研究報告

臺灣肖楠葉子與臺灣杉葉子精油對人體情緒紓緩的影響

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【摘要】現代社會步調快速、文化與科技不斷變革，使人們壓力漸增，其對心靈層面的追求亦日漸提升。即便精神藥物治療可有效解決相關疾病問題或紓緩緊張情緒，但天然方法仍具有一定的效益與需求。臺灣肖楠（*Calocedrus macrolepis* var. *formosana*）與臺灣杉（*Taiwania cryptomerioides*）爲珍貴國產林木，可作爲工藝、家具、建築等材料，但在撫育或木材收穫後，剩餘的葉子常因無所用途而被丟棄。本研究旨在評估臺灣肖楠與臺灣杉葉子精油做爲藥用的可行性。本研究利用氣相層析串聯質譜儀分析臺灣肖楠與臺灣杉葉子精油化學成分，並以嗅吸試驗評估精油對人體情緒之影響。結果顯示，吸聞臺灣肖楠葉子精油能顯著降低受試者沮喪及焦慮情緒；而臺灣杉葉子精油則能顯著降低焦慮情緒。此外，吸聞兩者之葉子精油後，受試者的副交感神經活性皆有所提升。進一步分析兩者之精油成分發現，臺灣肖楠葉子精油主要爲 α-Pinene 及 Limonene（分別爲 72.98% 及 10.34%），臺灣杉葉子精油主要爲 α-Pinene、Limonene 及 3-Carene（分別爲 14.79%、46.77% 及 12.22%），顯示此即是賦予臺灣肖楠與臺灣杉葉子精油紓緩情緒效果的成分。由上述結果可知，臺灣肖楠與臺灣杉葉子精油具有開發成爲精神相關輔助療法或藥物之潛力。而以臺灣肖楠與臺灣杉葉子作爲精油產品在精神紓緩方面的有效利用，亦能使這些剩餘資材成爲可永續應用的林業資源。

【關鍵詞】芳香療法、臺灣肖楠、精油、芬多精、臺灣杉

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Research paper

EMOTION MODERATING EFFECTS OF THE LEAF ESSENTIAL OILS FROM *CALOCEDRUS MACROLEPIS* VAR. *FORMOSANA* AND *TAIWANIA CRYPTOMERIOIDES*

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【**Abstract**】Stress is increased by rapid social, cultural, and technological changes and mental health issues are more prevalent. Psychotropic medications are effective but so also is immersion in a natural or relaxed situation. *Calocedrus macrolepis* var. *formosana* and *Taiwania cryptomerioides* are valuable plantation woods in Taiwan that are used for crafts, furniture and construction materials, but the leaves of these two woods are usually abandoned. This study determines the feasibility of using the essential oils from their leaves for medicinal purposes. The chemical composition of these essential oils from both the *C. macrolepis* var. *formosana* and *T. cryptomerioides* are identified using gas chromatography-mass spectrometry (GC/MS) and the effects on human emotions of inhaling these essential oils is determined. The results show that inhaling the essential oil from *C. macrolepis* var. *formosana* leaves significantly reduces levels of depression/dejection and tension/anxiety. Inhaling the essential oil from *T. cryptomerioides* leaves also significantly reduces tension/anxiety. Participants demonstrate significantly higher vagal activity after inhaling both essential oils from *C. macrolepis* var. *formosana* and *T. cryptomerioides* leaves. *C. macrolepis* var. *formosana* leaves have significant content of α-pinene and limonene (72.98% and 10.34%) and *T. cryptomerioides* leaves contain α-pinene, limonene, and 3-carene in (14.79%, 46.77%, and 12.22%), showing their emotion moderating effect is mainly contributed by α-pinene, limonene, and 3-carene. So, the essential oils from these leaves may be an adjuvant to psychotropic medications. This allows the development of sustainable, regenerative forest residues from *C. macrolepis* var. *formosana* and *T. cryptomerioides* leaves.

【**Key words**】 Aromatherapy, *Calocedrus macrolepis* var. *formosana*, Essential oil, Phytoncides, *Taiwania cryptomerioides*

I. Introduction

Stress is more common because of an accelerated pace of life and the elevated pressure that is associated with increased risks of mental problems, such as anxiety, depression, and insomnia (Johnson *et al*., 2006). The World Health Organization (WHO) statistics for 2015 show that the respective number of people suffering from depression and anxiety was 322 million and 263 million and many experienced both conditions simultaneously (WHO, 2017). However, studies show that insomnia is strongly associated with the incidence of depression, anxiety and other psychological disorders (Taylor *et al*., 2003). The use of psychotropic medications has increased rapidly over the last decade but these are associated with such as adverse psychological effects, behavioral toxicity and so forth (Tomba *et al*., 2018). These detrimental effects can persist long after administration of these drugs (Tomba *et al*., 2018; Framer, 2021).

Current studies show the physiological and psychological benefits of immersion in a forest or green environment and a key aspect of this regimen is olfaction stimuli. The health effects are associated with exposure to elements such as phytoncides and volatile organic compounds (VOCs) that are released from plants and trees (Tsunetsugu *et al*., 2010; Hansen *et al*., 2017). The shared neuronal connections in the brain between emotional and olfactory processing imply the close relationship between emotion and odors (Soudry *et al*., 2011; Kohli *et al*., 2016). Studies have revealed that essential oils have some mood-altering effects that are mediated by olfactory images and also non-olfactory-mediated psychopharmacological effects on arousal, activation, anxiety, quality of sleep, etc. (Antonelli *et al*., 2020).

The essential oil from *Citrus aurantium* demonstrates comprehensive anxiolytic activity in a mice model that is related to generalized anxiety and obsessive-compulsive disorder. These effects may derive from limonene, which is the most abundant component in *C. aurantium* essential oil (Lima *et al*., 2013; Suntar *et al*., 2018; Song *et al*., 2021). Kasuya *et al*. (2015a) demonstrated the anxiolytic-like effect and the intracerebral distribution of α-pinene in mice after inhalation of essential oil from *Chamaecyparis obtusa* and show that increased α-pinene in the brain affects the expression of emotional behavior-related neurotransmitters after inhalation of α-pinene alone, which alters the behavior of mice (Satou *et al*., 2014; Kasuya *et al*., 2015b).

α-Pinene and limonene, which are common constituents of natural essential oils, are reported to have anxiolytic effects (Salehi *et al*., 2019; Song *et al*., 2021). These two constituents are frequently found in valuable

plants that are native in Taiwan, such as *Juniperus chinensis* var. *kaizuka*, *Cryptomeria japonica*, *C. formosensis*, etc. (Kuo *et al.*, 2012; Lin *et al*., 2015; Chang *et al*., 2018), and are the main constituents of essential oils in leaves from *C. macrolepis* var. *formosana* and *Taiwania cryptomerioides* (Cheng *et al*., 2004; Su *et al*., 2006). The essential oils from the leaves of *C. macrolepis* var. *formosana* and *T. cryptomerioides* may have similar benefits on mood-altering. Essential oils that are derived from leaves may also allow regenerative and sustainable forest management. This study aims to investigate the effects of the essential oils from the leaves of *C. macrolepis* var. *formosana* and *T. cryptomerioides* on emotions and to determine the feasibility of using native plants in Taiwan for forest therapy or aromatherapy.

II. Materials and Methods

(I) Extraction of the essential oils from *C. macrolepis* var. *formosana* and *T. cryptomerioides* leaves

The leaves of both *C. macrolepis* var. *formosana* and *T. cryptomerioides* were collected from the forest plantation No. 72-1 of compartment 11 of the Qingshuigou Forest Management District and Butterfly Valley of compartment 16 of the Shuili Forest Management District in the Experimental Forest of National Taiwan University. After drying in the shade for 7 days, the essential oils of both leaves were extracted by hydrodistillation for 6 h. The yields of both essential oils from *C. macrolepis* var. *formosana* and *T. cryptomerioides* leaves were around 0.2% (w/w).

(II) Identification of the chemical composition of essential oil

The chemical compositions of both essential oils from *C. macrolepis* var. *formosana* and *T. cryptomerioides* leaves were identified using the gas chromatography/mass spectrometer (GC/MS, Trace GC Ultra and Polaris Q System, Thermo Scientific) equipped with a DB-5ms analytical column (30 m × 0.25 mm × 0.25 μm, J&W Scientific). The separation process used helium (99.9995%) as the carrier gas at the flow rate of 1 mL/min. A 1 μL diluted sample was injected (injector temperature: 250°C) for analysis at a splitting ratio of 10:1. The oven temperature was initially maintained at 60°C for 1 min and then increased to 220°C at a rate of 4°C/min. It was maintained at this temperature for 2 min; and then increased the temperature to 250°C at a rate of 20°C/min and maintained at this temperature for 5 min. Electron ionization mode was performed and the temperature of the ion source was 230°C. The scanning mass range was 50 - 400 amu.

The identification of the components in the essential oils were identified using the commercial mass databases from the National Institute of Standards and Technology (NIST, version 2.0), Wiley (version 7.0) and the mass database established by the ChemtreeLab of National Taiwan University. The identification results were also confirmed by the Kovats indices (KI) reported by Adams (2007) and Su *et al*. (2006) and co-injection of authentic compounds (STD). The authentic compounds used in this study are camphene (ICN Biomedicals), 3-carene (Acros Organics), α-copaene (Fluka), δ-cadinene (TCI Chemicals), cyclohexyl acetate (TCI Chemicals), isobornyl acetate (TCI Chemicals), limonene (Alfa Aesar), β-myrcene (Sigma-Aldrich), α-pinene (Acros Organics), sabinene (Sigma-Aldrich), α-terpineol (Acros Organics), thujopsene (Fluka), which were further purified.

(III) Essential oil sniffing test

Twenty healthy adults (aged 20-25 years) were recruited in this study. In a single-blind, independent group design, participants were randomly assigned to either *C. macrolepis* var. *formosana* leaves (n = 10) or *T. cryptomerioides* (n = 10) group. All participants had no history of respiratory or smell disorders and did not have symptoms of colds, influenza, or allergies during the experiment. Written informed consent was obtained from the participants enrolled. This study was approved by the University of Taipei Ethics Committee (IRB-2018-021) and conducted according to the ethical standards of the latest version of the Declaration of Helsinki.

During the sniffing test, participants were assigned to sniff essential oil of *C. macrolepis* var. *formosana* leaves (n = 10), or *T. cryptomerioides* leaves (n = 10) for 5 minutes in a quiet room. A constant dosage (50 μL in 1 mL of water) of the essential oils was nebulized by an ultrasonic nebulizer (KUN-868, King Ultrasonic Co., Ltd.) and delivered to the participants through a polypropylene tube with a mask. The profile of mood state (POMS), the heart rate variability (HRV), and blood pressure of subjects were measured before and after the sniffing test. In addition, the HRV of participants was continuously measured throughout the 5-min sniffing test.

(IV) Evaluation of the mood state of subjects

The short version of POMS, which was improved by Chen *et al*. (2002), is used for this study. There are 30 items in the short form of the POMS, which are classified as 7 emotional states: anger/hostility, confusion, depression/dejection, esteem, fatigue, tension-anxiety and vigor. A likert scale ranged from 0-4, for “not at all” to “extremely”, was used to rate each

item. The results for anger/hostility, confusion, depression/dejection, fatigue, tension/anxiety and vigor are evaluated for this study.

(V) Measurement of blood pressure, heartbeat, and heart rate variability

The blood pressure, heartbeat and heart rate variability (HRV) of subjects was measured before and after the sniffing test. The blood pressure and heartbeat were measured using a blood pressure meter (HEM-6232T, Omron). The HRV was measured using a heart rate sensor (H1, Polar) and was recorded using Elite HRV software (EHRV). The data set was then analyzed using Kubios HRV Standard software (Kubios) to transform the time-domain signals (R-R intervals) into frequency-domain signals, low frequency (LF) values, high frequency (HF) values and the LF/HF ratios.

(VI) Statistical analysis

The results of each experiment are expressed as mean ± S.D. (standard deviation). Significant differences between data sets are determined using a two-tailed paired *t*-test with levels of significance $\alpha = 0.05$, using Microsoft Excel 2019.

III. Results and Discussion

(I) Chemical compositions of the essential oils from *C. macrolepis* var. *formosana* and *T. cryptomerioides* leaves

The GC/MS chromatograms of the essential oils from *C. macrolepis* var. *formosana* and *T. cryptomerioides* leaves are shown in Fig. 1. Each component is listed in Table 1 and Table 2. The essential oil from *C. macrolepis* var. *formosana* leaves has abundant monoterpenes (87.64%), and α-pinene (72.98%) and limonene (10.34%) are the two major components. The essential oil from *T. cryptomerioides* leaves has abundant monoterpenes (79.12%), and limonene (46.77%), α-pinene (14.79%), and 3-carene (12.22%) are the major components. These results are similar to those of the studies by Cheng *et al*. (2004) and Su *et al*. (2006), which identified the major component in the essential oil of *C. macrolepis* var. *formosana* leaves as α-pinene (around 70%) and the major components in the essential oil of *T. cryptomerioides* leaves as limonene (around 45%) and α-pinene (around 14%).

(II) Effects of essential oils of *C. macrolepis* var. *formosana* and *T. cryptomerioides* leaves on the mood state of subjects

The results of the POMS before and after inhalation of essential oil from *C. macrolepis* var. *formosana* or *T. cryptomerioides* leaves

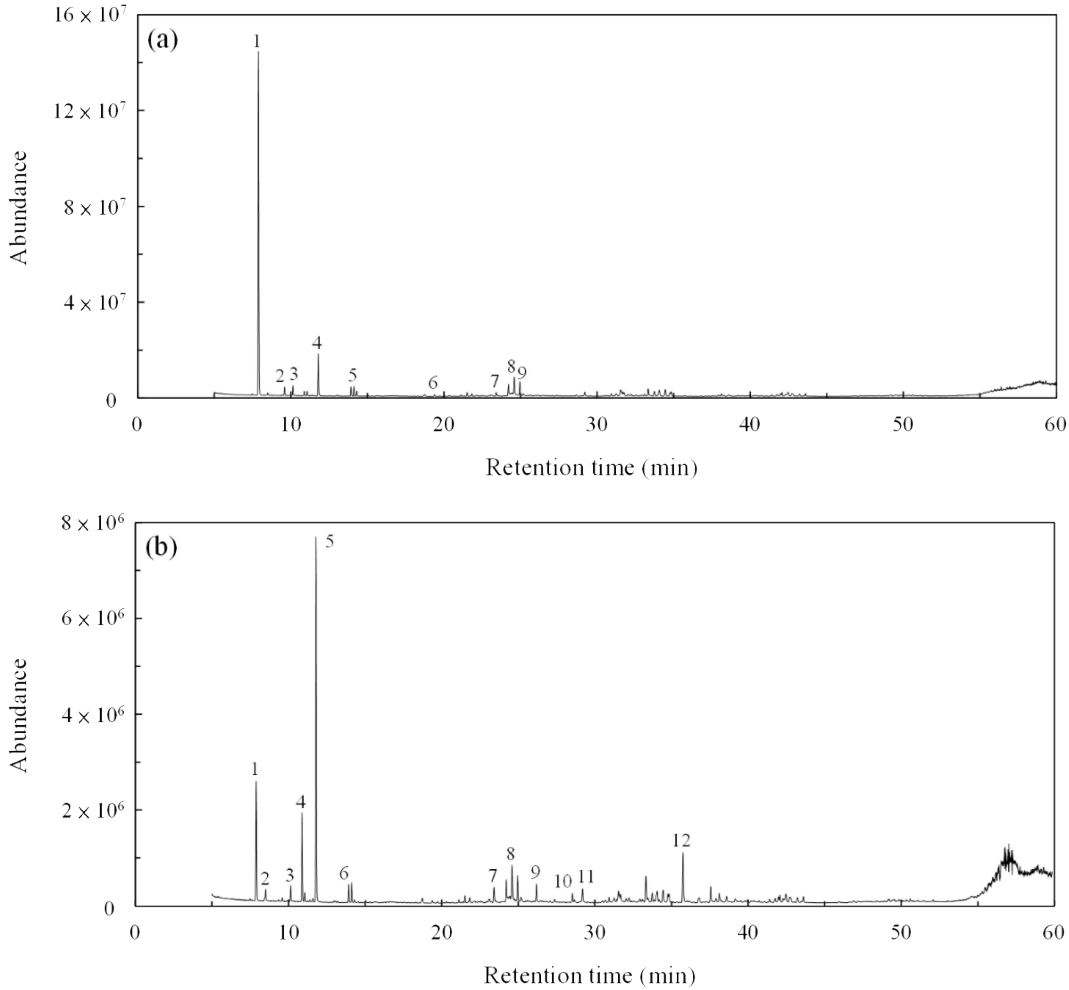

Fig. 1. GC/MS chromatograms of the leaf essential oils from (a) *C. macrolepis* var. *formosana* and (b) *T. cryptomerioides*.

are shown in Fig. 2. The scores for the six subscales (tension/anxiety, depression/dejection, anger/hostility, vigor, fatigue and confusion) all decrease significantly ($p < 0.05$) after inhaling the essential oils from *C. macrolepis* var. *formosana* leaves; and the scores for perceiving tension/anxiety and vigor decrease significantly ($p < 0.05$) after inhaling essential oils from *T. cryptomerioides* leaves. Feedback from participants shows that the specific perception of reduced vigor after sniffing is similar to feeling sleepy. Thereby, it might suggest that the essential oils from *C. macrolepis* var. *formosana* and *T. cryptomerioides* leaves have the potential to alleviate anxiety, soothe emotions, and induce sleep.

The essential oils of both leaves may alleviate anxiety because the significant components are limonene and α-pinene. The

Table 1. Chemical components in the leaf essential oil of *C. macrolepis* var. *formosana*

Peak number	Retention time (min)	Compound	Relative content (%)	KI	rKI*	Identification
1	7.89	α-Pinene	72.98	934	939	MS, KI, STD
2	9.59	Sabinene	2.15	977	975	MS, KI, STD
3	10.14	β-Myrcene	2.17	990	991	MS, KI, STD
4	11.79	Limonene	10.34	1030	1029	MS, KI, STD
5	14.12	Unknown	2.15	1081	-	-
6	19.38	α-Terpineol	0.72	1193	1189	MS, KI, STD
7	23.41	Isobornyl acetate	0.91	1282	1286	MS, KI, STD
8	24.59	Unknown	4.85	1313	-	-
9	24.95	Cyclohexyl acetate	3.73	1328	1319	MS, KI, STD
Monoterpenes			87.64			
Oxygenated monoterpenes			1.63			
Other oxides			3.73			
Identified content			93.00			

MS: mass spectrum; KI: Kovats indice; STD: authentic compound. *: refer to the Kovats indices from Su *et al*. (2006) and Adams (2007).

Table 2. Chemical components in the leaf essential oil of *T. cryptomerioides*

Peak number	Retention time (min)	Compound	Relative content (%)	KI	rKI*	Identification
1	7.89	α-Pinene	14.79	934	935	MS, KI, STD
2	8.50	Camphene	2.55	951	952	MS, KI, STD
3	10.14	β-Myrcene	2.79	990	990	MS, KI, STD
4	10.88	3-Carene	12.22	1007	1008	MS, KI, STD
5	11.79	Limonene	46.77	1030	1030	MS, KI, STD
6	13.92	Unknown	2.41	1077	-	-
7	23.42	Isobornyl acetate	2.81	1282	1283	MS, KI, STD
8	24.60	Unknown	5.39	1313	-	-
9	26.18	α-Copaene	2.76	1380	1373	MS, KI, STD
10	28.54	Thujopsene	1.35	1433	1431	MS, KI, STD
11	29.19	Unknown	2.45	1443	-	-
12	33.34	δ-Cadinene	3.71	1513	1514	MS, KI, STD
Monoterpenes			79.12			
Sesquiterpenes			7.82			
Oxygenated monoterpenes			2.81			
Identified content			89.75			

MS: mass spectrum; KI: Kovats indice; STD: authentic compound. *: refer to the Kovats indices from Su *et al*. (2006) and Adams (2007).

effects on mood are similar to the effects of other essential oils that contain α-pinene and/or limonene, such as *Citrus sinesis, C. formosensis* (Meniki) and *C. obtusa* (Hinoki) (Kasuya *et al*., 2013; Chen *et al*., 2015; Wolffenbüttel *et al*., 2018). Previous studies show that anxiolytic-like behaviors in the elevated plus maze (EPM) for mice are related to the accumulation and metabolism of α-pinene in the brain regions (Satou *et al*., 2014; Kasuya *et al*., 2015a, b). Furthermore, due to the abundant limonene in *C. sinesis* essential oil, some studies (Lima *et al*., 2013; Song *et al*., 2021) of the inhalation of pure limonene also demonstrate an anxiolytic-like effect for mice. Besides, Yang *et al*. (2016) showed that α-pinene significantly decreases sleep latency in the pentobarbital-induced sleep test for mice via oral administration, implying the hypnotic effect of α-pinene. The research group further showed that 3-carene (12.22%), which is one of the main constituents of the essential oil in *T. cryptomerioides* leaves, has a similar sleep-enhancing effect through the same route (Woo *et al*., 2019).

(III) Effects of essential oils of *C. macrolepis* var. *formosana* and *T. cryptomerioides* leaves on heart rate variability (HRV), blood pressure and heartbeat

The results of the HRV and blood pressure measurements before and after inhalation of essential oil from *C. macrolepis* var. *formosana* or *T. cryptomerioides* leaves are respectively shown in Fig. 3 and Fig. 4. These results indicate that the frequency domain measures, LF value and LF/HF ratio decrease very significantly ($p < 0.01$) while the HF value increases very significantly ($p < 0.01$) after inhalation of essential oil of *C. macrolepis* var. *formosana* leaves. After

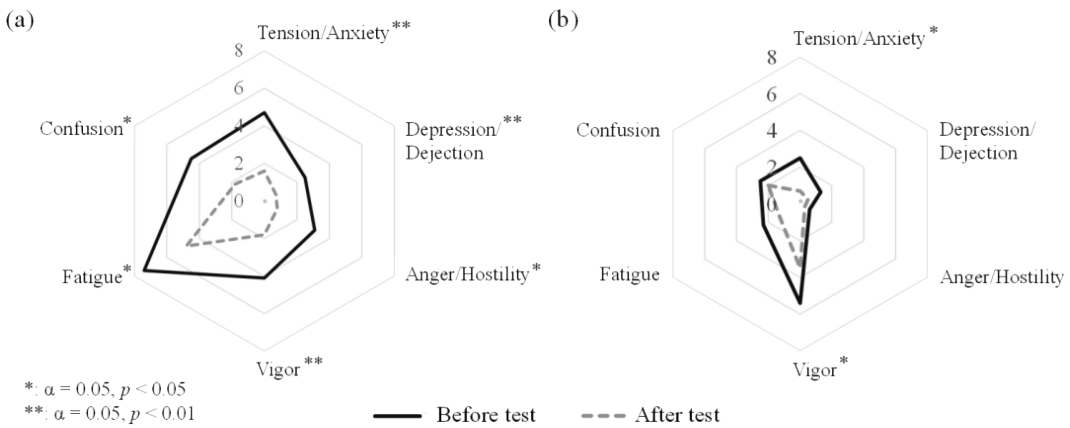

Fig. 2. Changes in emotional states after inhalation of leaf essential oils from (a) *C. macrolepis* var. *formosana* (b) *T. cryptomerioides*. Data are expressed as average scores from the emotional states of participants ($n = 10$).

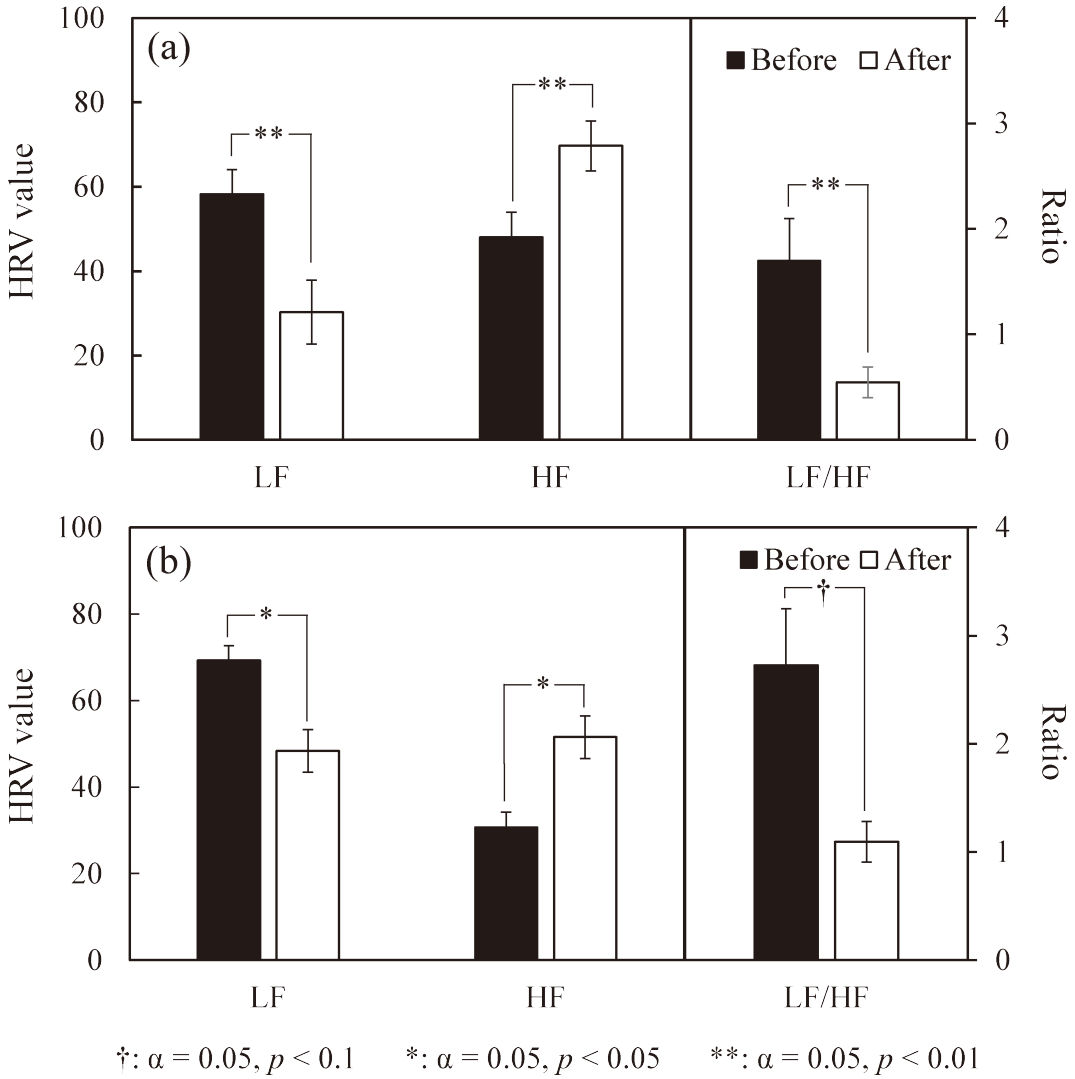

Fig. 3. Changes in heart rate variability (HRV) after inhalation of leaf essential oils from (a) *C. macrolepis* var. *formosana* and (b) *T. cryptomerioides*. Data are expressed as mean ± S.E. (*n* = 10).

inhalation of essential oil of *T. cryptomerioides* leaves, the HF value increases significantly ($p < 0.05$) and the LF value decreases significantly ($p < 0.05$); however, there is a less significant difference in the LF/HF ratio. The increase in HF value reflects higher vagal activity to regulate the autonomic nervous system, while higher LF value and LF/HF ratio reflect more sympathetic activity (Thayer *et al*., 2012). These results revealed that the essential oils from *C. macrolepis* var. *formosana* and *T. cryptomerioides* leaves positively affect vagal activity.

Positive vagal activity is produced by

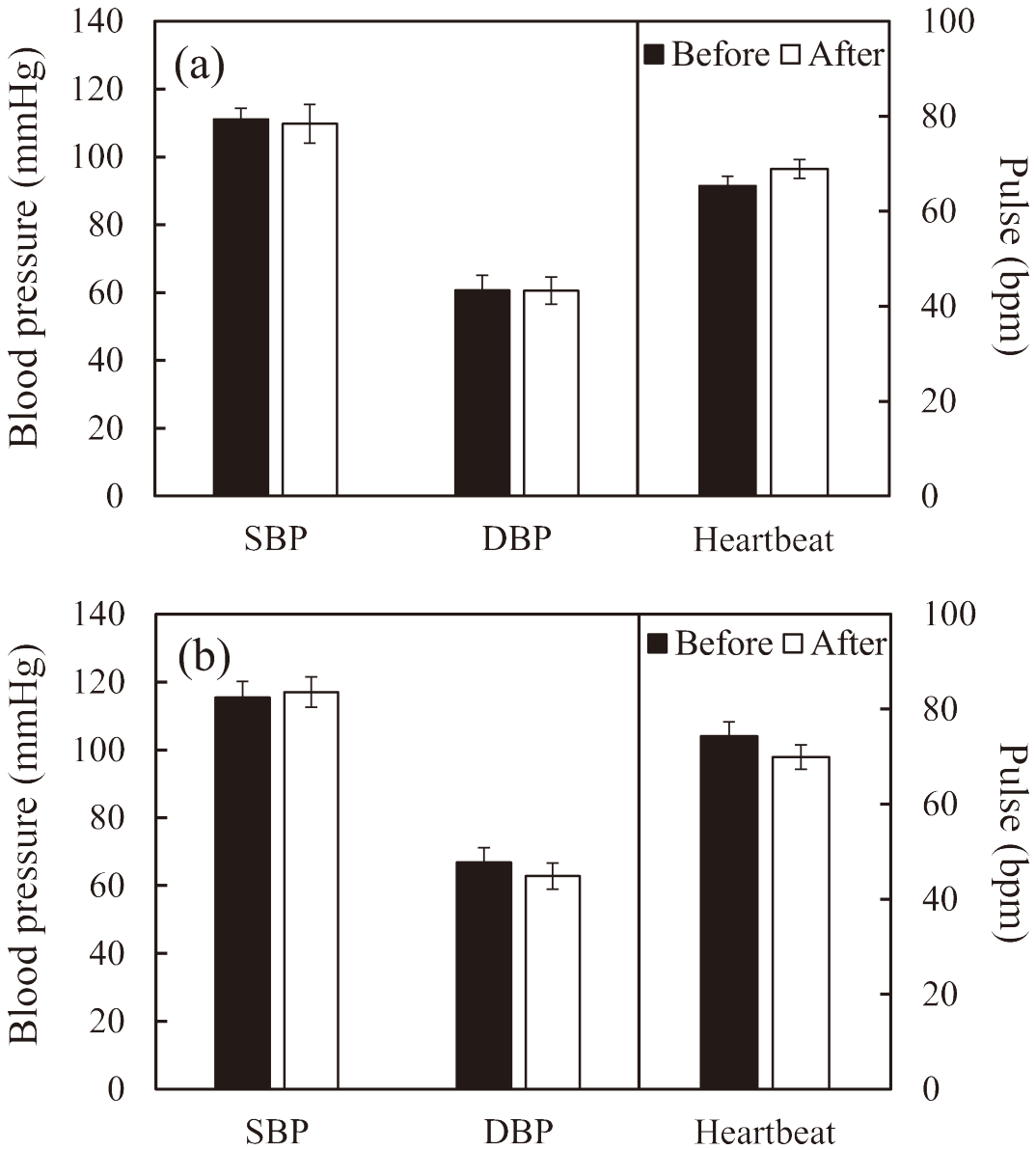

Fig. 4. Changes in blood pressure and heart rate after inhalation of leaf essential oils from (a) *C. macrolepis* var. *formosana* and (b) *T. cryptomerioides*. Data are expressed as mean ± S.E. (*n* = 10).

both leaf essential oils from *C. macrolepis* var. *formosana* and *T. cryptomerioides*, as shown in Fig. 4, but there is no significant difference in heart rate, systolic blood pressure (SBP), diastolic blood pressure (DBP) or heartbeat before and after the inhalation. Studies show that vagal activity is related to downregulation of physiological arousal and psychological and behavioral responses, and a higher HRV is related to better emotion control (Petrocchi

et al., 2019). *C. formosensis* (Meniki) wood essential oil also produces a similar change in HRV values (Chen *et al*., 2015): the HF value significantly increases, while the LF value significantly decreases after inhalation of Meniki essential oil; however, the effect on blood pressure of Meniki essential oil is not consistent with the results of present study. Although these observations from exposure to elements of these tree-derived essential oils might echo the benefits of immersion in a forest or green environment, the modest differences in physiological response differ for the major components. The major components of the essential oils from *C. macrolepis* var. *formosana* and *T. cryptomerioides* are α-pinene (72.98% and 14.79%) and limonene (10.34% and 46.77%) (Table 1 and Table 2), respectively. In contrast, the major components of Meniki essential oil are δ-cadinene (26.3%) and γ-cadinene (9.9%) rather than α-pinene (3.3%) and limonene (0.2%) (Chen *et al*., 2015).

Previous studies indicate that the anxiolytic activity of limonene is attributed to increased release of GABA (Song *et al*., 2021). α-Pinene and 3-carene also effect the allosteric modification at the BZD-binding site of the $GABA_A$ receptor, which mediates the sedative-hypnotic properties in the brain and produces the anxiolytic and sleep-facilitating effects in mice (Yang *et al*., 2016; Woo *et al*., 2019). Due to the significant content of α-pinene and limonene (72.98% and 10.34%) in *C. macrolepis* var. *formosana* leaves and the combination of α-pinene, limonene and 3-carene (14.79%, 46.77% and 12.22%) in *T. cryptomerioides* leaves, these essential oils from forest leaves might have tremendous potential being as adjuvant to psychotropic medications.

IV. Conclusions

This study demostrates the soothing effects of inhalation of atomized essential oils from *C. macrolepis* var. *formosana* and *T. cryptomerioides* leaves on mood moderation in conjunction with autonomic nervous system activity. These effects might be attributed to the synergy among their components, mainly α-pinene, limonene, 3-carene, and so forth. It provides a perspective of developing sustainable, regenerative forest residues, *C. macrolepis* var. *formosana* and *T. cryptomerioides* leaves, for medicinal uses or alternative therapies in health. Furthermore, exploring the application potential of native species of plants for forest therapy and aromatherapy will be a better way for eco-friendly and sustainable forest management in Taiwan.

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VI. Literature cited

Adams, R. P. (2007) Identification of Essential Oil Components by Gas Chromatography/Mass Spectroscopy 4th Ed. Allured Pub. Corp.: IL, USA.

Antonelli, M., D. Donelli, G. Barbieri, M. Valussi, V. Maggini and F. Firenzuoli (2020) Forest volatile organic compounds and their effects on human health: A state-of-the-art review. International Journal of Environmental Research and Public Health 17(18): 6506.

Chang, T.-K., C.-Y. Lin and S.-T. Chang (2018) Study on the composition and amount of phytoncies emitted from *Juniperus chinensis* L. var. *kaizuka* Hort. leaves. Journal of the Agricultural Association of China 19(1): 42-59. [*In Chinese*]

Chen, C.-J., K. J. Kumar, Y.-T. Chen, N.-W. Tsao, S.-C. Chien, S.-T. Chang, F.-H. Chu and S.-Y. Wang (2015) Effect of hinoki and meniki essential oils on human autonomic nervous system activity and mood states. Natural Product Communications 10(7): 1305-1308.

Chen, K.-M., M. Snyder and K. Krichbaum (2002) Translation and equivalence: The profile of mood states short form in English and Chinese. International Journal of Nursing Studies 39: 619-624.

Cheng, S.-S., C.-L. Wu, H.-T. Chang, Y.-T. Kao and S.-T. Chang (2004) Antitermitic and antifungal activities of essential oil of *Calocedrus formosana* leaf and its composition. Journal of Chemical Ecology 30: 1957-1967.

Framer, A. (2021) What I have learnt from helping thousands of people taper off antidepressants and other psychotropic medications. Therapeutic Advances in Psychopharmacology 11: 2045125321991274.

Hansen, M. M., R. Jones and K. Tocchini (2017) Shinrin-Yoku (forest bathing) and nature therapy: A state-of-the-art review. International Journal of Environmental Research and Public Health 14(8): 851.

Johnson, E. O., T. Roth and N. Breslau (2006) The association of insomnia with anxiety disorders and depression: Exploration of the direction of risk. Journal of

Psychiatric Research 40(8): 700-708.

Kasuya, H., E. Hata, T. Satou, M. Yoshikawa, S. Hayashi, Y. Masuo and K. Koike (2013) Effect on emotional behavior and stress by inhalation of the essential oil from *Chamaecyparis obtusa*. Natural Product Communications 8(4): 515-518.

Kasuya, H., S. Iida, K. Ono, T. Satou and K. Koike (2015a) Intracerebral distribution of α-pinene and the anxiolytic-like effect in mice following inhaled administration of essential oil from *Chamaecyparis obtusa*. Natural Product Communications 10(8): 1479-1482.

Kasuya, H., N. Okada, M. Kubohara, T. Satou, Y. Masuo and K. Koike (2015b) Expression of BDNF and TH mRNA in the brain following inhaled administration of alpha-pinene. Phytotherapy Research 29(1): 43-47.

Kohli, P., Z. M. Soler, S. A. Nguyen, J. S. Muus and R. J. Schlosser (2016) The association between olfaction and depression: A systematic review. Chemical Senses 41(6): 479-486.

Kuo, P.-M., F.-H. Chu and S.-Y. Wang (2012) Effect of methyl jasmonate on the amounts of volatile compounds emitted from *Chamaecyparis formosensis* Matsum. leaves. Quarterly Journal of Forest Research 34(1): 83-95. [*In Chinese*]

Lima, N. G. P. B., D. P. De Sousa, F. C. F. Pimenta, M. F. Alves, F. S. De Souza, R. O. Macedo, R. B. Cardoso, L. C. S. L. de Morais, M. de F. F. Melo Diniz and R. N. de Almeida (2013) Anxiolytic-like activity and GC-MS analysis of (*R*)-(+)-Limonene fragrance, a natural compound found in foods and plants. Pharmacology Biochemistry and Behavior 103(3): 450-454.

Lin, C.-Y., T.-C. Chang, Y.-H. Chen, Y.-J. Chen, S.-S. Cheng and S.-T. Chang (2015) Monitoring the dynamic emission of biogenic volatile organic compounds from *Cryptomeria japonica* by enclosure measurement. Atmospheric Environment 122: 163-170.

Petrocchi, N. and S. Cheli (2019) The social brain and heart rate variability: Implications for psychotherapy. Psychology and Psychotherapy 92(2): 208-223.

Salehi, B., S. Upadhyay, I. E. Orhan, A. K. Jugran, S. L. D. Jayaweera,

D. A. Dias, F. Sharopov, Y. Taheri, N. Martins, N. Baghalpour, W. C. Cho and J. Sharifi-Rad (2019) Therapeutic potential of α- and β-pinene: A miracle gift of nature. Biomolecules 9(11): 738.

Satou, T., H. Kasuya, K. Maeda and K. Koike (2014) Daily inhalation of alpha-pinene in mice: Effects on behavior and organ accumulation. Phytotherapy Research 28(9): 1284-1287.

Song, Y., S. Seo, S. Lamichhane, J. Seo, J. T. Hong, H. J. Cha and J. Yun (2021) Limonene has anti-anxiety activity via adenosine A2A receptor-mediated regulation of dopaminergic and GABAergic neuronal function in the striatum. Phytomedicine 83: 153474.

Soudry, Y., C. Lemogne, D. Malinvaud, S. M. Consoli and P. Bonfils (2011) Olfactory system and emotion: Common substrates. European Annals of Otorhinolaryngology, Head and Neck Diseases 128(1): 18-23.

Su, Y.-C., C.-L. Ho and E. I-C Wang (2006) Analysis of leaf essential oils from the indigenous five conifers of Taiwan. Flavour and Fragrance Journal 21: 447-452.

Suntar, I., H. Khan, S. Patel, R. Celano and L. Rastrelli (2018) An overview on *Citrus aurantium* L.: Its functions as food ingredient and therapeutic agent. Oxidative Medicine and Cellular Longevity 2018: 7864269.

Taylor, D. J., K. L. Lichstein and H. H. Durrence (2003). Insomnia as a health risk factor. Behavioral Sleep Medicine 1(4): 227-247.

Thayer, J. F., F. Ahs, M. Fredrikson, J. J. 3rd Sollers and T. D. Wager (2012) A meta-analysis of heart rate variability and neuroimaging studies: Implications for heart rate variability as a marker of stress and health. Neuroscience and Biobehavioral Reviews 36(2): 747-756.

Tomba, E., J. Guidi and G. A. Fava (2018) What psychologists need to know about psychotropic medications. Clinical Psychology and Psychotherapy 25(2): 181-187.

Tsunetsugu, Y., B. J. Park and Y. Miyazaki (2010) Trends in research related to "Shinrin-Yoku" (taking in the forest atmosphere or forest bathing) in Japan. Environmental Health and Preventive Medicine 15(1): 27-37.

Wolffenbüttel, A. N., A. Zamboni, G. Becker, M. K. Dos Santos, B. T.

Borille, K. de Cassia Mariotti, A. C. Fagundes, J. L. de Oliveira Salomón, V. R. Coelho, L. V. Ruiz, V. de Moura Linck, E. Dallegrave, P. Cano, A. I. Esquifino, M. B. Leal and R. P. Limberger (2018) Citrus essential oils inhalation by mice: Behavioral testing, GCMS plasma analysis, corticosterone, and melatonin levels evaluation. Phytotherapy Research 32(1): 160-169.

World Health Organization (2017). Depression and other common mental disorders: global health estimates. *World Health Organization*, Geneva, Switzerland.

Woo, J., H. Yang, M. Yoon, C. G. Gadhe, A. N. Pae, S. Cho and C. J. Lee (2019) 3-Carene, a phytoncide from pine tree has a sleep-enhancing effect by targeting the GABA(A)-benzodiazepine receptors. Experimental Neurobiology 28(5): 593-601.

Yang, H., J. Woo, A. N. Pae, M. Y. Um, N. C. Cho, K. D. Park, M. Yoon, J. Kim, C. J. Lee and S. Cho (2016) α-Pinene, a major constituent of pine tree oils, enhances non-rapid eye movement sleep in mice through $GABA_A$-benzodiazepine receptors. Molecular Pharmacology 90(5): 530-539.