Chapter 1

Introductory Chapter: Postharvest Physiology and Technology of Horticultural Crops

İbrahim Kahramanoğlu

Additional information is available at the end of the chapter

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A huge effort, natural resources, and money are spent for the production, collection and/or harvesting of produce, but on the other hand around 10–15% in developed countries and 20–40% in developing countries, depending on the produce, is being lost after harvest. This means that about one-quarter of what is produced never reaches the consumers. On the other hand, world population is increasing day-by-day and demand for food is rising. According to FAO (2015), about one in eight of the world population was suffering from chronic undernourishment in 2014–2016 [1]. The main reasons of hunger in the world are poverty, conflict, the increment in world population, food and agricultural policies and climate change. Since natural resources are being depleted at matchless rates, it is utmost important to protect natural resources and provide sustainability in production systems, but at the same time, it is also important to efficiently handle, store, and utilize products to be able to feed the world in the future. At this point, postharvest handling is becoming more important, which is the main determinant of the postharvest losses. Preventing postharvest losses would increase the amount of food supplied to the global market and reduce the need to intensify production. These, in turn, help to protect natural resources and provide sustainability.

The postharvest loss might be defined as the degradation in both quality and quantity of a produce occurred after harvest till the consumption [2]. The term "quality" refers external, internal, and hidden attributes, including weight loss, changes in color, visual quality "the acceptability", occurrence of decay, changes in nutrient content, flavor, etc. And "quantity" refers to the loss of the amount of a product. Sometimes, loss in quality does not change the quantity but highly affect marketability and price of the product. Losses arise due to the fact that freshly harvested fruits, vegetables, and flowers are living things which breathe and undergo changes during postharvest handling. There are some biological factors which cause deterioration on harvested produce, these are:

- **Respiration:** Respiration is a basic process of all plant materials. It might simply be defined as the reverse of photosynthesis. It is a set of metabolic reactions take place in the cells of

organisms to convert biochemical energy from stored food (produced during photosynthesis, i.e. starch and sugar) into adenosine triphosphate (ATP) for growth, ripening etc. During respiration, plants take oxygen from the air and give off carbon dioxide, moisture, and heat. Respiration continues until the stored starch and sugar reserves are depleted and crops would age and die. Temperature dictates the speed of respiration and is the most important factor influencing the postharvest life of the given produce. The oxygen in the surrounding environment is at utmost important, while it is the primary gas used during respiration. Lowering the oxygen in the air lowers the respiration rate, but if there is not enough oxygen, and then, product goes in anaerobic fermentation and produces alcohols with abnormal flavors.

- **Transpiration (water loss):** Most fruits and vegetables contain between 80 and 95% water by weight. The loss of water in a vapor state from living tissues is known as transpiration. It causes shriveling, wilting, softening, poorer texture, loss in weight, and lower quality. It can be reduced in storage by (1) raising the relative humidity, (2) reducing the air movements, (3) lowering the air temperature, (4) using protective coverage, i.e. waxing, and (5) protective packaging, i.e., polyethylene film, modified atmosphere packaging etc. Furthermore, many studies conducted about the protective and anti-fungal effects of natural extracts and/or plant and animal derived products on the postharvest quality of fruits and vegetables. For example, propolis extract, eucalyptus oil, and *Aloe vera* jell are reported to be successful in slowing down transpiration and having anti-fungal effects [3–5].

- **Ethylene:** Ethylene gas (C_2H_4) is a colorless, odorless, natural hormone produced by some fruits (climacteric) and vegetables as they ripen and promotes additional ripening of produce exposed it [6]. This can lead to the premature ripening of produce in storage facilities. Ethylene is capable of stimulating many reactions within plants. It is involved in the normal ripening process in many fruits, such as apples and bananas. Ethylene can also have undesirable effects on fruits, i.e. premature ripening, skin damage etc. The presence of CO_2, lack of O_2, and low temperatures can inhibit ethylene production on fruits, while on the other hand ethylene production is higher at injured produce. Ethylene can also be produced artificially and used as an environmental factor to stimulate ripening. An important point here is that the plants which produce ethylene, i.e. apple, should not be stored with fruits, vegetables or flowers known to be sensitive to it, i.e., cabbage. It may cause injuries on produce, loss of quality, and reduce shelf life.

- **Postharvest diseases:** Stored products are subject to a variety of rots and decay caused by fungi or bacteria. Most known fungus are *Penicillium expansum*, *Botrytis cinerea*, *Alternaria alternata*, *Rhizopus stolonifer*, *Phytophthora infestans* and *Fusarium* spp and the bacteria are *Ervinia carotovora* and *Pseudomona* spp. These diseases might cause light brown and soft spots on fruits and vegetables. Infection of diseases may start before or after harvest. When products transferred to storage, infections continue to develop. Mechanical damages, wounds or bruises are known to be the common entry points for bacteria and fungi. To prevent postharvest diseases, careful monitoring and management of diseases need to be started during growing period and continue in the storage. Preventing mechanical damage and harvesting the products during the cool times of the day are crucial points. Preharvest and postharvest application of suitable fungicides, bactericides might be helpful in managing disease problems. However, it must be kept in mind that environmental conditions are highly important for the development of diseases. They usually require warm temperatures

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and high moisture. On the other hand, sanitation is of utmost importance for handlers not only to protect products from postharvest diseases but also to protect consumers from foodborne illnesses, i.e., *Escherichia coli* 0157: H7 and *Salmonella*.

On the other hand, there are some environmental factors (temperature, relative humidity, atmospheric composition, and light) which accelerate or retard deterioration by directly or indirectly influencing biological factors:

- **Temperature:** Temperature is the most important environmental factor which influences the postharvest life of a produce. The optimum storage temperature of commodities is differing among not only commodities but for species. Typically, for every increase of 10°C, the rate of deterioration increases between 2- and 3-fold [7]. Temperature greatly affects water loss. Lowering the temperature also slows the pathogen development. Temperatures outside the optimal range can cause chilling injury, freezing or heat injuries. The severity of chilling, freezing and heat injuries depend on the storage duration and temperature. Among these three injuries, chilling injury is the most known and threat for storage. The critical temperature for chilling injury is mainly below 5–13°C depending on produce and maturity stage. Chilling injury symptoms are changing among commodities but generally include brown discoloration of the skin, necrotic pitting, and increased susceptibility to decay. Intermitted warming, application of some essential oils, salicylic acid, jasmonic acid, calcium chloride, etc. are reported to be helpful in delaying or preventing chilling injury [8, 9].

- **Relative humidity:** While fruits and vegetables contain between 80 and 95% water by weight, it is utmost important to provide favorable environmental conditions to reduce transpiration of the produce. Higher relative humidity (85–95%) slows water loss from the commodity. However, at the same time, high relative humidity (free moisture) might stimulate pathogen development and might weaken the packaging materials i.e. cartoon boxes.

- **Atmospheric composition:** Respiration is the basic process causing deterioration on the harvested produce and is mainly depend on the atmospheric composition (level of O_2 and CO_2) as well as on the temperature, ethylene and water vapor. Therefore, regulating the gas concentrations in the surrounding atmosphere of the produce is highly important for reducing respiration and increasing preservation time [10]. Reduction of O_2 and elevation of CO_2can delay deterioration of fresh horticultural crops. However, it is highly depended on the type of commodity, cultivar, maturity, and temperature. Modified atmosphere packaging (MAP) is a useful system which makes it possible to regulate the composition of the atmosphere in the packaging headspace. During respiration, O_2 is consumed, and CO_2, ethylene, and water vapor are generated, thus the packaging material allows the transfer of all of these gasses through the packaging material by regulating the inner composition at favorable levels to preserve the produce [11]. MAP slows down respiration and other metabolic processes, reduces sensitivity to ethylene, reduces the development of some physiological disorders i.e. chilling injury and may inhibit pathogen development.

- **Light:** Light is also a cause of some abnormal changes in product quality. It might affect some biological process. For example, exposure of potatoes to light would results in formation of chlorophyll, which appears as greening and formation of solanine [12] which is known to be toxic to humans.

The big question here is "how to handle produce and the surrounding environment to retard this aging process and prevent quality?" For example, it is important to reduce temperatures to prevent respiration and transpiration, but decreasing temperatures may cause chilling or freezing injuries. On the other hand, increasing relative humidity is important for reducing transpiration and weight loss, but free moisture stimulates pathogen developments. Moreover, factors affecting postharvest losses vary widely from produce to produce. In conclusion, correct management of the environmental factors is crucial for the prolongation of the postharvest life of produce. Pre-harvest applications, correct maturity at harvest, harvesting gently, pre-cooling, transportation conditions, sorting, sanitation, fungicide treatment, protective coverage, grading, sizing, packaging, and storage are the basic steps in postharvest handling. In the light of this information, the present book is intended to provide useful and scientific information about the postharvest handling of different produces.

Author details

İbrahim Kahramanoğlu

Address all correspondence to: ibrahimcy84@yahoo.com

1 Alnar Pomegranate Ltd., Güzelyurt, KKTC, Turkey

2 European University of Lefke, Lefke, KKTC, Turkey

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