

Article

Characterization of Volatile Profiles and Correlated Contributing Compounds in Pan-Fried Steaks from Different Chinese Yellow Cattle Breeds through GC-Q-Orbitrap, E-Nose, and Sensory Evaluation

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Table S1. Qualitative and quantitative analyses of volatile organic compounds (VOCs) of pan-fried steaks from different yellow cattle breeds.

Type s of VOC s	N O.	Compounds Information		Relative contents of VOCs (µg/kg)							SE M
		Component Name	Cal- cu- lated RI ^x	Li- brary RI ^y	BH	JX	YL	WS	XJ	PL	
Alde- hyde s	1	Acetaldehyde	706	702	462.92 b	780.86a	551.79 b	771.33a	753.15a	755.44a	51.6 7
	2	Butanal	906	877	74.08c	115.36 b	86.81c	126.48a b	130.97a b	145.60a	9.06
	3	3-Methyl-butanal	921	923	53.75c	90.01c	51.31c	73.52c	139.77 b	206.48a	12.7 7
	4	Pentanal	983	991	78.78b	86.59b	200.12a b	376.03a	275.22a	327.56a	56.8 4
	5	Hexanal	1086	1098	2591.35 b	2864.51 b	7626.23 ab	12495.0 7a	9546.86 ab	11539.1 5a	2224 .46
	6	Heptanal	1190	1192	619.65c	475.61c	1257.02 bc	3104.26 a	1446.47 bc	2147.91 ab	411. 08
	7	Octanal	1295	1298	492.43c	465.04c	1266.89 b	2348.26 a	904.80 bc	1528.70 b	215. 90
	8	(E)-2-Heptenal	1332	1335	22.33b	26.72b	57.74a b	93.63a	86.05a	81.74a	14.1 6
	9	Nonanal	1400	1402	1984.34 d	1672.72 d	6919.63 b	12250.1 8a	3607.64 cd	6133.55 bc	1018 .44
	10	(E)-2-Octenal	1438	1441	161.06 b	193.96 b	450.27a b	641.19a	565.28a	660.01a	102. 25
	11	Decanal	1506	1508	84.27c	85.31c	186.05 b	311.87a	159.36 bc	158.39 bc	28.5 4
	12	Benzaldehyde	1537	1541	14837.1 3d	21394.3 3bc	18745.5 7cd	27236.6 5ab	24484.8 8bc	32321.4 4a	1989 .02
	13	(E)-2-Nonenal	1545	1547	223.84 b	218.94 b	419.57 b	838.83a	555.05a b	932.20a	127. 47
	14	(E)-2-Decenal	1654	1644	34.38d	34.46d	93.54bc	164.27a	61.97c d	113.04 b	13.6 8
	15	Benzeneacetaldehyde	1657	1661	2451.95 c	3139.09 bc	2812.43 bc	4040.99 b	5624.90 a	6305.57 a	422. 71
	16	4-Ethyl-benzaldehyde	1724	1721	20.00d	31.59c d	63.79bc d	95.38b	81.66bc	150.61a	17.1 3
	17	E-Citral	1742	1744	1.06d	1.17d	13.26b	32.94a	2.60c	3.83c	0.46
	18	(E)-2-Undecenal	1762	1751	125.58 d	126.48 d	285.71 bc	411.62a	212.66c d	374.47a b	36.5 9
	19	(E,Z)-2,4-Decadienal	1775	1754	11.68b	13.37b	27.58a b	45.81a	34.29a	44.36a	5.64
	20	(E,E)-2,4-Decadienal	1822	1823	15.60b	17.36b	29.09a b	41.29a	47.60a	48.90a	6.76
	21	4-Pentyl-benzalde- hyde	2023	2003	12.41d	22.57c d	40.01bc	50.35b	57.63b	84.44a	7.89
	22	4-Methoxy-benzalde- hyde	2045	2011	19.18d	25.02c d	73.96b	166.36a	37.90c	30.57c d	4.67
Alco- hols	23	Isopropyl alcohol	931	927	201.51 b	174.37 b	2792.24 a	216.41 b	286.30 b	191.46 b	35.3 5
	24	1-Hexanol	1352	1355	126.10	103.59	105.78	182.05	83.55	137.40	28.4 4

	25	1-Octen-3-ol	1449	1451	546.40c	796.94c	2023.49	3222.68	1682.69	2378.40	375.12
							ab	a	bc	ab	
	26	1-Octanol	1558	1557	321.35c	269.12	1078.54	1619.16	466.41c	746.45	135.18
					d	d	b	a	d	bc	
	27	(Z)-5-Octen-1-ol	1617	1619	94.50c	123.40c	301.47	498.21a	229.62	340.10a	52.1
							b		bc	b	9
	28	alpha-Terpeneol	1703	1706	7.18d	5.96d	16.37b	41.36a	10.79c	7.10d	0.87
	29	Benzenemethanol	1885	1890	53.18b	60.34b	81.88b	1016.79	67.36b	65.14b	37.7
							a				3
	30	2-Ethyl-hexanoic acid	1953	1964	37.19	70.81	125.19	54.25	4.86	86.57	27.8
											5
Fatty acid	31	Nonanoic acid	2171	2171	7812.41	9573.99	8646.77	10375.9	94.26b	11852.5	1695
					a	a	a	9a		3a	.85
	32	Decanoic acid	2277	2289	132.77a	149.64a	136.16a	174.71a	21.03b	184.82a	18.7
											7
	33	Methyl-pyrazine	1271	1266	63.40c	164.25	83.02c	89.44c	217.24a	223.55a	10.6
					b						9
	34	2,5-Dimethyl-pyrazine	1327	1320	908.38c	2500.21	1251.54	1522.94	3034.71	3791.42	198.
					b	c	c	b	a		72
	35	2,6-Dimethyl-pyrazine	1333	1328	318.82c	948.45	417.08c	483.07c	1244.16	1259.11	70.0
					b			a	a		0
Ni-tro-gen-con-tain-ing-hetero-cyclic-compounds	36	2,3-Dimethyl-pyrazine	1352	1344	26.34d	66.19b	39.29c	44.37c	87.65a	95.30a	4.70
							d				
	37	2-Ethyl-6-methyl-pyrazine	1390	1387	51.92c	162.97	90.28c	90.58c	247.85a	271.42a	17.1
					b						4
	38	2-Ethyl-5-methyl-pyrazine	1397	1387	8.80d	26.27c	12.39d	16.22d	36.11b	47.90a	2.56
	39	Trimethyl-pyrazine	1408	1402	698.94c	2252.85	1124.88	1333.00	2753.97	3548.70	222.
					b	c	c	b	a		68
	40	2,3-Dimethyl-3-ethylpyrazine	1450	1469	639.77c	1551.66	1145.15	1571.32	1734.43	3044.94	193.
					b	bc	b	b	a		99
	41	2,3-Dimethyl-5-ethylpyrazine	1467	1469	139.38	434.30	230.97	290.20c	548.71	847.38a	59.0
					d	bc	d	d	b		1
	42	2,5-Dimethyl-3-(3-methylbutyl)-pyrazine	1663	1666	16.82b	23.55b	18.84b	33.70b	33.12b	75.53a	6.19
	43	6,7-Dihydro-2,5-dimethyl-5H-cyclopentapyrazine	1685	1672	1.24c	3.89b	1.52c	2.57c	4.42b	5.79a	0.42
	44	2-Acetylpyrrole	1981	1973	291.74c	892.01a	283.50c	376.75c	1081.83	750.19	78.6
					b				a	b	8
	45	Methanethiol	677	692	330.79c	660.03	310.79c	1153.21	668.15	1089.64	103.
					b		a	b	a		67
Sul-fur-con-tain-ing-compounds	46	Carbon disulfide	734	735	259.90	316.99	157.40	158.36	229.24	2008.83	146.
					b	b	b	b	b	a	49
	47	Dimethyltrisulfide	1395	1398	7.96ab	8.62a	4.37c	5.74bc	6.42abc	8.39ab	0.85
	48	Methional	1465	1469	53.57c	35.48d	35.41d	62.04c	95.28b	121.44a	7.36
					d						
	49	2-Acetylthiazole	1660	1664	28.23c	47.72b	32.17bc	37.84bc	76.66a	75.04a	4.97
	50	2-Acetyl-2-thiazoline	1773	1778	140.19	669.05a	299.62c	225.62c	611.36a	407.81	33.8
					d		d		b		7
	51	Dimethyl sulfone	1913	1920	17.57c	366.34	34.22c	62.76c	81.52c	687.29a	72.0
					b						0
	52	Benzothiazole	1977	1981	31.18c	33.85c	40.31bc	62.53a	48.79b	32.46c	3.96
Oxy-gen-	53	2-Pentyl-furan	1237	1241	121.18	183.14	347.92a	659.81a	436.56a	585.80a	97.1
					b	b	b		b		3

containing heterocyclic compounds	54	Furfural	1473	1477	309.97 bc	318.73 bc	252.72c	257.16c	375.59a b	457.66a	27.6 4
	55	Butyrolactone	1645	1652	10.89d	22.98a b	15.40c d	19.00bc	27.68a	21.89a b	1.94
	56	2-Furanmethanol	1663	1668	14.95a	14.77a	5.46c	8.17bc	11.75a b	10.22b	1.25
	57	gamma-Octalactone	1934	1938	8.89a	8.94a	4.37b	5.98b	5.83b	6.83ab	27.5 5
	58	Ethyl maltol	2025	2050	6.00bc d	4.45cd	3.66d	10.18a	8.19ab	6.42bc	0.74
Esters	59	Octanoic acid, methyl ester	1395	1396	130.35 b	107.18 b	15.55c	43.01c	0.33c	256.22a	14.9 2
	60	alpha-Terpinenyl Acetate	1708	1692	6.80c	5.06c	11.12b	51.55a	7.42c	8.07bc	1.13
	61	2-Butanone	905	908	89.64c	135.71 b	100.78c	146.57a b	153.80a b	175.02a	10.6 3
	62	2-Pentanone	980	981	10.16	702.98	248.64	22.77	39.03	544.23	272. 51
	63	2-Heptanone	1186	1182	41.18b	45.96b	78.24a b	120.94a	91.65a b	114.49a	16.4 6
Ketones	64	Acetoin	1291	1298	1972.04 c	3855.65 b	3409.76 b	3471.91 b	5672.99 a	6381.39 a	299. 41
	65	2,5-Octanedione	1328	1319	357.12c	483.96 bc	1063.04 abc	2632.37 a	2227.80 ab	1959.56 abc	528. 03
	66	6-Methyl-5-hepten-2-one	1343	1346	13.71d	17.53d	38.59bc	81.73a	28.71c	44.81b	3.37
	67	Methyl-cyclopentane	675	975	1507.13 d	2372.67 bc	2042.57 bc	2462.13 b	1989.99 c	3005.83 a	130. 95
	68	Benzene	946	957	26.53d	63.10d	450.39 b	227.50c	8.30d	712.05a	31.3 4
Hydrocarbons	69	Toluene	1045	1049	2749.03 c	3002.99 bc	1815.72 c	2395.32 c	4207.19 b	8656.97 a	406. 51
	70	Undecane	1101	1100	63.88b	58.68b	38.88bc	53.36b	1.30c	178.54a	14.5 2
	71	Ethylbenzene	1133	1129	1006.73 c	854.48c d	405.19 d	586.57c d	1528.47 b	2903.28 a	157. 66
	72	p-Xylene	1142	1138	1819.63 bc	1506.62 cd	693.13 d	1091.86 cd	2612.19 b	5261.35 a	286. 26
	73	m-Xylene	1148	1143	9309.34 c	8216.51 c	3750.99 d	5546.81 cd	14191.22 7b	26161.3 9a	1370 .99
	74	1-Butyl-cyclohexene	1165	1187	28.18b	11.71bc	13.61bc	19.47bc	5.45d	55.45a	6.14
	75	o-Xylene	1193	1199	1795.84 c	1564.96 cd	729.02 d	1091.30 cd	2659.37 b	4920.96 a	265. 31
	76	dl-Limonene	1206	1211	95.25c	71.59c	61.10c	179.89 b	273.73a	272.94a	19.2 6
	77	Styrene	1266	1270	270.99c	255.98c	191.05c	252.20c	722.88 b	1434.76 a	97.9 3
	78	Cymene	1279	1269	21.00c	19.19c	13.66c	25.98c	43.80b	77.96a	4.74
	79	Tridecane	1303	1300	201.15 b	153.69 b	77.35c	211.00 b	17.78d	282.10a	19.1 8
	80	3-Pentyl-cyclohexene	1310	1289	43.56bc	40.63bc	26.58c	54.78b	0.00d	108.12a	6.97
	81	Tetradecane	1403	1399	293.40 b	203.81 bc	212.67 bc	402.85a	143.89c	389.49a	29.3 3
	82	1,3-bis(1,1-Dimethylethyl)-benzene	1435	1427	1.18c	1.02c	1.41bc	28.55a	2.26bc	6.91b	1.71

	83	1,2,3,5-Tetramethyl-benzene	1449	1422	19.66c	16.76c	71.77a	51.26b	41.67b	45.63b	3.24
	84	trans-Caryophyllene	1616	1595	5.95c	4.67c	4.48c	39.74a	29.45b	24.32b	2.02
	85	Heptadecane	1704	1699	10.58d	11.77c _d	15.91bc	21.37a	10.72d	16.88b	1.40
	86	Naphthalene	1762	1764	460.64 _b	207.59c	251.41c	621.15a	457.38 _b	386.35 _b	32.7 ₅
	87	Octadecane	1793	1799	25.08c	9.45d	36.86b	53.58a	13.05d	31.53bc	2.81
	88	Trichloromethane	1024	1022	342.94 _{bc}	365.70 _{bc}	234.49c	313.91c	575.03 _b	1722.66 _a	78.3 ₁
	89	Chloro-benzene	1223	1233	1.65c	0.40c	0.32c	1.19c	34.76a	3.98b	0.45
Oth-	90	N,N-dibutyl-formamide	1779	1757	328.56 _b	275.72 _b	549.36a	543.77a	569.12a	652.44a	53.4 ₈
ers	91	Anethole	1841	1817	4.71d	4.42d	8.47bc	24.46a	6.28cd	9.07b	0.75
	92	3-Methyl-phenol	2091	2099	58.68d	58.38d	107.68a	97.27a _b	76.14bc	77.41bc	6.94

^x Retention index (RI) calculated according to the retention times of n-alkanes standard (C₆–C₃₀).

^y Retention index (RI) matched from NIST and WILEY libraries.

a–d different letters in the same row indicate significant differences at $p < 0.05$.

SEM, standard error of the mean.

BH, Bohai Black Cattle; JX, Jiaxian Red Cattle; YL, Yiling Cattle; WS, Wenshan Cattle; XJ, Xinjiang Brown Cattle; PL, Pingliang Red Cattle.

Table S2. Volatiles of odor activity values (OAVs) ≥ 1 of pan-fried steaks from different yellow cattle breeds.

Compounds Information			OAV					
NO.	Component Name	Threshold($\mu\text{g/kg}$)	BH	JX	YL	WS	XJ	PL
1	Butanal	15.90	4.66	7.26	5.46	7.95	8.24	9.16
2	3-Methyl-butanal	13.00	4.13	6.92	3.95	5.66	10.75	15.88
3	Pentanal	100.00	0.79	0.87	2.00	3.76	2.75	3.28
4	Hexanal	750.00	3.46	3.82	10.17	16.66	12.73	15.39
5	Heptanal	550.00	1.13	0.86	2.29	5.64	2.63	3.91
6	Octanal	248.00	1.99	1.88	5.11	9.47	3.65	6.16
7	(E)-2-Heptenal	40.00	0.56	0.67	1.44	2.34	2.15	2.04
8	Nonanal	260.00	7.63	6.43	26.61	47.12	13.88	23.59
9	(E)-2-Octenal	0.20	805.31	969.79	2251.37	3205.95	2826.38	3300.03
10	Benzaldehyde	4600.00	3.23	4.65	4.08	5.92	5.32	7.03
11	(E)-2-Nonenal	0.69	324.41	317.30	608.08	1215.69	804.42	1351.02
12	Benzeneacetaldehyde	30.00	81.73	104.64	93.75	134.70	187.50	210.19
13	(E)-2-Undecenal	1.40	89.70	90.35	204.08	294.01	151.90	267.48
14	(E,Z)-2,4-Decadienal	0.07	166.90	190.99	393.99	654.37	489.81	633.65
15	(E,E)-2,4-Decadienal	10.00	1.56	1.74	2.91	4.13	4.76	4.89
16	4-Methoxy-benzaldehyde	27.00	0.71	0.93	2.74	6.16	1.40	1.13
17	1-Octen-3-ol	100.00	5.46	7.97	20.23	32.23	16.83	23.78
18	(Z)-5-Octen-1-ol	6.00	15.75	20.57	50.25	83.03	38.27	56.68
19	2-Ethyl-6-methyl-pyrazine	40.00	1.30	4.07	2.26	2.26	6.20	6.79
20	2,3-Dimethyl-3-ethylpyrazine	1.00	639.77	1551.66	1145.15	1571.32	1734.43	3044.94
21	2,3-Dimethyl-5-ethylpyrazine	1.00	139.38	434.30	230.97	290.20	548.71	847.38
22	2-Acetylpyrrole	100.00	2.92	8.92	2.84	3.77	10.82	7.50
23	Methanethiol	4.00	82.70	165.01	77.70	288.30	167.04	272.41

24	Carbon disulfide	5.00	51.98	63.40	31.48	31.67	45.85	401.77
25	Dimethyltrisulfide	0.10	79.62	86.21	43.71	57.41	64.17	83.87
26	3-(Methylthio)-propanal	1.80	29.76	19.71	19.67	34.47	52.93	67.47
27	2-Acetylthiazole	10.00	2.82	4.77	3.22	3.78	7.67	7.50
28	2-Acetyl-2-thiazoline	1.30	107.84	514.66	230.48	173.55	470.28	313.70
29	Dimethyl sulfone	175.00	0.10	2.09	0.20	0.36	0.47	3.93
30	2-Pentyl-furan	14.50	8.36	12.63	23.99	45.50	30.11	40.40
31	p-Xylene	1000.00	1.82	1.51	0.69	1.09	2.61	5.26
32	m-Xylene	1100.00	8.46	7.47	3.41	5.04	12.90	23.78
33	o-Xylene	1800.00	1.00	0.87	0.41	0.61	1.48	2.73
34	Trichloromethane	307.00	1.12	1.19	0.76	1.02	1.87	5.61
