STUDY ON THE AROMA MODEL OF VIETNAMESE CORIANDER LEAVES (*Polygonum odoratum*)

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ABSTRACT

The volatiles present in fresh Vietnamese coriander (*Polygonum odoratum*) were isolated by solvent extraction and analyzed by GC analyses, aroma extract dilution analysis and omission test. The fresh herb was characterized as green, citrusy, pungent, and floral odors. The saturated aldehydes C₁₀, C₁₁, C₁₂, hexanal and decanal were most likely the principal contributors to Vietnamese coriander's characteristic aroma. The aroma reconstitution was finally examined by sensory evaluation methods based on the 5 key odorants mentioned above. The results of the omission experiments confirmed that dodecanal, decanal, hexanal and undecanal have significant impacts on the odor of Vietnamese coriander, while decanol does not play an important role.

Keywords: Vietnamese coriander, *Polygonum odoratum*, potent odorant, aroma model.

1. INTRODUCTION

Vietnamese coriander (*Polygonum odoratum*) belongs to the family Polygonaceae and has been widely used in the same manner in various cultures and times. It is commonly eaten fresh in salads, meat dishes as well as in some hot soups. In addition, this plant is believed to have a range of medicinal uses. It can be used to treat swellings, acne, indigestion, flatulence, and stomachaches [1, 2].

Vietnamese coriander possesses strong green, citrus peel, coriander leaf odor. Dung et al. [3] studied the composition of this herb oil isolated by steam distillation and identified 28 volatile components, in which β-caryophyllene (36.5 %), dodecanal (11.4 %) and caryophyllene oxide (8.2 %) were the main components. Hunter M. [4] employed steam distillation for the isolation of the herb oil constituents and identified 17 volatile compounds with dodecanal (44.1 %) and decanal (27.7 %) as the major components. Cadwallader [5] used a cold direct solvent extraction method and reported that dodecanal (27.5 %) and decanal (23.2 %) were in highest abundance, accounting for over 50 % of the volatile composition.
There have been substantial researches on the essential oil content and composition of Vietnamese coriander herb. However, there is limited information on the characteristic odor active components as well as the contribution of each component to the aromatic quality of the essential oil of this herb at the present time. Thus, the purpose of this study is to clarify the character of this herb. In addition, the odor quality was characterized by sensory evaluation using reconstructed models of odor mixtures of this fresh leave.

2. MATERIALS AND METHODS

2.1. Materials

The Vietnamese coriander leaves used in the experiments were harvested on a farm, immediately exported from Hanoi (Vietnam), and botanically authenticated at the National Center for Scientific Research Technology, Vietnam. The herb was stored under cool conditions during transportation, and kept at 4 °C until it was used. The plant was handled within 4 days after being harvested.

Hexanal, decanal, undecanal, dodecanal, tetradecanal, decanol, dodecanol and ethyl nonanoate were purchased from Tokyo Kasei Kogyo (Tokyo, Japan). The other chemicals were commercially obtained from Wako Pure Chemical Industries (Osaka, Japan) and Aldrich Chem. (USA).

2.2. Isolation of the aroma concentrates

Isolation of aroma concentrates from fresh Vietnamese coriander leaves was conducted by solvent extraction methods according to the procedure described in our previous paper [6]. Fresh leaves (10 g) were immersed in liquid nitrogen. For the extraction of organic compounds from plant leaves, the frozen leaves were ground into a fine powder with a mortar and pestle and then were extracted by methanol three times. The obtained extract was adjusted to a 10 % methanol aqueous solution with MQ water, before being subjected to chromatography in a column packed with 20 g of Porapak Q resin (Waters, 50/80 mesh). The absorbed aroma compounds were eluted with 200 mL of a mixture of pentane and diethyl ether (1:1, v/v). After desorption, 3 µg of ethyl nonanoate in diethyl ether was added as an internal standard (IS). The obtained aroma concentrate was analyzed by GC and GC-MS.

2.3. GC and GC-MS conditions

GC analyses were performed with an Agilent GC 6890 equipped with a flame-ionization detector (FID). Helium was used as the carrier gas at a flow rate of 1 ml/min. The capillary column was 60 m x 0.25 mm i.d., 0.25 µm film thickness coated with DB-WAX (J&W Scientific, USA). The oven temperature was held at 60°C for 4 min and then increased to 220 °C at a rate 2 °C/min. The injector and detector temperatures were set at 200 °C and 220 °C, respectively. GC/MS analyses were performed with an Agilent-MSD-5973 mass selective detector in full scan mode. GC conditions were the same as those used for the above GC analysis. Each compound was identified by the agreement of mass spectrum with those of the authentic compound.

2.4. GC-Olfactometry (GC-O) and Aroma Extract Dilution Analysis (AEDA)
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The samples were analyzed by two trained sniffers. The flavor dilution (FD) factors of odor-active compounds were determined by the method of aroma extract dilution analysis (AEDA) [7]. The original aroma concentrate was diluted stepwise 4-fold with diethyl ether by volume and then subjected to a GC-Olfactometry. The GC-O conditions were the same as those described above, with the exception of the column size (60 m × 0.53 mm i.d., 1 μm film thickness) and the flow rate of 8.3 ml/min of helium carrier gas. The effluent was split into equal parts at the end of the column and the parts were conveyed to an FID and a sniffing port respectively. The odor-active compounds were located in the chromatograms, and each odorant detected was assigned an FD factor representing the highest dilution in which the odorant was detectable.

2.5. Quantitative analysis

The aroma components in the concentrate of the herb were quantitatively analyzed. The volatile isolation was performed by the same method as described in the foregoing section on the "Isolation of the volatile compounds", but with the addition of the ethyl nonanoate as an internal standard to accurately determine the amount of the aroma components in the Vietnamese corianders. The absolute concentrations of the odor-active components in the concentrate were determined by the ratios of the peak areas % of the compounds to the internal standard and the calibration curves of authentic samples. Calibration curves were prepared using the mixture of authentic samples of odor-active compounds and the internal standard (ethyl nonanoate).

2.6. Sensory Evaluation

Sensory evaluation panel and evaluation term. A panel consisting of 12 females (aged 21 to 26 years old) was enrolled in a training program to detect and to identify sensory attributes of Vietnamese coriander herb, to share common perceptions on the intensity rankings of all of odor qualities rated. They were asked to evaluate the odor characteristics of this herb in each of the attributes and to rate the intensity by using a 10-cm line scale (0: absent; 10: strong). Two evaluation sessions were conducted: the first to evaluate the natural Vietnamese coriander odor and the reconstructed model aroma using Quantitatively Descriptive Analysis (QDA) [8], and the second to elucidate the effects of the respective components [9]. The data were analyzed by Tukey's multiple comparison tests.

Odor of natural Vietnamese coriander extracts. These leaves (1 g) were cut into about 1 cm in length and immediately subjected to a 50-ml glass bottle (with a plastic screw cap) for the sensory evaluation.

Odor of reconstructed model. The fresh herb solution was prepared in the same way as that for aroma profile analysis. The aroma model mixture was prepared by using authentic samples to quantify the extracted odor-active compounds. All stock solutions were prepared in absolute ethanol in the proportions indicated by the data from the quantitative analysis of the aroma concentrate (Table 1). The model mixture was diluted with purified water until the strength of odor impression of the model mixture reproduced that of the original Vietnamese coriander aroma on the basis of the sensory evaluation.

Omission experiments. To investigate the odor contribution of the individual aroma compounds, partial odor recombinants were prepared one by one by omitting a single odor compound from the complete odor reconstituent (Table 2). Each of the partial recombinants was presented to the panelists in comparison with the complete odor reconstituent, using QDA test. Twelve panelists were asked to evaluate whether or not the solutions were identical in each odor.
Those panelists were asked to rate the intensity of the given odor descriptors of each of the partial recombinants on a linear five-point scale (-4; -2; 0; 2; 4) with the fresh herb solution as control sample. The samples were served in a random order to each panelist.

3. RESULTS AND DISCUSSION

3.1. Analysis of the odor active compounds of Vietnamese coriander leaves

The aroma concentrate reproduced the characteristic odor of Vietnamese corianders well. By agreement of the mass spectra and its authentic compounds, the main volatiles in the aroma concentrate of this herb were identified (Table 1). The concentration of each compound is expressed by its peak area % and IS ratio on the GC trace.

Table 1. Main odor active compounds identified in the aroma concentrate of Vietnamese coriander leaves.

| Compound          | Odor description |
|-------------------|------------------|
| **Aliphatic aldehydes** |                  |
| hexanal           | citrus, sweet, pungent |
| decanal           | sweet, green, floral |
| undecanal         | citrus, pungent, cilantro |
| dodecanal         | fatty, green      |
| tetradecanal      | fatty, green      |
| **Total**         | 86.71            |
| **Alcohols**      |                  |
| 2-ethylhexanol     | green, sweet      |
| decanol           | oily, herbal, citrusy |
| undecanol         | oily             |
| dodecanol         | oily, citrus      |
| **Total**         | 9.18             |
| **Acids**         | 1.51             |
| **Esters**        | 0.23             |
| **Terpenoids**    | 1.03             |
| **Others**        | 2.20             |

*Odor quality perceived at the sniffing port; *b* Peak area % on GC. *c* GC peak area ratio of each component to the internal standard. *d* Flavor dilution factors.

The results showed that the straight-chained aldehydes were the most abundant compounds of this fresh herb (86.71 %), where decanal and dodecanal accounted for the major proportions (27 % and 57.55 %, respectively). These findings are in agreement with those of some studies in
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which aliphatic saturated aldehydes were the predominant odor components of this fresh herb [3-5]. Aliphatic alcohols were the second major group of this concentrate, accounting for 9.18%, followed by acids and esters at 1.51% and 0.23%, respectively.

The flavor dilution (FD) factors of potent odor compounds in the aroma concentrate were determined by an aroma extract dilution analysis (AEDA). The AEDA results showed that such saturated aldehydes as decanal and dodecanal were most likely the principal contributors to Vietnamese coriander's characteristic aroma with the highest FD factor (4,096 and 1,024, respectively), followed by undecanal (256), hexanal (64) and decanol (16). Additionally, the alcohol group represented by tetradecanal and dodecanol also contributed to the overall aroma of this herb with a relatively low FD factor of 4, so these probably make a minor contribution to the overall aroma of this herb compared to that of the aliphatic aldehyde group.

3.2. Aroma model of Vietnamese coriander

Table 2. Contents of the key odor compounds in Vietnamese coriander herb sample and model mixture for sensory evaluation.

| Compounds       | Contents, µg | fresh sample | model mixture |
|-----------------|--------------|--------------|---------------|
| hexanal         | 12.48        | 0.12         |
| decanal         | 288.01       | 2.88         |
| undecanal       | 21.28        | 0.21         |
| dodecanal       | 602.00       | 6.02         |
| decanol         | 38.51        | 0.38         |

Content in 100 g of fresh herb, calculated by using calibration curves for authentic compounds. bContent in model mixture.

Figure 1. Odor profile of Vietnamese coriander obtained from fresh leaves and reconstructed odor model.

Table 2 lists the concentrations of 5 compounds considered as the most odor-active in the Vietnamese coriander herb sample (FD factor ≥ 16). To clarify whether the odorants with high FD factors were actually the key compounds of the Vietnamese coriander herb, the aroma model was compared to its corresponding fresh herb. The aroma models were prepared with authentic
samples of the corresponding odor-active compounds in the determined concentrations, according to the recipes listed in Table 2.

Model mixture and the original fresh Vietnamese coriander herb were evaluated at the same time by the 12 trained panelists on a scale of 10 cm for the characteristic attributes. The sensory evaluation results are shown in Figure 1. It is concluded that the odor profile of the aroma model was very similar to the one of the fresh Vietnamese coriander sample ($p<0.05$), indicating that the characteristic odors of these leaves were closely duplicated by the aroma model containing these above key odor-active compounds.

### 3.3. Effects of the respective components on the overall odor of Vietnamese coriander

Following the above experiments, investigations to confirm the odor contribution of the fifth key-odor components and individual compounds by omission experiments were conducted. In this experiment, individual odor recombinants lacking in one odor compound and the complete odor recombinant were evaluated by QDA test using the fresh herb sample as the control. Panelists were asked to rate the intensity of the given odor descriptors of each of the partial recombinants on a linear five-point scale from -4 to 4. Results are shown in Figure 2.

![Figure 2](image)

*Figure 2. Omission test for Vietnamese coriander model mixture. The composition of each model mixture is shown in Table 2; *$p \leq 0.05$, **$p \leq 0.1$.*

As a result, the panelists rated the partial recombinant lacking dodecanal as being significantly less citrusy, pungent and floral sweet than the total recombinant, thus fitting well with the highest FD factor determined for this compound. Hexanal omission also gave significant reduction to the green and floral odor. In addition, note that the omission of decanal and undecanal also resulted in a significant reduction of floral sweet odor when compared to the complete recombinant. In contrast, omission of decanol from the odor complete recombinant was not detectable by the sensory panelists. Therefore, this compound might make a minor contribution to overall odor.
4. CONCLUSIONS

The results shown that the aliphatic saturated aldehydes were the most abundant compounds of this fresh herb, accounting for 86.71 %, whereas decanal and dodecanal accounted for the major proportions (27 % and 57.55 %, respectively). Aliphatic alcohols were the second major group of this concentrate (9.18 %), followed by acids and esters at 1.51 % and 0.23 %, respectively. Furthermore, it can be concluded that dodecanal, decanal, hexanal and undecanal have a significant impact on the odor of Vietnamese coriander, while decanol does not play an important role. These obtained results should contribute to evaluate the odor compounds of Vietnamese herbs, to expand the utilization in pharmaceutics, cosmetics, and would be useful for further studies on the aromatic compounds.

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TÔM TẮT

NGHIÊN CỨU MÔ HÌNH MÙI ĐẶC TRUNG CỦA LÁ RAU RÂM VIỆT NAM
(Polygonum odoratum)

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Các thành phần hóa học đặc trưng của rau râm Việt Nam (Polygonum odoratum) được trích li bằng dung môi và các chất tạo mùi chính được tìm ra bằng phương pháp GC-O kết hợp AEDA. Kết quả chỉ ra rằng hexanal, decanol và các aldehyde từ C10 đến C12 đặc trưng bởi mùi hoa quả và mùi ngọt của hoa quả, là các thành phần chính có trong rau râm. Mô hình mùi được xây dựng dựa trên thành phần của 5 chất tạo mùi đặc trưng và được đánh giá bằng phương pháp cảm quan. Kết quả của phương pháp thêm bớt mùi chỉ ra rằng dodecanal, decanal, hexanal, undecanal là các chất rất quan trọng tạo mùi đặc trưng của rau râm Việt Nam, trong khi đó decanol không có ảnh hưởng nhiều đến cung độ mùi chung của loại rau này.

Từ khóa: Vietnamese coriander, Polygonum odoratum, chất tạo mùi chính, mô hình mùi.