POSTHARVEST HANDLING OF TROPICAL VEGETABLE CROPS

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Although the total vegetable area in the developing countries of the world is larger than those with well-developed economies by about 6 times, the mean yield per hectare for all vegetables is only half (Table 1). Moreover, the export of vegetables in developing nations is rather low, because quality is demanded in the export market, and uniform quality control is difficult in the fragmented vegetable areas of the tropics. Individual farms average only a hectare or less. Former big landholdings have been fragmented by the system of land tenure and customs of inheritance. A few large commercial growers may cultivate as much as 10 to 50 hectares. The largest single area devoted to vegetables in a country is usually formed by processing companies cultivating as much as 200 hectares. Many farmers grow vegetables as cash crops after their main crops of rice, corn or tobacco.

Although it is continually hot in the tropics, two main seasons are recognized: the dry and the wet. The peak of vegetable production is usually at the end of the wet season and start of the dry season utilizing residual moisture in the soil. At the height of the dry season, shortage of water is a problem. Where irrigation is present, 3 to 4 crops a year are grown. Multiple cropping is practiced in certain areas, principally Taiwan. During the wet season, too much water is a problem and there is a shortage of vegetables.

Farmers are most often handicapped by lack of capital. This leads to a limitation of production inputs, which results in poor crop quality.

Diversity of vegetable use

There are more vegetables utilized in the tropics than in the temperate zone. Local preferences occur within relatively small geographic areas due to differences in dietary habits. This diversity in the kind of vegetables used creates some problems in handling.

Vegetables requiring relatively cool temperatures like cabbage, carrots, lettuce, potato and cauliflower are usually grown in the highlands where the elevation is 1,000 m or more, such as Benguet Province in the Philippines, Cameron Highlands in Malaysia, Dalat in Vietnam, highlands centering around Bandung in Indonesia, and Nuwara Elija in Ceylon. These highland vegetables have been introduced, and most seeds being used are still imported. Since these vegetables are brought from distant places to centers of population, they are usually more expensive than vegetables grown in the lowlands. Demand for them is proportional to income. Lower income groups are likely to buy cheaper vegetables. Temperate vegetables could also be grown but with less success, in the lowlands during the cooler months of the year, when temperature drops to 10–15°C. Introductions of heat-tolerant varieties of cabbage, cauliflower and tomatoes have increased the percentage of success in growing these vegetables in the lowlands.

On the basis of acreage, volume of production and value, the 10 commercially important vegetables grown in the tropics are: cabbage, sweet potato, eggplant, potato, tomato, onion, garlic, radish, beans and peas, and leafy greens. Some countries export a portion of what they produce, notably the African countries south of the Sahara, Taiwan and India. The export trade from the tropical countries is increasing, but on the whole, the volume is still negligible. While the export potential of the tropics is great, two serious limitations are the failure to maintain the quality of produce and inappropriate handling techniques to reduce losses after harvest.

Postharvest losses

In many tropical countries, postharvest waste among vegetables may range from 22 to 78% when movement is delayed. On a daily basis losses ranged from 3 to 11%. These are due to decay, overripening, mechanical injury, weight loss, trimming, sprouting, browning and culls (Table 2). The dollar value of postharvest loss increases as the price increases. When the cost of handling the percentage of produce that does not reach the consumer is included, the economic value is further increased. We must, therefore, give importance to the methods that could minimize postharvest losses.

We must identify first the problems at each handling step (Table 3). Vegetables are harvested, packaged, transported, prepared for the market, ripened in the case of fruit vegetables, stored and finally sold in the retail market. For each step, the existing practice of produce handling must be surveyed, the specific problem areas must be identified, and possible solutions must be devised.

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Table 1. Total land area, agricultural area, production, mean yield, export and import of countries at various economic levels.

Agricultural components	Countries at various economic levels	
	Developing	Well-developed
Total land area (million ha.)	6.6	3.3
Total agricultural area (million ha.)	2.0	1.3
Total vegetable area (1,000 ha.)	58	10
Production (million MT)	216	135
Mean yield (tons ha.)	.7	14
Import (million MT)	1.7	6.1
Export (million MT)	2.7	5.0

Handling procedures

Table 4 shows the disparity in the postharvest handling of tomatoes in developing countries compared to developed countries. In many countries of the tropics, the frequency of handling, from harvesting until the product is sold on the retail market, could range from 14 to 24 times compared to only 9 to 10 times in well-developed areas. This may require about 100 to 150 man-hours per ton using antiquated handling methods compared to only about one to two hours (excluding transport time) with bulk handling. The reasons for this difference are analyzed below.

The small size and isolation of vegetable farms makes it logical to employ manual harvest labor, which is relatively cheap and non-organized. Traditional methods of harvesting are still employed using a minimum of mechanical aids.

Many of the farmers plant without concern for the market. Price considerations are usually given more weight than the quality of the produce. Early harvesting of carrots, chayote, snap beans, squash and bottle gourd gives better quality but lower yield. On the other hand, vegetables may be harvested before reaching prime quality if the prevailing market price is high due to the scarcity of the product.

Knowledge of maturity indices is often inadequate. In most instances visual indices are used. Therefore, more experienced farmers can deliver better quality products than those with less experience.

The deterioration of a product starts during the harvesting operation. The more carefully a product is handled, the slower the deterioration process during the subsequent handling operations. However, the farmer and his workers may be indifferent to the condition of the product after harvest. Thus, harvesting procedures may be rather careless. The only constraint is to avoid external injury. Until farmers are convinced that careful handling will increase profits, it will be difficult to persuade them otherwise.

In many cases, contract buying is practiced. The broker takes charge of the harvesting and may exert strict supervision of the operation, because he has more at stake in the quality of the produce than the farmer.

Transport

The main problem in transporting products over land is not the distance, but the condition of the roads from the field to the packingshed or assembly area and finally to the market. Market gardeners do not have this problem because they are near the centers of populations. The majority of vegetable farms, however, are in areas far from the highway, where the road conditions are not at par or are not regular routes for the usual means of transport. Increasing urbanization has forced the vegetable growers to look for areas even farther from the centers of population. Thus, carts, sleds, horses or bullocks, or even people, are employed to carry the products either to the area where transportation can be obtained or to collection points. Many roads have been constructed and conditions have improved over the years but in most countries, there is still a need for an adequate road system connecting the farms to the ultimate markets.

Transporting to distant markets over land is by truck or by rail. The former is usually preferred as it takes a product a shorter time to reach the market and involves less handling. The lower expense and less handling involved means less decline in quality and more profit to the middleman, but not necessarily to the farmer.

Where fields are near the coast or river banks or lakes, water transportation plays a big role in transporting vegetables. Barges are popular means of transporting vegetables in Bangkok. Inter-island

Table 2. Postharvest losses in some vegetables.

Vegetable	Days held	Other conditions	% loss due to: Decay	Trimming	Mechanical damage	Wt loss	Other	Total
Beans, snap	2	In sacks	–	–	15	5–8	5[z]	25–28
Cabbage	4	exposed	15–20	15–20	10	–	–	40–50
Cauliflower	7	exposed	10	2–4	2–4	5	15[y]	34–38
Corn, sweet	2	At 10°C	–	–	–	5	50[x]	55
Onions, white	150	w	15–25	5	2–3	10	15–35[v]	47–78
red	240	w	10–15	5	2–3	5	5–20[v]	27–48
Irish potato	300	At 4°C	5–15	–	2–3	5	10[v]	22–33
Tomato	4	Degreened	1–12	–	4–6	2–4	15–12[u]	22–32
Total range								22–78%

[z]Loss of turgor.
[y]Change of color of curd.
[x]Decrease in soluble solids (sweetness).
[w]For white: stored at 4½ mos at 1°C, 2 weeks at 27°C. For red: stored for 7½ mos at 0°C, 2 weeks at 27°C.
[v]Sprouting in storage.
[u]Over-ripening and culls (very small, misshapen, etc.).

Table 3. General problems for each vegetable group at each handling step.

Vegetable type	Handling step: Harvesting	Packing	Transporting	Grading	Storage	Retail
Fruits	Right stage of maturity	Over packing Improper container	Rough handling Poor road conditions	Uneven ripening	Chemical changes	Over ripening Shrivelling Browning
Roots	Excessive moisture may lead to rotting	Mechanical injury in sacks	Bruising	Malformation	Sprouting Improper curing	Sprouting
Tubers and Corms	Mechanical injury	Mechanical injury in sacks	Bruising	Malformation	Improper curing Sprouting and greening	Sprouting Rotting Shrivelling Weight loss
Leaves	Excessive wilting Rotting under high moisture conditions	Unsuitable container size Mechanical injury	Rough handling High transit temperature	Over trimming Mixed sizes	Wilting at low relative humidity Insufficient humidity	Over trimming Excessive wilting Bacterial soft rot
Flowers	Flower shedding	Improper packaging	High transit temperature	Loose curds Insufficient wrapper leaves	Yellowing of curds.	Loosening of curds. Fading
Stem	Improper method of harvesting	Breaking	High transit temperature	Malformation	Elongation of existing structure	Shrivelling
Bulbs	Maturity	Bruising and other mechanical injury	Improper condition in sacks	Misshapen	Sprouting	Shrivelling and sprouting Fading

transport requires ships. Uncertainties in schedules and weather, and handling delays at loading and unloading points is detrimental to the quality of perishable produce.

Airlifting of vegetables is less frequent. Most airlines offer the service mainly to fill gaps in their passenger service. If a regular air freight service is available and reasonably cheap, export of fresh vegetables is encouraged.

It is usually institutional buyers who take advantage of air-lifted vegetables since they are willing to pay the additional price, as long as they get the necessary good quality or the kind of vegetable that may not be supplied by growers in the area.

Packaging

The use of proper containers would do much to maintain the quality of vegetables brought to market. However, farmers usually opt for the cheapest of the available containers, which is usually bamboo. This has several disadvantages. Sharp edges easily bruise the products during the handling operations. Some designs lack sidewise strength. Since they may hold 50–100 kg of vegetables, they are rather heavy. Handlers often throw rather than lift them gently.

Jute sacks or mesh bags and wooden crates are also used. In India, Arhar (*Cajanus cajan*) stick baskets are popular.

Where contract buying is practiced, the middleman usually provides the containers to hold the produce and the truck to haul them.

Small farmers often bundle leafy vegetables to market with fibers from bananas, abaca, or papyrus. Cabbages, muskmelons, watermelons, squashes and gourds are often transported in bulk by trucks, generally covered by tarpaulin. Grass, leaves, rice straw and newspapers are used as liners when needed or desired.

Consumer packaging is almost absent except in self service retail markets or supermarkets.

Market preparation

Minimum market preparation is practiced, and may entail washing of some root vegetables and trimming parts which are not acceptable to the intended buyer. The amount of trimming done depends on the fastidiousness of the buyer.

Grading is a practice that most farmers are loath to do unless they are convinced that it will bring them added revenue or increase the acceptance of their products. A farmer may separate different varieties if they are distinguishable. Most consumers in the tropics are more price-conscious than quality-conscious. That is not to say that they are unmindful of the quality, but if good quality products cost much more than their pocketbooks could adequately support, they are willing to settle for a poorer quality product. With the variety of vegetables offered for sale, there is no difficulty in getting a cheaper substitute.

Institutional buyers are more quality-conscious. They are willing and able to pay higher price.

Problems of storage

One of the greatest impediments to preserving quality through storage is the consumers' strong preference for freshly-harvested produce and resistance to stored produce.

Information on the storage temperature and humidity requirements of vegetables, and the length of time they can be kept without decline in market value are either inadequate or unknown to those who need the information. If a farmer is persuaded to store his produce in cold storage and the market value decreases due to inadequate knowledge

Table 4. A comparison of tomato handling procedures in developing and in developed countries.

Handling steps	Countries: Developing — Frequency	Developing — Approximate rate	Developing — Nature of operation	Developed — Frequency	Developed — Approximate rate	Developed — Nature of operation
Harvesting	2–5	15-20 man hr/ton	Selective manual picking	1	5 min/ton	Mechanized picking
Field sorting	2–3	3-10 man hr/ton	Sizing; sorting for maturity	1	–	–
Field packing	1–2	10-15 man hr/ton	Small collecting containers to shipping crates	1	5 min/ton	Bulk handling in pallet bins
Hauling to packinghouse	1	30 min/km	Animal drawn transport	1	2 min/km	Bulk transport
Packinghouse operations						
Washing/cleaning	1–2	20-25 man hr/ton	Small water tank; hand brushing	1	20-30 min/ton	Forced-water spray; rotary brush type of cleaning
Sorting	1–2	6-8 man/hr /ton	Hand sorting limited to blemish & decay	1	15–20 min/ton	Using roller conveyor or reflectance meter
Sizing	1–2	15 hr/ton	Manual, utilizing diam & length	1	15–20 min/ton	Mechanical sizing by wt or diam
Packaging	1	20-25 man hr/ton	Hand packed in baskets or wooden crates	1	10-15 min/ton	Mechanical filling equipment
Transport	2–3	8-10 hr	Farm to collecting station to market	1–2	3-5 hr	Direct transport from packinghouses to wholesale markets to retailers
Wholesale market	–	16 hr/ton	Repacking	0	–	Due to improved transport, pretransit treatment & prepackaging in the farm, repacking is seldom necessary
Retail market	2–3	10-15 hr/ton	Reclassified into degree of ripeness & sizes for display	0	–	Produce in different consumer packages of varying contents with appropriate labels

on the proper utilization of cold storage, he is not only disillusioned but his friends will also be convinced of the non-profitability of cold storage.

Lack of capital may also force farmers to ignore the use of cold storage even when available. Many farmers depend on daily sales for their daily subsistence and hence prefer a lower price but immediately received to an anticipated higher price. There is also the storage rental price which the farmer may not be willing to pay, unless he is thoroughly convinced that he will not only recover his investment but will also profit.

Approaches and solutions

The solution to the problem of improper handling of produce in the tropics is rather difficult owing to the complexity of the problem. It requires that technical problems be solved as well as problems of credit, land, transportation and marketing availability. It also requires a change of peoples' attitudes to proposed solutions and new innovations. Such an approach can only be accomplished over the years, tackling specific problems in a stepwise fashion. There must be concerted efforts by the private and government sectors.

Extension work is needed to show that postharvest procedures are as important as production techniques. It is not enough to produce good quality commodities through variety improvements and proper regulation of soil and climatic factors. The whole process from planting until the harvested products reach the consuming public must be a mutual undertaking between the growers and those who will handle the product after harvest. Postharvest handling up to marketing must be considered as a single system. The success of maintaining the harvest-fresh quality of produce demands control of each step in the system, and each step depends upon the previous one. If the initial quality of the product is poor, no postharvest treatment can improve it. So, handling procedures from harvesting until the product reaches the consumers are chains of interdependent activities.

The establishment of wholesale markets or cold storage facilities by government must also meet the general approval of the persons who must use them. Of what use would a modern wholesale market be if the wholesalers would rather use an antiquated one that is more accessible to them? The establishment of a cold storage plant in an area accessible to farmers must be accompanied by a sustained information campaign on its use. Emphasis must be laid on the benefits to the farmer. Low rental rates and payments after the sale of products could attract the farmers to use the facility.

The establishment of cooperatives has done wonders in certain countries but only where the organizations are effectively run and the members are aware of their responsibilities as well as the benefits. The farmers involved will have greater bargaining power, and the certainty of selling their produce at a reasonable profit may spur them to improve or maintain the quality of their produce. They may also be encouraged to obtain credit.

Technical knowledge of postharvest handling has been increasing and there is a need to translate this body of knowledge into systems and techniques that the farmer can understand and use. Agricultural extension information must be reliable. The extension worker must have a good grasp of his job and must know where to turn when he cannot solve the problems himself.

A continuing problem is the low educational level of farmers in developing countries and their skepticism toward new methods they have not tried or seen before. Farming, especially of vegetables, is not looked upon as an attractive occupation. Often, farming is an occupation of last resort. Vagaries of weather make farming a risky business, and knowledgeable as well as enterprising farmers are few.

In a way, acceptance of improvements and innovations is tied up with the economic progress of a nation. If the buying power of the people is increased, they are more willing to accept the increase in prices associated with the improvement in the postharvest handling of vegetables.