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POSTHARVEST HANDLING PRACTICES FOR FRUIT CROPS

Steliana RODINO¹

Abstract: *The fruit production is a competitive and dynamic sector with many uncertainties coming from fruit biology, diseases and pests that attack them, the climate change, the distribution market and the complexity of logistics activities. Post-harvest handling activities can considerably improve the conditions that maintain fruit quality as they are circulating along the supply chain. Depending on the size of the agricultural holding and its financial possibilities, there are different specific practices considered appropriate for the achievement of management objectives after the harvest. The aim of this paper is to provide post-harvest storage, packaging and handling recommendations for small-scale specialized horticultural growers. It was demonstrated that the implementation of appropriate storage and packaging conditions can increase the storage time of fruits by 300 to 800%. Vertical diversification in the fruit sector by combining the application of traditional and modern processing technologies, both pre-harvesting and post-harvesting, represents a possibility of shortening the distribution chain, and implicitly increasing profitability. At the same time, it is necessary to develop closer collaboration between scientific research, production, distribution and marketing, in order to build strategic alliances to improve technologies and skills, as well as to increase the competitiveness of products offered on the market.*

Keywords: *post-harvest management, fruit crops, packaging methods*

Jel Classification: *L15;O14;Q16*

INTRODUCTION

Post harvest management of fruit production is a necessity originating from the need to reduce the production losses that occur after the harvest. In practice, fruits must be harvested when they reach maturity and have optimal quality characteristics and need to be handled with care to avoid mechanical damage, cool quickly to remove heat accumulated in the field, stored in a modified atmosphere - if there are technologies suitable for the harvested species - and kept at acceptable temperatures during storage (Watkins și Nock, 2012). Post-harvest handling activities can considerably improve the conditions that maintain fruit quality as they are circulating along the supply chain.

The optimum conditions for packing and storage of fruit production can vary considerably depending on the variety of fruits considered, the variety of processing after harvesting, the maturity at harvest time, the harvest time and much more (Irimia, 2013). Vertical diversification in the fruit sector by combining the application of traditional and modern processing technologies (Turek et al., 2009), both pre-harvesting and post-harvesting, represents a possibility of shortening the distribution chain, and implicitly increasing profitability.

The purpose of this paper is to provide an overview of post-harvest storage, packaging and handling recommendations for small specialized horticultural growers.

MATERIALS AND METHODS

The study aims to highlight the main post-harvest processing techniques of fruit production, with particular emphasis on the packaging of fresh fruit. The data were extracted from statistical information provided by the Eurostat database, from the specialized scientific literature. The research has a conceptual and methodological dimension. The information has been processed by analyzing, evaluating and comparing data from tables and diagrams that can lead to the identification of current status and future trends, thus providing the necessary arguments for an objective conclusion and visualizing some correlations between existing conceptual models. Thus, innovative packaging processes are presented, incorporating state-of-the-art technologies, described in the national and European scientific literature.

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GENERAL CONSIDERATIONS

The fruit processing industry is one of the largest economic activities in the world. Efficient management of post-harvest handling activities is essential because they are designed to maintain fruit quality as fresh produce moves along the distribution chain. Post-harvest handling is that stage of plant production immediately after harvesting, including cooling, cleaning, sorting and packaging.

Post-harvest losses are the losses occurring during the period running from the time of harvesting the fruit to actual consumption (Tănăsescu și colab, 2015). This loss term refers broadly to all types of possible losses along the distribution chain, from the farm to the trader and to the final consumer.

Practically, in order to reduce losses along the distribution chain, preparation of the production for marketing and the primary selection of the fruit must start right from the field, alongside with the harvesting operation, by removing non-compliant, diseased crops that may compromise the healthy fruits they come into contact with. Specialists from various fields, such as biology, biochemistry, chemistry, plant nutrition, carry out intensive research to extend fruit storage after harvesting by various means. For example, it has recently been demonstrated that a gamma irradiation (γ) dose (0.1-0.5 kGy) could increase fruit storage by about a week to two weeks, which could help minimize damage during storage and transport (Santos și colab, 2015).

OPTIMISATION OF POST HARVEST MANAGEMENT

Among the most important parameters that are considered for the optimization of post-harvest management and to maintain the quality of fruit harvest are the following:

- *temperature*
- *humidity*
- *modified atmosphere*

Biotechnology practices can make it possible to introduce crop varieties of improved crops with high potency in terms of yield and resistance to diseases and pests. **Genetic transformation technology** is based on the technical aspects of plant tissue culture and molecular biology for: production of improved varieties; the production of plants resistant to diseases (viruses); genetic transformation; production of secondary metabolites; the production of varieties tolerant to salinity, drought and heat stress.

In the last decades, techniques used in biotechnology for plant cell genetics have evolved into a new era, focusing on the production of a large number of secondary plant products. In the second half of the last century, the development of genetic engineering techniques and molecular biology allowed for the emergence of improved agricultural products that have kept growing demand in the productive systems of many countries around the world (James, 2008). However, quality control and compliance with both national and international standards must be strictly followed in order to achieve the best results. As far as possible, damage to fruit production due to the post-harvest activities (eg cross-contamination by water, equipment, transport or handling) should be avoided.

Previous studies have shown that **gamma irradiation** causes modifications of the metabolic pathways, which can delay the production of essential precursors and the energy required for fruit maturation.

An alternative method designed to increase the shelf life of fruit could be the regulation of **endogenous ethylene production**. Classic processing strategies to maintain the freshness of horticultural products involve storage at low temperatures, blocking the biosynthesis of ethylene and their action. Currently, it is conducting research to develop new ethylene measurement devices that will allow for the detection of critical ethylene concentrations during storage and transport (Janessen et al., 2014).

Recent research has shown that degradation of fruit damage could be achieved by such **genetically modified crops** (GM), in which the genetic expression of key enzymes responsible for

fruit maturation is altered. However, the adoption of such technologies has so far been discouraged by food safety concerns associated with genetically modified crops. Other new perspectives arise through the use in post-harvest treatments of *natural or transformed natural products*, tested with great success. Of these, chitosan and carvone can be mentioned. Chitosan has fungistatic and fungicidal properties. (Beceanu, 2002; Turtoi, 2004).

Another strategy for preventing damage to fruit as well as supporting the interests of farmers in the field could be the use of *modern packaging techniques* for post-harvest production. This could be achieved by improving conventional methods, as well as by developing non-conventional products of commercial interest (Surendranathan, 2005).

Fruits become susceptible to damage immediately after maturation, as different chemical and physical processes occur. A matured fruit, depending on the variety, has a shelf life limited from a few days to 1 or 2 weeks. In addition, a mature fruit is more prone to physical damage, lesions, and increased losses due to degradation. It is therefore necessary to develop both the technology and the appropriate infrastructure for proper storage and transport of fruit production.

The main objectives of international research on post-harvest biology of fresh fruit are the reduction of quantity and quality losses and the maintenance of food safety between harvesting and consumption sites.

At present, the activities undertaken to test decontamination methods aimed for extending the shelf life of horticultural products (both fresh and minimally processed) take into account the following research directions:

- Maintaining freshness attributes
- Limiting the fruit depreciation caused by pathogenic organisms;
- Preserving the nutritional qualities of the fruits

One of the reasons for the low commercial activity in the fruit and vegetable sector may be the lack of organized logistics activities related to the storage and transport of the harvest.

One way to achieve this could be by developing a feasible technology to extend the post-harvest conservation period.

Thus, it is important to have a correct assessment of the available technologies, as well as an understanding of the physiology and biochemistry of fruit maturation processes (Surendranathan, 2005; Simson și Straus, 2010; El-Ramady și colab., 2015).

INNOVATIVE PACKAGING TECHNOLOGIES

Packaging methods should be chosen so as to meet a number of conditions at the same time:

- reducing the consumption of raw materials;
- increasing packaging performance by using complex materials;
- reconsidering the product-packaging-environment relationship, by using recyclable packaging

The main packaging methods used to market fruit production are: aseptic packaging, vacuum or vacuum packing, active packaging (with modified atmosphere packaging and antimicrobial packaging) and intelligent packaging. In the following paragraphs, the *active packing and intelligent packaging* options will be described.

ACTIVE PACKAGING

New packaging concepts for fruits and other fresh products are currently being optimized. Such packaging products were designed with the implementation of innovative technologies and does not only act as a passive, inert, barrier to external conditions, but plays an active role in protecting packaged products. The active packaging used for packing fruit production uses active principles that are generated by or come from within the package and exert a specific effect on packaged fruit to trigger defense mechanisms such as antimicrobial agents, oxygen sorbents, capture of ethylene, etc. (Prasad și Kochhar, 2014; Brody și colab., 2001).

The purpose of using this method in the packaging of fruit production is to maintain organoleptic and nutritive qualities and to extend the storage period along the distribution chain as well as to the consumer. Examples of active packaging techniques include systems that absorb oxygen, ethylene, humidity, carbon dioxide and odors, as well as systems that release carbon dioxide, ethanol, antimicrobial agents, antioxidants and flavors.

Active packaging is not synonymous with intelligent packaging!! Intelligent packaging refers to packaging that is able to perceive and provide information about the function and properties of packaged foods (Day, 2003).

In a recent review of active packaging systems used in the food industry (Mane, 2016), the following variants of this method were enumerated:

- Oxygen scavengers
- Carbon dioxide emitters and scavenger
- Ethylene scavengers
- Ethanol emitters
- Moisture absorbers
- Antimicrobial agents
- Flavour/odour absorbers
- Temperature-controlled packaging

Other authors have included other variants such as antioxidant packaging. Antioxidants are widely used in fruit packaging to improve the oxidation stability of fresh fruit slices and to extend shelf life. Incorporation of natural antioxidants such as vitamin C and E on packaging film can reduce oxidative reactions, leading to the development of smell and color changes. Vitamin E is also safe and effective and has been shown to be stable under processing conditions (Biji și colab, 2015). Lately, the use of antimicrobial packaging (ethanol, enzymes, plant extracts in volatile oils, silver ions) is becoming more and more frequent.

Modified atmosphere Packaging

Modified Atmosphere Packaging technology known as MAP technology and Controlled Atmosphere Storage - CAS are innovative new techniques that are widely applied to conserve agricultural products, especially for fruits and vegetables. Modified atmosphere packaging technology has been defined as "packaging a perishable product in a modified atmosphere so that the composition inside the packaging is different from air (Hintlian & Hotchkiss, 1986).

Basically, the atmosphere inside the packaging is modified by introducing a gas. Choosing the gas used to modify the atmosphere inside the packaging or gas mixture depends on the type of fruit and the main types of possible deterioration of its quality (attack of pathogenic microorganisms, fruit oxidation processes). Oxygen (O₂), carbon dioxide (CO₂) and nitrogen (N₂) are most commonly used in MAP. Although there are studies in the literature that report on investigations and other gases such as nitrogen and nitrogen oxides, sulfur dioxide, ethylene, chlorine, as well as ozone and propylene oxide, they are not yet widely applied for reasons of food safety, legislative regulations and production costs. Success in controlling the fruit respiration process as well as ethylene production can result in fruit with outstanding organoleptic qualities. The control of these processes depends on the control of working temperature, one of the most important external factors influencing the quality of the packaged fruit in a modified atmosphere. Therefore, the temperature is controlled and maintained within the limits prescribed during storage for each species (Sandhya, 2010).

Antimicrobial packaging

Antimicrobial packaging is an active packaging form in which the packaging incorporates elements that act to reduce, inhibit or delay the growth of pathogenic microorganisms that may be present in packaged food or in packaging material itself (Appendini and Hotchkiss, 2002). In order to control the pathogenic microorganisms present on the fruit surface, antimicrobial substances can be incorporated into the package or can cover fruit packaging materials.

A variety of natural antimicrobial agents derived from herbal extracts derived from herbs (cinnamon, cloves, thyme, rosemary, oregano, etc.) and other plant extracts such as onion, garlic, horseradish and mustard have been reported in the literature. Packaging systems releasing volatile substances with antimicrobial action include chlorine dioxide, sulfur dioxide, carbon dioxide and ethanol. Chitosan has been used as a protective layer to protect fresh fruit from fungal attacks. It also acts as a barrier between nutrients contained in fruits and pathogenic microorganisms.

Edible and anti-microbial packaging and coating, made from polysaccharides, proteins and lipids, present a variety of advantages such as biodegradability, edibility, biocompatibility, aesthetic appearance, and fruit isolation properties (Biji și colab, 2015).

INTELLIGENT PACKAGING

Intelligent packaging uses various principles to monitor the status of the packaged product and to communicate this status. Intelligent packaging devices include time and temperature indicators, gas detection paints, microbial growth indicators, physical shock indicators, and so on (Day, 2003). Intelligent packages used for fruit production are packaging containing indicators on the quality of the fruit inside the packaging: quality, temperature, gas concentration in the packaging.

Intelligent packaging of fruit usually involves the ability to perceive or measure a fruit attribute, the inner atmosphere of the packaging or the exposure environment. This information can be communicated to users or can trigger active packaging functions (Yam et al., 2005). Basically, there are three types of intelligent packaging systems: Sensors, Indicators and Radio Frequency Identification (RFID).

In the speciality literature were identified different indicators used in intelligent packaging systems, referring to different parameters, as follows:

- Freshness indicators
- Temperature time indicators
- Integrity indicators
- Gas concentration indicators

CONCLUSIONS

In addition to the basic post-harvesting technologies of temperature management, a number of others, including various types of physical packaging (heat, irradiation and packaging), chemical treatments (antimicrobial, antioxidant and anti-aging) have been developed. The packaging currently used presents innovative technologies and new techniques and materials are added each year to fresh fruit and fruit processed products (juices, compotes, purees, jams, marmalades, jams).

Consumer preferences indicate their orientation towards fresh fruit consumption, therefore most of the studies on the improvement of post-harvest processing technologies have been carried out for this form of marketing.

Vertical diversification in the fruit sector by combining the application of traditional and modern processing technologies both in pre-harvest and post-harvesting is a possibility of shortening the distribution chain, and implicitly increasing profitability. In the same time, it is necessary to develop closer links between scientific research, production and distribution and marketing, in order to build strategic alliances to improve technologies and skills as well as to increase the competitiveness of products offered for marketing.

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