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Instrumental and sensory analyses were carried out on sesame-flavored dressings to identify the odorants affecting their perceived quality. The sampling of the odor-active compounds was performed by simultaneous steam distillation extraction (SDE) and solid-phase microextraction (SPME). The odor intensity and character of the compounds were evaluated and quantified using gas chromatography/olfactometry (GC/O). The GC/O and the sensory data were processed and analyzed on the basis of food *kansei* model. Seven perceptual factors affecting the aroma and flavor were abstracted by principal component analysis (PCA) of the sensory data. According to the percentage of contribution, the first perceptual factor of "roast and spicy" was identified as a key factor. The correlations between the odorants and the "roast and spicy" factor clarified the importance of sulfurous compounds. Four sulfurous compounds were identified as butanethiol, prenyl mercaptane, 2-methyl-3-furanthiol and dimethyl trisulfide.

Keywords: sesame-flavored dressing, simultaneous steam distillation extraction (SDE), solid-phase microextraction (SPME), gas chromatography/olfactometry (GC/O), sensory analysis, food *kansei* model

Introduction

In many parts of the world, sesame (*Sesamum indicum* L.) is an important oil seed crop. Because of their unique odor and high nutritive value, roasted sesame seeds are popular on bread and bakery goods in East Asian countries and also in other countries such as Egypt and the United States. Recently sesame-flavored dressings have been widely used in Japan as a condiment or seasoning for many types of dishes.

The flavor of sesame oil is influenced significantly by the conditions of the roasting process (Shahidi, 1997; Shimoda *et al.*, 1997; Nakada *et al.*, 1998a; Ryu *et al.*, 1999), which are often characterized as burnt, caramel, fatty, roasted or meat-like (Cadwallader and Heo, 2001). The volatile compounds of roasted sesame seeds or the oil extracted from roasted seeds have been extensively studied and more than 220 compounds have either been positively or tentatively identified (Kinoshita and Yamanishi, 1973; Manley *et al.*, 1974; Soliman *et al.*, 1975, 1986; El-Sawy *et al.*, 1988; Nakamura *et al.*, 1989; Park *et al.*, 1995; Ha, Shimoda *et al.*, 1998). On the basis of earlier studies, pyrazines, furans, phenols and sulfur-containing compounds seem to be the main flavor contributors. Above all, pyrazines such as acetylpyrazine and alkylpyrazines, and sulfur-containing compounds such as 2-mercaptoacetaldehyde and hydrogen sulfide are considered to play an important role in the character of the sesame oil flavor.

Several studies have been conducted on the sensory contribution of the individual volatile compounds in the flavor of roasted sesame seeds and oils (Nakamura *et al.*, 1989; Schieberle, 1996; Shimoda *et al.*, 1996; Cadwallader and Heo, 2001). The most odor-active compounds of roasted sesame seeds and oil have been identified by using gas chromatography/olfactometry (GC/O), which includes the so-called 'dilution analyses', such as aroma extract dilution analysis (AEDA) and CharmAnalysis^{TM}. However, there has been limited research done with respect to perceived quality on the influence odor-active compounds have on food perception (Nakada *et al.*, 1998b; Takei *et al.*, 2002).

A specified paradigm and methodology of *kansei* engineering has been proposed as "food *kansei* engineering" by Sagara (1994). The "food *kansei* model" correlates the physicochemical properties of food products with their perceived quality, and it was applied to the development of green tea beverages and bitter beverages (Ikeda *et al.*, 2003, 2004). When applying the food *kansei* model, it is necessary to measure the physicochemical and sensory properties of food products quantitatively from the aspects of food perception and acceptance.

The extracted compounds are so dependent on the extraction process that it is necessary to select a suitable analysis method for identifying key compounds concern-

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ing their perceived quality. Simultaneous steam distillation extraction (SDE) has been widely used in the analysis of odor compounds from food materials (Shimoda and Osajima, 2000). Simultaneous steam distillation extraction has the advantages of extractability and efficiency in sampling high-molecular-mass and low volatility compounds. However, this form of extraction is rather time-consuming and it requires much effort to obtain reproducible results. Solid-phase microextraction (SPME) is one form of headspace gas analysis using a polymer-coated silica fiber, and it is known to be a simple, rapid and highly reproducible sampling method. It can be applied to extract highly volatile compounds that make up the top-note of the sample (Akiyama *et al.*, 2003; Jibao *et al.*, 2001).

Gas chromatography/olfactometry (GC/O) combines gas chromatography and olfactometry by human detectors to assess the odor activity in defined air streams with the gas chromatographic separation of volatiles (Acree, 1993). The method is useful for evaluating the odor intensity and the character of volatile compounds in a food sample. This methodology appeared to be useful for food *kansei* engineering and the development of a new sesame-flavored dressing.

The objective of this study is to elucidate the odor-active compounds affecting the perceived quality of sesame-flavored dressings by estimating their sensory contributions.

Materials and Methods

Sample Preparation Seven commercially available sesame-flavored dressings (CA～CG) were prepared for instrumental and sensory analysis. The sesame flavors of the samples were confirmed to be clearly detectable, even in the low-flavored samples.

Simultaneous Steam Distillation Extraction (SDE) A Likens-Nickerson-type SDE head was used for preparing the SDE extract (Likens and Nickerson, 1964). A 500-mL round-bottom flask was used to hold 100 mL of sesame-flavored dressing sample and 100 mL of distilled water. A 100-mL pear-shaped flask containing 50 mL of diethyl ether was attached to the solvent arm of the SDE head. The sample solution and the solvent were heated to their boiling points, and distillation/extraction was continued for 15 min. The extracts were dried over anhydrous sodium sulfate and concentrated to 1.0 mL using a gentle stream of nitrogen gas (99.9995% purity) under reduced pressure. For GC/O, the serial dilution of the concentrate was prepared by using diethyl ether at concentration ratios of 1, 1/3 and 1/9. The injection volume of the diluted solution for GC/O was 1.0 μL.

Solid-phase Microextraction (SPME) Sesame-flavored dressing samples (150 g) were placed and stirred in a Pyrex glass bottle (volume ca. 500 mL, Shibata Scientific Technology Ltd., Tokyo, Japan). Solid-phase microextraction sampling was carried out at 38℃, and the SPME fiber, polydimethylsiloxane/divinylbenzene (PDMS/DVB, Sigma-Aldrich Co., St. Louis, MO), was exposed to the effluent nitrogen gas at 1.0 L/min for 10 min. It was conducted in triplicate using different length of fibers. According to the procedure applying SPME to GC/O (Deibler, 1999), the serial dilution was prepared by adjusting the fiber length to 1.0, 0.5 and 0.25 cm, which were exposed fully, one-half and one-quarter to the headspace of the sample, respectively. After sampling the volatile compounds, the fiber was placed into the injection port of the GC/O directly and thermally desorbed for 10 min at 250℃.

Gas Chromatography/Olfactometry (GC/O) GC/O (CharmAnalysis™) was performed on a gas chromatograph (6890, Agilent, Palo Alto, CA) modified by DATU, Inc. (Geneva, NY), using the fused silica capillary column J&W DB-WAX (15 m × 0.32 mm, 0.25 μm film thickness, Agilent). The flow of carrier gas helium was 3.2 mL/min. The temperature was initially set at 40℃, then increased at a rate of 6℃/min to 230℃, and was held at 230℃ for 20 min. The injection and detector ports were maintained at 250℃ and the injection purge on the GC was off for the first minute. The GC effluent gases of each sample dilution were sniffed with humidified air by a trained panelist "sniffer" who recorded the time length and the character of the smell. Each session consisted of 30 minutes.

The odor descriptors to record the characters of smelled odors were chosen from the existing sensory terms of sesame oil flavor and the established descriptor of sesame flavor compounds and common aroma chemicals (Nakada *et al.*, 1997; Schieberle, 1996; Cadwallader and Heo, 2001). Table 1 shows 15 odor descriptors created by preliminary GC/O analyses of the most concentrated aroma extracts of 7 samples more than once until the list of used descriptors was acceptable to the sniffer. The odor descriptor of "fermented" indicates the odor of fermented yeast.

The odor strength of volatile compound was repre-

Table 1. Odor descriptors extracted from preliminary session.

No.	Odor descriptor
1	Acidic/rancid
2	Burnt/smoky
3	Caramel
4	Citrus/green
5	Fermented
6	Metallic/mushroom
7	Mustard
8	Nutty
9	Oily
10	Roast/cooked
11	Sesame
12	Soy sauce
13	Sulfur
14	Sweet
15	Phenolic/medicine

sented as "Charm value" by integrating the time length recorded for each odorant. The Charm value (CV) was calculated by integrating the time length and the dilution level as follows,

$$CV = \int_{peak} F^{n-1} di \qquad \text{Eq. (1)}$$

where, F: dilution factor, n: number of dilution, di: time length. The dilution factors for SDE and SPME were set to 3 and 2 according to their dilution rates of 1/3 and 1/2, respectively. Serial dilution of three levels was prepared in order to measure the odor strength reliably, which allows sniffing and sensing the odors twice at different dilution levels. The time length was the interval between the start and finish time of the smell. Fig. 1 shows the typical results of GC/O, "aroma chromatogram", representing the odor activity of the volatile compounds in a sesame-flavored dressing. The horizontal axis showed the retention index (RI). The vertical axis showed the dilution value (Fn^{-1}), indicating the aroma intensity of each odorant. The number of each odorant by SDE and SPME corresponds to the numbers in Table 3 and Table 4, respectively.

Sensory Analyses A laboratory panel of 20 members (ages 20–50 s; 15 men and 5 women) participated in the sensory analyses of 7 samples. All the members were trained in sensory analyses for at least two weeks. Table 2 shows the 30 terms for describing the aroma and flavor properties of sesame-flavored dressings. These terms were characterized during a six-hour discussion and two-hour screening of the laboratory panel using the seven commercially available samples. The term "light" represents the topnote or initial impact of the aroma and flavor. The aroma was evaluated before putting the samples into the mouth, and the flavor was evaluated for the retronasal smell in the mouth. Fig. 2 shows a section of the questionnaire having a seven-point scale to describe the perceived intensities of the aroma and flavor. The terms of

Table 2. Terms for describing aroma and flavor properties.

No.	Aroma term	Flavor term
1	Spicy aroma	Spicy flavor
2	Nutty aroma	Nutty flavor
3	Toasted sesame aroma	Toasted sesame flavor
4	Roast aroma	Roast flavor
5	Light aroma	Light flavor
6	Acid aroma	Acid flavor
7	Oily aroma	Oily flavor
8	Irritating aroma	Irritating flavor
9	Burnt aroma	Burnt flavor
10	Caramel aroma	Caramel flavor
11	Soy sauce aroma	Soy sauce flavor
12	Spice aroma	Spice flavor
13	Mellow aroma	Mellow flavor
14	Citrus aroma	Citrus flavor
15	Remaining aroma	Remaining flavor

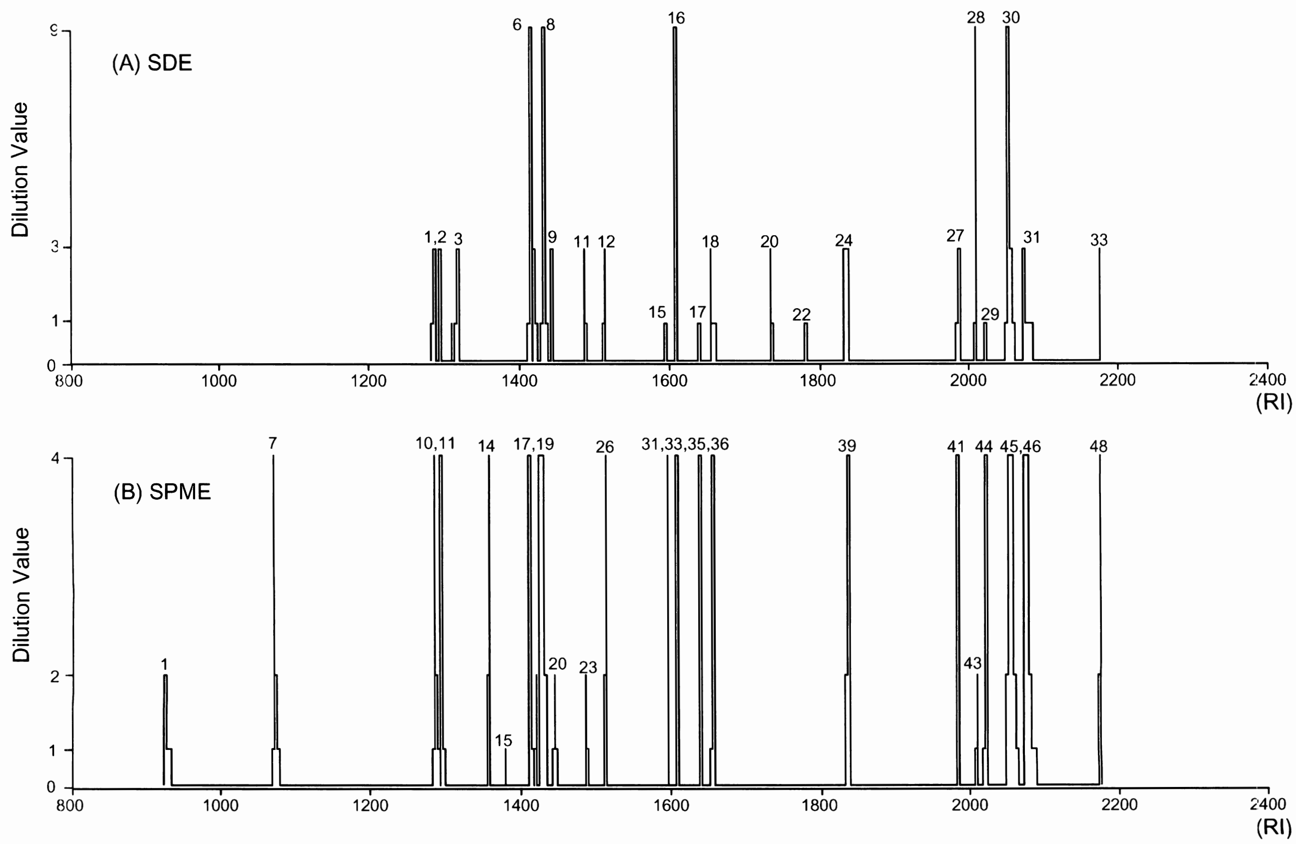

Fig. 1. Typical aroma chromatograms of volatile compounds from sesame-flavored dressing.

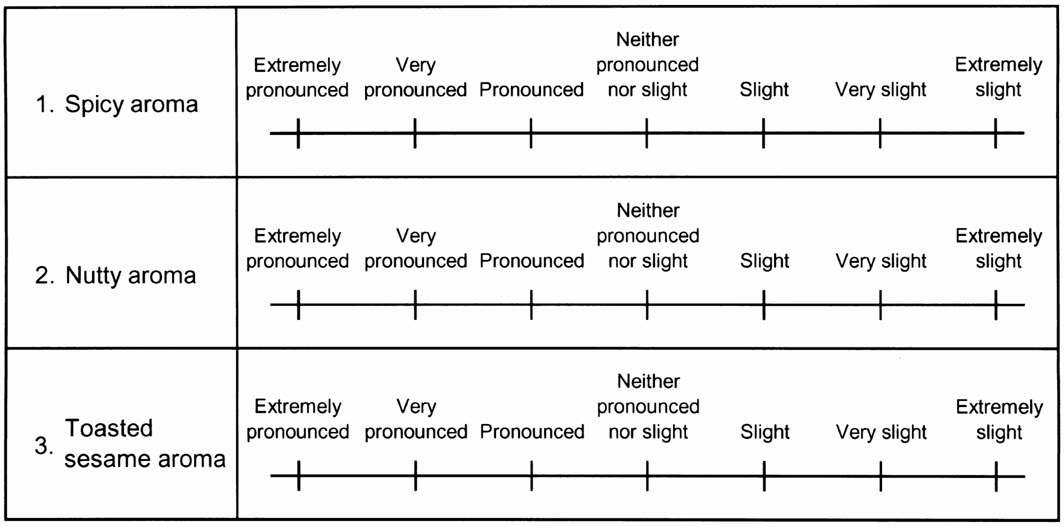

Fig. 2. A part of the questionnaire with seven-point scale to describe the perceived intensity.

Table 3. Detected odorants in the 7 samples by SDE-GC/O.

No.	RI	Odor descriptor	Mean	SD
1	1289	6.metallic/mushroom	99	49
2	1294	13.sulfur	172	215
3	1318	10.roast/cooked	10	27
4	1359	4.citrus/green	18	35
5	1395	10.roast/cooked	6	16
6	1415	10.roast/cooked	198	118
7	1425	1.acidic/rancid	73	19
8	1434	12.soy sauce	490	84
9	1445	8.nutty	72	58
10	1479	8.nutty	6	17
11	1489	4.citrus/green	105	48
12	1516	4.citrus/green	117	32
13	1529	4.citrus/green	7	18
14	1542	4.citrus/green	43	115
15	1596	10.roast/cooked	74	58
16	1612	14.sweet	272	81
17	1644	8.nutty	60	78
18	1659	1.acidic/rancid	112	42
19	1674	10.roast/cooked	4	12
20	1734	4.citrus/green	44	62
21	1741	4.citrus/green	10	26
22	1785	9.oily	56	77
23	1794	13.sulfur	27	71
24	1835	2.burnt/smoky	149	96
25	1936	8.nutty	10	25
26	1978	15.phenolic/medicine	99	83
27	1984	8.nutty	15	40
28	2010	2.burnt/smoky	24	44
29	2015	3.caramel	58	35
30	2045	3.caramel	433	83
31	2070	3.caramel	155	103
32	2105	8.nutty	44	117
33	2170	2.burnt/smoky	94	124

"extremely pronounced", "very pronounced", "pronounced", "neither pronounced nor slight", "slight", "very slight" and "extremely slight" corresponded to 7 to 1 points, respectively. Each sample was evaluated in one session, and only one session was conducted on one day. The sample (15 mL) was served at room temperature in a brandy glass (200 mL) having a lid. The panelist conveyed the sample to the mouth using a stainless steel spoon.

Statistical Analyses The statistical analyses were carried out using the computer software JMP 5 (SAS Institute, Inc., Cary, NC), based on the procedure of food *kansei* modeling (Ikeda *et al.*, 2004). In the present study, it was assumed that 1) the odor-active compounds detected by GC/O were related to perceived properties of aroma and flavor, and 2) the perceived properties determined the palatability. The degrees of association between the Charm values and the scores of perceived properties were estimated.

One-way analysis of variance (ANOVA) was applied to the sensory scores of the 30 terms to show the effect of samples on their perceived quality. In order to summarize the perceived properties of sesame-flavored dressings, principal component analysis (PCA) was carried out on the sensory data. As the measure of correlation between the Charm values and the average scores of principal components (PC), regression coefficients were estimated using simple linear regression analysis. In the regression analysis, the Charm values were used as independent variables, centered by mean and scaled by range/2. The standardized coefficients used to compare the effectiveness of odor characters and sampling methods.

Results and Discussion

GC/O Analyses of Volatile Compounds Extracted by SDE and SPME Table 3 summarizes the results of SDE-GC/O applied to the 7 commercially available samples. It shows the RI and odor descriptor of smelled odors and the mean and standard deviation (SD) of Charm values

Table 4. Detected odorants in the 7 samples by SPME-GC/O.

No.	RI	Odor descriptor	Mean	SD
1	920	13.sulfur	105	207
2	931	13.sulfur	58	102
3	1022	13.sulfur	18	32
4	1031	13.sulfur	16	43
5	1076	13.sulfur	116	200
6	1137	13.sulfur	10	17
7	1177	10.roast/cooked	5	13
8	1186	8.nutty	9	23
9	1274	4.citrus/green	6	17
10	1283	6.metallic/mushroom	317	137
11	1294	13.sulfur	289	274
12	1350	8.nutty	4	12
13	1352	13.sulfur	68	58
14	1358	4.citrus/green	47	77
15	1381	13.sulfur	61	104
16	1384	8.nutty	18	48
17	1413	10.roast/cooked	192	166
18	1424	1.acidic/rancid	74	63
19	1434	12.soy sauce	514	122
20	1444	8.nutty	230	132
21	1476	8.nutty	81	94
22	1484	10.roast/cooked	28	52
23	1488	4.citrus/green	11	29
24	1495	10.roast/cooked	9	23
25	1507	8.nutty	5	14
26	1515	4.citrus/green	168	104
27	1526	4.citrus/green	30	79
28	1541	4.citrus/green	90	238
29	1544	10.roast/cooked	14	24
30	1568	8.nutty	25	33
31	1594	10.roast/cooked	129	158
32	1600	10.roast/cooked	13	34
33	1610	14.sweet	284	96
34	1621	10.roast/cooked	7	19
35	1642	10.roast/cooked	193	121
36	1658	1.acidic/rancid	196	99
37	1708	12.soy sauce	34	89
38	1750	8.nutty	7	19
39	1837	2.burnt/smoky	336	137
40	1939	8.nutty	16	43
41	1985	15.phenolic/medicine	80	106
42	1996	8.nutty	7	19
43	2012	2.burnt/smoky	54	62
44	2021	3.caramel	244	94
45	2052	3.caramel	868	204
46	2077	3.caramel	460	222
47	2123	8.nutty	20	52
48	2176	2.burnt/smoky	292	123

Table 5. Total Charm values of odor descriptors detected by SDE-GC/O and SPME-GC/O.

	SDE-GC/O			SPME-GC/O		
Odor descriptor	N[a]	Mean	SD	N[a]	Mean	SD
1.acidic/rancid	2	185	48	2	270	145
2.burnt/smoky	3	267	148	3	682	234
3.caramel	3	647	164	3	1572	389
4.citrus/green	7	344	154	6	352	397
5.fermented	0	ND[b]	ND[b]	0	ND[b]	ND[b]
6.metallic/mushroom	1	99	49	1	317	137
7.mustard	0	ND[b]	ND[b]	0	ND[b]	ND[b]
8.nutty	7	207	199	11	423	169
9.oily	1	56	77	0	ND[b]	ND[b]
10.roast/cooked	5	292	165	9	589	330
11.sesame	0	ND[b]	ND[b]	0	ND[b]	ND[b]
12.soy sauce	1	490	84	2	548	169
13.sulfur	2	199	233	9	742	562
14.sweet	1	272	81	1	284	96
15.phenolic/medicine	1	99	83	1	80	106

a; the number of odorants showed the same odor descriptor.
b; not detected.

among 7 samples. It revealed that 33 odorants were detected by SDE-GC/O in the range of RI 1289 to 2170. Odorant no.6 (roast/cooked) followed by the odorants no. 8 (soy sauce), 16 (sweet), 24 (burnt/smoky), 30 and 31 (caramel) were found in most samples with high Charm values over the upper quartile of the distribution. No odorant indicated sesame odor as well as the fermented and mustard odor by itself. Table 4 summarizes the results of SPME-GC/O applied to the 7 commercially available samples. It indicates that 48 odorants were detected in the range of RI 920 to 2176. Oily odorants were not collected by SPME. The odorant 19 (soy sauce), 45 and 46 (caramel) were considered to correspond to the odorants no. 8, 30 and 31 in SDE-GC/O, respectively.

Table 5 shows the total Charm values of the odorants having the same odor descriptor. According to the total Charm values of SDE-GC/O, the sesame dressing flavor appeared to be composed primarily of the odors of "caramel" and "soy sauce". The total Charm values of SPME-GC/O indicate the importance of "caramel" and "soy sauce" as well as "burnt/smoky", "roast/cooked" and "sulfur". By comparing the detected number of odorants between SDE- and SPME-GC/O, it was found that a greater number of "sulfur" odorants was collected by SPME than SDE. This chromatographic difference was considered to result from the volatility of the "sulfur" odorants no. 1~6 that were collectable only in the headspace gas.

Sensory Analysis of Aroma and Flavor Fig. 3 shows the average scores of perceived properties evaluated by the sensory analysis. The results of ANOVA are also presented in Fig. 3, which indicate that the average scores of samples were significantly different for 20 aromas and flavors. The aroma and flavor having the same terms were likely to have close scores. The "spice" and "citrus" properties were weakly perceived in most samples except for the sample CE. To summarize the perceived properties, perceptual factors were extracted by PCA of the sensory data of 30 terms describing the aroma and flavor. Varimax rotation was also applied to the axes that indicated eigenvalues over 1.0 in order to make the axes clear. Table 6 shows the configuration matrix of factor loadings on the aroma terms, showing the values over 0.5. The factor loadings on the flavor terms were quite similar to the aroma terms (data not shown). The factor loadings range from -1.0 to 1.0, representing the correlation between the PC and the sensory terms. The first PC (PC 1) loaded heavily on the terms of "roast", "toasted sesame", "spicy" and "burnt", and the first dimension was identified as the perceptual factor of "roast and spicy" which accounted for 23.5% of the variation in the sensory data. Similarly, the following PCs were identified; PC2 "mellow", PC3 "citrus and spice", PC4 "soy sauce", PC5 "light", PC6 "oily" and PC7 "remaining". These 7 PCs combined accounted for 67.7% of the variance of the 30 terms describing the aroma and flavor.

Table 7 shows the average PC scores of the 7 samples. The grand means of the PC scores were nearly equal to zero. The average scores of the PCs were dispersed

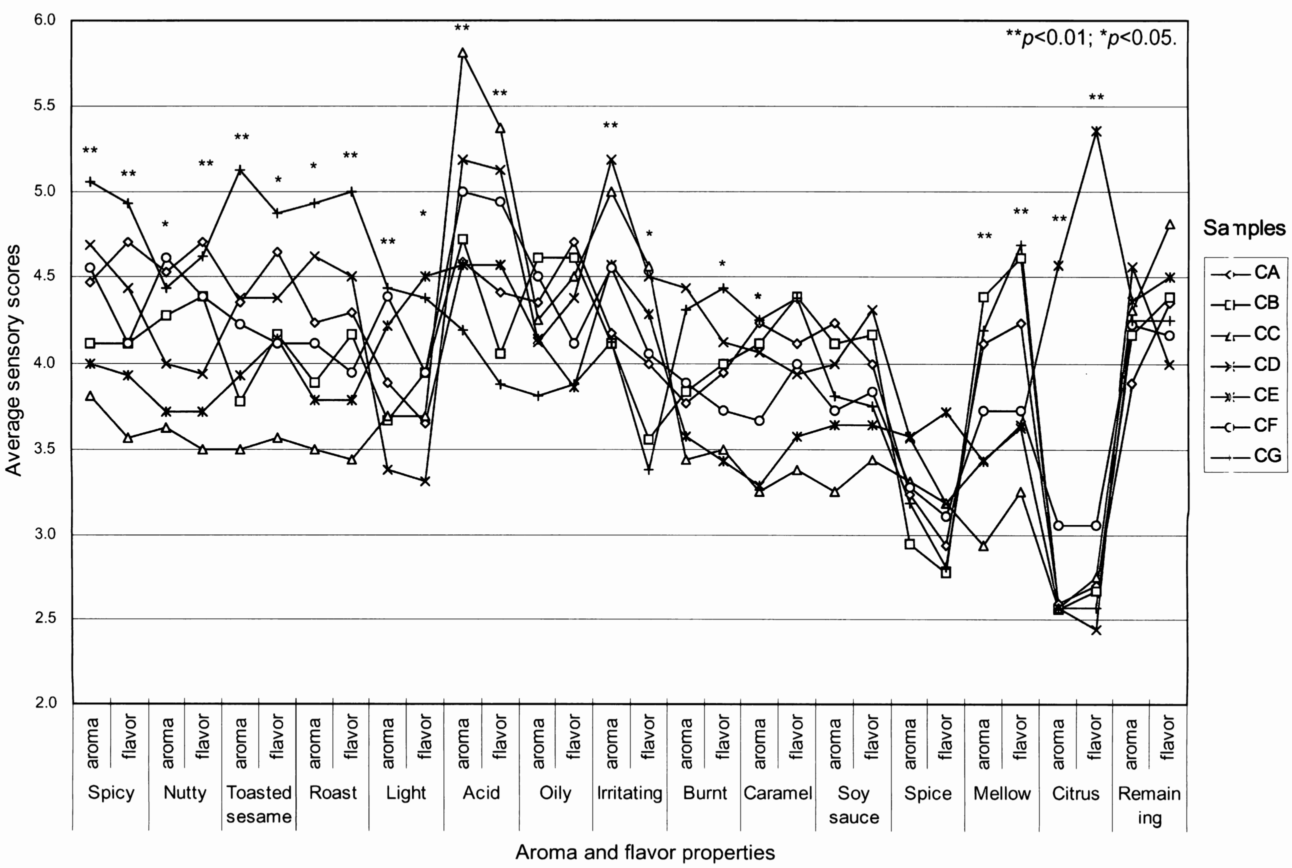

Fig. 3. The average scores of perceived properties evaluated by the sensory analysis.

Table 6. Configuration matrix of high factor loadings for the aroma, flavor and taste items.

	PC1	PC2	PC3	PC4	PC5	PC6	PC7
Aroma term	Roast and spicy	Mellow	Citrus and spice	Soy sauce	Light	Oily	Remaining
Roast aroma	0.82						
Toasted sesame aroma	0.80						
Spicy aroma	0.79						
Burnt aroma	0.69						
Caramel aroma	0.57						
Nutty aroma	0.53						
Mellow aroma		0.72					
Spice aroma			0.86				
Citrus aroma			0.82				
Soy sauce aroma				0.65			
Light aroma					0.76		
Oily aroma						0.80	
Remaining aroma							0.78
Irritating aroma		-0.79					
Acid aroma		-0.80					
Variance	7.1	3.9	3.2	2.6	2.0	1.9	1.6
Percent (%)	23.5	13.0	10.6	8.7	6.7	6.3	5.3
Cumulative percent (%)	23.5	47.1	34.1	55.8	62.5	74.0	67.7

Table 7. Average PC scores of the 17 samples.

	PC1	PC2	PC3	PC4	PC5	PC6	PC7
Sample	Roast and spicy	Mellow	Citrus and spice	Soy sauce	Light	Oily	Remaining
CA	0.20	0.22	-0.07	-0.05	-0.06	0.48	-0.28
CB	-0.27	0.60	-0.34	0.21	0.03	0.46	-0.04
CC	-0.52	-0.65	-0.10	-0.28	-0.19	-0.05	0.38
CD	0.40	-0.69	0.03	0.54	-0.81	-0.30	-0.07
CE	-0.46	0.10	0.84	-0.23	0.52	-0.32	0.19
CF	0.01	-0.11	0.07	-0.16	0.23	0.11	-0.09
CG	0.61	0.46	-0.29	-0.06	0.32	-0.52	-0.04
Mean	-0.01	-0.01	0.02	0.00	0.01	-0.02	0.01
SD	0.43	0.51	0.39	0.29	0.43	0.39	0.21

around the grand means with SD 0.21 to 0.51.

Correlations between Odorants and Perceptual Factor For the important percentage of contribution of PC1 "roast and spicy" (23.5%), Fig. 4 shows the regression coefficients from the odorants detected by SDE-GC/O to PC 1. The standardized regression coefficients (β) and standard errors (SE) were estimated by simple linear regression analysis. The odorants of "sweet" were correlated negatively to PC1 ($\beta=-0.38, p=0.13$). Fig. 5 shows the standardized regression coefficients from the odorants detected by SPME-GC/O. The odorants of "sulfur" ($\beta=0.40, p=0.13$) and "phenolic/medicine" ($\beta=0.35, p=0.05$) were correlated positively to PC1. The difference between the results of SDE and SPME may be attributed to the sensitivity of the top-note odors. As shown in Table 4, SPME was sensitive to the top-note odors like the "sulfur" odorants detected before RI 1000. These odorants were not detected by SDE.

For the purpose to control the PC1 "roast and spicy" factor, it seemed effective to adjust the odor compounds having both positive correlation with PC1 and large SD of Charm values among samples. The "sulfur" odorants detected by SPME showed the highest regression coefficient, considered to have the potential to control PC1. While the "phenolic/medicine" odorants also showed positive correlation with PC1, the SD of the Charm values was definitely smaller than "sulfur" odorants (Table 5). Therefore, it was considered desirable to adjust "sulfur" odorants for the design of "roast and spicy" aroma and flavor.

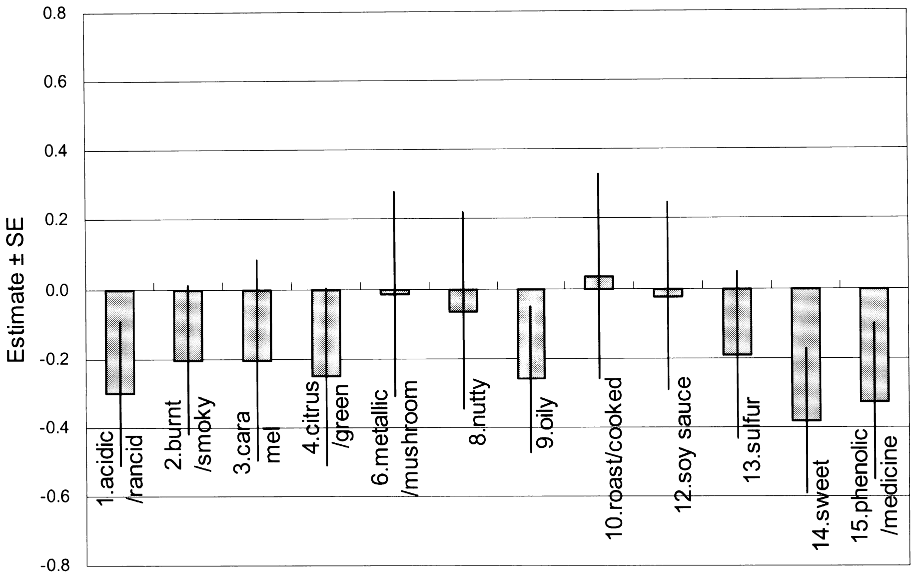

Fig. 4. Estimates of regression coefficients from the odorants by SDE-GC/O to PC1.

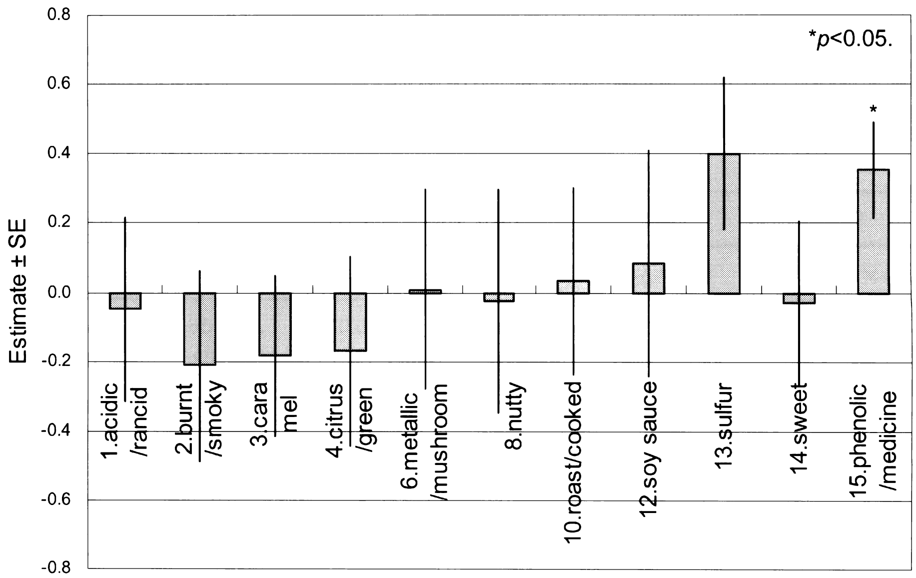

Fig. 5. Estimates of regression coefficients from the odorants by SPME-GC/O to PC1.

Based on the conformity of the RI and the odor character, the following four sulfurous compounds were identified as "sulfur" odorants: butanethiol (RI 920), prenyl mercaptane (RI 1076), 2-methyl-3-furanthiol (RI 1294) and dimethyl trisulfide (RI 1352). The fourth compound, dimethyl trisulfide, was already known as a volatile compound from roasted sesame seed oil (Shimoda, 1998). The other three compounds were not reported as the volatile compounds from any kinds of sesame products.

In order to extract potential odorants which influence the perceived quality, it also seemed advisable to apply another sampling method. The retronasal aroma simulation (RAS) device is known to produce a measurable flavor release similar to that of the mouth. The solvent assisted flavor evaporation method (SAFE) allows fast and careful isolation of volatiles from the solvent extracts of foods. For further studies, RAS and SAFE are recommended as methods of sample preparation in combination with GC/O.

Conclusions

Instrumental and sensory analyses were carried out on sesame-flavored dressings to identify the odor-active compounds affecting the perceived quality of the dressings. Sampling of the odor-active compounds were performed by SDE or SPME methods, and the character and strength of the odorants were quantified by means of GC/O. It revealed that the main odorants of sesame-flavored dressings were "caramel", "soy sauce", "burnt/smoky", 'citrus/green", "nutty", "roast/cooked" and "sulfur" odorants. Seven perceptual factors were abstracted by PCA of the sensory data, e.g. "roast and spicy", "mellow", "citrus and spice", "soy sauce", "light", "oily" and "remaining" factors, which consisted of the aroma and flavor of sesame-flavored dressings. Among them the first perceptual factor of "roast and spicy" was identified to be the most important factor having the highest percentage of contribution. The correlations between the odorants and the "roast and spicy" factor clarified the importance of "sulfur" odorants. These sulfurous compounds were identified as butanethiol, prenyl mercaptane, 2-methyl-3-furanthiol and dimethyl trisulfide. Some of the sulfurous compounds were detected only by SPME, therefore it would be important to apply a suitable method to extract and collect the potential odorants responsive to the perceived quality.

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