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Ministry of Agriculture Key Laboratory of Tropical Fruit Biology, South Subtropical Crops Research Institute, Chinese Academy of Tropical Agricultural Sciences, Zhanjiang, Guangdong, China

Evaluation of 28 mango genotypes for physicochemical characters, antioxidant capacity, and mineral content

S. Shi, X. Ma*, W. Xu, Y. Zhou, H. Wu, S. Wang

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Summary

Mango germplasm remains underutilized due to the limited knowledge of its quality properties. The objective of this study was to analyze and compare the physicochemical characters, antioxidant capacity, and mineral content of 28 mango genotypes, in order to assess useful information for the utilization of mango genetic resources in China. All the genotypes were grown under the same geographical conditions and with the same standard cultural practices. The results showed that there were significant differences among the genotypes in all studied traits. Potassium, calcium, manganese, and iron were the dominant mineral components; sucrose and/or fructose were the dominant sugars; and malic and citric acid were the dominant organic acids. Variation in sugars (glucose, 15.37-218.20 $mg \cdot g^{-1}$ fresh weight [FW]; fructose, 39.42-327.67 $mg \cdot g^{-1}$ FW; and sucrose 26.32-472.69 $mg \cdot g^{-1}$ FW), total phenolic compounds (13.69-82.65 mg gallic acid·100 g^{-1} FW), and total carotenoids (10.91-71.21 $\mu g \cdot g^{-1}$ FW) was significant among the genotypes. The total antioxidant potency composite index varied among the genotypes (6.12-81.39) and was significantly correlated with total phenolic compounds, but not with total carotenoids. Overall, the results demonstrated that the physicochemical characteristics, antioxidant capacity, and mineral content in mango are genotype-dependent.

Introduction

Mango [*Mangifera indica* L. (Anacardiaceae)] is a widely grown horticulture crop in many tropical and subtropical countries and is the fifth largest fruit industry in the world after citrus, banana, grape, and apple. It is popularly known as "the king of tropical fruits" for its succulence, different flavors and aromas, delicious taste, high carotenoid content, and high pro-vitamin A value (THARANATHAN et al., 2006).

China is the second-largest mango producer after India, in terms of production, marketing, and consumption. The total acreage planted to mango is approximately 129,000 ha, distributed in Hainan, Guangxi, Yunnan, Sichuan, and Guangdong provinces, and the total annual production is approximately 906,000 t (WU et al., 2014). In China, the dry-hot valley of the Jinsha River is the most suitable area for mango cultivation, especially for late production that commands high prices. Approximately 40 % of the mango production in China occurs in this area (CHEN, 2013).

China is the center of the natural distribution of wild mango germplasm (NI et al., 2008); however, mango breeding industry in China is not as well developed as that in America, Australia, and India. Most of the cultivars that used in China were introduced from Australia, America, and India prior to 1980, except for some new cultivars that were released by our group (HE et al., 2006).

Germplasm resources are the basis of genetic improvement and cultivar development. Due to the long history of cultivation, extensive geographical distribution, and intense selection, there are more than a thousand mango cultivars worldwide. During the past decades, the Chinese Academy of Tropical Agricultural Sciences has collected and conserved more than 300 mango genotypes representative of worldwide genetic variability, in order to produce new cultivars with better traits such as high soluble solid content, early-ripening, late-maturing, middle size, red peel, resistance to anthracnose, and higher yield performance. However, mango germplasm remains underutilized due to the limited knowledge of quality properties.

The quality of mango greatly depends on fruit physical properties, such as shape, vertical diameter, cross section, weight, stone weight, pulp recovery, pulp fibrosis, and fruit color, and on chemical properties such as total soluble solids, titratable acidity, total sugars, vitamin C, taste, and aroma. Many studies have focused on the physicochemical and nutritional properties, such as phenolic compounds (ROCHA RIBEIRO et al., 2007; MANTHEY and PERKINS-VEAZIE, 2009), sugars (MEDLICOTT and THOMPSON, 1985), organic acids (VALENTE et al., 2011; LIU et al., 2013), antioxidant capacity (MAHATTANATAWEE et al., 2006; KIM et al., 2010), fruit aroma (PINO and MESA, 2006; PANDIT et al., 2009), and carotenoids (POTT et al., 2003). However, studies on the comprehensive and systematic evaluation of fruit quality attributes and the relationships among pomological traits are limited, particularly for mango germplasm in the China.

The objective of this study was to analyze and compare the physicochemical characters, antioxidant capacity, and mineral content of 28 mango genotypes from the South Subtropical Crops Research Institute of the Chinese Academy of Tropical Agricultural Sciences, in order to assess useful information for the utilization of mango genetic resources in China.

Materials and methods

Plant materials and quality properties

Twenty-eight genotypes grown in the orchards of the South Subtropical Crops Research Institute (SSCRI) in Zhanjiang, China were used in this study (Tab. 1). All the genotypes were grown under the same geographical conditions and with the same standard cultural practices. For each genotype, four replicates (consisting of five fruits each) were carried out and used for analysis. Fruits were incubated at 25 °C for ripening, which was ascertained for each cultivar by conventional indices such as ripening period after harvest, change in skin color, smell, and softness to touch. Ripe fruits were washed, drained, and dried with paper towels, and fruit weight was immediately measured on a balance with accuracy of 0.01 g. The pulp was manually separated from the fruit and cut into small pieces to obtain homogeneous samples. A 300-g fruit pulp sample was homogenized in a blender, and stone weight, pH, total soluble solids (TSS), and titratable acidity (TA) were evaluated. The remaining flesh sample was immediately ground in liquid nitrogen and stored at -70 °C until use. The pH values were determined from the juice of each sample with a digital pH meter (DL 25, Mettler Toledo, Greifensee, Switzerland). Tiratable acidity (TA) was expressed as a percentage of malic acid, and total soluble solids (TSS) were measured with a digital refractrometer (ATC-20E, Atago, Tokyo, Japan).

* Corresponding author

Tab. 1: Origin and parentage of the mango genotypes asseyed

Genotype	Origin	Parentage	Genotype	Origin	Parentage
Yuexi No. 1	China	Carabao	Kensinton	Australia	Brooks
Hongmang No. 8	Australia	Unknown	Lippens	America	Haden
Saigon	Vietnam	Unknown	Bambaroo	India	Unknown
Irwin	America	Lippens	KRS	Australia	Unknown
Guangxi No. 4	China	India 901 × Yingzui	Xiaoji	China	Unknown
Mallika	India	Dashehari × Neelum	Edward	America	Haden × Carabao
Sijimang	Thailand	Unknown	Zihua	China	Ok-Rung
Lilley	America	Unknown	Guixiang	China	Golock × Neelum
Carabao	Philippines	Unknown	Jinshui	China	Zihua
Glenn	America	Unknown	Renong No.1	China	Unknown
Nam Dok Mai	America	Unknown	Vandyke	America	Unknown
Tommy	America	Haden	Xiangjiao	Thailand	Unknown
Lianmang	China	Chance seedling	Valencia Pride	America	Haden
Aimang	China	Chance seedling	Yingzui	China	Unknown

Mineral content

Dry fruit material (0.5 g) was heated at 550 °C in a muffle furnace for 4-5 h. The resultant ash was dissolved in 2 mL of 30% (v/v) HNO_3 and distilled water was added until the total volume was 50 mL. Calcium (Ca), zinc (Zn), magnesium (Mg), iron (Fe), manganese (Mn) and copper (Cu) were measured using a Hitachi Z-8000 atomic absorption spectrometer, and potassium (K) was determined using a flame photometer (410 Corning) according to the Association of Analytical Communities (AOAC, 1995).

Sugars and organic acids

Sugars and organic acids were determined by high-performance liquid chromatography (HPLC) (LC-20A, Shimadzu Corp., Kyoto, Japan). A 2-g flesh sample was mixed and homogenized with 10 mL distilled water, incubated at 37 °C for 30 min, and then centrifuged at 5000 × g for 10 min. The supernatant was collected and evaporated to dryness at 75 ºC in a water bath. The residue was dissolved with 5 mL distilled water and filtered before analysis. Analysis of sugars was carried out using an amino column (250 mm × 4.6 mm; Kromasil, Bohus, Sweden) with a flow rate of 1.0 mL·min^{-1} at 35 °C. For the mobile phase, acetonitrile and twice distilled water (70:30 v/v) were used along with a refractive index detector as described by Liu et al. (2006) with some modifications. Organic acids were extracted from a 2-g fruit sample mixed with 8 mL of 0.2% metaphosphoric acid. The reaction mixture was centrifuged at 4,000 × g for 10 min and 1 mL of the supernatant was used for further analysis. The elution system consisted of 0.2% metaphosphoric acid running isocratically with a flow rate of 1 mL·min^{-1}. The organic acids were eluted through a Venusil XBP-C18 column (250mm × 4.6mm) and detected at 210 nm. Sugars and organic acids were identified and calculated using the corresponding external standards.

Carotenoids, total phenolic compounds, and antioxidant capacity

The total amount of carotenoids was determined as described by Zhao et al. (2013). Carotenoids were extracted from 1-g flesh using an ethanol:acetone solution (1:3 v/v) at room temperature for 60 min. After centrifugation at 4,000 × g for 10 min at 4 °C, the supernatant was collected, and its absorbance was measured in a spectrophotometer at 450 nm. The total carotenoid content was calculated using the extinction coefficient of β-carotene, $E^{1\%} = 2592$.

A 50-g flesh sample was homogenized and extracted in 200 mL of ethanol: acetone (7:3 v/v) for 1 h at 37 °C as described by Lee and Wicker (1991). The extract was filtered through Whatman No. 41 paper and rinsed with 50 mL of ethanol: acetone (7:3 v/v). Extraction of the residue was repeated under the same conditions and the two filtrates were combined. The combined extract was used to determine total phenol and antioxidant activity.

The amount of total phenols was determined following the Folin-Ciocalteu colorimetric method (Rapisarda et al., 1999). Absorbance was measured at 765 nm and total phenols were expressed as mg·L^{-1} of gallic acid equivalents (GAE). Gallic acid standard solutions were prepared with concentrations ranging between 0 and 1000 mg·L^{-1}.

The antioxidant capacity was evaluated using 2,2-diphenyl-1-picrylhydrazyl (DPPH), 2,2-azinobis (3-ethyl-benzothiazoline-6-sulfonic acid) (ABTS), ferric reducing antioxidant power (FRAP), superoxide radical scavenging activity (SRSA), and metal chelating capacity (MCC). DPPH scavenging capacity was measured as described by Masuda et al. (1999) with some modifications. A 25-µL extract sample was mixed with 2 mL of 62.5 µM DPPH methanol solution and 30 min later the absorbance was measured at 517 nm. Results were expressed as trolox equivalent antioxidant capacity. ABTS assay was performed as described by Re et al. (1999). A 25-µL extract sample was mixed with 2 mL ABTS solution and 30 min later the absorbance was measured at 734 nm. The radical-scavenging activity of the test samples were expressed as trolox equivalent antioxidant capacity. FRAP was assayed as described by Benzie and Strain (1996). A 20-µL extract sample was mixed with 1.8 mL 2,4,6-tris(2-pyridyl)-s-triazine (TPTZ) reagent consisted of 0.3 M acetate buffer (pH 3.6), 10 mM TPTZ, and 20 mM ferric chloride, and the absorbance of the colored product was measured at 593 nm. The antioxidant activity was expressed as µmol Trolox equivalents.

SRSA was assayed as described by Chen and Yen (2007) with a minor modification. A 50-µL extract sample was mixed with 1 mL of 0.1 M phosphate buffer (pH 7.4) containing 150 µM nitro blue tetrazolium, 60 µM N-methylphenazinium methylsulfate, and 468 µM nicotinamide adenine dinucleotide phosphate and then incubated for 8 min at 25 ºC. Absorbance was measured at 560 nm. The superoxide anion scavenging activity was calculated as follows: scavenging activity (%) = (1-absorbance of sample/absorbance of

control) × 100. MCC was determined as described by DINIS et al. (1994). A 1-mL mango extract in 2.8 mL distilled water was mixed with 50 µL of 2 mM $FeCl_2 \cdot 4H_2O$ and 150 µL of 5 mM ferrozine. The mixture was shaken for 10 min and then Fe^{2+} was measured by monitoring the formation of ferrous ion-ferrozine complex at 562 nm. The metal chelating capacity was calculated as follows: scavenging activity (%) = (1-absorbance of sample/absorbance of control) × 100.

The overall antioxidant potency composite (APC) index was calculated as described by SEERAM et al. (2008): antioxidant index score = (sample score/best score) × 100.

Statistical analysis

All samples were prepared and analyzed in triplicate. Analysis of variance (ANOVA) were performed with SAS 9.0 (SAS Corp., Cary, NC, USA). Correlation coefficients (r) were determined by Pearson correlation matrix method also using SAS 9.0. Probability values of $p < 0.05$ and $p < 0.01$ were considered statistically significant and very significant, respectively. The eigenvectors, contribution rate, and accumulative contribution rate in principal component analysis were processed using XLStat (Addinsoft, Paris, France) software package.

Results and discussion

Quality properties

Tab. 2 presents the fruit mass, stone mass, edible ratio, pH, soluble solids, and titrable acidity of each mango genotype. Valencia Pride had the highest fruit mass (771.73 g) and stone mass (60.22 g), whereas Yuexi No. 1 had the lowest fruit mass (138.06 g) and stone mass (16.71 g). The edible ratio ranged from 67.27% in Xiaoji to 83.96% in Nam Dok Mai. We also found a significant positive correlation between fruit mass and edible ratio ($r = 0.594$, $p < 0.001$), suggesting that the bigger-fruit genotypes also had a higher edible ratio. These results were in agreement with those reported by SHI et al. (2011). Mango acidity that assessed by pH or titratable acid was the highest in Guixiang, regardless the method. The pH values ranged between 3.35 and 5.09. The highest titratable acidity content was identified in Guixiang (2.35 g·100 g^{-1}), whereas the lowest

Tab. 2: Fruit mass (g), stone mass (g), edible ratio (%), pH, total soluble solids (TSS, °Brix), and titratable acidity (TA, % citric acid) of 28 mango genotypes.

Genotype	Fruit mass	Stone mass	Edible ratio	pH	TSS	TA	TSS/TA
Yuexi No. 1	138.06^{k}	16.71^{i}	70.94^{hi}	4.09^{c-f}	9.40^{jk}	0.98^{c-e}	9.56^{mn}
Hongmang No. 8	336.01^{c-g}	33.20^{b-e}	79.00^{a-e}	3.75f	15.10^{b-e}	1.71^{b}	8.85^{n}
Saigon	227.97^{h-k}	34.77^{bc}	71.99^{g-i}	3.59^{d-f}	14.13^{d-f}	0.36^{h-l}	39.39^{e-g}
Irwin	266.22^{f-j}	22.04^{d-i}	78.82^{a-f}	3.53^{d-f}	10.87^{ij}	0.85^{de}	12.71^{k-n}
Guangxi No. 4	205.84^{h-k}	21.42^{e-i}	77.17^{b-g}	4.33^{b-f}	16.27^{a-c}	0.30^{i-l}	54.98^{cd}
Mallika	377.24^{b-e}	31.32^{b-f}	80.75^{a-c}	3.62^{d-f}	15.67^{a-d}	0.74^{e-g}	21.31^{i-m}
Sijimang	211.31^{h-k}	22.76^{d-i}	71.56^{g-i}	4.08^{c-f}	15.27^{b-e}	0.23^{kl}	67.48^{b}
Lilley	227.51^{h-k}	25.89^{b-i}	73.34^{e-h}	4.20^{b-f}	12.47^{f-i}	0.23^{kl}	54.98^{cd}
Carabao	225.50^{h-k}	21.38^{e-i}	78.57^{a-f}	3.93^{c-f}	17.27^{a}	1.12^{c}	15.46^{j-n}
Glenn	420.06^{bc}	31.99^{b-f}	80.92^{a-c}	4.33^{b-e}	12.20^{f-i}	0.44^{h-k}	27.67^{g-j}
Nam Dok Mai	274.24^{f-j}	17.96^{hi}	83.96^{a}	5.09^{ab}	17.40^{a}	0.14^{l}	120.16^{a}
Tommy	422.11^{b-e}	37.41^{b}	82.04^{ab}	4.87^{a-c}	13.47^{e-g}	0.38^{kl}	35.44^{bc}
Lianmang	242.43^{g-k}	29.20^{b-h}	74.50^{d-h}	5.54^{a}	16.47^{a-c}	0.23^{h-l}	71.59^{ef}
Aimang	178.77^{jk}	20.31^{f-i}	70.96^{hi}	4.03^{c-f}	17.00^{ab}	0.89^{c-e}	19.04^{h-l}
Kensinton	398.13^{b-e}	33.37^{b-e}	78.62^{a-f}	4.04^{c-f}	14.73^{c-e}	1.79^{b}	8.21^{n}
Lippens	348.02^{b-f}	27.70^{b-i}	79.20^{a-e}	4.21^{b-f}	11.67^{g-i}	0.34^{i-l}	34.71^{f-h}
Bambaroo	298.67^{e-i}	30.49^{b-g}	75.76^{c-h}	3.66^{d-f}	13.27^{e-h}	0.54^{g-j}	24.49^{h-l}
KRS	353.07^{b-f}	37.08^{b}	77.87^{b-f}	3.37^{ef}	13.60^{e-g}	1.87^{b}	7.28^{n}
Xiaoji	144.69^{k}	24.97^{c-i}	67.27^{i}	3.91^{c-f}	13.60^{e-g}	0.29^{j-l}	46.34^{de}
Edward	445.48^{b}	26.32^{b-i}	79.99^{a-d}	4.25^{b-f}	14.60^{c-e}	0.56^{f-j}	26.30^{h-k}
Zihua	188.46^{jk}	27.37^{b-i}	73.03^{f-h}	4.27^{b-f}	7.60^{k}	1.02^{cd}	7.42^{n}
Guixiang	207.97^{h-k}	25.15^{c-i}	75.37^{c-h}	3.35^{d-f}	11.47^{hi}	2.35^{a}	4.88^{n}
Jinshui	186.35^{jk}	19.18^{h-g}	78.62^{a-f}	3.66^{d-f}	8.60^{k}	0.94^{c-e}	9.15^{mn}
Renong No. 1	405.61^{b-d}	35.02^{bc}	80.49^{a-c}	4.31^{b-f}	11.27^{i}	0.48^{g-k}	23.39^{h-l}
Vandyke	307.02^{d-h}	30.38^{b-g}	77.31^{b-g}	4.47^{b-d}	14.77^{c-e}	0.61^{f-h}	24.33^{h-l}
Xiangjiao	201.19^{i-k}	27.90^{b-i}	71.78^{g-i}	4.43^{b-d}	13.33^{e-h}	1.66^{b}	8.02^{n}
Valencia Pride	771.73^{a}	60.22^{a}	78.40^{a-f}	3.95^{c-f}	11.67^{g-i}	0.80^{d-f}	14.55^{k-n}
Yingzui	214.12^{h-k}	31.53^{b-f}	70.51^{hi}	4.86^{a-c}	16.00^{a-d}	0.56^{f-i}	28.69^{g-i}

Different superscript letters indicate significant differences across genotypes at $p < 0.01$.

in Nam Dok Mai (0.14 g·100 g^{-1}). These results were in agreement with those reported by VASQUEZ-CAICEDO et al. (2002). The highest TSS (17.00-17.40%) were found in Kensinton, Carabao, and Nam Dok Mai, whereas the lowest in Zihua and Jinshui (7.60-8.60%). It is widely believed that the TSS/TA ratio is widely applied as the most reliable parameter to evaluate mango fruit quality, and the typical values for high quality mango fruits range between 23 and 50 (VAQUEZ-CAICEDO et al., 2005). In this study, 11 (39.3%) mango genotypes fell within this range, suggesting high quality.

Mineral content

The mineral concentration of mango genotypes is shown in Tab. 3. Mineral content differed widely and significantly among the genotypes. Potassium (K), magnesium (Mg), and calcium (Ca) were the dominant minerals in mango pulp. K, an essential mineral for controlling the salt balance in human tissues, is the most abundant mineral in mango fruits. Lippens had the highest K content [32.80 g·Kg^{-1} dry weight (DW)], while Kensinton had the lowest (7.81 g·Kg^{-1} DW). Mg is the second most abundant element in mango fruits, which is required by many enzymes, especially sugar and protein kinases that catalyze ATP-dependent phosphorylation reactions (GORINSTEIN et al., 2001). Banana had the highest Mg content (816.98 g·Kg^{-1} DW) and Carabao had the lowest (312.76 g·Kg^{-1} DW). Ca is the third most abundant mineral and in this study ranged between 146.77 g·Kg^{-1} DW in Saigon and 640.82 g·Kg^{-1} DW in Renong No. 1. Ca concentration is closely related to cell structure and membrane stability and associated with the physiological diseases of mango. Our results showed that Renong No.1, Xiaoji, and Jinshui had the highest Ca content and can be used as potential donors for developing Ca-rich mango varieties. Trace elements (i.e., Fe, Mn, Cu, and Zn) are essential regulators of cell redox homeostasis, because they are co-factors for several antioxidant enzymes as well as contributors to signal transduction (LU et al., 2014). Among the different mango genotypes, the highest content was found for Mn (12.69-103.48 mg·Kg^{-1} DW), followed by Fe (8.84-16.49 mg·Kg^{-1} DW), Zn (5.17-12.12 mg·Kg^{-1} DW), and Cu (3.84-7.18 mg·Kg^{-1} DW). Guangxi No. 4 had the highest content of Fe and Cu, while Xiaoji had the highest content of Mn and Zn and considerable amounts of Fe and Cu.

Our study is one of the few to focus on mineral content as part of mango quality. While mineral content is influenced by many factors,

Tab. 3: Minerals content (mg·Kg^{-1}) of 28 mango genotypes referred to dry matter (DM) content.

Genotype	K	Ca	Mg	Fe	Mn	Zn	Cu
Yuexi No. 1	14504.25^{c-d}	205.62^{j}	606.10^{e-h}	13.05^{b-d}	16.95^{m}	9.08^{bc}	6.54^{ab}
Hongmang No. 8	10449.68^{g-j}	230.89^{ij}	806.98^{ab}	11.38^{c-g}	23.90^{jk}	5.53^{f-h}	5.10^{d-h}
Saigon	11823.86^{d-h}	146.77^{k}	489.07^{kl}	11.00^{c-g}	22.37^{kl}	6.23^{e-g}	4.24^{f-i}
Irwin	9424.95^{h-j}	347.53^{f}	535.58^{ij}	10.29^{d-g}	22.07^{kl}	3.91^{h}	4.66^{e-i}
Guangxi No. 4	8206.01^{ij}	454.95^{d}	472.10^{lm}	16.49^{a}	28.54^{hi}	6.69^{d-g}	7.18^{a}
Mallika	9462.35^{h-j}	216.78^{j}	449.17^{mn}	10.50^{d-g}	36.81^{e}	5.52^{f-h}	4.67^{e-i}
Sijimang	9614.98^{h-j}	292.68^{g}	614.04^{e-h}	12.78^{b-e}	18.14^{m}	7.36^{c-f}	5.14^{d-g}
Lilley	11559.55^{d-i}	456.62^{d}	583.34^{h}	13.58^{a-d}	54.30^{d}	5.59^{f-h}	5.16^{d-g}
Carabao	9188.43^{h-j}	298.43^{g}	312.76^{p}	11.64^{c-g}	34.00^{ef}	6.54^{d-g}	3.93^{i}
Glenn	14641.88^{c-d}	250.13^{i}	632.98^{d-f}	10.28^{d-g}	29.21^{g-i}	8.22^{cd}	3.95^{i}
Nam Dok Mai	14112.69^{b-f}	255.53^{hi}	552.86^{i}	12.00^{c-g}	12.69^{n}	6.45^{d-g}	4.27^{g-i}
Tommy	17063.11^{b}	331.21^{f}	610.92^{e-h}	10.19^{d-g}	31.91^{f-h}	6.01^{fg}	5.17^{d-f}
Lianmang	10365.92^{g-j}	169.07^{k}	433.90^{n}	15.78^{ab}	21.85^{kl}	5.90^{fg}	3.84^{i}
Aimang	11299.45^{d-j}	281.61^{gh}	778.06^{b}	11.49^{c-g}	25.54^{i-k}	9.08^{bc}	4.71^{e-i}
Kensinton	7814.45^{j}	502.46^{c}	601.31^{f-h}	11.23^{d-g}	58.32^{c}	7.10^{d-g}	5.63^{cd}
Lippens	142798.9^{a}	330.48^{f}	442.69^{mn}	10.18^{d-g}	27.21^{ij}	5.20^{g-h}	4.45^{f-i}
Bambaroo	14284.10^{b-e}	356.25^{f}	656.56^{d}	8.84^{g}	20.15^{ml}	7.95^{c-e}	7.00^{a}
KRS	13541.25^{c-g}	285.67^{g}	599.50^{gh}	12.66^{b-f}	26.49^{ij}	7.91^{c-e}	5.49^{c-e}
Xiaoji	9689.88^{h-j}	628.71^{a}	808.14^{ab}	14.35^{a-c}	103.48^{a}	12.12^{a}	6.18^{bc}
Edward	10580.14^{g-j}	294.87^{g}	515.28^{jk}	11.13^{c-g}	17.58^{m}	10.49^{ab}	4.33^{f-i}
Zihua	8998.00^{h-j}	409.56^{e}	635.62^{de}	10.53^{d-g}	36.81^{e}	5.52^{f-h}	4.67^{e-i}
Guixiang	11017.39^{e-j}	444.81^{d}	629.18^{d-g}	9.28^{e-g}	57.87^{c}	5.53^{f-h}	3.90^{i}
Jinshui	16486.78^{bc}	544.45^{b}	740.09^{c}	13.55^{a-d}	65.52^{b}	11.62^{a}	4.07^{i}
Renong No.1	11579.99^{d-i}	640.82^{a}	389.84^{o}	11.56^{c-g}	29.23^{g-i}	5.17^{gh}	4.34^{f-i}
Vandyke	10767.57^{f-j}	361.40^{f}	603.90^{e-h}	9.02^{fg}	32.59^{fg}	5.81^{fg}	4.74^{e-i}
Xiangjiao	14471.75^{c-d}	336.53^{f}	816.98^{a}	11.62^{c-g}	60.58^{c}	8.04^{c-e}	4.42^{f-i}
Valencia Pride	9688.39^{h-j}	232.69^{ij}	538.20^{ij}	11.91^{c-g}	17.87^{m}	5.63^{f-h}	5.19^{d-f}
Yingzui	10131.47^{g-j}	256.34^{hi}	547.37^{i}	11.48^{c-g}	27.19^{ij}	6.31^{e-g}	5.81^{b-d}

Different superscript letters indicate significant differences across genotypes at $p < 0.01$.

such as environmental conditions, agricultural practices, and water quality, the present study demonstrated that in mango fruits, the accumulation of K, Ca, Mg, Fe, Mn, Zn, and Cu is primarily dependent on genotype.

Sugars and organic acids

The organoleptic quality of fruits greatly depends on the content and composition of sugars in fruits. Three soluble sugars were detected and quantified in mango flesh. The concentration of glucose, varied significantly between 15.37 and 218.20 mg·g^{-1} FW; of fructose between 39.42 and 327.67 mg·g^{-1} FW; and of sucrose between 26.32 and 472.69 mg·g^{-1} FW (Tab. 4). Based on the concentration of fructose and sucrose, mango varieties were classified into 2 groups. The first group included 16 genotypes (Saigon, Guangxi No. 4, Mallika, Sijimang, Lilley, Nam Dok Mai, Tommy, Lianmang, Lippens, Bambaroo, Xiaoji, Edward, Renong No. 1, Vandyke, Valencia Pride, and Yingzui) with higher sucrose than fructose concentration. The two genotypes with the highest sucrose content were Nam Dok Mai and Lianmang that was 3.13 and 2.17 times higher than fructose, respectively. The second group included 12 genotypes (Yuexi No. 1, Hongmang No. 8, Irwin, Carabao, Glenn, Aimang, Kensinton, KRS, Zihua, Guixiang, Jinshui, and Xiangjiao) with higher fructose than sucrose concentration. However, Liu et al. (2013) found that sucrose predominated in mango varieties. This difference between the two studies could be attributed to the different mango genotypes and number of samples used in the experiments. It is concluded that the content and composition of sugars in mango fruit is genotype-depended. Total sugars ranged between 138.38 and 698.12 mg·g^{-1} FW. The highest total sugars were found in Edward (698.12 mg·g^{-1} FW) and Aimang (671.38 mg·g^{-1} FW), while the lowest in Vandyke (138.38 mg·g^{-1} FW) (Tab. 4).

In the present study, statistically significant differences were found in the individual organic acids and the total acid content among the 28 genotypes. Total acids ranged between 12.91 and 57.08 mg·g^{-1} FW (Tab. 4). The three genotypes with the highest acid content were Edward, Guixiang, and Hongmang No. 8. In all mango genotypes, malic acid was the dominant organic acid, which ranged between 4.31 and 41.74 mg·g^{-1} FW, followed by citric acid that ranged between 0.59 and 20.63 mg·g^{-1} FW (Tab. 4). These results are in agreement with previous studies (Tovar et al., 2001). The high malic acid content genotype, Edward, and the three high tartaric acid content genotypes (Hongmang No. 8, KRS, and Kensinton) were distinct from all other genotypes. Oxalic acid content ranged between 1.98 and 6.17 mg·g^{-1} FW (Tab. 4) and two genotypes, Saigon and Guangxi No. 4, had the highest content. Previous studies showed that the content of tartaric acid is genotype-depended. Liu et al. (2013) found no tartaric acid in any mango samples, while Medlicott and Thompson (1985) identified a low concentration of tartaric acid in Keitt. In this study, five genotypes (Sijimang, Lilley, Cacarbao, Glenn, and Zihua) had no tartaric content; 23 genotypes had a low tartaric content that ranged between 0.07 and 5.58 mg·g^{-1} FW; and 2 genotypes (Vandyke and Nam Dok Mai) had high tartaric content (Tab. 4). In addition, previous studies also found (Tovar et al., 2001; Liu et al., 2013) that mango fruit contains trace levels of succinic and a-ketoglutaric acid, in addition to the high levels of ascorbic and fumaric acid.

Carotenoids, total phenolic compounds, and antioxidant capacity

Carotenoids are the main pigments in mature mango fruit. Considerable variation was found in total carotenoids among the 28 mango genotypes (Tab. 4). The highest total carotenoid content (68.34-71.21 μg·g^{-1} FW) was found in Tommy, Vandyke, Bambaroo, and Zihua, while the lowest in Lianmang, Kensinton, Vanlencia Pride, and Renong No.1 (10.91-16.67 μg·g^{-1} FW). The mean values of total carotenoids did not differ significantly from a previous study in 60 mango cultivars (10.52-50.24 μg·g^{-1} FW; Zhao et al., 2013), but the maximum values of total carotenoids were higher in the present study. Phenolic compounds are considered the most important antioxidants of plant materials. Mean values of the total phenolic content varied between 13.69 and 82.65 mg gallic acid·100 g^{-1} FW. A relatively high total phenolic content was found in Aimang and Lianmang, whereas low values were found in Lippens and Valencia Pride (Tab. 4).

The antioxidant capacity of fruits is an important indicator of health promoters, and a number of methods have been adapted to assess antioxidants. Our results showed that there were significant differences in antioxidant capacity among the 28 genotypes (Tab. 5). The range of DPPH was 807.17-2963.89 μM Trolox, of ABTS 237.23-1573.07 μM Trolox, of FRAP 8607.88-58298.18 μM Trolox, of SRAR 2.50-93.33%, and of MCC 1.87-26.17%. Tab. 5 shows the rank order of mango genotypes according to the APC index. The APC index showed significant variation (6.12-81.39) among the 28 mango genotypes. Aimang and Lianmang had the highest APC indices, while Lippens and Tommy the lowest. Therefore, Aimang and Lianmang had a stronger antioxidant capacity than other mango genotypes, which is a potential trait for further utilization and improvement.

Correlation analysis was used to explore the relationships among the different antioxidant variables measured in all mango extracts (Tab. 6). FRAP, ABTS, and DPPH were significantly correlated with total polyphenols ($p < 0.01$, FRAP, $r = 0.629$; ABTS, $r = 0.624$; DPPH, $r = 0.741$). No significant correlation was found between MCC and SRSA and total polyphenols. The absence of correlation between the two assays and total polyphenols was probably due to a diverse sensibility of MCC and SRSA assays for hydrophilic antioxidants. Some research (Perez-Jimenez and Saura-Calixto, 2005) suggested that carotenoids may also contribute to the antioxidant activity of carotenoid-rich fruits. However, no significant relationship was observed between carotenoids and antioxidant capacity determination methods. Therefore, total polyphenols are probably the major contributor of the antioxidant capacity in mango fruits.

PCA of genotypes

PCA was used in order to understand the underlying interrelationships and to select the best linear combination of measured traits that explains the largest proportion of variation. The results showed that more than 80% of the observed variability was explained by 9 components (Tab. 7). The results indicated that variation in mango fruit quality was multi-directional, in accordance with previous results demonstrating that mango fruit quality is influenced by multiple traits (Pradeepkumar et al., 2006). PC1 represented 21.24% of the variation and PC2 represented 16.70% of the variation. Fig. 1 shows the score scatter plot of PCA of all mango samples. Fig. 1 as a total shows the relationships between genotypes (scores) and variables (loadings). The positive values for PC1 indicated genotypes with a higher content of citric acid and glucose and higher titratable acidity (Guixiang, Kensinton, and Hongmang No. 8), while the negative values indicated genotypes with higher pH, SSC/TA, and sucrose content (Nam Dok Mai and Guangxi No. 4). The positive values for PC2 indicated genotypes with higher total phenolic content and antioxidant capacity (Xiaoji, Lianmang, and Aimang), while the negative values indicated genotypes with higher fruit weight, stone weight, and edible rate (Valencia Pride and Lippens).

Conclusions

Mango quality is defined as the conjunction of good appearance and inherent qualities to the consumable product. In China, mango

Tab. 4: Carotenoids (μg·g^{-1}), total phenolics (mg·100 g^{-1}), total sugars (mg·100 g^{-1}), and organic acids (mg·100 g^{-1}) of 28 mango genotypes.

Genotype	Carotenoids	Total phenolics	Fructose	Glucose	Sucrose	Total sugars	Oxalic acid	Tartaric acid	Malic acid	Citric acid	Total acids
Yuexi No. 1	42.90^{c-f}	48.69^{de}	196.45^{c-g}	123.48^{de}	29.23^{ij}	349.15^{h-j}	3.44^{d-i}	4.13^{ab}	13.06^{mn}	9.70^{g}	30.33^{f}
Hongmang No. 8	27.52^{e-k}	26.45^{lm}	249.16^{bc}	186.69^{ab}	39.75^{h-j}	475.61^{e-h}	2.57^{g-i}	3.34^{ab}	30.55^{de}	20.63^{a}	57.08^{a}
Saigon	30.81^{d-k}	33.80^{h-j}	148.71^{f-j}	60.98^{f-i}	426.20^{ab}	635.89^{a-b}	6.17^{a}	4.18^{ab}	15.79^{kl}	7.17^{hi}	33.31^{ef}
Irwin	20.23^{h-k}	24.89^{mn}	221.06^{b-e}	135.77^{c-e}	89.58^{h}	446.41^{f-h}	3.32^{d-i}	1.34^{ab}	21.18^{ij}	7.39^{h}	33.22^{ef}
Guangxi No. 4	37.24^{d-h}	32.24^{h-k}	158.87^{f-j}	29.17^{ij}	293.07^{f}	481.11^{e-h}	5.79^{ab}	0.07^{b}	15.08^{kl}	3.72^{kl}	24.67^{g}
Mallika	46.26^{b-e}	35.41^{hi}	151.99^{f-j}	141.90^{c-e}	184.49^{g}	478.39^{e-h}	2.44^{hi}	2.82^{ab}	32.12^{cd}	9.18^{g}	46.55^{b}
Sijimang	25.69^{e-k}	37.43^{gh}	128.48^{h-j}	69.89^{f-i}	362.30^{c-e}	560.66^{b-f}	4.29^{b-g}	0.00^{b}	24.58^{j}	7.28^{h}	36.15^{c-e}
Lilley	57.96^{a-c}	35.96^{hi}	168.97^{d-j}	46.33^{h-j}	429.35^{a-b}	644.65^{ab}	4.41^{b-f}	0.00^{b}	5.01^{qr}	3.49^{l}	12.91^{i}
Carabao	34.64^{d-j}	69.08^{b}	275.36^{ab}	198.88^{ab}	142.25^{g}	616.50^{a-d}	5.70^{ab}	0.00^{b}	13.97^{lm}	14.82^{e}	34.49^{d-f}
Glenn	50.70^{a-d}	35.75^{hi}	207.57^{c-f}	102.87^{ef}	176.88^{g}	487.32^{d-g}	3.34^{d-i}	0.00^{b}	11.28^{n}	7.84^{h}	22.46^{gh}
Nam Dok Mai	30.02^{d-k}	37.59^{gh}	121.12^{j}	28.65^{ij}	472.69^{a}	622.46^{a-c}	3.50^{d-i}	5.53^{a}	12.28^{mn}	1.86^{m}	23.18^{gh}
Tommy	68.34^{a}	19.21^{o}	135.00^{h-j}	49.87^{h-j}	290.92^{f}	475.79^{e-h}	3.59^{d-i}	2.41^{ab}	9.20^{o}	3.84^{kl}	19.04^{h}
Lianmang	10.91^{k}	81.51^{cd}	137.22^{g-j}	73.99^{f-h}	458.26^{a}	669.47^{ab}	4.29^{b-g}	3.68^{ab}	28.11^{f}	4.49^{j-l}	40.57^{c}
Aimang	60.52^{a-c}	82.65^{fg}	275.79^{ab}	218.20^{a}	177.39^{g}	671.38^{ab}	3.58^{d-i}	3.17^{ab}	22.61^{hi}	9.47^{g}	38.82^{cd}
Kensinton	15.26^{i-k}	54.50^{c}	327.67^{a}	217.82^{a}	43.48^{h-j}	588.98^{a-e}	2.67^{f-i}	2.34^{ab}	7.21^{p}	17.70^{c}	29.93^{f}
Lippens	42.03^{c-g}	13.69^{p}	124.26^{ij}	71.36^{f-i}	391.24^{bc}	586.87^{a-e}	2.33^{hi}	0.26^{b}	16.61^{k}	4.07^{j-l}	23.27^{gh}
Bambaroo	70.29^{a}	27.23^{k-m}	155.54^{f-j}	48.35^{h-j}	295.45^{f}	499.34^{c-g}	3.87^{c-h}	0.43^{b}	4.31^{r}	5.05^{j}	13.67^{i}
KRS	31.90^{d-k}	29.42^{j-m}	226.90^{b-d}	176.77^{bc}	39.61^{h-j}	443.27^{h-f}	2.40^{hi}	2.56^{ab}	6.25^{pq}	19.49^{b}	30.71^{f}
Xiaoji	65.67^{ab}	78.99^{a}	124.52^{i-j}	65.73^{f-i}	377.12^{b-d}	567.37^{a-f}	4.79^{a-d}	3.29^{ab}	34.09^{b}	4.13^{j-l}	46.30^{b}
Edward	30.18^{d-k}	81.14^{a}	185.98^{d-h}	165.25^{bc}	346.88^{c-f}	698.12^{a}	2.56^{g-i}	2.88^{ab}	41.74^{a}	6.29^{i}	53.47^{a}
Zihua	71.21^{a}	43.37^{f}	164.18^{e-j}	77.38^{f-h}	60.62^{h-j}	302.18^{j}	5.40^{a-c}	0.00^{b}	23.65^{gh}	9.49^{g}	38.54^{cd}
Guixiang	22.05^{f-k}	31.28^{i-l}	207.07^{c-f}	162.19^{b-d}	26.32^{ij}	395.58^{g-j}	3.48^{d-i}	2.59^{ab}	32.91^{bc}	16.44^{d}	55.41^{a}
Jinshui	36.71^{d-i}	27.70^{k-m}	141.06^{g-j}	102.10^{e-g}	74.38^{h-j}	317.54^{ij}	2.97^{e-i}	1.91^{ab}	16.22^{k}	9.63^{g}	30.73^{f}
Renong No.1	16.67^{h-k}	28.81^{j-m}	116.48^{j}	59.46^{g-i}	310.72^{ef}	486.66^{d-g}	3.22^{d-i}	4.27^{ab}	7.79^{op}	3.54^{l}	18.81^{h}
Vandyke	69.62^{a}	37.39^{gh}	39.42^{k}	15.37^{j}	83.59^{hi}	138.38^{k}	4.97^{a-d}	5.58^{a}	11.49^{n}	0.59^{n}	22.63^{gh}
Xiangjiao	20.74^{g-k}	44.89^{ef}	250.25^{bc}	170.16^{bc}	22.03^{j}	442.45^{f-i}	4.50^{a-e}	1.35^{ab}	11.44^{n}	13.82^{f}	31.10^{f}
Valencia Pride	13.45^{jk}	20.05^{no}	160.32^{f-j}	140.59^{c-e}	177.87^{g}	478.78^{e-h}	1.98^{i}	0.89^{ab}	28.84^{ef}	6.32^{i}	38.02^{c-e}
Yingzui	34.70^{d-j}	36.30^{g-i}	183.76^{d-i}	76.96^{f-h}	331.03^{d-f}	591.75^{a-e}	4.89^{a-d}	0.32^{b}	19.94^{j}	4.59^{jk}	29.73^{f}

Different superscript letters indicate significant differences across genotypes at $p < 0.01$.

Tab. 5: Antioxidant capacity in pulp extract of 28 mango genotypes determined by ferric reducing antioxidant power (FRAP; µM Trolox), 2,2-azinobis (3-ethyl-benzothiazoline-6-sulfonic acid) (ABTS; µM Trolox), 2,2-diphenyl-1-picrylhydrazyl (DPPH; µM Trolox), metal chelating capacity (MCC; %), superoxide radical scavenging activity (SRSA; %) and antioxidant index score (APC; %).

Genotype	FRAP	MCC	ABTS	SRSA	DPPH	APC index	Rank
Yuexi No. 1	37188.92^{b-d}	23.83^{ab}	1573.07^{a}	26.67^{j-m}	2419.36^{b-d}	69.80	4
Hongmang No. 8	15801.16^{l-n}	20.33^{b-e}	953.07^{e}	69.17^{b-d}	1008.69^{kl}	45.21	21
Saigon	23282.55^{h-k}	21.25^{b-e}	1342.44^{a-c}	25.83^{i-m}	1241.20^{f-h}	47.52	20
Irwin	11969.22^{no}	22.58^{a-d}	291.14^{f}	19.17^{j-n}	1823.78^{i-k}	32.27	25
Guangxi No. 4	14773.55^{m-o}	1.83^{j}	279.16^{f}	11.67^{l-n}	1682.79^{fg}	13.23	26
Mallika	22408.60^{i-l}	14.42^{f}	965.05^{e}	93.33^{a}	1281.51^{i-k}	50.98	16
Sijimang	35133.70^{c-f}	10.75^{gh}	1570.07^{a}	66.67^{b-e}	1287.71^{i-k}	56.39	11
Lilley	22206.92^{i-l}	14.25^{fg}	1303.50^{a-c}	52.50^{e-h}	1495.42^{g-i}	48.92	18
Carabao	41107.29^{bc}	26.17^{a}	1558.09^{a}	15.00^{k-n}	2318.53^{c-e}	69.59	5
Glenn	19681.11^{k-m}	13.17^{fg}	1189.69^{c-e}	62.50^{c-e}	1239.65^{i-k}	45.11	23
Nam Dok Mai	27143.30^{g-j}	12.33^{fg}	1570.07^{a}	50.00^{e-h}	1689.18^{f-h}	54.57	13
Tommy	9760.34^{no}	2.50^{j}	237.23^{f}	9.17^{l-n}	1388.65^{h-j}	7.86	27
Lianmang	53246.55^{a}	21.42^{b-e}	1555.10^{a}	57.50^{c-g}	2400.68^{b-d}	80.55	2
Aimang	31820.37^{c-f}	23.17^{ab}	1573.07^{a}	83.33^{ab}	2630.85^{bc}	81.39	1
Kensinton	29918.81^{e-h}	21.92^{b-e}	1258.58^{b-d}	46.67^{e-i}	2182.12^{de}	62.74	7
Lippens	8607.88^{o}	8.67^{hi}	258.19^{f}	2.50^{n}	827.10^{l}	6.12	28
Bambaroo	20420.61^{j-m}	18.25^{e}	1024.95^{de}	65.00^{b-e}	965.28^{kl}	45.12	22
KRS	25597.08^{g-k}	20.58^{b-e}	1195.68^{c-e}	46.67^{e-i}	1307.86^{i-k}	50.86	17
Xiaoji	29381.00^{e-i}	13.17^{fg}	1546.11^{a}	49.17^{e-h}	1990.38^{ef}	58.41	9
Edward	58298.18^{a}	22.83^{a-c}	1564.08^{a}	5.83^{mn}	2963.89^{a}	77.85	3
Zihua	36910.41^{b-d}	23.17^{ab}	1567.08^{a}	28.33^{i-l}	1535.72^{ef}	61.22	8
Guixiang	28900.80^{f-i}	23.17^{ab}	1201.67^{c-e}	74.17^{a-c}	1064.49^{a}	58.13	10
Jinshui	23023.25^{h-k}	20.08^{b-e}	1471.23^{ab}	40.83^{f-i}	1535.72^{g-i}	54.38	14
Renong No.1	23292.16^{h-k}	18.92^{de}	1357.42^{a-c}	38.33^{g-j}	1259.80^{j-l}	48.72	19
Vandyke	15205.72^{m-o}	19.17^{c-e}	1558.09^{a}	15.00^{k-n}	2346.44^{b-d}	53.67	15
Xiangjiao	36132.50^{b-e}	18.83^{de}	1570.07^{a}	19.17^{j-n}	2674.61^{ab}	65.95	6
Valencia Pride	42682.32^{b}	20.67^{b-e}	446.89^{f}	33.33^{h-k}	807.17^{l}	39.05	24
Yingzui	23090.48^{h-k}	6.00^{i}	1390.36^{a-c}	60.83^{c-f}	2604.11^{bc}	55.89	12

Different superscript letters indicate significant differences across genotypes at $p < 0.01$.

Tab. 6: Correlation coefficients between antioxidant content and antioxidant capacity determined by ferric reducing antioxidant power (FRAP; µM Trolox), 2,2-azinobis (3-ethyl-benzothiazoline-6-sulfonic acid) (ABTS; µM Trolox), 2,2-diphenyl-1-picrylhydrazyl (DPPH; µM Trolox), metal chelating capacity (MCC; %), and superoxide radical scavenging activity (SRSA; %).

	TPC	TC	FRAP	MCC	ABTS	SRSA	DPPH
TPC	1						
TC	0.030^{ns}	1					
FRAP	0.671^{**}	-0.336^{ns}	1				
MCC	0.320^{ns}	-0.245^{ns}	0.518^{**}	1			
ABTS	0.623^{**}	0.036^{ns}	0.571^{**}	0.454^{*}	1		
SRSA	-0.073^{ns}	0.004^{ns}	0.023^{ns}	0.067^{ns}	0.278^{ns}	1	
DPPH	0.696^{**}	-0.022^{ns}	0.491^{**}	0.214^{ns}	0.524^{**}	-0.195^{ns}	1

Note: TC: Total carotenoids; TPC: Total phenolics; ns: Non-significant; *: level of significance (* $p < 0.05$, ** $p < 0.001$).

Tab. 7: Eigenvectors and percentages of accumulated contribution of principal components (PC).

	PC1	PC2	PC3	PC4	PC5	PC6	PC7	PC8	PC9
Fruit weight	-0.056	-0.601	-0.508	0.023	0.259	-0.207	-0.466	0.004	0.093
Stone weight	-0.014	-0.548	-0.314	-0.038	0.263	-0.058	-0.487	-0.280	-0.066
pH	-0.548	0.378	-0.278	0.176	-0.155	-0.067	-0.203	0.097	-0.024
SSC	-0.146	0.414	-0.498	-0.314	-0.190	0.353	-0.114	0.179	0.052
Edible rate	-0.172	-0.568	-0.391	0.177	-0.052	-0.069	-0.068	0.482	-0.011
Carotene	-0.259	0.099	0.601	0.074	0.076	0.227	-0.102	-0.058	0.559
Fructose	0.731	-0.008	-0.146	-0.424	-0.435	-0.048	-0.045	0.109	0.069
Glucose	0.889	-0.072	-0.287	-0.203	-0.139	-0.085	-0.014	0.114	0.143
Surcose	-0.762	0.370	-0.308	-0.182	0.196	-0.046	0.112	0.039	0.030
Total sugar	-0.142	0.405	-0.574	-0.515	-0.037	-0.118	0.105	0.153	0.136
TA	0.858	-0.298	0.090	-0.018	-0.149	0.071	0.034	0.072	-0.166
SSC/TA	-0.709	0.428	-0.276	-0.086	0.088	0.175	0.080	0.215	-0.177
Total phenolic	0.380	0.799	-0.092	0.007	-0.007	-0.161	-0.104	0.071	0.278
K	-0.308	-0.333	-0.009	-0.105	0.020	-0.328	0.491	0.181	0.400
Ca	0.003	0.023	0.598	-0.040	0.193	-0.418	-0.012	0.322	-0.311
Mg	0.394	0.133	0.521	-0.131	0.314	0.257	-0.193	0.145	0.152
Fe	-0.156	0.517	-0.024	-0.339	0.059	-0.277	-0.096	-0.047	-0.503
Mn	0.270	0.233	0.578	-0.151	0.312	-0.268	0.073	0.227	-0.195
Zn	0.263	0.527	0.318	-0.088	0.302	-0.235	-0.253	0.233	0.238
Cu	-0.160	0.031	0.418	-0.484	-0.035	0.070	-0.455	-0.245	0.037
FRAP	0.375	0.541	-0.461	0.188	0.089	-0.294	-0.165	-0.240	-0.041
MCC	0.721	0.061	-0.150	0.446	-0.096	-0.048	0.044	-0.073	-0.031
ABTS	0.312	0.705	0.053	0.378	-0.035	0.161	-0.038	0.109	-0.069
SRSA	0.256	0.121	-0.077	-0.301	0.328	0.665	0.017	0.138	-0.122
DPPH	0.227	0.706	-0.069	0.196	-0.338	-0.188	-0.202	0.039	0.190
Oxlic acid	-0.271	0.514	0.311	0.071	-0.373	0.104	0.150	-0.431	-0.159
Tartaric acid	0.046	0.203	-0.162	0.550	0.201	0.296	-0.149	0.378	-0.122
Malic acid	0.312	0.243	-0.361	-0.002	0.647	-0.051	0.271	-0.299	0.106
Citric acid	0.858	-0.210	-0.044	-0.222	-0.180	0.107	0.087	0.075	-0.139
Total acid	0.643	0.193	-0.324	-0.014	0.466	0.060	0.265	-0.209	-0.007
Eigen value	6.371	5.009	3.665	1.969	1.900	1.585	1.399	1.350	1.267
Contribution rate (%)	21.238	16.698	12.217	6.562	6.333	5.284	4.664	4.501	4.224
Cumulative percentage (%)	21.238	37.936	50.153	56.715	63.048	68.332	72.996	77.497	81.721

germplasm resources are valuable gene pools of resistance, performance, and functional constituents that used in genetic improvement programs. In the present study, we analyzed the physicochemical characters, antioxidant capacity, and mineral content of 28 mango genotypes. Considerable variation was found in all measured traits among the genotypes. Since all the genotypes were grown under the same environmental conditions and with the same standard conditions of irrigation, fertilization, and disease control, trait variation corresponded to the genetic diversity of the genotypes.

The content and composition of sugars and acids in mango fruits was genotype-depended. Sucrose and/or fructose were the dominant sugars, while malic and citric were the dominant organic acids in mango fruits. Edward showed the highest content of total sugars and organic acid content, whereas Vandyke and Lilley had the lowest values, respectively. Aimang had the highest total phenolic content, and Zihua had the highest total carotenoid content. Aimang and Lianmang had significantly higher APC indices than the other mango genotypes. Among all studied genotypes, Valencia Pride showed the highest fruit mass, edible ratio, and total sugar content, traits preferred by the processing industry. However, Edward, Aimang, and Zihua were the most suitable genotypes for fresh consumption, due to their better biochemical properties and related health benefits.

Our work provided information on the physicochemical characters, antioxidant capacity, and mineral content of 28 mango genotypes. However, mango fruit quality is affected by many factors, such as geographic region, climate, soil characteristics, and cultivation techniques. Therefore, further studies are needed to investigate the genotype by environment interactions and identify superior genotypes suitable for fresh consumption, processing, or breeding research.

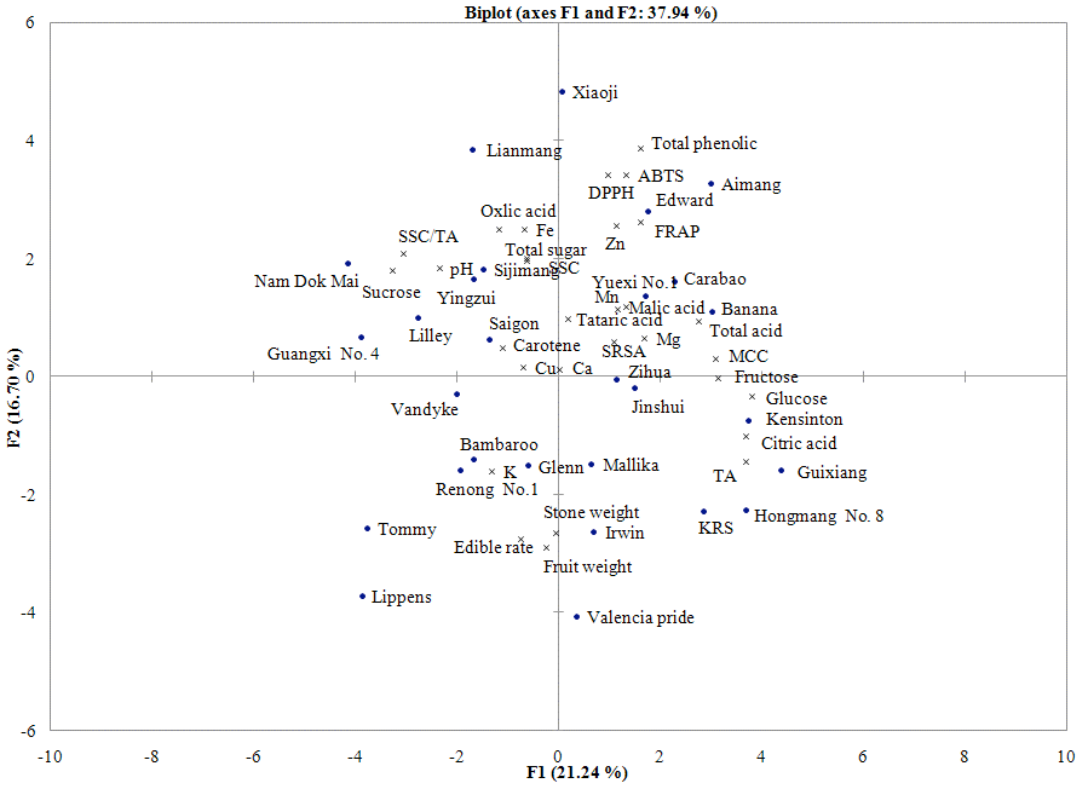

Fig. 1: Segregation of 28 mango genotypes according to their quality characteristics determined by principal component analysis (PCA).

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Address of the corresponding author:
E-mail: maxiaowei428@126.com