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Bioactive Compound Profiling in Loquat (*Eriobotrya japonica* Lindl.): Associations with Flesh Color, Ploidy Level and Antioxidant Capacity

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Abstract

Loquat (*Eriobotrya japonica* Lindl.) is a widely popular fruit with significant medicinal value due to its rich content of bioactive compounds. However, a systematic analysis of differences in bioactive compounds among loquats with distinct flesh colors and ploidy levels remains lacking. Here, a comprehensive analysis of bioactive compound accumulation patterns was conducted across 12 loquat varieties with varying ploidy levels and flesh colors using UPLC-MS/MS. A total of 44 bioactive compounds were detected and genistin content in orange-flesh loquats was significantly higher than that in white-flesh loquats ($p < 0.05$). Tricin content in triploid loquats was significantly higher than in diploid loquats ($p < 0.05$), whereas naringin content was significantly lower than in diploid loquats ($p< 0.05$). Additionally, antioxidant capacity testing revealed that the $\bullet O_2^-$ scavenging activity was significantly correlated with hyperin ($p< 0.01$) and the total antioxidant capacity exhibited a significant correlation with umbelliferone ($p< 0.01$) in loquat fruits. Our work not only reveals for the first time the accumulation pattern of the bioactive compounds and antioxidant capacity in loquat fruits of different colors and ploidy levels, but also offers a theoretical foundation and breeding materials for cultivating functional loquats rich in bioactive compounds.

Keywords: Loquat; Flesh color; Ploidy level; Bioactive compounds; Antioxidant capacity.
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1. Introduction

Loquat (*Eriobotrya japonica* Lindl.), an evergreen subtropical fruit tree belonging to the Rosaceae family, is native to South-West China.[1] As a popular fruit, loquat is not only consumed fresh but also utilized in the food industry to process juices, jams, wines, and syrups, as well as traditional Chinese medicine.[2-4] As early as 1590 CE, loquat was recorded to use for treatment of coughing in the Chinese Encyclopedia of Botany and Medicines. The medicinal value of loquat is attributed to its rich content of bioactive compounds. The main bioactive compounds in loquat fruit are composed of triterpenoids, phenolics, flavonoids and so on.[5] Among them, triterpenoids, including ursolic acid, oleanolic acid and corosolic acid, have been reported as key bioactive compounds in loquats [3,6] with various biological activities, such as anti-inflammatory, anticancer, and antidiabetic activities.[7-9] Besides, phenolics and flavonoids exhibit antioxidant and antimicrobial, antidiabetic activities.[10,11] Therefore, loquat fruits have attracted widely attention for their high content of bioactive substances.

Loquat varieties are divided into two groups based on the degrees of their flesh color, white- and orange-flesh loquats.[12] Compared with orange-flesh loquats, the white-flesh loquats are usually preferred by consumers for their superior flavor. In fruits, flavonoids and carotenoids are the two primary pigments accumulated in the flesh that influence fruit appearance.[13] In loquats, it has been confirmed that a higher content of carotenoids (especially β -carotene and β-cryptoxanthin) leads to a darker flesh color,[14] while no positive correlation exists between total flavonoid content and flesh color.[15] Previous studies indicate that a 333-bp deletion on the 3′ terminal of *EjPSY2A* causes truncation and inactivation of the carotenoid synthase protein, thereby

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blocking carotenoid accumulation and ultimately resulting in white-flesh loquat fruit.[12,16] In addition, compared with the orange-flesh loquats, white-flesh loquats accumulate fewer compounds responsible for sourness, bitterness, and astringency, resulting in a fresher taste.[12]

Traditionally, common loquat varieties are diploid with small fruits and numerous seeds. In the quest for loquat varieties with large fruit and high edible rate, breeders have created triploid loquats, including white- and orange-flesh varieties.[17] Since the limited material resources, previous studies focused solely on metabolic differences between diploid orange-flesh and white-flesh loquats[12,18] or between triploid orange-flesh and white-flesh loquats.[17] However, there is still a lack of systematic analysis of differences in bioactive compound contents between orange-flesh and white-flesh loquats, between diploid and triploid loquats, as well as among their cross-combinations.

In this study, ultra-performance liquid chromatography-tandem mass spectrometry (UPLC-MS/MS) was used to detect the contents of bioactive compounds such as flavonoids, phenolics, triterpenoids, and coumarins in 12 loquat varieties composed of three diploid orange-flesh, three triploid orange-flesh, three diploid white-flesh, and three triploid white-flesh loquats. Besides, the antioxidant capacities of the pulp from 12 loquat varieties were tested. Our study systematically analyzed for the first time the differences in bioactive compounds and antioxidant activities among loquats with varied flesh colors and ploidy levels, providing a theoretical foundation and breeding materials for cultivating functional loquats rich in bioactive compounds.

2. Materials and methods

2.1 Plant materials

Twelve loquat varieties planted in the loquat germplasm nursery of Southwest University (Chongqing, China) were used as the test materials. These test varieties were composed of three diploid orange-flesh varieties [Dawuxing (DWX), Longquan 1 (LQ1), Zaozhong 6 (ZZ6)], three triploid orange-flesh varieties [A322, B356, Wuhe Fuzao (WHFZ)], three diploid white-flesh varieties [Changbai 1 (CB1), Huabai 1 (HB1), Ruantiao Baisha (RTBS)], and three triploid white-flesh varieties [Wuhe Zaoyu (WHZY), Huayu Wuhe 1 (HYWH1), Wuhe Guoyu (WHGY)]. (Fig. S1A) All the test varieties were planted in the fruit germplasm resources orchard of the Key Fruit Lab, of the College of Horticulture and Landscape Architecture, Southwest University. In accordance with standard horticultural management practices,[19] all plants were cultivated and fertilized using identical methods. Based on observations of the development and ripening process of loquat fruits, and with reference to other reports,[20] ZZ6, RTBS, WHFZ and WHZY were harvested on 5 May 2025. DWX, LQ1, WHGY and A322 were harvested on 15 May 2025. Additionally, CB1, HB1, HYWH1 and B356 were harvested on 23 May 2025. The harvested fruits were immediately frozen in liquid nitrogen, and stored at −80 °C for subsequent analysis, with three replicates.

2.2 Ploidy identification

The ploidy levels of the test varieties were identified using flow cytometer (CyFlowCube6, Partec, Germany). Fresh leaves of the test varieties were rinsed with clean water, cut into 1 cm² discs, placed in a culture dish and dropped with 2 mL of nuclei isolation buffer (Partec). Subsequently, the leaf discs were quickly chopped vertically with a blade, and the cell suspension was filtered through a 400-mesh cell filter into a 2 mL test tube. The nuclear filtrate was added 50 μL of 6 μg/mL DAPI (4′-6-diamidino-2-phenylindole) staining solution and stained in the dark for 5 minutes. The fluorescence intensities of the samples were detected using the program template with the fluorescence intensity intervals of diploid and triploid loquats already set. The ploidy of the tested variety is determined as $FT / FR \times P$, where FT is fluorescence intensity peak of the tested sample, FR is fluorescence intensity peak of the reference, and P is ploidy of the reference. DWX was used as the reference.

2.3 Measurement of flavonoids

The fruit fresh-frozen samples were ground into powder in the presence of liquid nitrogen. Next, 1 g of the fresh-frozen sample powder was dissolved in 4 mL methanol solution containing 1% HCl, vortexed and shaken for 1 min, and extracted by ultrasonicate in an ice-water bath for 30 min. After centrifuging at 11,000 × g for 30 min, the supernatant of the extract was fixed to 10 ml. 1 mL of the extract was taken to pass through an organic phase filtration membrane (0.22 μm pore size) and stored in a sample bottle at -20 °C for subsequent analysis.

The sample extracts were analyzed using a 1260 Infinity II HPLC system (Agilent, USA) coupled with tandem 6420A MS system (Agilent, USA). HPLC column was 3.5 μm, 2.1 × 150 mm (Agilent ZORBAX Eclipse Plus C18). The mobile phase was composed of solvent A, water (0.3% formic acid), and solvent B, acetonitrile (0.3% formic acid). The detection adopted a gradient program using conditions of 80% A and 20% B for 1 min, 10% A and 90 % B for 4.1 min, 80 % A and 20 % B for 4.9 min. The column temperature was set at 35 °C, the injection volume was 3 μL, and the flow rate was 0.3 mL/min. To identify the metabolites, the mass spectrometer was operated in electrospray ionization (ESI) negative ion mode with following conditions: curtain gas, 15 psi; capillary voltage, -4 kV; desolvation temperature, 400 °C; collision gas pressure, 65 psi; auxiliary air pressure, 70 psi. Samples were analyzed in the multiple reaction monitoring (MRM) mode. The standard reagents used were list in Table S1. Six different concentrations (0.5–200 ng/mL) of the standard reagents were prepared using methanol solution containing 1% HCl. Standard curves were established based on the concentrations of the standard reagents and their corresponding mass spectrometry signals. The contents of flavonoids were

calculated according to the standard curve and the mass spectrometry signals of the samples.

2.4 Detection of phenolics, triterpenoids, and coumarins

Similar to the measurement of flavonoids, 1 g of the fruit fresh-frozen powder was dissolved in 2 mL 80% aqueous methanol containing 1% ascorbic acid vortexed and shaken for 10 s, and extracted by sonication for 30 min at room temperature. After centrifuging at 11,000 × g for 30 min, the supernatant of the extract was fixed to 5 ml with the 80% aqueous methanol. 1 mL of the extract was taken to pass through an aqueous filtration membrane (0.22 μm pore size) and stored in a sample bottle for subsequent analysis.

The sample extracts were analyzed using a 1260 Infinity II HPLC (high performance liquid chromatography) system (Agilent, USA) coupled with tandem Xevo TQS mass spectrometer (MS, Waters, USA) system. HPLC column was 2.7 μm, 2.1 × 150 mm (Agilent poroshell 120 EC-C18). The mobile phase was composed of solvent A, water (0.1% formic acid), and solvent B, acetonitrile. The detection adopted a gradient program using initial conditions of 90% A and 10% B for 1.5 min, 80% A and 20 % B for 2.5 min, 10 % A and 90 % B for 4 min, 5% A and 95% B for 2.1 min, 90% A and 10% B for 1.9 min. The column temperature was set at 30 °C, the injection volume was 1 μL, and the flow rate was 0.3 mL/min. The mass spectrometer conditions and the quantitative methods referred to the method for measurement of flavonoids. The standard reagents used were list in Table S1.

2.5 Detection of antioxidant capacity

Referred to the method reported by Lin *et al.* [21] with some modifications, the superoxide anion radical ($\bullet O_2^-$), hydroxyl radical (•OH), and 1,1-Diphenyl-2-picrylhydrazyl (DPPH) scavenging activities were determined. 1 g of pulp was sampled to measure these scavenging activities using $\bullet O_2^-$ scavenging capacity assay kit (BC1410, Solarbio, Beijing, China), •OH scavenging activity capacity assay kit (KTB1091, Abbkine, Wuhan, China), and DPPH free radical scavenging capacity assay kit (BC4750, Solarbio, Beijing, China), respectively. These scavenging activities were expressed as percentage (%). Subsequently, the total antioxidant capacity was determined using ferric-reducing antioxidant power assay (FRAP),[22] using the total antioxidant capacity assay kit with FRAP method (T01005, Leagene, Beijing, China). The results are showed as mmol Fe (II)/100 g of fresh weight (FW) of sample.

2.6 Statistical analysis

Significance analysis of differences was carried out using the SPSS (v22) software. Principal component analysis (PCA) and Mantel test were performed using SIMCA (v14.1) and R (v4.3.1), respectively. Data analysis and graphical representation were conducted using GraphPad Prism (v8.0.1).

3. Results

3.1 Characteristics of the test 12 loquat varieties and the accumulation of bioactive compound

To investigate the accumulation patterns of bioactive orange-flesh, and CB1, HB1, RTBS, WHZY, HYWH1, and WHGY are white-flesh. According to the formula for calculating ploidy and the fluorescence intensity detected, DWX, LQ1, ZZ6, CB1, HB1, and RTBS were diploid, with the fluorescence intensity peak of 12,288; while A322, B356, WHFZ, WHZY, HYWH1, and WHGY were triploid, exhibiting a fluorescence intensity peak of 18,432—1.5 times the peak value of the diploid varieties (Fig. S1B). Therefore, the 12 loquat varieties were divided into four groups, namely diploid orange flesh (orange-flesh 2×), triploid orange flesh (orange-flesh 3×), diploid white flesh (white-flesh 2×), and triploid white flesh (white-flesh 3×). The contents of bioactive compounds in loquat flesh were detected using UPLC-MS/MS (Fig. S1C). A total of 44 bioactive compounds were detected, classified into flavonoids (52%), phenolic acids and their derivatives (34%), triterpenes (7%), and coumarins (7%) (Fig. S1D). PCA of the 12 loquat varieties based on the content of bioactive compounds indicated that principal component 1 explained 29.99% of the variance, and principal component 2 explained 17.04% (Fig. S1E). The PCA result revealed that there was no obvious distinction among the four groups.

3.2 Accumulation pattern of flavonoids

A total of 23 flavonoids were detected in the 12 loquat varieties. Based on the contents of these flavonoids, PCA revealed the first component accounted for 44.9% of the variance and the second accounted for 18.3% of the variance (Fig. 1A and B). The PCA score scatter plot showed that except for A322 and B356, 10 loquat varieties were distributed in the second and third quadrants (Fig. 1A). Correspondingly, most flavonoids were scattered in the first and fourth quadrants (Fig. 1B). The content heatmap of flavonoids indicated that multiple flavonoids had the highest contents in A322 (Fig. 1C). The percentage of flavonoid components in the 12 loquat varieties revealed that epicatechin had the highest proportion with an average of 89.44% (Fig. 1D). Comparing epicatechin content across 12 varieties signified that HB1 had the highest epicatechin content (7.87 μg/g, $p < 0.05$), followed by A322 (6.74 μg/g), RTBS (6.56 μg/g), DWX (4.57 μg/g), HYWH1 (4.98 μg/g) and CB1 (4.03 μg/g). Additionally, among the four variety groups, white-flesh 2× group had the highest epicatechin content (Fig. 1E).

3.3 Accumulation pattern of phenolic acids and their derivatives

A total of 15 phenolic acids and their derivatives were detected in the 12 loquat varieties. Based on the contents of these phenolic acids and their derivatives, PCA indicated the first component accounted for 29.4% of the variance and the second accounted for 17.8% of the variance (Fig. 2A and B). The PCA score scatter plot failed to clearly separate different

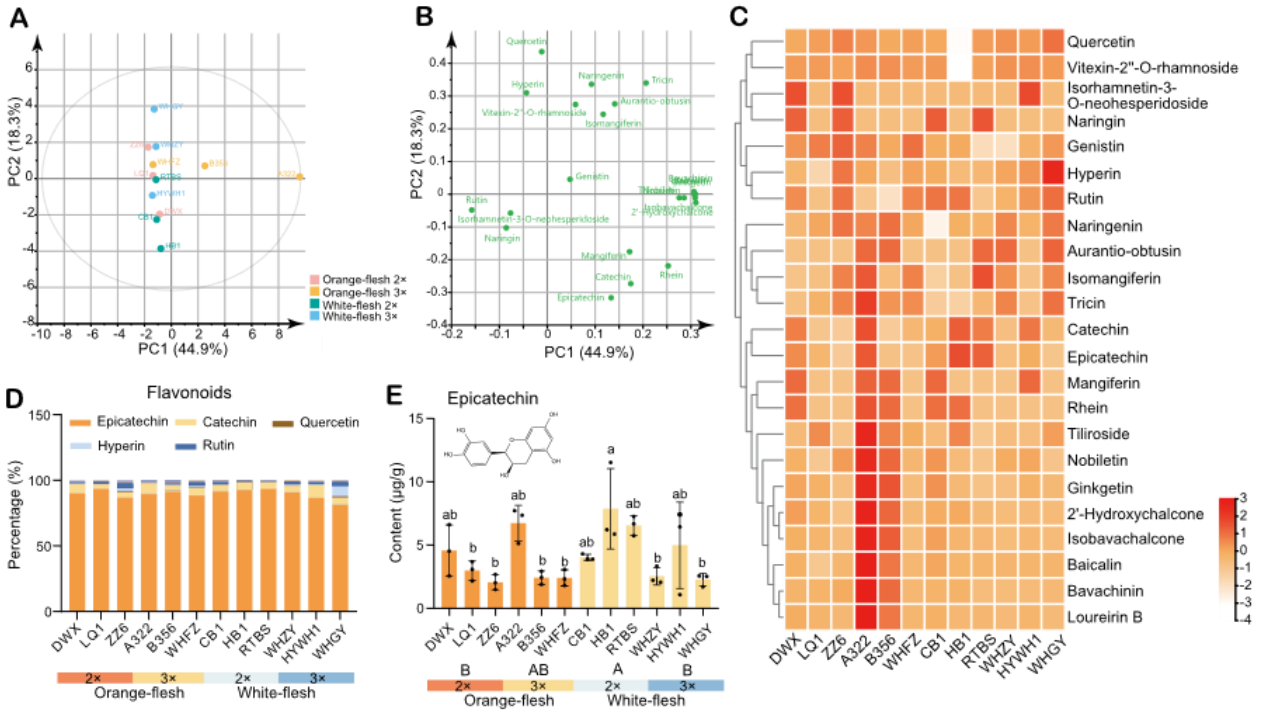


Fig. 1: Accumulation pattern of flavonoids in the 12 loquat varieties. PCA score scatter (A) and loading scatter (B) plots of flavonoids (R2 = 0.632, Q2 = 0.0485). (C) Heatmap showing the contents of flavonoids. Percentage of flavonoid components (D) and the content of epicatechin (E) in the 12 loquat varieties. The error bar represents the standard deviation (SD). Different lowercase and uppercase letters indicate significant differences among the 12 loquat varieties and among the 4 combinations, respectively (ANOVA and Tukey HSD, $p < 0.05$).

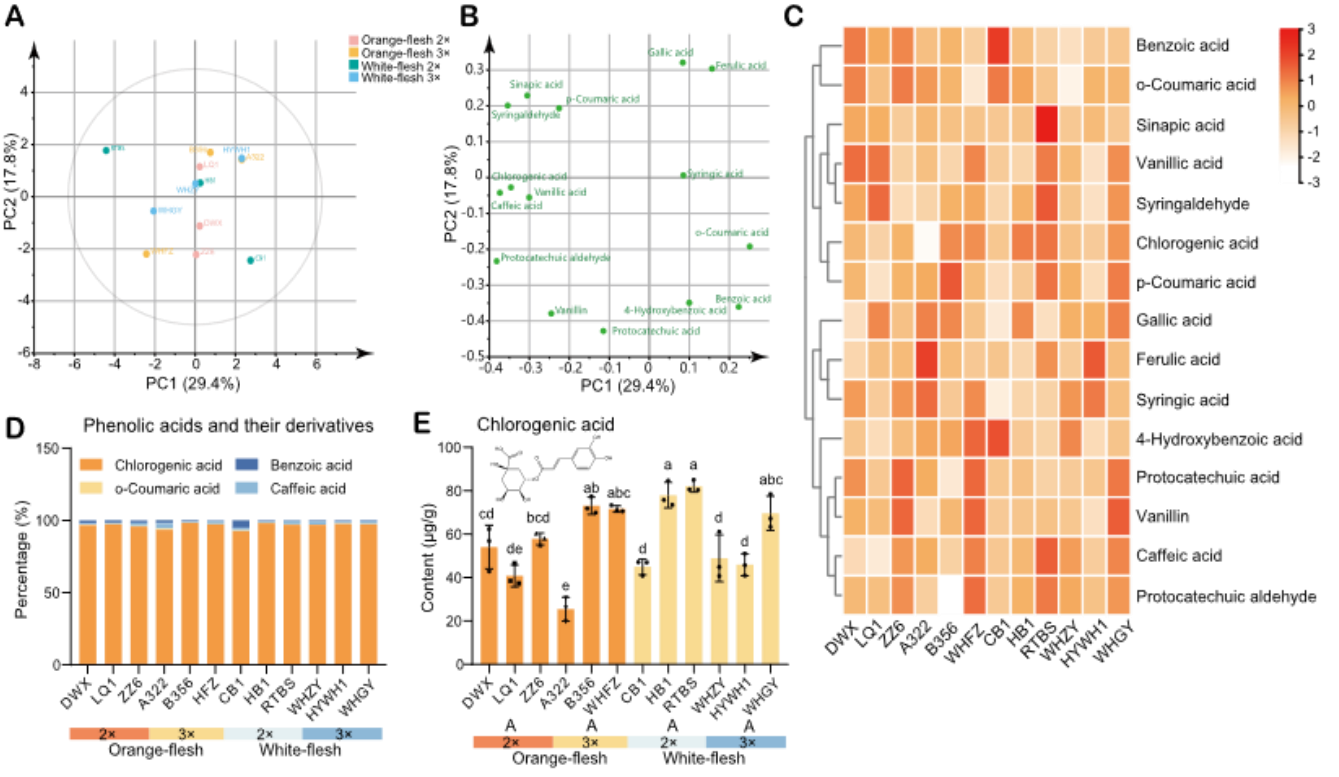


Fig. 2: Accumulation pattern of phenolic acids and their derivatives in the 12 loquat varieties. PCA score scatter (A) and loading scatter (B) plots of phenolic acids and their derivatives (R2 = 0.472, Q2 = -0.21). (C) Heatmap showing the contents of phenolic acids and their derivatives. Percentage of phenolic acids and their derivatives (D) and the content of chlorogenic acids (E) in the 12 loquat varieties. The error bar represents SD. Different lowercase and uppercase letters indicate significant differences among the 12 loquat varieties and among the 4 combinations, respectively (ANOVA and Tukey HSD, $p < 0.05$).

types of loquat varieties (Fig. 2A). Six of the 15 phenolic acids and their derivatives were distributed in the third quadrant (Fig. 2B). The content heatmap of phenolic acids and their derivatives revealed that several phenolic acids and their derivatives had the highest content in RTBS (Fig. 2C). The percentage of phenolic acids and their derivatives among the 12 loquat varieties indicated that chlorogenic acid had the highest proportion with an average of 95.79% (Fig. 2D), consistent with previous study.[23] Comparing the chlorogenic acid content across the 12 varieties revealed that the chlorogenic acid content in RTBS (82.00 μg/g) and HB1 (77.98 μg/g) was highest ($p < 0.05$). No differences were observed among the four variety groups (Fig. 2E).

3.4 Accumulation pattern of triterpenes and coumarins

Three triterpenoids and three coumarins were further detected, which accumulated specifically in different loquat varieties (Fig. 3A). Column stacked plot of triterpenoids revealed that the total content of the three triterpenoids in HYWH1 was the highest and the average proportion of corosolic acid across the 12 loquats was the highest (55.34%) (Fig. 3B). Column stacked plot of coumarins indicated that the total content of the three coumarins in ZZ6 was the highest and umbelliferone had the highest proportion in most loquats apart from DWX, B356, and HYWH1 (Fig. 3C). Since triterpenoids are the main active compounds in loquats,[3] the content of corosolic acid, ursolic acid, and oleanolic acid in the 12 loquat varieties were compared. The results signified that, among the 12 loquat varieties, WHGY had the highest corosolic acid content (5.79 μg/g), HYWH1 had the highest ursolic acid content (4.64 μg/g), and HB1, WHFZ, and CB1, had the highest oleanolic acid contents which were 0.71 μg/g, 0.68 μg/g, and 0.66 μg/g, respectively (Fig. 3D). Besides, among triterpenes, only corosolic acid showed significant differences across the four variety groups ($p < 0.05$), with the highest content observed in the white-flesh 3× group (Fig. 3D).

3.5 Representative differential substances between loquats with different colors and ploidy

To screen representative differential substance between loquats with different colors, the contents of bioactive compounds between orange-flesh and white-flesh loquats were compared. The result revealed that the content of genistin was significantly higher in orange-flesh loquats than in white-flesh loquats ($p < 0.05$), with the highest content observed in the ZZ6 (21.32 ng/g) (Fig. 4). Besides, there were no differences between orange-flesh 2× and orange-flesh 3× groups, as well as between white-flesh 2× and white-flesh 3× groups. Comparing the contents of bioactive compounds between diploid and triploid loquats indicated that the content of tricin was significantly higher in triploid loquats than in diploid loquats ($p < 0.05$), with the highest content observed in the A322 (5.51 ng/g). Conversely, the naringin content in triploid loquats was significantly lower than that in

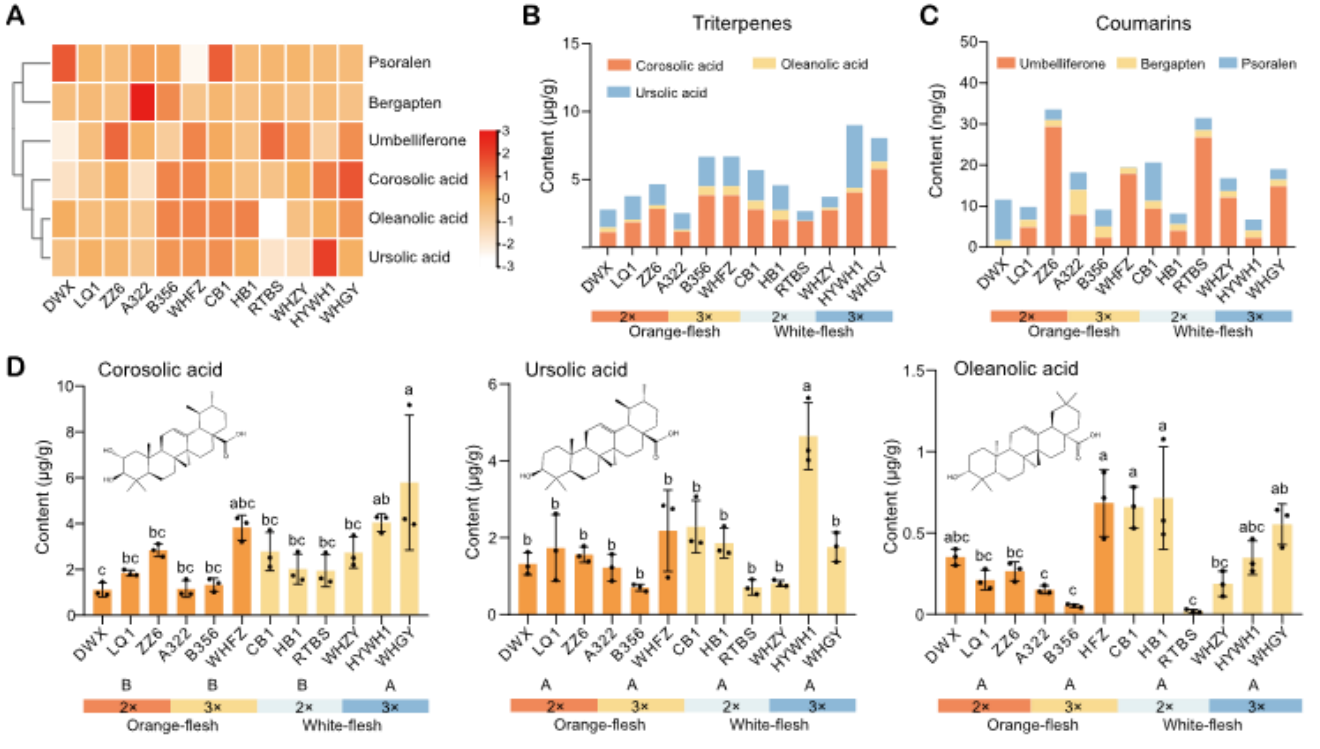


Fig. 3: Accumulation pattern of triterpenes and coumarins in the 12 loquat varieties. (A) Heatmap showing the contents of triterpenes and coumarins. (B-C) Column stacked plot of the content of triterpenes (B) and coumarins (C). Numbers and colors represent compounds. (D) The content of corosolic acid, ursolic acid, and oleanolic acid in the 12 loquat varieties. The error bar represents SD. Different lowercase and uppercase letters indicate significant differences among the 12 loquat varieties and among the 4 combinations, respectively (ANOVA and Tukey HSD, $p < 0.05$).

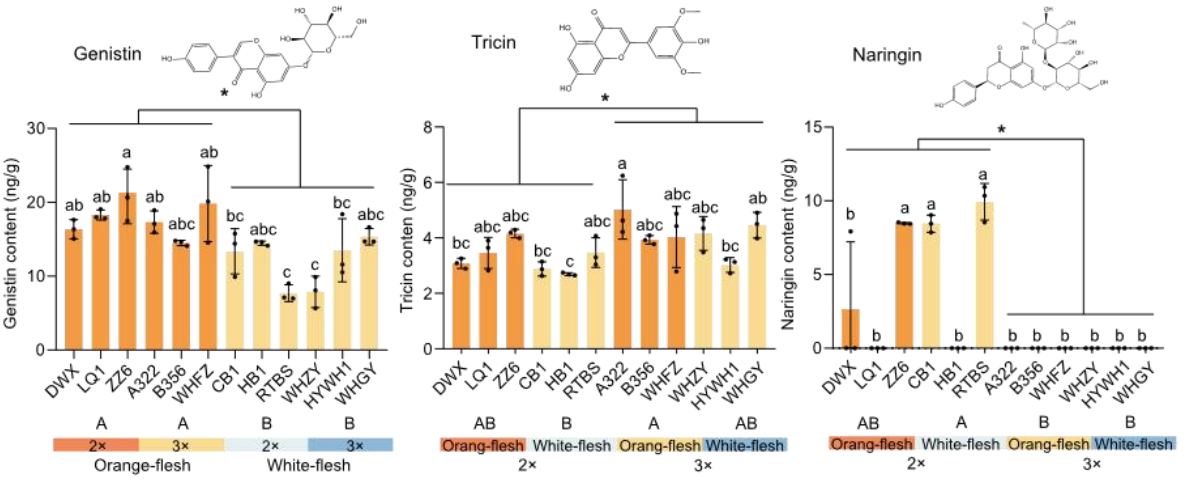


Fig. 4: The content of genistin, tricin, and naringin in the 12 loquat varieties. The error bar represents SD. An asterisk (*) indicates a significant difference (*t*-tests, $p < 0.05$). Different lowercase and uppercase letters indicate significant differences among the 12 loquat varieties and among the 4 combinations, respectively (ANOVA and Tukey HSD, $p < 0.05$).

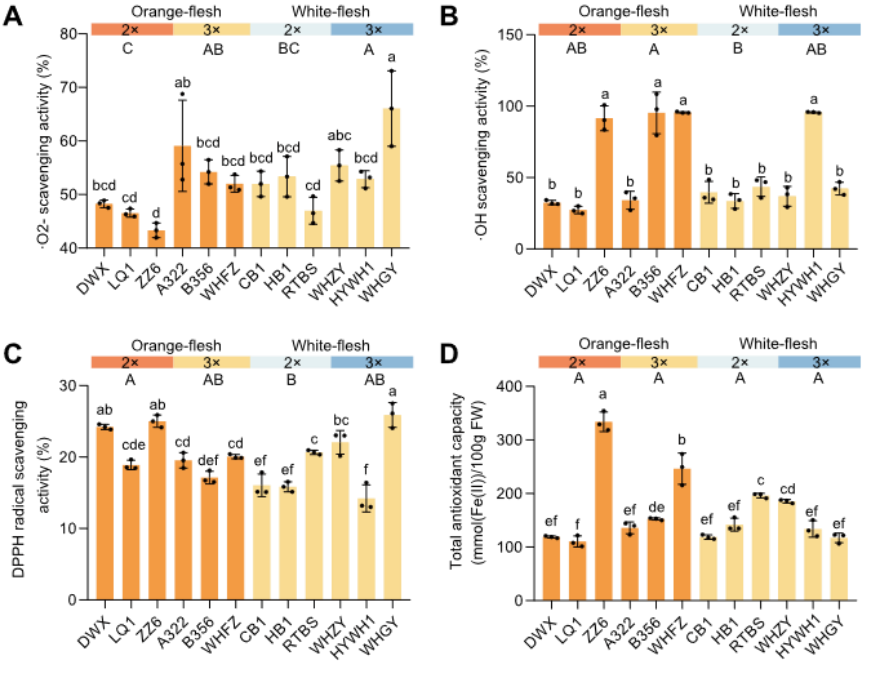


Fig. 5: The antioxidant capacity of pulp from the 12 loquat varieties. (A) Superoxide anion radical ($\bullet O_2^-$), (B) hydroxyl radical (•OH), (C) 1,1-Diphenyl-2-picrylhydrazyl (DPPH) scavenging activities and (D) total antioxidant capacity of fruit pulp from the 12 loquat varieties. The error bar represents SD. Different lowercase and uppercase letters indicate significant differences among the 12 loquat varieties and among the 4 combinations, respectively (ANOVA and Tukey HSD, $p < 0.05$).

diploid loquats ($p < 0.05$), with the highest content observed in the RTBS (10.33 ng/g), followed by CB1 (8.68 ng/g) and ZZ6 (8.48 ng/g) (Fig. 4).

Apart from epicatechin, corosolic acid, genistin, tricin and naringin, 14 differentially accumulated bioactive compounds were identified in four groups of loquat fruits with different colors and ploidy (Fig. S2). Among the 14 differentially accumulated bioactive compounds, 12 bioactive compounds had the highest contents in orange-flesh 3× group, suggesting that triploid orange-flesh loquats accumulated more bioactive compounds.

3.6 The antioxidant capacity of fruit pulp from the 12 loquat varieties

The $\bullet O_2^-$ scavenging activity of pulp from the 12 loquat varieties revealed that the $\bullet O_2^-$ scavenging activity was highest in white-flesh 3× group ($p < 0.05$), and WHGY had the strongest scavenging activity (66.06%), followed by A322 (59.09%) (Fig. 5A). For the •OH scavenging activity, it was highest in orange-flesh 3× group. The •OH scavenging activities of HYWH1 (95.61%), WHFZ (95.60%), B356 (95.27%), and ZZ6 (91.52%) were significantly higher than those of other loquat species ($p < 0.05$) (Fig. 5B). The DPPH

scavenging activity was highest in WHGY (25.90%), followed by ZZ6 (25.02%) and DWX (24.22%) ($p < 0.05$). Among the four variety groups, the orange-flesh 2× group exhibited the highest DPPH scavenging activity (Fig. 5C). Additionally, among the 12 loquat varieties, ZZ6 had the highest total antioxidant capacity (TAC) (333.86 mmol Fe (II)/100 g), followed by WHFZ (246.32 mmol Fe (II)/100 g) ($p < 0.05$) (Fig. 5D). However, there were no differences in TAC among the four variety groups. These findings suggested that different loquat varieties exhibited varying scavenging activities toward different types of reactive oxygen species.

3.7 Correlation analysis of bioactive compounds and antioxidant capacity

The correlation heatmap of bioactive compounds in loquats was shown in Fig. S3 based on the Pearson's coefficient (r). The results revealed that the strongest correlations existed among flavonoids, particularly among 2'-hydroxychalcone, bavachinin, isobavachalcone, nobiletin, rhein, baicalin, loureirin B, tiliroside, and ginkgetin ($r > 0.8$). Interestingly, bergapten of coumarins exhibited strong correlations with above-mentioned flavonoids ($r > 0.8$) (Fig. S3). Besides, the relationships between bioactive compounds and antioxidant capacity of loquats were studied by the Mantel test (Fig. S3). The $\bullet O_2^-$ scavenging activity was found to be strongly correlated with hyperin ($p < 0.01$). The DPPH scavenging activity was correlated with quercetin, vanillin, and ursolic acid ($p < 0.05$). Additionally, TAC showed a significant correlation with umbelliferone ($p < 0.01$), followed by genistin, protocatechuic acid, and protocatechuic aldehyde ($p < 0.05$). However, no correlation was found between the •OH scavenging activity and the detected bioactive compounds.

4. Discussion

4.1 Differences in bioactive compound content among loquats with different flesh colors

Previous studies have confirmed that the dominant pigments responsible for the diverse flesh colors in loquat fruits are carotenoids rather than flavonoids.[12,14,15] However, it remains uncertain whether there are differences in the content of bioactive compounds between orange- and white-flesh loquat fruits. Through metabolomics analysis, Su *et al*.[12] identified 18 metabolites serving as biomarkers for distinguishing orange-flesh loquats from white-flesh loquats. In this study, the accumulation pattern of bioactive compounds in loquat pulp exhibited variety specificity. Among the 44 detected compounds, only genistin content was found significantly higher in orange-flesh than white-flesh loquats ($p < 0.05$) (Fig. 4). Genistin, an isoflavones, has shown potential benefits for both the cardiovascular and reproductive systems.[24-26] It has also been reported to significantly alleviate the symptoms of metabolic dysfunction-associated fatty liver disease induced by a high-fat diet in rats.[27] Additionally, genistin also plays a crucial role in the responses of plants to various adverse conditions, such as low temperature,[28] drought,[29] and disease,[30] by enhancing antioxidant capacity. Since flavonoids are considered to impart a bitter taste,[12,31] whether genistin affects the flavor of orange-flesh loquats still requires further investigate.

4.2 Differences in bioactive compound content among loquats with different ploidy levels

Increased ploidy levels could significantly enhance the content of secondary metabolites.[32-35] Compared to the diploid plants, tetraploid plants of *Dracocephalum kotschyi* Boiss exhibited over accumulation of methoxylated hydroxyflavones in their leaves.[36] In *Lonicera japonica*, the contents of phenolic acids and flavonoids from tetraploid plants were significantly higher than those in the diploid plants.[37] However, in this study, among the 44 detected compounds, tricin content in triploid loquat fruits was significantly higher than in diploid loquat fruits ($p < 0.05$), whereas naringin content was significantly lower than in diploid loquat fruits ($p < 0.05$) (Fig. 4). Our findings support that polyploidization cannot be universally employed as a strategy to enhance metabolite yield.[38] Both tricin and naringin have been considered as promising nutraceutical for human.[39,40] Tricin has been reported to exhibit antiviral,[41] antioxidant,[42] anti-inflammatory,[43] anticancer,[44,45] and anti-aging activities.[46] Similarly, naringin also have anti-inflammatory,[47] hepatoprotective,[48] anticancer,[49] and antidiabetic[50] properties. However, like two sides of a coin, tricin and naringin may respectively affect the flavor of triploid and diploid loquats.

4.3 The correlation between bioactive compounds and antioxidant capacity of loquat

Antioxidant activity primarily depends on the content of antioxidant components, such as flavonoids and phenolic compounds in loquat leaves, flowers, and fruits.[51-54] The primary antioxidants in loquat flower extract were hesperidin and gallic acid.[55] In this study, the $\bullet O_2^-$ scavenging activity was found to be strongly correlated with hyperin ($p < 0.01$) and TAC was strongly correlated with umbelliferone ($p < 0.01$) (Fig. S3). Hyperin and umbelliferone are well-known for their antioxidant properties.[56,57] Hyperin has been reported to have potent antioxidant activity on DPPH free radicals.[58] Among the 27 compounds extracted from black chokeberry (*Aronia melanocarpa*) fruits, hypericin exhibited the strongest antioxidant activity.[59] In diabetic rats, umbelliferone played a role in protecting from the risk of diabetic complications by decreasing lipid peroxidation markers and enhancing antioxidants' status.[60] The antioxidant potential of umbelliferone was further evaluated using the DPPH assay, confirming its DPPH scavenging activity.[61] Additionally, Triterpenes, particularly ursolic acid, are key bioactive compounds in loquats.[3,6] Our work revealed that DPPH scavenging activity was correlated with ursolic acid ($p < 0.05$) (Fig. S3), supporting the antioxidant activity of ursolic acid.[62] However, no correlation was found in this study between the •OH scavenging activity and the detected bioactive

compounds, which may be attributed to the absence of relevant bioactive compounds in our detection.

5. Conclusion

This study systematically analyzed the differences in the content of bioactive compounds between orange-flesh and white-flesh loquats, as well as between diploid and triploid loquats, and explored the relationship between bioactive compounds and antioxidant capacity in loquats. The results revealed that genistin content in orange-flesh loquats was significantly higher than that in white-flesh loquats ($p < 0.05$). Tricin content in triploid loquats was significantly higher than in diploid loquats ($p < 0.05$), whereas naringin content was significantly lower than in diploid loquats ($p < 0.05$). The $\bullet O_2^-$ scavenging activity of loquat fruits showed a significant correlation with hyperin ($p < 0.01$) and TAC exhibited a significant correlation with umbelliferone ($p < 0.01$). Our work provides an insight into the bioactive compounds and antioxidant capacity of loquat fruit, and also offers a theoretical foundation and breeding materials for cultivating functional loquats rich in bioactive compounds.

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Conflict of Interest

There is no conflict of interest.

Supporting Information

Applicable.

CRediT Statement

Junxiu Wang: Data curation, Methodology, Writing – Original draft. **Yudie Duan:** Methodology, Writing – Original draft. **Jinting Pan**, **Yuting Li, Zhuli Wang** and **Weiping Nie:** Methodology. **Haiyan Sun** and **Suqiong Xiang:** Methodology, Writing – Review & editing. **Jiangbo Dang** and **Qigao Guo:** Supervision, Funding acquisition, Writing – Review & editing.

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