Evaluation of the effect of topical application of lavender oil on autonomic nerve activity in dogs

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Objective—To investigate the effect of topical application of undiluted lavender oil on sympathovagal activity in dogs.

Animals—5 healthy adult male Beagles.

Procedures—An ambulatory ECG monitor (Holter recorder) was placed on each dog (day0), and 48-hour ECGs were recorded, beginning at 8:00 the next day (day 1). Lavender oil (0.18 mL) or saline (0.9% NaCl) solution (0.18 mL) was topically applied to the inner pinnas of both ears of all dogs at 8:30, 12:00, 15:30, and 19:00 on day 2. Each trial was duplicated in each dog, with an interval of 3 to 4 days between trials. Spectral indices of heart rate variability, power in the high-frequency range, and the ratio of low-frequency to high-frequency power were calculated as an indirect estimate of autonomic nerve activity.

Results—When dogs were treated with lavender oil, the mean heart rate was significantly lower during the period of 19:00 to 22:30 on day 2, compared with the mean heart rate during the same period when dogs were treated with saline solution. On the other hand, high-frequency power during the period of 15:30 to 19:00 was significantly higher when dogs were treated with lavender oil, compared with the high-frequency power during the same period when dogs were treated with saline solution.

Conclusions and Clinical Relevance—The study revealed some evidence that topical application of lavender oil affected vagal activity in dogs. However, whether such an effect exists and whether lavender oil has a calming effect on dogs remains equivocal and requires additional investigation. (*Am J Vet Res* 2009;70:764–769)

Several studies[1–6] involving humans and laboratory animals (rats and mice) have revealed that lavender oil can act as a CNS depressant with sedative properties when inhaled, thus improving sleep quality. Some researchers have suggested that in vitro exposure of inotropic γ-amino butyric acid A receptors to essential oils can modulate neural transmission, and in vivo exposure may therefore have an effect on mood.[7] Results of a study[8] performed by our research group suggested that the apparent anxiolytic and antidepressant-like effects of inhalation of lemon oil vapor in mice may be caused by suppression of dopaminergic neuronal activity via enhanced activity of neurons that release 5-hydroxytryptamine. However, similar investigations in dogs are limited because of difficulties in assessing the neurologic and psychologic effects of essential oils.

Abbreviations

HF	High frequency
LF	Low frequency

On the other hand, the mechanisms and degree of absorption and metabolism of chemicals in dogs differ from those in humans; values from assessment of autonomic nerve activity are also different. Therefore, some chemicals that are innocuous in humans might be associated with adverse effects in dogs. For example, ingestion of xylitol, which generally causes no ill effects in humans, causes hypoglycemia and hepatic failure in dogs.[9,10] Consequently, we believe that the psychologic effects of essential oils may differ between humans and dogs and that, furthermore, certain essential oils may actually have opposite effects for dogs versus humans.

The purpose of the study reported here was to investigate the effect of topical application of lavender (*Lavandula angustifolia*) oil on sympathovagal activity in dogs. Our hypothesis was that application of lavender oil would result in reduced sympathovagal activity

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(an indicator of degree of relaxation), compared with activity when a placebo was applied.

Materials and Methods

Animals—Five healthy male laboratory Beagles with a mean ± SD age of 31.4 ± 8.8 months and mean body weight of 13.17 ± 1.4 kg were used. The dogs were considered healthy on the basis of results of a physical examination, CBC, and serum biochemical analysis. The dogs were housed separately in stainless steel cages (width × depth × height, 570 × 570 × 700 mm) in a temperature-controlled environment, and entry to the room was unlimited between 8:00 and 19:00. Lights were turned on at 7:00 and turned off at 19:00 daily. The dogs were provided with water ad libitum. They were lightly exercised outside the cages each day for approximately 30 minutes, during which time the cages were cleaned (a total of 2 cleanings/d at 8:00 and 17:00). After exercise, dogs were fed with the same diet. The use of these dogs, as well as the procedures performed, was approved by the Animal Research Committee at Tottori University.

ECG recording and computer analysis—Forty-eight–hour ECGs were obtained in the study by use of a digital ambulatory ECG recorder[a] (Holter monitor). To apply the Holter monitor, the hair over the ventral thorax of each dog was shaved and adhesive electrodes were affixed to the shaved region. The ECGs were recorded on 2 channels by use of an RL lead and MX lead.[11] Electrodes for RL lead were placed with the negative lead on the point 2 to 3 cm from the sternum, between the fifth and sixth ribs on the right side of the ventral thorax, and the positive lead was placed on the same point on the left side. Electrodes for the MX lead were placed with the negative lead over the manubrium of the sternum and the positive lead over the xiphoid process.[12] The Holter monitor was carried by dogs in a side pocket of a specially designed jacket.[b]

Electrocardiographic data recorded by the Holter monitor were averaged for 5-minute periods by use of an ECG analysis system.[c] For signal processing, a Hamming window function was used to minimize spectral leakage. A fast Fourier transform function was used to obtain the power spectrum of the fluctuation. Squared magnitudes and the products of the computed discrete Fourier transformed values were averaged to obtain spectral estimates. Values for LF and HF powers and the LF-to-HF ratio were obtained. The HF power reportedly reflects modulation solely of parasympathetic tone by respiration and is primarily associated with vagal activity, whereas the LF-to-HF ratio is considered an index of cardiac sympathovagal balance.[13] Frequencies ranging from 0.01 to 0.10 Hz were regarded as LF, and those ranging from 0.10 to 0.60 Hz were regarded as HF. Heart rate variability, HF power, and LF-to-HF ratio are reportedly useful for evaluating the effects of various drugs on the autonomic nervous system.[14]

Essential oil—The chemical composition of the undiluted lavender oil[d] was determined at an independent facility[e] by use of gas chromatography–mass spectrometry (**Appendix**). The specific gravity of the oil was 0.883 at 20° to 22°C, and the optical rotation was –7.824° (at 20°C). Prior to the experiment, all dogs were tested for sensitivity to the lavender oil (patch test). One drop of oil was applied to skin on the abdomen, and for 36 hours, the site of application was repeatedly examined for evidence of irritation. Ten to 14 days afterward, the test was repeated on the same area.

Experimental protocol—The effects of lavender oil were evaluated in a mean of 4 trials/dog, and each trial adhered to the same protocol. One day before each experimental trial began, each dog was fitted with a Holter monitor and a jacket was applied to familiarize the dog with the apparatus. On the next

Table 1—Mean ± SD serial changes in heart rate, HF power, and LF-to-HF ratio recorded by use of an ambulatory ECG monitor in 5 Beagles before treatment (day 1) and after topical treatment* with saline (0.9% NaCl) solution (placebo) or lavender oil (day 2) at various periods.

		Period evaluated					
Variable by day	**Treatment assignment**	**8:30–12:00**	**12:00–15:30**	**15:30–19:00**	**19:00–22:30**	**22:30–07:00**	**Entire period**
Heart rate (beats/min)							
Day 1	Placebo	77.8 ± 18.6	70.4 ± 16.7	98.8 ± 20.7	80.0 ± 9.0	75.1 ± 9.7	79.1 ± 16.9
	Lavender oil	74.2 ± 16.8	66.3 ± 9.8	90.5 ± 18.8	75.7 ± 6.5	72.6 ± 9.6	75.1 ± 14.3
Day 2	Placebo	77.8 ± 21.5	68.5 ± 12.9	98.0 ± 24.7	79.7 ± 13.3	75.6 ± 11.1	78.9 ± 18.4
	Lavender oil	78.9 ± 18.5	68.2 ± 13.1	88.4 ± 18.1	71.0 ± 6.1†	70.6 ± 8.5	74.3 ± 14.4
HF power (ms^2)							
Day 1	Placebo	469.1 ± 177.9	555.6 ± 118.8	278.3 ± 122.9	381.6 ± 136.9	508.1 ± 129.3	455.4 ± 163.8
	Lavender oil	496.6 ± 161.7	575.1 ± 95.0	343.6 ± 139.4	405.4 ± 174.0	503.9 ± 165.6	474.4 ± 170.0
Day 2	Placebo	501.4 ± 175.0	563.1 ± 106.2	295.9 ± 137.6	380.4 ± 129.9	457.9 ± 150.2	444.1 ± 165.2
	Lavender oil	450.4 ± 183.6	569.0 ± 110.5	368.8 ± 152.0†	507.5 ± 145.8	557.9 ± 131.1	507.0 ± 159.4
LF-to-HF ratio							
Day 1	Placebo	0.63 ± 0.21	0.71 ± 0.18	0.65 ± 0.19	0.47 ± 0.14	0.48 ± 0.16	0.56 ± 0.20
	Lavender oil	0.66 ± 0.21	0.70 ± 0.19	0.64 ± 0.20	0.48 ± 0.14	0.51 ± 0.14	0.57 ± 0.19
Day 2	Placebo	0.62 ± 0.21	0.68 ± 0.17	0.66 ± 0.18	0.46 ± 0.10	0.54 ± 0.17	0.58 ± 0.19
	Lavender oil	0.62 ± 0.18	0.71 ± 0.20	0.58 ± 0.18	0.41 ± 0.11	0.53 ± 0.20	0.56 ± 0.20

*Treatments were administered at 8:30, 12:00, 15:30, and 19:00 on day 2. †Value for lavender oil is significantly ($P < 0.05$) different from that for placebo at the indicated period.

day (day 1) at 8:00, an ECG recording was started. On the following day (day 2) at 8:30, 12:00, 15:30, and 19:00, dogs received the assigned treatment. On day 3 at 8:00, the Holter monitor and jacket were removed for 3 to 4 consecutive days as washout period between trials.

For the 4 experimental trials, choice of treatment alternated between an application of 0.18 mL of lavender oil to the inner pinna of each ear (approx 0.18 mL/ear) and 0.18 mL of saline (0.9% NaCl) solution to the same sites (placebo). Dogs were randomly assigned to treatment order, and those treated with lavender oil were housed in a room separate from those treated with a placebo.

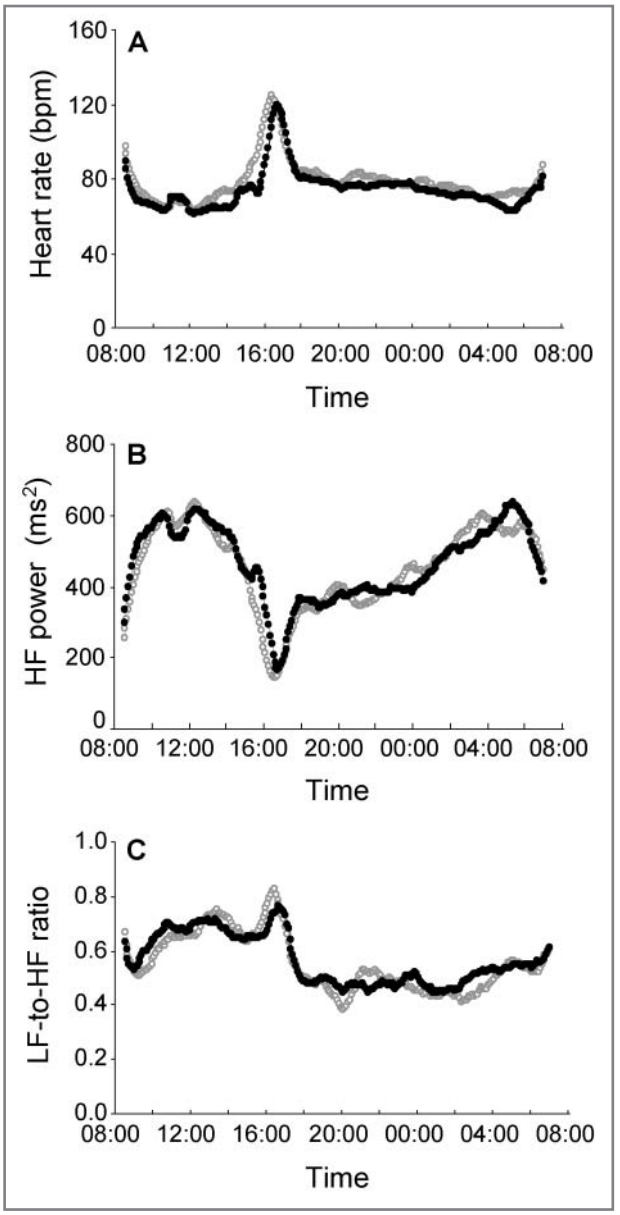

Figure 1—Serial changes in heart rate (A), HF power (B), and LF-to-HF ratio (C) recorded during study day 1 in 5 Beagles before dogs received any treatment. Dogs were assigned to topical treatment with saline (0.9% NaCl) solution (white circles) or lavender oil (black circles) the following day. Data were obtained by use of an ambulatory digital ECG monitor. Circles represent 12-segment running means of means obtained at 5-minute intervals. bpm = Beats per minute.

Dogs were evaluated to verify that their Holter monitors were working properly and ECGs were being recorded each day at 8:30, 12:00, 15:30, and 19:00. The small memory card and battery in each Holter monitor was replaced on day 2 at 8:00 because the memory card permitted recording of data for approximately 24 hours only.

Statistical analysis—All statistical analysis was performed by use of standard software.[f] The R-R intervals before and after an ECG artifact were excluded from the analysis. Values for heart rate, HF power, and LF-to-HF ratio were expressed as 12-segment moving averages for changes in the means obtained at 5-minute intervals. Effects of the 2 treatments were compared by use of repeated-measures MANOVA with respect to serial changes in heart rate, HF power, and LF-to-HF ratio for 24 hours from the first treatment at 8:00 on day 2 to 8:00 on day 3, for 3.5 hours after each treatment had been administered (ie, at 12:00, 15:30, 19:00, and 22:30 on day 2), and for the 9.5 hours from 22:30 on day 2 to 8:00 on day 3. Values of $P < 0.05$ were considered significant.

Results

Evaluation of dogs for sensitivity to lavender oil applied to the abdomen revealed no signs of irritation. In addition, successive applications of the lavender oil to the inner pinna of each ear did not result in any gross dermatologic lesions.

During the ECG recording, a circadian rhythm was evident in serial changes in heart rate, HF power, and LF-to-HF ratio, regardless of the treatment that dogs received (ie, heart rate and the LF-to-HF ratio were high and HF power was low during exercise outside the cages at 8:00 and 17:00 every day, and in the morning, HF power was high and heart rate and LF-to-HF ratio were low). Comparison of data between dogs when treated with lavender oil and when treated with a placebo revealed similar serial changes in heart rate ($P = 0.21$), HF power, ($P = 0.60$), and LF-to-HF ratio ($P = 0.81$) for 24 hours on day 1 (**Table 1**; **Figure 1**) because no treatment had been given to either group on that day. When serial changes on treatment day 2 were compared between treatments, heart rate was significantly ($P = 0.04$) lower for dogs when treated with lavender oil versus placebo only during the period of 19:00 to 22:30 (**Figure 2**). In addition, HF power (vagal activity) was significantly ($P = 0.03$) higher when dogs were treated with lavender oil only during the period of 15:30 to 19:00, compared with the HF power during the same period when dogs were treated with placebo. The HF power throughout the entire trial appeared to be higher when dogs were treated with lavender oil, compared with HF power when dogs were treated with placebo; however, the difference was not significant ($P = 0.08$). There were no significant ($P = 0.74$) differences in serial changes of LF-to-HF ratio between the 2 treatments during any measurement period.

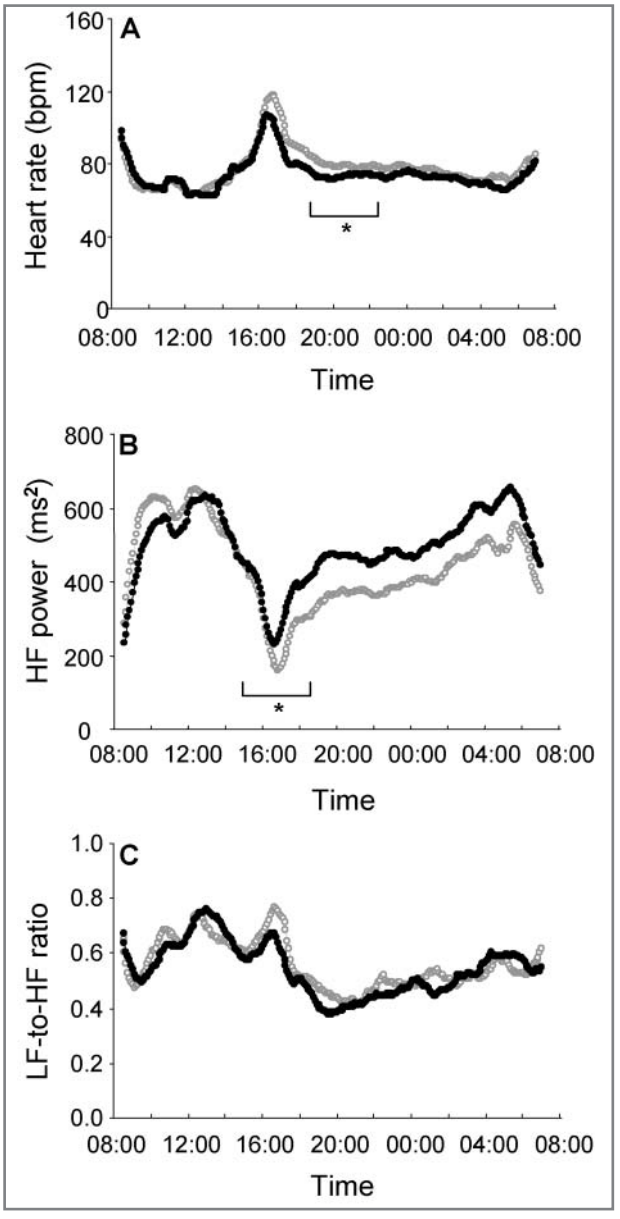

Figure 2—Serial changes in heart rate (A), HF power (B), and LF-to-HF ratio (C) recorded during study treatment day 2 in 5 dogs treated with topically administered saline (0.9% NaCl) solution (white circles; 0.18 mL/pinna) or lavender oil (black circles; 0.18 mL/pinna). Treatments were administered at 8:30, 12:00, 13:30, and 19:00. *Value for lavender oil is significantly ($P < 0.05$) different from that for saline solution during the indicated interval (brackets). *See* Figure 1 for remainder of key.

Discussion

Exposure of dogs to the odor of lavender can reportedly result in behaviors suggestive of relaxation[15] and alleviation of travel-induced excitement.[16] In our study, we sought to obtain physiologic evidence of the effects of undiluted lavender oil in dogs by use of digital ambulatory ECG recorders for assessment of variability in heart rate.

Monitoring of heart rate variability is an accepted method for the evaluation of autonomic modulation of the heart.[17,18] Frequency-domain analysis allows heart rate variability to be dissected into its specific frequency components. For example, the HF component is synchronous with respiratory sinus arrhythmia and is primarily associated with vagal activity,[19] whereas the LF component is largely correlated with efferent activity of the sympathetic nervous system.[19] On the other hand, the LF-to-HF ratio is believed to mirror sympathovagal balance or reflect modulation of the sympathetic nervous system.[20] For these reasons, we chose frequency-domain analysis to assess modulation of the autonomic nervous system.

When dogs were treated with a placebo in the present study, serial changes during day 1 and treatment day 2 were similar with respect to heart rate, HF power, and LF-to-HF ratio. These results suggested that none of the dogs were excited or distressed by wearing the ECG electrodes and Holter monitor jacket. If the dogs had been excited, then one would have expected these values to differ between day 1 and treatment day 2 as dogs became acclimatized to the apparatus with time.

Heart rate variability and autonomic nerve activity in dogs assumed a circadian rhythm regardless of whether dogs were treated with lavender oil or placebo. Such rhythmicity was also detected in another study[14] involving healthy adult Beagles. When dogs were treated with lavender oil, heart rate was significantly decreased and HF power was significantly increased during 1 period only (19:00 to 22:30 and 15:30 to 19:00, respectively), compared with values of the same variables when dogs were treated with a placebo. A decrease in heart rate and increase in vagal activity are believed to reflect calming of animals as assessed behaviorally.[4,20–23] Therefore, our findings suggested that topical application of lavender oil may have enhanced vagal activity, at least at certain time points, and may have made the dogs more relaxed. Results of similar studies[4,23,24] involving humans suggest that a foot bath with lavender oil and inhalation of lavender odorant enhances vagal activity.

The fact that only 2 significant differences between treatment groups were detected at 2 time points may have been attributable to an insufficient number of dogs used in the study. However, if lack of power had been an issue, one would have expected larger SDs than were actually obtained. Another possibility is that the ability of lavender oil to enhance vagal activity in dogs might not have been of sufficient strength in the morning or daytime, when HF power and LF-to-HF ratio were highest. A third explanation, not withstanding the possibility that the lavender oil simply had no effect, is that there may have been a cumulative effect from lavender oil having been applied 4 times during the daytime.

The lavender oil was applied inside the pinnas of both ears, and we believed that the chemical components of the oil would penetrate the skin and enter the bloodstream because these components are presumably soluble in lipids. The scent of the lavender oil could also have stimulated the olfactory system chemically, resulting in a physiologic response, or some components of the oil could have been inhaled. Confirmation that chemicals from the oil had entered the bloodstream would have been difficult to achieve because the active components have not been identified.

The mechanism by which lavender oil may act on the CNS in humans and other animals is poorly under-

stood. Some studies have revealed that linalool, which is a major component of lavender oil and many other essential oils, can alter brain activity in vitro. For example, linalool reportedly interferes with the glutaminergic system[25] and enhances activity of the dopaminergic system[26] in rats. Because all research involving dogs to date has yielded equivocal results, additional research is needed to support or refute the hypothesis that administration of lavender oil has a calming effect on dogs.

Whole lavender oil is typically not used in research because the major components of an essential oil can differ greatly in quality from one batch to another. Plants used in the production of essential oils may be of different species, and there can be intraspecies differences as well[27,28] because plants vary in chemical composition and hence toxicity, depending on how and where the plant grows and depending on the conditions that exist when the plant is harvested. The chemical composition of commercially produced essential oils is likely similarly variable. Furthermore, commercial essential oils used in aromatherapy can contain synthetic components or adulterants.[27,28] Even a drop of genuine essential oil can contain dozens of compounds, which may work synergistically or may inhibit each other.[27]

The amount of lavender oil applied to abdomens of the dogs in the present study did not appear to elicit any adverse effects. In our research, we typically use a concentration of 4%, and this concentration was chosen on the basis of the concentration suggested for humans.[29] However, in our experience, the undiluted lavender oil used in the present study can be topically applied without resulting in irritation of the skin. We would not recommend that other clinicians should apply undiluted lavender oil simply on the basis of our experience.

a. Holter recorder QR2100, Fukuda ME Kogyo, Tokyo, Japan.
b. Holter jacket, Fukuda ME Kogyo, Tokyo, Japan.
c. ECG analyzing system HS1000V, Fukuda ME Kogyo, Tokyo, Japan.
d. Aroma-Vet International, San Diego, Calif.
e. Essential Oil University, New Albany, Ind.
f. JMP software, version 5.1.1, SAS Institute Japan Inc, Tokyo, Japan.

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Appendix appears on the next page

Appendix

Main components of lavender oil as analyzed by use of gas chromatography–mass spectrometry.

Compound	Retention time (min)	Area (%)
α-Thujene	21.69	0.10
α-Pinene	22.14	0.24
Camphene	23.26	0.18
1-Octen-3-ol	25.97	0.17
3-Octanone	26.51	1.04
Myrcene	26.86	0.61
Butyl butyrate	27.29	0.13
N-Hexyl acetate	28.72	0.43
p-Cymene	29.42	0.19
δ-3-Carene	29.73	0.54
1,8-Cineole	29.90	0.69
(Z)- β-Ocimene	30.70	3.27
(E)- β-Ocimene	31.47	1.14
γ-Terpinene	32.19	0.19
cis-L halool oxide	33.30	0.14
α-Terpinolene	34.53	0.23
Linalool	35.86	32.82
Octen-3-yl acetate	36.58	0.78
Octanol acetate	37.48	0.07
Ocimene	37.78	0.30
Camphor	38.93	0.33
Hexyl isobutanoate	39.34	0.08
Borneol	40.61	0.76
Lavandulol	40.80	0.74
Terpinen-4-ol	41.57	1.84
α-Terpineol	42.54	1.02
Nerol	45.37	0.30
Cumin aldehyde	46.17	0.11
Linalyl acetate	47.70	41.63
Bornyl acetate	49.59	0.35
Lavandulyl acetate	49.96	2.01
Geranyl acetate	56.33	1.04
α-cis-Bergamotene	58.53	0.07
β-Caryophyllene	58.94	3.25
cis-α-Bergamotene	59.86	0.26
(E)- β-Farnesene	61.22	2.01
d-Germacrene	62.92	0.60
γ-Cadinene	65.00	0.15
Caryophyllene oxide	69.35	0.16