Bio-mechanical Behavior of Kiwifruit as Affected by Fruit Orientation and Storage Conditions

Abstract

Bio-mechanical properties of fruits and vegetables are important for agricultural and food engineers, due to different causes. In this research, some engineering parameters such as bio-yield point, firmness, puncture force, cutting force and cutting energy were determined with respect to the fruit orientation and storage period under ambient and cold conditions. Also, water loss during storage period was investigated. Results indicated that fruit orientation had significant effect on the firmness and bio-yield point, while the effect of fruit orientation was not significant on the puncture force, cutting force and cutting energy. By increasing storage time, the firmness, cutting force and bio-yield point decreased with respect to the rate of reduction during last week of storage was higher than the rate of first week storage. Storage at ambient in comparison with cold storage decreased the fruit firmness and bio-yield point. At the end of 16 days storage, the fruit quality losses in cold and ambient conditions were 5.3 and 13.4%, respectively.

Keywords: Mechanical properties, Kiwifruit, Firmness, Storage

1. Introduction

Many agricultural products are considered as biological materials. They are susceptible to mechanical damages during harvest and post harvesting process such as pick up, sorting, packaging and transporting. These damages are related to the external forces in the form of splits, punctures and bruises. Also, storage of fruits after harvesting can cause significant changes in physical and mechanical properties (Singh and Reddy, 2006). The bio-mechanical characteristics of fruits are important in adoption and design of various postharvest systems. The fruit compression test simulates the condition of static loading that is withstood in mechanical handling and storage (Gorji Chaksepori et al, 2010). Many researchers have investigated the mechanical properties of fruits and vegetables. Kheiralirop et al. (2009) investigated some mechanical and nutritional properties of ten Iranian varieties. Oztork et al. (2009) studied some physico-mechanical properties of pear cultivars. Singh and Reddy (2006) investigated physicomechanical properties of orange peel and fruit.

Effects of storage time and conditions on quality control are important aspects of food processing for acceptable nutritional value and providing food safety to consumers. The rate of kiwifruit softening is affected by storage period, temperature, ethylene levels and maturity of the fruit (Ritenour et al., 1999). A study of respiratory and physico-chemical changes of four kiwifruit cultivars during cold storage indicated that physiological behavior of kiwifruit varieties in relative storage time (Manolopoulos and Padadoglu, 1998). The importance of water status for fruit firmness also reveals itself through the reversible physical effect as seen for apples and kiwifruit (Jeffery and Banks, 1994). With increasing and decreasing temperature, the water inside the fruits expands and contracts in volume (Chen, 1993). Ayman et al. (2012) investigated mechanical properties of pears during storage under variable conditions. They found that change of temperature significantly affected the mechanical properties of pears.

2. Materials and Methods

2.1. Materials

Kiwifruit, ‘Hayward’, was harvested at fully mature stage from different trees of a commercial orchard located in Amol, Mazandaran province of Iran in autumn 2012. Random samples were drawn from a freshly harvested lot of kiwifruits at the time of harvest. A total of 40 kiwifruit were divided in cold storage in two sets. One set was set at 6°C for cold storage at 6°C and 61% RH. Another lot of fruits were kept in ambient at a temperature of 21°C and 75% RH. RH was measured with digital psychrometer. The kiwifruit were determined with respect to orientation and the storage period in both ambient and cold conditions.

2.2. Water loss

For determining weight loss in kiwifruit during storage, ten fruits in each experimental lot were numbered and kept in ambient and cold conditions. Weight of the fruit was measured with respect to storage period with electronic balance having least count of 0.01 g. The loss in weight was expressed as percentage of original fresh weight of the fruit. The cumulative losses in weight were calculated as percent of initial weight loss.

2.3. Firmness, bio-yield point and rupture

Compression force was applied using a flat base plate of Texture Analyzer (Model FG-5000A, Lutron Ltd, Taiwan). Probe carrier was fixed with an 80 mm diameter flat plate and brought in contact with the fruit. The firmness expressed as the force required to compress to fruit to 10 mm distance. The firmness tests were carried out every day on five fruit samples after being taken out of ambient and cold storage. Fruit compression test were performed in horizontal and vertical orientation (Figure 1). The average values of triplicates are reported for 16 days storage in both ambient and cold conditions. The bio-yield point was considered as the force required causing permanent deformation indicated by the peak force before a sudden drop as shown in force-displacement curve (Figure 1).

3. Results and Discussion

3.1. Firmness, bio-yield point and rupture

Table 1 shows the fruit firmness and bio-yield point of kiwifruit at ambient and cold storage conditions for two directions of loading. The fruit firmness varied from 32.6 N to 13.4 N at ambient and from 37.2 N to 18.2 N at cold conditions after 16 days of storage when it compressed at horizontal direction. For vertical direction the changes of firmness were from 47.1 N to 28.3 N at ambient and from 49.8 N to 34.4 N at cold storage. The firmness in vertical orientation was significantly higher than horizontal direction under both ambient and cold storage (Table 1). The changes of firmness with respect to the storage period were significant for both conditions and orientations. No significant differences was observed between firmness of two conditions for horizontal and vertical orientations. It is also clear from Table 2 that in ambient storage there is a more rapid decrease in firmness of fruit whereas in cold storage, this process occurred with a slow rate.

3.2. Cutting force and energy

Table 3 shows the cutting force and cutting energy for kiwifruit at two directions when stored at ambient and cold conditions. No significant difference was observed between cutting force of horizontal and vertical directions of cutting. Also, similar result was observed for cutting energy, by increasing the storage period cutting force and energy significantly decreased at both direction of loading. Singh and Reddy (2006) found that cutting force and energy for citrus decreased with the storage period. Cutting force for cold storage was higher than that obtained for ambient conditions but for cutting energy no significant difference was observed between two storage conditions.

4. References


