

# 'Redvita': A Yellow-fleshed Kiwifruit with Red Color Around the Core

Yong-Bum Kwack<sup>1</sup>, Hong-Lim Kim<sup>1</sup>, Jae-Han Lee<sup>2</sup>, Kyeong-Ho Chung<sup>3</sup>, and Won Byoung Chae<sup>4\*</sup>

<sup>1</sup>Namhae Branch, National Institute of Horticultural and Herbal Science, Rural Development Administration, Namhae 55365, Korea

<sup>2</sup>Protected Horticulture Research Institute, National Institute of Horticultural and Herbal Science, Rural Development Administration, Haman 52054, Korea

<sup>3</sup>Apple Research Institute, National Institute of Horticultural and Herbal Science, Rural Development Administration, Gunwi 39000, Korea

<sup>4</sup>Department of Vegetable, National Institute of Horticultural and Herbal Science, Rural Development Administration, Wanju 55365, Korea

\*Corresponding author: [chaeddang@korea.kr](mailto:chaeddang@korea.kr)

## Abstract

Kiwifruits introduced to Korea typically have green fruit flesh, yellow flesh, or yellow flesh with red coloration around the core. Here, we describe a new cultivar called 'Redvita', the first kiwifruit cultivar of Korea with yellow flesh and red coloration around the core. A conventional field cross was conducted in 2003, and permission for the final release of 'Redvita' was obtained in 2012. 'Redvita' originates from 'Red Princess', a maternal vine known for the red coloration in its flesh. The pollinizer is 'NHK0013' (IT233175), which blooms in early May. A principal feature of 'Redvita' is its high vitamin C content, which at an average of 140 mg per 100 g of fresh weight is 2 - 4 times higher than other commercial cultivars. The average fruit weight is 97 g; bigger than that of the control cultivar 'Hongyang'. 'Redvita' blooms in mid-May and is usually harvested in early to mid-October, approximately 150 - 160 days after anthesis. 'Redvita' produces 3 or 4 flowers per fruiting shoot, with no small lateral flowers, therefore does not need to be thinned before blooming for commercial production. The cultivar is acidulous because of a high titratable acidity content (about 1.5%), which is higher than other cultivars (less than 1.0%). 'Redvita' was registered with the Korean Seed and Variety Service in 2015 for plant variety protection rights (no. 5604).

**Additional key words:** *Actinidia*, breeding, cultivar, flesh color, vitamin C

## Introduction

Many kiwifruit cultivars have been developed and variation among cultivars exists in fruit shape and color as well as in total phenolic, antioxidant and flavonoid contents (Lee et al., 2015). The green-fleshed kiwifruit cultivar 'Hayward' is the most popular cultivar produced around the world (Ferguson 1999). However, its dominant market share has decreased since the introduction of the yellow-fleshed cultivar 'Hort16A' in the late 20<sup>th</sup> century (Muggleston et al., 1998). As of 2015, the total area of kiwifruit cultivation

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in Korea was about 1300 ha, mostly located in three southern provinces: Jeollanam-do, Gyeongsangnam-do, and Jeju-do (Kwack et al., 2016). The leading kiwifruit cultivars in Korea are yellow-fleshed or green-fleshed, although yellow-fleshed cultivars with red coloration around the core exist. Consumer demand for yellow-and-red colored kiwifruits such as the Chinese cultivar 'Hongyang' has increased because of their sweetness and attractive coloration.

Working with the Rural Development Administration (RDA), before 2000, the objective of our kiwifruit breeding team was to develop cultivars comparable to the green-fleshed kiwifruit 'Hayward'. However, since the launch of the yellow-fleshed kiwifruit 'Hort16A', we have aimed at breeding yellow-fleshed kiwifruit cultivars with red coloration around the core. Compared to 'Hayward', the commercial red-fleshed cultivar 'Hongyang' has several unfavorable traits, including small fruit size and non-elliptical fruit shape (Wang et al., 2003). From research beginning in 2003, we have developed a yellow-fleshed kiwifruit cultivar with red coloration around the core, known as 'Redvita'. This has bigger and more elliptical fruits than 'Hongyang'. Here we describe the characteristics of the cultivar 'Redvita'.

### Origin

A conventional field cross was conducted in 2003 at the RDA kiwifruit breeding orchard (latitude: 34°48'N; longitude: 127°55'E) in Namhae, the southern coastal region of South Korea. The parents of 'Redvita' originated from germplasm collections of *Actinidia chinensis* var. *chinensis* introduced from China. The red-fleshed kiwifruit 'Red Princess' was the maternal vine, and 'NHK0013' (IT233175) was the paternal germplasm (Fig. 1). In 2004, 351 seedlings were grown from seeds collected in the winter of 2003. In 2005, the seedlings were transplanted to a breeding orchard. The line '2003 - 1 - 129' was first selected in 2007 for its expression of red color around the core of the fruits. In 2008, the selected line was propagated by grafting, and fruit and vine characteristics were evaluated for a further three years. Finally, the cultivar 'Redvita' was released in 2012.

All fruits and vine characteristics were observed and evaluated according to the test guidelines of the Korea Seed & Variety Service (KSVS) for kiwifruit (2007), and the International Union for the Protection of New Varieties of Plants (UPOV) guidelines for *Actinidia* (2001).

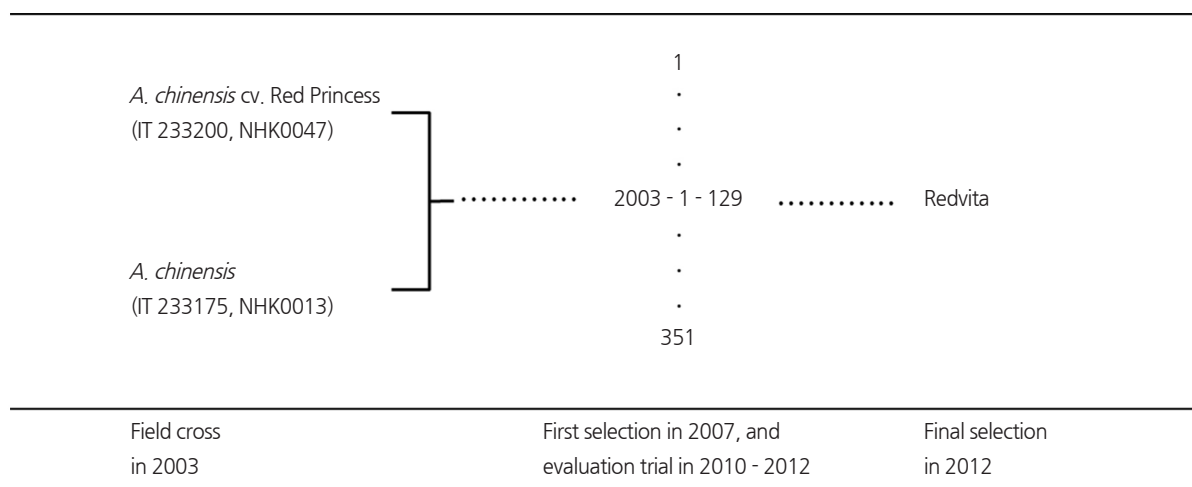


Fig. 1. Pedigree of the new red-centered kiwifruit 'Redvita'.

## Description

'Redvita' has a golden yellow pericarp with red coloration around core. It is tetraploid and produces elliptical fruits (Fig. 2). Like other *A. chinensis* cultivars, it has no bud cover. It also weakly expresses a calyx ring when fruits are mature. The fruits have sparse downy hairs on their exterior, and a yellowish outer pericarp when ripe (Table 1).

'Redvita' usually blooms in mid-May. In our experimental field, 'Hongyang' bloomed 4 - 5 days earlier than 'Redvita' over three consecutive season trials. 'Redvita' was harvested in mid-October (150 - 160 days after anthesis); approximately 13 - 15 days earlier than 'Hongyang' (Table 2). 'Redvita' has one of the earliest harvest times of all commercial cultivars, including 'Hayward' whose fruits are usually harvested in 180 days after anthesis.

Kiwifruit is well known for its high vitamin C content. The vitamin C content of 'Redvita' is 140 mg per 100g of fresh weight (FW); 2 - 3 times higher than other commercial cultivars (Fig. 3). It has slightly lower soluble solids content (SSC) and higher acidity than 'Hongyang' (Table 3). When grown at the same time and in the same place, the average fruit weight of 'Redvita' was 97.4 g FW, which is heavier than the control cultivar 'Hongyang' (66.4 g FW). The fruit length and diameter of 'Redvita' were 64.8 mm and 50.7 mm, respectively, longer than 'Hongyang', and the flat ratio (maximum-to-minimum equatorial diameter) of 'Redvita' was 1.07, which is lower than that of 'Hongyang'.

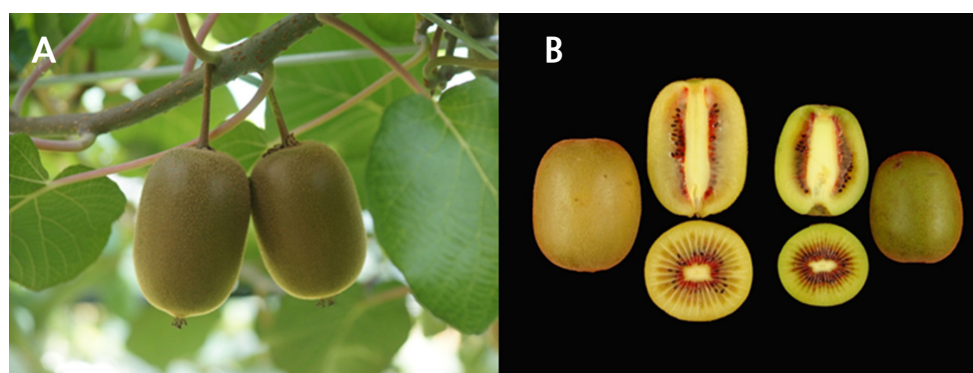


Fig. 2. (A) Fruitset of 'Redvita'. (B) Cross sections of 'Redvita' (left) and 'Hongyang' (right).

Table 1. Qualitative characteristics of the kiwifruit cultivars 'Redvita' and 'Hongyang' grown in open fields from 2010 - 2012 in Namhae, South Korea.

Cultivar	Ploidy <sup>z</sup>	Bud cover	Number of flowers per cyme	Fruit shape	Fruit flesh color	Hair on the fruit skin	Fruit calyx ring
Redvita	Tetraploid	Absent	1	Elliptical	Yellowish	Downy	Weak
Hongyang	Diploid	Absent	1 - 3	Obovoid	Greenish yellow	Downy	Weak

<sup>z</sup>Ploidy level was determined according to flow cytometry using a Partec ploidy analyzer, Partec CyFlow SL (Partec GmbH, Münster, Germany).

Table 2. Bud break, blooming and harvest time of the kiwifruit cultivars 'Redvita' and 'Hongyang' grown in open fields from 2010 - 2012 in Namhae, South Korea.

Cultivar	Bud break	Beginning of bloom <sup>z</sup>	Full bloom <sup>y</sup>	Harvest time <sup>x</sup>
Redvita	1 - 4 April	11 - 20 May	14 - 22 May	10 - 15 October
Hongyang	30 March - 1 April	7 - 14 May	9 - 26 May	25 - 28 October

<sup>z</sup>Beginning of bloom, date at which up to 10% of flowers on the vines had bloomed.

<sup>y</sup>Full bloom, date at which 70 - 80% of flowers on the vines had bloomed.

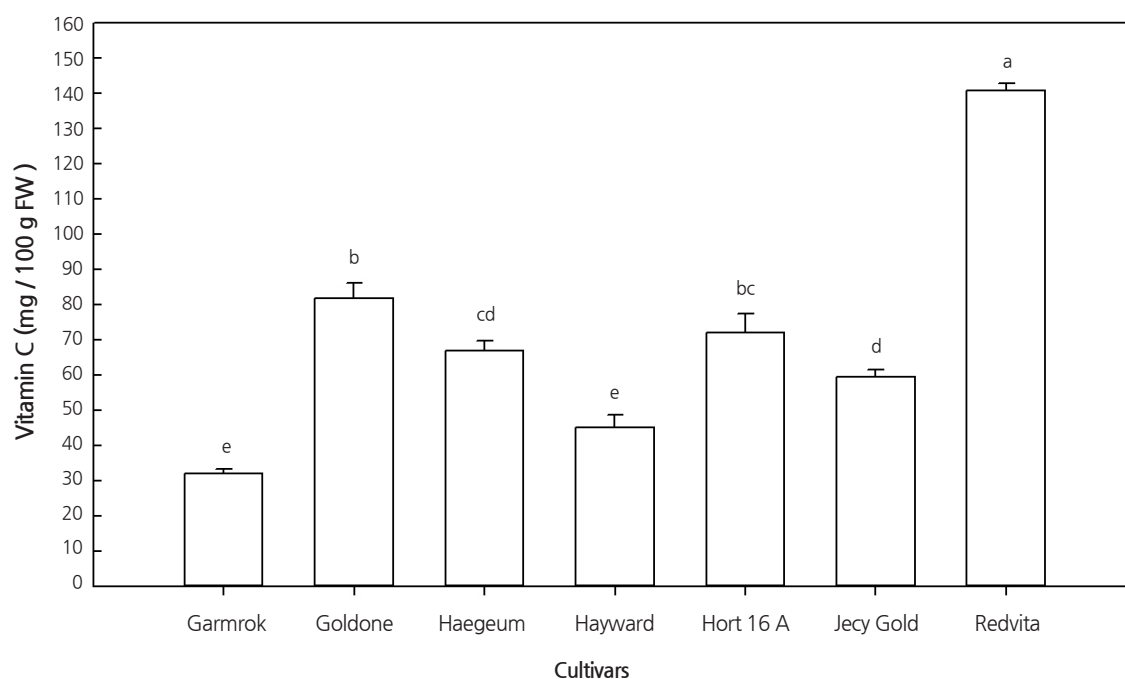
<sup>x</sup>Harvest time, determined based on soluble solids content, with the date reaching up 7.5 - 8.5° Brix.

## Performance

'Redvita' is not self-fertile, therefore needs artificial pollination for fruitset, like other cultivars in the genus (Ferguson 1990). However, there are no commercially available male vines for artificial pollination, which bloom at the same time or earlier than 'Redvita'. 'Redvita' growers must keep pollen grains in a deep freezer for at least one year before artificial pollination.

'Redvita' has 3 or 4 flowers per fruiting shoot, and no lateral flower in fruiting shoots (data not shown), thus requires no flower thinning before it blooms.

Compared to other cultivars, 'Redvita' is relatively acidulous (less than 1.0%) because of its high acid content (1.54%) (Table 3). However, as observed in a practical orchard-growing test, its sour taste can be masked by sweetness, since fruits with high SSC (18 - 20° Brix) can



**Fig. 3.** Vitamin C content of 'Redvita' and other cultivars in 2015. Vertical bars indicate standard error of the means, and letters above the bars indicate mean separation according to Duncan's multiple range test ( $p \leq 0.05$ ). Analysis was conducted using a high performance liquid chromatograph (YL9100 model, Young Lin Instrument Co., South Korea), and an Agilent XDB-C18 column. FW, fresh weight.

**Table 3.** Quantitative characteristics of the kiwifruit cultivars 'Redvita' and 'Hongyang' grown in open fields from 2010 - 2012 in Namhae, South Korea.

Cultivar	Fruit weight (g)	Fruit length (mm)	Fruit diameter (mm)	Flat ratio <sup>z</sup>	Soluble solids content (°Brix) <sup>y</sup>	Titrateable acidity (%) <sup>x</sup>	Flesh hardness (kg·cm <sup>-2</sup> ) <sup>w</sup>
Redvita	97.4 ± 3.0a <sup>y</sup>	64.8 ± 1.3a	50.7 ± 0.4a	1.07 ± 0.00b	13.8 ± 0.7b	1.54 ± 0.23a	0.55 ± 0.06b
Hongyang	66.4 ± 3.8b	57.3 ± 2.3b	45.3 ± 0.5b	1.12 ± 0.03a	14.4 ± 0.8a	0.95 ± 0.18b	0.95 ± 0.22a

<sup>z</sup>The ratio of the maximum fruit diameter to the minimum fruit diameter

<sup>y</sup>Soluble solids content was measured using a refractometer (PR-32  $\alpha$ , Atago, Bellevue, WA, USA)

<sup>x</sup>Citric acid content was titrated with an automated titrimeter (TitroLine Easy, Schott, Mainz, Germany)

<sup>w</sup>Flesh hardness was measured after cutting into the fruit skin c. 2 mm with a handy hardness meter (12 mm probe diameter, Fujiwara Scientific Co., Japan)

<sup>v</sup>Lower case letters represent mean separation within columns according to t tests (LSD) at  $p \leq 0.05$ .

be produced under certain growing conditions (data not shown). Resistance to several diseases including ripe rot during storage is similar to that of 'Hayward'. Storage in a cold room for 3 - 4 months seems appropriate for 'Redvita', although further study is needed.

### Availability

'Redvita' was officially registered as a new cultivar in 2015, according to the Plant Variety Protection Act by the Commissioner of the KSVS. The plant variety rights grant number is 5604. It was released for commercial growth in the Republic of Korea in 2016. The rights to propagate and sell vines of this cultivar have been granted to several domestic nurseries through contracts approved by the RDA.

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