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Deodorizing Effect of Coriander on the Offensive Odor of the Porcine Large Intestine

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The deodorizing effect of coriander (*Coriandrum sativum* L.) on the offensive odor caused by porcine large intestine was studied. Both 0.5 and 2.0 g of coriander were found to deodorize the stench of 2.0 g porcine large intestine almost completely, and the deodorant effect of coriander was maintained for 6 hrs or more even after the peculiar odor of the coriander disappeared. We detected four main compounds that contributed to the porcine large intestine odor: 4-Methylphenol (a sludge-like substance), unknown compound I (porcine large intestine-like), unknown compound II (a sludge-like substance) and Indole (excrement-like). Eleven main compounds of coriander odor were detected: Decanal, 2-Decenal, Undecanal, 2-Undecenal, 1-Decanol, (*E*)-2-Undecen-1-ol, 2-Dodecenal, (*E*)-2-Tetradecenal, Hexadecanal, Octadecenal and 9-Octadecenal. Although the four main compounds were not significantly decomposed by the coriander treatment, the coriander had a remarkable deodorant effect on the offensive odor emitted by the porcine large intestine.

Keywords: coriander, deodorizing effect, offensive odor, porcine large intestine, sensuous deodorization, volatile compound

Introduction

Coriander (*Coriandrum sativum* L.) is an herbaceous annual plant of the cicely family. The leaves, sometimes called "cilantro," are widely used in Southeast Asia to add flavor to foods or to hide the unpleasant smell of certain cooking materials. The fresh leaf has a unique odor that is similar to the smell of Kamemushi (*Halyomorpha picus*), and the seeds have a refreshing aroma and sweet taste, and are frequently used as a spice.

One of the important attributes of coriander is aroma quality, and this quality as paramount to the culinary value of the fresh herb, usually decreasing before the visual quality decreases (Loaiza and Cantwell, 1997). The aroma and volatile compounds in coriander have been extensively described in the literature (Fan and Sokorai, 2002). A lot of information is available on the identification of coriander fruit essential oils (Taskiness and Nykanen, 1975; Bandoni *et al.,* 1998; Smallfield *et al.,* 2001). Recently, the volatile compounds of coriander leaves have been reported with regards to their functionality, such as their bactericidal effect against the microorganisms of *Salmonella choleraesuis* (Kubo *et al.,* 2004). To date, the deodorizing effects of various plants such as thyme, sage and hydrangea against offensive components have been recognized (Tokita *et al.,* 1984; Nakatani *et al.,* 1989; Harasawa and Tagashira, 1994), whereas the coriander plant or coriander essential oil (seed oil) have not been reported to have a deodorization effect until now.

The porcine large intestine is a popular food material in Southeast Asia and China, and as such is a precious food resource. This food material was used empirically with coriander to remove its strong offensive odor. Up to now, there have been no reports on deodorization of the offensive odor of the porcine large intestine by the coriander leaf and stem.

The aim of this study was to examine the deodorizing effect of coriander on the offensive odor of the porcine large intestine, to compare its effect with the reported effect of herbs, wild grasses and green tea, and to identify the characteristic odor compound of the porcine large intestine and coriander.

Materials and Methods

Materials Coriander [*Coriandrum sativum* L. (Sakata Seed Co., Ltd., Kanagawa, Japan)] was cultured in a greenhouse at Hiroshima Prefectural University from 10 March through 10 July 2001. The stems and leaves were sampled at the seedling stage (40 days after sowing). Wild grasses such as dandelion, spiny sowthistle (*Taraxacum albidum* Dahlst. and *Sonchus asper*) and two herbs, thyme and rosemary (*Thymus vulgaris* L. and *Rosmarinus officinalis* L.) were collected at the university farm, and green tea (*Camellia sinensis*) was purchased at a supermarket in Shobara City. The fresh leaves and stems of the plant samples, except for the green tea, were clipped from the plants using solvent-rinsed stainless steel scissors and tweezers, and the surface moisture was lightly wiped from the samples with a paper towel after the samples

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Table 1. Comparison of the deodorizing activity of various plant materials against porcine large intestine.

Plant	Odor intensity [1]					
	Amount of plant materials added to the porcine large intestine (g)					
	0	0.1	0.5	2.0	2.0 (3hr) [2]	2.0 (6hr)
Coriander	4.0	2.5 [3] abc	0.5 cd	0.3 d	0.1 d	0.1 d
				+++ [4]	++	+
Thyme		2.7 b	1.8 bc	1.0 cd	0.5 cd	0.2 d
				+++	+++	+++
Rosemary		2.7 b	1.9 bc	1.1 cd	0.2 d	0.3 d
				+++	+++	+++
Dandelion		3.2 a	2.4 b	0.9 cd	1.6 c	1.5 c
				+++	+++	+++
Spiny sowthistle		3.4 a	3.3 ab	2.0 bc	1.1 cd	1.2 cd
				+++	+++	+++
Green tea [5]		2.1 bc	0.8 cd	0.4 d	1.1 cd	1.2 cd
				+++	++	+

[1] Deodorization intensity (0: perfectly deodorized, 1: almost deodorized, 2: considerably deodorized, 3: a little deodorized, 4: completely not deodorized).
[2] The deodorization activity was carried out in the porcine large intestine (2.0 g) immediately after the addition of each plant sample (0.1, 0.5 or 2.0 g).
[3] Each plant sample (2.0 g) was added to the porcine large intestine (2.0 g), and is the deodorization intensity of the sample set for 3 or 6 hours after addition at 40℃.
[4] Symbols are the odor intensity of each plant material (+++: very strong, ++: strong, +: a little).
[5] The green tea dry matter added was in a quantity converted into a fresh leaf quantity.
a, b, c: Mean values with different superscripts are significantly different according to the LSD test ($p<0.05$, $n=3$).

were washed with running water. All samples were frozen with liquid nitrogen, and crushed and stored at −80℃ until the time of the deodorizing activity test or extraction of volatile compounds.

The porcine large intestine of a pig with its internal organs was prepared at the slaughter house in Fukuyama City, Hiroshima. The large intestine was washed by distilled water, and it was immediately transported to our laboratory under 0℃, then rewashed and cut into minced meat and stored at −80℃. Small samples were thawed and used as the need arose during the experiment.

Simultaneous Distillation Extraction method (SDEM) We performed SDEM as described previously (Maneerat *et al.,* 2002). A sample flask with 10.0 g coriander and 2.0 g porcine large intestine was mixed with 600 ml distilled water in a 1-L round-bottom flask. Ten μl of 1% cyclohexanol solution was added as an internal standard. A 200-ml V-shaped bottom flask containing 100 ml of diethyl ether was attached to the solvent arm of the SDE head. The separation of volatile compounds was carried out under reduced pressure (75 mmHg, 80℃) for 60 min. The condenser of the SDE head was cooled with a mixture of water and ethylene glycol at −5℃. The extract was dried over anhydrous sodium sulfate and concentrated to ～100 μl under a nitrogen stream before 1 μl of the sample was drawn for gas chromatograph (GC) analysis or gas chromatograph mass spectrometry (GC-MS) analysis.

Gas chromatograph (GC) analysis GC analysis was performed with a Shimadzu GC-17A with a flame ionization detector and a Shimadzu Chromatopac C-R7A integrator (Shimadzu Co., Ltd., Kyoto, Japan). The compounds were separated on a 30 m×0.25 mm (i.d.) fused silica capillary column coated with a 0.25-μm film bonded polar DB-WAX (J&W Scientific Inc., Folsom, CA). The capillary column was maintained at 40℃ for 10 min after injection and then programmed at 3℃ min-1 to 220℃, which was maintained for 30 min. Open split injection was conducted with a split ratio of 1: 20; helium was used as the carrier gas at 250 Pa. For each column the injector temperature was 230℃ and the detector temperature was 250℃. Some individual components could be identified by both the injection of pure compounds and by comparison of their retention times (as a Kovats index).

Gas chromatograph- mass spectrometer (GC-MS) analysis GC-MS was performed with a Shimadzu GC-17A gas chromatograph coupled with a Shimadzu QP5050 mass spectrometer (Shimadzu Co., Ltd., Kyoto, Japan). The column (DB-WAX, 60 m×0.25 mm i.d.; J&W Scientific Inc., Folsom, USA) and temperature programs used were the same as those used for the GC analysis. Split injection was performed with helium as the carrier gas. The compounds were identified by the use of NIST and our own mass spectra libraries.

Gas chromatograph-olfactometry (GC-O) analysis A Shimadzu GC-17A (Shimadzu Co., Ltd., Kyoto, Japan) was equipped with a Y connector outside a capillary, allowing

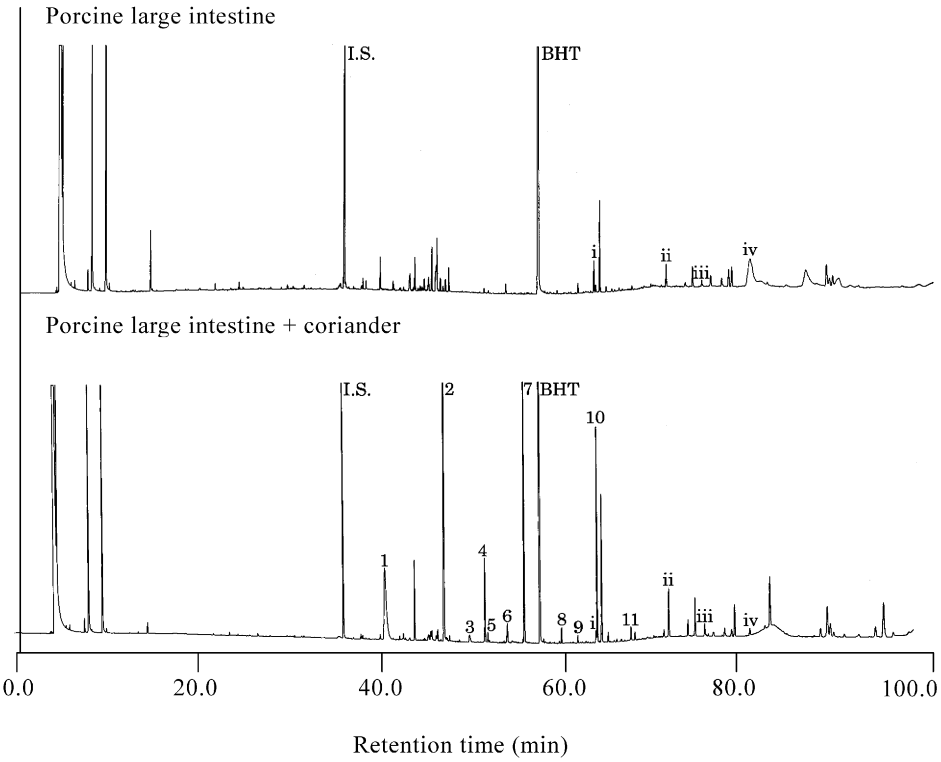

Fig. 1. Chromatogram of volatile compounds of porcine large intestine added to coriander or not.
Abbreviations: I.S., Internal standard; BHT, 2,6-Bis (1,1-dimethylethyl)-4-methylphenol
※ Porcine large intestine used 2.0 g addition fresh weight coriander 0.5 g.
※ The main offensive odors compounds (i: 4-Methylphenol, ii: unknown compound I, iii: unknown compound II and iv: Indole) of the porcine large intestine were identified comparing their mass spectra with mass spectral databases and comparing their retention index.
※ The coriander odors compounds (from Decanal; 1, 2-Decenal; 2, Undecanal; 3, 2-Undecenal; 4, 1-Decanol; 5, (*E*)-2-Undecen-1-ol; 6, 2-Dodecenal; 7, (*E*)-2-Tetradecenal; 8, Hexadecanal; 9, Octadecenal; 10 and 9-Octadecenal; 11) of coriander were identified comparing their mass spectra with mass spectral databases and comparing their retention index.

the effluent to be split between a sniffing port and a flame ionization detector (FID). The column was a DB-Wax fused silica capillary column (60 m×0.25 mm i.d.; J&W Scientific Inc., Folsom, USA), and the oven temperature was maintained at 40℃ for 10 min and then increased by 3℃/min to 220℃, where it was maintained for 30 min. The injector and detector temperatures were 230 and 250℃, respectively. The flow rate of the helium carrier gas was 30 cm/s. The split ratio of the injector was 1: 20. The values of the relative amounts of volatile compounds were calculated by dividing the GC peak area by the internal standard area. The calculations of these relative amount values were repeated four times. In the sniffing experiments, three panelists sniffed directly from the sniffing port, and the odor attributes of each compound were repeatedly assessed by different panelists on separate runs. The expression of each aroma compound was determined by agreement between at least two of the trained members.

Aroma extract dilution analysis (AEDA) The significance of each odor compound in the porcine large intestine odor was evaluated by its potency using the AEDA method of Hayata *et al* (2003). The volatile extract (50 μl) collected using the SDE method was used and diluted with diethyl ether in the ratio 1: 3^n, where n was selected from 1, 2, 3 or n as the dilution factor. All odor qualities were defined by two assessors, whereas stepwise dilution analysis was performed only one time.

The deodorizing activity test The offensive odor samples (2.0 g of the porcine internal organs) were placed in a 100-ml conical beaker and boiled for 10 minutes, after which 0.1 g, 0.5 g and 2.0 g of the samples was added to the coriander or the wild grasses, herbs, and green tea, respectively. The odor of the porcine large intestine was sniffed by the ten trained members (ten healthy adults, four men and six women, ranging in age from 21 to 47 years, who were recruited at Hiroshima Prefectural University; all subjects were non smokers), and the deodorizing activity test was carried out. The deodorizing activity against the offensive odor was measured using 5 grades (Perfectly deodorized: 0, Almost deodorized: 1, Considerably deodorized: 2, A little deodorized: 3, Completely not deodorized: 4).

Results and Discussion

Up to now, there have been many reports on the deodorization effect on offensive odors of wild grasses and herbs, so we compared the deodorization effect of corian-

Table 2. Comparison of main volatile compound of coriander and the porcine large intestine.

PN [2]	KI [3]	Compound	Peak area ratio [1] Amount of coriander added to the porcine large intestine (g)				Odor intensity[4]	Odor [5]
			0	0.1	0.5	2.0		
i	2034	4-Methylphenol	0.02 ± 0.01 a	0.04 ± 0.01 a	0.02 ± 0.01 a	0.03 ± 0.02 a	+++	sludge-like
ii	2265	Unkown I	0.04 ± 0.01 a	0.04 ± 0.03 a	0.02 ± 0.02 a	0.03 ± 0.03 a	+	sludge-like
iii	2329	Unkown II	0.01 ± 0.01 a	0.03 ± 0.02 a	0.01 ± 0.02 a	0.03 ± 0.01 a	++	porcine large intestine-like
iv	2454	Indole	0.03 ± 0.03 a	0.02 ± 0.01 a	0.02 ± 0.01 a	0.01 ± 0.02 a	+++	excrement-like
1	1496	Decanal	nd	0.25 ± 0.04[6] a	1.01 ± 0.03 a	3.64 ± 0.63 b	+	oily, green
2	1637	2-Decenal	nd	0.06 ± 0.01 a	0.33 ± 0.04 a	1.12 ± 0.15 b	+++	coriander
3	1727	Undecanal	nd	0.02 ± 0.01 a	0.15 ± 0.01 a	0.54 ± 0.05 b	+	green
4	1745	2-Undecenal	nd	0.08 ± 0.01 a	0.25 ± 0.01 a	1.44 ± 0.21 b	+	kamemushi-like
5	1752	1-Decanol	nd	0.01 ± 0.01 a	0.03 ± 0.01 a	0.18 ± 0.01 b	+	green
6	1816	(*E*)-2-Undecen-1-ol	nd	0.04 ± 0.01 a	0.08 ± 0.01 b	0.29 ± 0.05 c	+	green, oily
7	1856	2-Dodecenal	nd	0.39 ± 0.14 a	1.71 ± 0.07 b	2.56 ± 0.35 c	+++	coriander
8	1975	(*E*)-2-Tetradecenal	nd	0.01 ± 0.01 a	0.05 ± 0.01 a	0.18 ± 0.02 b	+	coriander
9	2020	Hexadecanal	nd	0.01 ± 0.01 a	0.05 ± 0.03 a	0.24 ± 0.10 b	+	oily
10	2088	Octadecenal	nd	0.27 ± 0.04 a	1.21 ± 0.17 a	6.14 ± 0.50 b	++	coriander
11	2213	9-Octadecenal	nd	0.07 ± 0.01 a	0.20 ± 0.11 a	0.72 ± 0.06 b	+	coriander

Abbreviations: PN, Peak number; KI, Kovats index; nd, not detected.
[1] Values are GC peak area of compound/GC peak area of internal standard.
[2] Peak number (see in Figure 1.).
[3] Kovats index on DB-WAX
[4] Symbols are the odor intensity of each volatile compound in the odor character of a porcine large intestine with coriander 0.5 g (+++: very strong, ++: strong, +: a little strong).
[5] The odor character of the volatile compounds by GCO.
[6] Values presented as means and standard errors for 3 times.
a, b, c: Mean values with different superscripts are significantly different according to the LSD test ($p < 0.05$).

der to several of these plants. A comparison of the deodorization effects against the offensive odor of porcine large intestine is shown in Table 1. The deodorization effect of coriander was significantly elevated when the treatment amount increased from 0.1 g to 2.0 g. Wild grasses such as dandelion and spiny sowthistle had a strong deodorant effect against the offensive odor in Methyl mercaptan (Urabe *et al.,* 1999), but not against the porcine large intestine. Whereas the deodorization effect of coriander was higher than thyme, and that rosemary and green tea had the deodorization effect against the offensive odor in raw meat or fish. In this study, the effect of coriander was maintained longer than 6 hrs, even though the smell of coriander had almost disappeared within 3 hrs after the treatment. On the other hand, the deodorization effect of green tea declined rapidly as time passed concomitant with the decrease of its green tea odor. In both thyme and rosemary, the strong odor and deodorant effects lasted for 6 hrs. These results suggested that the deodorization effect of coriander is not dependent on its odor as a masking effect, whereas the odor of green tea plays a role in its deodorant effect on offensive odors.

The chromatogram of the volatile compounds in the porcine large intestine with and without the treatment of 0.5 g coriander by SDEM revealed that a total of 189 and 87 volatile compounds in both treatments were contained, respectively (Fig. 1). Among these compounds, 89 and 36 of the volatile compounds in the porcine large intestine with and without coriander were clarified to have odors by GC-O. The four main compounds were detected as the porcine large intestine odor, and the eleven main compounds were sniffed as coriander odor, as shown in Table 2. By GC-MS and the Kovats index (KI), the four volatile compounds were 4-Methylphenol (i: sludge-like odor), unknown compound I (ii: KI=2265, sludge-like odor), unknown compound II (iii: KI=2329, porcine large intestine-like odor) and Indole (iv: excrement-like odor). In the test of odor intensity by GCO, 4-Methylphenol and Indole were very strong (+++), and the unknown compound II and the unknown compound I were strong (++) and a little strong (+), respectively. The FD values of Indole and unknown compound II were the highest among all the main compounds (FD=729), followed by 4-Methylphenol and unknown compound I (FD=243) (data not shown). 4-Methylphenol is the main end product of the fermentation of the amino acid tyrosine, and Indole results from the microbial degradation of tryptophan (Mackie *et al.,* 1998). It has been reported that 4-Methylphenol or Indole are offensive odors from feces in pigs

(Schaefer, 1997). In this study, we could not identify unknown compounds I and II because these compounds were at a very low level in the offensive odor for GC-MS analysis, and the results suggest that the compounds 4-Methylphenol and Indole are responsible for the offensive odor of the porcine large intestine, regardless of feces.

Eleven main compounds having a coriander odor were identified: Decanal, 2-Decenal, Undecanal, 2-Undecenal, 1-Decanol, (*E*)-2-Undecen-1-ol, 2-Dodecenal, (*E*)-2-Tetradecenal, Hexadecanal, Octadecenal and 9-Octadecenal. In particular, 2-Decenal (No. 2), 2-Dodecenal (No. 7) and Octadecenal (No. 10) had the strong characteristic odor of coriander. Potter (1996) previously reported that 2-Decenal, 2-Dodecenal and (*E*)-2-Tetradecenal are the main components in coriander leaf oil. Those compounds were also detected, and Octadecenal was clarified to be an important compound for the coriander odor in our research. The peak area ratios of eleven volatile compounds were significantly increased by the treatment of coriander from 0.1 g to 2.0 g fresh weight.

As for the deodorization mechanism, four types of mechanisms have been reported: chemical, physical, biological and sensuous deodorant activities (Ikemoto, 1996). Those deodorant activities, except sensuous activities, are due to the decomposition or absorption of offensive odor compounds. The sensuous deodorizing effect is thought to be a masking and modification effect (Nishida and Ishikawa, 1996). The former refers to hiding the offensive odor with another strong odor, and the latter refers to modulation of the offensive odor compound to be a different odor compound.

We found that the deodorization mechanism of coriander to the offensive odor of the porcine large intestine was not due to chemical or physical activities, because the treatment of coriander did not decompose the main offensive odors. Moreover, coriander's deodorization effect is not considered to be a masking deodorization by the coriander smell, because the remarkable deodorant effect was maintained for 6 hrs, even though the smell of coriander rapidly disappeared.

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