Volatile Components of Water-Boiled Duck Meat and Cantonese Style Roasted Duck

Chung-May Wu* and Su-Er Liou

Food Industry Research and Development Institute (FIRDI), Hsinchu, Taiwan, Republic of China

The volatile compounds of water-boiled duck meat, duck fatty tissue, and Cantonese style roasted duck and its gravy were isolated by steam distillation and solvent extraction and then identified by GC and GC-MS, respectively. The major volatiles identified from water-boiled duck meat were the common degradation products of fatty acids except indole, which was identified for the first time in the water-boiled meat. It may be specifically related to duck meat aroma. Cantonese style roasted duck contained most of the volatiles found in duck meat plus pyrazines, pyridines, thiazoles, isoamyl alcohol, and phenyl ethyl alcohol.

It has long been a matter of common observation that the organoleptically desirable odor and taste of meat develop on cooking. Many types of heat-induced reactions lead to the production of meat flavors. Those believed to be particularly important have been summarized (Heath and Reineccius, 1986) and include the pyrolysis of peptides and amino acids, the degradation of sugars, the oxidation, dehydration, and decarboxylation of lipids, the degradation of thiamin and ribonucleotides, and interactions involving sugars, amino acids, fats, H_2O, and NH_3.

Duck meat is consumed very commonly in China and other parts of the world. However, no report on the volatile compounds of duck meat has been presented. Cantonese style roasted duck is prepared by roasting whole ducks with the addition of some seasonings. Volatile components of both samples were studied for this paper.

EXPERIMENTAL PROCEDURES

Sample Preparation. Twenty ducks were cleaned, the heads, wings, and feet were removed, and the carcasses were divided into duck meat (25.5 kg) and skin including duck fatty tissue (10.1 kg). Two portions were extracted for 3 h in a pilot plant scale Likens-Nickerson apparatus with distilled water (Romer and Renner, 1974). Glass-distilled pentane and diethyl ether (1:1, 500 mL) were used as extracting solvents. C_{17} alkane (E. Merck) was added as an internal standard in the solvent after extraction. The volatile extracts were dried with anhydrous Na_2SO_4 and concentrated to a minimum volume by using a spinning band distillation apparatus (Kontes). Cantonese style roasted duck was a commercial product. Sodium glutamate, salt, and rice wine were added as stuffing, sugar syrup was smeared over the outside skin, and then the duck was aged for 4 h and then roasted. The procedure of flavor isolation of Caontonese style roasted duck (3 kg), which included the whole duck except heads, wings and feet, and its gravy (0.7 kg) was the same as that described for water-boiled duck meat. All of the duck meat and fat tissues were cut to 6-8-cm^3 cubes before steam distillation.

Gas Chromatography. Gas chromatography was conducted on a Shimadzu GC-9A equipped with a flame ionization detector. A 50 m × 0.32 mm fused silica column (CP-Wax 52CB) (Chrompack International, B.V.) was used. The oven temperature was held at 50 °C for 10 min, then programmed from 50 to 200 °C at 1.5 °C/min, and then held at 200 °C for 80 min. The carrier gas was hydrogen at a flow rate of 1.5 mL/min. The data were recorded on a Chem-Lab PC base integrator. The linear retention indices of the volatile components were calculated with n-paraffin (C_6-C_{25}, Alltech Associates) as references (Majlat et al., 1974).

Gas Chromatography-Mass Spectrometry. GC-MS was conducted with a Hewlett-Packard 5985B system, and operational parameters were as follows: carrier gas, helium; ionization voltage, 70 eV; electron multiplier voltage, 2800 V; ion source temperature, 200 °C. GC conditions in GC-MS analysis were the same as in GC analysis described above.

RESULTS AND DISCUSSION

Figure 1 shows the gas chromatograms of isolated volatiles of duck meat, duck fat tissue, Cantonese style roasted duck, and Cantonese style roasted duck drained gravy. Table I shows the volatiles identified. The major compounds identified in these samples were the common degradation products of fatty acids (Wu et al., 1986; Wu and Liou, 1990) such as aldehydes, alcohols, ketones, hydrocarbons, esters, and furans. The only nitrogen-containing compound identified in duck meat and duck fat tissue was indole. So far, there has been no report of the presence of indole in cooked meats (Maarse and Visscher, 1989); indole can be a speciality for duck meat aroma. Indole has an extremely diffusive and powerful odor, almost tarry—repulsive and choking when concentrated—but in concentrations lower than 0.1% or in compositions, it shows powerful floral notes and pleasant radiation. Concentrations below 0.2 ppm have a fairly pleasant taste, but the effect is strongly dependent upon the presence of other flavor materials and their flavor character (Arctander, 1969). Indole was reported to occur in several natural products as a complex compound that decomposes during enfleurage or steam distillation, yielding free indole. It was reported to be found in the essential oil from the flower of *Jasminum grandiforum*, in neroli oil, and in the oil extracted from flowers of bitter orange; it was also reported in the flowers of several plants, including lemon and coffee (Furia and Bellanca, 1975). Indole was also found in oolong tea; it was one of the compounds related to the high quality of oolong tea (Wu and Liou, 1992).

The volatile compound differences between water-boiled duck meat and fatty tissue were mostly quantitative, not qualitative. Indole was 0.73% of the total duck meat volatile compounds, but duck fat tissue aroma contained only 0.37% indole. Meat always contains fat; therefore, the volatile compounds derived from fatty acids were the major volatiles for both samples.

In roasting, many types of heat-induced reactions lead to the production of heterocyclic compounds such as pyrazines, pyridines, and thiazoles. Alkylpyrazines and thiazoles were the major heterocyclic compounds formed in the roasted duck as shown in Table I. The alkylpyrazines possess roasted nutlike notes (Ohloff and Flament, 1979).

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Table I. Volatile Components of (A) Duck Meat, (B) Duck Fat, (C) Cantonese Style Roasted Duck, and (D) Cantonese Style Roasted Duck Gravy

				amount, ppb, wet basis			
peak[a]	compound	RI[b]	MW	A	B	C	D
1	heptane	700	100	1.34	3.47	17.29	6.51
2	octane	800	114	3.87	18.23	94.58	73.46
3	ethyl acetate	870	88	tr[c]	2.43	23.94	tr
4	3-methyl-2-butanol	940	88	0.91	4.17	7.14	86.98
5	2-ethylfuran	1004	96	1.89	29.66	7.39	172.85
6	methylbenzene	1019	92	1.26	4.02	2.79	9.02
7	1-hexanal	1044	100	19.86	79.81	67.72	736.66
8	ethylbenzene	1072	106	0.47	2.55	4.07	12.30
9	*p*-xylene	1084	106	0.72	5.97	10.64	21.23
10	*m*-xylene	1099	106	0.99	4.29	9.61	18.09
11	1-penten-3-ol	1112	86	0.68	2.57	47.82	42.58
12	*o*-xylene	1141	106	1.85	14.91	1.90	10.29
13	2-heptanone	1145	114	5.68	11.62	38.44	63.45
14	heptanal	1156	114	4.06	7.64	tr	tr
15	isoamyl alcohol	1183	88	1.22	3.54	245.41	475.14
16	2-pentylfuran	1204	138	8.43	22.90	131.68	78.75
17	unk [41 (100), 81 (57), 39 (48), 54 (44), 53 (14), 51 (12), 80 (10), 104 (9)]	1210		0.58	1.62	12.71	3.83
18	3-octanone	1225	128	0.57	8.65	2.41	27.76
19	2-octanone	1229	128	0.08	0.91	tr	tr
20	trimethylbenzene	1234	120	1.68	21.13	7.91	8.28
21	1-octanal	1247	128	9.30	13.64	9.66	38.08
22	(*E*)-2-heptenal	1273	112	3.19	19.97	10.63	31.64
23	(*E*)-2-pentenylfuran	1282	136	0.95	4.65	36.59	11.89
24	2,5-dimethylpyrazine	1294	108	–[d]	–	2.10	tr
25	1-hexanol	1305	102	22.84	31.74	70.83	96.31
26	cyclohexanol	1327	100	0.15	0.76	–	–
27	2-ethyl-3-methylpyrazine	1327	122	–	–	10.64	2.35
28	2-ethyl-5-methylpyrazine	1336	122	–	–	3.18	1.73
29	2-nonanone	1342	142	1.53	5.51	14.05	3.66
30	2,3,5-trimethylpyrazine	1344	122	–	–	17.30	111.95
31	1-nonanal	1352	142	31.79	24.97	8.04	48.87
32	(*E*)-2-octenal	1375	126	5.30	15.36	9.53	44.21
33	1-octen-3-ol	1394	128	1.90	37.83	22.02	72.52
34	heptanol	1402	116	6.20	10.04	139.62	27.51
35	unk [72 (100), 113 (82), 70 (39), 55 (38), 41 (31), 56 (30), 69 (20), 85 (19)]	1407		0.65	2.80	–	–
36	3-ethyl-2,5-dimethylpyrazine	1408	136	–	–	10.99	15.71
37	(*E*)-2-hepten-1-ol	1423	114	0.45	2.33	11.25	8.73
38	(*E*,*Z*)-2,4-heptadienal	1436	110	0.94	12.54	6.66	2.22
39	(*E*,*E*)-2,4-heptadienal	1443	110	1.21	4.03	5.24	2.94
40	2-ethylhexanol	1449	130	1.50	6.58	17.27	21.82
41	benzaldehyde	1470	106	0.85	7.77	5.18	tr
42	(*E*)-2-nonenal	1477	140	4.12	7.27	16.38	31.41
43	3,5-octadien-2-one	1486	124	–	–	3.29	134.32
44	1-octanol	1503	130	8.88	12.69	32.01	32.85
45	2-amylpyridine	1513	149	–	–	23.28	6.35
46	(*Z*)-2-octen-1-ol	1552	128	0.94	2.21	6.16	tr
47	(*E*)-2-octen-1-ol	1555	128	1.28	7.97	14.55	26.65
48	2-acetylthiazole	1569	127	0.99	tr	6.10	8.48
49	furfuryl alcohol	1573	98	0.19	1.21	1.93	8.89
50	nonanol	1586	142	8.87	10.98	19.67	83.33
51	(*E*)-2-undecenal	1606	154	9.59	5.17	–	–
52	unk [97 (100), 41 (20), 39 (14), 55 (13), 111 (10), 139 (10), 121 (8), 158 (5)]	1608	168	–	–	71.99	tr
53	(*E*,*Z*)-2,4-nonadienal	1617	138	1.07	1.70	–	–
54	unk [152 (100), 123 (75), 134 (67), 109 (61), 110 (61), 53 (58), 95 (56), 119 (54)]	1617	152	–	–	67.11	54.69
55	(*E*,*E*)-2,4-nonadienal	1634	138	0.48	2.84	20.51	15.31
56	naphthalene	1647	128	0.52	4.41	2.30	1.12
57	2-*n*-butyl-4,5-dimethylthiazole	1658	169	–	–	2.94	3.17
58	unk [44 (100), 163 (37), 43 (29), 71 (29), 56 (25), 60 (19), 103 (18), 57 (16)]	1677	163	–	–	66.12	263.56
60	(*E*,*Z*)-2,4-decadienal	1704	152	9.55	17.34	–	–
61	(*Z*)-2-decen-1-ol	1713	158	0.28	1.48	4.50	13.86
62	cyclodecanone	1723	154	0.25	0.96	0.89	11.90
63	(*E*,*E*)-2,4-decadienal	1745	152	8.20	39.39	16.90	1066.36
64	phenyl ethyl alcohol	1828	122	1.27	7.31	5.29	59.69
65	BHT	1855	220	2.62	4.42	3.10	tr
66	unk [82 (100), 57 (85), 96 (83), 55 (80), 41 (74), 43 (72), 67 (62), 83 (62)]	2093	268	37.84	32.21	2.27	23.77
67	indole	2179	117	1.72	2.28	–	–
	total			234.50	611.55	1531.55	4235.03

[a] Peak numbers refer to Figure 1. [b] GC retention index using C_6–C_{25} alkanes as standards. [c] <0.05 ppb. [d] Not detected.

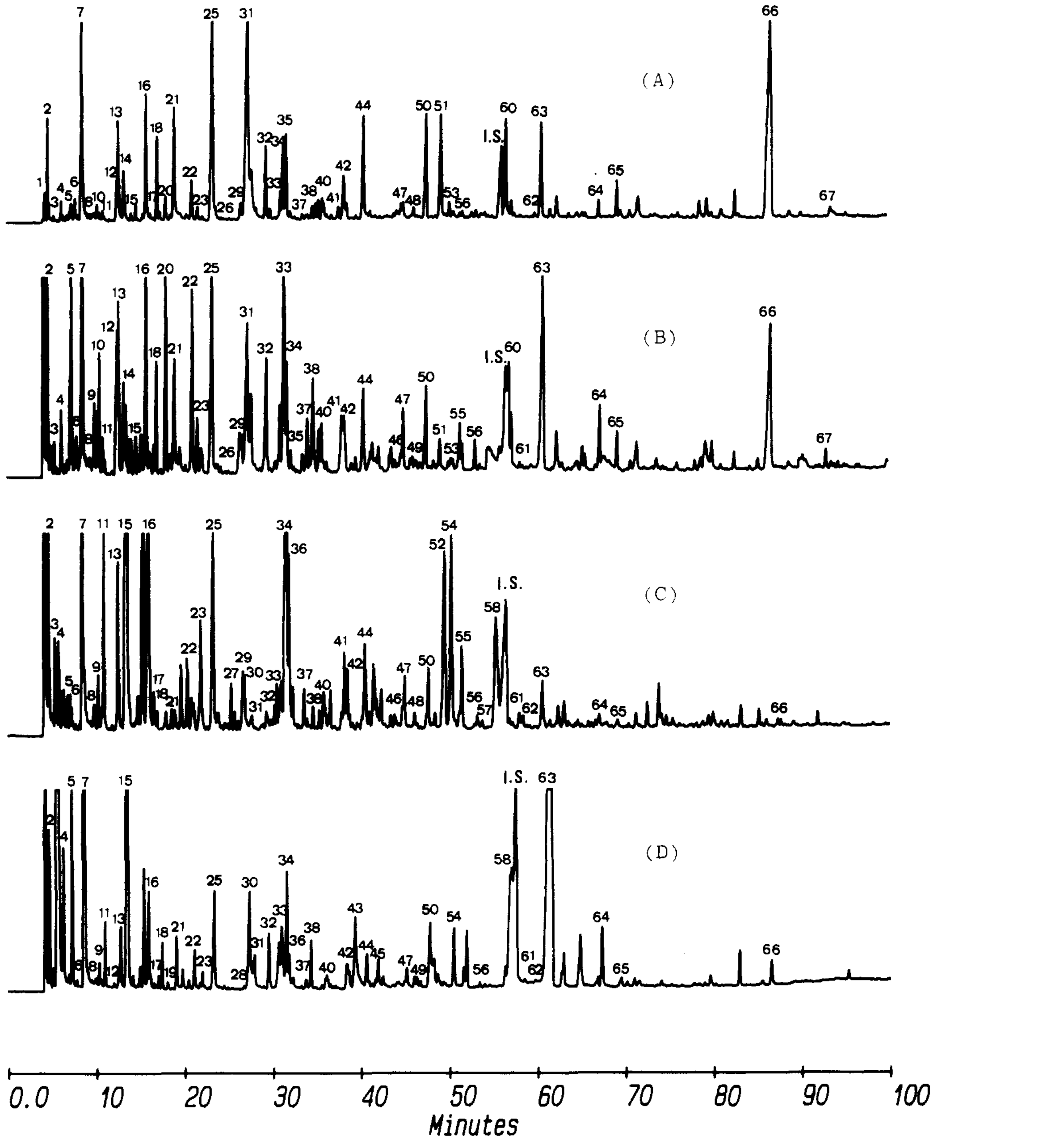

Figure 1. Gas chromatograms of (A) duck meat, (B) duck fat, (C) Cantonese style roasted duck, and (D) Cantonese style roasted duck gravy.

Thiazoles and pyrazines have somewhat similar sensory properties. The alkylthiazoles give green, nutty, roasted, vegetable or meaty notes (Ho and Jim, 1985). Generally, these compounds were only present in the Cantonese style roasted duck and gravy, indicating Maillard reaction occurred in the roasting. Besides Maillard reaction, the oxidative degradation products of fatty acids, such as hexanal and decadienals, were produced significantly in the roasted duck. Therefore, Maillard reaction and oxidative degradation of fatty acids are in the main pathways that produce the special roasted duck volatiles. We also found significant amounts of phenyl ethyl alcohol and isoamyl alcohol in roasted duck. These were postulated to arise from the rice wine which was used as seasoning in the roasted duck. The seasoning was the third factor affecting the aroma and taste of roasted duck. Indole was not present in roasted duck.

In this study, the volatile compound composition of duck meat, duck fatty tissue, and Cantonese style roasted duck and its gravy was reported. Because of the low concentration of the low volatile compounds of the samples, a pilot plant scale Likens-Nickerson extractor was used, but the volatile compound recoveries from various tissues should be different. The choice of other flavor isolation methods will also meet the same problem. Therefore, the quantitative data in Table I show only experimental values, but they are still valuable information.

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LITERATURE CITED

Arctander, S. *Perfume and Flavor Chemicals*; Arctander, S., Ed.; published by the author: Elizabeth, NJ, 1969; No. 1772.

Furia, T. E.; Bellanca, N. *Fenaroli's Handbook of Flavor Ingredients*, 2nd ed.; CRC Press: Cleveland, OH, 1979.

Heath, H.; Reineccius, G. *Flavor Chemistry and Technology*; AVI: Westport, CT, 1986; pp 71–72.

Maares, H.; Visscher, C. A. *Volatile Compounds in Food Qualitative and Quantitative Data*; TNO-civo Food Analysis Institute: Zeist, The Netherlands, 1989.

Majlat, P.; Erdos, E.; Takacs, J. Calculation and Application of Retention Indices in Programmed Temperature Gas Chromatography. *J. Chromatogr.* **1974**, *91*, 89.

Oheoff, G.; Flament, I. The Role of Heteroatomic Substances in the Aroma Compounds of Foodstuffs. *Fortschr. Chem. Org. Naturst.* **1979**, *36*, 231.

Romer, G.; Renner, E. Simple Methods for Isolation and Concentration of Flavor Compounds from Food. *Z. Lebensm. Unters. Forsch.* **1974**, *156*, 329–332.

Wu, C. M.; Liou, S. E. Effect of Water Content on Volatile Compounds Derived from Soybean Oils in Cans. *J. Am. Oil Chem. Soc.* **1990**, *67*, 96–100.

Wu, C. M.; Liou, T. S. The Volatile Components of Oolong Tea which Relate Its Quality. To be presented at the 12th International Congress of Flavour, Fragrances and Essential Oils, Vienna, Austria, Oct 4–8, 1992.

Wu, C. M.; Liou, S. E.; Wang, M. C. Changes in Volatile Constituents of Bell Peppers Immediately and 30 Minutes after Stir Frying. *J. Am. Oil Chem. Soc.* **1986**, *63*, 1172–1175.

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Registry No. BHT, 128-37-0; 2,5-dimethylpyrazine, 123-32-0; 2-ethyl-3-methylpyrazine, 15707-23-0; 2-ethyl-5-methylpyrazine, 13360-64-0; 2,3,5-trimethylpyrazine, 14667-55-1; 3-ethyl-2,5-dimethylpyrazine, 13360-65-1; 3,5-octadien-2-one, 38284-27-4; 2-amylpyridine, 2294-76-0; 2-*n*-butyl-4,5-dimethylthiazole, 76572-48-0; cyclohexanol, 108-93-0; (*E*)-2-undecenal, 53448-07-0; (*E*,*Z*)-2,4-nonadienal, 21661-99-4; (*E*,*Z*)-2,4-decadienal, 25152-83-4; indole, 120-72-9; heptane, 142-82-5; octane, 111-65-9; ethyl acetate, 141-78-6; 3-methyl-2-butanol, 598-75-4; 2-ethylfuran, 3208-16-0; methylbenzene, 108-88-3; 1-hexanal, 66-25-1; ethylbenzene, 100-41-4; *p*-xylene, 106-42-3; *m*-xylene, 108-38-3; 1-penten-3-ol, 616-25-1; *o*-xylene, 95-47-6; 2-heptanone, 110-43-0; heptanal, 111-71-7; isoamyl alcohol, 123-51-3; 2-pentylfuran, 3777-69-3; 3-octanone, 106-68-3; 2-octanone, 111-13-7; trimethylbenzene, 25551-13-7; 1-octanal, 124-13-0; (*E*)-2-heptenal, 18829-55-5; (*E*)-2-pentenylfuran, 70424-14-5; 1-hexanol, 111-27-3; 2-nonanone, 821-55-6; *n*-nonanal, 124-19-6; (*E*)-2-octenal, 2548-87-0; 1-octen-3-ol, 3391-86-4; heptanol, 111-70-6; (*E*)-2-hepten-1-ol, 33467-76-4; (*E*,*Z*)-2,4-heptadienal, 4313-02-4; (*E*,*E*)-2,4-heptadienal, 4313-03-5; 2-ethylhexanol, 104-76-7; benzaldehyde, 100-52-7; (*E*)-2-nonenal, 18829-56-6; 1-octanol, 111-87-5; (*Z*)-2-octen-1-ol, 26001-58-1; (*E*)-2-octen-1-ol, 18409-17-1; 2-acetylthiazole, 24295-03-2; furfuryl alcohol, 98-00-0; 1-nonanol, 143-08-8; (*E*,*E*)-2,4-nonadienal, 5910-87-2; naphthalene, 91-20-3; (*Z*)-2-decen-1-ol, 4194-71-2; cyclodecanone, 1502-06-3; (*E*,*E*)-2,4-decadienal, 25152-84-5; phenyl ethyl alcohol, 60-12-8.