Evaluation of the Harmonizing Effect of Ylang-Ylang Oil on Humans after Inhalation

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Original Paper

Abstract

Scientific evaluations of the effects of fragrances on humans are rather scarce. The aim of this investigation was to study the effects of ylang-ylang oil (*Cananga odorata,* Annonaceae) on human physiological parameters and self-evaluation. Twenty-four healthy volunteers participated in the experiments. Fragrances were administered by inhalation. Physiological parameters recorded were skin temperature, pulse rate, breathing rate and blood pressure. Self-evaluation was assessed in terms of alertness, attentiveness, calmness, mood, relaxation and vigor. Additionally, fragrances were rated in terms of pleasantness, intensity and effect. The present investigation showed that ylang-ylang oil may be characterized by the concept of "harmonization" rather than relaxation/sedation. Compared to an odorless placebo, ylang-ylang oil caused significant decreases in blood pressure and pulse rate as well as significant increases of subjective attentiveness and alertness. Correlational analyses revealed that the observed effects are mainly due to a subjective odor experience.

Key words
Human physiological parameters · Inhalation · subjective evaluation · ylang-ylang oil · *Cananga odorata* · Annonaceae

Introduction

Ylang-ylang oil (the essential oil of *Cananga odorata,* Annonaceae) is widely used as a fragrance in perfumery and cosmetic industries. In medicine the interest in the usage of ylang-ylang oil as a therapeutically active agent has grown considerably. Especially in aroma therapy, ylang-ylang oil has been used as an antidepressant in cases of depression and nervousness as well as for reducing blood pressure in cases of hypertension. Clinical experience in aroma therapy suggests that beneficial effects of essential oils are not only exerted by absorption of fragrance molecules through the skin but also by inhalation of the vapor. It is long known that inhalation of essential oils causes physiological and psychological changes in humans [1] and it is assumed that the effects of essential oils are evoked by both pharmacological and psychological mechanisms. The former acts directly on the physical organism, the latter acts via the sense of smell and may thereby elicit physiological effects. The pharmacological and psychological effects are quite distinct although they often occur simultaneously [2].

In order to study the effects of fragrances, researchers have taken a great variety of approaches including measuring changes in the patterns of electromagnetic activity in the brain, in physiological parameters, e. g., heart rate and electrodermal activity, in mental and physical performance and in mood [3], [4], [5], [6], [7], [8].

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Kovar et al. [9] reported that rosemary oil induced increased locomotor activity in mice both after oral intake and inhalation. Buchbauer et al. [10] reported that fragrance compounds and essential oils with sedative effects influence the motility of mice after inhalation. They found that the essential oil of lavender, neroli and sandalwood as well as the pure fragrances linalool and citronellal led to a decrease of the motility of mice. On the other hand, orange terpenes, thymol, isoborneol and isoeugenol provoked an increase of motility. In addition, physiological changes elicited by odor stimulation have been demonstrated in many other parameters, e.g., blood pressure, muscle tension, skin temperature and skin conductance [11], [12]. However, up to now, no experiments about the effects of ylang-ylang oil on human physiological parameters and on behavioral measures after inhalation have been carried out. Therefore, the main objectives of the present study were: (i) to investigate the effects of ylang-ylang oil on parameters of the autonomic nervous system as well as on mental and emotional condition in healthy human subjects following inhalation in order to assess their influence on the level of ANS arousal and of subjective behavioral activation and (ii) to elucidate the mechanisms underlying the effects of the fragrance after inhalation.

Materials and Methods

Subjects and fragrance administration

Twenty-four healthy volunteers took part in the experiments. Subjects were tested in individual sessions and randomly assigned to either the control group or the ylang-ylang oil group. Each group consisted of 12 subjects. They were fully briefed, gave written informed consent to all aspects of the study (Srinakharinwirot University ethic commission granted permission) and were free to withdraw at any time. Ylang-ylang oil (available from FPI Sale Ltd., Stamford, England) was used as fragrance in this study. The ylang-ylang oil (fraction II) was obtained by steam distillation of the dry, fresh picked flowers of Cananga odorata (DC.) Hook. f. et Thoms. (Annonaceae). Ylang-ylang oil was identified by Ms. Nantana, Scientific and Technological Research Equipment Center, Chulalongkorn University, Thailand. A voucher specimen has been deposited under No. 30298 – 05. The oil mainly contains methyl benzoate (34.00%), 4-methylanisole (19.82%), and benzyl benzoate (18.97%). The minor components are iso-caryophyllene (9.28%), germacrene D (8.15%), α-farnesene (2.73%), linalyl acetate (2.11%), α-caryophyllene (2.04%), copaene (1.65%), and cadinene (1.25%). The fragrance and a placebo substance were administered by inhalation. 1.0 g of the appropriate fragrance in the experimental group or of the placebo (water) in the control group were used per subjects.

Experimental design

The experimental design is shown in Fig. **1**. One session consisted of two trials of 20 minutes each. At the beginning as well as at the end of each trial, subjective mental and emotional conditions were assessed by visual analogue scales (VAS). Physiological parameters were recorded continuously during each trial. In the first trial, which served as a control for influences of the experimental setup, the placebo substance was administered to all subjects. In the second trial the placebo was again administered to the control group, whereas in the experimental groups the appropriate fragrance was administered. The fragrances as well as the placebo were administered to the subject throughout 20 minutes of each trial.

Acquisition of physiological parameters and visual analogue scales (VAS)

Breathing rate (BR), pulse rate (PR), and skin temperature (ST) were measured using Power Lab/4SP hardware (ADInstruments, Inc., NSW, Australia). Sampling rate was 100 Hz. Systolic and diastolic blood pressure (SBP and DBP) were by sphygmomanometry using an automated system (Digital Electronic Model DS-155E, Japan). Details of the recording system and procedure have been described elsewhere [12]. Visual analogue scales were used to assess subjective mental and emotional condition. They consisted of 100 mm lines for six items: relaxation, vigor, calmness, attentiveness, mood and alertness. Each subject was asked to mark his or her feeling for each item between the two possible extremes.

Procedure

All experiments were conducted in a bright and quiet room. Ambient temperature was 24 – 26 °C. Upon arrival, the volunteers were interviewed about their personal data. In addition, they were asked about the rating of mental and emotional condition. After completion of the interview and rating scales, SBP and DBP were measured. Subsequently, subjects were informed about the proceedings. Afterwards subjects were seated in a semi-reclined position, providing easy access to attach the electrodes. Electrodes were attached at suitable positions. The fragrance or the placebo substance was administered. Then the recording of the physiological parameters was started. After completion of the first trial subjects were asked to rate the rating scales. SBP and DBP were measured at the end of the first trial. This procedure was repeated in the second trial.

Data reduction

The physiological recordings of each subject were computed trial by trial using Chart® software. For each subject and every parameter the mean value in the second trial was subtracted from

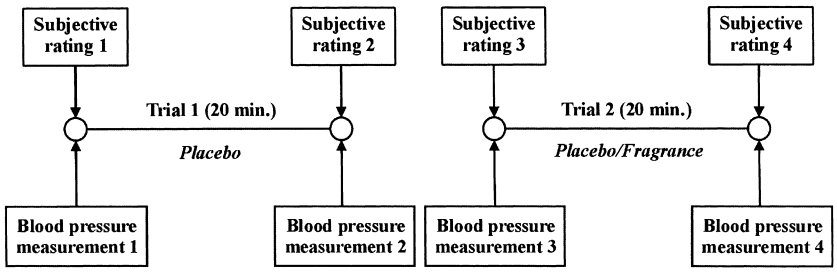

Fig. **1** Experimental design.

the mean value in the first trial to give the individual inter-trial difference score. Additionally, for each subject difference scores between blood pressure measurements 2 and 4 were calculated. For subjective ratings, on each scale the distance of the mark from the left-hand side was measured in mm. Individual difference scores between ratings 2 and rating 4 were calculated for each item. For the fragrance ratings individual difference scores between the first and the second rating were computed.

Statistical analysis

Systat 9.0 (SPSS Inc., 1999) was used for data analysis. The Mann-Whitney U test analysis of variances was used in this study. The effects of fragrances on physiological parameters, ratings of mental and emotional conditions, and fragrance ratings were determined by comparing the difference scores between the control group and the experimental groups. Correlational analyses were performed by means of Bravais-Pearson correlation and Spearman rank-order correlation. To evaluate correlations among physiological parameters the Bravais-Pearson correlation was carried out. The Spearman rank-order correlation coefficient was used to analyze the relation between subjective ratings and physiological parameters.

Results

Mean and SEM of physiological parameters of the control group and the experimental group are presented in Table **1**. The SBP of subjects in the control group increased at the end of the second trial as compared to the end of the first trial. In contrast, the SBP of subjects in the ylang-ylang oil group decreased at the end of the second trial as compared to the end of the first trial. The difference score of the ylang-ylang oil group was in marginal contrast to that of the control group (P = 0.083). The DBP of subjects in the control group increased at the end of the second trial as compared to the end of the first trial. The DBP of subjects in the ylang-ylang oil group only marginally changed at the end of the second trial as compared to the end of the first trial. The difference score of the ylang-ylang oil group was in significant contrast to that of the control group (P = 0.040). The PR of subjects in the control group increased in the second trial as compared to the first trial. In contrast, the PR of subjects in the ylang-ylang oil group decreased in the second trial as compared to the first trial. The difference score of the ylang-ylang oil group was in marginal contrast to that of the control group (P = 0.060). No significant effects of the ylang-ylang oil on BR and on ST were found (P > 0.100 for all).

Mean and SEM of self-evaluation of the control group and the experimental group are presented in Table **2**. Subjects in the control group felt less attentive at the end of the second trial as compared to the end of the first trial. In contrast, subjects in the ylang-ylang oil group judged themselves more attentive at the end of the second trial as compared to the end of the first trial. Comparison of these difference scores revealed a significant increase of subjective attentiveness in the ylang-ylang oil group as compared to the control group (P = 0.024). In addition, subjects in the control group and the ylang-ylang oil group felt more alert at the end of the second trial as compared to the end of the first trial. Comparison of these difference scores revealed a significant

Table **1** Mean and SEM of physiological parameters of the control group and the experimental group

		C		*YL*		*Significant differences*
		Trial 1	*Trial 2*	*Trial 1*	*Trial 2*	
SBP	Mean (SEM)	110.00 (2.44)	114.78 (1.82)	107.00 (3.64)	106.33 (3.50)	*
DBP	Mean (SEM)	67.90 (2.60)	77.90 (3.34)	62.00 (1.87)	62.50 (1.89)	**
PR	Mean (SEM)	74.84 (3.49)	75.14 (2.63)	73.29 (3.71)	68.38 (3.22)	*
BR	Mean (SEM)	16.03 (1.17)	15.07 (1.38)	15.36 (1.65)	15.67 (0.91)	NS
ST	Mean (SEM)	33.62 (0.75)	33.64 (0.79)	35.80 (0.38)	35.25 (0.56)	NS

C: control group, YL: ylang-ylang oil group; SBP: systolic blood pressure DBP: diastolic blood pressure, PR: pulse rate, BR: breathing rate, ST: skin temperature; Significant differences between the experimental group and the control group, NS: non-significant, *significant at $0.050 < P \leq 0.100$, **significant at $P \leq 0.050$.

Table **2** Mean and SEM of self-evaluation of the control group and the experimental group

		C		*YL*		*Significant differences*
		Trial 1	*Trial 2*	*Trial 1*	*Trial 2*	
AT	Mean (SEM)	35.91 (3.36)	39.59 (3.57)	32.90 (3.81)	25.80 (3.51)	**
AL	Mean (SEM)	48.27 (2.15)	45.14 (4.91)	43.18 (5.22)	24.45 (4.00)	**
C	Mean (SEM)	38.63 (4.64)	42.79 (4.79)	24.29 (4.40)	35.71 (6.91)	NS
R	Mean (SEM)	45.92 (6.26)	38.50 (5.64)	28.42 (3.98)	34.92 (7.34)	NS
M	Mean (SEM)	39.79 (2.86)	36.36 (4.42)	34.67 (4.12)	34.79 (5.18)	NS
V	Mean (SEM)	54.00 (2.72)	48.63 (5.40)	43.42 (6.18)	34.88 (6.11)	NS

C: control group, YL: ylang-ylang oil group; AT: attentiveness, AL: alertness, C: calmness, R: relaxation, M: mood, V: vigor; Significant differences between the experimental group and the control group, NS: non-significant, **significant at $P \leq 0.050$.

increase of subjective alertness in the ylang-ylang oil group as compared to the control group (P = 0.022). No significant effects of the ylang-ylang oil on subjective calmness, relaxation, mood, and vigor were found (P > 0.100 for all).

Mean and SEM of fragrance ratings of the control group and the experimental group are presented in Table **3**. Subjects in the control group and the ylang-ylang oil group rated the odor of water in the second trial more stimulating than that of water in the first trial. Comparison of the difference scores revealed a significantly larger stimulating effect of the odor of ylang-ylang oil than of the placebo substance (P = 0.020). Furthermore, subjects in the control group rated the odor of water in the second trial slightly more intense than that of water in the first trial. Also, in the experimental group the odor of ylang-ylang oil in the second trial were experienced as clearly more intense than that of water in the first trial. Comparison of these difference scores showed that odor intensity was judged significantly higher in the experimental group than in the control group ($P \leq 0.001$). No significant differences of odor pleasantness were found between groups (P > 0.100 for all).

Correlations

In the control group changes of SBP were correlated with changes of DBP and PR: the more SBP increased, the more DBP and PR rose (r = +0.646, P = 0.023 and r = +0.590, P = 0.044, respectively). Also, a relation between changes of DBP and ST was revealed: the more DBP increased, the less ST rose (r = –0.815, P = 0.001). Changes of subjective attentiveness were correlated with change of BR: the more attentive subjects rated themselves, the more BR rose (ρ = –0.503). Subjective evaluation of the fragrance's effect and intensity interacted with changes of DBP and ST: the more stimulating the substance was rated the less ST rose (ρ = –0.533); the more intense the substance was rated the more DBP increased and the less ST increased (ρ = +0.545 and –0.720, respectively). Additionally, interactions between changes of subjective vigor and alertness were found: the more vigorous the subjects felt, the more alert they judged themselves (ρ = +0.567). Interactions were revealed between subjective evaluation of the fragrance's effect and changes in subjective vigor: the less stimulating the substance was rated the more vigorous the subjects felt (ρ = +0.552). Also, subjective rating of the fragrance's effect was correlated with subjective rating of the intensity: the more stimulating the substance was rated the more intense the substance was judged (ρ = +0.575). In the experimental group changes of SBP were correlated with changes of DBP and ST: the more SBP increased, the more DBP rose and the less ST rose (r = +0.677, P = 0.016 and r = –0.690, P = 0.013, respectively). Changes of subjective alertness were correlated with change of PR: the more attentive subjects rated themselves, the less PR rose (ρ = +0.517). Subjective evaluation of the fragrance's pleasantness interacted with changes of DBP: the more pleasant the substance was rated the less DBP rose (ρ = –0.510). Additionally, interactions between changes of subjective vigor and alertness were found: the more vigorous subjects felt, the more alert they judged themselves (ρ = +0.888). Interactions were revealed between subjective evaluation of the fragrance's effect and changes in subjective vigor and alertness: the less stimulating the substance was rated the less vigorous and the less alert subjects felt (ρ = +0.588, ρ = +0.729, respectively) (Table **4**).

Discussion

In the present investigation essential ylang-ylang oil was administered to healthy subjects by inhalation. Physiological para-

Table **3** Mean and SEM of fragrance ratings of the control group and the experimental group

		C		*YL*		*Significant differences*
		Trial 1	*Trial 2*	*Trial 1*	*Trial 2*	
E	Mean (SEM)	54.23 (5.30)	51.68 (4.75)	47.27 (5.45)	29.55 (4.67)	**
I	Mean (SEM)	71.41 (5.71)	69.27 (4.25)	62.42 (4.47)	19.96 (3.14)	***
P	Mean (SEM)	45.17 (3.54)	46.17 (3.20)	46.71 (6.91)	50.67 (5.65)	NS

C: control group, YL: ylang-ylang oil group; E: stimulating effect, I: intensity, P: pleasantness; Significant differences between the experimental group and the control group, NS: non-significant, **significant at $P \leq 0.050$, ***significant at $P \leq 0.001$.

Table **4** Correlational analyses for the control group and the experimental group

Substance	*PHY/PHY*	*PHY/SE*	*PHY/FR*	*SE/SE*	*FR/SE*	*FR/FR*
Placebo	ST ↓/DBP ↑ SBP ↑/DBP ↑ SBP ↑/PR ↑	BR ↑/AT ↑	DBP ↑/I ↑ ST ↓/E ↑ ST ↓/I ↑	V ↑/AL ↑	E ↓/V ↑	E ↑/I ↑
Ylang-ylang oil	SBP ↑/ST ↓ SBP ↑/DBP ↑	PR ↓/AL ↑	DBP ↓/P ↑	V ↑/AL ↑	E ↓/AL ↓ E ↓/V ↓	

PHY: physiological parameter, PR: pulse rate, BR: breathing rate, ST: skin temperature, ↑/↓: increase/decrease in trial 2 as compared with trial 1, SBP: systolic blood pressure, DBP: diastolic blood pressure, ↑/↓: increase/decrease on measurement 4 as compared with measurement 2; SE: self-evaluation, V: vigor, AT: attentiveness, AL: alertness, ↑/↓: increase/decrease on rating 4 as compared with rating 2; FR: fragrance rating, E: (stimulating) effect, I: intensity, P: pleasantness, ↑/↓: increase/decrease of rated odor quality in rating 2 as compared with rating 1, ↑/↓: increase/decrease.

meters, i. e., blood pressure, pulse rate, breathing rate, and skin temperature, were recorded as indicators of the arousal level of the autonomic nervous system. In addition, subjects had to rate their mental and emotional conditions in terms of relaxation, vigor, calmness, attentiveness, mood, and alertness in order to assess subjective behavioral arousal. Inhalation of ylang-ylang oil affected pulse rate, diastolic blood pressure, and systolic blood pressure. Inhalation of ylang-ylang oil led to a trend towards a larger decrease of pulse rate than inhalation of odorless water. Since pulse rate is mainly controlled by the autonomic nervous system (ANS) the decrease of pulse rate after inhalation of ylang-ylang oil is likely to show an increase in vagal tone, i. e., a decrease of ANS arousal. In addition, inhalation of ylang-ylang oil led to a trend towards a larger decrease of systolic blood pressure than inhalation of odorless water. Since blood pressure is determined by the activity of the sympathetic branch of the ANS a decrease of systolic blood pressure shows a decrease of sympathetic tone, i. e., a decrease of physiological arousal. At the behavioral level inhalation of ylang-ylang oil led to changes of subjective alertness and attentiveness. Subjects who had inhaled ylang-ylang oil felt more alert and more attentive than subjects in the control group. These findings show an increase of arousal in terms of self-evaluation. Analysis of the subjective odor ratings showed that subjects in the ylang-ylang oil group rated the odor to be more stimulating than subjects in the control group. Not surprisingly, a significantly higher subjective odor intensity of ylang-ylang oil as compared to the placebo substance was found. Correlational analyses showed that changes of subjective alertness were correlated with changes of pulse rate in the ylang-ylang oil group. The more pulse rate decreased in subjects in the ylang-ylang oil group the more alert they judged themselves. Obviously, a decrease of physiological activation was correlated with an increase of arousal at the subjective level. This finding may indicate that inhalation of essential ylang-ylang oil results in the uncoupling of physiological and behavioral arousal processes [13]. The observed effects of essential ylang-ylang oil are not precisely characterized by concepts like relaxation or sedation, since deactivation on both the physiological level and on the level of self-evaluation is associated with these concepts. Inhalation of essential ylang-ylang oil, however, reduced the level of arousal of the autonomic nervous system but did not lead to deactivation at the behavioral level, i. e., after the administration of the oil subjects did not feel more relaxed or drowsy, but in contrast reported to feel more attentive and more alert than before the administration of the oil. Thus, the effects of essential ylang-ylang oil may be characterized by the concept of "harmonization" rather than relaxation/sedation which has also been described for the essential oil of lavender [14], [15] as well as for the essential of sandalwood oil [16]. Elucidation of the different mechanisms involved in the effectiveness of odorous molecules is crucial for our understanding of how these substances act on human bodily functions and on behavior. The present study supplies evidence that both mechanisms are not only involved but are also active simultaneously when fragrances are administered by means of inhalation and olfactory processing takes place. The results of the present investigation are similar to recent research performed by Buchbauer's group [7], [12], [17], [18] which demonstrated in addition that pharmacological effects of fragrances are accessible by means of percutaneous administration of the substances and exclusion of olfactory processing. Therefore, in order to differentiate between pharmacological and psychological effects of fragrances, subjective evaluation of the odors must be prevented.

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