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Analysis of Volatiles from Fresh and Dry Rhizome, Pseudostem and Leaf of Musa Basjoo

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Abstract. Background: Musa basjoo Sieb. et Zucc. is widely distributed around the world, used to treat a variety of diseases. Volatile oils as an important component of the Musa basjoo, but it received less attention. In this study, Volatile constituents in both fresh and dry rhizome, pseudostem and leaf of Musa basjoo were studied.

Materials and Methods: a gas chromatography–mass spectrometry (GC–MS) with solid-phase micro extrac-tion (SPME) method was developed for the analysis of fresh and dry rhizome, pseudostem and leaf of Musa basjoo.

Results: 60, 73, 52, 70, 31, and 45 volatile components were indentified from fresh rhizome, dry rhizome, fresh pseudostem, dry pseudostem, fresh leaf and dry leaf, respectively. Only 14 compounds were mutual in the volatiles of six Musa basjoo parts. Comparison among fresh Musa basjoo rhizome, pseudostem and leaf, the mutual compounds were 30, 18, 14 compounds, respectively. The main compounds were Hexadecanal and Hexhanal. 35 mutual compounds were detected in the dry rhizome, pseudostem and leaf samples. 59, 36, 40 compounds were identified as the mutual constituents in the volatiles of dry rhizome, pseudostem and leaf, respectively.

Conclusion: the results showed that the volatiles from fresh and dry rhizome, pseudostem and leaf of Musa basjoo are quite different. And this work was conductive to the development and utilization of Musa basjoo.

1 Introduction

Cultivated and wild resources *Musa basjoo* Sieb. et Zucc. are wide distributed in China. The dried rhizome of *Musa basjoo* is Rhizoma Musae, a herb has been used for centuries in Miao medicine practice for heat-clearing and detoxifying treatments, as well as quenching of thirst and as a diuretic (Drug Administration of Guizhou Province, 2003; Bao, J., 1999). *Musa basjoo* pseudostem juice is used to treatment of convulsion, epilepsy, high blood pressure headache, otitis media, burns etc., *Musa basjoo* leaf has heat, diuretic, detoxification active. the two herbs records in the Chinese materia medica (Editorial board of state administration of traditional Chinese medicine for Chinese herbal medicine, 1999). several studies have suggested that Rhizoma Musae has anti-bacteria, anti–α-glucosidase, anti-inflammatory, anti-diabetic, and analgesic properties (Qian et al. 2010; Wei et al. 2010; Zhang et al. 2010; Qian et al. 2012; Xu et al. 2014; Zhang et al. 2010), another study has shown that the alkaloids of *Musa basjoo* pseudostem exhibits acute hypotensive effect on dog (Zhu et al. 1989).

Volatile oil is an important component of medicinal plants. Therefore, the research on volatiles is important. The volatile constituents from fresh and dry Rhizoma Musae extracted by steam distillation have been determined by gas chromatography with less identified volatile compounds, accounting for 76.28% and 81.78%, respectively (Wang et al. 2011). The volatiles of fresh and dry Musa basjoo pseudostem and leaf have not detected. Differences in *Musa basjoo* rhizome, pseudostem and leaf volatiles also have not compared. So in the paper, six medicinal parts (fresh and dry rhizome, pseudostem and leaf) of *Musa basjoo* were analysis by gas chromatography–mass spectrometry (GC–MS) with solid-phase micro extraction (SPME). Then, the comparison among the fresh and dry *Musa basjoo* rhizome, pseudostem and leaf was made. A comparative analysis on volatiles in different parts of *Musa basjoo* also evaluated.

2 Plant Materials

The *Musa basjoo* whole plant was collected from Jinsha county, guizhou province, P.R. China, in 2014 and further identified by Dr. X.P. Wang, Department of Pharmacognosy Guiyang College of Traditional Chinese Medicine, P. R. China. All voucher specimens were deposited in the Department of Pharmacognosy, Guiyang College of Traditional Chinese Medicine, P.R. China. The *Musa basjoo* rhizome, pseudostem and leaf were cut into small pieces, half of the samples were stored in a refrigerator and the temperature was set at -20 ℃, the other samples were placed in a cool dark place (temperatures between 20-30 ℃) to dry naturally.

3 Solid-Phase Micro Extraction Procedure

The accurately weighed fresh and dry rhizome, pseudostem and leaf small pieces (5.0 g) of *Musa basjoo* were placed into 20-mL sample vials from Supelco (Bellefonte, USA), respectively. Then, a 2cm-50/30um DVB-CAR-PDMS Stable Flex fiber (Bellefonte, USA) was used to the headspace above the samples for extracting 30 min under about 90 ℃. then the extraction head was removed from sample vials and immediately inserted onto the GC injection port. Desorption of analytes from the fiber coating was performed by heating the fiber in the injection port at 250 ℃ for 3 min.

4 Determination Conditions

HP6890 GC-5975C MSD (Agilent Technologie s, Palo Alto, CA, U.S.A.) using a ZB-5MSI (5% Phenyl-95% DiMethylpolysiloxane) fused silica capillary column (30 m×0.25 mm×0.25 μm) was used for constituents separation. The samples were injected in the splitless mode at 250 ℃. the initial column temperature was kept at 40 ℃ for 2 min, then adjusted to 280 ℃ at a rate of 4 ℃ /min and held for 2 min. High-purity of Helium (99.999%) was used as the carrier gas at a flow rate of 1.0 ml/min.

The mass spectrometer was fitted with an EI source operated at 70eV, the source temperature was 230 ℃, and the interface temperature was 280 ℃ with a solvent delay time of 1.5 min. Mass spectra were recorded in the full scan acquisition mode (m/z range 20-450). Volatile compounds were identified by comparing the obtained mass spectra of the analytes with those of authentic standards from the NIST2005 library and Wiley275 library.

5 Results and Discussion

Volatile of many herbs in China is responsible for their active substances. In order to study *Musa basjoo* volatile components, the fresh and dry rhizome, pseudostem and leaf of *Musa basjoo* samples were subjected to gas chromatography-mass spectrometry analysis. The volatiles in the fresh and dry rhizome, pseudostem and leaf of *Musa basjoo* are presented in the table 1-3 and figure 1-3.

Figure 1

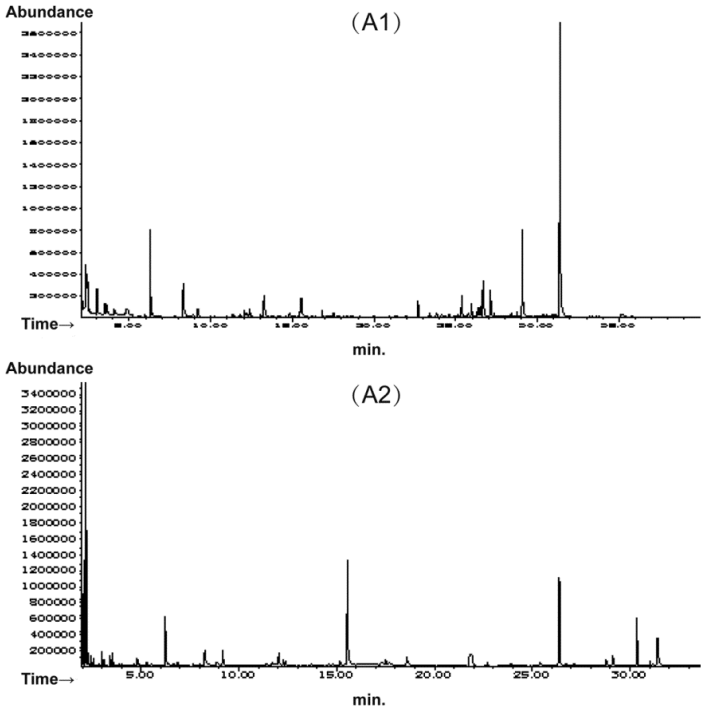

Figure 1. Typical total ion chromatograms of the volatile constituents from fresh (A1) and dry (A2) rhizome of *Musa basjoo*

Figure 2

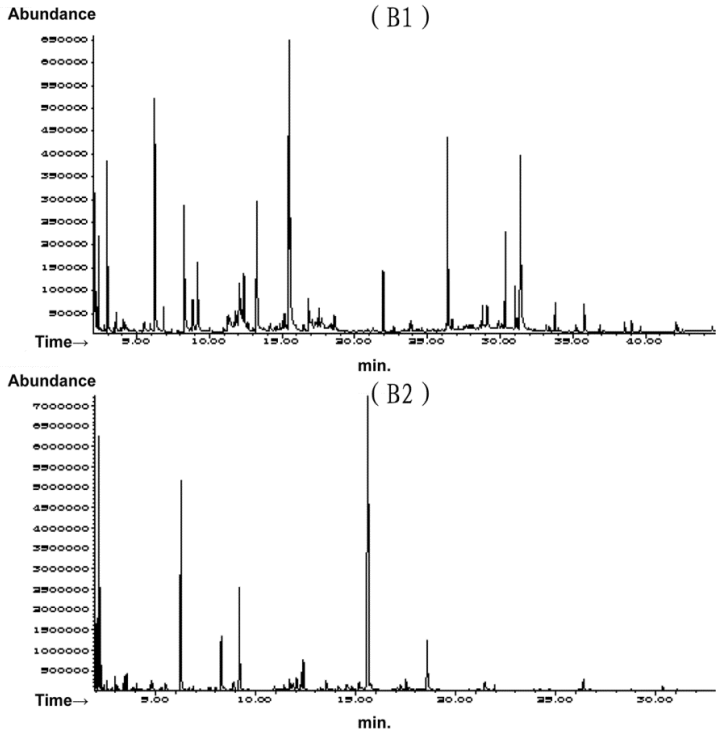

Figure 2. Typical total ion chromatograms of the volatile constituents from fresh (B1) and dry (B2) pseudostem of *Musa basjoo*

Figure 3

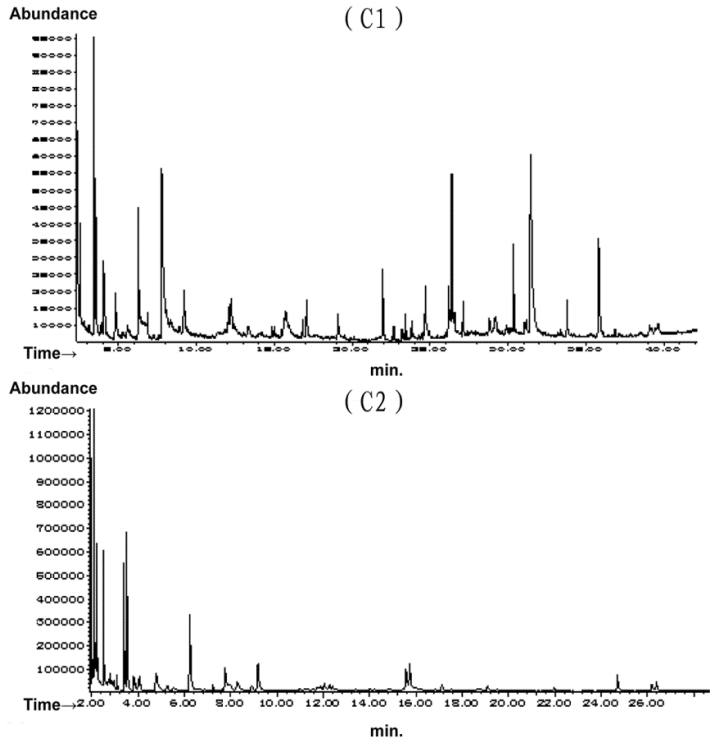

Figure 3. Typical total ion chromatograms of the volatile constituents from fresh (C1) and dry (C2) leaf of *Musa basjoo*

60 compounds were identified from the fresh *Musa basjoo* rhizome, accounting for the 93.83%, The main constituents were Hexadecanal (32.3%), Hexanal (7.56%),1-Hexanol (5.28%), Hexadecanol (4.38%), and Methyl acetate (3.31%). while, in the dry *Musa basjoo* rhizome, there were 73 chemical compositions were identified, which comprised 96.33% of the total volatile fraction (table 1). The content of Nonanal (17.80%), Ethanol (17.63%), Hexanal (7.33%), Ethanal (3.70%), 1-Hexanol (7.33%) was higher in the total volatiles. This result did not agreement with the previous studies (Wang et al. 2011). The volatile compounds of Rhizoma Musae may be affected by seasonal, location, sample pretreatment methods, extraction methods, and individuals. And 35 compounds were simultaneously detected in fresh and dry Rhizoma Musae. Alcohols (17.44%), aldehydes (56.12%), alkenes (10.45%) were the main compositions in the fresh Rhizoma Musae, but the content of these compositions were reduced in the drying process.

Table 1 Volatiles from fresh and dry rhizome of *Musa basjoo*

No.	Retention time (min)	Compound name	Formula	Molecular Weight	The percentage (%)	
					Fresh samples	Dry samples
1	2.02	Ethanal	C_2H_4O	44	-	4.24
2	2.14	Ethanol	C_2H_6O	46	-	17.63
3	2.44	Methyl acetate	C_3H_6O	74	3.31	0.66
4	2.55	Isobutanal	C_4H_8O	72	-	0.65
5	2.59	Isobutanol	C_4H_8O	72	0.25	-
6	2.63	(E)-2-Butanal	C_4H_6O	70	-	0.05
7	2.83	2-Butanone	C_4H_8O	72	-	0.15
8	3.02	Ethyl acetate	$C_4H_8O_2$	88	2.43	1.04
9	3.12	Isobutanol	$C_4H_{10}O$	74	-	0.51
10	3.47	3-methyl-Butanal	$C_5H_{10}O$	86	0.81	1.04
11	3.59	2-methyl-Butanal	$C_5H_{10}O$	86	0.97	1.35
12	3.84	1-Penten-3-ol	$C_5H_{10}O$	86	-	0.05

13	3.88	Triethylamine	$C_6H_{15}N$	101	-	0.37
14	4.09	Pentanal	$C_5H_{10}O$	86	0.59	0.29
15	4.12	2-ethylfuran	C_6H_8O	96	-	0.20
16	4.31	Ethyl propionate	$C_5H_{10}O_2$	102	-	0.11
17	4.61	2,4,5-trimethyl-1,3-dioxolane	$C_6H_{12}O_2$	116	-	0.21
18	4.68	1,1-diethoxy-Ethane	$C_6H_{14}O_2$	118	-	0.17
19	4.77	3-methyl-1-Butanol	$C_5H_{12}O$	88	0.80	0.94
20	4.87	2-methyl-1-Butanol	$C_5H_{12}O$	88	0.77	0.99
21	5.29	Ethyl isobutyrate	$C_6H_{12}O_2$	116	-	0.38
22	5.6	1-Pentanol	$C_5H_{12}O$	88	0.27	0.30
23	5.96	Diethyl carbonate	$C_5H_{10}O_3$	118	0.26	-
24	6.28	Hexanal	$C_6H_{12}O$	100	7.56	7.33
25	6.66	Butyl acetate	$C_6H_{12}O_2$	116	-	0.33
26	7.25	3-methyl-Hexan-2-one	$C_6H_{10}O_2$	114	-	0.04
27	7.67	Ethyl 2-methylbutyrate	$C_7H_{14}O_2$	130	-	0.23
28	7.79	(Z)-3-Hexenal	$C_6H_{10}O$	98	0.23	0.30
29	8	Ethyl benzene	C_8H_{10}	106	-	0.15
30	8.31	1-Hexanol	$C_6H_{14}O$	102	5.28	3.70
31	8.45	Isoamyl acetate	$C_7H_{14}O_2$	130	-	0.38
32	8.74	5-methyl-3-methylene-5-Hexen-2-one	$C_8H_{12}O$	124	-	0.09
33	8.89	Styrene	C_8H_8	104	-	0.49
34	8.9	2-Heptanone	$C_7H_{14}O$	114	0.30	0.46
35	8.93	m-xylene	C_8H_{10}	106	-	0.26
36	9.14	(Z)-4-Heptenal	$C_7H_{12}O$	112	0.12	-
37	9.17	Heptanal	$C_7H_{14}O$	114	-	2.74
38	9.2	3-Methyl-2-Hexanol	$C_7H_{16}O$	116	1.22	-
39	9.94	Methyl caproate	$C_7H_{14}O_2$	130	0.08	-
40	10	3-Methyl-4-Heptanone	$C_8H_{16}O$	128	0.15	-
41	11.28	3-methyl-4-Heptanol	$C_8H_{18}O$	130	0.28	-
42	11.38	2-methyl-4-Heptanol	$C_8H_{18}O$	130	0.27	-
43	11.42	Heptanol	$C_7H_{16}O$	116	-	0.48
44	11.71	1-Octen-3-ol	$C_8H_{16}O$	128	0.10	0.44
45	11.79	2,3-Octanedione	$C_8H_{14}O_2$	142	0.16	0.36
46	11.84	6-methyl-5-Hepten-2-one	$C_8H_{14}O$	126	-	0.56
47	12.04	2-Pentyl-Furan	$C_9H_{14}O$	138	0.53	2.00
48	12.2	3-Octanol	$C_8H_{18}O$	130	0.45	-
49	12.27	Ethyl Caproate	$C_8H_{16}O_2$	144	-	0.80
50	12.38	Octanal	$C_8H_{16}O$	128	0.99	0.73
51	13.02	(S)-3-ethyl-4-Methylpentanol	$C_8H_{18}O$	130	0.37	-
52	13.24	2-ethyl-1-Hexanol	$C_8H_{18}O$	130	1.95	0.16
53	13.28	1,8-Cineole	$C_{10}H_{18}O$	154	0.89	-
54	13.56	3-Octen-2-one	$C_8H_{14}O$	126	-	0.22
55	13.7	Nitrohexane	$C_6H_{13}NO_2$	131	-	0.48
56	14.17	(E)-2-Octenal	$C_8H_{14}O$	126	-	0.26
57	14.61	(E,E)-3,5-Octadien-2-one	$C_8H_{12}O$	124	-	0.72
58	14.81	Allyl disulfide	$C_6H_{10}S_2$	146	0.29	0.34
59	15.17	2-Nonanone	$C_9H_{18}O$	142	-	0.93
60	15.46	Linalool	$C_{10}H_{18}O$	154	0.61	-
61	15.54	Nonanal	$C_9H_{18}O$	142	2.69	17.80
62	16.82	Camphor	$C_{10}H_{16}O$	152	0.64	0.26
63	17.29	(E)-2-Nonenal	$C_9H_{16}O$	140	-	1.53
64	17.51	endo-Borneol	$C_{10}H_{18}O$	154	0.44	1.14
65	17.7	Nonanol	$C_9H_{20}O$	144	-	1.08
66	18.41	Dodecane	$C_{12}H_{26}$	156	-	0.14

67	18.59	Decanal	$C_{10}H_{20}O$	156	0.27	2.46
68	19.99	1-butoxy-1-(2-methylpropoxy)-Butane	$C_{12}H_{26}O_2$	204	0.12	-
69	20.9	Bornyl acetate	$C_{12}H_{20}O_2$	196	0.11	-
70	21.11	2-Vndecanone	$C_{11}H_{20}O$	170	-	0.04
71	21.24	Tridecane	$C_{13}H_{18}$	184	-	0.18
72	22.58	α-Copaene	$C_{15}H_{24}$	204	-	0.21
73	22.69	α-Cubebene	$C_{15}H_{24}$	204	1.36	0.55
74	23.42	α-Ylangene	$C_{15}H_{24}$	204	0.42	0.19
75	23.81	β-Elemene	$C_{15}H_{24}$	204	0.38	-
76	23.89	Tetradecane	$C_{14}H_{30}$	198	0.22	0.45
77	24.27	Junipene	$C_{15}H_{24}$	204	-	0.23
78	24.59	(E)-Caryophyllene	$C_{15}H_{24}$	204	0.28	0.24
79	24.92	Calarene	$C_{15}H_{24}$	204	0.15	-
80	25.14	α-Garjunene	$C_{15}H_{24}$	204	0.13	-
81	25.36	(E)-β-farnesene	$C_{15}H_{24}$	204	1.96	0.68
82	25.97	Selin-4,7(11)-diene	$C_{15}H_{24}$	204	1.14	0.31
83	26.28	Alloaromadendrene	$C_{15}H_{24}$	204	0.45	-
84	26.5	α-Selinene	$C_{15}H_{24}$	204	0.98	0.34
85	26.67	Hexadecanol	$C_{16}H_{34}O$	242	4.38	0.60
86	27.12	1s,(Z)-Calamene	$C_{15}H_{22}$	202	2.72	0.66
87	27.36	Cadina-1,4-diene	$C_{15}H_{24}$	204	0.34	-
88	27.64	α-Calacorene	$C_{15}H_{20}$	200	0.14	-
89	28.77	Hexadecane	$C_{16}H_{34}$	226	0.47	1.25
90	29.08	Tetradecanal	$C_{14}H_{28}O$	212	9.08	2.30
91	31.02	Heptadecane	$C_{17}H_{36}$	240	0.25	0.76
92	31.14	2,6-dimethyl-Heptadecane	$C_{19}H_{40}$	268	0.24	0.41
93	31.39	Hexadecanal	$C_{16}H_{32}O$	240	32.3	8.51
94	33.17	Octadecane	$C_{18}H_{38}$	254	0.14	-
95	35.11	9,12-Octadecadienal	$C_{18}H_{32O}$	264	0.51	-
96	35.22	Nonadecane	$C_{18}H_{38}$	254	1.16	-
97	35.79	Methyl plamitate	$C_{17}H_{34}O_2$	270	0.20	-

Table 2 Volatiles from fresh and dry pseudostem of *Musa basjoo*

No.	Retention time(min)	Compound name	Formula	Molecular Weight	The percentage (%)	
					Fresh samples	Dry samples
1	2.02	Ethanal	C_2H_4O	44	-	2.69
2	2.14	Ethanol	C_2H_6O	46	2.3	10.23
3	2.4	Methyl acetate	C_3H_6O	74	1.65	0.24
4	2.55	Isobutanal	C_4H_8O	72	-	0.41
5	2.63	(E)-2-Butanal	C_4H_6O	70	-	0.07
6	2.82	2-Butanone	C_4H_8O	72	-	0.10
7	2.98	Ethyl acetate	$C_4H_8O_2$	88	3.64	0.57
8	3.12	Isobutanol	$C_4H_{10}O$	74	-	0.27
9	3.39	(Z)-2-Butenal	C_4H_6O	70	-	0.04
10	3.42	3-methyl-Butenal	$C_5H_{10}O$	86	-	0.77
11	3.55	2-methyl-Butenal	$C_5H_{10}O$	86	-	0.89
12	3.57	1-Butanol	$C_4H_{10}O$	74	0.75	-
13	3.83	1-Penten-3-ol	$C_5H_{10}O$	86	-	0.11
14	3.88	Triethylamine	$C_6H_{15}N$	101	-	0.19
15	4.04	Pentanal	$C_5H_{10}O$	86	0.36	0.42
16	4.31	Ethyl propionate	$C_5H_{10}O_2$	102	-	0.05
17	4.61	2,4,5-trimethyl-1,3-dioxolane	$C_6H_{12}O_2$	116	-	0.09
18	4.68	1,1-diethoxy-Ethane	$C_6H_{14}O_2$	118	-	0.07

19	4.77	3-methyl-1-Butanol	$C_5H_{12}O$	88	-	0.59
20	4.85	2-methyl-1-Butanol	$C_5H_{12}O$	88	-	0.49
21	5.29	Ethyl isobutyrate	$C_6H_{12}O_2$	116	-	0.20
22	5.52	1-Pentanol	$C_5H_{12}O$	88	0.37	0.60
23	5.92	Diethyl carbonate	$C_5H_{10}O_3$	118	0.32	-
24	6.24	Hexanal	$C_6H_{12}O$	100	8.62	14.32
25	6.66	Butyl acetate	$C_6H_{12}O_2$	116	-	0.16
26	7.24	3-methyl-Hexan-2-one	$C_6H_{10}O_2$	114	-	0.16
27	7.41	3-Methyl-3-Hexanol	$C_7H_{16}O$	116	0.13	-
28	7.67	Ethyl 2-methylbutyrate	$C_7H_{14}O_2$	130	-	0.20
29	7.78	(Z)-3-Hexenal	$C_6H_{10}O$	98	0.14	0.28
30	8	Ethylbenzene	C_8H_{10}	106	-	0.19
31	8.26	1-Hexanol	$C_6H_{14}O$	102	7.02	4.61
32	8.45	Isoamyl acetate	$C_7H_{14}O_2$	130	-	0.15
33	8.74	5-methyl-3-methylene-5-Hexen-2-one	$C_8H_{12}O$	124	-	0.08
34	8.86	2-Heptanone	$C_7H_{14}O$	114	1.65	0.26
35	8.89	Styrene	C_8H_8	104	-	0.52
36	8.93	m-xylene	C_8H_{10}	106	-	0.24
37	9.14	(Z)-4-Heptenal	$C_7H_{12}O$	112	0.11	-
38	9.19	3-Methyl-2-Hexanol	$C_7H_{16}O$	116	3.56	-
39	9.19	Heptanal	$C_7H_{14}O$	114	-	6.98
40	9.61	Methoxy-phenyl-oxime	$C_8H_9NO_2$	151	-	0.14
41	9.99	3-Methyl-4-Heptanone	$C_8H_{16}O$	128	0.18	-
42	10.93	(E)-2-Heptenal	$C_7H_{12}O$	112	-	0.38
43	11.41	Heptanol	$C_7H_{16}O$	116	-	0.59
44	11.7	1-Octen-3-ol	$C_8H_{16}O$	128	-	0.73
45	11.79	2,3-Octanedione	$C_8H_{14}O_2$	142	0.46	0.43
46	11.88	6-methyl-5-Hepten-2-one	$C_8H_{14}O$	126	-	0.54
47	12.05	2-Pentyl-Furan	$C_9H_{14}O$	138	1.59	0.90
48	12.28	Ethyl Caproate	$C_8H_{16}O_2$	144	-	1.15
49	12.38	Octanal	$C_8H_{16}O$	128	3.11	1.98
50	12.65	(E)-β-Ocimene	$C_{10}H_{16}$	136	0.25	-
51	13.25	2-ethyl-1-Hexanol	$C_8H_{18}O$	130	4.89	0.22
52	13.29	1,8-Cineole	$C_{10}H_{18}O$	154	1.73	-
53	13.53	3-Ochen-2-one	$C_8H_{14}O$	126	-	0.93
54	14.13	(E)-2-Octenal	$C_8H_{14}O$	126	-	0.51
55	14.46	(E)-Sabinene hydrate	$C_{10}H_{18}O$	154	0.22	-
56	14.54	(E,E)-3,5-Octadien-2-one	$C_8H_{12}O$	124	-	1.03
57	14.81	Allyl disulfide	$C_6H_{10}S_2$	146	-	0.28
58	15.17	2-Nonanone	$C_9H_{18}O$	142	-	0.58
59	15.27	2-Methoxy-3-isopropyl pyrazine	$C_8H_{12}N_2O$	152	0.09	-
60	15.47	Linalool	$C_{10}H_{18}O$	154	12.12	-
61	15.55	Nonanal	$C_9H_{18}O$	142	6.7	30.88
62	16.49	(Z)-Limonene oxide	$C_{10}H_{16}O$	152	0.28	-
63	16.83	Camphor	$C_{10}H_{16}O$	152	2.07	0.13
64	17.24	(E)-2-Nonenal	$C_9H_{16}O$	140	-	0.62
65	17.52	endo-Borneol	$C_{10}H_{18}O$	154	1.45	0.88
66	17.66	Nonanol	$C_9H_{20}O$	144	-	0.33
67	18.27	α-Terpineol	$C_{10}H_{18}O$	154	0.27	-
68	18.41	Dodecane	$C_{12}H_{26}$	170	0.22	0.11
69	18.6	Decanal	$C_{10}H_{20}O$	156	1.08	4.85
70	19.08	1,3,4-trimethyl-3-cyclohexene-1-carboxaldehyde	$C_{10}H_{16}O$	152	-	0.14
71	20.91	Bornyl acetate	$C_{12}H_{20}O_2$	196	0.12	-
72	21.09	2-Vndecanone	$C_{11}H_{20}O$	170	-	0.11
73	21.24	Tridecane	$C_{13}H_{28}$	184	0.10	0.07

74	21.45	Dodecanal	$C_{12}H_{24}O$	184	-	1.27
75	22.59	α-Copaene	$C_{15}H_{24}$	204	0.12	0.04
76	22.7	α-Cubebene	$C_{15}H_{24}$	204	0.27	0.06
77	23.83	β-Elemene	$C_{15}H_{24}$	204	0.40	-
78	23.9	Tetradecane	$C_{14}H_{30}$	198	0.40	0.09
79	24.26	Junipene	$C_{15}H_{24}$	204	-	0.12
80	24.69	α-Ionone	$C_{13}H_{20}O$	192	-	0.29
81	26.18	β-Ionone	$C_{13}H_{20}O$	192	-	0.19
82	26.7	Seychellene	$C_{15}H_{24}$	204	0.44	0.16
83	27.13	Calamenene	$C_{15}H_{22}$	202	0.22	-
84	28.78	Hexadecane	$C_{16}H_{34}$	226	1.02	0.21
85	29.11	Tetradecanal	$C_{14}H_{28}O$	212	1.61	-
86	31.03	Heptadecane	$C_{17}H_{36}$	240	1.55	0.09
87	31.16	2,6-dimethyl-Heptadecane	$C_{19}H_{40}$	268	0.53	0.06
88	31.39	Hexadecanal	$C_{16}H_{32}O$	240	10.98	-
89	31.54	Methyl myristate	$C_{15}H_{30}O_2$	242	0.70	-
90	33.17	Octadecane	$C_{18}H_{38}$	254	0.26	-
91	35.23	Nonadecane	$C_{19}H_{40}$	268	0.30	-
92	35.78	Methyl palmitate	$C_{17}H_{34}O_2$	270	1.72	-
93	37.1	Ethyl pentadecanoate	$C_{17}H_{34}O_2$	270	0.12	-
94	38.57	10-Heneicosene	$C_{21}H_{42}$	294	0.60	-
95	39.05	Heneicosane	$C_{21}H_{44}$	296	0.57	-
96	42.11	11-Tricosene	$C_{23}H_{46}$	322	0.53	-

Table 3 Volatiles from fresh and dry leaf of *Musa basjoo*

No.	Retention time(min)	Compound name	Formula	Molecular Weight	The percentage (%)	
					Fresh samples	Dry samples
1	1.98	Ethanal	C_2H_4O	44	-	8.95
2	2.1	Ethanol	C_2H_6O	46	-	11.91
3	2.39	Methy acetate	$C_3H_6O_2$	74	1.68	-
4	2.53	Isobutanal	C_4H_8O	72	1.23	6.96
5	2.79	2-Butanone	C_4H_8O	72	-	0.60
6	2.99	Ethyl acetate	$C_4H_8O_2$	88	-	0.41
7	3.11	Isobutanol	$C_4H_{10}O$	74	-	0.76
8	3.39	(Z)-2-Butenal	C_4H_6O	70	-	6.68
9	3.41	3-methyl-Butanal	C_5H_6O	86	9.35	1.81
10	3.54	2-methyl-Butanal	C_5H_6O	86	4.30	10.12
11	3.81	1-Penten-3-ol	$C_5H_{10}O$	86	-	0.73
12	3.87	Triethyl amine	$C_6H_{15}N$	101	-	0.44
13	4.03	Pentanol	$C_5H_{10}O$	86	-	0.77
14	4.05	Pentanal	$C_5H_{10}O$	86	4.14	-
15	4.09	2-ethyl-furan	C_6H_8O	96	-	1.00
16	4.6	2,4,5-trimethyl-1,3-dioxolane	$C_6H_{12}O_2$	116	-	0.10
17	4.67	1,1-diethoxy-Ethane	$C_6H_{14}O_2$	118	-	0.12
18	4.77	3-methyl-1-Butanol	$C_5H_{12}O$	88	1.66	1.37
19	4.85	2-methyl-1-Butanol	$C_5H_{12}O$	88	1.02	1.92
20	5.27	Ethyl isobutyrate	$C_6H_{12}O_2$	116	-	0.64
21	5.53	1-Pentanol	$C_5H_{12}O$	88	-	0.19
22	6.23	Hexanal	$C_6H_{12}O$	100	5.67	10.48
23	7.23	3-methyl-Hexan-2-one	$C_6H_{10}O_2$	114	-	0.79
24	7.67	Ethyl 2-methylbutyrate	$C_7H_{14}O_2$	130	-	0.22
25	7.75	(Z)-3-Hexenal	$C_6H_{10}O$	98	17.33	3.88
26	7.99	Ethyl benzene	C_8H_{10}	106	-	1.23
27	8.29	1-Hexanol	$C_6H_{14}O$	102	-	2.12
28	8.9	Styrene	C_8H_8	104	-	0.43
29	8.93	m-xylene	C_8H_{10}	106	-	0.46
30	9.18	Heptanal	$C_7H_{14}O$	114	-	4.07
31	9.2	3-Methy-2-Hexanol	$C_7H_{16}O$	116	3.30	-

32	10.99	(E)-2-Heptenal	$C_7H_{12}O$	112	-	0.47
33	11.72	1-Octen-3-ol	$C_8H_{16}O$	128	-	0.58
34	11.79	2,3-Octanedione	$C_8H_{14}O_2$	142	-	0.35
35	11.9	6-methyl-5-Hepten-2-one	$C_8H_{14}O$	126	-	0.71
36	12.06	2-Pentyl-Furan	$C_9H_{14}O$	138	1.13	1.10
37	12.28	Ethyl Caproate	$C_8H_{16}O_2$	144	-	0.80
38	12.4	Octanal	$C_8H_{16}O$	128	-	0.70
39	14.01	2,4,4-trimethyl-2-Cyclohexen-1-ol	$C_9H_{16}O$	140	-	0.34
40	14.83	Allyl disulfide	$C_6H_{10}S_2$	146	-	0.32
41	15.47	Linalool	$C_{10}H_{18}O$	154	0.29	-
42	15.64	Nonanal	$C_9H_{18}O$	142	1.42	3.34
43	15.73	Neoisomenthol	$C_{10}H_{20}O$	156	-	3.94
44	16.82	Camphor	$C_{10}H_{16}O$	152	0.87	-
45	17.52	Endo-Borneol	$C_{10}H_{18}O$	154	-	0.23
46	19.08	1,3,4-trimethyl-3-cyclohexene-1-carboxaldehyde	$C_{10}H_{16}O$	152	1.45	0.68
47	22.58	α-Copaene	$C_{15}H_{24}$	204	-	0.06
48	22.69	α-Cubebene	$C_{15}H_{24}$	204	0.41	-
49	23.19	(+)-Cycloisosativene	$C_{15}H_{24}$	204	0.54	-
50	23.42	α-Ylangene	$C_{15}H_{24}$	204	0.97	-
51	23.82	β-Elemene	$C_{15}H_{24}$	204	0.61	-
52	24.26	Junipene	$C_{15}H_{24}$	204	-	0.05
53	24.69	α-Ionone	$C_{13}H_{20}O$	192	2.41	2.30
54	26.18	β-Ionone	$C_{13}H_{20}O$	192	3.03	1.20
55	26.57	α-Muurolene	$C_{15}H_{24}$	204	1.30	-
56	27.12	σ-Cadinene	$C_{15}H_{24}$	204	1.41	-
57	28.8	Hexadecane	$C16H_{34}$	226	1.00	-
58	31.05	Heptadecane	$C_{17}H_{36}$	240	0.58	-
59	31.17	2,6-dimethyl-Heptadecane	$C_{19}H_{40}$	268	0.62	-
60	31.44	Hexadecanal	$C_{16}H_{32}O$	240	17.85	-
61	33.18	Octadecane	$C_{18}H_{38}$	254	0.30	-
62	35.81	Nonadecane	$C_{19}H_{40}$	268	7.17	-
63	39.06	Heneicosane	$C_{21}H_{44}$	296	0.37	-
64	39.6	Methyl Stearate	$C_{19}H_{38}O_2$	298	0.42	-

The indentified volatile compounds of dry *Musa basjoo* pseudostem were more than the fresh pseudostem samples, 73 compounds were indentified, accounting for the 98.33% of the total volatiles, The main constituents were Nonanal (30.88%), Heptanal (6.98%), Hexanal (14.32%), Ethanol (10.23%), 1-Hexanol (4.61%), Ethanal (2.69%). In the fresh pseudostem, only 52 compounds were indentified, accounting for 89.89%. Linalool (12.12%), Hexadecanal (10.98%), Hexanal (8.62%), 1-Hexanol (7.02%), Nonanal (6.70%), and 2-ethyl-1-Hexanol (4.89%) were the main constituents in the total volatiles. There were 26 mutual compounds in the fresh and dry *Musa basjoo* pseudostem. Alcohols and aldehydes were the main compositions in the *Musa basjoo* pseudostem volatiles. Esters in fresh *Musa basjoo* pseudostem were much higher than in the dry sample (table 2).

31 and 45 volatile compounds were detected in the fresh and dry *Musa basjoo* leaf, respectively. The content of identify compounds was higher than 93% in the total volatiles of both fresh and dry *Musa basjoo* leaf. The main constituents were Hexadecanal (17.85%), (*Z*)-3-Hexenal (17.33%), 3-methyl-Butanal (9.35%), Hexanal (5.67%), 2-methyl-Butanal (4.30%), and Pentanal (4.14%). In the dry leaf, the main constituents included Ethanol (11.91%), Hexanal (10.48%), 2-methyl-Butanal (10.12%), Ethanal (8.95%), Isobutanal (6.96%), (*Z*)-2-Butenal (6.68%), and Heptanal (4.07%). Neoisomenthol (3.94%) (*Z*)-3-Hexenal (3.88%), and Nonanal (3.34%). The aldehydes and alcohols were the higher compounds in the fresh and dry leaf. The esters in fresh leaf were 9.27%, while only 2.07% in the dry sample. It may be associated with the volatility of esters during the drying process (table 3).

Comparison of the volatiles of fresh rhizome, pseudostem and leaf of *Musa basjoo*, only 14 compounds were mutual in the volatiles of six *Musa basjoo* parts. Comparison among fresh rhizome, pseudostem and leaf, the mutual compounds were 30, 18, 14 compounds, respectively. The main compounds were Hexadecanal and Hexhanal. 35 mutual compounds were detected in the dry rhizome, pseudostem and leaf samples. 59, 36, 40 compounds were identified as the mutual constituents in the volatiles of dry rhizome, pseudostem and leaf, respectively. Some main compounds, such as Ethanal, Hexanal, Nonanal, Ethanol, and 1-Hexanol were mutual in the dry rhizome, pseudostem and leaf, accounting for 50.70%, 62.73% and 36.8% of the identified compound in the three parts volatiles of *Musa basjoo*, respectively.

From the above, the results showed that there is a great difference between the fresh and dry (rhizome, pseudostem and leaf) samples. The volatile oil components among different parts of the *Musa basjoo* had significant differences, too. In the development and utilization of *Musa basjoo* volatile oils, the difference among the three parts volatiles is important. Volatile oils have antibacterial (Abdul et al. 2014), anti-inflammatory (Soares et al. 2014) and anti-tumor activity (Jiang et al. 2012) etc. *Musa basjoo* have a variety of pharmacological activities with rich resources, so more works should do on its pharmacological activities.

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References

[1] Bao, J.& Ran, M.X. 1999. *The study, development and re-evaluation of the Miao people’s medicines of Guizhou Province*. Guiyang: Guizhou Science and Technology Press.

[2] Drug Administration of Guizhou Province. 2003. *Herbs, national medicinal quality standards in Guizhou Province.* Guiyang: Guizhou science and Technology Press.

[3] Editorial board of state administration of traditional Chinese medicine for Chinese herbal medicine. 1999. *Chinese herbal medicine.* Shanghai: Shanghai Science and Technology Press.

[4] Jiang, J. L.& Ding, H. T.& Su, X.& Yuan, Y.J. 2012. Identification of anti-tumor ingredients in curcuma volatile oil based on composition-activity relationship. *Chin. J. Anal. Chem. 40:* 1488-1493.

[5] Laghari, A. H.& Memon, S.& Nelofar, A.& Khan, K.M. 2014. Determination of volatile constituents and antimicrobial activity of camel thorn (Alhagi camelorum) flowers. *Anal. Lett. 47(3):* 413-421.

[6] Qian, H.B.& Hao, J.J.& Wang. X.P. 2012. Effect of effective parts from Musa basjoo on blood glucose and glucose tolerance in mice. *Chin. J. Exp. Tradit. Med. Form. 18:* 187-189.

[7] Qian, H.B.& Sun, Y. & Huang, J.& Wang, X.P. 2010. Experimental study on anti-inflammatory and analgesic effects of different extracts from Musa basjoo. *Lishizhen Med. Mater. Med. Res. 21:* 780-781.

[8] Soares, D. J.& Walker& Pignitter, M.& Walker, J. M.& Imboeck, J. M.& Ehrnhoefer-Ressler, M. M.& Somoza, V. 2014. Pitanga (Eugenia uniflora L.) fruit juice and two major constituents thereof exhibit anti-inflammatory properties in human gingival and oral gum epithelial cells. *Food Funct. 5(11):* 2981-2988.

[9] Wei, J.F.& Zhang, Q.& Zhao, L.& Kang, W.Y. 2010. Antimicrobial activity of Musa basjoo in vitro. *Chin. J. Exp. Tradit. Med. Form. 16:* 69-71.

[10] Wang, X.P.& Xu, S.N.&Wu, H.M.& Jin, F.Y. 2011. Study on Chemical Components of Essential Oils from Fresh and Dry Rhizoma Musae by Gas Chromatography-Mass Spectrometry. *Chin. J. Exp. Tradit. Med. Form. 17:* 82-85.

[11] Xu, F.& Wu, H.& Wang, X. P.& Yang, Y.& Wang, Y. M.& Qian, H. B.& Zhang, Y. Y. 2014. RP-HPLC characterization of lupenone and β-sitosterol in Rhizoma Musae and evaluation of

the anti-diabetic activity of lupenone in diabetic sprague-dawley rats. *Molecules 19:* 14114-14127.

[12] Zhang, Q.& Chang, X.& Kang, W.Y. 2010. α-glucosidase inhibitory activity of Musa Basjoo. *Sci. Tech. Food Ind. 31:* 125-126, 130.

[13] Zhang, Q.& Kang, W.Y. 2010. Active constituents of Musa basjoo. *Chin. J. Chin. Mater. Med. 35:* 2424-2426.

[14] Zhu, S.Q.& Mo, S.Z. 1989. The alkaloids of Musa basjoo pseudostem on blood pressure in dogs. *Mod. Appl. Pharm. 6:* 47.