Aroma-Active Components in Wild and Cultured Sweet Smelts Fed with Various Diets

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INTRODUCTION

Sweet smelt (*Plecoglossus altivelis*), having a characteristic watermelon aroma, has been favored by Koreans and Japanese for centuries. In particular, the cultured one harvested in Korea has been increased with developing aquaculture technology in recently years. However, flavor qualities of the cultured fish in Korea are slightly inferior comparing to that of fish in Japan in terms of skin color and desirable aroma such as watermelon. For enhancing the quality of cultured one in Korea, rearing sweet smelt with various diets which composed mainly of PUFA such as 18:3n-3, 20:5n-3 and 22:6n-3 were attempted by Jeong *et al.*¹⁾

The objective of this study is to identify and compare aroma-active components in the wild and cultured ones fed with various diets for 4 weeks as a series of studies on improving quality of cultured sweet smelt.

MATERIALS AND METHODS

Cultured sweet smelts, weighing of 40 g each, were reared with 4 diet groups in concrete tanks (5,000 L each) for 4 weeks. Four experimental white fish meal-based diets were designed as follows; a control diet (C) was added soybean oil (2%) which is used as supplementary oil in Korea, a diet (CA) supplemented with an alga *Enteromorpha compressa* meal (2%) to control diet, a diet (CP) added perilla oil (2%) as lipid source instead of soybean oil and a diet (CPA) supplemented with the alga meal (2%) and perilla oil (2%). More details were described in a previous paper.¹⁾ Volatile flavor compounds of sample were extracted by liquid liquid continuous extraction (LLCE) method. Details are described by Cha *et al.*²⁾ Extractions were performed in duplicate. Flavor analysis from LLCE extract was performed by GC/MS. Details of GC/MSD procedure have been described elsewhere.³⁾ Duplicated analyses were performed on each LLCE extract. For detecting of

aroma-active components in LLCE extract of sample (1:3 diluted with diethyl ether), GC/olfactometry (GC/O) was performed on each extract by three trained panelists. Panelists were asked to assign odor properties and rate odor intensity of each compound using an 8-point scale (where 0 = no odor detected, 7 = very strong). Further details of procedure have been reported elsewhere.³⁾ Volatile compounds were identified by matching retention indices (RI)⁴⁾ and mass spectra of samples with those of authentic standards (Aldrich Chemical Co.). Tentative identifications were based on standard MS library data (Hewlett-Packard Co.). The relative abundance of each compound was expressed by the ratio of its total ion peak area to that of an internal standard.

RESULTS

A total of 104 volatile compounds were detected in wild (68) and cultured sweet smelts including C (78), CA (85), CP (83) and CPA (83) by LLCE/GC-MS method (no data). These compounds were composed mainly of aldehydes (10), ketones (7), alcohols (19), acids (10), esters (6), terpenes (4), aromatic compounds (25) and miscellaneous compounds (23). A total of 33 aroma-active compounds, including 8 aldehydes, 5 alcohols, 2 terpenes, 1 ketone, 1 ester, 1 sulfur containing compound and 15 unknowns, were also detected by GC/O in wild and cultured sweet smelts (Table 1). Among 8 aldehydes detected, (*E,Z*)-2,6-nonadienal and (*E*)-2-nonenal were in highest odor intensities in all samples. In particular, (*E*)-2-nonenal was detected with high odor intensity in wild one, while the odor intensities of (*E,Z*)-2,6-nonadienal in sweet smelts fed diets with CA and CP were higher than that of wild one. These compounds contributed to the strong cucumber and melon-like odors and characteristic of the overall aroma of sweet smelt.

Additionally, 3,6-nonadien-1-ol, having a cucumber and/or melon-like odor, was also detected with higher

Table 1. Aroma-active components in wild and cultured sweet smelts fed with various diets

Compound ^a	RI ^b	Mean odor intensity ^c					Odor description ^e
		C ^d	CA ^d	CP ^d	CPA ^d	N ^d	
Ethyl acetate	<900	2.2	4.5	3.0	3.0	1.4	Sweet, floral
2-Pentanone	966	1.0	2.1	3.3	2.2	1.0	Sweet, wine, floral
α-Pinene	1022	2.5	3.1	Nd ^f	2.2	1.0	Green, pine
Unknown	1055	Nd ^f	4.6	Nd ^f	2.6	2.1	Candy, floral
Hexanal	1078	1.3	2.5	2.3	2.2	4.0	Green, grassy
Unknown	1120	Nd ^f	Nd ^f	Nd ^f	Nd ^f	2.1	Fatty, wet paper
β-pinene	1131	1.7	2.1	1.7	2.1	1.5	Plant, pine
Unknown	1140	Nd ^f	Nd ^f	Nd ^f	Nd ^f	2.3	Fatty, meaty
Unknown	1160	Nd ^f	Nd ^f	Nd ^f	1.3	2.2	Fruity
2-Methyl-2-pentenal	1177	Nd ^f	2.3	1.4	1.2	1.3	Grassy, moldy
1-Penten-3-ol	1199	Nd ^f	Nd ^f	Nd ^f	Nd ^f	2.5	Plant, stale
3-Methyl-1-butanol	1228	2.4	2.3	1.5	1.3	1.3	Chocolate
Unknown	1258	2.6	3.2	Nd ^f	4.2	2.1	Soy sauce, savory
Unknown	1273	3.0	Nd ^f	3.3	2.1	3.3	Earthy, mushroom
Octanal	1289	1.3	5.3	2.4	3.0	2.3	Sweet, wine, green
Unknown	1327	3.2	2.5	2.2	1.6	2.2	Nutty, soy sauce
Nonanal	1388	1.1	3.2	3.5	2.4	1.4	Fatty, fishy
Unknown	1403	Nd ^f	Nd ^f	Nd ^f	Nd ^f	4.5	Sweet, honey
Unknown	1431	Nd ^f	1.2	3.5	Nd ^f	Nd ^f	Sour, apple cider
1-Octen-3-ol	1448	2.2	3.1	3.2	2.2	3.2	Mushroom
1,5-Octadien-3-ol	1472	2.1	2.1	3.3	3.2	4.2	Metallic, geranium
Decanal	1494	3.3	3.1	3.3	3.1	3.1	Oily, fatty
Unknown	1520	2.0	3.2	5.5	3.3	4.3	Fatty, sweet, nutty
(E)-2-nonenal	1554	2.7	4.2	4.5	3.6	5.2	Cucumber
(E,Z)-2,6-Nonadienal	1582	3.3	5.2	4.9	4.2	3.3	Cucumber, melon
Undecanal	1605	2.6	2.6	3.4	2.1	1.6	Fatty, chocolate
Unknown	1703	Nd ^f	2.4	3.3	2.6	1.3	Cucumber, fatty
Unknown	1740	2.7	3.6	2.4	2.5	1.4	Nutty, grainy, fatty
3,6-Nonadien-1-ol	1790	2.1	4.4	4.6	3.3	3.2	Cucumber, melon
Unknown	1906	Nd ^f	Nd ^f	3.2	Nd ^f	2.6	Plant
Benzothiazole	1990	1.0	2.0	2.7	2.2	Nd ^f	Seaweed
Unknown	2112	Nd ^f	2.2	3.4	2.1	2.0	Floral, sweet
Unknown	2187	Nd ^f	3.0	3.0	2.0	Nd ^f	Fatty, plant

^a Compounds identified by comparison of their MS, RI and odor properties with authentic standards.

^b Retention index on DB-WAX column. ^c Mean odor intensity from six replications

^d Experimental diet groups: C, added soybean oil (2%); CA, added alga meal (2%);

CP; added perilla oil (2%); CPA, added alga meal (2%)+ perilla oil (2%); N, wild one.

^e Odor as perceived during olfactometry. ^f No odor detected.

intensity in CA and CP than in wild one. Unidentified compound (RI=1703) having cucumber-like odor was also detected in 3.3-1.3 of odor ranges in all samples except for control (C). The C₈ alcohols including 1-octen-3-ol and 1,5-octadien-3-ol were strongly detected with mushroom and geranium leaf-like odors in wild sweet smelt and followed by CP, CA, CPA and C in order. However, 2 terpenes having pine and plant odors, α and β-pinenes, were detected in higher intensities in CA supplemented with alga meal.

DISCUSSION

In general, the generation of characteristic fish odor involves both enzymic and nonenzymic oxidative mechanism that initiate hydroperoxide formation in fish lipid system. This system is known to be responsible for the formation of volatile compounds, such as short chain carbonyls and alcohols.⁵⁾ Furthermore, the characteristic odor of wild smelt was revealed in the viscera and skin, while it was nearly

imperceptible in the muscle by many researchers.^{5,6)} Certain volatile nine-carbon aldehydes and alcohols, including (E)-2-nonenal, (E,Z)-2,6-nonadienal and 3,6-nonadien-1-ol are also derived from PUFAs such as EPA and DHA through lipoxygenase-mediated reaction, and known to act as the key compounds contributing to the characteristic aroma of cucumber and watermelon to the sweet smelt.⁶⁾ In particular, enzymically derived carbonyls and alcohols such as 1-penten-3-ol, 1-octen-3-ol, 1,5-octadien-3-ol, 3,6-nonadien-1ol, (E)-2-nonenal, (E,Z)-2,6-nonadienal and hexanal were detected with high odor intensities in all samples. Meanwhile, the C₉ compounds generated from hydroperoxides, such as (E)-2-nonenal and (E,Z)-2,6-nonadienal, should contribute to the characteristic flavor of sweet smelt with low thresholds, 0.08ppb and 0.01ppb, respectively. There was no significant difference in odor intensity between wild and cultured sweet smelts on the desirable aroma levels.

From the results on this study, feeding diet supplemented with alga meal or perilla oil is useful for improvement of the flavor quality of cultured sweet smelt.

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