International Journal of Biology and Life Sciences
ISSN: 2957-9511 | Vol. 5, No. 2, 2024

Liquid-liquid Extraction and Solid Phase Extraction to Identify the Volatile Components of Luzhou-flavor Liquor

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Abstract: In this paper, trace volatile components in Luzhou flavor Baijiu were analyzed by using different solvents, liquid-liquid extraction and solid-phase extraction combined with gas chromatography-mass spectrometry. A total of 166 substances were identified, including 23 substances with concentrations above 10mg/L, 9 substances with concentrations between 5mg/L-10mg/L, 38 substances with concentrations between 1mg/L-5mg/L, and the remaining 96 substances with concentrations below 1mg/L. There is a certain degree of complementarity between compounds extracted by solvents with different polarities, and solid-phase extraction performs poorly in extracting compounds with higher polarities.

Keywords: Liquid-liquid Extraction; Solid Phase Extraction; Luzhou-flavor Liquor; Different Solvents.

1. Introduction

Luzhou-flavor liquor is the highest market share of a liquor, from the production of raw materials, Luzhou-flavor liquor is divided into two kinds, one is using the sorghum as the sole raw material, another is using sorghum, rice, glutinous rice, wheat, corn, five kinds of raw materials, the flavor characteristics of the two differences, the former highlights the fermentation process, the latter may be due to the addition of grains during the cooking process, resulting in a richer flavor. At present, it is confirmed that ethyl caproate is the most important flavor ingredient of Luzhou-flavor liquor, and its content directly affects the quality of Luzhou-flavor liquor.

Based on the need of the analysis of other low-content substances in the flavor analysis, we need to extract all the flavor components of liquor as much as possible. Liquid-liquid extraction is one of the most widely used and simple methods of flavor substance extraction, and almost every chemical laboratory can complete this experiment. Compared with liquid extraction, solid phase extraction has the advantages of environmental friendliness. Solid phase extraction method can automatically complete the enrichment and initial separation of substances during elution[1]. Ethyl ether and dichloromethane are the most common extractants in the extraction of liquor flavor substances, but there are still differences in the extraction of some compounds in liquor[2]. In this study, liquid-liquid extraction, solid phase extraction combined with gas chromatography and mass spectrum were used to analyze the volatile components of Wuliang Luzhou-flavor liquor.

2. Materials and Methods

2.1. Reagents and Equipment

Sample was purchased from Yibin Wuliangye Co., Ltd., with the model of Jianzhuang Baijiu,52%voL.Solvents (Dichloromethane, n-pentane, ethyl ether) were obtained from Sinopharm Chemical Reagent Co., Ltd. (Beijing, China). All standards were of GC quality with at least 95% purity. Compounds including ethyl acetate, ethyl lactate, ethyl value, ethyl butyrate, caproic acid, isopentanol, etc. were obtained from J&K Chemical Co. (Beijing, China).

2.2. Method

2.2.1. Extraction of Flavor Substances in Baijiu

LLE: accurately absorb 50 mL of wine sample, dilute with 200 mL of 12% vol, and add sodium chloride to saturation. Extract with 50 mL of extraction three times, layer and merge the organic phase, add excess anhydrous sodium sulfate to the organic phase, dry at-20℃ overnight to remove water, concentrate nitrogen to 1 mL for analysis by GC-MS. Using the above method, the wine samples were extracted with dichloromethane, n-pentane, and ether, and the extraction samples were repeated twice for each solvent.

SPE: accurately absorb 10 mL liquor, add 40 mL of ultrapure water to dilute to 12% vol, and add sodium chloride to saturation. C18 solid phase extraction column was used for adsorption, and 10 mL organic solution was used as the elution agent to elute the volatile components in the solid phase column to obtain the organic phase. After anhydrous sodium sulfate drying, nitrogen was concentrated to 1 mL and dried for GC-MA analysis. Four organic solvents were selected for dichloromethane, diethyl ether, hexane and methanol, and the extraction sample of each solvent was repeated twice.

2.2.2. Instrumentation

Chromatographic conditions: DB-WAX (30m,0.25mm 0.25 μ m, Agilent); carrier gas is high purity helium, flow rate 1 mL / L, split ratio 40:1, sample volume 1 μ L. The inlet temperature is 250℃. Heating procedure: Maintain at 40 ℃ for five minutes, raise to 220 ℃ at 5 ℃/min. Solvent delay of 300 seconds.

Mass spectrum conditions: electron ionization source (EI), electron energy of 70 eV, ion source temperature of 230℃, transmission temperature of 250℃, MS solvent detection delay of 120s, full scanning mode, scanning range m/z is 25-550amu.

2.3. Qualitative Analysis

Qualitative analysis using standard comparison; For

substances without standard standards, qualitative analysis will be conducted through NIST1 spectrometry library retrieval and retention time.

3. Results and Discussion

The volatile components of Luzhou-flavor liquor were analyzed by liquid extraction, solid phase extraction and GC-MS, along with qualitative methods such as standard products, retention index and spectral library retrieval. The total ion flow chart is shown in Figure 1 to Figure 6, and the analysis results are shown in Table 1.

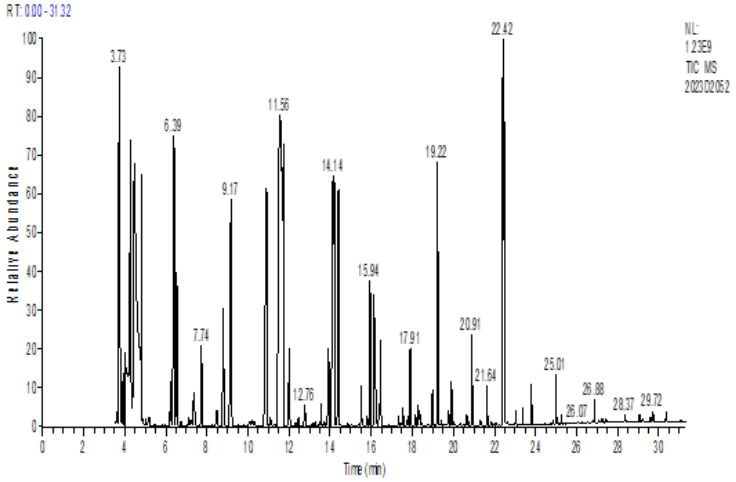

Figure 1. Total ion flow diagram of GC-MS by LLE, Dichloromethane

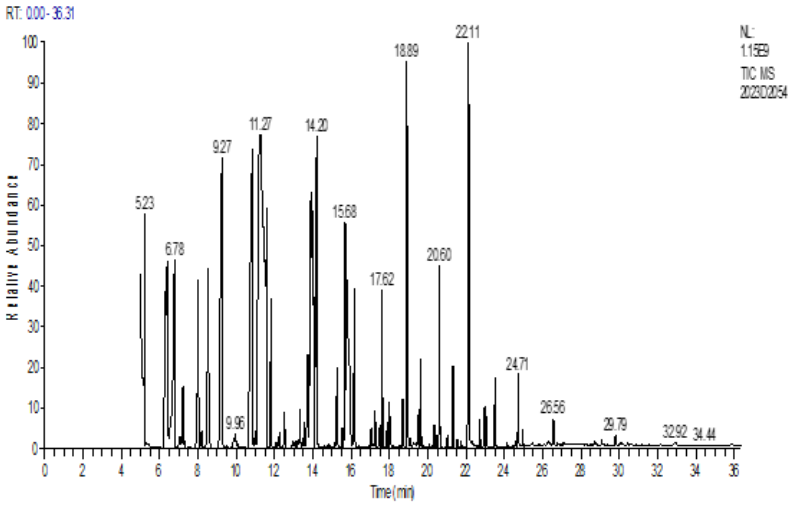

Figure 2. Total ion flow diagram of GC-MS by LLE, ethyl ether

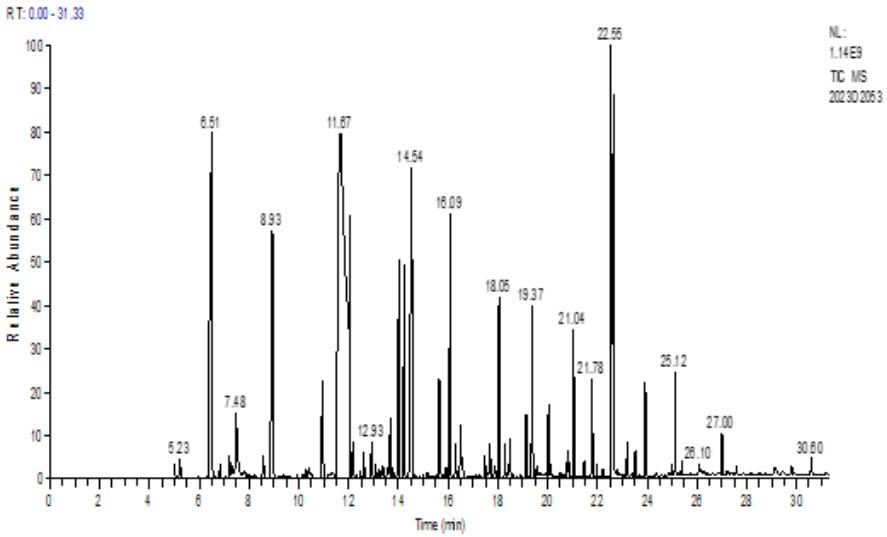

Figure 3. Total ion flow diagram of GC-MS by LLE, hexane

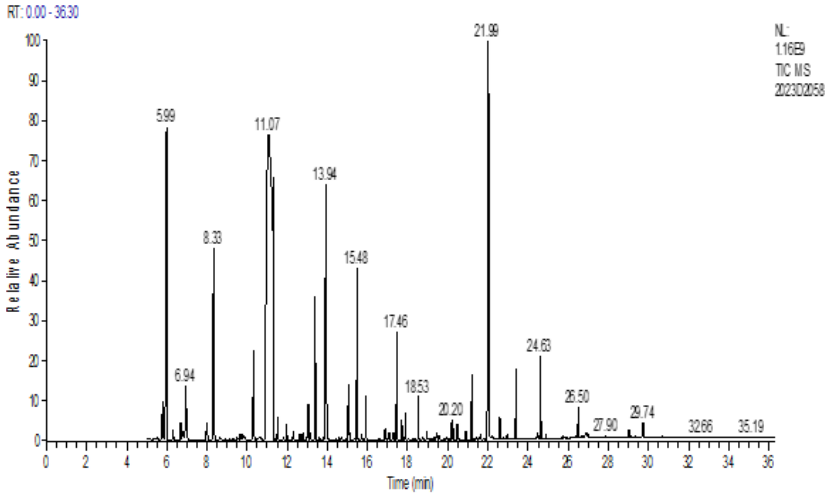

Figure 4. Total ion flow diagram of GC-MS by SPE, Dichloromethane

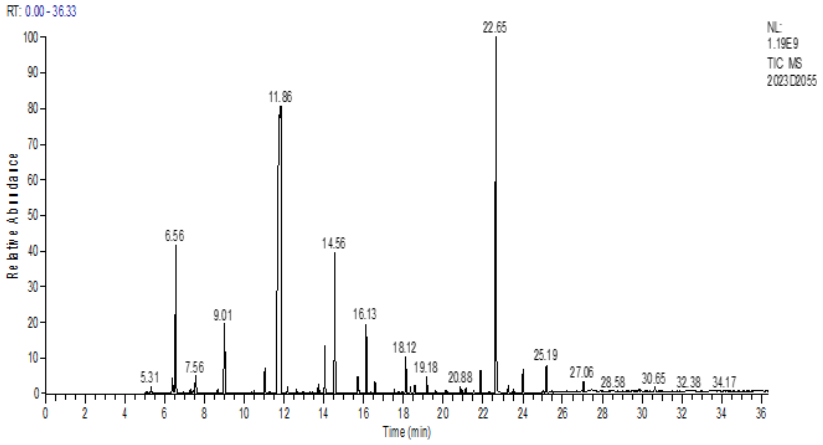

Figure 5. Total ion flow diagram of GC-MS by SPE, ethyl

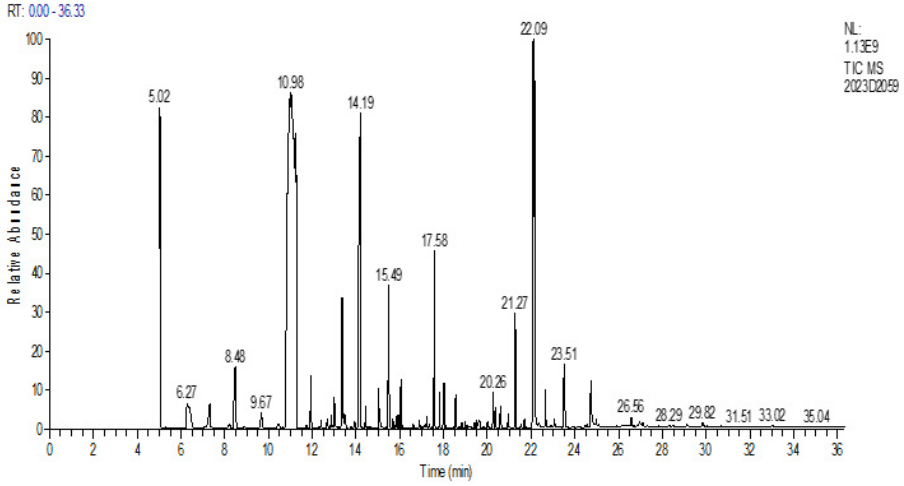

Figure 6. Total ion flow diagram of GC-MS by SPE, hexane

Using both LLE and SPE two methods, 177 substances were identified, including 66 esters, 43 alcohols, 15 acids, 7 ketones, two aldehydes, 9 aromatic and phenolic compounds, and 26 acetals, hydrocarbons and other heterocyclic compounds. Using liquid-liquid extraction method, a total of 116 substances were extracted from 63, 91, and 75 extractants of dichloromethane, ether, and n-hexane, including 47 esters, 28 alcohols, 15 acids, 6 ketones, 3 aldehydes, 9 aromatic compounds (excluding esters), 9 acetals, hydrocarbons, and other heterocyclic compounds. Using solid-phase extraction method, 66, 77, and 77 substances were detected in three extractants: dichloromethane, ether, and n-hexane, totaling 109 substances, including 56 esters, 20 alcohols, 9 acids, 4 ketones, 1 aldehyde, 8 aromatic compounds, 11 hydrocarbons (including acetals), and heterocyclic compounds.

Table 1. Analysis Results of Volatile Components in Wuliang Luzhou flavor Baijiu

Retention Time	RI	Compound	Substance Content (mg/L)					
			LLE			SDE		
			D	E	H	D	E	H
		Ester						
4.9	829	Ethyl propionate	0.48	-	-	-		-
5.11	867	2-Methylpropanoate ethyl ester	0.78	-	0.34	-	1.04	-
6.31	942	2-Methylbutyrate ethyl ester	0.77	-	1.91	1.60	1.25	-
6.39	856	Ethyl butyrate	69.24	111.07	113.96	82.56	93.10	114.68
6.68	898	3-Methylbutyrate ethyl ester	1.40	1.72	3.26	2.73	2.12	-
6.76	916	Butyl acetate	1.42	-	1.33	0.93	0.01	-
8.15	879	Ethyl valerate	54.54	44.25	54.94	42.40	45.85	40.14
9.66	934	Methyl hexanoate	-	1.73	1.42	1.19	1.15	-
10.07	722	5-Methylvalerate ethyl ester	1.35	3.01	2.67	1.73	1.90	4.73
11.09	807	Butyl butyrate	2.78	-	-	1.10	1.27	1.51
11.59	849	Ethyl hexanoate	290.65	216.53	287.20	336.27	291.60	224.80
11.74	920	Butyric acid, 3-methylbutyl ester	-	1.14	0.85	0.42	0.36	0.49
12.24	915	Hexyl acetate	1.48	2.85	3.56	2.16	2.25	-
12.26	888	5-Methylhexanoate ethyl ester	-	-	-	-	-	0.23
12.31	852	Isoamyl isobutyrate	0.58	-	-	-	-	-
12.39	778	E-2-hexene benzoate	-	0.10	-	-	-	-
12.92	852	Butyl valerate	-	-	-	0.57	0.43	0.39
13.33	929	Propyl hexanoate	3.90	7.81	8.28	4.99	5.06	4.79
13.37	911	Ethyl heptanate	17.70	29.77	36.71	21.90	25.01	23.64
13.76	803	Caproic acid, 2-methylpropyl ester	-	-	-	-	-	0.38
13.8	905	Isobutyl hexanoate	-	-	-	0.22	-	-
13.92	912	Ethyl L(-)-lactate	132.53	147.03	119.83	137.20	110.50	120.53
14.22	908	Butyl hexanoate	7.04	12.07	15.47	8.17	9.66	7.20
14.25	810	Heptyl acetate	-	-	-	0.03	-	-
14.28	875	Hexyl butyrate	-	-	-	0.44	-	-
14.48	841	1,2-Dimethylpropyl ethanoate	-	0.19	-	-	-	-
14.64	825	Valproic acid, 3-methylbutyl ester	-	-	0.32	-	-	-
14.69	912	Ethyl octanoate	23.23	23.19	46.26	25.98	34.71	23.89
15.13	898	Isopentyl hexanoate	3.83	-	9.21	5.86	6.93	1.84
15.38	829	1,1-Ethanediol, Diacetate	-	-	-	0.87	0.77	1.55
15.5	890	Ethyl 3-hydroxybutyrate	0.43	1.38	0.26	-	-	0.14
16.89	818	Amyl hexanoate	1.56	3.08	3.70	1.78	2.29	1.16
17.13	903	2-hydroxy-4-methylvalerate ethyl ester	12.27	21.37	24.45	14.09	17.96	24.51
17.22	860	2-Hydroxybutyl propionate	-	5.62	5.35	1.32	-	2.06
17.33	888	Ethyl nonanoate	-	-	2.48	1.01	1.24	0.61
17.92	902	Hexyl hexanoate	5.76	9.56	12.04	5.96	7.96	4.16
18.01	878	isoamyl lactate	-	4.02	7.12	3.87	4.60	6.84
18.03	826	Ethylene glycol di-n-butyrate	-	-	-	0.15	-	-
18.36	881	Methoxyacetic acid, 3-methylbutyl ester	2.12	-	-	-	-	-
18.45	842	2-hydroxyhexanoate ethyl ester	-	-	-	-	-	0.15
18.83	857	Methoxyacetic acid, amyl ester	-	-	-	0.42	0.40	0.82
18.99	873	Ethyl decanoate	0.75	1.27	1.78	0.93	1.15	0.88
19.52	904	Ethyl benzoate	-	-	-	1.56	1.93	1.15
19.64	895	Diethyl succinate	0.59	1.15	1.24	0.53	0.74	1.01
19.78	801	Ethyl carbamate	-	0.13	-	-	-	-
19.91	864	Methoxyacetic acid hexyl ester	0.96	1.66	1.95	1.39	1.75	2.54

Retention Time	RI	Compound	Substance Content (mg/L)					
			LLE			SDE		
			D	E	H	D	E	H
20.08	824	Caproic acid, 1-methylhexyl ester	-	-	-	-	-	0.14
20.72	824	Octyl heptanate	-	0.29	0.41	-	0.19	-
20.77	862	Ethyl phenylacetate	6.09	10.82	13.07	8.52	11.55	15.13
21.22	944	Acetic acid, 2-phenylethyl ester	0.43	0.90	1.20	0.69	0.75	1.34
21.46	873	Ethyl dodecanoate	-	-	-	-	-	0.14
22.16	891	Ethyl phenylpropionate	2.02	3.29	4.08	2.76	3.60	4.67
22.29	811	Furyl caproate	-	0.14	-	0.09	-	-
18.1	809	Butyl Butyrylactate	-	-	0.38	-	-	0.38
24.56	874	Ethyl hexadecaneate	0.46	0.65	1.29	0.88	1.23	0.40
25.92	840	Hexadecane methyl ester	-	-	-	-	-	-
26.25	893	Ethyl hexadecaneate	2.65	2.82	4.33	3.08	3.72	1.26
26.83	783	9-Ethyl hexadecenoate	-	-	-	0.11	-	0.01
29.11	854	(E) -9-Octadecylenoic acid ethyl ester	0.90	0.99	1.38	1.12	1.09	0.34
29.35	925	Acetic acid, octadecyl ester	-	-	-	0.16	-	-
29.82	901	9,12-Octadecyldienoic acid ethyl ester	1.88	1.76	2.88	2.38	2.40	0.81
30.44	924	Ethyl phenylacetate	-	0.31	-	-	-	-
30.84	820	(Z) -5,11,14,17-Icosatetraenoic acid methyl ester	-	-	-	0.06	-	-
		alcohol						
6.23	951	2-butanol	8.75	-	-	-	-	-
6.78	856	2-propanol	-	56.26	-	-	-	-
7.52	891	1-Propanol	34.79	-	-	-	-	-
8.01	938	2-methyl-1-propanol	16.13	34.70	-	-	-	-
8.21	804	3-Methylacetic acid 1-butanol	-	3.48	4.87	4.01	3.47	1.30
8.6	918	(R) -2-pentanol	4.88	3.88	-	-	-	-
8.9	887	(S)-2-butanol, 3-methyl	-	-	-	-	-	0.33
9.33	843	1-butanol	72.53	117.72	0.32	-	0.32	-
10.32	883	1-butanol, 3-methyl	244.83	196.76	220.13	194.98	203.14	207.55
10.97	921	(Z) 2-butene-1-ol	-	2.02	-	-	-	-
11.44	879	(R)-2-hexanol	-	-	-	-	0.05	-
11.92	929	1-Pentanol	15.18	28.26	6.11	3.67	3.85	9.13
13	906	Cyclopentanol	-	0.93	-	-	-	-
13.16	898	2-Heptanol	-	-	-	1.24	-	-
13.81	897	(S)-2-Heptanol	0.86	-	1.42	-	1.24	-
14.19	874	1-hexanol	56.29	95.08	78.48	67.60	90.61	106.87
14.87	864	3-octanol	-	-	-	-	-	0.08
15.37	869	(S)-2-Octanol	-	-	-	-	-	0.05
15.44	821	2-Heptanol, 3-Methyl	-	0.10	-	-	-	-
15.79	854	1-Nonen-3-ol	-	-	-	0.21	-	-
15.82	881	(R)-2-Octanol	-	-	0.43	-	-	-
16.05	904	1-Heptanol	-	-	-	-	-	6.46
16.44	844	1-Octene-3-ol	-	-	0.34	-	0.15	-
16.69	818	2-Propyl-1-pentanol	-	0.11	-	-	-	-
16.74	817	Cis hepta-4-enol	-	-	-	-	-	0.04
16.82	820	4-Heptanol	-	0.25	-	-	-	-
17.03	836	(E)-2-Heptane-1-ol	-	-	-	-	-	0.23
17.81	918	1-Octanol	-	-	-	2.51	3.02	4.72
18.2	803	[S - (R *, R *)]-2,3-Butanediol	-	0.36	-	-	-	-
18.69	867	(E)-2-Octene-1-ol	-	-	-	-	-	0.18

Retention Time	RI	Compound	Substance Content (mg/L)					
			LLE			SDE		
			D	E	H	D	E	H
18.69	846	1,1-dibutanol ethane	-	-	-	-	0.13	-
19.46	876	2-furan methanol	2.67	4.45	-	-	-	-
19.79	876	(E)-6-Nonen-1-ol	-	-	-	0.02	-	0.13
19.93	782	N-nonyl alcohol	-	-	0.62	0.35	0.38	0.75
20	865	6-undecane alcohol	-	0.42	0.74	0.38	0.45	0.80
20.37	822	(Z)-3-Nonen-1-ol	-	-	-	-	0.01	-
22.59	807	Benzyl alcohol	-	0.16	-	-	-	-
22.65	931	Phenylethanol	2.75	3.93	3.44	0.68	0.84	1.20
		acids						
25.87	804	2-Methylacetate benzyl alcohol	-	0.19	-	-	-	-
16.13	913	acetic acid	39.53	-	-	-	-	-
17.2	861	propionic acid	2.53	5.22	-	-	-	-
17.65	920	2-methylpropionic acid	3.49	6.55	-	-	-	-
19.37	916	butyrate	53.55	80.02	55.06	-	-	-
19.6	800	3-Methylbutyric acid	8.64	14.84	12.18	-	-	1.49
20.94	805	Caproic acid and anhydride	-	1.87	-	1.16	1.41	1.92
21.02	852	2-Methylvaleric acid	-	-	-	-	-	0.43
21.53	903	4-Methylvaleric acid	0.72	1.11	1.71	0.34	0.48	0.77
22.33	726	Trans-2-dodecenoic acid	-	0.35	-	-	-	-
22.42	898	Caproic acid	100.58	107.62	80.92	98.36	81.86	91.66
23.2	866	Heptanoic acid	6.30	9.14	11.84	8.73	11.51	12.76
25.71	870	Nonanoic acid	-	0.31	0.35	0.26	-	-
26.7	844	Decanoic acid	-	0.18	0.38	0.21	0.15	-
26.94	798	Palmitic acid	-	1.28	-	1.49	2.24	0.96
29.43	950	Benzoic acid	0.61	0.95	0.77	-	-	-
		ketone						
9.51	890	2-heptanone	-	0.53	-	0.49	0.34	-
11.55	827	3-Octanone	-	-	-	-	-	0.04
12.34	785	2,2-dimethyl-3-heptanone	-	-	0.29	-	-	-
13.15	853	2-butanone, 3-hydroxy	5.73	-	-	-	-	-
14.62	910	2-Nonanone	-	0.72	0.72	0.32	0.19	0.44
19.29	762	Acetophenone	-	-	-	-	-	0.05
19.86	939	2-Nonen-4-one	-	-	-	0.08	-	0.10
25.01	949	2- (methoxy) -1-phenylethanone	-	0.26	-	0.10	-	-
		aldehyde						
7.3	890	N-hexanal	-	0.95	-	-	-	-
19.12	838	Phenylacetaldehyde	0.56	1.08	1.22	-	0.06	0.44
		aromatic compounds						
18.59	771	Benzene, (1-ethoxy-3-butenol)	-	0.15	-	-	-	-
19.74	881	Benzene, (2,2-diethoxyethyl)-	1.64	2.94	3.61	2.48	3.11	4.54
22.2	735	(2,2-diethoxyethyl) - benzene	-	-	-	0.17	-	-
22.42	850	Butyl hydroxytoluene	6.72	4.88	-	-	1.52	-
24.13	925	phenol	-	0.53	-	-	-	-
24.44	880	4-ethyl-2-methoxyphenol-	-	0.17	-	-	0.11	0.19
24.97	815	3-Methylphenol-	1.28	2.02	-	0.45	0.63	0.69
25.39	940	4-Methylphenol,	-	-	1.88	-	-	-
25.89	823	2-ethylphenol	-	-	-	-	-	0.13
26.77	861	2,4-Di-t-butylphenol	0.40	0.32	1.03	0.26	-	0.37
		heterocyclic compound						

Retention Time	RI	Compound	Substance Content (mg/L)					
			LLE			SDE		
			D	E	H	D	E	H
14.74	798	2-ethyl-3-methylpyrazine	-	-	-	-	-	0.11
14.92	769	trimethyl pyrazine	-	-	-	0.12	-	-
15.55	740	2- (3-methylbutyl) -3,5-dimethylpyrazine	-	-	0.27	-	-	-
16.49	813	Tetramethylpyrazine	-	-	-	-	-	0.04
16.57	902	3-Furfural	15.48	34.42	2.80	-	-	-
12.4	831	2,2 '- [Oxobis (methylene)] difuran	-	7.17	5.91	1.52	1.50	1.27
16.33	815	3-methyl-2,3-dihydrofuran	-	-	-	0.03	-	-
16.92	908	2-Acetofuran	-	0.29	-	-	-	-
18.14	806	1-Acetone, 1- (2-furanyl)	-	0.09	-	-	-	-
24.48	811	gamma-Nonanolactone	-	-	-	0.27	-	0.19
		acetal						
6.82	802	1,1-diethoxy-2-methylbutane	-	1.01	0.61	0.75	-	-
6.13	771	1,1-diethoxybutane	-	-	-	0.05	-	-
10.17	711	4-ethoxy-2-butanone	-	0.09	0.99	-	-	-
7.31	829	1,1-diethoxy-3-methylbutane	8.81	8.71	13.39	13.31	14.96	7.61
12.68	764	1,1-diethoxy-2-methylpropane	-	1.61	2.85	0.90	3.67	1.64
12.86	935	1,1,3-Triethoxypropane	1.03	1.06	2.17	1.07	0.94	1.84
15.53	778	2-Ethoxypropane	-	2.85	-	-	-	-
		alkane						
8.23	893	2,3,6,7-Tetramethyloctane	-	-	0.80	-	-	-
13.1	871	2,7,10-trimethyldodecane	-	-	1.66	-	-	-
17.36	915	1-cyclopropylpentane	1.87	3.18	4.57	-	-	-
18.9	859	Hexadecane	-	-	0.68	-	-	-
26.04	795	2,6-Dimethylheptadecane	-	0.17	-	-	-	-
14.89	770	6-Methyloctadecane	-	0.27	-	-	-	-
15.35	861	Tetradecane	-	-	0.27	-	0.40	-
18.5	715	2-undecane	-	0.58	-	-	-	-
25.45	862	Tetradecane	-	0.88	-	-	-	-
14.33	837	Dimethyl trisulfide	-	-	0.34	0.05	-	-

Esters are the most kinds of substances detected, a total of 67 species. At the same time, the ester flavor substances, including, ethyl caproate (figure 1, RT 11.56), ethyl lactate (figure 1, RT14.14) due to its high height in liquor (usually reached the level of g/L), almost reached saturation in the extractions, their quantitative results deviating greatly from the true values, having no reference value. Another important ester ethyl acetate (figure 1 RT4.15), due to its high content, was removed in the solvent delay stage, did not enter the chromatographic to analysis. Among other esters, ethyl butyrate, ethyl valerate, ethyl hetanate, ethyl acid, and 2-hydroxyl-4-methyl-valerate were higher between 10 mg/L and 100 mg/L. The third highest content esters are hexanoate esters, including propyl hexanoate, butyl hexanoate, isoamyl hexanoate, and hexyl hexanoate, with a content ranging from 5mg/L to 10mg/L. Other unmentioned esters have a content of around 1mg/L or even lower.

Alcohols are the second most diverse substance detected in this study. 3-methyl-1-butanol is the alcohol with the highest content, followed by 1-butanol, 2-butanol, 1-propanol, 2-methyl-1-propanol, 1-pentanol, and 1-hexanol. Except phenylethanol, the content of other alcohols not mentioned in Baijiu is almost at the level of ug/L.

In addition to alcohol and ester, acid is another important component of liquor[3], which plays an important role in the coordination of wine body. Generally speaking, acids have a higher boiling point, are not volatile, and are generally not easy to measure by gas chromatography. The highest levels of acids were acetic acid, caproic acid and butyric acid.

A total of 9 aldehyde and ketone substances detected in this time, the highest content of 3-hydroxy-2-butanone, at about 5 mg/L, which is almost pure in all the fermentation products.

In addition, A total of four pyrazine compounds were identified by LLE and SPE methods. They are Trimethylpyrazine, tetramethylpyrazine, 2-ethyl-3-methylpyrazine, and 2- (3-methylbutyl) -3,5-dimethylpyrazine, tetramethylpyrazine is a bioactive substance [4]. However, pyrazine compounds have limited contribution to the flavor of Luzhou flavor Baijiu.

Seven acetals were detected, usually produced by distillation in production and during the storage of liquor[5]. Alkane may result from contamination of other production processes such as packaging. A dimethyl trisulfide was detected, although its content is very low (ug / L), but it may have some impact on liquor flavor due to its very low aroma threshold[5].

Compared with LLE, SPE method prefers the extraction of esters, aromatic compounds and heterocyclic compounds, but

not organic acids, alcohols and aldones. This may be related to the properties of experimental solid phase extraction pillar, the experiment used in solid phase pillar filling material for common C18 material, its polarity is very weak, according to the similar dissolution principle, weak polarity is more likely to be adsorbed on solid phase column, and the extraction machine acid with strong polar compounds, does not have an advantage. As a kind of distilled liquor, the alcohol content is often about 50% vol. At present, in the report on liquid extraction, most experiments are to dilute liquor to 10 ~ 14% vol, which is equivalent to the alcohol level of wine. If the liquor is directly extracted without dilution, the organic phase and water phase cannot be layered due to the influence of ethanol, and the extraction effect of the target is poor[6]. It is true that the dilution of liquor samples can significantly reduce the effect of ethanol on the extract[7], but at the same time, the already extremely trace components of liquor (ug / L) are also diluted. This issue should be considered in follow-up studies.

4. Conclusion

The volatile components of Wuliang Luzhou-flavor liquor were analyzed by liquid extraction and solid phase extraction combined with GC-MS. A total of 166 species of substances, 66 esters, 43 alcohols, 15 acids, 7 ketones, two aldehydes, 9 aromatic and phenolic compounds, and 26 acetals, hydrocarbons and other heterocyclic compounds were identified. The compounds extracted from different polar solvents are different, and a variety of solvents can be used at the same time in extracting the flavor of liquor, which can extract the flavor substances in liquor more comprehensively.

This study further improved the analysis of the volatile components of Wuliang liquor, and made the relative quantitative analysis of the trace substances with very low content, which made a certain contribution to the comprehensive understanding of the organic components of Wuliang liquor and the accurate determination of the extreme content of the characteristic flavor components.

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