Scientia Horticulturae 222 (2017) 57–61

Contents lists available at ScienceDirect

Scientia Horticulturae

journal homepage: www.elsevier.com/locate/scihorti

Short communication

Characteristic of fruit development for optimal harvest date and postharvest storability in 'Skinny Green' baby kiwifruit

Seong Bok Oh[a], Sowbiya Muneer[a], Yong-Bum Kwack[b], Mi Hee Shin[a], Jin Gook Kim[a,c,*]

[a] Department of Horticulture, College of Agriculture and Life Sciences, Gyeongsang National University, Jinju 52828, Republic of Korea
[b] Namhae branch, National Institute of Horticultural & Herbal Science, Rural Development Administration, Namhae 52430, Republic of Korea
[c] Institute of Agriculture and Life Science, Gyeongsang National University, Jinju 52828, Republic of Korea

ARTICLE INFO

Keywords:
Actinidia arguta
Dry matter
Harvest index
Maturity
Storage

ABSTRACT

Actinidia arguta, commonly known as hardy kiwifruit or baby kiwifruit has become very popular in the market due to its taste and can be eaten raw without peeling. However, characteristics of fruit development for optimal harvest date and postharvest storability of baby kiwifruit is diverse in contrast to those of green kiwifruit and yellow kiwifruit. This study was conducted to find the characteristics of fruit development for optimal harvest date and storability period post harvesting in baby kiwifruit for two years (2013–2014). The results showed that fruit weight increased showing a single sigmoid curve. The starch and sugar contents increased significantly and reached to a maximum level at 130–133 days after full bloom (DAFB) respectively. The soluble solids content (SSC) and fruit dry matter also increased and reached to a maximum stage until harvesting. Post-harvested fruits were examined after cold storability at 1 °C for 65 days. The physiochemical measurements such as SSC, fruit firmness increased with a reduction of starch content and titratable acidity (TA) at initial DAFB. However, the fruits harvested at latter stage (approx. 130–133 DAFB) after cold storability showed higher SSC content and a lower TA and fruit firmness. Moreover, the respiration rate in fruit increased till 20 days of storage and thereafter decreased slowly. This study demonstrated that quality of baby kiwifruit can be optimized through identification of ideal harvest date and by controlling storage conditions.

1. Introduction

Actinia arguta (Sieb. et Zucc.) called as hardy kiwifruit and/or baby kiwifruit is very promising fruit species native to East-Asia (Ferguson and Huang, 2007) with increasing commercial production worldwide (Williams et al., 2003). Baby kiwifruits comprises smooth edible skins and are smaller than green flesh kiwifruits (*A. deliciosa*). They have well balanced sweet and sour taste with an exceptional aroma (Kabaluk et al., 1997; Matich et al., 2003; Kim et al., 2009). The fruit also contains high rate of ascorbic acid approximately 25–155 mg per 100 g (Kabaluk et al., 1997) and is also characterized by a high protease activity and actinidin which contributes in digestion of human body (Nishiyama et al., 2004). The fruit is also rich in phenolic compounds as well as minerals such as P, Ca, Fe and Zn (Strick and Hummer, 2006; Latocha and Jankowski, 2011). The baby kiwifruits are a staple to Asian countries like Korea and Japan and are also commercialized in the United States, Canada, Chile, New Zealand, and Europe. Because of ready to eat and due to several health benefits, the value of baby kiwifruit has been increased in commercial markets. Thus, the value of superior cultivars is being endeavored in several countries (Williams et al., 2003; Jo et al., 2007; Latocha and Krupa, 2007; Kataoka et al., 2010).

The baby kiwifruit is harvested when they are physiologically mature and firm because they are too soft to package and ship if picked vine ripe (Fisk et al., 2006; Kim et al., 2009, 2012). The ripening of the fruit is then allowed when refrigerated which is also a common practice in other kiwifruits such as green flesh kiwifruit (Kabaluk et al., 1997; Fisk et al., 2006). Likewise, the ideal harvest time and storability for green kiwifruits has been observed when soluble solid content (SSC) is approximately 6.5% though, the ideal information for harvesting time is limited for hardy kiwifruits. Moreover, when growers followed 6.5% SCC for hardy kiwifruits the eminence of a fruit were described having insufficient aroma, taste, and sucrose content (Fisk et al., 2006).

The ideal fruit harvesting time and post-harvest storability is very important in baby kiwifruit for the necessity of good aroma, taste, and firmness towards effective commercialization. Several major barriers to market the fruit have been identified due to different fruit quality, dehydration and short shelf life in contrast to green flesh kiwifruit and yellow flesh kiwifruit. The emergent knowledge on fruit harvesting date and storability in baby kiwifruit would be valuable for the high quality

* Corresponding author at: Department of Horticulture, College of Agriculture and Life Sciences, Gyeongsang National University, Jinju 52828, Republic of Korea.
E-mail address: jgkim119@gnu.ac.kr (J.G. Kim).

http://dx.doi.org/10.1016/j.scienta.2017.05.003
Received 8 December 2016; Received in revised form 5 April 2017; Accepted 2 May 2017
Available online 11 May 2017
0304-4238/

products for commercial markets. The 'Skinny green' baby kiwifruit was bred by interspecies crossing with *A. arguta* and *A. deliciosa* in Korea (Kwack et al., 2010). The present study revealed the optimal harvest date and storability period post harvesting in baby kiwifruit 'Skinny Green' for two years (2013–2014).

2. Material and methods

2.1. Fruit collection

The baby kiwifruit cultivar 'Skinny Green' were harvested in 2013 and 2014 from a National Horticultural Research Institute, Republic of Korea. Vines were maintained a T-bar system and managed by a general cultivate practices. The fruits were packaged in low-vent plastic clam-shell container (HPL826 M, LocknLock, China), 20 fruits each container and were immediately moved to the laboratory of fruit science, Gyeongsang National University, Korea. After screening of fruits, only healthy fruits were used for experimental analysis, additionally fruits were stored in −20 °C for further analytical evaluation.

2.2. Fruit harvesting date

To examine the fruit developmental characteristics in 2013 a total of 7 time harvest were followed starting from June 19 to October 11 (after full bloom period of 30, 63, 93, 126, 133, 144, and 155 days). At each harvest a screening of healthy fruits were selected with 9 biological replicates. After the sorting of healthy fruit, soluble solids content (SSC), and total acidity (TA) content, the firmness of the fruit were measured. Starch content and sugar content was investigated after deep freezing (−20 °C).

In 2014 the fruit developmental characteristics were examined starting from June 19 to October 11, a total of 7 time harvest were followed (after full bloom period of 30, 60, 90, 120, 130, 140, and 150 days). At each harvest a screening of healthy fruits were selected with 9 biological replicates. The all measurement and phytochemical analysis of fruits were followed by 2013 season.

2.3. Fruit storability conditions

After observing fruit harvesting date in 2013–2014, the healthy fruits were packed in a polypropylene airtight container (HPL826 M 2.1L vessel, LocknLock, China) and were stored at 1 °C temperature for approximately 65 days at 95% relative humidity. The physiochemical parameters such as SSC, TA, firmness, and respiration rate were investigated with 9 biological replicates. The total starch and sugar content were investigated after frozen at −20 °C.

2.4. Physiochemical measurements

2.4.1. Soluble solids content (SSC)

The SSC was observed in a fruit juice with 9 biological replicates. The fruit was wrapped in a four layer cheese cloth, and absorbance was read using portable refractometer (Pocket Refractometer, PAL-1, Atago, Japan).

2.4.2. Titratable acidity (TA)

The titratable acidity (TA) of fruit juice was assayed by titration with 0.05 mol L^{-1} NaOH. The TA content was expressed as citric acid equilibrium.

2.4.3. Fruit firmness

The fruit firmness was measured with a probe diameter of 3 mm at a horizontal axis using a rheometer (RHEO TEX SD-700, Sun Scientific Inc, Japan) (3 mm depth).

2.4.4. Starch content

Two g of sample from flesh was homogenized in a 20 mL of dimethyl sulfoxide (DMSO) for 1 min. The homogenates was stirred for 24 h followed by centrifugation two times. The total volume was made up to 50 mL with DMSO. 5 mL of the solution was mixed with 15 mL of 80% ethanol (v/v), and then centrifuged. The resulting residue was dissolved in 5 mL of 0.1 M NaOH. Using this solution, starch was analyzed by modified phenol-sulfuric method (Dubois et al., 1956). The reaction mixture contained a 0.5 mL extraction solution, 0.5 mL phenol, and 2.5 mL sulfuric acid. After vortexing, starch content was determined calorimetrically using spectrophotometer (UV–1800, Shimadzu Corp., Japan) at 490 nm. Glucose was used as a standard solution.

2.4.5. Total sugar content

Two g of pooled sample from flesh was homogenized with 10 mL of 80% ethanol (v/v). The homogenates was incubated for 30 min in a water bath at 60 °C with continuous shaking, and then centrifuged at 10,000*g* for 10 min at 20 °C. The extraction was repeated twice and resulting supernatant was combined and made to 40 mL with 80% ethanol. Using this solution, total sugar was analyzed by modified phenol-sulfuric method (Dubois et al., 1956). The reaction mixture contained a 0.5 mL extraction solution, 0.5 mL phenol, and 2.5 mL sulfuric acid. After vortexing, total sugar content was determined calorimetrically using spectrophotometer (UV–1800, Shimadzu Corp., Japan) at 490 nm. Glucose was used as a standard solution.

2.4.6. Respiration rate (CO_2) and ethylene evolution (C_2H_4)

The polypropylene airtight container (HPL851-2.1 L, Locknlock, China) containing kiwifruit were allowed to incubate for 4 hours at room temperature. After incubation 1 mL of gas from each container were then analyzed for CO_2 and C_2H_4 gas by injecting into (GC-FID & TCD) gas chromatograph with flame ionization detector (GC 6890, Agilent Technologies, USA). The setting of GC-FID & TCD was as follows: oven temperature 100 °C, front inlet 100 °C, back inlet 375 °C, front detector 250 °C, and back detector 150 °C. The standard used for CO_2 and C_2H_4 analysis was 285 μL L^{-1} and 5.2 μL L^{-1} commercial standards.

2.5. Statistical analysis

All the fruits were harvested randomly, with analysis performed on nine biological replicates. The data analysis was analyzed with SAS statistical software Release 8.2 (SAS Inst., Cary. N.C., USA) following analysis of variance (ANOVA) and Tukey's T-test.

3. Results and discussion

3.1. Physiochemical characteristics of fruit during harvesting

The dry matter increased by 14.7% at 126 day after full bloom (DAFB) and was significantly induced at 155 DAFB by 16.2% (Fig. 1). In 2014 the dry matter content significantly increased by 12.6% at 120 days which was more increased by 16.7% at 130 DAFB. The dry matter content latter decreased after 130 DAFB in 2014 however, increased until a harvest in year 2013. The dry matter content has been observed to be increased in varieties of baby kiwifruit from China and Japan such as in *Actinidia* the dry matter content increased by 20% (Boldingh et al., 2000), and in 'Hayward' and 'Heanam' the dry matter content increased by 16% (Park et al., 2014) during the period of harvesting.

The total sugar and starch content increases in fruit till ripening due to increase in water content and after certain period of time decreased (Boldingh et al., 2000; Crisosto et al., 2012). Our results showed that the starch content increased significantly to 11.9 g per 100 g FW^{-1} in 2013 at 133 DAFB and 10.1 g per 100 g FW^{-1} in 2014 (Fig. 1). At 130