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AROMA COMPONENTS OF WAGYU BEEF AND IMPORTED BEEF

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Introduction

We have clarified the existence of a preferable odor of Wagyu (Japanese Black cattle) beef, i.e., Wagyu beef aroma (Matsuishi et al., 2001). This aroma is generated remarkably in highly-fat-marbled Wagyu beef which is sliced, stored in the presence of oxygen for several days and then cooked at 80℃. The odor quality is sweet and fatty. This aroma is specific to Wagyu beef, while imported beef with low level of fat-marbling has little amount of the aroma. Japanese people are considered to prefer Wagyu beef because of the existence of this aroma (Japan Meat Information Service Center, 1998).

Thus far, there are a few reports on aroma components of Wagyu beef. Sato et al. (1994) analyzed aroma components in Wagyu lean meat patties containing fat from Wagyu beef, Holstein beef or imported beef by gas chromatography-mass spectrometry (GC-MS) and showed that the contents of lactones and ketones were higher in the patties containing Wagyu beef fat than other fat. Boylston et al. (1996) analyzed volatile compounds of Japanese Wagyu beef, American Wagyu beef and American Angus beef and found that the contents of aldehydes were higher in the Japanese and American Wagyu beef than in the American Angus beef. However, what components contributed to Wagyu beef aroma was not demonstrated in those reports.

Objectives

In this study, the aroma components of Wagyu beef were compared with those of imported beef to reveal the components contributing to Wagyu beef aroma. Further, the contribution rate of each aroma component of Wagyu beef to Wagyu beef aroma was presumed by the odor quality determined by gas chromatography (GC)-sniffing and the flavor dilution factors (FD factors) determined by aroma extract dilution analysis (AEDA).

Methodology

The chuck rolls of the commercial domestic Wagyu beef and imported Australian beef (Angus breed beef) were used. The aging times and packaging/storage conditions for both beef were unknown. Twenty gram of minced beef was homogenized with 100 ml of 1% NaCl solution and 0.1 ml of 0.05 μg/ml n-hexadecane/diethyl ether solution (as a internal standard). The obtained homogenate was subjected to the simultaneous distillation/extraction for 30 min according to the method of Nickerson and Likens (1996), so that aroma components were collected in a diethyl ether. This procedure was repeated thirty times and the aroma fraction was obtained from 600 g of meat. The aroma fraction was dehydrated and concentrated for the analysis by GC, GC-MS and GC-sniffing.

Conditions for the GC analysis were as follows: The carrier gas was N_2. The column was TC-WAX (0.25 mm i.d. x 60 m) (GL Sciences Inc., Tokyo). The column temperature was programmed 50℃ for 4 min at the initial stage, then to increase to 190℃ at 4 ℃/min. The split ratio was 20:1. The detector was FID.

Conditions for the GC-MS analysis was as follows: The carrier gas was He. The split ratio was 50:1. The ion source was EI at 70 eV. Compounds were identified by comparing their mass spectra with those contained in the NIST. Other conditions were as for the GC analysis.

In the GC-sniffing analysis, at the end of the capillary column, the effluent was split 1:1 into a FID and a sniffing port (GL Sciences Inc., Tokyo). Other conditions were as follows: The carrier gas was He. The column was TC-Wax (0.53 mm i.d. x 30 m). The split ratio was 15:1. The temperature program was as for the GC analysis.

In AEDA (Gasser and Grosch, 1988), the aroma fractions which were stepwise diluted with diethyl ether (4^0 to 4^7 times) were subjected to GC and at the end of the capillary column panelists sniffed the odor. The FD factor is the highest dilution rate at which a substance is still smelled.

Results & Discussion

The analysis of GC-MS resulted in the identification of forty-eight components, which were five lactones, five ketones, eight alcohols, three unsaturated alcohols, two esters, nine aliphatic aldehydes, eight aliphatic unsaturated aldehydes, two acids and six other components. These components were classified into five groups on the basis of odor quality and the relative amounts, the detailed odor quality and the FD factors in Wagyu beef of the five groups were shown in Table 1. The total amount of identified components of Wagyu beef was about 2.5 times as much as that of imported beef. In comparison of relative amount of each component between Wagyu beef and imported beef, 1-nonenal, hexadecanal and benzaldehyde were in larger amount in imported beef, while most of lactones, ketones, aldehydes and alcohols were in larger amount in Wagyu beef. Especially, the Wagyu beef/imported beef ratios of lactones were remarkably large. Sato et al. (1994) and Boylston et al. (1996) also reported that lactones, ketones, aldehydes, alcohols were in larger amount in Wagyu beef than in imported beef or Angus breeds beef. The fat oxidation would occur more markedly in Wagyu beef with more marbled fat than other beef, so that oxidation products such as those compounds would increase more remarkably in Wagyu beef than in other beef.

Wagyu beef contained remarkably large amount of lactones with the coconuts-like and peach-like odor, and the FD factor of γ-nonalactone was high value of 1024. Lactones of which odor quality was accompanied with sweetness were considered to contribute to the part of the sweet sensation of Wagyu beef aroma. The compounds of which odors were fruity except coconuts-like and peach-like or green were mainly composed of ketones, alcohols and aldehydes, which were detected in larger amount in Wagyu beef than in imported beef. However, the Wagyu beef/imported beef ratios of those compounds were less than that of lactones. Although among those compounds, hexylpropionate and hexanal showed high FD factor of 256 and 4096, respectively, those would not be major contributor to Wagyu beef aroma judging from their odor quality. Among the compounds with butter-like or fatty odor, diacetyl, acetoin and *E*-2-nonenal showed high FD factor of 256. These compounds would contribute to the part of the fatty sensation of Wagyu beef aroma judging from their odor quality. The compounds with other various odors such as sour, rose-like and mushroom-like odors would not be major contributor to Wagyu beef aroma judging from their odor quality.

Conclusions

Most of forty-eight compounds identified were detected in larger amount in Wagyu beef than in imported beef. Among these compounds, lactones with coconuts-like and peach-like aroma would contribute to the part of the sweet sensation of Wagyu beef aroma, while compounds such as diacetyl, acetoin and *E*-2-nonenal with butter-like or fatty aroma would contribute to the part of the fatty sensation of Wagyu beef aroma.

References

Boylston TD, Morgan SA, Johnson KA, Wright RW, Busboom JR, Reeves JJ. 1996. Volatile lipid oxidation products of Wagyu and domestic breeds of beef. J. Agric. Food Chem., 44: 1091–1095.

Gasser U, Grosch W. 1988. Identification of volatile flavor compounds with high aroma values from cooked beef. Zeit. Lebensm. –Unters. Forsch., 1866: 489–494.

Sato M, Nakamura T, Homma S, Abe H, Sato A, Fujimaki M. 1994. Flavor and taste comparison between Japanese Black Cattle beef, dairy cattle beef and imported beef. Anim. Sci. Technol. (Jpn.), 65: 142–148.

Matsuishi M, Fujimori M, Okitani A. 2001. Wagyu beef aroma in Wagyu (Japanese Black cattle) beef preferred by the Japanese over imported beef. Anim. Sci. J., 72:498–504.

Nickerson GB, Likens ST. 1966. Gas chromatographic evidence for the occurrence of hop oil components in beer. J. Chromatogr., 21: 1–5.

Japan Meat Information Service Center. 1988. Report on seasonal trends in meat consumption, 40tu examination on consumer in December of 1998: 67–80.

Tables and Figures

Table 1. The relative amount, odor quality and FD factor of identified compounds from Wagyu beef and imported beef

K.I.†	Identified compound	Relative amount¶		Odor quality	FD factor of Wagyu beef
		Wagyu beef	imported beef		
	coconuts-like, peach-like				
2026	γ -nonalactone	1.45±1.44	tr	coconuts-like, sweet	1024
2124	γ -decalactone	0.29±0.12	-	peach, coconuts-like	16
2200	γ -decalactone	0.73±0.24	tr	peach-like, milky	16
2327	γ -undecalactone	0.37±0.05	tr	peach-like, milky	4
2431	γ -dodecalactone	tr	-	peach-like, milky	1
	fruity except coconuts-like and peach-like				
1381	hexylpropionate	0.10*	tr	pear-like	256
1459	decanal	0.99*	0.63±0.10	orange, lemongrass-like	256
1822	2-tridecanone	0.20±0.08	0.09±0.07	fruity, waxy	64
1206	2-heptanone	2.72±0.61	2.05±0.53	fruity	16
1372	1-hexanol	3.83±0.87	1.03±0.35	fruity, floral	16
1564	1-octanol	5.56±3.30	3.18±0.56	fruity, milky	16
1630	1-nonanol	0.40±0.47	0.44±0.26	fruity, floral	16
1678	dodecanal	2.11±2.05	1.84±0.87	lemongrass-like, rose	16
1915	tetradecanal	4.49*	0.23±0.10	lemongrass-like, cardboard	16
1214	*d*-limonene	4.13±1.98	1.10±0.16	citrus, fatty	16
1290	2-octanone	0.24±0.16	0.08*	fruity, passion fruits	1
1475	1-heptanol	2.82±0.50	0.83±0.35	fruity, citrus	1
1950	1-dodecanol	1.09*	0.61±0.09	fruity, fatty	1
1552	benzaldehyde	4.72±0.84	4.75±4.05	fruity, orange, fatty	1
1641	2-decenal	3.36±2.43	1.08±0.58	citrus, rose-like	1
	green				
1078	hexanal	50.55±29.49	6.01±3.04	green apple-like, floral	4096
1794	(*E*,*E*)-2,4-nonadienal	2.41±1.27	0.82±0.36	green, metallic	256
1396	nonanal	4.70±5.10	0.29±0.09	pine-like	64
1292	octanal	0.45±0.17	0.17±0.07	green, citrus	16
1844	(*E*,*E*)-2,4-decadienal	0.19±0.14	0.05±0.01	green, metallic,	16
1871	hexanoic acid	4.50±1.00	3.54±5.13	green, fatty	16
2151	hexadecanal	9.98±5.60	11.8±3.39	green, strawberry, apricot	4
1252	*E*-2-hexenal	2.58±1.34	0.60±0.40	green, aldehydic, herbal	4
	butter-like, fatty				
979	diacetyl	8.64±6.70	2.36±0.52	butter-like, fermented	256
1311	acetoin	4.95±4.51	3.16±1.10	butter-like, fatty	256

1541	*E*-2-nonenal	1.30±0.52	0.55±0.09	green, citrus, fatty	256
1428	*E*-2-octenal	2.78±2.20	0.78±0.09	green, citrus, fatty	16
2046	pentadecanal	1.71±0.75	0.83±0.54	sweet fatty	4
1133	ethylbenzene	0.14±0.16	0.13±0.05	sweet fatty corn cream	1
1469	7-octen-4-ol	13.22±3.41	2.96±0.94	corn creamy, milky, oily	—
	others				
1739	2-undecenal	0.83±0.13	0.52±0.13	withered rose-like	256
1482	acetic acid	0.26±0.22	0.38±0.30	sour	256
1268	1-pentanol	17.37±8.52	4.69±0.25	coumarin-like	16
1641	1-nonen-4-ol	0.48±0.18	0.58±0.37	cardboard	16
1685	phenylacetaldehyde	0.65±0.73	1.57*	rose-like	16
1218	2-pentylfuran	0.61±0.18	0.13*	petroleum-like, oxidized fat	16
1994	1,3,5-undecatriene	0.08*	0.52±0.53	violet, seaweed-like	16
1108	1-penten-3-ol	1.11±0.22	0.62±0.28	mushroom-like	4
1150	1-butanol	2.72±1.60	0.96±0.28	alcoholic	4
1703	(*E*,*E*)-2,4-octadienal	1.13±1.31	2.27±1.00	rubbery	4
878	ethyl acetate	9.12±3.09	7.26±4.48	rum	1
1782	tridecanal	1.45±0.12	0.75±0.49	solvent-like	1
1496	2-propyl-1-pentanol	0.83±0.24	0.74±0.57	alcoholic	—
	total	184.34	73.34		

†Kovats Index
relative peak area of each peak when the value of the internal standard (n-hexadecane) is regarded as 100.
Mean±standard deviation(n＝3)
*Mean (n＝2)
tr; trace amount
—: not determined