Korean J. Plant Res. 28(3):329-332(2015)
http://dx.doi.org/10.7732/kjpr.2015.28.3.329

Print ISSN 1226-3591
Online ISSN 2287-8203

Original Research Article

Changes of Physicochemical Quality in Hardy Kiwifruit (*Actinidia arguta*) during Storage at Different Temperature

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Abstract - The effect of storage temperature and the storage period of hardy kiwifruits on the fruit firmness, soluble solids and fruit weight were studied in this work. The investigation was carried out on the Sae-Han cultivar of *Actinidia arguta*. It has an edible smooth skin and contains high amounts of sugar and vitamin C (ascorbic acid). In this research, the measurement of fruit firmness, soluble solids, and fruit weight were carried out at various temperatures (5, 10, 15, and 20℃) during 14 days. Fruit firmness rapidly decreased and soluble solids content increased at 15 and 20℃. We also investigated the correlation between fruit firmness and soluble solids content. There was a strong correlation between fruit firmness and soluble solids content. That means that fruit firmness affect the soluble solids content of hardy kiwifruit.

Key words - *Actinidia arguta*, Firmness, Fruit weight, Soluble solids, Storage

Introduction

Actinidia arguta (Sieb. & Zucc.) Planch. ex Miq., called hardy kiwifruit, has peel without hair and an edible smooth skin. It can be eaten whole and contains high amounts of sugar, vitamin C (ascorbic acid) and distinctive flavor (Kim *et al*., 2006). From the flower of *A. arguta*, liac alcohol epoxide was isolated and identified (Matich *et al*., 2003). Additionally, a hardy kiwifruit is called a healthy fruit because it has a lot of vitamin C, lutein, phenolics, and some minerals, such as P, Ca, and Zn (Nishiyama *et al*., 2004). It is also studied that *A. arguta* leaf showed significant NO inhibition activity (Kim *et al*., 2013).

It is native to north China, Korea, and Japan. Because of its high frost resistance, it may be commercially cultivated in countries whose climate is colder, not suitable for *A. deliciosa* cultivation. To make new cultivar with larger fruit and high yielding, we have been selected of new *A. arguta* cultivar, Sea-Han, Dae-Sung, and Chil-Bo and registered as a new variety denomination and certificated variety production and merchandising in 2013 (Park *et al*., 2007).

Actinidia fruits are an abundant source of vitamin C (Nishiyama *et al*., 2004; Rassam and Laing, 2005). Kiwifruits can be stored at the temperature of 0℃ for many months without any decrease in quality. According to Okamoto and Goto (2005), there are from 150 to 200 ㎎ vitamin C per 100 g in fruits of *A. arguta* and this content did not change significantly after two months of storage at a temperature near 0℃. According to study of Strike (2005), since hardy kiwifruits (like *A. arguta*) are more sensitive than *A. deliciosa,* it may only be stored for up to 7~10 weeks. In the study of Abdala *et al*. (1996) and Fisk *et al*. (2006), during storage of kiwi and hardy kiwifruits, the firmness of fruit were gradually decreased. For increasing the storage period of *A. arguta* fruit, it is important to know the change of fruit quality during storage at different temperature. So far, no research has been done on quality changes in *A. arguta* fruit during storage at different temperature. In this study, we measured fruit firmness, soluble solids, and fruit weight which carried out at various temperatures (5, 10, 15, and 20℃) during 14 days.

Materials and Methods

Materials and sample preparation

A. arguta, grown in the Korea Forest Institute (Suwon, Korea) were utilized. The fruit weight, length and width of Sae-Han cultivar of *A. arguta* are listed on Table 1. The fruits

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Table 1. The fruit characteristics of hardy kiwifruit (*A. arguta*) of Sae-Han cultivar[z]

Cultivar	Length (㎜)	Width (㎜)	Weight (g)	shape
Sae-Han	36.8 ± 5.2	30.8 ± 7.0	18.1 ± 2.3	oval

[z]Each value is presented as mean ± standard deviation (n = 20).

of hardy kiwifruit were harvested on September 16 (fruit set on June 5), and measured the changes of physicochemical quality every 2 days stored at different temperature (5℃, 10℃, 15℃ and 20℃) with a relative air humidity of about 85% for 14 days.

Measurement of soluble solids, firmness, and weight

To assess the morphological characteristics of hardy kiwifruits of Sae-Han cultivar was used and analyzes by SAS system (Park *et al*., 2010). Fruit firmness was measured using Ez-Test/CE (Shimadzu Co., Japan) and expressed in g/㎠. Soluble solids content expressed as °Brix were measured by RA-510 (Kyoto Electronics MFG. Co., Ltd, Japan) at 20℃. The juice obtained from the fruit of *A. arguta* by pressing was used to measure the soluble solids content with a digital refractometer. The weight of fruit were measured by digital balance.

Statistical analysis

To evaluate the significance of differences between mean values of the changes of fruit firmness, soluble solids content and fruit weight at various temperature during storage, the Duncan's test was applied at the significance level of P = 0.05.

Results

Changes of fruit firmness, soluble solids content, fruit weight at different temperature

Generally, firmness of fruit is a basic quality feature describing deformation resistance of fruit. Since the firmness can assess the ripening stage of fruit, it is important to know the change of firmness during storage at different temperature. The firmness of fruit harvested at the storage maturity stage was 2,410 g/㎠ (Fig. 1). The firmness of 14 days of storage was much lower and ranged from 127.5 to 137.1 g/㎠. After 4 days later, a rapid decrease in firmness of the fruit stored at 15 and 20℃ were observed. However, a slow decrease in firmness of the fruit were observed which stored at 5 and 10℃.

During a maturation time and storage period, a decrease in firmness of fruit is observed as a result of polygalacturonase activity. This activity depends on storage conditions, and cultivars (Tavarini *et al*., 2009). According to other researches (White *et al*., 2005; Fisk *et al*., 2006), the storage of fruit of *A. arguta* caused a significant decrease in fruit firmness with the most rapid decrease in the first week of storage.

The soluble solids is important determinants of fruit taste quality. The soluble solids content of hardy kiwifruit of ripe stage (14 days of storage) was estimated from 16.21 °Brix (at 5℃) to 19.48 °Brix (at 20℃) (Fig. 2). However, at first stage of storage, the soluble solids content of fruit was lower and amounted to 9.69 °Brix. There was an increase in soluble

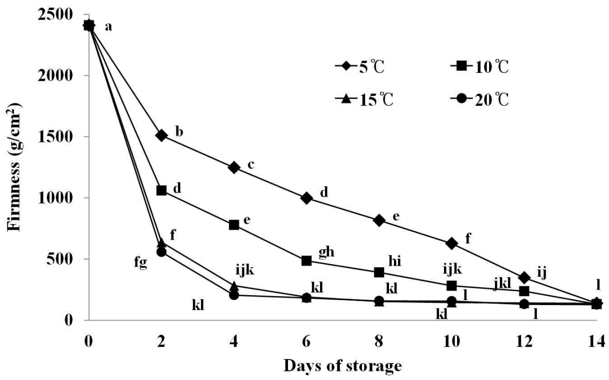

Fig. 1. Fruit firmness depending on time and temperature of storage of hardy kiwifruit; each value is presented as mean ± standard deviation (n = 20).

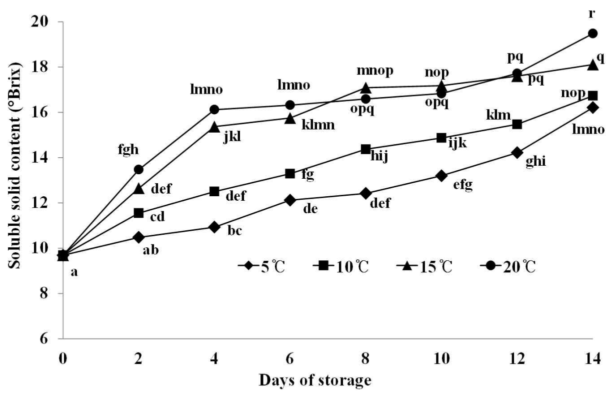

Fig. 2. Soluble solids content depending on time and temperature of storage of hardy kiwifruit; each value is presented as mean ± standard deviation (n = 20).

solids contents in fruit during the storage period. After 4 days and 8 days of storage, in case of 15℃ and 20℃, the fruit had similar level of soluble solids content to the fruit ripened, respectively. This means that the sweetness of fruit stored for 4 days and 8 days stored at 15℃ and 20℃ should be similar to that of fruit ripening. However, in case of stored at 5℃ and 10℃, the soluble solids content in fruit was increased slowly.

The increase in soluble solids content of fruit during storage observed in this study are consistent with the observation of Fisk *et al*. (2006). The increase in soluble solids content in the fruit of *A. arguta* after a storage period can be explained that the activity of glycolytic enzyme cause starch degradation and net starch to sucrose conversion (MacRae *et al*., 1992). It is also studied that the activity of these enzyme in the fruit is increased during the time of maturity (Langenkamper *et al*., 1998).

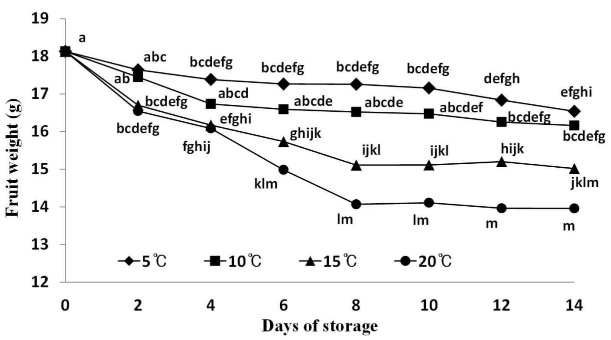

Fig. 3. Fruit weight depending on time and temperature of storage of hardy kiwifruit; each value is presented as mean ± standard deviation (n = 20).

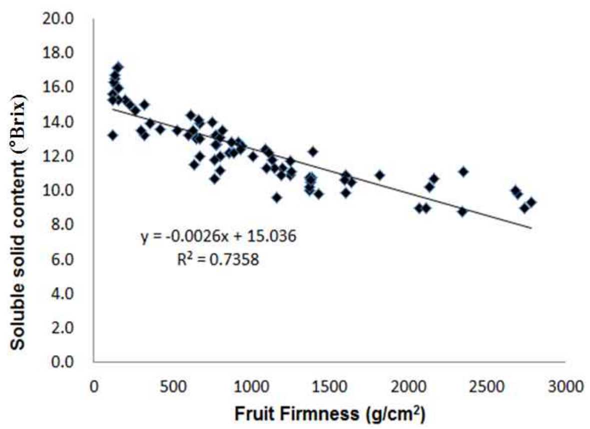

Fig. 4. Correlation analysis between fruit soluble solids content and fruit firmness stored at 5℃.

The weight of hardy kiwifruit of ripe stage (14 days of storage with a relative air humidity of about 85%) was estimated from 13.96 to 16.53 g (Fig. 3). However, at first stage of storage, the weight of fruit was higher and amounted to 18.13 g. There was an decrease in fruit weight during the storage period, because of the dryness of fruit.

Correlation between fruit firmness and soluble solids content at different temperature

As observed in Fig. 4, a linear correlation (r^2 = 0.7358) was shown between fruit firmness and soluble solids content in hardy kiwifruit stored at 5℃. These results provided evidence that the fruit firmness is closely correlated with fruit soluble solids content.

From the results of this study, we can conclude that during storage, the most remarkable changes in quality characteristics were observed in flesh firmness and soluble solids. In this research, the measurement of fruit firmness, soluble solids, and fruit weight were carried out at various temperatures (5, 10, 15 and 20℃) with a relative air humidity of about 85% during 14 days. We can also observed that fruit firmness rapidly decreased and soluble solids content increased at 15 and 20℃ more than 5 and 10℃. These results improve knowledge of the effect of ripening on different stored temperatures that could help to establish the optimum stored temperature data for various usages. We also investigated the correlation between fruit firmness and soluble solids content. There was a strong correlation between fruit firmness and soluble solids content.

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(Received 24 November 2014 ; Revised 5 June 2015 ; Accepted 8 June 2015)