

Volatile Characterization of Major Apricot Cultivars of Southern Xinjiang Region of China

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ABSTRACT. The characterization of aroma of the 14 main apricot (*Prunus armeniaca* L.) cultivars in Xinjiang was evaluated using high-performance solid-phase microextraction (HP-SPME) with gas chromatography-mass spectroscopy (GC-MS). A total of 208 volatiles that include 80 esters, 25 aldehydes, 15 terpenes, 21 ketones, 39 alcohols, 27 olefins, and 1 acid were identified from these cultivars. The compounds propyl acetate, 3-methyl-1-butanol acetate, (*Z*)-3-hexen-1-ol acetate, α -limonene, β -linalool, hexanal, hexyl acetate, butyl acetate, β -myrcene, ethyl butanoate, and β -cis-ocimene were the major compounds responsible for aroma in these cultivars. GC-MS results showed that Kuchexiaobaixing, Guoxiyuluke, and seven other cultivars were characterized by a high level of esters and were considered to be fruity apricot aroma. 'Luotuohuang' and 'Heiyexing' accumulate high levels of terpenes and exhibited an outstanding floral aroma. Higher levels of alcohols and aldehydes were observed in 'Danxing', 'Sumaiti', and 'Kumaiti'. The latter are considered green aroma cultivars. These three types of cultivars with different aroma characteristics can be significantly differentiated by using the principal component analysis (PCA) method. The contributions of volatiles to the apricot aroma were assessed by using the partial least squares regression (PLSR) model. Esters, terpenes, and C6 components were shown to be responsible for the fruity, floral, and green character of fresh apricots, respectively.

Fruit quality is mainly a composite of color, texture, flavor, and nutrition. Flavor is the most important organoleptic factor for fruit quality. It has a major impact on the consumers' preference (Snyder-Derek et al., 2008). There are many compounds that contribute to the fruit flavor quality. Sugars and organic acids in fruit produce sweet and sour taste, respectively (Husain, 2010); while the aroma depends on a large number of volatiles in fruit. Although taste and aroma are well integrated in their contribution to the overall flavor, aroma is often considered to play a dominant role (Kader, 2008; Tieman et al., 2012).

Apricot, a member of the Rosaceae family, is highly popular with consumers owing to its unique aroma (Gurrieri et al., 2001) and is widely consumed as fresh fruit, juice, puree, jam, and dried fruit (Schmitzer et al., 2011). The apricot originated in China, with its center of origin lying in central Asia including Xinjiang, China. China has rich apricot resources. It is estimated that among over 3000 cultivars worldwide, there are more than 2000 cultivars in China. Commercially available

cultivated apricots include many cultivars differing in color, shape, and flavor. As an important origination center, Xinjiang has almost all of the apricot cultivars in China besides the endemic species itself.

For the past several years, aroma sensation evaluations of apricots have been conducted by many researchers. These studies mainly focus on the effect of maturation (Gonzalez-Agüero et al., 2009), extraction techniques (Solis-Solis et al., 2007), ethylene inhibition (Botondi et al., 2003), and storage conditions (Defilippi et al., 2009) on apricot aroma evaluation. Although the effect of cultivars on aroma quality has also been evaluated in previous studies, all of the apricot cultivars studied primarily belong to cultivar groups in northern China (Aubert and Chanforan, 2007; Botondi et al., 2003). As the primary cultivation area, there are more than 120 cultivars in Xinjiang. They are from the central Asia ecological cultivar group and have a strong and rich aroma; however, data on the aroma profile of the main apricots cultivated in Xinjiang are lacking.

In this study, aromas of the 14 main apricots cultivated in Xinjiang, China were identified and determined using HP-SPME with GC-MS. The differences in the aroma composition and content among cultivars were analyzed and the main characteristic aroma volatiles in these cultivars were ascertained by using the PCA method with the GC-MS results. This

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work will provide useful information for identifying the genetic components involved in the quality of these fruit to facilitate breeding of new cultivars meeting the consumer's expectations.

Materials and Methods

SAMPLE PREPARATION. Apricot fruit were collected from the National Fruit Tree Germplasm Repository, Academy of Xinjiang Agricultural Sciences, Luntai, Xinjiang, China (Table 1). Three trees were sampled per cultivar and 40 fruit per tree were harvested at the commercial maturity stage based on their external color. Fruit were transported to the laboratory on the day of harvest. Fruit with uniform size and without disease or damage were screened for experiments, and stored at 20 °C for 8 d; the relative humidity was maintained at 92% to 98%.

DETERMINATION OF THE FRUIT RIPENING PARAMETERS. The total soluble solids (TSS), titratable acidity (TA), and ethylene production are correlated with flavor. In the study, TSS, TA, and ethylene were determined to indicate the maturation state of apricot. In fact, even fruit were harvested at the commercial maturity stage based on external color and size uniformity, the maturation condition may more or less has an impact on the volatiles profiles, so TSS, TA, and ethylene were presented in this study.

Ethylene concentrations were measured by placing every third fruit in a sealed container for 1 h. One-milliliter gas samples were then withdrawn and injected into a GC (7820A; Agilent, Santa Clara, CA). Detection conditions: flame ionization detector (FID), the temperatures of the injector, column, and oven were 200, 80, and 150 °C, respectively. Nitrogen was the carrier gas.

The fruit firmness was measured at the equator of the fruit using a penetrometer (HL300; Xianlin Non Detection Device Co., Nanjing, China) with an 8-mm-diameter head. Two measurements were made on opposite sides of each fruit after the removal of a 1-mm-thick slice of skin.

Measurements of the TSS and TA were conducted on juice samples collected from 30 fruit per treatment. TA measurements were performed by titrating 10 mL of fruit juice with 0.2 mol·L⁻¹ NaOH to a pH 8.2 and expressing the results as grams per liter malic acid. The TSS on the opposite sides of each fruit was measured with handheld refractometers (B32T Brix Meter; Guangzhou RuiQi Trade Co., Guangzhou, China).

Table 1. Apricot cultivars of the southern Xinjiang region of China for which volatiles were characterized in this study.

No.	Cultivar	Flesh character	Repository no.
1	Kuchexiaobaixing	Light-yellow flesh	XD083
2	Guoxiyuluke	Light-yellow flesh	XD080
3	Kuerleituoyong	Light-yellow flesh	XD503
4	Dabaiyou	Light-yellow flesh	XD081
5	Heiyexing	Light-yellow flesh	XD151
6	Danxing	Yellow flesh	XD076
7	Kuchetuoyong	Yellow flesh	XD024
8	Kuikepiman	Light-yellow flesh	XD013
9	Dayoujia	Yellow flesh	XD075
10	Sumaiti	Yellow flesh	XD019
11	Kumaiti	Yellow flesh	XD559
12	Luotuohuang	Light-yellow flesh	XD111
13	Mulongxing	White flesh	XD084
14	Aketuoyong	Yellow flesh	XD028

AROMA VOLATILES ANALYSIS. The concentrations volatile compounds were determined according to the method described by Xi et al. (2012). In all, 5 g of frozen flesh tissue from 30 fruit was homogenized with saturated sodium chloride, and equilibrated at 40 °C for 30 min. A fiber coated with 65 µm of polydimethylsiloxane and divinylbenzene (Supelco, Bellefonte, PA) was used for volatiles' extraction. The volatiles were then analyzed using a GC-MS (GCMS-QP2010 Plus; Shimadzu, Kyoto, Japan) equipped with a FID detector and a Ttx-1 MS capillary chromatographic column (0.25 mm, 30 m, 0.25 µm; J&W Scientific, Folsom, CA). Helium was used as a carrier gas at 1.2 mL·min⁻¹. The oven temperature was held at 40 °C for 2 min, increased by 5 °C per min to 140 °C, held for 2 min, then increased by 10 °C per min to 250 °C and held for 2 in. MS conditions were as follows: ion source, 200 °C; electron energy, 70 eV; with a scan range of 45–450 mass units. All reagent-grade compounds were obtained from Sigma-Aldrich (St. Louis, MO). Quantitative determination of compounds was carried out using the peak of the internal standard [100 µL of 2-octanol (401.3 µg·mL⁻¹)] as a reference value and calculated based on standard curves of the reagent-grade compounds.

AROMA ACCEPTABILITY EVALUATION. Aroma acceptability was evaluated according to Altisent et al. (2008). Fruit from each cultivar were divided into two groups, one for analyzing aroma volatiles and the other for consumer evaluation. Twenty apricots per cultivar were used for the aroma sensation evaluation. Every fruit that was sliced into a cube (2 × 2 cm) was placed on a white plate and immediately presented to a tasting panel of 20 consumers who conducted a sensory evaluation. The same 20 participants assessed all of the cultivars. All of the test participants were experienced apricot consumers. Mineral water was used as a palate cleanser between samples. Each consumer assessed all the three samples and was asked to indicate his/her degree of like/dislike using a 4-point hedonic scale (4 = extreme aroma, 3 = aroma, 2 = moderate aroma, 1 = poor aroma).

STATISTICAL ANALYSIS. A completely randomized design was used in the experiments. OriginPro 7.5 G (Microcal Software, Northampton, MA) was used to determine the standard errors and to create figures. The differences indicated in the figures were based on a least significant difference (LSD) test at the 5% level (DPS version 2.00; Zhejiang University, Hangzhou, China). The Unscrambler (version 9.7; Asia Pacific CAMO Software, Bangalore, India) was used to develop the PCA and the PLSR model. Two PCA models were performed to provide an easy visualization of the complete data set in a reduced dimension plot. The differences in the aroma composition and content including aldehydes, alcohols, esters, lactones, C13 norisoprenoids, sugar, organic acid, and flavor among cultivars were analyzed and the main characteristic aroma volatiles in these cultivars were ascertained by using PCA with the GC-MS results. The PLSR model considered volatile compounds as *x* variables and aroma acceptability as the *y* variable. This procedure allowed a rapid assessment of relationships between the dependent variable (*y*) and a set of potentially explanatory variables (*x*).

Results and Discussion

CHANGE IN FRUIT FIRMNESS, ETHYLENE, TSS, AND TA DURING POSTHARVEST RIPENING. At harvest, the firmness of the experimental cultivars ranged from 5.23 to 8.41 N, 'Kuikepiman' had

the lowest firmness and 'Heiyexing' had the highest firmness value, which showed that all fruit are edible when picked (Table 2). The ethylene production ranged from 25.75 ('Aketuoyong') to 45.84 nL·g⁻¹·s⁻¹ ('Kumaiti') at harvest. A significant TSS variation was observed in the studied cultivars, ranging from 25.6% to 17.5% (Table 2). The TSS is the sum of sugars, acids, and other minor components in the pulp (Beckles,

2012). Although slight differences of TA were found in some studied cultivars, TA only ranged from 0.41 to 0.66 g·L⁻¹ (Table 2).

COMMON AROMA VOLATILES IN XINJIANG APRICOT CULTIVARS. It is reported that more than 300 aroma compounds have been identified from apricot. A total of 208 aroma volatiles were identified from these studied cultivars, including 80 esters, 25 aldehydes, 39 alcohols, 21 ketones, 27 olefins, 1 acid (data not shown), and 15 other trace compounds (Table 3). The result had compared with previous report (Zhang et al., 2008) that 107 volatile compounds were detected in northern Xinjiang cultivars. This suggests that Xinjiang apricot cultivars are rich in aroma compounds. Propyl acetate, 3-methyl-1-butyl acetate, (Z)-3-hexen-1-ol acetate, D-limonene, β-linalool, and hexanal were all detected in all of the studied cultivars, with concentrations over 1 μg·g⁻¹. In addition, the contents of hexyl acetate, butyl acetate, β-myrcene, and β-cis-ocimene also were above 1 μg·g⁻¹ in most of the cultivars studied. This suggested that these

Table 2. Physiological parameters of 14 apricot cultivars fruits at harvest in southern Xinjiang, China.

Cultivar	Wt (g)	Firmness (N)	Ethylene (nL·g ⁻¹ ·s ⁻¹)	TSS ^z (%)	TA ^z (g·L ⁻¹)
Kuchexiaobaixing	29.03 e ^y	6.32 c	33.59 b	22.9 c	0.41 c
Guoxiyuluke	41.3 c	7.94 b	42.62 a	20.8 c	0.62 a
Kuerleituoyong	46.21 b	7.68 b	28.91 c	21.3 c	0.63 a
Dabaiyou	37.4 c	7.46 b	37.63 b	21.1 d	0.58 a
Heiyexing	26.31 f	8.41 a	31.89 c	22.4 b	0.59 a
Danxing	26.05 f	7.35 b	29.12 c	20.6 d	0.48 c
Kuchetuoyong	26.71 f	8.35 a	30.76 c	17.5 f	0.49 c
Kuikipiman	41.4 l c	5.23 e	28.33 c	20.9 d	0.66 a
Dayoujia	36.31 d	7.57 b	35.65 b	21.4 d	0.55 b
Sumaiti	31.11 e	5.66 d	32.72 b	18.9 e	0.49 c
Kumaiti	19.02 g	6.82 c	45.84 a	19.6 e	0.58 a
Luotuhuang	57.41 a	7.27 c	38.39 b	25.6 a	0.62 a
Mulongxing	19.01 g	6.65 c	34.62 b	23.8 b	0.48 c
Aketuoyong	14.22 h	5.94 d	25.75 d	22.7 c	0.55 b

^zTSS = total soluble solids; TA = titratable acidity.

^yMeans with different letters within a column are significantly different at $P < 0.05$ by LSD test.

Table 3. Concentration of the main aroma components in pulp of 14 apricot cultivars from southern Xinjiang, China.

Volatiles categories		Concn (μg·g ⁻¹) ^z													
Aroma volatiles		KH	GX	KL	DB	HY	DX	KC	KK	DY	SM	KM	LT	ML	AK
Ketones	3-Hydroxy-2-butanone	nd ^y	nd	nd	nd	nd	nd	nd	nd	6	1.19	0.25	nd	nd	Nd
	β-Linalool	19.36	15.59	18.58	23.57	22.66	62.6	20.65	22.34	11.98	33.88	31.17	0.68	24.25	7.57
	2-Pentylfuran	0.42	nd	nd	nd	nd	nd	nd	nd	0.82	nd	nd	nd	nd	Nd
	2-Methyl-3-furanethiol	nd	5.73	nd	nd	7.53	nd	nd	nd	nd	nd	nd	nd	nd	Nd
Aldehydes	Pentanal	0.53	4.03	nd	0.48	6.66	1.69	1.03	nd	nd	nd	nd	nd	nd	Nd
	Hexanal	1.52	3.07	0.73	1.47	3.22	1.29	0.7	0.53	3.4	5.54	1.52	0.42	5.78	2.95
Esters	Decanalbutyl acetate	1.02	0.15	0.13	1.72	0.19	1.39	1.73	1.58	0.17	0.96	4.15	nd	0.51	0.61
	Hexyl acetate	30.08	13.74	5.61	26.43	nd	nd	11.47	17.77	9.2	4.76	3.61	8.84	5.11	13.76
	Butyl acetate	12.95	15.81	17.98	11.22	1.4	1.42	6.51	10.9	22	nd	5.4	7.04	28.9	28.53
	Propyl acetate	3.18	1.92	1.82	2.75	2.76	2.15	2.66	2.4	5.1	1.45	6.35	0.73	2.58	6.34
Acid	Butanoic acid,4-hexen-1-yl ester	nd	0.04	4.73	nd	nd	nd	nd	0.1	nd	nd	nd	nd	nd	nd
	(E)-2-hexen-1-ol acetate	nd	0.15	nd	8.17	0.46	nd	nd	nd	nd	nd	nd	nd	nd	nd
	Hexyl butanoate	nd	2.22	nd	nd	nd	nd	5.77	nd	0.15	nd	nd	nd	nd	1.32
	Ethyl 2-hydroxybutanoate	1.93	nd	3.76	nd	nd	nd	nd	3.82	nd	nd	2.2	6.02	nd	nd
	(Z)-3-hexen-1-ol acetate	14.44	14.44	11.07	5.32	12.98	0.2	16.6	12.84	14.62	11.28	3.75	19	7.16	12.7
	3-Methyl-1-butanol acetate	0.68	0.3	0.63	0.77	0.3	0.3	0.72	0.8	2.06	0.93	0.73	0.17	1.68	0.92
	Ethyl butanoate	nd	nd	1.8	1.58	nd	0.17	1.3	0.76	1.89	nd	nd	0.02	nd	2.02
	Linalyl butyrate	nd	2.97	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	3.15
	Acetic acid	nd	nd	2.57	nd	nd	5.49	5.75	4.81	nd	nd	10.48	1.74	nd	nd
	Megastigma-4,6(E), 8(E)-triene	3.41	nd	nd	nd	nd	nd	nd	nd	nd	nd	0.54	nd	nd	nd
Terpenes	β-Myrcene	2.12	4.58	nd	2.02	4.77	1.03	0.62	2.78	2.99	9.38	2.93	3.28	5.99	nd
	α-Terpinene	0.85	nd	nd	nd	1.78	3.24	0.33	nd	0.8	1.58	nd	nd	nd	nd
	D-Limonene	0.95	2.03	0.89	0.7	2.65	1.36	0.7	0.91	1.66	3.7	1.19	1.93	2.08	1.19
	β-cis-ocimene	0.76	2.4	1.07	0.415	2.65	1.88	1.05	1.14	nd	4.19	2.34	3.2	2.63	nd
	cis-β-terpineol	nd	nd	nd	0.62	nd	nd	nd	nd	nd	nd	nd	37.6	nd	nd

^zKH = Kuchexiaobaixing; GX = Guoxiyuluke; KL = Kuerleituoyong; DB = Dabaiyou; HY = Heiyexing; DX = Danxing; KC = Kuchetuoyong; KK = Kuikipiman; DY = Dayoujia; SM = Sumaiti; KM = Kumaiti; LT = Luotuhuang; ML = Mulongxing; AK = Aketuoyong.

^yNot detected.

Table 4. Aromatic categories and concentrations in pulp of 14 apricot cultivars from southern Xinjiang, China.

Cultivar	NIC ^z	Aroma volatile concn ($\mu\text{g}\cdot\text{g}^{-1}$)						
		Esters	Aldehydes	Alcohols	Terpenes	Ketones	Acids	Alkyls
Kuchexiaobaixing	42	59.55 c ^y	5.83 c	20.27 e	3.236 d	3.67 b	nd ^x	9.55 c
Guoxiyuluke	58	52.31 d	10.75 a	23.2 d	3.604 d	0.78 d	nd	12.67 b
Kuerleituoyong	54	67.95 b	2 c	22.28 d	0.784 f	0.57 d	2.57 d	3.82 e
Dabaiyou	54	53.78 d	6.12 c	25.15 d	1.452 e	5.46 a	nd	9.38 c
Heiyexing	52	23.22 h	11.28 a	32.65 c	34.74 b	0.64 d	nd	21.19 a
Danxing	47	9.42 k	7.71 b	64.68 a	3.004 d	3.8 b	5.49 c	8.9 c
Kuchetuoyong	59	59.04 c	6.86 b	23 d	1.08 e	1.54 c	5.81 c	3.75 e
Kuikipiman	61	57.49 c	3.25 d	26.98 d	1.932 e	0.53 d	4.81 c	6.93 d
Dayoujia	40	59.79 c	5.46 c	15.22 f	2.18 e	7.27 a	nd	11.44 c
Sumaiti	42	20.75 h	10.89 a	39.33 b	12.54 c	1.1 c	nd	26.32 a
Kumaiti	48	29.24 g	8.25 b	34.46 b	2.8 e	6.27 a	10.48 b	10.81 c
Luotuohuang	40	35.77 f	1.52 e	41.28 b	48.4 a	1.51 c	1.74 d	10.59 c
Mulongxing	46	47.7 e	9.47 a	15.76 f	4.28 d	1.77 c	24.38 a	0.91 f
Aketuoyong	47	75.46 a	7.7 b	7.66 g	0.476 d	1.81 c	nd	6.14 d
NOC ^z	208	80	25	39	15	21	1	27

^zNIC = numbers identified from all cultivars; NOC = number of compounds.

^yMeans with different letters within a column are significantly different at $P < 0.05$ by LSD test.

^xNot detected.

10 compounds were the main characteristic aroma volatiles in Xinjiang apricot cultivars (Table 4). In this study, only six common aroma volatiles were found in the studied cultivars; this result is consistent with the previous work. Terpenol was considered to be the characteristic aroma volatile in apricot (Takeoka et al., 1990). However, Guichard et al. (1990) found that lactones should be the main characteristic aroma compounds of apricot. These studies showed that the typical aroma of apricot should be dependent on the interaction of a large number of aroma volatiles; the role of one compound is very limited, and it may be replaced by other aroma compounds.

UNIQUE AROMA VOLATILES IN XINJIANG APRICOT CULTIVARS. High contents of other specific compounds were also detected in some studied cultivars (Table 3). The level of 2-methyl-3-pentenal in 'Guoxiyuluke' was more than $0.232 \mu\text{g}\cdot\text{g}^{-1}$. Hexanoic acid-4-hexene-1-ester and butyl 2-methylbutyrate were present at 0.97 and $1.583 \mu\text{g}\cdot\text{g}^{-1}$, respectively. The level of ethyl α -hydroxy-butyrate in 'Dabaiyou' was over $1.69 \mu\text{g}\cdot\text{g}^{-1}$. The contents of β -cyclocitral and γ -butyrolactone in 'Kuerleituoyong' were 1.24 and $0.99 \mu\text{g}\cdot\text{g}^{-1}$, respectively. Ethyl 2-methylbutyrate, 3-hexylfuran, 3,7-dimethyl-1,6-octadien-3-yl butyrate, and hexylbutyrate were the main aroma volatiles in 'Aketuoyong'. The level of 6,6-dimethyl-2-methylenebicyclo heptane and 5E-2, 6-dimethyl-1,6-octadien-2-ol in 'Heiyexing' were 2.413 and $1.32 \mu\text{g}\cdot\text{g}^{-1}$. 2,3-Dimethyl-pentanal and γ -decalactone were the main aroma volatiles in 'Danxing'. 2,2,4-Trimethyl-1, 3-pentanediol and ocimenol were the main aroma compounds in 'Sumaiti'. The level of formic acid 3-methyl-1-butyl ester and ethyl 2-methylpropanoate in 'Kumaiti' were 1.29 and $3 \mu\text{g}\cdot\text{g}^{-1}$, respectively. Apricot aroma depends not only on the concentration but also on the threshold of aroma compounds. Therefore, although low concentrations of many aroma compounds were detected in Xinjiang apricot cultivars, the low threshold of some compounds should be emphasized.

COMPARISON OF AROMA VOLATILES FOR DIFFERENT CULTIVARS. As shown in Table 4, 'Kuchexiaobaixing', 'Guoxiyuluke', 'Kuerleituoyong', 'Dabaiyou', 'Kuchetuoyong', 'Kuikipiman', 'Dayoujia', 'Luotuohuang', 'Mulongxing', and 'Aketuoyong'

were characterized by high level of esters. Based on report (Zhang et al., 2009), these 10 cultivars were considered to have the fruity aroma of Xinjiang apricot. Higher levels of alcohols were observed in 'Heiyexing', 'Danxing', 'Sumaiti', and 'Kumaiti'. These are the green aroma cultivars. Significant differences of aroma volatiles were found among all of the studied cultivars. Among all of the studied cultivars, the highest content of esters was found in 'Aketuoyong' ($75.45 \mu\text{g}\cdot\text{g}^{-1}$), and 'Danxing' had the lowest ester content ($9.42 \mu\text{g}\cdot\text{g}^{-1}$). The highest level of aldehydes was found in 'Heiyexing' ($11.27 \mu\text{g}\cdot\text{g}^{-1}$), whereas aldehyde in 'Luotuohuang' was only $1.52 \mu\text{g}\cdot\text{g}^{-1}$. 'Danxing' had the highest ketone content ($7.27 \mu\text{g}\cdot\text{g}^{-1}$), with only $0.53 \mu\text{g}\cdot\text{g}^{-1}$ of ketones found in 'Kuikipiman'.

Acids ($19.38 \mu\text{g}\cdot\text{g}^{-1}$) were detected in 'Mulongxing', but no acid was detected in 'Kuchexiaobaixing', 'Guoxiyuluke', 'Dabaiyou', 'Kuchetuoyong', 'Kuikipiman', 'Dayoujia', 'Sumaiti', or 'Aketuoyong'. 'Danxing' had the highest level of alcohols ($64.68 \mu\text{g}\cdot\text{g}^{-1}$) and $7.66 \mu\text{g}\cdot\text{g}^{-1}$ alcohols were found in 'Aketuoyong'. 'Sumaiti' had the highest level of alkyl compounds ($26.33 \mu\text{g}\cdot\text{g}^{-1}$), only $0.91 \mu\text{g}\cdot\text{g}^{-1}$ alkyl compounds was detected in 'Mulongxing'.

PCA MODEL ACCORDING TO FLAVOR COMPOUND. A PCA model provided an overview of the relationships within the whole dataset. PC1 and PC2 accounted for 72% and 23% of the total variability, respectively. When all of the volatile compounds, including esters, aldehydes, ketones, acids, alcohols, and alkyls, were used to characterize apricot fruit at harvest, the fruit of different cultivars could be distinguished from each other (Fig. 1A). In a scores plot, 'Kuchexiaobaixing', 'Guoxiyuluke', 'Kuerleituoyong', 'Dabaiyou', 'Kuchetuoyong', 'Kuikipiman', 'Dayoujia', 'Mulongxing', and 'Aketuoyong' were grouped in cluster A (Fig. 1A) and were characterized by high level of esters (Fig. 1B). 'Luotuohuang' and 'Heiyexing' were clustered into one group B (Fig. 1A) and were characterized by a high level of terpenes (Fig. 1B). 'Danxing', 'Sumaiti', and 'Kumaiti' were clustered into group C (Fig. 1A) and were characterized by high levels of aldehydes and alcohols (Fig. 1B). These changes are consistent with the GC-MS results.

The contribution of aroma compounds to the customer's aroma acceptability based on the PLSR model.

To know the concrete contribution of all of the aroma compounds responsible for the customer's aroma acceptability, a PLSR model was developed with the aim of identifying the dominant variables influencing consumer aroma acceptability (Fig. 2). As shown in Fig. 2, aroma acceptability was positive for ketones, esters, and terpenes; whereas acceptability was negative for aldehydes, alcohols, alkyl compounds, and acids. Among these volatiles, esters, and terpenes were the greatest contributors to the aroma acceptability of Xinjiang apricot, with aldehydes and alcohols second. The PLSR model strongly confirmed the GC-MS and PCA results. This identified the

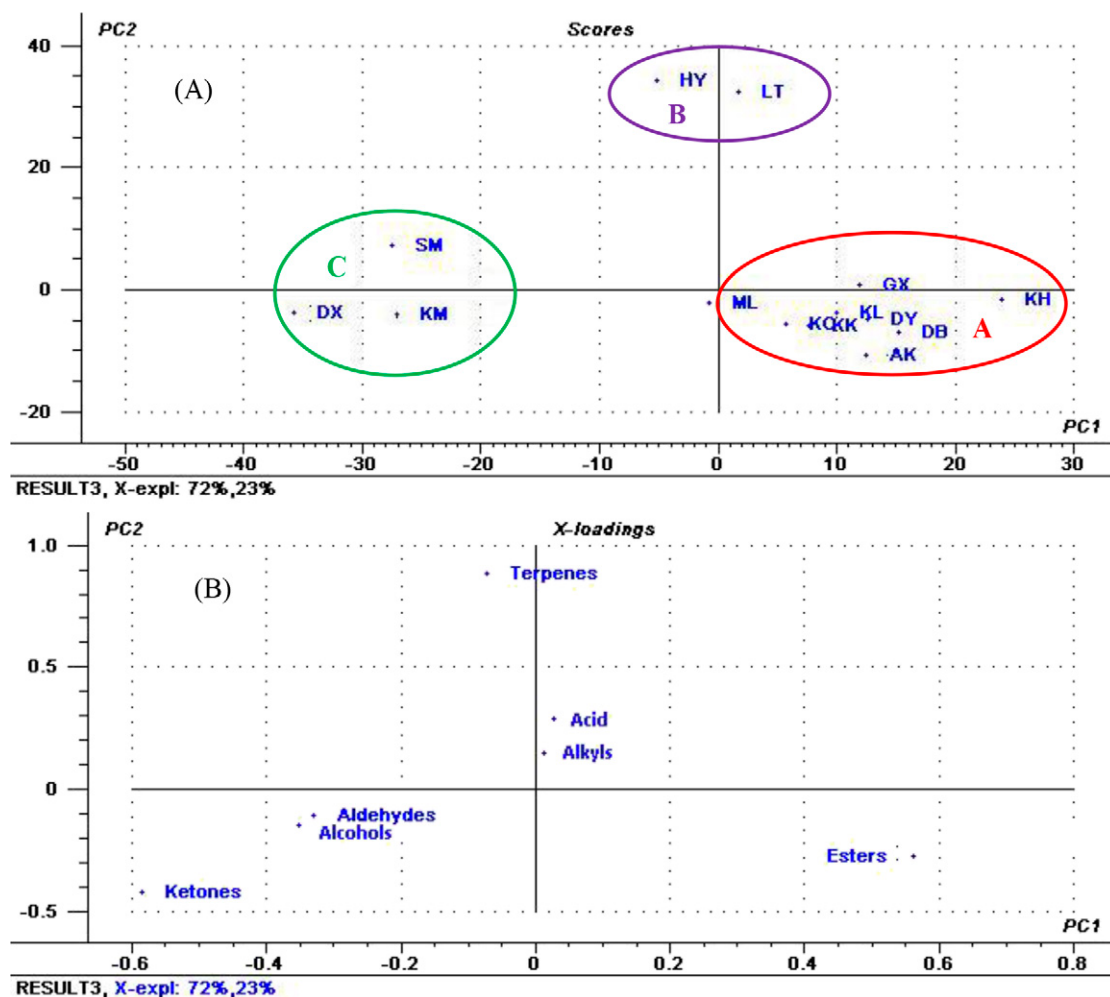


Fig. 1. Differences in the aroma composition and content including aldehydes, alcohols, esters, lactones, C13 norisoprenoids, sugar, organic acid, and flavor among fruit of 14 apricot cultivars after harvest and 5 d at ambient temperature. Fruit were analyzed and the main characteristic aroma volatiles were ascertained by using principal component analysis (PCA) of gas chromatography-mass spectroscopy (GC-MS) results: (A) PCA scores plot, (B) volatile compound loading plot according to the PCA model: KH = Kuchexiaobaixing; GX = Guoxiyulvke; KL = Kuerletuoyong; DB = Dabaiyou; HY = Heiyexing; DX = Danxing; KC = Kuchetuyong; KK = Kuikepiman; DY = Dayoujia; SM = Sumaiti; KM = Kumaiti; LT = Luotuohuang; ML = Mulongxing; AK = Aketuoyong.

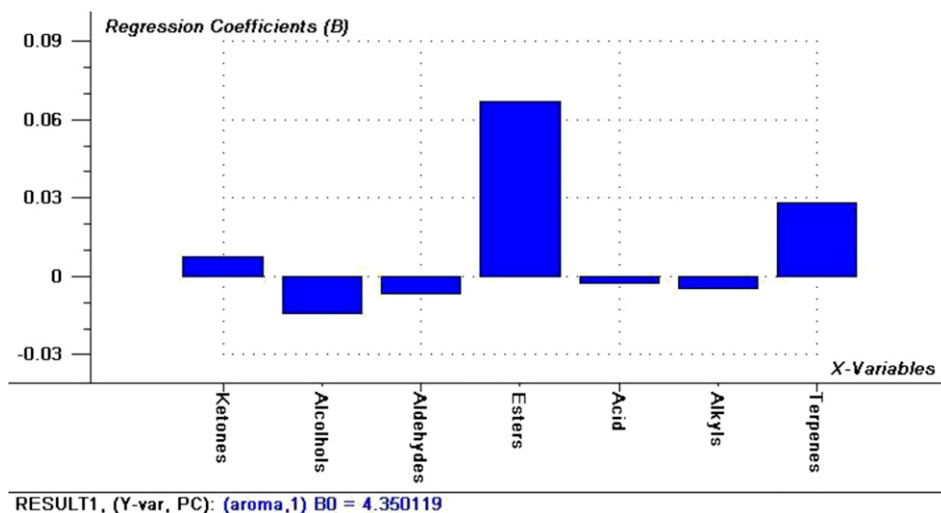


Fig. 2. Loading weight plot of principal components, PC1 vs. PC2 from a partial least squares regression (PLSR) model of volatile compounds, quality parameters, and sensory attributes (x variables) vs. consumer acceptability (y variables) for apricot fruit after harvest and 5 d at ambient temperature.

genetic components involved in the quality of these fruit to facilitate breeding of new cultivars meeting the consumer's expectations.

Conclusion

Overall, the main cultivars of apricot cultivated in Xinjiang are abundant in aroma volatiles. In total, 208 aroma volatiles were identified from these cultivars, including 80 esters, 25 aldehydes, 15 terpenes, 21 ketones, 39 alcohols, 27 olefins, and 1 acid. The GC results indicated that the main volatile constituents were propyl acetate, 3-methyl-1-butanol acetate, (Z)-3-hexen-1-ol acetate, D-limonene, β -linalool, hexanal, hexyl acetate, butyl acetate, β -myrcene, ethyl butanoate,

and β -cis-ocimene. ‘Kuchexiaobaixing’, ‘Guoxiyuluke’, ‘Kuerleituoyong’, ‘Dabaiyou’, ‘Kuchetuoyong’, ‘Kuikepi-man’, ‘Dayoujia’, ‘Mulongxing’, and ‘Aketuoyong’ were characterized by a high level of esters, and were considered to be fruity aroma apricot. Higher levels of alcohols and aldehydes were observed in ‘Danxing’, ‘Sumaiti’, and ‘Kumaiti’; they are the green aroma cultivars. ‘Luotuohuang’ and ‘Heiyexing’ accumulate high levels of terpenes and exhibited an outstanding floral aroma. In the analysis of the PCA model, all of the separated fruity aroma cultivars were consistent with the GC-MS results.

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