Antioxidant compounds of kiwifruit during post-ripening process at ambient temperature

D. Liang¹, X.L. Lv¹, J. Wang¹, H. Xia¹*, Y. Xie², M.Z. Li² and Y.Z. Wang²

¹Institute of Pomology and Olericulture, Sichuan Agricultural University, Chengdu 611130, China
²Sichuan Province Natural Resources Science Academy, Chengdu 610015, China
*Corresponding author

Abstract. Kiwifruit is well-known for an excellent source of antioxidants. In this study, contents of total phenolics (TPC), total flavonoids (TFC), total flavanols (TFAC) and vitamin C were investigated in different fruit tissues during post-ripening process at ambient temperature. The results explored that TPC and TFC showed declining trend with the increase in storage interval in different tissues. TFAC raised with the increase in storage interval in different fruit tissues, while was followed a decrease in later process. Vitamin C content was stable in outer and inner pericarp in prometaphase of post-ripening.

1. Introduction

As one of the most popular fruits today, kiwifruit is also well-known for an excellent source of antioxidants, such as vitamin C, vitamin E, carotenoids, flavonoids, polyphenol, pigments et al. [9,10,12]. All these antioxidant compounds have strong antioxidant functions that enable them to scavenge free radicals or suppressing formation of free radicals in vitro and in vivo [6,8]. It has been considered that a network of bioactive compounds with different physicochemical properties may function in a synergistic way to protect human from chronic diseases, cardiovascular diseases, cancer, and delaying aging [1,2,13,14].

Kiwifruit is a typical kind of respiratory climatic fruit. Many scholars are interested in the study of the conditions, qualities, preservation effect of kiwifruit during storage [5,10,11,12], but few people attention to the changes in the antioxidant activities of kiwifruit during post-ripening process. Here, the total phenolics, total flavonoids, total flavanols, and vitamin C were determined in outer pericarp, inner pericarp and core of ‘Hongyang’ (Actinidia chinensis) kiwifruit. Our object was to provide references for consumer purchase behavior and theoretical basis for further research on its medicinal value and antioxidant mechanism.

2. Materials and methods

2.1 Materials

‘Hongyang’ kiwifruits used in this study were harvested from Kiwifruit Resource Orchard in Shifang (104°16′N, 31°13′E), Chengdu, China. Fruits were selected according to the uniformity of the shape on September 20th (all fruits samples have reached physiological maturity) and stored at ambient conditions (25±2°C and 62±6% RH) without any treatment. 8 fruits were sampled randomly every 3 days, 3 replicates, and stored at -72°C for further studies.
2.2 Preparation of kiwifruit extracts
At least 8 fruits were combined for each of the three replicated samples. The fruits samples was divided into three part, including outer pericarp, inner pericarp and core, each part (0.1g) was homogenised and extracted three times respectively in 1mL of ethanol: methanol: formic acid (14:35:1, v/v) at 0°C. The homogenate was transferred to a centrifuge tube; another 1.0 mL of extraction solution was used to wash the mortar and pestle before being added to the first homogenate. After being shaken in a thermomixer at 30 °C for 3h at 400 rpm, this combined homogenate was centrifuged at 10,000 g for 10 min. The supernatant was then filtered through a 0.45μm syringe filter prior to analysis of the total phenolics, total flavonoids, total flavanols, vitamin C and antioxidant activities.

2.3 Determination of total polyphenols, total flavonoids, total flavanols and Vc
The total phenolic content (TPC) was determined using the Folin-Ciocalteu method (Singleton and Rossi 1965). Absorbance was read at 765 nm before TPC was calculated from a calibration curve, using gallic acid as the standard to obtain gallic acid equivalents (GAE).

The total flavonoid content (TFC) was determined according to a procedure derived from Jia et al. [3]. The absorbance was measured against a blank at 510 nm. Afterward, TFC was calculated from a calibration curve using rutin as the standard to obtain rutin equivalents (RE).

The total flavanol content (TFAC) was detected with p-DMACA [7]. Absorbance was read at 640 nm. The TFAC was calculated from a calibration curve using catechin as the standard (catechin equivalents, CE).

The vitamin C (Vc) was described according to a procedure derived from Kampfenkel et al. [4]. Absorbance was read at 525 nm. The Vc was calculated from a calibration curve using AsA as the standard.

3. Results and discussion
3.1 Total phenolics content (TPC)
We examined TPC of the extracts from outer pericarp, inner pericarp, and core of ‘Hongyang’ kiwifruit during post-ripening process at ambient temperature. Basically, core and inner pericarp has higher TPC than outer pericarp during whole post-ripening process (Fig. 1A). Similar change patterns with respect to TPC were observed in different fruit tissues, which showed declining trend with the increase in storage interval (Fig. 1A). These results got the support of Sharma et al. [11] who had reported such variations in phenolic content in different cultivars of kiwifruit. However, Tavarini et al. [12] have reported increase in phenolic compounds during room storage of ‘Hayward’ kiwifruit after long-time low temperature storage. Generally, the reason why phenol content may either increase or decrease in fruits may depend on the storage conditions.

3.2 Total flavonoids (TFC)
During the days of post-ripening process, the change of TFC in the outer pericarp and inner pericarp of kiwifruit shared in the similarly decline trend, falling from 768.07 mg RE/100g FW to 474.54 mg RE/100g FW and 661.69 mg RE/100g FW to 419.47 mg RE/100g FW, relatively (Fig. 1B). In core, there was an increase of TFC after 6 days, finally up to 1.82 times than that at 0th day, which was higher than that in the internal and external pulp (Fig. 1B).

3.3 Total flavanols (TFAC)
Different from TFC, TFAC in core of fruit was higher than that of outer and inner pericarp during post-ripening process (Fig. 1C). In this process, the TFAC of core gradually increased, reaching highest at 12th day with value of 48.58 mg CE /100g FW. However, the TFAC of outer pericarp and inner pericarp increased clearly until the 9th days then decreased rapidly.
3.4 Vitamin C (Vc)

Vitamin C is one of the most important indexes to measure the quality of fruit, especially for its antioxidant properties. The content of Vc in kiwifruit is higher than that in strawberry, grape, cherry fruit, and almost tenfold of that in apple and peach (Fu et al. 2011). In our study, the content of Vc outer pericarp and inner pericarp were higher than that of core in whole post-ripening process (Fig. 1D). During the post-ripening process, the change of Vc content in outer pericarp was stable until 9th day, and then declined slightly. Vc content in inner pericarp increased to the highest value at 3rd day then remained stable until 9th day, followed small decline. However, the content of Vc in core was slowly falling down after 3 days during storage.

![Graphs showing changes in TPC, TFC, TFAC, and Vc content during post-ripening process.](image)

**Fig. 1** Changes of content of TPC (A), TFC (B), TFAC (C), and Vc (D) in ‘Hongyang’ kiwifruit during post-ripening process at ambient temperature.

4. Conclusions

Kiwifruit is an excellent fruit, which contains abundant antioxidants. Here, we investigated the change of four antixoidants (TPC, TFC, TFAC and Vc) of different kiwifruit tissues (outer pericarp, inner pericarp and core) during post-ripening process. In a summary, TPC showed declining trend with the increase in storage interval in different tissues. Similar patterns of TFC also were uncovered in outer and inner pericarp. TFAC raised with the increase in storage interval in different fruit tissues, while was followed a decrease in later process. Vc content was stable in outer and inner pericarp in prometaphase of post-ripening.

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