during transport and that the haulage of produce be quick and efficient. To this end, produce should be properly packaged and properly loaded on a suitable vehicle.

**Losses Caused by Transportation**

The damage and loss incurred during non-refrigerated transport are caused primarily by mechanical damage and by overheating.

*Mechanical damage:* Damage of this type occurs for many reasons, including:

- careless handling of packed produce during loading and unloading; vibration (shaking) of the vehicle, especially on bad roads; fast driving and poor condition of the vehicle; poor stowage, which allows packages in transit to sway; the stow may collapse packages stacked too high; the movement of produce within a package increases in relation to its height in the stack.

*Overheating:* This can occur not only from external sources but also from heat generated by the produce within the package itself. Overheating promotes natural breakdown and decay, and increases the rate of water loss from produce.
Marketing

Factors affecting post-harvest food losses of perishables vary widely from place to place and become more and more complex as systems of marketing become more complex. In Zambia for instance, a farmer who is growing fruits for his family's consumption probably doesn't mind if his produce has a few blemishes and bruises. But if producing for a market at any distance from his own locality, however, he and his workers, if he has any, must have a different attitude if he hopes to get the best money return on his work.

It is more important for the grower to change the attitude of himself and his workers toward reducing post-harvest losses than it is for him to think that buying fancy packaging will automatically solve his problems and improve his income. Reduction of post-harvest losses reduces cost of production, trade and distribution, lowers the price for the consumer and increases the farmer’s income. In preserving the quality of the produce reaching the final market, the whole marketing chain from the producer to the final consumer must be examined for any weakness. The reduction of post harvest losses makes significant contributions, minimizing the postharvest losses have been made through research on the physiological changes in the product after storage, new long life varieties, suitable the product after storage, new long life varieties, suitable cultivation circumstances, optimum harvesting indices, recommended storage recommendations, precooling refrigerated transport and careful handling.

Diseases and Pests

All living material is subject to attack by parasites. Fresh produce can become infected before or after harvest by diseases widespread in the air, soil and water. Some diseases are able to penetrate the unbroken skin of produce; others require an injury in order to cause infection. Damage so produced is probably the major cause of loss of fresh produce.

The influences of all three causes are strongly affected by the various stages of post-harvest operations, discussed below. Furthermore, they all have great effect on the marketability of the produce and the price paid for it.

Traditional Post-harvest losses

Traditional post-harvest technologies which make use of very simple techniques are predominant in low income countries Zambia inclusive. These technologies which are, in general, applied by subsistence farmers are very rudimentary and labour-intensive. They are focused on handling household food requirements and any surplus is sold in local market outlets.

There is limited post harvest technology being practiced for fruits in Zambia. However, traditionally, vegetable preservation is done by many people in rural agricultural areas by boiling and drying in the harvest period. Vegetables loses reduced by drying include, paprika and chilis on
commercial purposes. It is important to note that this technology is limited to commercial farmers.

In Zambia farmers have poor control or influence over the markets like the major urban markets where middlemen have significant influence and push prices down. Various attempts have been made to increase returns to the farmer and to improve access to markets. Several out-grower schemes linking smallholders to high value markets appear to be functioning successfully but most of these are located around Lusaka. These markets however tend to demand high levels of quality and consistency of supply that most smallholders are unable to meet.

Another problem faced by smallholders is that they usually have limited access to water for dry season cropping. This is a major limitation to increased productivity and extension of the growing season because rainfall is only from November to April and in agro-ecological region 1 the total is less than 800 mm. Farmers are compelled to produce vegetables under rain-fed conditions which are conducive to high levels of pests and diseases. The main production period for vegetables is therefore after the rainfall season up to the time when ground water reserves dry up (from April to about August). This problem can be overcome by the development of irrigation facilities; however credit facilities and other initiatives to encourage purchase of low cost pumps are not readily available to most smallholders. This means that dry season production is confined to perennial water sources or wetlands (dambos). Some smallholder growers however have tried to specialise in vegetable production due to the higher profit levels and they tend to be more responsive to extension advice and market demands and they are more willing to invest their own resources (e.g. they buy pumps with their own money).

**Recommendations for Future Research on Post Harvest Loss Reduction**

**Focus should**

1. Not only be limited to storage conditions but also to market requirements, breeding and cultivating circumstances.
2. Focus on treatments to arrest deterioration, harvesting at correct maturity, pre-cooling to reduce field air, care during sorting, packaging, transportation are also determinant post-harvest factors.
3. Consider a significant change to the current seasonal production system to having year round vegetable production and it is important to have good training and extension support so the farmers adapt to the new production system.
4. Water harvesting technology should be encouraged among small scale farmers to enhance irrigation and continuous production.
5. Extension services should be extended further to small scale farmers for enhanced disease prevention.
6. Small scale farmers should form cooperatives to have collective access to meet big markets such as supermarkets.
Conclusion

Technology to reduce post-harvest losses of fruits and vegetables should be encouraged through the use of local technology which in most cases is cheaper and sustainable. Small scale farmers should have access to extension services to learn about measures to reduce post harvest losses. As stated earlier, fruits and vegetables can greatly contribute to food security and empowerment of vulnerable sectors of society like women and the rural farmers.

References

Group Discussion
Group Discussion

Session Chair: Dr. Fu-Wen Liu

Three topics will be covered in group discussion for the three groups as following:
1. Challenges and opportunities in the improvement on post-harvest handling technologies to reduce losses and maintain quality of fruits and vegetables.
2. Priorities and strategies in overcoming the challenges in the development of post-harvest technologies.
3. Priorities and strategies in future research, development and application of post-harvest technologies.

Group I is responsible to make a solid conclusion on topic 1, Group II is responsible for topic 2, and Group III for topic 3.

Report of Group I

Topic: Challenges and opportunities in the improvement on post–harvest handling technologies to reduce losses and maintain quality of fruits and vegetables
Adviser: Dr. Fu-Wen Liu

Member:

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<td>Dr. Mohammad Aqeel Faraj Al-Awaida</td>
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<td>Mr. Adrian Phiri</td>
<td>Zambia</td>
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1. Losses in fruits and vegetables

There are huge losses that occur in fruits and vegetables due to poor post-harvest practices. Losses in Afro-Asian countries usually range between 5%-35% in the local market but for the export market it is about 15%-45%.
2. Major Challenges

(1) Poor Marketing System

Generally, there are no formal marketing institutions dealing with fruits and vegetables. In most of the countries, farmers and producers deal as individuals and in very informal ways for marketing their commodities. The trade lacks exhibition sheds, loading and unloading platforms, cold stores, and trucks loading equipments. Therefore, the producers sell their products at very low prices especially perishable vegetables.

The performance of the horticultural crops marketing system is irregular in terms of prices, profits, and cost of production and is unsustainable hence it is a traditional and ineffective system. In most of the countries, no effective market linkages have been established and also weak management skills in sorting, processing, and selling cause huge losses prior to fresh consumption as well as for export.

Cooperative marketing systems and rapid transportation of the produce to the wholesale market can minimize the post-harvest losses. Avoiding the middleman's interest farmers can get more values for their cash crops.

(2) Absence of appropriate policies, infrastructure

The government of most of the countries has no proper or appropriate policy for maintaining post-harvest losses. Poor infrastructure and logistics which include inadequate transport system, absence of refrigerated transport, insufficient cold storage, lack of grading and packing facilities are mainly responsible for high post-harvest loses. Complicated custom services and poor handling also cause losses. So government should formulate appropriate policy to support every stakeholder involved in post-harvest management process chain. Government should also develop requisite infrastructure like; roads, power, cold storage, etc… to facilitate in minimizing post-harvest losses.

(3) Lack of Capacity in Postharvest Management

Limited number of well-trained researchers and technical staff also the lack of proper knowledge in post-harvest practices by both producers and exporters.

(4) No significant emphasis on research and development.

Poor allotment for research and development is one of the great concerns for PHM – MQFV. For minimizing losses and maintaining quality of fruits continues research and development is a must. Without R&D no improved technology or performance can be achieved. Sufficient allotments can encourage the scientists and research people to perform well and find out the way for improving PHL and MQFV.

(5) Climate change

Changing in climatic conditions is affecting production in terms of both quality and quantity of fruits and vegetables. Adverse climatic conditions such as extreme temperatures, drought and
rainfall hamper productivity which ultimately leads to poor yielding. Awareness building and adaptation technique can minimize this kind of losses. It needs to be addressed globally.

3. Opportunities in Post Harvest Handling Technologies

(1) Increasing huge demand for fresh fruits and vegetables for local consumption as well as for export market is a great opportunity for PHL and MQFV.

(2) Comparative advantages of different countries to explore by joint collaboration in the different field of Land, Water and Labour Technology etc should be utilized by joint collaboration. So that every country can get benefit by optimum of their resources. Every country should avail this opportunity by continual efforts increasing productivity and maintaining the quality of fruits and vegetables.

(3) As the convergent has not enough resources parivet sector come forward to invest in the sector to change the situation. For e.i. establishing the processing industry which can play a great role in value addition, Private Sector Investment in processing industry for employment generation as well as value addition, in establishing cold storage, fruit-vegetable shade in village areas etc.

(4) Sharing of knowledge regarding post-harvest technology within member countries and also with other countries.

(5) Collaboration with large international agencies and institutions like FAO, World Bank, Asian Development Bank etc.

(6) NGOs which are engaged in income generating activities with farmers and women in rural areas can be involved in the process of post-harvest management to minimize losses.

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Report of Group II

**Topic:** Priorities and strategies in overcoming the challenges in the development of post harvest technologies  
**Adviser:** Dr. Syed Mohammed Ilyas  
**Member:**

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<th>Name</th>
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<td>Mr. Sita Ram Jat</td>
<td>India</td>
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<td>Mauritius</td>
<td>Secretary</td>
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<td>Mr. Mohamed Abdalla Mohamed Imam</td>
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<td>Ms. Ya-Ling Chang</td>
<td>R.O. China (Taiwan)</td>
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<tr>
<td>Mr. Chie-Hsiang Liu</td>
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Development and application of new technologies in the field of post harvest management is, of necessity to reduce the losses in fruits and vegetables after harvest. This sector must continue to develop and use the best technologies available all over the world and it should be able to serve the agriculture sector in most competitive way globally. We must recognize that the business world and the professional world are becoming more “action and results” oriented, and less “domain or territory” oriented.

The challenges of the Euro-Retailer Produce for Good Agricultural Practice benchmarks in areas of traceability, records keeping, timely availability of high quality planting material, appropriate soils, efficient input use, selective plant protection, timely harvest & effective post harvest management, hygiene, Safety and environment issues are suitably dealt with. There is increasing concern about the environmental effects and safety of chemical pesticides and fungicides all over the world. Integrated pest management with emphasis on biological control of pre- and post harvest insects and diseases has been one of the most extensively studied alternatives and appears to be a viable technology. Huge commercial successes in biological control are still rare. Currently, the main hurdle facing widespread use of post harvest bio-control strategies is the decreasing efficacy and lack of consistency found when these methodologies are applied as standalone treatments under commercial conditions.

Advantage of using inhibitors of ethylene action to protect the tissue against both endogenous and exogenous ethylene has been established. Development and commercial availability of water-soluble inhibitors will expand the potential use of the inhibitors in PHM.

Appropriate post harvest handling can minimize moisture loss, slow down respiration rate and inhibit the development of decay causing pathogens. Temperature is the most important determinant of fresh produce deterioration rate. An important supplement to proper temperature and relative humidity management is the use of controlled (CA) or modified (MA) atmosphere. Knowledge about physiological factors affecting shelf life and applications of modified atmosphere packaging (MAP) and related technology in prolonging shelf life of fresh fruits and vegetables, films available for packaging fresh produce, classification of horticultural commodities according to respiration and ethylene production rates and MAP potential for benefit for whole and fresh-cut fruits and vegetables are not available. The use of nano-technology in developing the packaging films has great potential.

Growth in demand has led to increased marketing of fresh fruits and vegetables in fresh-cut products form. The physical and mechanical damages caused during preparation increases respiration and ethylene production, which leads to increase in other biochemical reactions responsible for changes in colour, flavour, texture and nutritional quality such as vitamin loss as well as being subjected to bacterial and fungal infestation. Thus keeping freshness in fresh-cut horticultural produce and finally the maturity, quality and marketing of fruits and vegetables also needs further studies.
Maturity at harvest is one of the main factors determining the quality of a product. Post harvest technologies deal with separation, sampling, sizing, sorting, grading and marketing operations. These post harvest handling procedures are most important as they may either protect the quality or ruin much that was achieved up to this stage.

A one or two days delay in marketing can make the difference between profit and loss. Therefore, need to develop maturity indices, quality standards according to country wise and cultivars/ variety wise so as to sensitize the producers at governmental or cooperative levels for assuring uniform quality, positively impacting the marketing systems.

The losses at post production level being huge need to be minimised considerably by using appropriate technology, equipment and practices. There is a need to develop suitable protocols for optimising the operations in view of reducing delays in transactions at all levels. The governments must provide support to transfer the knowledge and technologies by using different modes of media.

The group has considered all the relevant issues and proposes the following action plan:

### A. Harvesting:

<table>
<thead>
<tr>
<th>Challenge</th>
<th>Existing practice</th>
<th>Areas of Improvement/new technology</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lack of proper timing harvest</td>
<td>Practised as their indigenous knowledge</td>
<td>Training &amp; Sensitization for optimum harvest time/stage of produce and Further research on determination of optimum harvest time/stage.</td>
</tr>
<tr>
<td>Poor quality of produce.</td>
<td>Use of traditional unscientific practices</td>
<td>1. Sensitization of farmers on quality production through mass media methods.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2. Appropriate dosage of pesticides prior to harvest(MRL)</td>
</tr>
<tr>
<td>Improper techniques/ tools to harvest the produce</td>
<td>Manual harvesting mostly by hand tools &amp; use of energy inefficient techniques</td>
<td>1. Specialized tools/or machinery</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2. Development/application of electronic nose/machine vision for determination of optimum stage.</td>
</tr>
<tr>
<td>Global gap principles</td>
<td>Growers not aware about the principles</td>
<td>Training &amp; demonstration on Global Gap principles.</td>
</tr>
</tbody>
</table>

### B. Handling and Transport of fruits and vegetables:

<table>
<thead>
<tr>
<th>Challenge</th>
<th>Existing practice</th>
<th>Areas of Improvement/new technology</th>
</tr>
</thead>
<tbody>
<tr>
<td>Improper handling</td>
<td>Harvested produce mostly kept exposed</td>
<td>Special efforts to create awareness/popularization of safe harvest methods</td>
</tr>
<tr>
<td>Inadequate on farm facilities</td>
<td>Operations carried out by manually mostly by untrained workers</td>
<td>Sensitization on comparative advantages &amp; development/application of cheaper mechanical/electronic sorters, graders, equip.</td>
</tr>
<tr>
<td>Poor cool/ cold chain</td>
<td>In existence or fragmented cold chain</td>
<td>Development of suitable protocols and modern machinery on subsidised rates</td>
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</table>
### Improper Loading & Unloading

**Careless loading and unloading, over stacking & mixed loads**

1. Awareness on safe produce handling.
2. Development/popularization of easily workable loading/unloading implements

### Poor Transport Network

**Unreliable train, sea and air transport**

Development of produce specific protocols and suitable machinery for transport system.

### C. Packaging/Storage

<table>
<thead>
<tr>
<th>Challenge</th>
<th>Existing practice</th>
<th>Areas of Improvement/new technology</th>
</tr>
</thead>
</table>
| Inadequate packhouse & cold storage facilities | Poorly designed packhouse & mostly single commodity based cold storages | 1. Strong government support (policy, technical and financial)  
2. Introduction & promotion of multi-commodity & multi-chamber storages  
3. Dev. of protocols & adoption of C.A. and M.A storage |
| Poor packing materials | Mainly locally available packing materials | 1. Use of produce specific packing materials  
2. Promotion of packing line concept. |
| Energy inefficient machinery based storages | Old, outdated, ill-maintained evaporative cooling/refrigeration system. | 1. Development/introduction of energy efficient, low cost refrigeration systems.  
2. R&D on application of renewable energy sources in cooling/refrigeration |
| Lack of parameters | Unscientific storage by non-trained workers | Awareness about and application of produce specific storage protocols. |

### D. Marketing

<table>
<thead>
<tr>
<th>Challenge</th>
<th>Existing technology/practice</th>
<th>Areas of Improvement/new technology</th>
</tr>
</thead>
<tbody>
<tr>
<td>Seasonal nature of produce</td>
<td>Irregular/fragmented supply of produce, seasonal gluts</td>
<td>Research and development on high yielding varieties with longer shelf life and Staggered production schedules.</td>
</tr>
</tbody>
</table>
| Lack of market intelligence | No systematic demand and supply information on fruits and vegetables | 1. ICT based marketing system  
2. Regular forecasts on the market demand and prices using mass media. |
| Multiplicity of intermediaries | Lack of transparency in marketing and trade | Promotion of modern wholesale/terminal markets having electronic auction along with hub & spoke marketing system. |
| Poor market infrastructure | Disorganised and unhygienic marketing system | 1. Government policies/support for creating modern marketing infrastructure.  
2. Establishment of commodity boards. |
| Lack of traceability | Absence of labelling on produce pack | Introduction of concept of traceability and conforming to quality & safety standards of domestic and export markets |
Priorities in overcoming the challenges in the development of post harvest technologies:
1. Reduction of post harvest losses
2. Training of farmers in quality and safety of produce
3. Development of post harvest and marketing infrastructure
4. Formulation of post harvest management enabling policies
5. Incentives and financial support from farmers to growers for following GAP and achieving high quality of raw material
6. Strengthening the infrastructure for cool/cold chain and dedicated road, rail and water shipment of perishable produce
7. Establishment of pesticide residue testing laboratories at strategic locations

Strategies in overcoming the challenges in the development of post harvest technologies:
1. Initiation of farmer supporting policies & programmes by the governments and creation of modern cold chain & modern markets infrastructure near the production catchments
2. Liberal government support for R&D and extension on post harvest management and also promoting peoples action towards achieving higher value addition at each node of post harvest value chain
3. Development and commercial availability of water-soluble inhibitors reducing spoilage in ethylene producing fruits
4. Technology/ knowledge about physiological factors affecting shelf life of fresh produce, quality of films used for packaging in MA storage, classification of horticultural commodities according to respiration and ethylene production rates and nano-technology for developing the packaging films.
5. R&D for keeping freshness in fresh-cut fruits & vegetables, maturity standards according to the country’s need and marketing of fruits and vegetables in efficient way.
6. Sensitization/ training of farmers in the quality and safety standards & practices through application of mass media.
8. Establishment of packing houses with the facilities of sorting, grading, waxing and packaging concept such that all the major production catchments are covered.
9. Development and popularization of minimal processing and their appropriate marketing.
10. Develop novel value added products from ethnic fruits & vegetable for niche market and export as health foods/ green foods etc.
11. Encouragement of cooperative/corporate / PPP for promoting contract farming of high quality fruits & vegetables and to minimise the multiple intermediaries between grower and processor;
12. Promotion of private & corporate sectors in sharing investment in the establishment of efficient marketing systems of fruits and vegetables;
14. Incentives/ financial support including subsidies to growers for using efficient cleaning, grading, sorting etc equipments for effecting appropriate post harvest management.
Report of Group III

Topic: Priorities and strategies in future research, development and application of postharvest technologies

Adviser: Dr. Chao-Chia Huang

Member:

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<td>Bangladesh</td>
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<td>Mr. Shih-Huang Huang</td>
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General objective:

To reduce post harvest losses and address the issues of quality and food safety of fruits and vegetables.

<table>
<thead>
<tr>
<th>Priority</th>
<th>Strategy</th>
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<tbody>
<tr>
<td>Research</td>
<td>Innovation of new technologies and useful tools needed in respective countries or area including the following: Asking funds for research from international organization, government, and industry, etc. Exchange of experience and technology among groups (farmers, countries, etc) Exchange of information</td>
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<tr>
<td>1. Preharvest factors</td>
<td>1. Preharvest factors</td>
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<tr>
<td>- Water</td>
<td>- Water</td>
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<td>- Organically produced</td>
<td>- Organically produced</td>
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<td>- Nutrient management</td>
<td>- Nutrient management</td>
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<tr>
<td>- Pesticide management</td>
<td>- Pesticide management</td>
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<td>- Plant hormones</td>
<td>- Plant hormones</td>
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<tr>
<td>- Fruit thinning</td>
<td>- Fruit thinning</td>
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<tr>
<td>- Bagging</td>
<td>- Kinds of bagging materials</td>
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<tr>
<td>- Maturity determination of fruits and vegetables</td>
<td>- Maturity indices of fruits and vegetables</td>
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<tr>
<td>- Method of harvesting</td>
<td>- Improvement of harvesting tools and techniques</td>
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<td>- Sorting by size, color, TSS (quality)</td>
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<td>Priority</td>
<td>Strategy</td>
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<td>4. Precooling</td>
<td>4. Precooling</td>
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<td>5. Grading and standardization</td>
<td>5. Grading and standardization</td>
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<td>6. Cleaning</td>
<td>6. Cleaning</td>
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<td>7. Ripening</td>
<td>7. Ripening</td>
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<td>- Climacteric and non-climacteric</td>
<td>- Climacteric and non-climacteric</td>
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<td>8. Disease and insect control</td>
<td>8. Disease and insect control</td>
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<td>- Low cost packaging</td>
<td>- Low cost packaging</td>
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<tr>
<td>10. Storage</td>
<td>10. Storage</td>
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<tr>
<td>- Low cost storage</td>
<td>- Low cost storage</td>
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<tr>
<td>- Refrigeration</td>
<td>- Refrigeration</td>
</tr>
<tr>
<td>11. Food safety</td>
<td>11. Food safety</td>
</tr>
<tr>
<td>- Intact and fresh-cuts fruits and vegetables</td>
<td>- Intact and fresh-cuts fruits and vegetables</td>
</tr>
<tr>
<td>Development</td>
<td>Pilot project for commercial use</td>
</tr>
<tr>
<td>Establishment and adaptation of new technologies with good results from research on the items mentioned above particularly on: - Harvesting tools and methods</td>
<td>Experience and technology exchange among groups (farmers, countries, etc)</td>
</tr>
<tr>
<td>- Precooling</td>
<td>Collaboration of researchers with the industry</td>
</tr>
<tr>
<td>- Use of appropriate containers</td>
<td>Asking for funds from international organizations, government, and industry etc. for the development of technology</td>
</tr>
<tr>
<td>- Transport system</td>
<td></td>
</tr>
<tr>
<td>- Postharvest laboratories, facilities, infrastructures</td>
<td></td>
</tr>
<tr>
<td>- Food safety</td>
<td></td>
</tr>
<tr>
<td>- Intact and fresh-cuts fruits and vegetables</td>
<td></td>
</tr>
<tr>
<td>Application</td>
<td>Training of postharvest experts</td>
</tr>
<tr>
<td>Extension of established technologies</td>
<td>Workshops</td>
</tr>
<tr>
<td>- HACCP</td>
<td>Demonstration</td>
</tr>
<tr>
<td>- Traceability</td>
<td>Experience and technology exchange among groups (farmers, countries, etc)</td>
</tr>
<tr>
<td>- GAP, GMP</td>
<td>Asking for funds for extension from international organization, government, and industry etc.</td>
</tr>
<tr>
<td>- Awareness of postharvest handling and food safety among the players (extension workers, farmers, handlers, service providers)</td>
<td>Asking for information</td>
</tr>
</tbody>
</table>

Conclusion: If we are able to satisfy and address the issues which we have enumerated, the problem of huge postharvest losses would be minimized resulting in
Conclusion of Group Discussion

From the discussion, we know that postharvest losses is severe or very severe in each country. The distribution must be improved for consumer demand and also increase the profit of farmers. To improve the situation, we need technology. There is lack of postharvest experts and we need them to do research and extension. They should develop technologies which would be implemented. Road condition is poor and there is a need to improve transport. To improve transport, we need national support. We need sufficient funding and manpower.

In some countries, there are more land resources, others have advanced technologies and others have a supply of labor. It is putting these together so that there is complementation. Assistance from the international organizations and the private sector could be tapped. We need improvement and in order to improve, we have to exchange knowledge.

In the future, we must strengthen the collaboration with each other and extend more to other countries. In so doing, we will lower the postharvest wastage by 5%. In effect, the consumers and growers will be benefited.
Closing Remarks
Closing Ceremony Address

Dr. Junne-Jih Chen
Director General
Taiwan Agricultural Research Institute

Good morning, Honorable Mr. Sanjeeb Kumar Behera, Dr. Fu-Wen Liu and Dr. S. M. Ilyas, Distinguished Participants from Member Countries of AARDO, Ladies and Gentlemen:

The workshop is finally come to an end today. I would like to use this opportunity to congratulate on all the participants for your successfully completing the entire program. Later on you will be presented a certificate for this achievement. I have no doubt that you all have a productive learning from the lectures delivered by resource speakers, from the sharing of country reports given by your pal delegates, and from the activities of field trip and group discussion. I hope that the knowledge and experience you gained from the workshop may feedback in some way to your work as well as agricultural production of your country.

Secondly, I believe that you have established a very good friendship among yourselves during the period of this workshop. I wish you all value this precious friendship and the common memory you share together here in Taiwan. When you go back to your home country, do not forget to keep contact with new friends you make here. Contact each other often for exchanging knowledge and technologies on post-harvest handling, or at least, send a mail to say hello once in a while.

I would like to once again express my sincere gratitude to AARDO and COA for their fully supports to this workshop, to resource speakers and Dr. Fu-Wen Liu for the kind contribution help to mobilize the session. Without your warmly participations and co-operation, this workshop could not be so great and extremely successful.

Finally, I would like to say thanks to my colleagues, you spent your valuable time even in the weekends in preparing and serving the workshop. Ladies and gentlemen, please join me to give them a big thanks and hands.

Bon Voyage! I wish you all have a safe and pleasant trip back to your home.

Thank you.
Respected Dr. Junne-Jih Chen, Director General, Taiwan Agricultural Research Institute, Distinguished Resource Persons of the Workshop, Participants from AARDO Member Countries, Co-ordinates of the Workshop Dr. Huang and His Team Members, the Future Agricultural Scientists of Taiwan, Who are Attending this Workshop as Observer, Ladies and Gentlemen:

Thank You is a too small expression for you all and as I do not have any other better substitute, I began this concluding remarks with a big thanks to our host, TARI and its Director General for all that you have done for us- for AARDO and its participants of the workshop. We are really highly impressed with your hospitality. You provide us an excellent platform for discussion and sharing of ideas. On behalf of the Organization and the participants, I extend my sincere thanks to TARI, its dedicated team members and the Council of Agriculture for organizing this workshop.

The resource persons of the workshop exposed the participants to the various techniques adopted in Taiwan, India and elsewhere to reduce the post harvest losses. They made our participants involved so much that the discussion was not just confined to the four wall of the workshop room. I noticed discussion on the topic even in the bus and dinner table. On behalf of the Secretary General of AARDO, I extend my sincere thanks to our learned resource persons for their valuable contribution for the successful completion of this workshop.

My thanks is also due to the AARDO member countries and its nodal ministries, who responded our request and allow their senior officials to be here for the workshop. I also extend my sincere thanks to all distinguished participants of the workshop for their contribution to the workshop and I hope that they have learned something new in this island country. I know, everything can not go smooth but we, i.e. AARDO and TARI made all our efforts to make you comfortable. However, if we have failed somewhere, kindly excuse us. I wish you all a safe return journey back home.

Finally, I once again thanks all those, who have worked for the successful completion of the workshop.

Thanks you for kind attention.
### Program Schedule

<table>
<thead>
<tr>
<th>Date</th>
<th>Time</th>
<th>Activities</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sun, Oct.03</td>
<td>08:50-09:20</td>
<td>Arrival of the participants</td>
</tr>
<tr>
<td>Mon, Oct.04</td>
<td>08:50-10:00</td>
<td>Registration</td>
</tr>
<tr>
<td></td>
<td>10:00-10:20</td>
<td>Coffee break</td>
</tr>
<tr>
<td></td>
<td>10:30-11:20</td>
<td>Presentation and discussion of resource paper I: “An Overview of Postharvest Biology and Technology of Fruits and Vegetables” by Dr. Chun-Ta Wu, Assistant Professor of Horticulture Department, National Taiwan University, ROC. Moderated by Associate Professor Tsu-Tsuen Wang</td>
</tr>
<tr>
<td></td>
<td>11:20-12:10</td>
<td>Presentation and discussion of resource paper II: “Application of Postharvest Technologies for Vegetable Crops in Taiwan” by Dr. Tsu-Tsuen Wang, Associate Professor of Horticulture Department, National Taiwan University, ROC. Moderated by Assistant Professor Chun-Ta Wu</td>
</tr>
<tr>
<td></td>
<td>12:10-13:10</td>
<td>Lunch break</td>
</tr>
<tr>
<td></td>
<td>13:10-14:00</td>
<td>Presentation and discussion of resource paper III: “Application of Postharvest Technologies for Fruit Crops in Taiwan” by Huey-Ling Lin, Associate Professor of Horticulture Department, National Chung Hsing University, ROC. Moderated by Associate Professor Tsu-Tsuen Wang</td>
</tr>
<tr>
<td></td>
<td>14:10-14:50</td>
<td>Presentation of country papers (Bangladesh, 2 participants) Moderated by Associate Professor Tsu-Tsuen Wang</td>
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<tr>
<td></td>
<td>14:50-15:20</td>
<td>Coffee break</td>
</tr>
<tr>
<td></td>
<td>15:20-16:00</td>
<td>Presentation of country papers (R. O. China, 2 participants) Moderated by Assistant Professor Chun-Ta Wu</td>
</tr>
<tr>
<td>Date</td>
<td>Time</td>
<td>Activities</td>
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<tr>
<td></td>
<td>16:00-17:00</td>
<td>Briefing of TARI</td>
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<td></td>
<td>18:00-20:30</td>
<td>Welcome Reception at the Splendor-Taichung hosted by COA, ROC</td>
</tr>
<tr>
<td>Tus, Oct. 05</td>
<td>09:00-09:50</td>
<td>Presentation and discussion of resource paper IV: “Development and Application of Citrus Storage Technologies with Concurrent Consideration of Fruit Quality Preservation, Energy Use, and Costs.” by Dr. Fu-Wen Liu, Professor Emeritus, Cornell University, USA. Moderated by Dr. S.M. Ilyas.</td>
</tr>
<tr>
<td>Tus, Oct. 05</td>
<td>09:50-10:40</td>
<td>Presentation and discussion of resource paper V: “Best Practices for efficient Post-harvest Management of Fruits and Vegetables for Higher Value Addition and Profitability” by Dr. S.M. Ilyas, Director, Distance Education Cell, National Institute of Rural Development, India. Moderated by Dr. Chao Chia Huang, associate researcher, TARI.</td>
</tr>
<tr>
<td></td>
<td>10:40-11:00</td>
<td>Coffee break</td>
</tr>
<tr>
<td></td>
<td>11:00-12:00</td>
<td><strong>Presentation of country papers</strong> (India, Jordan, Kenya, 3 participants)</td>
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<tr>
<td></td>
<td></td>
<td>Moderated by Dr. Chao Chia Huang, TARI.</td>
</tr>
<tr>
<td></td>
<td>12:00-13:00</td>
<td>Lunch break</td>
</tr>
<tr>
<td></td>
<td>13:00-13:40</td>
<td><strong>Presentation of country papers</strong> (Mauritius, Gambia, 2 participants)</td>
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<td></td>
<td></td>
<td>Moderated by Dr. S.M. Ilyas</td>
</tr>
<tr>
<td></td>
<td>13:40-14:20</td>
<td><strong>Presentation of country papers</strong> (Oman, Philippines, 2 participants)</td>
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<td></td>
<td></td>
<td>Moderated by Professor Fu-Wen Liu</td>
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<tr>
<td></td>
<td>14:20-15:00</td>
<td>Coffee break</td>
</tr>
<tr>
<td></td>
<td>15:00-16:40</td>
<td><strong>Visit Soil Museum and Plant Germplasm Division</strong> in TARI</td>
</tr>
<tr>
<td>Wed, Oct. 06</td>
<td>09:00-09:50</td>
<td>Presentation and discussion of resource paper VI: “Residue Control by Using Rapid Bioassay of Pesticide Residues (RBPR) for Market Inspection and Farm Education” by Ms. Ching-Hua Kao, Researcher, TARI, ROC. Moderated by Dr. S.M. Ilyas.</td>
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<tr>
<td></td>
<td>09:50-10:50</td>
<td><strong>Presentation of country papers</strong> (Philippines, Sudan, 3 participants)</td>
</tr>
<tr>
<td>Date</td>
<td>Time</td>
<td>Activities</td>
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<td></td>
<td>10:50-11:10</td>
<td>Coffee break</td>
</tr>
<tr>
<td></td>
<td>11:10-11:50</td>
<td><strong>Presentation of country papers</strong> <em>(Syria, Zambia, 2 participants)</em> Moderated by Ms. Ching-Hua Kao</td>
</tr>
<tr>
<td></td>
<td>11:50-13:00</td>
<td>Lunch break</td>
</tr>
<tr>
<td></td>
<td>13:00-13:20</td>
<td>Preparation of group discussion (grouping)</td>
</tr>
<tr>
<td></td>
<td>13:20-15:10</td>
<td><strong>Group discussion</strong> At Training Center, TARI. Moderated by Professor Fu-Wen Liu, Dr. S.M. Ilyas, and Dr. Chao Chia Huang,</td>
</tr>
<tr>
<td></td>
<td>15:10-15:30</td>
<td>Coffee break</td>
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<tr>
<td></td>
<td>15:30-17:30</td>
<td><strong>Group discussion</strong> (continued)</td>
</tr>
<tr>
<td>Thu, Oct. 07</td>
<td>09:30</td>
<td>Field trip</td>
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<tr>
<td></td>
<td>09:30-10:00</td>
<td>Proceed to Taichung Industrial Park, Taichung</td>
</tr>
<tr>
<td></td>
<td>10:00-11:00</td>
<td><strong>Visit Unispace Cold Storage Co., LTD, Taichung</strong></td>
</tr>
<tr>
<td></td>
<td>11:00-12:00</td>
<td>Proceed to Visit HanKuan Fruit &amp; Vegetables Production Cooperative, Silou, Yunlin Hsien</td>
</tr>
<tr>
<td></td>
<td>12:00-13:00</td>
<td>Lunch break</td>
</tr>
<tr>
<td></td>
<td>13:00-14:30</td>
<td><strong>Visit HanKuan Fruit &amp; Vegetables Production Cooperative, Silou</strong></td>
</tr>
<tr>
<td></td>
<td>14:30-14:40</td>
<td>Proceed to the next site</td>
</tr>
<tr>
<td></td>
<td>14:40-16:30</td>
<td><strong>Visit Siluo Fruit and Vegetables Wholesale Market</strong></td>
</tr>
<tr>
<td></td>
<td>17:30-19:30</td>
<td><strong>Farewell dinner at</strong> E-LU restaurant Wufeng, hosted by TARI</td>
</tr>
<tr>
<td>Fri, Oct. 08</td>
<td>08:50-09:50</td>
<td><strong>Summing-up of group discussion,</strong> Moderated by Professor Fu-Wen Liu, Dr. S.M. Ilyas, and Dr. Chao-Chia Huang</td>
</tr>
<tr>
<td></td>
<td>10:00-11:00</td>
<td><strong>Concluding session,</strong> Oral presentation group by each group, Moderated by Professor Fu-Wen Liu</td>
</tr>
<tr>
<td>Date</td>
<td>Time</td>
<td>Activities</td>
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<tr>
<td></td>
<td>11:00-11:20</td>
<td>Coffee break</td>
</tr>
<tr>
<td></td>
<td>11:20-12:00</td>
<td><strong>Closing ceremony</strong></td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Closing remarks by Dr. Junne-Jin Chen, Director-General, TARI</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Awarding the certificate by Dr. Sanjeeb Kumar Behera, Head of Research Division, AARDO</td>
</tr>
<tr>
<td></td>
<td>12:00-13:30</td>
<td>Lunch break</td>
</tr>
<tr>
<td></td>
<td>14:30-</td>
<td>Visit National Museum of Natural Science</td>
</tr>
<tr>
<td>Sat, Oct. 09</td>
<td></td>
<td>Return of participants and resource persons to respective countries</td>
</tr>
</tbody>
</table>
Appendix II: List of Participants

Information of resource speakers, AARDO officials, participants, and observers

Resource speakers

Name: Dr. Chun-Ta Wu  
Position:  Assistant Professor  
Organization:  National Taiwan University  
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### List of participants

<table>
<thead>
<tr>
<th>Name</th>
<th>Position</th>
<th>Organization</th>
<th>Mail address</th>
<th>Tel</th>
<th>Fax</th>
<th>E-mail</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mr. Mohammad Mosaddeque Ali</td>
<td>Deputy Secretary (Administration)</td>
<td>Rural Development &amp; Cooperative Division</td>
<td>Room No. 629, Building No.7, Bangladesh Secretariat, Dhaka, <strong>Bangladesh</strong></td>
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</tr>
<tr>
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</tr>
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<td>886-4-23338162</td>
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</tr>
<tr>
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<td>Agricultural Assistant</td>
<td>Food Technology Service, Department of Agricultural Services</td>
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<td></td>
<td><a href="mailto:darbocyanuka@yahoo.com">darbocyanuka@yahoo.com</a></td>
</tr>
</tbody>
</table>
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Fax : 00968-26893097  
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(Now Postharvest and Seed Sciences Division)  
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Name: **Mr. Mohamed Abdalla Mohamed Imam**  
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