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Research Article
Comparison on Flavor Compounds of Jujube Brandies Brewed from Eleven Varieties

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Abstract

Background and Objective: Grape brandy and apple cider both have proper varieties for making wine. Faced with so many jujube varieties, in this study determined the suitable choice of jujube variety for brewing high quality brandy. **Methodology:** Odor activity value, principal component analysis and cluster analysis were used to compare the feature and flavor compounds of eleven kinds of jujube brandies. Data were statistically analyzed by the software of SPSS. **Results:** Esters are the most important odor-active compounds of jujube brandy, followed by acids and alcohols, specifically including ethyl caproate, ethyl octanoate, ethyl benzoate, ethyl decanoate, octanoic acid, decanoic acid, lauric acid and phenethyl alcohol. Fuping, Xingtang and Huizao jujube brandy had the most odor-active compounds, Junzao had the most unique aroma. Fuping jujube brandy rank first on the total peak area of aroma, followed by Huping, Cangzhou and Yuanling. **Conclusion:** Jujube variety of Fuping, Huping and Cangzhou are suitable for brewing brandy.

Key words: Jujube variety, jujube brandy, principal component analysis, cluster analysis, brewing brandy

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Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

Jujube brandy is produced by solid-state fermentation, solid-state distillation and aging, using Chinese jujube as raw material[1-3]. However, the development of jujube brandy market is severely restricted because of absence of mature production technology[4-6]. The brewing technology of grape and apple brandy has already been quite mature and suitable high-quality varieties for brewing wine have been clear[7-8]. For example, Cabernet Franc, Cabernet Sauvignon, Chardonnay and Riesling are good grape choice for brewing wine and Breakwellings seedling, Nehou, Reine Des Hative and Taylors are suitable apple choice[9-11]. Faced with a wide variety of jujube, it is essential to determine suitable kinds of jujube for brewing brandy, which is one of the focuses of the jujube brandy manufacturer[12-15].

The variety and quality of raw material directly decide the quality of brandy[16-17]. Plenty of reducing sugar is necessary for fermentation, amino acids are important precursors of many aroma compounds[18-19]. Fruit ingredient composition is one of the important sources of brandy aroma[20-22]. Content of sugar, amino acids, flavor compounds in different jujube are not the same due to the different varieties and origin. Choosing the suitable jujube varieties is the key to brew high quality jujube brandy.

Alcohol content and aroma components of jujube brandy are the main assessment criteria. Wine aroma, one of the most important characteristics of wine quality, represents a good balance of several hundred volatile compounds. The quality of wine is closely related to its aroma components[23-24]. Different groups of volatile compounds, such as alcohols, esters, aldehydes, lactones, terpenes and phenols, have been identified in wines in a wide concentration range. These groups affect wine aroma even at low concentrations. Among the volatiles, alcohols and esters have the highest contents in wines. Esters are important constituents of wine aroma and they possess high fruity nuances[25]. Higher alcohols are the main byproduct in the fermentation process, can make wine full bodied and mellow[26-27]. In jujube brandy, isoamyl alcohol and isobutanol are the major higher alcohols, then propanol, butanol and pentanol[28-29]. Excessive higher alcohols make wine taste bitter, may result in a headache, dizziness and vomiting, low higher alcohols content let the smell thin and heavy water, so proper higher alcohols are one of the evaluation criteria of distillation wine quality[30].

The aim of this study was to determine the feature of jujube brandies from different varieties and relationship between jujube variety and aroma compounds of jujube brandies. Odor activity value, principal component analysis and cluster analysis were used to compare the feature and flavor compounds of eleven kinds of jujube brandies, to find suitable jujube choice of making brandy and improve the quality of jujube brandy.

MATERIALS AND METHODS

Samples

Eleven kinds of Jujube varieties: Junzao (Shanxi, 34°36'-40°44' N, 110°15'-14°32' E), Huping (Shanxi, 34°36'-40°44' N, 110°15'-114°32' E), Fuping (Fuping, 38°9'-39°7' N, 113°45'-114°31' E), Cangzhou (Cangzhou, 38°3' N, 116°83' E), Xingtang (Xingtang, 114°23' N, 38°19' E), Huizao (Xinjiang, 34°25'-48°10' N, 73°40'-96°18' E), Hetian (Xinjiang, 34°25'-48°10' N, 73°40'-96°18' E), Goutou (Shanxi, 33.71 N, 110.35 E), Linze (Gansu, 39°13' N, 100°17' E), Xinzheng (Xinzheng, 34°16'-34°39' N, 113°30'-113°54' E) and Yuanling (Shandong, 34°22'-38°23' N, 114°19'-122°43' E). The jujubes selected for this study were harvested in 2015. Jujube brandy is produced by solid fermentation, solid distillation and aging (The average alcohol is 50%), which wine making process was that usual in China[1]. The study was carried out in September, 2016, 3 replications have been done in each test.

Jujube brandy brewing process: Brewing process of jujube brandy:

- Shredded jujube was added to equal water, then soaked 5-6 h
- Boiled, added 1/6 rice hull after cooling
- About 0.5% yeast was taken in 100 mL of 2% glucose water, 40°C water bath for 30 min. Then activated yeast was inoculated, maintained fermentation for 6 days under 28°C
- Jujube brandy sample was obtained by distilling fermentation materials 2 times

Analysis of enological parameters: The reducing sugar, total acid and alcoholic degree were evaluated following the OIV official analytical methods.

GC-FID analysis of higher alcohols: Higher alcohols of jujube brandy were detected by GC-FID (Agilent 7890A Gas Chromatograph, Santa Clara, USA), quantified using an external standard. A DB-FFAP column (60 m×0.25 mm ID and 0.25 μm film thickness) was used for separation. The working parameters were as follows: Injector temperature of 220°C and FID temperature of 300°C. The initial

Table 1: Regression equation, linear range and detection limit of higher alcohols

Higher alcohols	Standard curves	Correlation coefficient (r^2)	Linear range (mg mL^{-1})	Detection limit (mg)
Methanol	Y = 17.43X-3.60	0.9969	0.50~16.00	0.095
N-propanol	Y = 419.27X+0.73	0.9995	0.10~2.00	0.003
Isobutanol	Y = 494.22X-0.05	0.9995	0.10~2.00	0.004
N-butanol	Y = 472.12X+0.01	0.9994	0.025~0.50	0.002
Isoamyl alcohol	Y = 499.34X+5.17	0.9995	0.10~2.00	0.003
N-pentanol	Y = 487.56X-0.47	0.9995	0.10~2.00	0.007

temperature was 45°C for 3 min, which was increased to 130°C at a rate of 6°C min^{-1}, then increased to 140°C at a rate of 2°C min^{-1}. The temperature was further raised to 220°C at 15°C min^{-1}. The carrier gas had a flow rate of 2.0 mL min^{-1}. Samples of 0.7 μL were injected using the split mode of 30:1. Ethanol of jujube brandy was detected by alcohol meter. Regression equation, linear range and detection limit show as Table 1.

SPME-GC-MS analysis of flavor compounds: Jujube brandy was diluted by distilled water (10% alcohol content). Sodium chloride (1 g) was added to 7.5 mL of sample solution in a 20 mL sealed glass vial. The sample was exacted at 40°C for 40 min with 50/30 μm DVB/CAR/PDMS fiber, then used to GC-MS analysis.

Flavor compounds of jujube brandy were detected by GC-MS. The contents of flavor compounds were quantified using an internal standard (3-octanol, 99%, Sigma-Aldrich). Wine volatile compounds were analyzed using an Agilent 5975 Mass Spectrometer coupled to an Agilent 7890A Gas Chromatograph (Agilent, Santa Clara, USA). A DB-WAX column (60 m×0.25 mm ID and 0.25 μm film thickness) was used for separation. The working parameters were as follows: Injector temperature of 250°C, EI source of 230°C, MS Quad of 150°C and transfer line of 250°C. The initial temperature was 50°C for 3 min, which was increased to 80°C at a rate of 3°C min^{-1}. The temperature was further raised to 230 at 5°C min^{-1} and maintained at 230°C for 6 min. The carrier gas had a flow rate of 1.0 mL min^{-1}. Samples were injected using the splitless mode. A mass range of 50-550 m/z was recorded at one scan sec^{-1}. Flavor compounds were identified by Nist 2005 library of GC-MS.

Statistical analysis: Every determination was repeated 3 times and 2 replications of one treatment were performed. All the data were statistically analyzed by the software of SPSS 17.0 (SPSS Inc., Chicago, IL, USA), prominent differences levels including 0.05 (a)-significant differences ($p<0.05$) and 0.01 (A)-highly significant differences ($p<0.01$).

RESULTS AND DISCUSSION

Comparison of enological parameters: Significant difference appeared about the concentration of reducing sugar, total acid and alcohol in different kinds of jujube varieties (Table 2, $p<0.05$). Reducing sugar in raw material is power and energy for wine fermentation, lower content of reducing sugar directly influence wine fermentation and the formation of alcohol[31]. The content of reducing sugar can be divided into three levels from high to low: Fuping, Cangzhou, Xingtang as the first level (49.049-52.843 g/100 g), Xingtang has the highest content, Huizao, Linze, Xinzheng, Yuanling as the second level (38.358-46.178 g/100 g), Junzao, Huping, Hetian, Goutou as the third level (26.191-31.397 g/100 g) and Junzao has the lowest content. Jujube can also be divided into three levels according to total acid concentration. Total acid concentration of Goutou jujube is obviously higher than other varieties (0.83 g/100 g), Junzao, Fuping, Xingtang, Hetian and Linze maintained at about 0.50 g/100 g, the rest jujube varieties with total acid 0.20 g/100 g. Under the same fermentation and one-time distillation condition, Huping has the highest alcohol content (34°C), followed by Hetian, Junzao, Huizao, Goutou, Fuping and Cangzhou, reach 25-30°C, while Xingtang, Linze, Xinzheng and Yuanling has the lowest alcohol content. Therefore, Fuping, Cangzhou, Xingtang jujube had more power and energy for wine fermentation while Huping and Hetian jujube are beneficial for alcohol production. In the previous study, the reducing sugar content of jujube to approximately 42% is very suitable for fermenting alcoholic beverages[1]. It seems Fuping, Cangzhou, Xingtang jujube are better choice for brewing brandies.

Comparison of higher alcohols of jujube brandy: The total content of higher alcohols can be divided into three grades: Cangzhou and Huizao take the first grade with content of above 1.9 g L^{-1}, Junzao, Huping, Xingtang, Goutou and Linze take the second grade with content of 1-2 g L^{-1}, Fuping, Hetian, Xinzheng and Yuanling take the third grade with content of 1 g L^{-1}. Isopropanol was not found in Junzao and

Table 2: Comparison of enological parameters

Sample	Junzao	Huping	Fuping	Cangzhou	Xingtang	Huizao	Hetian	Goutou	Linze	Xinzheng	Yuanling
Reducing sugar (g/100 g)	26.191±0.425	27.338±0.204	49.726±0.185	49.049±0.20	52.843±0.174	38.358±0.133	31.397±0.214	29.617±0.368	45.162±0.402	40.437±0.284	46.178±0.324
Total acid(g/100 g)	0.500±0.04	0.310±0.03	0.490±0.05	0.190±0.02	0.480±0.02	0.240±0.03	0.540±0.04	0.830±0.05	0.420±0.02	0.150±0.01	0.280±0.01
Alcohol (%, v/v)	26.000±0.20	34.000±0.5	26.500±1.00	26.300±0.80	24.000±0.60	27.000±0.40	28.000±0.70	26.000±0.40	22.500±1.00	21.000±0.40	22.300±0.30

Values are the Means±standard deviation (n = 3)

Huping, n-butanol can only be detected in Hetian, Goutou, Linze and Xinzheng (Table 3). Excessive and low higher alcohols concentration are not suggested, higher alcohols content of high quality jujube brandy were less than 2 g L^{-1} [30], Junzao, Huping, Xingtang, Goutou and Linze jujube bandies (the second grade) had suitable content of higher alcohols.

Comparison of OAV: Esters are the most important odor-active compounds for jujube brandy, followed by acids and alcohols, specifically including hexenoic acid ethyl ester, octanoic acid ethyl ester, phenylpropionic acid ethyl ester, decanoic acid ethyl ester, octanoic acid, decanoic acid, lauric acid and phenethyl alcohol. In order to understand the contribution of each compound to odor quality, it is not sufficient just to know whether these compounds are present or absent, one also must have knowledge of how they are perceived at given concentrations[32]. OAV is a measure of evaluating a compound contributes to aroma and when OAV is greater than 1, it is believed contribute to the aroma, when OAV is greater than 10, it is considered an important aroma component[33]. The variety of Fuping, Xingtang and Huizao held the most odor-active compounds (11), especially compounds of OAV>500 in Fuping surpass the other two and Goutou showed the least odor-active compounds of all the varieties (7). According to the comparison of odor-active compounds, the rank of jujube varieties is Fuping, Huizao, Xingtang, Cangzhou, Huping, Xinzheng, Yuanling, Goutou, Junzao, Linze, Hetian (Table 4).

Comparison of aroma compounds of jujube brandy: About 194 kinds of flavor compounds were detected in different varieties of jujube brandies, including 70 esters, 14 alcohols, 6 acids, 34 aldehyde and ketone and 34 hydrocarbons (Table 6). Main flavor compounds of jujube are esters, aldehyde and ketone, acids and hydrocarbons. Total peak area of aroma rank: Fuping>Huping, Cangzhou, Yuanling>Hetian, Linze, Huizao, Xingtang, Goutou>Xinzheng, Junzao (Fig. 1).

Esters: Main esters in jujube brandy are ethyl esters of lauric acid, decanoic acid, octylic acid and nonanoic acid, followed by ethyl esters of undecanoic acid, tetradecanoic acid, heptanoic acid and hexanoic acid. About 107 kinds of esters were detected in different varieties of jujube brandies, including 12 straight-chain ethyl esters, 3 branched-chain acid esters, 12 branched-chain alcohol esters, 10 unsaturated esters, 11 aromatic esters, 4 acetate, 6 methanol esters. Straight-chain ethyl esters were also main esters. Fuping has the most ester peak area, followed by Huping and Yuanling.

Table 3: Comparison of higher alcohols of different kinds of jujube brandies

Higher alcohols	Isopropanol	N-propanol	Isobutanol	N-butanol	Isopentanol	Active amyl alcohol	Total
Junzao	-	0.167±0.006	0.138±0.004	-	0.633±0.005	0.799±0.003	1.737[c]
Huping	-	0.274±0.012	0.116±0.003	-	0.535±0.006	0.713±0.006	1.638[e]
Fuping	0.145±0.008	0.043±0.002	0.087±0.002	-	0.651±0.008	0.143±0.004	1.069[i]
Cangzhou	0.224±0.010	0.070±0.004	0.178±0.008	-	1.240±0.012	0.284±0.002	1.996[a]
Xingtang	0.170±0.006	0.059±0.003	0.139±0.006	-	0.946±0.011	0.285±0.006	1.599[f]
Huizao	0.192±0.009	0.070±0.005	0.220±0.010	-	1.170±0.014	0.256±0.007	1.908[b]
Hetian	0.205±0.011	0.190±0.011	0.075±0.003	0.037±0.002	0.408±0.009	0.064±0.002	0.979[j]
Goutou	0.196±0.007	0.103±0.006	0.137±0.006	0.054±0.002	0.744±0.010	0.140±0.006	1.374[g]
Linze	0.193±0.005	0.111±0.008	0.149±0.006	0.037±0.001	0.973±0.016	0.241±0.003	1.704[d]
Xinzheng	0.180±0.006	0.266±0.012	0.111±0.009	0.019±0.003	0.314±0.008	0.082±0.002	0.972[k]
Yuanling	0.151±0.004	0.045±0.006	0.093±0.004	-	0.635±0.012	0.151±0.008	1.075[h]

Values are Mean±SD, letters (a, b, c, d, etc) represent significance difference ($p<0.05$) in total values, Unit: g L^{-1}

Table 4: OAV value of eleven jujube varieties

Liquor samples	OAV>500	500≥OAV 100	100≥OAV 10	OAV>1
1	Octanoic acid, ethyl ester	Hexanoic acid, ethyl ester, Benzenepropanoic acid, ethyl ester	Nonanoic acid, ethyl ester, Benzoic acid, ethyl ester	Heptanoic acid, ethyl ester, Decanoic acid, Dodecoic acid
2	Hexanoic acid, ethyl ester, Octanoic acid, ethyl ester, Decanoic acid, ethyl ester	Nonanoic acid, ethyl ester, Benzoic acid, ethyl ester, Benzenepropanoic acid, ethyl ester	Acetic acid, 2-phenylethyl ester	Heptanoic acid, ethyl ester, 3-methyl-1-Butanol
3	Hexanoic acid, ethyl ester, Octanoic acid, ethyl ester, Benzenepropanoic acid, ethyl ester	Decanoic acid, ethyl ester	Nonanoic acid, ethyl ester, Benzoic acid, ethyl ester, Acetic acid, 2-phenylethyl ester	Heptanoic acid, ethyl ester, Phenylethanol, Octanoic acid, Dodecoic acid
4	Hexanoic acid, ethyl ester, Octanoic acid, ethyl ester		Nonanoic acid, ethyl ester, Decanoic acid, ethyl ester, Benzoic acid, ethyl ester, Benzenepropanoic acid, ethyl ester	Heptanoic acid, ethyl ester, Acetic acid, 2-phenylethyl ester, Decanoic acid, Dodecoic acid
5	Octanoic acid, ethyl ester	Hexanoic acid, ethyl ester, Decanoic acid, ethyl ester, Benzenepropanoic acid, ethyl ester	Benzoic acid, ethyl ester, Acetic acid, 2-phenylethyl ester	Heptanoic acid, ethyl ester, Nonanoic acid, ethyl ester, Phenethanol, Decanoic acid, Dodecoic acid
6	Octanoic acid, ethyl ester	Hexanoic acid, ethyl ester, Decanoic acid, ethyl ester, Benzenepropanoic acid, ethyl ester	Nonanoic acid, ethyl ester, Benzoic acid, ethyl ester, Acetic acid, 2-phenylethyl ester	Phenethanol, Octanoic acid, Decanoic acid, Dodecoic acid
7	Octanoic acid, ethyl ester	Hexanoic acid, ethyl ester, Decanoic acid, ethyl ester	Nonanoic acid, ethyl ester, Benzoic acid, ethyl ester, Benzenepropanoic acid, ethyl ester	Heptanoic acid, ethyl ester
8	Hexanoic acid, ethyl ester	Decanoic acid, ethyl ester, Benzenepropanoic acid, ethyl ester	Nonanoic acid, ethyl ester, Benzoic acid, ethyl ester	Heptanoic acid, ethyl ester, Acetic acid, 2-phenylethyl ester, Octanoic acid, Decanoic acid
9	Octanoic acid, ethyl ester	Hexanoic acid, ethyl ester, Decanoic acid, ethyl ester	Nonanoic acid, ethyl ester, Benzoic acid, ethyl ester, Benzenepropanoic acid, ethyl ester	Heptanoic acid, ethyl ester, Acetic acid, 2-phenylethyl ester
10	Octanoic acid, ethyl ester, Decanoic acid, ethyl ester	Hexanoic acid, ethyl ester, Benzenepropanoic acid, ethyl ester	Nonanoic acid, ethyl ester, Benzoic acid, ethyl ester	Octanoic acid, Decanoic acid, Dodecoic acid
11	Hexanoic acid, ethyl ester, Octanoic acid, ethyl ester	Decanoic acid, ethyl ester, Benzenepropanoic acid, ethyl ester	Nonanoic acid, ethyl ester, Benzoic acid, ethyl ester	Heptanoic acid, ethyl ester, Acetic acid, 2-phenylethyl ester, Decanoic acid

Four unique compounds can be found in Junzao, including Benzoic acid, ethyl ester, Ethyl 9-decenoate, Ethyl trans-2-decenoate and Benzoic acid, 2-hydroxy-, ethyl ester. Butanoic acid, 3-methyl-, ethyl ester, 10-Bromodecanoic acid, ethyl ester, Nonanoic acid, 9-bromo-, ethyl ester and Decanedioic acid, diethyl ester can only be detected in Yuanling, Xingtang, Cangzhou and Fuping, respectively (Table 5).

Alcohols and acids: Main alcohols in jujube brandy are isopentanol, phenylethanol, isobutanol and hexanol. Cangzhou and Huping jujube brandy have more unique alcohols. Cangzhou has unique trans-2-Undecen-1-ol, 1-Decanol and (Z)-3-Nonen-1-ol. Huping has 1-Octanol and 1-Dodecanol. Junzao has Benzyl alcohol. Main acid in jujube brandy are decanoic acid and lauric acid, followed by octoic

Table 5: Comparison on peak area of aroma compounds of different kinds of jujube brandies

	Junzao	Huping	Fuping	Cangzhou	Xingtang	Huizao	Hetian	Goutou	Linze	Xinzheng	Yuanling
Esters	8.71E+09	1.50E+10	1.81E+10	1.19E+10	1.02E+10	1.03E+10	1.22E+10	1.07E+10	1.08E+10	1.09E+10	1.30E+10
Alcohols	3.77E+08	6.23E+08	1.17E+09	1.90E+09	1.30E+09	1.43E+09	4.51E+08	6.72E+08	1.10E+09	1.29E+08	9.35E+08
Acids	4.09E+08	0.00E+00	1.49E+08	5.68E+08	5.00E+08	4.00E+08	2.48E+08	2.33E+08	1.81E+08	3.08E+08	2.96E+08
Aldehydes and ketone	9.99E+08	1.66E+08	1.63E+08	2.38E+08	1.20E+08	1.04E+08	2.23E+08	4.44E+08	2.20E+08	8.37E+07	1.69E+08
Hydrocarbons	6.85E+08	2.54E+08	4.90E+08	2.86E+08	2.08E+08	1.95E+08	1.44E+08	1.54E+08	2.03E+08	1.96E+08	4.27E+08
Others	2.13E+08	85255070	82892262	1.1E+08	54895755	64255306	89802983	55794504	68826447	43512341	1.33E+08
Total	1.14E+10^{j}	1.61E+10^{b}	2.02E+10^{a}	1.50E+10^{c}	1.24E+10^{g}	1.25E+10^{f}	1.34E+10^{d}	1.23E+10^{h}	1.26E+10^{e}	1.17E+10^{i}	1.50E+10^{c}

Peak area values are expressed in scientific notation, letters (a, b, c, d, etc) represent significance difference ($p<0.05$) in total values

Table 6: Comparison of flavor compounds of jujube brandy

Time	Aroma (mg L^{-1})	Junzao	Huping	Fuping	Cangzhou	Xingtang	Huizao	Hetian	Goutou	Linze	Xinzheng	Yuanling
Ethyl esters												
5.36	Butanoic acid, 3-methyl-, ethyl ester	-	-	-	-	-	-	-	-	-	-	0.644
6.41	Pentanoic acid, ethyl ester	-	2.564	1.516	1.692	0.629	0.461	0.713	1.172	0.874	-	1.669
8.12	Hexanoic acid, ethyl ester	25.292	92.271	63.046	41.17	21.952	17.926	16.065	30.555	21.842	14.403	38.937
9.94	Heptanoic acid, ethyl ester	19.917	94.141	41.931	35.256	14.69	-	22.584	47.323	29.823	8.342	45.04
10.27	Ethyl 2-hexenoate	1.784	-	1.139	-	0.481	0.447	0.649	-	-	0.725	1.2
11.74	Octanoic acid, ethyl ester	87.656	745.491	245.321	173.056	52.605	92.572	86.31	-	126.33	81.586	133.766
12.09	2-Heptenoic acid, ethyl ester, (E)-	2.36	5.23	4.542	1.244	2.114	1.94	2.075	4.368	3.779	-	3.439
12.7	3-Octenoic acid, ethyl ester	-	8.979	5.611	6.157	-	-	-	-	-	-	6.43
13.38	Nonanoic acid, ethyl ester	33.532	437.751	83.83	57.047	27.364	55.157	42.165	157.475	57.702	49.495	53.531
14.25	3-Nonenoic acid, ethyl ester	-	6.182	-	-	-	-	-	-	0.845	-	-
15.01	Decanoic acid, ethyl ester	-	1848.067	406.168	38.097	386.856	300.008	282.736	510.135	287.351	604.75	333.776
15.48	4-Decenoic acid, ethyl ester, (Z)-	-	46.88	-	-	-	-	-	-	-	1.066	-
15.5	Ethyl trans-4-decenoate	-	-	-	10.452	8.155	11.7	9.513	28.062	16.337	13.568	-
15.54	Benzoic acid, ethyl ester	-	184.675	68.456	22.396	19.41	17.601	36.39	87.826	-	40.058	65.854
15.83	Ethyl 9-decenoate	-	130.018	41.546	35.485	26.346	20.946	39.012	67.445	-	21.7	-
16.42	Undecanoic acid, ethyl ester	197.535	259.246	127.086	23.051	60.337	41.546	42.291	73.183	23.197	48.396	34.247
16.8	Ethyl trans-2-decenoate	-	53.208	9.237	-	-	-	-	22.128	8.195	10.801	-
18.18	Dodecanoic acid, ethyl ester	244.131	2649.446	659.586	438.915	531.776	667.947	203.139	668.854	347.603	481.216	415.826
18.77	Ethyl 9-hexadecenoate	-	-	-	-	3.965	3.626	2.411	-	2.221	4.703	1.751
18.8	Benzenepropanoic acid, ethyl ester	54.548	33.521	105.223	5.284	16.198	14.928	8.106	20.666	3.656	18.593	17.549
19.17	(E)-9-Octadecenoic acid ethyl ester	-	13.002	-	-	1.71	0.943	0.697	1.321	0.911	-	1.034
19.85	Ethyl tridecanoate	4.381	34.46	13.939	3.216	6.467	4.915	4.775	-	-	5.837	-
20.69	Benzoic acid, ethyl ester	103.701	-	-	-	-	-	-	-	-	-	-
20.79	Ethyl 9-decenoate	20.584	-	-	-	-	-	-	-	-	-	-
20.91	Ethyl 9-hexadecenoate	-	16.161	6.591	1.391	-	1.436	1.651	4.973	0.921	2.355	0.972
22.46	Tetradecanoic acid, ethyl ester	11.824	121.206	69.721	18.34	22.841	26.4	11.924	24.9	16.781	32.04	12.284
22.59	Ethyl trans-2-decenoate	3.294	-	-	-	-	-	-	-	-	-	-
24.62	Benzoic acid, 2-hydroxy-, ethyl ester	1.953	-	-	-	-	-	-	-	-	-	-
25.14	2-Propenoic acid, 3-phenyl-, ethyl ester	-	-	1.714	-	-	-	-	-	-	0.878	-
25.55	Pentadecanoic acid, ethyl ester	-	3.172	1.55	-	-	-	0.325	-	-	-	-
25.63	10-Bromodecanoic acid, ethyl ester	-	-	-	-	0.819	-	-	-	-	-	-
25.63	Nonanoic acid, 9-bromo-, ethyl ester	-	-	-	0.399	-	-	-	-	-	-	-
27.63	Hexadecanoic acid, ethyl ester	-	54.38	18.582	4.975	4.028	4.761	2.644	5.578	3.337	5.532	2.266

Table 6: Continue

Time	Aroma (mg L^{-1})	Junzao	Huping	Fuping	Cangzhou	Xingtang	Huizao	Hetian	Goutou	Linze	Xinzheng	Yuanling
28.08	Ethyl 9-hexadecenoate	43.244	102.717	1.857	9.795	-	-	-	-	-	-	-
28.27	E-11-Hexadecenoic acid, ethyl ester	-	78.441	36.273	-	7.847	7.572	4.394	11.793	5.333	9.509	-
28.66	Decanedioic acid, diethyl ester	-	-	0.655	-	-	-	-	-	-	-	-
Acetate												
6.22	1-Butanol, 3-methyl-, acetate	1.223	6.946	3.586	6.782	2.435	3.333	0.883	3.105	1.585	0.742	1.813
10.65	Acetic acid, heptyl ester	-	1.503	-	0.626	-	-	0.253	0.569	0.249	-	0.473
14	Acetic acid, nonyl ester	-	8.583	-	1.247	-	-	0.741	-	-	-	-
17.64	Acetic acid, 2-phenylethyl ester	1.566	10.688	10.547	8.644	14.073	10.6	-	5.157	6.813	-	3.777
Branched-chain esters												
8.06	1-Butanol, 3-methyl-, formate	135.273	-	-	-	-	-	-	-	-	45.187	-
10.33	Hexanoic acid, 2-methylpropyl ester	-	-	0.74	0.666	-	-	-	0.705	-	-	0.685
10.54	Pentanoic acid, 3-methylbutyl ester	-	-	-	0.922	-	-	-	-	-	-	-
12.15	Isopentyl hexanoate	2.947	22.737	17.525	12.559	6.946	10.53	3.118	15.12	9.48	3.51	14.803
13.58	n-Caprylic acid isobutyl ester	-	4.414	-	-	1.069	0.862	-	-	1.252	-	-
13.81	Heptanoic acid, 3-methylbutyl ester	-	-	-	-	4.326	3.058	-	-	-	-	9.972
15.41	Octanoic acid, 3-methylbutyl ester	-	-	35.543	-	28.192	27.671	12.393	29.085	31.074	12.718	18.08
18.38	Pentadecanoic acid, 3-methylbutyl ester	3.115	52.344	49.84	15.861	40.049	33.125	6.278	22.124	16.353	13.174	18.599
20.12	Isobutyl laurate	-	-	2.506	0.849	1.482	1.913	-	-	0.752	1.098	0.92
22.97	Isoamyl laurate	-	4.296	9.594	-	3.763	3.737	0.533	1.402	1.29	1.339	1.878
24.69	3-Phenylpropionic acid, 3-methylbutyl ester	-	-	-	-	1.108	-	-	-	-	-	0.669
27.12	1-Butanol, 3-methyl-, benzoate	5.07	-	-	-	-	-	-	-	-	-	-
Methyl ester												
14.32	Decanoic acid, methyl ester	-	-	-	-	2.45	-	-	-	-	-	-
17.09	Benzoic acid, 2-hydroxy-, methyl ester	-	4.074	1.26	-	-	-	-	-	1.185	0.524	-
17.35	Undecanoic acid, 10-methyl-, methyl ester	-	13.366	-	-	-	-	2.336	-	2.511	-	-
17.35	Dodecanoic acid, methyl ester	-	-	6.767	7.968	16.561	9.295	-	4.277	-	3.669	5.455
19.1	Methyl 3-(2-formylethyl)-3-nonenoate	2.243	-	-	-	-	-	-	-	-	-	-
21.34	Methyl tetradecanoate	-	-	-	-	2.708	-	-	-	-	-	-
27.44	7-Hexadecenoic acid, methyl ester, (Z)-	-	-	-	-	0.657	-	-	-	-	-	-
Other esters												
13.06	Propyl octanoate	-	6.763	-	-	-	-	-	-	-	-	-
16.24	Decanoic acid, propyl ester	-	14.803	4.251	1.649	2.716	2.312	2.122	3.736	2.689	5.274	2.776
17.31	1,2-Ethanediol, monobenzoate	-	-	-	-	-	-	-	0.905	-	-	-
17.68	Phenyl ethyl tiglate	-	-	-	-	-	-	1.125	-	-	-	-
18.07	Nonyl chloroformate	7.376	-	-	-	-	-	-	-	-	-	-
19.49	Dodecanoic acid, propyl ester	-	8.826	-	-	-	-	-	-	-	-	-
24.72	Benzenepropanoic acid, pentyl ester	-	-	4.763	-	-	-	-	-	-	-	-
26.02	Hexanoic acid, 2-phenylethyl ester	-	-	1.656	2.51	3.703	1.869	-	-	0.999	-	1.42
27.99	Phthalic acid, octyl 2-phenylethyl ester	-	-	-	-	-	-	-	-	0.531	-	-
27.99	Oxalic acid, isohexyl 2-phenylethyl ester	-	-	-	-	-	0.647	-	-	-	-	-
29.52	Octanoic acid, 2-phenylethyl ester	-	-	-	0.308	-	0.319	-	-	-	-	0.298
Alcohols												
5.98	1-Propanol, 2-methyl-	8.369	4.879	6.583	-	4.359	6.105	-	5.143	2.813	-	-
8.06	1-Butanol, 3-methyl-	-	261.26	155.656	102.715	119.138	119.531	26.426	103.999	72.474	-	61.78
10.48	1-Hexanol	2.798	3.358	1.802	-	1.245	-	0.887	-	1.46	-	-
11.12	3-Octanol	4.08	2.72	4.08	4.08	4.08	4.08	4.08	4.08	4.08	4.08	4.08
12.16	Heptanol	2.533	1.844	-	-	-	-	-	-	-	-	-

Table 6: Continue

Time	Aroma (mg L^{-1})	Junzao	Huping	Fuping	Cangzhou	Xingtang	Huizao	Hetian	Goutou	Linze	Xinzheng	Yuanling
12.87	trans-2-Undecen-1-ol	-	-	-	1.537	-	-	-	-	-	-	-
13.76	1-Octanol	-	9.209	-	-	-	-	-	-	-	-	-
15.31	1-Nonanol	-	22.244	-	-	-	5.013	-	-	-	3.372	-
16.17	2-Undecanol	-	-	1.182	-	1.329	-	-	-	-	-	-
16.78	1-Decanol	-	-	-	13.762	-	-	-	-	-	-	-
17.19	3-Nonen-1-ol, (Z)-	-	-	-	1.222	-	-	-	-	-	-	-
19.37	Phenylethyl Alcohol	20.584	-	35.902	27.991	39.98	57.914	-	-	25.272	10.847	24.472
20.33	1-Dodecanol	-	4.72	-	-	-	-	-	-	-	-	-
26.16	Benzyl Alcohol	3.242	-	-	-	-	-	-	-	-	-	-
Acids												
20.22	Heptanoic acid	1.803	-	-	-	-	-	-	2.683	-	-	-
23.05	Octanoic Acid	1.809	-	2.766	-	-	3.559	1.598	6.883	2.696	7.658	2.472
26.12	Nonanoic acid	1.257	-	-	-	1.434	-	0.491	2.231	0.839	2.154	0.868
28.09	n-Decanoic acid	27.121	-	-	28.691	30.928	35.131	10.461	22.415	10.374	24.5	19.165
29.58	Undecanoic acid	0.591	-	0.903	0.578	0.518	0.848	-	-	-	-	-
30.82	Dodecanoic acid	14.961	-	22.874	18.051	33.443	15.108	4.738	6.151	3.52	9.469	6.125
Aldehydes and ketones												
5.61	Hexanal	1.09	-	-	0.158	-	-	0.419	1.055	-	-	-
7.36	Heptanal	-	-	-	-	-	-	0.428	1.284	0.633	-	0.911
9.28	Octanal	-	-	-	0.917	-	-	1.304	-	1.119	-	-
9.53	1-Octen-3-one	-	-	1.82	1.488	-	-	1.287	-	-	-	-
9.98	2-Heptenal, (Z)-	-	-	-	-	-	-	0.401	-	0.415	-	-
10.19	5-Hepten-2-one, 6-methyl-	-	-	-	-	0.601	-	-	-	-	-	-
11.09	Nonanal	4.271	-	2.644	-	-	-	-	4.871	-	-	-
12.46	Furfural	1.696	2.317	4.337	2.325	2.854	2.975	2.05	4.621	-	1.316	-
12.84	Decanal	5.811	-	-	-	1.898	1.48	1.782	5.379	2.295	2.284	2.557
13.44	2-Nonenal, (E)-	-	4.655	-	-	-	-	-	-	-	-	-
14.35	2-Undecanone	3.157	12.73	4.15	3.582	2.605	1.665	0.863	3.179	2.488	2.681	2.891
14.47	5-Hepten-2-one, 6-methyl-	1.202	-	-	-	-	-	-	-	-	-	-
14.55	Tetradecanal	-	-	-	-	-	-	-	-	1.221	-	-
14.56	Undecanal	-	-	-	-	-	-	-	-	-	-	2.437
14.78	1-Cyclohexene-1-carboxaldehyde, 2,6,6-trimethyl-	-	4.111	1.241	-	-	0.724	-	1.281	1.356	0.892	-
15.35	2-Nonanone	0.762	-	-	-	-	-	-	-	-	-	-
16.20	2-Tridecenal, (E)-	6.081	-	-	-	-	-	-	-	-	-	-
16.39	6-Tridecanone	-	-	-	-	-	-	1.278	-	1.834	-	-
17.48	2-Tridecanone	-	19.374	4.764	2.814	3.889	2.981	2.324	4.569	3.548	3.408	3.225
17.74	2-Buten-1-one, 1-(2,6,6-trimethyl-1,3-cyclohexadien-1-yl)-, (E)-	-	-	3.839	3.11	3.368	3.053	1.282	2.023	3.251	-	2.581
18.00	Benzaldehyde	17.454	-	-	-	-	-	-	-	-	-	-
18.26	5,9-Undecadien-2-one, 6,10-dimethyl-, (E)-	-	28.445	-	3.794	-	-	-	5.828	-	-	-
19.79	Benzeneacetaldehyde, .alpha.-ethylidene-	-	-	-	-	-	-	1.549	36.989	1.62	-	-
20.26	Benzeneacetaldehyde	44.094	-	-	-	-	-	-	-	-	-	-
21.64	2-Pentadecanone	-	3.171	-	-	-	-	-	-	-	-	-
22.11	2(3H)-Furanone, dihydro-5-pentyl-	-	-	-	-	-	-	-	-	-	-	0.673
22.8	2-Nonenal, 8-oxo-	-	-	-	0.683	-	-	-	-	-	-	-
23.17	2H-1-Benzopyran-2-one, 3,4-dihydro-	11.244	-	-	-	-	-	-	-	-	-	-
23.43	5-Methyl-2-phenyl-2-hexenal	-	-	-	-	-	-	-	4.406	-	-	-
23.66	2(3H)-Benzofuranone, 3-methyl-	11.232	-	-	-	-	-	-	-	-	0.052	-
24.86	2-Pentadecanone, 6,10,14-trimethyl-	-	7.919	2.034	0.975	0.707	1.345	0.596	1.244	0.733	1.28	1.022

Table 6: Continue

Time	Aroma (mg L^{-1})	Junzao	Huping	Fuping	Cangzhou	Xingtang	Huizao	Hetian	Goutou	Linze	Xinzheng	Yuanling
25.46	5,9-Undecadien-2-one, 6,10-dimethyl-, (E)-	7.177	-	-	-	-	-	-	-	-	-	-
25.84	1-Methyl-2-phenylpiperidin-4-one	-	-	-	-	-	-	-	-	0.617	-	-
27.62	Benzeneacetaldehyde, .alpha.-ethylidene-	0.845	-	-	-	-	-	-	-	-	-	-
Others												
4.97	Furan, 2,5-dihydro-	-	-	-	-	-	-	-	-	-	1.477	-
7.42	Vinyl Ether	-	-	-	0.669	-	-	-	-	-	-	-
7.94	Furan, 2-pentyl-	-	6.512	-	0.998	-	-	-	-	-	-	-
8.51	Phenol, 3,4-dimethyl-	-	-	0.647	-	-	-	-	-	-	-	-
9.32	1,2-Dimethyl-3-ethyldiaziridine	-	-	-	-	-	-	-	-	-	-	0.577
9.64	Pyridine-3-carboxamide, oxime, N-(2-trifluoromethylphenyl)-	-	-	-	0.484	-	-	-	-	-	-	-
10.47	Hexyl chloroformate	-	-	-	1.244	-	-	-	-	-	-	-
12.53	Naphthalene, 1,2,3,4-tetrahydro-1,5,8-trimethyl-	-	-	-	-	-	-	0.323	-	-	-	-
11.96	Naphthalene, 1,2,3,4-tetrahydro-1,1,6-trimethyl-	-	-	-	0.97	-	0.792	-	-	0.615	-	1.03
14.05	1,4-Methanoazulene, decahydro-4,8,8-trimethyl-9-methylene-, [1S-(1.alpha.,3a.beta.,4.alpha.,8a.beta.)]-	-	-	-	-	-	1.478	-	-	-	-	-
14.64	Cedrene-V6	-	8.501	-	-	-	-	-	-	-	-	-
14.84	Thujopsene	-	-	-	1.659	-	-	-	-	-	-	-
16.63	Naphthalene	3.277	16.899	4.179	-	1.649	1.503	1.123	4.74	-	-	-
16.73	Oxime-, methoxy-phenyl-_	19.77	-	-	-	-	-	-	-	3.822	3.334	-
17.86	Naphthalene, 1,2,3,4-tetrahydro-2,5,8-trimethyl-	-	-	-	-	-	-	-	-	-	-	1.06
17.87	Benzene, 1-methoxy-4-(1-propenyl)-	-	-	3.607	-	-	-	-	-	-	-	-
19.5	Naphthalene, 1,2-dihydro-1,1,6-trimethyl-	-	-	-	-	-	-	2.178	-	-	-	4.663
20.44	Naphthalene, 2,6-dimethyl-	-	2.579	-	0.612	-	-	-	-	-	-	-
20.44	Naphthalene, 1,5-dimethyl-	-	-	-	-	0.833	-	-	-	-	-	-
20.44	Naphthalene, 1,6-dimethyl-	-	-	-	-	-	-	-	1.768	-	-	-
20.45	Naphthalene, 2,7-dimethyl-	-	5.158	1.531	-	-	1.049	0.497	-	0.738	-	-
20.46	Naphthalene, 1,7-dimethyl-	-	-	-	-	-	-	-	-	-	-	1.034
21.06	Biphenyl	-	-	-	-	-	-	0.472	1.024	-	-	-
21.06	Naphthalene, 2-ethenyl-	-	-	-	-	-	-	-	-	-	-	0.589
21.17	Naphthalene, 2,6-dimethyl-	-	-	-	-	-	-	-	-	-	-	-
21.33	Naphthalene, 1,4-dimethyl-	-	-	-	-	-	-	-	-	1.056	-	-
21.34	Naphthalene, 1,6-dimethyl-	-	-	-	-	-	2.511	-	-	-	-	-
21.34	Naphthalene, 2,3-dimethyl-	-	-	3.031	1.205	-	-	0.901	2.119	-	1.38	1.713
22.82	Naphthalene, 1,4,6-trimethyl-	-	2.809	1.739	-	-	0.9	-		-		0.547
24.25	Naphthalene, 1,6,7-trimethyl-	-			0.599	0.765	-	0.441		-		0.757
26.83	Naphthalene, 2-methyl-	0.801			-	-	-	-		-		-
27.06	Naphthalene, 1,6-dimethyl-4-(1-methylethyl)-	-			0.598	3.509	0.554	0.319		0.392		0.844
28.71	Phenol, 2,4-bis(1,1-dimethylethyl)-	-			-	0.522						
29.03	Phenol	0.859			-							
30.75	2,5-Pyrrolidinedione				0.162							

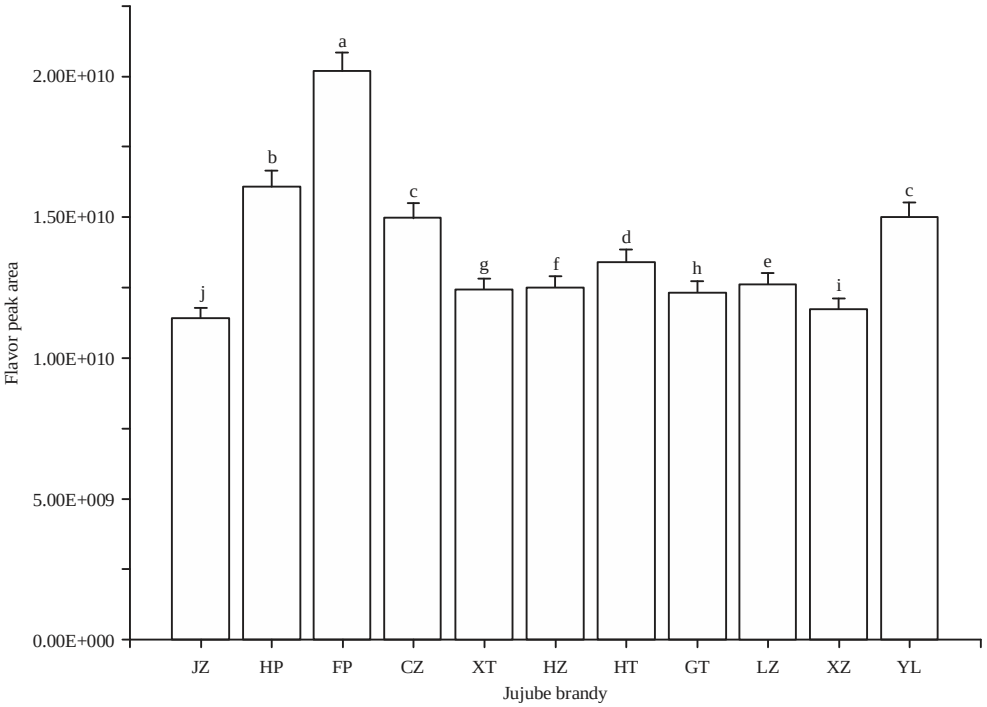

Fig. 1: Comparison of flavor peak area of different kinds of jujube brandies
Bars are Mean±SD, Letters (a,b,c,d, etc) represent significance difference($p<0.05$)

acid. Types and content of acids in Junzao and Xingtang jujube brandy were significantly higher than other varieties. Heptanoic acid was unique for Junzao and Goutou brandy. But no acids were detected in Huping brandy.

Aldehydes and ketones: Main aldehydes and ketones in jujube brandy are 2-Tridecanone, 2-Undecanone, Decanal, Furfural and (E)-1-(2,6,6-trimethyl-1,3-cyclohexadien-1-yl)-2-Buten-1-one. Most unique aldehydes and ketones are unsaturated. Xingtang has 6-methyl-5-Hepten-2-one, Huping has (E)-2-Nonenal, Junzao has 6-methyl-5-Hepten-2-one and (E)-2-Tridecenal, Cangzhou has 8-oxo-2-Nonenal, Linze has 5-Methyl-2-phenyl-2-hexenal. For saturated aldehydes and ketones, Tetradecanal and Undecanal were only detected in Linze and Yuanling, respectively. For unique aldehydes and ketones, Junzao and Xinzheng have 3,4-dihydro-2H-1-Benzopyran-2-one and 3-methyl-2(3H)-Benzofuranone. Besides these, Junzao has more unique aldehydes and ketones, like 2-Nonanone and (E)-6,10-dimethyl-5,9-Undecadien-2-one. Linze has unique 1-Methyl-2-phenylpiperidin-4-one, Huping has 2-Pentadecanone. In addition, 3 characteristic aldehydes and ketones((E)-6,10-dimethyl-5,9-Undecadien-2-one, alpha-ethylidene-Benzeneacetaldehyde and dihydro-5-pentyl-2(3H)-Furanone) were also found in jujube brandy.

Hydrocarbon and others: Main hydrocarbon in jujube brandy is Styrene, then Pentadecane. Type and content of hydrocarbon in Junzao were obviously higher than others. For other flavor compounds, main flavor coponents are Naphthalene, followed by Methoxy-phenyl-oxime. Many kinds of flavor compounds were found, like 3 Terpenoids (longifolene, V6-cedrene and thujopsene), 2 furans (2, 5-dihydro-furan and 2-amyl-furan), 3 kinds of phenols (3, 4-dimethyl-phenol, 2,4-bis (1,1-dimethylethyl)-phenol and phenol), 1 ether (Vinyl Ether) and anethole.

PCA and cluster analysis of flavor compounds: The PCA was conducted using the concentrations of main volatile compounds in jujube brandy samples from different varieties as analytical variables. This was done to reduce the dimensionality within the data set, to analyze the main sources of variation within the data set and to detect similarities and/or differences among wine samples. This demonstrated the effects of different varieties on the volatile composition of jujube brandy, as well as the correlations/relationships between compounds and wine samples.

A bi-plot showing the score plots as well as the loadings plots of the first two principal components (PC1 and PC2, respectively), PC1 and PC2 accounted for 87.045% of the total variability for jujube brandy samples, with 73.054 and

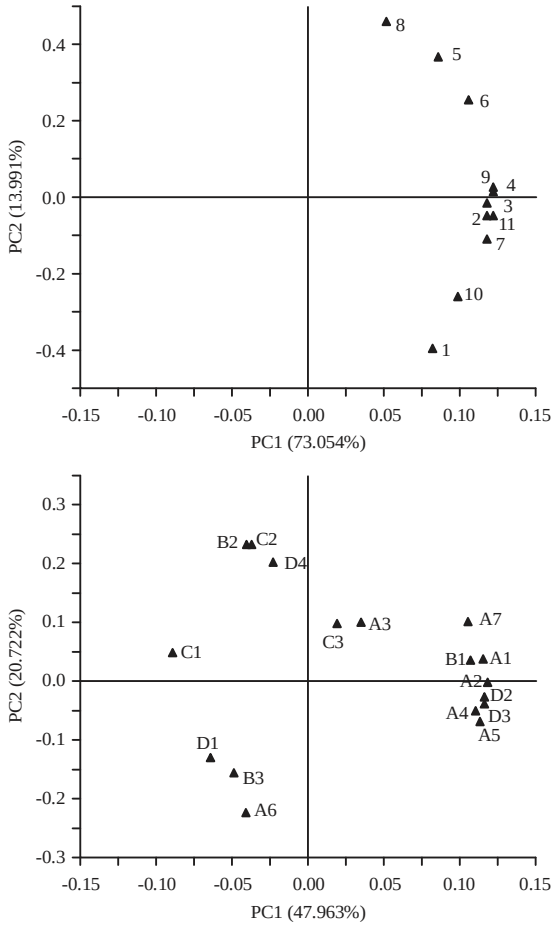

Fig. 2: Main components scattered diagram of flavor compounds and load scatter plot

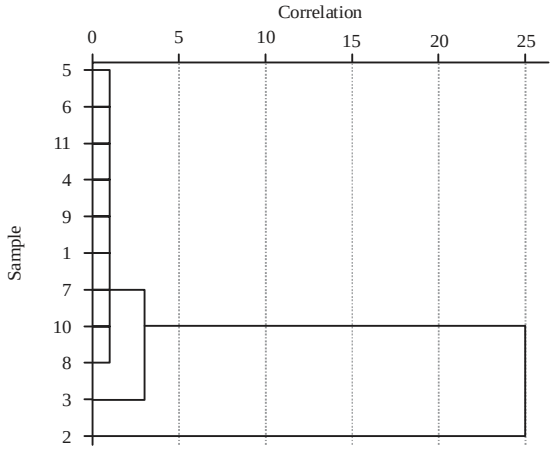

Fig. 3: Cluster analysis on flavor compounds of eleven jujube brandies

Sample 1: Junzao, sample 2: Huping, sample 3: Fuping, sample 4: Cangzhou, sample 5: Xingtang, sample 6: Huizao, sample 7: Hetian, sample 8: Goutou, sample 9: Linze, 10: Xinzheng, sample 11:Yuanling

Table 7: Cluster analysis on flavor compounds of jujube brandy

	Cluster combination			1st cluster		
Stair	Cluster 1	Cluster 2	Coefficient	Cluster 1	Cluster 2	Next stair
1	5	6	3448.431	0	0	4
2	4	9	6273.452	0	0	3
3	1	4	14553.218	0	2	5
4	5	11	18802.074	1	0	6
5	1	7	36771.940	3	0	6
6	1	5	45410.187	5	4	7
7	1	10	51242.439	6	0	8
8	1	8	105987.734	7	0	9
9	1	3	1875868.757	8	0	10
10	1	2	18182302.843	9	0	0

13.991% of the variability being explained by PC1 and PC2, respectively as provided by Fig. 2. For the observed sample distribution, the loadings show the relative importance of each individual volatile compound. Generally, the distribution of the different volatiles will reflect the differences observed among jujube brandies from different varieties.

Eleven jujube brandies were all distributed in the positive axis of PC1. Wine samples of Huping, Fuping, Cangzhou, Hetian, Linze, Yuanling had a relation with hexanoic acid ethyl ester (A1), octylic acid ethyl ester (A2), heptanoic acid ethyl ester (A4), pelargonic acid ethyl ester (A5), 3-methyl-1-butanol (A7), 1-hexanol (B1), 2-undecanone (D2) and 2-tridecanone (D3). Similar methods were used and reported in previous studies[34]. In the loadings plots of compounds, all kinds of flavor components were distributed in four quadrants. Phenylethyl alcohol (B2), dodecoic acid (B2), beta-Damascenone (D4) gathered, which were distributed in the second quadrant. Tetradecanoic acid ethyl ester (A6), octanoic acid (B3), decanal (D1) gathered, which were distributed in the third quadrant (Fig. 2).

Cluster analysis was carried out in order to evaluate the number of subsets of similar samples appearing in the complete data set (Table 7). We can clearly recognize the three main clusters, (1) Huping, (2) Fuping and (3) The rest of the wine samples, which represent the rest of the wine samples held high similarity and they were obviously different with wine samples of Huping and Fuping wine samples (Fig. 3).

In the current study, fruit variety is very important in making wine and brandy. Nutrients difference cause different flavor and quality of liquor. Similar findings were reported in previous studies[35-37].

CONCLUSION

Odor activity value, principal component analysis and cluster analysis were used to compare the feature and flavor compounds of eleven kinds of jujube brandies. Odor-active compounds of jujube brandy include ethyl caproate, ethyl octanoate, ethyl benzoate, ethyl decanoate, octanoic acid,

decanoic acid, lauric acid and phenethyl alcohol. Fuping, Xingtang and Huizao jujube brandy had the most odor-active compounds, Junzao had the most unique aroma. Fuping jujube brandy rank first on the total peak area of aroma, followed by Huping, Cangzhou and Yuanling. The aroma of Huping and Fuping jujube brandy were unique and the other brandy samples had high similarity by cluster analysis. Therefore, Fuping, Huping and Cangzhou jujube are found suitable for brewing brandy, which is beneficial for improving the quality of jujube brandy.

SIGNIFICANCE STATEMENTS

This study discovered the key and unique flavor compounds of different jujube brandies that can be beneficial for highlighting the feature and characteristic. This study help the researcher to uncover the critical areas of selection of brewing varieties that many researchers were not able to explore. Thus a new theory on brewing characteristics may be arrived at.

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