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Review

Quality and safety of fresh horticultural commodities: Recent advances and future perspectives

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ABSTRACT

Fresh fruit and vegetables are a major source of biologically active compounds essential for human wellbeing. They are, however, perishable living products that require coordinated actions by growers, storage operators, processors, and retailers to maintain their quality and reduce food loss and waste. Recent advances in shelf life extension have been achieved by the combination of treatments including suitable temperature, humidity, and gas composition that maintain their quality and safety. Fresh produce attributes such as appearance, texture, flavour and nutritional value have been traditional quality criteria, but increasingly safety and traceability are important for all the role players along the supply chain from the farm to consumer. Non-destructive techniques for analysing the quality of fresh produce are valuable tools applicable along the supply chain. Advances in optical methods were touched in this perspective article pointing to new methods to inform the user. Quality deterioration and microbial contamination leading to spoilage and postharvest losses can occur at any of the supply chain stages. Therefore, postharvest treatments are essential to minimise quality loss, microbial spoilage and reduce the risk of pathogen contamination. Various postharvest physical, chemical and gaseous treatments can be applied to maintain fresh-like quality without compromising the sensory and nutritional aspects. The consequences of these techniques on quality and safety of fresh horticultural commodities are highlighted in this paper. Future research should aim at improving organoleptic quality and meeting safety standards of fresh produce at all steps of the supply chain.

1. Introduction

Fresh fruit and vegetables provide essential part of human nutrition, as they are important sources of nutrients, dietary fibre and phytochemicals with potential health benefits; insufficient fruit and vegetable consumption increases the risk of various chronic diseases. However, to deliver these nutritional benefits, each product must have the characteristic appearance, texture, flavour and aroma expected by the consumer. Each product must also be safe and not contaminated, and in addition, consumers are increasingly concerned about where their food comes from, use of chemicals, and about energy and sustainability.

In addition, fruit and vegetables tend to be perishable because of high water contents and continued active metabolism after harvest, which presents a critical pursuit against time for all the role players along the supply chain (growers, shippers, and retailers) to maintain quality and reduce food losses. It is important to remember that after harvest, the quality of the products can only be maintained, not improved. It has been estimated that roughly one-third of food produced for human consumption is lost or wasted globally (FAO, 2011). Losses in agricultural production dominate for all three industrialized regions, mostly due to post-harvest fruit and vegetable grading caused by quality standards set by retailers (Fig. 1). Waste at the end of the supply chain is also substantial in all three regions, with 15–30% of purchases by weight discarded by consumers. In developing regions, losses in agricultural production dominate total losses throughout the supply chain. Losses during post-harvest and distribution stages are also severe, which can be explained by deterioration of perishable crops in the warm and humid climate of many developing countries as well as by

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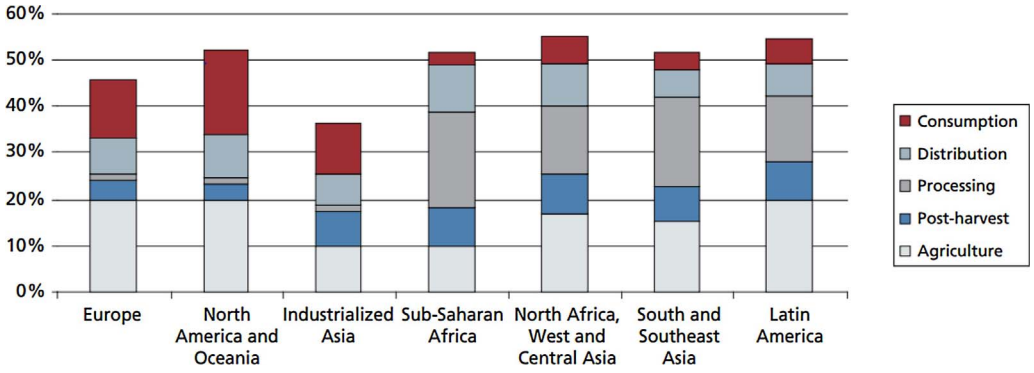

Fig. 1. Part of the initial production lost or wasted at different stages of the supply chain for fruits and vegetables in different regions.
(Source: FAO, 2011).

seasonality that leads to unsaleable gluts. Postharvest losses are especially costly because the total investments in the production, harvesting, processing and distribution of the agricultural produce are lost without any commercial return. Therefore, the reduction of these losses and maintaining their quality while extending shelf life is an urgent global need.

Industrial developments during the last century have resulted in urbanization coupled with changes in consumer lifestyles and dietary habits. Technological advancement also made it convenient to meet the requirements for processed foods. Horticultural industries are using various proven and emerging approaches to manage harvest, storage and transport of horticultural commodities to ensure maintenance of nutritional, sensory and microbial quality. This article reviews the current status of postharvest technologies that can be used to maintain quality and safety of fresh horticultural commodities, but also considers preharvest factors and microbiological issues. Preharvest factors are critical as the responses of products to postharvest technologies can be greatly affected by cultivar selection and preharvest management as both can affect metabolic rates. Cultivars are often chosen on the basis of marketability (appearance) and yield as these factors directly affect economic sustainability of the growers. Other factors include storability, resistance to postharvest diseases and physiological disorders as well as resistance to handling abuses during in the supply chain. Microbiological issues have also become increasingly important because of food safety concerns and renewed focus on microbial contamination on the farm, during harvest, packing, storage, transportation, and at the retail level.

2. Preharvest conditions affecting quality

The involvement of preharvest factors on quality of fruit and vegetables is critical. The most important of these is the plant part and cultivar as each has inherent physiologies and biochemistries. These include factors such as skin characteristics that affect gas exchange and water loss, rates of metabolism especially respiration rates as these tend to be strongly associated with storage potential, as well as non-climacteric or climacteric status of the product. In addition, the harvested plant part varies greatly with products representing many developmental stages, ranging from sprouts, stem and leaves (e.g. asparagus, celery, lettuce), inflorescences (e.g. artichoke, broccoli), partly developed fruit (e.g. cucumber, green bean, sweet corn), fully developed fruit (e.g. apple, citrus, tomato), and roots and tubers (e.g. carrot, potato).

The type of product and cultivar can affect its response to postharvest technologies such as cold storage and modified/controlled atmosphere storage and 1-methylcyclopropene (1-MCP). However, most products in the marketplace are not identified by cultivar, the most notable exceptions being apples and pears.These fruit types in particular are grown in many temperate growing regions around the world, export to markets occurs worldwide, they are subject to long term storage, and vary in susceptibility to a number of senescent, storage atmosphere and temperature-related physiological disorders. A large literature on the effects of management factors such as planting distances, pruning, and mineral nutrition exists for many fruit and vegetables.

In the case of fresh-cut products, the relationship between preharvest factors affecting quality and shelf life has received much greater attention (Gil, 2016). Understanding the complex interaction among different preharvest factors and the way that they can be managed to provide producers and processors with the most adequate raw material with a consistent quality all year-round remains a challenge. The literature on the main preharvest factors related to the quality of leafy vegetables reflects the influence of genotype, environmental conditions, agricultural practices and maturity at harvest among others (Gil, 2016). In this section, only recent advances in this area, particularly for leafy vegetables, are presented.

Cultivar selection is critical because of its strong influence on the “freshness” of fresh and cut products. The criteria to produce an excellent fresh-cut product include consistency of quality of raw material, for the consistency of fresh-cut product quality and consistency of the stability of the shelf life data. In the case of lettuce, it is very important to develop cultivars with reduced discoloration potential after cutting. Breeding programs are constantly selecting new cultivars with improved quality and better adaptability to environmental conditions and disease resistance. There is a need to identify and develop cultivars that are suitable for processing such as those with reduced discoloration potential. One example of a breeding program for lettuce is the one from Rijk Zwaan (2017) a major vegetable breeding company, that has win the Innovation Award 2017 at Fruit Logistica for Knox™, a trait in lettuce cultivars. The lettuce leaves discolour less rapidly after cutting and therefore Knox™ extends shelf life by about two days. For the selection of cultivars, a wide range of them must be grown under the same environmental conditions and agricultural practices. Selection of cultivars for the fresh-cut industry should be based on those with lower response to cutting. It is important to standardize a protocol for the breeding and processing companies to select those cultivars most appropriate for the specific requirements. Pros and cons issues have been described for the storage conditions that are better used for the screening of lettuce cultivars for fresh-cut (Tudela, Hernández, Pérez-Vicente, & Gil, 2016). Development of browning as one of the main causes of quality loss can be examined in different cultivars by objective measurements such as image analysis in which browning is calculated through Hue, Saturation and Value (HSB) colour parameters just after cutting and storage. Strong off-odour development, as another major problem associated with quality loss of salad greens, can be evaluated for the screening of different cultivars. The presence of off-odours is a challenge after storage and there is little information on the volatile organic compounds (VOCs) responsible for the product rejection. Recently, loss of freshness of baby spinach has been evaluated by a sensory panel and also by an olfactometry technique for the identification of odour-active compounds responsible for the odour sensations (Díaz-Mula, Marín, & Jordán, 2017). In general, off-odours are not the result of one single odour rather than a complex combination of compounds