Chapter 13

Advances in Refrigerated and Controlled Atmosphere Storage of Fruits and Vegetables

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ABSTRACT

Long term storage of a variety of crops as well as long-distance transport, has allowed meeting the consumers’ expectations in the supply of many types of fresh fruits and vegetables throughout the year. This is only possible with the use of several postharvest technologies. This chapter starts with a brief historical context followed by an overview of the technologies used for fruits and vegetables storage, including refrigerated and controlled atmosphere (CA) storage as well as the most recently developed technologies for storing these produces. We also address the innovation requirements in the refrigeration systems when integrating cold storage with CA, including the need for higher refrigeration capacity, use of air tight storage chambers, CO2 scrubbers and atmosphere generators. The effects of these methodologies on fruit physiology and quality during storage are further discussed. Finally, the current recommendations for long term storage using ‘Rocha’ pear as a case study are presented.

INTRODUCTION

In a global market a high postharvest quality and increased postharvest life of fresh fruits and vegetables is of utmost importance for meeting consumers’ demand for the availability of many types of fresh fruits and vegetables throughout the year (A. K. Thompson, 2010). Most fruits have a relatively narrow harvest period where the supply largely exceeds the demand. After harvest, the deterioration process initiates as sugars and starches used on fruit respiration and the moisture loss through transpiration are no longer compensated by the plant. In climacteric fruits, which are capable to ripen to good quality after detached from the plant, it is essential to avoid the ripening process in order to maximize the retention
of quality attributes. Fruit ripening is a process that occurs from the latter stages of fruit growth and development until the early stages of senescence. This process involves many changes on the produce including colour and texture changes, tissue softening, volatiles’ production, and changes on sugar content, respiratory metabolism and ethylene production, among others (DeEll, Prange, & Peppelenbos, 2003). Ethylene is the plant hormone responsible for accelerating fruit ripening and senescence and is known to coordinate many ripening phenomena (DeEll et al., 2003). After harvest, the ethylene production increases but the rapid removal of field heat from the product through precooling and placement under cold storage reduces the production of ethylene also reducing the sensitivity of the fruits to ethylene allowing the maximum retention of fruit quality. Cold storage of fruits and vegetables reduces all the metabolic processes simultaneously avoiding spoilage by microorganisms. Therefore, cold storage is an important aspect which is particularly critical in cases where long term storage is required. This is the case of several fruits and vegetables (e.g. pears, apples, kiwi, plums, persimmon, pomegranate, oranges, eggplant, grapes, cabbage, pumpkin (Candan, Graell, & Larrigaudière, 2008; Kader, 2004; Massolo, Concellón, Chaves, & Vicente, 2011; Schirra & Cohen, 1999; J. F. Thompson & Kader, 2004) which are harvest in a given date and can be stored for months before being consumed. For instance, ‘Rocha’ pear is harvested in mid-August and is consumed in May of the following year.

Although fresh fruits and vegetables need low temperature during storage to preserve their quality characteristics (such as taste, aroma, acidity, soluble solids content and nutritional properties) they have a ‘critical temperature’ below which undesirable effects occur and irreversible reactions take place. Moreover, when setting up the refrigeration system there are three other important parameters that should be taken into account: relative humidity (RH), ventilation and air circulation inside the cold room. High RH (generally above 90%) is required to prevent loss of moisture from fruits and vegetables during storage. Although fruit metabolism is reduced to a minimum during cold storage there is still consumption of oxygen (O₂) and production of carbon dioxide (CO₂) and ethylene (responsible for fruit ripening) at low levels. Thus, ventilation is essential to restore the atmosphere inside the chamber. Air circulation ensures the uniform cooling of the stored fruits but it should be kept low in order to avoid transpiration phenomena that may cause water loss with consequent fruit dehydration. In this chapter a brief historical overview on the cold storage procedures that have been adopted through time for fruit preservation is given. The technological advances introduced in the refrigeration systems due to the extra-concerns generated by the integration of cold storage and controlled atmosphere (CA) technologies, which include the higher refrigeration requirements, the use of air tight storage chambers, CO₂ scrubbers and atmosphere generators, are also addressed. Afterwards, there are discussed the effects of current refrigerated CA technologies on maintenance of fruit physiology and quality during storage. Due to the importance of ‘Rocha’ pear for the Portuguese agricultural sector and the strong dependence of this fruit for a long-term storage (for details see section 0) we have selected this fruit as a case study, ending this chapter presenting the current recommendations for long term storage.

**HISTORICAL CONTEXT**

Plant foods, including vegetables and fruits, begin to spoil the moment they are harvested. In order to circumvent this problem, ancient men started resorting to different methods of food preservation and storage. This enabled settling in specific locations, and forming a community. Also, storing and preserving food meant that man no longer had to consume the harvested produces immediately, but could preserve