Evaluation of biochemical components and antioxidant capacity of different kiwifruit (Actinidia spp.) genotypes grown in China

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ABSTRACT
Kiwifruit from eight Actinidia genotypes were evaluated for soluble sugar content (SSC), titratable acidity content (TAC), sugar–acid ratio (SAR), vitamin C (Vc) content, superoxide dismutase (SOD) activity, total phenolic content (TPC), total flavonoid content (TFC) and antioxidant capacity using four assays: 2,2’-azino-bis(3-ethylbenzothiazoline-6-sulphonic acid) (ABTS) radical-scavenging assay; 2,2-diphenyl-1-picrylhydrazyl (DPPH) radical-scavenging assay; oxygen radical absorbance capacity (ORAC) and ferric reducing antioxidant power (FRAP) assay. These analyses demonstrated that ‘AnminR1’ and ‘AnminR2’ of Actinidia arguta have significantly higher SSC, TAC and SAR than other Actinidia genotypes, indicating better flavour. The analyses also demonstrated that the antioxidant capacity of Actinidia kolomikta and A. arguta fruits was significantly higher than that of other genotypes (Actinidia chinesis and Actinidia deliciosa), which was approximately 2.37–5.51 fold higher than A. deliciosa cv. There was extensive variety in the Vc content, SOD activity, TPC and TFC amongst Actinidia genotypes, which significantly correlated with TAC. We determined that significant genotypic differences exist in the biochemical components and TAC of Actinidia fruits. The hardy A. kolomikta and A. arguta genotypes have significantly higher antioxidant capacity than the commercial cultivars of A. chinesis and A. deliciosa indicating that the hardy Actinidia genotypes have more health benefits than the commercial cultivars of Actinidia.

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Introduction
Free radical-induced oxidative stress has been associated with several toxic cellular processes, including oxidative damage to protein and DNA, membrane lipid oxidation, enzyme inactivation, and gene mutations that may lead to carcinogenesis [1]. The leading causes of death in the United States are cardiovascular diseases and cancer. Willet [2] estimated that roughly 32% of cancers could be avoided by dietary modifications. Plant extracts from fruits, vegetables and medicinal herbs reportedly have anticancer activity, comparable to chemotherapy and hormonal treatments. Epidemiological and laboratory studies have also shown that taking abundant fruits and vegetables in the human diet is associated with a lower risk of heart disease and cancer [3]. Fruits and vegetables contain many phytochemicals with various bioactivities including antioxidant, anti-inflammatory and anticancer activities. In a previous study, it was found that fruits provide the largest contribution of antioxidants in the human diet due to an abundance of vitamins, phenolic compounds and carotenoids [4].

Kiwifruit is a perennial deciduous vine fruit tree, belonging to Actinidia in the family of Actinidiaceae. A very small number are monoecious, and a large number of kiwifruit are dioecious. The genus Actinidia includes 76 species and about 125 known taxa worldwide [5]. Kiwifruit has become an important horticultural cash crop in the fruit industry worldwide [5,6]. Today, the kiwifruit species mainly used for commercial cultivation are A. chinesis, A. delicosa and less commonly A. eriantha and A. arguta [7,8].

Previous studies have shown that kiwifruit contains high levels of bioactive compounds such as vitamin C, vitamin E, flavonoids, carotenoids, minerals and others (reviewed in [9]). Vc has been found to prevent the formation of N-nitroso compounds, which are cancer causing substances formed from the nitrates and nitrites found in preserved meats and some drinking water [10]. According to Leong and Shui [11], Actinidia fruits have high antioxidant capacity. Phenolics and Vc content significantly affect the antioxidant quality of the fruit [12,13]. Different types
of kiwifruit have different growth and developmental variations, as well as fruit quality and flavour [14]. Zou et al. [15] demonstrated that different Actinidia genotypes have different antioxidant and cancer preventive (antiproliferative) properties.

The purpose of this study was to investigate the biochemical components of eight different Actinidia genotypes, including soluble sugar content (SSC), titratable acidity content (TAC), sugar-acid ratio (SAR), vitamin C content, superoxide dismutase (SOD) activity, total polyphenolic content (TPC) and total flavonoid content (TFC) using different chemical components of eight different Actinidia genotypes. These results provide a theoretical and scientific basis for the selection and breeding of different Actinidia genotypes.

Material and methods

Chemicals

All chemicals were of analytical grade. Nitroblue tetrazolium (NBT), riboflavin, gallic acid, Folin-Ciocalteu phenol reagent, 2,4,6-tri(2-pyridyl)-s-triazine (TPTZ), 2,2-diphenyl-1-picrylhydrazyl (DPPH), 2,2-diphenyl-1-picrylhydrazyl (DPPH) radical-scavenging assay; oxygen radical absorbance capacity (ORAC); and ferric reducing antioxidant power (FRAP) assays. In addition, we determined the relationship between these biochemical components and TAC. These results provide a theoretical and scientific basis for the selection and breeding of different Actinidia genotypes.

Vitamin C content

The vitamin C content was determined as described [17]. Samples (2.0 g fresh of each kiwifruit) were homogenized in 8 mL of 6% (w/v) trichloroacetic acid pre-cooled on ice and centrifuged at 10,000 × g for 20 min. The vitamin C content was determined based on the reduction of Fe³⁺ to Fe²⁺ by vitamin C in acidic solution. Fe²⁺ forms complexes with 2,2’-bipyridyl, to impart a pink colour with a maximum absorbance at 525 nm measured using a spectrophotometer (722 G, Shanghai City, China). A standard curve of vitamin C was also used in this study. Vitamin C content was expressed as milligrams of vitamin C equivalents (VCE): 100 g⁻¹ FW ± SD of kiwifruits.

Superoxide dismutase activity

An adapted version of the method introduced by Beaucamp and Fridovich [18], which is based on the photo-reduction of nitroblue tetrazolium (NBT), was used to obtain the total SOD activity in the extract. The reaction mixture consisted of 3 mL of 0.05 mol L⁻¹ sodium phosphate buffer (pH 7.8) containing 13 mmol L⁻¹ methionine, 75 µmol L⁻¹ NBT, 0.01 mmol L⁻¹ EDTA-Na₂, 0.002 mmol L⁻¹ riboflavin and 0.1 mL of 25%, 50%, 75% and 100% concentrations of each sample. Lastly, riboflavin was added as a source of superoxide. Cuvettes containing the reaction mixture were illuminated by two 15-W fluorescent lamps until the reaction mixture without
SOD achieved a moderated blue colour. The absorbance of the reaction mixture was measured at 560 nm using a spectrophotometer (722 G, Shanghai City, China). The non-irradiated reaction mixture served as a control and was deducted from the $A_{560}$ of each sample. The volume of the extract corresponding to 50% inhibition of the reaction was considered to be one enzyme unit. Total SOD activity was expressed in units (U)·100 g$^{-1}$ FW ± SD of kiwifruit.

**Total phenolic content**

A colourimetric method using Folin–Ciocalteu’s (FC) phenol reagent [19] with slight modifications [20] was used. The standard or fresh kiwifruit extract (0.2 mL) was mixed with 1.0 mL FC reagent and 0.8 mL Na$_2$CO$_3$ (7.5%) in a 20 mL vial and allowed to stand for 30 min at room temperature (20 °C). Absorption was measured at 765 nm in a Varian Cary 3C spectrophotometer. The measurement was compared to a standard curve of prepared gallic acid solutions and expressed as milligrams of gallic acid equivalents (GAE)·100 g$^{-1}$ FW ± SD of kiwifruit.

**Total flavonoid content**

The total flavonoid content (TPC) of each sample was measured using a modified colourimetric method [21,22]. A volume of 0.25 mL of a known dilution of extract was added to a test-tube containing 1.25 mL of distilled water. The mixture was added 0.075 mL of 0.5% sodium nitrite solution, and this was allowed to stand for 5 min. Then, 0.15 mL of 10% aluminum chloride was added. After 6 min, 0.5 mL of 1 mol L$^{-1}$ sodium hydroxide was added, and the mixture was diluted with another 0.275 mL of distilled water. The absorbance of the mixture at 510 nm was measured immediately using a Varian Cary 60 spectrophotometer and compared to a standard curve of prepared catechin solutions. The flavonoid content was expressed as milligrams of catechin equivalents (CE)·100 g$^{-1}$ FW ± SD of kiwifruit.

**ABTS radical-scavenging assay**

The total antioxidant activity (TAC) of each sample was measured using ABTS radicals [23]. AAPH (1 mmol L$^{-1}$) was mixed with 2.5 mmol L$^{-1}$ ABTS in phosphate buffered saline which was heated in a water bath at 70 °C for 30 min to create ABTS radicals. The solution of ABTS radicals was adjusted to an absorbance of 0.650 ± 0.020 at 734 nm. The reaction between the ABTS radical solution (980 μL) and the appropriately diluted extracts (20 μL) was conducted at 37 °C for 10 min. Absorbance at 734 nm was measured immediately. A vitamin C standard was used to build a calibration curve with concentrations of 10, 30, 60 and 100 mg·L$^{-1}$. The antioxidant capacity of each sample was expressed as milligrams of vitamin C equivalents (VCE)·100 g$^{-1}$ FW ± SD of kiwifruits.

**DPPH radical-scavenging assay**

The DPPH radical-scavenging capacity was determined as described [24]. The absorbance of fresh DPPH radicals in 80% (v/v) aqueous methanol was set to 0.650 ± 0.020 at 517 nm. The reaction between DPPH radical solution (2.95 mL) and the appropriately diluted extracts (50 μL) took place at 23 °C for 30 min. The reduction of absorbance at 517 nm was measured immediately. A vitamin C standard was used to build a calibration curve with concentrations of 10, 30, 60 and 100 mg·L$^{-1}$. The antioxidant capacity of each sample was expressed as milligrams of VCE·100 g$^{-1}$ FW ± SD of kiwifruits.

**Oxygen radical absorbance capacity assay**

The ORAC assay was performed as described [25]. Appropriately diluted extracts or the standard (25 μL) with 150 μL of 81.6 nmol L$^{-1}$ fluorescein solution were added to a 96-well plate and incubated at 37 °C for 10 min with 3 min of shaking. Twenty-five microliters of 153 mmol L$^{-1}$ AAPH solution was added and fluorescence was then detected every minute for 90 min using a micro-plate reader (ELx808, America) with 485 nm excitation and 520 nm emission wavelengths. The antioxidant capacity of each sample was expressed as milligrams of VCE·100 g$^{-1}$ FW ± SD of kiwifruits.

**Ferric reducing antioxidant power assay**

FRAP was determined using a previously described method [26]. Standard (L-ascorbic acid) or sample extract (10 mL) mixed with 300 μL of ferric-TPTZ reagent (prepared by mixing 300 mmol L$^{-1}$ acetate buffer pH 3.6, 10 mmol L$^{-1}$ TPTZ in 40 mmol L$^{-1}$ HCl and 20 mmol L$^{-1}$ FeCl$_3$ in a ratio of 10:1:1 (v/v/v)) was added to the wells. The plate was incubated at 37 °C for the duration of the reaction. Absorbance readings were taken at 593 nm at 0 and 4 min using a Varian Cary 60 spectrophotometer. The antioxidant capacity of each sample was expressed as milligrams vitamin C equivalents (VCE)·100 g$^{-1}$ FW ± SD of kiwifruits.

**Statistical analysis**

To verify statistical significance, means ± SD of three independent experiments were calculated. One-way
analysis of variance (ANOVA) and correlation analysis were performed using SPSS (20.0), followed by Duncan’s new multiple range test to assess differences between group means. \( P \) values of \(< 0.05\) were considered to be significant.

**Results and discussion**

The chemical components and biochemical capacities of different *Actinidia* genotypes, including SSC, TAC, SAR, Vc content, total SOD activity, TPC and TFC are shown in Table 1.

**Table 1. Chemical components and biochemical capacity of different *Actinidia* cultivars.**

| Cultivar       | Soluble sugar content (g 100 g\(^{-1}\) FW) | Titratable acidity content (g 100 g\(^{-1}\) FW) | Sugar–acid ratio | Vitamin C content (mg VCE 100 g\(^{-1}\) FW) | Total SOD activity (U g\(^{-1}\) FW) | Total phenolic content (mg GAE 100 g\(^{-1}\) FW) | Total flavonoid content (mg CE 100 g\(^{-1}\) FW) |
|----------------|------------------------------------------|-----------------------------------------------|------------------|---------------------------------------------|-----------------------------------|---------------------------------------------|-----------------------------------------------|
| Red sun (A. chinensis) | 10.02 ± 0.13c                           | 1.25 ± 0.02ab                                | 8.05 ± 0.25c     | 120.07 ± 102b                              | 49.39 ± 0.32a                     | 86.95 ± 0.43a                               | 68.47 ± 0.19a                                 |
| Cuiyu (A. chinensis)  | 9.19 ± 0.06b                            | 1.22 ± 0.03a                                | 7.53 ± 0.15c     | 90.99 ± 126a                               | 50.01 ± 0.59b                     | 83.23 ± 0.63a                               | 67.64 ± 1.03a                                 |
| Hayward (A. delicosa) | 8.75 ± 0.08b                            | 1.35 ± 0.03bc                               | 6.50 ± 0.24b     | 93.66 ± 120a                              | 50.21 ± 0.52ab                    | 78.17 ± 0.19a                               | 65.63 ± 0.73a                                 |
| Qinmei (A. delicosa) | 9.05 ± 0.06b                            | 1.44 ± 0.02cd                               | 6.27 ± 0.14b     | 191.8 ± 130c                             | 51.74 ± 0.50ab                    | 78.87 ± 0.81a                               | 66.03 ± 0.55a                                 |
| AnminR1 (A. arguta)   | 10.70 ± 0.21c                           | 1.37 ± 0.01cd                               | 7.80 ± 0.17c     | 440.97 ± 5.88d                            | 52.88 ± 0.26ab                    | 315.51 ± 3.00b                              | 169.61 ± 0.84b                                |
| AnminR2 (A. arguta)   | 10.29 ± 0.10c                           | 1.39 ± 0.00cd                               | 7.40 ± 0.24c     | 540.56 ± 4.90e                            | 52.04 ± 0.60ab                    | 330.69 ± 0.50c                              | 181.99 ± 1.51c                                |
| AnminG1 (A. kolomikta) | 8.54 ± 0.17ab                          | 1.42 ± 0.02cd                               | 6.01 ± 0.19b     | 768.26 ± 5.95f                            | 53.21 ± 0.45b                     | 441.42 ± 1.11d                              | 183.37 ± 1.44c                                |
| AnminG2 (A. kolomikta) | 7.89 ± 0.14a                           | 1.48 ± 0.01d                                | 5.33 ± 0.14a     | 833.70 ± 4.07g                            | 53.12 ± 1.01b                     | 461.12 ± 2.83e                              | 185.40 ± 0.53c                                |

Mean ± SD (standard deviation) of 3 measurements. Average values in rows marked with different letters differ significantly \( (p < 0.05)\).

**Soluble sugar content, titratable acidity content and sugar–acid ratio of different Actinidia genotypes**

The quality of kiwifruit can be evaluated in terms of sensory factors. It is known that the characteristic taste of fruit is determined largely by the content of sugars and organic acids [27]. Furthermore, the sugar–acid ratio is considered particularly useful as an index of acceptability in many fruits [28]. The sugar content, acidity, Vc content and other nutrients in fruit are important indicators for evaluating fruit quality and flavour; high levels of SSC, TAC, and SAR in fruits indicate better flavor [28,29]. Each genotype assayed in this study showed different levels of SSC, TAC and SAR (Table 1). The levels of SSC in different kiwifruit from the eight *Actinidia* genotypes ranged from 7.89 to 10.70 g 100^{-1} FW. The highest SSC was observed in ‘AnminR1’, and the lowest was found in ‘AnminG2’. The concentration of SSC of each kiwifruit genotype was in the following order: ‘AnminR1’ > ‘AnminR2’ > ‘red sun’ > ‘Cuiyu’ > ‘Qinmei’ > ‘Hayward’ > ‘AnminG1’ > ‘AnminG2’. There were no significant differences among ‘red sun’, ‘AnminR1’, and ‘AnminR2’ (10.02, 10.70 and 10.29 g 100^{-1} FW, respectively).

The next highest SSC was in the following order: ‘AnminG2’ (1.48 g 100^{-1} FW), and the lowest, in ‘Cuiyu’ (1.22 g 100^{-1} FW). Both genotypes were significantly different from the other genotypes. There were no significant differences between ‘Cuiyu’ and ‘red sun’ (1.25 g 100^{-1} FW) or ‘red sun’ and ‘Hayward’ (1.35 g 100^{-1} FW).

The highest SAR was found in ‘red sun’ (8.05 g 100^{-1} FW), while ‘AnminG2’ ranked the lowest (5.33 g 100^{-1} FW). The SAR in the different kiwifruit was found in the following order: ‘red sun’ > ‘AnminR1’ > ‘Cuiyu’ > ‘AnminR2’ > ‘Hayward’ > ‘Qinmei’ > ‘AnminG1’ > ‘AnminG2’. There were no significant differences among ‘red sun’, ‘AnminR1’, ‘Cuiyu’ and ‘AnminR2’.

Each *Actinidia* genotype showed different levels of SSC, TAC and SAR (Table 1). ‘AnminR1’ and ‘AnminR2’ both have higher SSC, TAC and SAR, indicating that they have better quality and flavour than the other *Actinidia* genotypes.

**Vitamin C and total SOD activity**

*Actinidia* fruits are an abundant source of Vc [30,31]. According to Okamoto and Goto [32], there was 150–200 mg Vc per 100 g FW in the fruit of *A. arguta*, and this content did not change significantly after two months of storage at a temperature near 0 °C. In this study, the eight *Actinidia* genotypes ranked in the following order based on the Vc content: ‘AnminG2’ > ‘AnminG1’ > ‘AnminR2’ > ‘AnminR1’ > ‘Qinmei’ > ‘red sun’ > ‘Cuiyu’ > ‘Hayward’, with values ranging from 93.66 to 833.70 mg vitamin C equivalents (VCE)-100^{-1} FW. The highest concentration of Vc, found in ‘AnminG2’, was approximately 9-fold higher than that found in ‘Hayward’, indicating that the Vc content in hardy *Actinidia*
genotypes is higher than in commercial Actinidia cultivars. Previous studies showed that the wild A. eriantha and A. latifolia species had significantly higher Vc content than A. chinensis and A. deliciosa cultivars [33], which is consistent with this study.

The exact length of time for which the ‘red sun’, ‘Cuiyu’, ‘Hayward’ and ‘Qinmei’ fruit had been in storage and/or displayed before purchasing was unknown. These potential differences might explain the natural variation that was encountered among the samples with respect to SOD content. Kiwifruit is a potential source of many antioxidant compounds that might contribute to total antioxidant capacity; however, it is not clear which components are responsible for the observed antioxidant capacity in this study. The results show that TPC was significantly different among the commercial and hardy Actinidia genotypes, ranging from 78.17 to 461.12 mg gallic acid equivalents (GAE) 100 g FW. The TPC of ‘red sun’, ‘Cuiyu’, ‘Hayward’ and ‘Qinmei’ was not significantly different. The highest TPC was found in ‘AnminG2’. These Actinidia genotypes were ranked based on TPC in the following order: A. kolomikta > A. arguta > A. chinensis > A. deliciosa, indicating that the fruits of hardy Actinidia genotypes have higher TPC than those of commercial Actinidia genotypes. According to Kim et al. [8], TPC is strongly correlated with astrin- genty of taste. The great differences in TPC among studied cultivars of some hardy Actinidia species suggest that it is possible to select cultivars with the highest concentration of these compounds, and as a consequence, more beneficial properties.

Flavonoids are the main phenolic compounds in plants and are usually considered effective antioxidants. In this study, TFC among the eight Actinidia genotypes was significantly different, with the highest value found in ‘AnminG2’ (185.40 mg catechin equivalents (CE) 100 g FW) and the lowest found in ‘Hayward’ (65.63 mg CE-100 g FW); these results were mostly consistent with the TPC results, indicating that TPC and TFC of Actinidia is strongly dependent upon species and cultivar.

**Antioxidant capacity of Actinidia extracts**

The antioxidant capacity was measured in the eight Actinidia genotypes using the ABTS radical-scavenging, DPPH radical-scavenging, ORAC and FRAP assays, as shown in Table 2. Each genotype expressed different levels of antioxidant capacity depending on the species.

The antioxidant capacity among the various kiwifruits was significantly different, ranging from 95.37 mg VCE-100 g FW to 747.59 mg VCE 100 g FW, as determined by the ABTS assay. The antioxidant capacity (mg VCE 100 g FW) for the various kiwifruits ranked in the following order: ‘AnminG2’ (474.59) > ‘AnminG1’ (369.58) > ‘AnminR2’ (260.69) > ‘AnminR1’ (254.36) > ‘red sun’ (135.03) > ‘Cuiyu’ (131.74) > ‘Qinmei’ (121.62) > ‘Hayward’ (95.37). All of the commercial genotypes had significantly (p < 0.05) lower antioxidant capacities than the hardy genotypes, as determined by the ABTS assay.

The antioxidant capacity of the various kiwifruits was in the range of 75.07–327.96 mg VCE 100 g FW, as determined by the DPPH assay. The antioxidant capacities of each hardy genotype were similar, on average, across all the commercial genotypes, and there were no

**Table 2. Antioxidant capacity of different Actinidia extracts using different methods (mg VCE-100 g FW).**

| Cultivar      | ABTS      | DPPH      | ORAC      | FRAP      |
|---------------|-----------|-----------|-----------|-----------|
| Red sun       | 135.03 ± 1.68c | 101.00 ± 0.94c | 1077.95 ± 19.27d | 149.94 ± 1.82d |
| Cuiyu         | 131.74 ± 4.99bc | 90.21 ± 0.31bc | 887.46 ± 3.61b | 128.24 ± 1.22b |
| Hayward       | 95.37 ± 1.73a | 75.07 ± 1.16a | 719.11 ± 7.09a | 117.27 ± 1.15a |
| Qinmei        | 121.62 ± 0.59b | 85.65 ± 1.03ab | 968.35 ± 5.65c | 137.90 ± 0.21c |
| AnminR1       | 254.36 ± 0.64d | 200.49 ± 1.31d | 1708.34 ± 3.91e | 376.15 ± 2.44e |
| AnminR2       | 260.69 ± 2.62d | 229.37 ± 5.00e | 1894.73 ± 9.24f | 399.78 ± 0.4f |
| AnminG1       | 369.58 ± 1.09e | 322.41 ± 2.99f | 2288.56 ± 12.41g | 528.50 ± 2.01g |
| AnminG2       | 474.59 ± 2.32f | 327.96 ± 2.74f | 2612.43 ± 7.14h | 646.63 ± 2.77h |

Mean ± SD (standard deviation) of 3 measurements. Average values in rows marked with different letters differ significantly (p < 0.05).
significant differences between the two *Actinidia* genotypes, with the exception of ‘AnminRI’ and ‘AnminR2’ of *A. arguta*.

The antioxidant capacity of the various kiwifruits ranged from 719.11 to 2612.43 mg VCE g⁻¹ FW, as determined by the ORAC assay. The antioxidant capacities (mg VCE g⁻¹ FW) of the genotypes were significantly different and ranked in the following order: ‘AnminG2’ (2612.43) > ‘AnminG1’ (2288.56) > ‘AnminR2’ (1894.73) > ‘AnminR1’ (1708.34) > ‘red sun’ (1077.95) > ‘Qinmei’ (968.35) > ‘Cuiyu’ (887.46) > ‘Hayward’ (719.11).

There are a few reported studies on the antioxidant capacity of *Actinidia* fruits. The antioxidant potential of commonly consumed fruit has been rated in the order of plum > kiwi > apple > pear [4]. The antioxidant capacity of kiwifruit was strongly affected by species and cultivars; wild or hardy species of *Actinidia* had the greatest antioxidant capacity [8,13,24,33,40]. The antioxidant capacity of the various kiwifruits ranged from 117.27 to 646.63 mg VCE 100 g⁻¹ FW, as determined by the FRAP assay; these results were consistent with the significant differences observed in the ORAC assay.

### Relationship among different biochemical capacities and antioxidant variables

In previous studies, highly significant linear correlations were observed between the antioxidant capacity of *Actinidia* fruit samples and their polyphenol and Vc contents [24]. Phenolic acids and flavonoid compounds have been reported to be the main phytochemicals responsible for the antioxidant capacity of fruit [41]. In this study, the Vc content, TPC and TFC were all strongly correlated with the antioxidant capacity, indicating that the antioxidant capacity of *Actinidia* may be significantly affected by Vc content, TPC and TFC.

Correlation analysis was used to explore the relationship amongst the different biochemical capacities and antioxidant variables measured for all *Actinidia* extracts (Table 3). The results from the ABTS, DPPH, ORAC and FRAP assays were significantly correlated with the Vc content.

Based on the four methods used to quantify the antioxidant capacity, the correlation coefficients between ABTS/DPPH, ABTS/ORAC and ABTS/FRAP were 0.9732, 0.9829 and 0.9898, respectively. The correlations between DPPH/ORAC and DPPH/FRAP were 0.9875 and 0.9863, respectively. The correlation between ORAC/FRAP was 0.9933. These results suggest that the antioxidant capacity of kiwifruits can be reliably measured using any of the four methods because of the similar trends they show.

The results from this study suggest that hardy kiwifruits (*A. kolomikta* and *A. arguta*) grown in the northeast of China may be a valuable source of antioxidant compounds. Further studies should be conducted to quantitatively evaluate individual and variable biochemical compounds during different development and storage periods in order to select kiwifruits that are rich in bioactive compounds for industrial application and optimal benefit to consumers.

### Conclusions

In summary, analysis of the data obtained from this study demonstrated that the biochemical components and antioxidant capacity were dependent on different *Actinidia* genotypes. The hardy *A. kolomikta* and *A. arguta* genotypes have significantly higher antioxidant capacity than the commercial cultivars of *A. chinensis* and *A. delicosa* which allows us to recommend them for marketing and consumption.

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### Disclosure statement

No potential conflict of interest was reported by the authors.

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Table 3. Linear correlation coefficients between biochemical capacities and antioxidant capacity, and linear correlation coefficients amongst the four methods for quantifying antioxidant capacity.

|         | ABTS      | DPPH      | ORAC      | FRAP      |
|---------|-----------|-----------|-----------|-----------|
| Vc      | 0.9736**  | 0.9905**  | 0.9873**  | 0.9885**  |
| SOD activity | 0.5765    | 0.5802*   | 0.6012    | 0.6085    |
| TPC     | 0.9610**  | 0.9883**  | 0.9827**  | 0.9873**  |
| TFC     | 0.8837**  | 0.9341**  | 0.9370**  | 0.9362**  |
| ABTS    | 1         |           |           |           |
| DPPH    | 0.9732**  |           |           |           |
| ORAC    | 0.9829**  | 0.9875**  |           |           |
| FRAP    | 0.9898**  | 0.9863**  | 0.9933**  |           |

*Correlation is significant at the p < 0.01 level.
**Correlation is significant at the p < 0.05 level.
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