# Postharvest Issues for Protected Agriculture Production

## Postharvest Handling and Monitoring of Quality for Vegetables Produced in Greenhouses in Hot, Arid Climates

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## Abstract

The general trend for increased vegetable production throughout the world may be attributed to improved cultivars, agricultural technology and increased demand. Increased consumer demand is partly as a result of increased awareness of the nutritional value of such food. However, consumers also demand a certain (high) quality in vegetable produce. Postharvest losses account for 10–50% of harvested vegetables world-wide—a significant waste. Losses may be caused by natural or handling processes, but all must be reduced. Respiration and transpiration (which continue after harvest) are key to natural decay and require careful control via handling and environmental optimization (temperature, relative humidity, air composition). To maximize vegetable shelf-life, only good-quality vegetables should be harvested, and these either early or late during the day at the right stage of maturity—quality can only be maintained after harvest, not improved. Careful handling at all stages is needed to prevent physical damage. If possible, transport and storage facilities should be refrigerated (to optimum storage temperature); otherwise transport should be done during cooler parts of the day and other cooling mechanisms used (e.g. shading or reflective containers). Quality standards need to be monitored, and certain aspects (e.g. pesticide use and residues) should be covered by governmental legislation.

## Summary of Major Issues Arising and Discussion

Consumers expect vegetables to be of a certain quality when they buy them. Proper postharvest handling is a complementary factor that can minimize vegetable deterioration between harvest and consumption. Postharvest losses are due to technological or non-technological causes.

Postharvest losses include physiological changes and vitamin C degradation of vegetables; these may be affected by postharvest temperature and respiration rate. Physiological losses—e.g. deterioration in texture, flavor and aroma—are less

obvious, but add to the losses of vegetables. Respiration rate is a good index of the potential postharvest life of a vegetable since it increases with the rate of deterioration.

Rough and careless picking, packing, loading and unloading cause mechanical damage. Rots are usually the greatest single cause of loss because most micro-organisms enter through mechanically damaged tissues.

Vegetables contain as much as 80–95% water. Water is lost not only through respiration, but also through transpiration and other metabolic processes. Temperature, relative humidity, gases, micro-organisms and insects are the most important environmental factors that affect water loss from vegetables.

Three main factors reduce losses: controlling growing factors, harvesting good-quality vegetables and avoiding physical damage. The cultivar, conditions during growth, the amount of care provided during production in terms of water supply and nutrient elements, and the control of insect pests, diseases and weeds determine the quality of the produce at harvest and subsequently.

A simple and inexpensive way of minimizing losses after harvest is to practise care in harvesting and throughout the handling chain. Another important point to remember is that, once harvested, the fruit's quality can only be maintained, not improved. Thus, it is best to start with good-quality vegetables and maintain their condition.

For easy, quick and cost-effective methods of monitoring the postharvest environment, the use of biosensors or 'electronic nose' is a potentially useful future approach.

The ultimate need for high quality is to maintain the freshness of vegetables, minimize their deterioration, and improve other quality aspects. This can be achieved through controlling growing factors, selecting the best cultivars, appropriate vegetable maturity, selecting good-quality vegetables at harvest, pre-cooling, avoiding physical damage, and controlling abiotic and biotic factors.

The discussion of this paper was entirely about pesticide residues. The question arose as to who provides the standards for allowable pesticide residues in (protected) agricultural produce; are the standards the same for example in the EU as they are in the Arabian Peninsula (AP) countries? It seems that there is as yet no uniform law (standard) on pesticide residues in the EU; at present, each country has its own standards. The relevant laws usually regulate the crops to which a pesticide may be applied, the number of applications per season, and the duration between the last application and harvest (which has a direct influence on the residue level in the harvested product), in addition to allowable (safe) residue levels in marketed produce. Globally, it seems that only a few countries have strict pesticide-residue regulation, for example the USA, Japan and EU countries.

In response to a question about which AP countries apply residue regulations, or are at least trying to establish standards for such, Oman has a toxicology laboratory and has been preparing standards since 1996. However, they have a major problem with protected-agriculture (PA) cucumber, as the last pesticide spray is too close to the harvest date and delay of harvest results in oversized cucumbers. Diseases of PA cucumber are not the main concern, as modern fungicides have low (human and environmental) toxicity and the fruit can be harvested shortly after the last spray. Insecticides, however, are a bigger problem. In fact, there are no insecticides currently approved for PA cucumber in Germany—the only answer to insect pests is biological control, but even here it is unlikely that imported biocontrol agents would be effective, so research is needed to identify suitable organisms in the AP countries themselves.

Kuwait has strong pesticide research. Control is implemented through inspections conducted by both the agriculture department and the municipalities. In addition, Kuwaiti consumers are particularly alert to the quality of food products.

Two useful references for those seeking to establish pesticide-residue standards are the FAO *Code of Conduct for Safe Use of Pesticides* and the FAO/WHO *Codex Alimentaris*.

One of the main issues of pesticide residues is that standards need to be enforced and policed. In the UK, supermarkets set their own rules and regulations, and test produce before buying. In continental Europe, there is closer contact between the farmers and the trade, which results in contract farming and consequent 'safer' produce.

Vegetables grow in a very short time under PA and timing of harvest is critical (often daily). Thus, spraying is simply not an option. Integrated production and protection management (IPP) recognizes that it is essential to combine production and protection management. It is really the only way forward for PA, although it is costly. The cost repays itself through quality produce without the need to resort to 'organic' farming.

## Future Activities and Research Priorities

Start quality management in the field.

Establish quality criteria according to the market and consumers' requirements (size, color, grading, etc.).

Rationalize the use of chemicals to avoid residues in harvested produce.

Introduce proper storage facilities.